



Meeting the Moment

A Strategic Roadmap for Advancing the Biosciences Industry Cluster in Greater Oklahoma City

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Executive Summary

Meeting the Moment

The Greater Oklahoma City region has made significant progress in biosciences cluster development over the last two decades by growing both its industry base and its significant research enterprise—two pillars of a competitive bioscience cluster where industry-university partnerships and clinical research collaborations are critical to transformative innovation.¹

The biosciences industry has well outpaced the region's overall private sector in job growth since the early 2000s, and the region's university and other institutional research in biosciences fields has more than doubled to exceed \$300 million annually, a sizable academic R&D complex that rivals many emerging, fast-growing U.S. regional bioscience hubs.

Regional stakeholders frequently acknowledge the exciting momentum in the biosciences industry cluster today, following the recent Economic Development Administration "Build Back Better Regional Challenge" (EDA-BBBRC) award that brought in \$35 million for targeted biosciences ecosystem investments. The application process and resulting project partnerships for the BBBRC grant, as well as recent efforts to capture additional federal cluster development resources, have spurred new collaborations and focus for the regional biosciences ecosystem. In addition, new leadership at several

¹ A recent study, for example, has found that 80% of the most transformative drugs over the last 25 years resulted from collaborations between industry and academia. Source: Tufts Center for the Study of Drug Development, *Public and Private Contributions to the R&D of the Most Transformational Drugs of the Last 25 Years*, January 2015.

In Greater Oklahoma City, the Biosciences Cluster represents:

Nearly **31,000 jobs**

10% employment growth since 2015

563 business establishments

\$84k average wages in the industrial biosciences

\$68k average wages in hospitals

\$316M in annual bioscience-related university/ biomedical institution R&D expenditures

key institutions and the physical and programmatic development of the new OKC Innovation District adjacent to the OU Research Park all contribute to this sense of excitement and promise, heralding a new day for regional biosciences and other advanced industry development.

But challenges persist, and the marathon of biosciences development requires consistent and significant nurturing and attention to realize its promise. Despite key investments and cluster leadership, the region's cluster development organization, OKBio, has waned and stagnated; its innovation and commercialization engines have lagged in their performance; high-growth firms cite workforce and talent development challenges—growing pains associated with hiring gains; and realizing the region's full potential requires robust and effective collaboration—an area stakeholders lament is limited due to organizational silos.

This strategic planning effort and resulting regional Roadmap seek to spotlight both the strengths and significant promise for Greater OKC in the biosciences, as well as weaknesses and challenges that must be addressed to seize the biosciences opportunity and meet the moment.²

Progress: OKC's Regional Biosciences Industry and R&D Engine Emerges with Growth and Varied Opportunities

Greater Oklahoma City has made great strides over the past two decades in building a solid foundation in the biosciences industry and research upon which to support additional investment.

The Biosciences Industry Growing Strongly with Specific Industry Niches Leading the Way

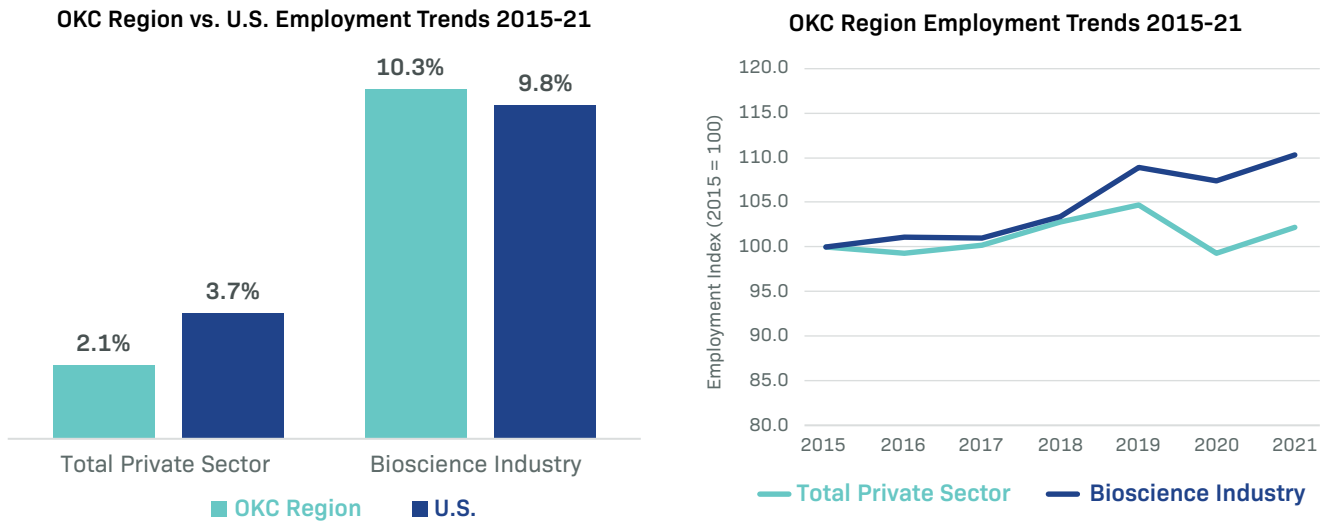
Since 2001, the cluster—composed of nonclinical biosciences industries and academic medical and other hospitals—has grown by nearly double the region's overall private sector rate, increasing by nearly 28% for the biosciences versus 16% for the overall economy. The biosciences continue to represent a strong growth driver for the Greater OKC regional economy, growing significantly faster than the region's private sector since 2015 and acting as an economic bulwark during the pandemic-induced economic downturn in 2020. Since 2015, the region's biosciences industry has grown by 10.3%, essentially matching the national average (see Figure ES-1).

By 2021, the region employed nearly 31,000 in the biosciences, with the majority of those jobs within the hospital subsector (85%) and almost 5,000 jobs in the combined industrial biosciences subsectors. Highlights from the regional industry assessment include the following:

- The region's complex of academic medical centers and other hospitals and health services stands out for OKC as a "specialized" regional industry concentration with a location quotient (LQ) of 1.19—meaning the region is 19% more concentrated in this sector relative to the national

2 For this study the Greater OKC region includes 10 counties: Canadian, Cleveland, Grady, Kingfisher, Lincoln, Logan, McClain, Oklahoma, Payne, and Pottawatomie.

Figure ES-1: Greater OKC Regional Bioscience Industry Employment Trends



Source: TEconomy Partners analysis of BLS, CEW data from Lightcast (2022.3)

average.³ The region is clearly a healthcare destination for Oklahoma residents statewide.

- Several other subsectors are clearly emerging in the region—growing but not yet specialized or even at the national average in their employment concentration.
 - Drug and pharmaceutical manufacturing has grown by 52% to reach 720 regional jobs. The region’s growth has been led by emergence in the biomanufacturing component of the biosciences by high-growth firms such as Cytovance Biologics in contract manufacturing producing biologics or large molecule therapeutics.
 - Medical device and equipment manufacturers have increased regional employment by nearly 25% since 2015 to more than 600 regional jobs across a varied set of detailed device and MedTech-related sectors.

- Bioscience-related distribution is also emerging with 16% growth since 2015 to reach just over 1,500 regional jobs by 2021. The distribution subsector is led by job growth in the pharmaceutical wholesaling component.

Despite the exciting growth and momentum, the region remains largely “under-concentrated” in the industrial (non-hospital) biosciences subsectors, with a location quotient 48% below the national average. So, while the region is growing, it remains a work in progress to advance the biosciences industry forward amidst a backdrop of fierce competition nationally.

The region’s industry base is involved in innovation-related activities that reveal forward-looking growth opportunities, particularly for patenting biosciences inventions and venture capital funding of emerging biosciences companies.

- In patenting activity, leading areas of patent invention in the region assigned to the industry

3 Employment concentration is a useful way to gauge the relative importance of an industry to a state or regional economy. Regional location quotients (LQs) measure the degree of job concentration within the region relative to the national average. States or regions with an LQ greater than 1.0 are said to have a concentration in the sector. When the LQ is significantly above average, 1.20 or greater, the state is said to have a “specialization” in the industry.

from 2015 through 2022 are found in the two broad areas of MedTech/HealthTech and therapeutic compounds.

- In venture funding, the leading areas of emerging companies receiving venture investments from 2015 through 2022 are biopharmaceuticals, MedTech, HealthTech, and AgTech.

Biosciences Research Reaching Higher Levels with a Diverse Focus

Leading regional universities, including the University of Oklahoma (OU) and Oklahoma State University (OSU), as well as the nonprofit Oklahoma Medical Research Foundation (OMRF), combine to form a more than \$300 million R&D and innovation engine that fuels life sciences and biomedical discovery. This is a substantial base of research activity that compares well to other regions with emerging biosciences clusters, such as Phoenix, Portland, Salt Lake City, and Louisville.

Like the long-term growth of the regional industry, bioscience-related R&D expenditures have more than doubled over two decades and, since 2015, have grown by 19% to reach \$316 million in 2020. This growth rate, while strong, has lagged behind that for the nation which has grown by 28%.

Detailed assessments of the region's R&D base were undertaken to identify regional biosciences research and technology competencies and serve as inputs into identifying growth opportunities going forward. This analysis included examining thousands of bioscience-related research publications, evaluating more than two dozen relevant university and institutional research centers and institutes, analyzing volumes and concentrations of research expenditures, researching university-related commercialization activities, and scrutinizing planned research-related investments and enhancements. These analyses

While the regional industry is growing, it remains “under-concentrated” and a work in progress to advance the biosciences industry forward amidst a backdrop of fierce competition nationally.

reveal a depth of strengths that, aligned with regional industrial strengths, form a set of diverse regional growth opportunities.

Three Broad Growth Opportunities in the Biosciences for Greater OKC Region Link Region's Industry Development and Research Capacities

A “line-of-sight assessment” was undertaken that aligns the “market pull” of biosciences industry development with the “technology push” of research capabilities at the region's anchor institutions to identify growth opportunities for the Greater OKC region. The assessment informs where the region has the capacity to grow and to leverage comparative advantage that is provided by an analysis of core research competencies and insights on industry innovation efforts, all with a forward-looking approach to high-growth market opportunities.

What emerges from the line-of-sight assessment are three broad growth opportunity areas in the biosciences for the Greater OKC region that align the region's biosciences industry development with the research competencies found across its anchor institutions.⁴ These three growth opportunity areas are summarized in Figure ES-2 and are detailed in the report to inform strategic recommendations.

⁴ For more details and the complete Line-of-Sight Assessment findings, see Appendix on Findings from the Core Competency Analysis, presented to the Advisory Committee on November 2, 2022.

Figure ES-2: Bioscience Growth Opportunities Identified for the Greater Oklahoma City Region

Source: TEconomy Partners’ line-of-sight assessment.

Bioscience Innovation Ecosystem Challenges are Limiting Growth

Although the continued growth and positioning of the Greater OKC region’s biosciences industry and research base offer a strong foundation for continued development, significant gaps, weaknesses, and challenges in the region’s biosciences innovation ecosystem are holding back development.

Three primary areas were uncovered via quantitative analyses and extensive stakeholder input solicited through one-on-one interviews, regional focus groups, and regular input from the project Advisory Committee:

- **The lack of an effective cluster development organization and “connecting entity”** seen as a trusted broker in the regional (and statewide) biosciences ecosystem and, at the same time, an interrelated lack of systematic collaboration across institutions and regions within the state, resulting in challenging silos.
- **Persistent innovation and commercialization challenges and their intersection in what is often referred to as the “valley of death” for innovative companies** have been identified frequently and consistently as a major weakness and challenge within the regional biosciences ecosystem.
- **Workforce and talent** and critical skill sets are misaligned with growing industry demand, resulting in a consistent gap often cited as the most significant challenge facing regional employers.

Strategic Recommendations to Meet the Moment for Regional Biosciences Development

The preceding analyses and the stakeholder inputs and insights gathered throughout the project effort coalesce into a set of strategic priorities for advancing the regional biosciences cluster in Greater Oklahoma City. These priorities were presented to and refined in partnership with the regional focus groups and project Advisory Committee, where there was strong agreement on the need for focused investments and interventions.

Four strategic priorities emerge as critical for advancing the region’s bioscience industry and ecosystem that involve:

1. Enhancing connectivity, collaborations, and targeted programming for the overall bioscience ecosystem through a reboot of OKBio.
2. Meeting the biosciences talent challenge.
3. Addressing commercialization challenges that overcome the “valley of death” in biosciences innovation.
4. Seizing and organizing around identified biosciences growth opportunities.

The Roadmap makes the case for the key findings and rationale behind each of the strategic priority areas and presents a set of associated recommended actions for the region to advance development for the biosciences industry cluster and its broader innovation ecosystem. The strategies and recommended actions are summarized in Figure ES-3.

Significant statewide benefits are expected to accrue by addressing these strategic priorities to grow the biosciences, given the considerable concentration of overall statewide research and industry activities

found in the Greater OKC region. Other regions of the state are highly interrelated with the region’s biosciences activities, particularly more rural areas where much of the state’s agricultural and food processing industries are located and where healthcare is a pressing need. Tulsa also stands out with its own biosciences cluster development that can benefit from increased collaborations with the Greater OKC region around specific growth opportunities and shared ecosystem needs.

The timing is ripe to seize the tangible momentum in the regional biosciences cluster. Greater Oklahoma City has seen a significant win for the industry and its innovation ecosystem, with substantial federal funding flowing to strategic biosciences projects, combined with an exciting spirit of collaboration and new leadership across the region. Regional industry and university R&D are growing, with a diverse mix of potential growth opportunities. Numerous activities and investments by regional players are ongoing but require greater connectivity and the region must coordinate around its talent, commercialization, and organizational challenges or it risks missing this key moment for biosciences development.

Figure ES-3: Strategic Priorities and Recommended Actions for Greater OKC Region Biosciences Development

<p>1. Enhancing connectivity, collaborations, and targeted programming for the overall bioscience ecosystem through a reboot of OKBio</p>
<p>Action 1.1: Reboot OKBio to be the independent cluster hub for advancing the biosciences sector serving not just the Greater OKC region, but all regions of the state.</p>
<p>2. Meeting the biosciences talent challenge</p>
<p>Action 2.1: Target post-doctoral researchers and graduate students in bioscience-related fields for entrepreneurial development.</p>
<p>Action 2.2: Invest in specific, targeted postsecondary programming in areas of demonstrated industry need including in biomanufacturing quality control/assurance (QC/QA) and in biotechnology programs for lab technicians and other applied industry roles.</p>
<p>Action 2.3: Bolster biosciences career awareness and connections to engage K-12 students, early college students, and parents about the wide array of career opportunities in the growing regional biosciences industry.</p>
<p>3. Addressing commercialization challenges that overcome the “valley of death” in biosciences innovation</p>
<p>Action 3.1: Consider establishing an Oklahoma Clinical Research Consortium to leverage the emerging activities and investments across the region’s anchor research institutions and to complement the rise of contract manufacturing with a stronger position in clinical research and clinical trials services across disease areas.</p>
<p>Action 3.2: Establish an Oklahoma Biosciences Innovation Partnership to establish integrated commercialization services across research institutions to advance biomedical commercialization and new venture formation.</p>
<p>Action 3.3: Establish a multi-institutional shared biosciences core research services program to enhance a range of capabilities such as sequencing, pre-clinical imaging, structural biology, animal models, etc.</p>
<p>Action 3.4: Stand up a health technology accelerator focused on rural health solutions—both of which are strengths in Greater OKC as well as a core mission and strength of OSU-CHS in and around Tulsa and represent a major need for the State of Oklahoma’s rural population.</p>
<p>4. Seizing and organizing around identified biosciences growth opportunities</p>
<p>Action 4.1: Establish an organizational infrastructure for supporting growth opportunity networks, led by OKBio with assistance from site miners at major anchor organizations.</p>

INTRODUCTION

Seizing the Momentum for the Biosciences Opportunity in Greater Oklahoma City

Greater Oklahoma City has long recognized the biosciences opportunity for the region—both as an economic growth and diversification driver as well as for the population health and quality of life dividend derived from one of the world’s most innovative industries advancing life-saving treatments and cures and addressing global challenges related to energy, shifts toward biobased products, and feeding the world. With this recognition, the region has invested over time, with a focus on biosciences cluster development as an ongoing regional economic development strategy since the late 1980s and early 1990s when community leaders conceived and launched the Presbyterian Health Foundation Research Park in Oklahoma City’s (OKC) growing medical district.

By 2005, the effort took a broader regional but more industry focused approach with the completion of the Battelle comprehensive biosciences strategic plan. Known as *Bio Ready, Bio Strong*, the plan envisioned a new Bio-corridor along I-35 connecting assets from Stillwater, OKC, and Norman.⁵ This strategic vision continues today, with the goal of establishing bioscience as “a key driver for the region’s economy, providing a high rate of return measured in high-wage jobs, high-quality health care, and career opportunities for the region’s talent base, with internationally recognized strengths in select areas and offering a place where agile entrepreneurs continually turn ideas

Biosciences offer an opportunity to:

Advance high-quality/high-wage industry jobs, with a broad range of employment opportunities

Diversify the regional economy

Leverage leading university research strengths

Capture a strong driver of inclusive economic growth

Generate a “health and quality of life dividend”

Reach urban, suburban, and rural communities

Ensure the resilience of supply chains critical to national security

⁵ For this study the Greater OKC region includes 10 counties: Canadian, Cleveland, Grady, Kingfisher, Lincoln, Logan, McClain, Oklahoma, Payne, and Pottawatomie.

into well-capitalized firms that are among the leaders in their industry segments.”⁶

The region has made significant progress in growing its industry base and research enterprise over the last two decades—two pillars of a competitive bioscience cluster where industry-university partnerships and clinical research collaborations are critical to transformative innovation.⁷ The biosciences industry has well outpaced the region’s overall private sector in job growth since the early 2000s, and the region’s university and other institutional research in biosciences fields has more than doubled to exceed \$300 million annually, a sizable academic R&D complex that rivals many emerging fast-growing U.S. regional bioscience hubs.

Following the recent Economic Development Administration “Build Back Better Regional Challenge” (EDA-BBBRC) award for \$35 million to fund targeted biosciences ecosystem investments, regional stakeholders regularly acknowledge the exciting momentum in the biosciences industry cluster. The application process and resulting project partnerships for the BBBRC grant, as well as new efforts aiming to capture additional federal cluster development resources, have spurred new collaborations and focus for the regional biosciences ecosystem. In addition, new leadership at several key institutions and both the physical and programmatic development of the new OKC Innovation District adjacent to the OU Research Park contribute to this sense of excitement and promise that herald a new day for regional biosciences and other advanced industry development.

But challenges persist, and the marathon of biosciences development requires consistent and significant nurturing and attention to realize its promise. Despite key investments and cluster leadership, the region’s cluster development organization, OKBio, has waned and stagnated; the region’s innovation and commercialization engines have lagged in their performance; high-growth firms cite workforce and talent development challenges—growing pains associated with hiring gains; and realizing the region’s full potential requires robust and effective collaboration—an area where stakeholders lament the limitations of operating in organizational “silos”. This strategic planning effort seeks to spotlight both the strengths and significant promise for Greater OKC in the biosciences, as well as weaknesses and challenges that must be addressed to seize the biosciences opportunity and meet the moment.

TEconomy Partners, LLC (TEconomy) has been engaged by the Greater OKC Chamber to develop this Strategic Roadmap to guide the region on its next decade of biosciences investments and growth. The approach has leveraged extensive quantitative data analysis to assess industry and ecosystem positioning and growth opportunities for the region, as well as qualitative engagement with regional stakeholders and leaders across the biosciences cluster to illuminate both opportunities and strategic challenges requiring interventions. This report brings together the key findings and resulting strategic recommendations from the project effort, supported by several Appendices—the detailed interim work products presented to the project Advisory Committee that guided this work.

6 Excerpt of Vision Statement from Greater OKC Chamber, *Bio Ready, Bio Strong: Briefing Report*, 2005.

7 A recent study, for example, has found that 80% of the most transformative drugs over the last 25 years resulted from collaborations between industry and academia. Source: Tufts Center for the Study of Drug Development, *Public and Private Contributions to the R&D of the Most Transformational Drugs of the Last 25 Years*, January 2015.

A Strategy Informed and Guided by Regional Stakeholder and Leadership Input

The strategic planning process has been informed by a dedicated leadership Advisory Committee, more than 50 one-on-one interviews, and three regional focus groups all to solicit feedback on key findings and gather input on strategic priorities and recommendations. Altogether, more than 70 regional biosciences leaders and stakeholders were consulted to guide the strategy.

The 17-member Advisory Committee provided input across three in-person meetings at key stages of the process. The Committee had broad representation across the ecosystem for biosciences development, representing leaders from industry, regional universities and biomedical research institutions, investors, economic and business development leadership, the regional chamber of commerce, and state government.

Throughout the report stakeholder insights are highlighted in dark pink call-out boxes such as this one.

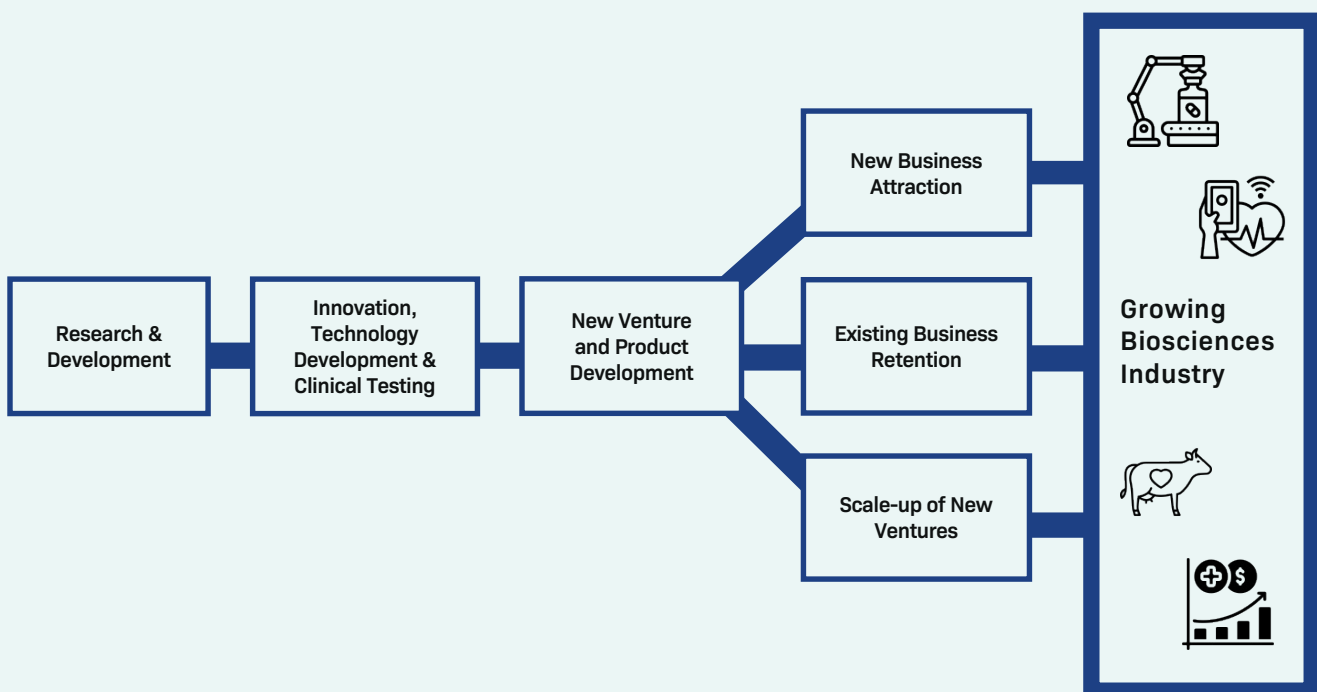
PROGRESS:

OKC's Regional Biosciences Industry and R&D Engine Emerges with Growth and Varied Opportunities

In assessing the performance of a region's biosciences cluster, the industry's unique development requirements make it critical to consider not only the trends and position of the region's industry progress and performance but also the region's research activities and overall biosciences innovation ecosystem capacities to spur innovation.

Although some regions obtain a toehold as a site for biosciences manufacturing or distribution based on their general business conditions and infrastructure, their ability to sustain and broaden that growth depends upon their relative ability and capacities to create opportunities for innovation.

Figure 1: Key Elements of a Biosciences Industry Cluster



Biosciences' Heightened Focus on Innovation

The Brookings Institution in its report on advanced industries—those leading industries that stand out in innovation and science, technology, engineering, and math (STEM) skills—found that the biopharmaceutical industry has the highest R&D spending per worker, far exceeding the next-highest industry, communications equipment, by more than 57%, and well above other innovative manufacturing industries such as autos and aerospace.*

And this R&D is critical for future success. By one estimate, 80% of the revenues for biopharmaceuticals and diagnostics in 2030 will be driven by advances that were not on the market in 2010.**

*Brookings Institution, *America's Advanced Industries*.

**Organisation for Economic Co-operation and Development (OECD), *The Bioeconomy to 2030*, 2009, page 199.

As illustrated in Figure 1, the key elements to consider in assessing the performance and position of a region's biosciences cluster and its innovation ecosystem include:

- Bioscience research capacities found at universities, academic medical centers, and nonprofit research institutes.
- Innovation and technology development capacities involving patenting of inventions, university technology transfer and commercialization, and clinical trials testing of new medicines and devices.
- Venture-funded startup activity across various stages of development from pre-seed (incubation and acceleration) and angel investments through seed and early stages to later rounds of formal venture capital.
- Bioscience industry development across the major industry subsectors that span drugs and pharmaceuticals, medical devices, agricultural and industrial biosciences, commercial research and testing, distribution, HealthTech, and hospitals.

An objective, fact-based assessment—presented in this section of the report—finds that the Greater OKC region continues to advance in its biosciences industry and research activities, providing it with a solid foundation upon which to grow its biosciences cluster with distinct areas of focus. But its broader biosciences innovation ecosystem performance remains uneven. This section presents both specific growth opportunities but also broader ecosystem challenges for the Greater OKC region in setting out a comprehensive strategy to advance its biosciences cluster.

A Solid Foundation of Industry Development and Research Activity with a Line-of-Sight to Growth Opportunities

Greater Oklahoma City has made great strides over the past two decades in building a solid foundation in the biosciences industry and research upon which to support additional investment.

The Biosciences Industry Growing Strongly with Specific Industry Niches Leading the Way

Since 2001, the cluster—made up of nonclinical biosciences industries and academic medical and other hospitals—has grown by nearly double the rate of the region’s overall private sector, increasing by nearly 28% for the biosciences versus 16% for the overall economy.

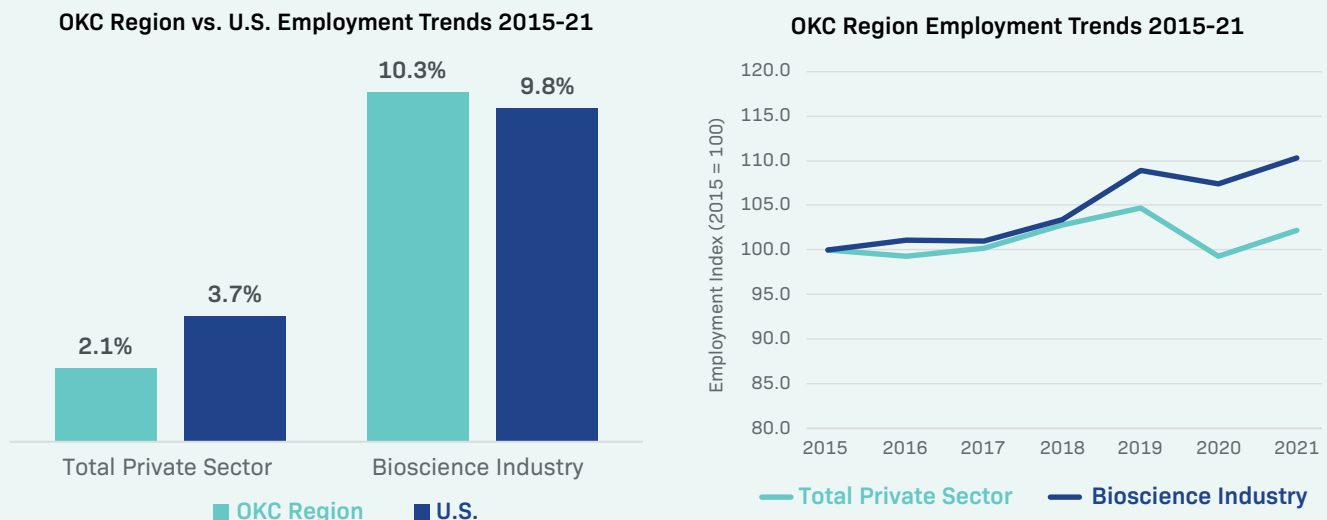
More recently, the biosciences continue to represent a strong growth driver for the Greater OKC regional economy—growing significantly faster than the region’s private sector since 2015 and acting as an economic bulwark during the pandemic-induced economic downturn in 2020. Since 2015, the focal point for the trend analyses conducted for this effort, the region’s biosciences industry has grown

Regional bioscience employees earn significantly higher wages than their counterparts in the overall private sector—nearly \$84k per year, on average for the Industrial Biosciences segment; \$68k per year in Hospitals vs. \$52k for the Total Private Sector.

by 10.3%, essentially matching the national average (see Figure 2).

By 2021, the region employed nearly 31,000 in the biosciences, with the majority of those jobs within the hospitals subsector (85%) and almost 5,000 jobs in the combined industrial biosciences subsectors.

Figure 2: Greater OKC Regional Bioscience Industry Employment Trends



Source: TEconomy Partners analysis of BLS, CEW data from Lightcast (2022.3)

Defining the Regional Bioscience Industry

The latest (2022) biennial TEconomy/Biotechnology Innovation Organization (BIO) State Initiatives report, *The U.S. Bioscience Industry: Fostering Innovation and Driving America's Economy Forward*, continues the nearly two-decade development and reporting out of an evolving set of major aggregated groupings that organize the life science industry into five major industrial subsectors shown here. The definition allows for comparable analysis of industry performance across states and metro regions.

Recognizing the importance of academic medical and health organizations to Greater Oklahoma City's biomedical innovation and clinical research activities and strengths, the hospitals and healthcare subsector has been combined with the nonclinical biomedical industries as a sixth sector for this strategic roadmap.

5 Industrial Biosciences Subsectors + Hospitals/Healthcare



For a detailed list of the North American Industry Classification System (NAICS) industry codes that define each subsector, see the Appendix to this report.

The region's complex of academic medical centers and other hospitals and health services stands out for OKC as a "specialized" regional industry concentration with a location quotient (LQ) of 1.19—meaning the region is 19% more concentrated in this sector relative to the national average.⁸ The region is clearly a destination for healthcare for Oklahoma residents statewide.

In addition to hospitals, three of the region's five industrial biosciences subsectors are emerging with double-digit employment growth since 2015.

The bubble chart in Figure 3 plots for the major subsectors of the bioscience industry the three key position and performance variables of industry employment size (size of bubble), growth (horizontal axis), and relative concentration as measured by LQs (vertical axis). Highlights from the industry assessment include the following:

- The specialized position of the regional hospitals subsector positions it high on the vertical axis. With job growth for hospitals reaching 10% since 2015, the sector is well-positioned in the upper right quadrant as a regional star performer.
- Several other subsectors are clearly emerging in the region—growing but not yet specialized or even at the national average in their employment concentration.
 - Drugs and pharmaceutical manufacturing has grown by 52% to reach 720 regional jobs in 2021. The region's growth has been led by emergence in the biomanufacturing component of the biosciences by high-growth firms such as Cytovance Biologics in contract manufacturing that produce biologics or large molecule therapeutics.

⁸ Employment concentration is a useful way to gauge the relative importance of an industry to a state or regional economy. Regional location quotients (LQs) measure the degree of job concentration within the region relative to the national average. States or regions with an LQ greater than 1.0 are said to have a concentration in the sector. When the LQ is significantly above average, 1.20 or greater, the state is said to have a "specialization" in the industry.

- Medical device and equipment manufacturers have increased regional employment by nearly 25% since 2015 to more than 600 regional jobs across a varied set of detailed device and MedTech-related sectors.
- Bioscience-related distribution is also emerging with 16% growth since 2015 to reach just over 1,500 regional jobs by 2021. The distribution subsector is led by job growth in the pharmaceutical wholesaling component.
- Not all biosciences industry segments have grown in recent years.
 - Research, testing, and medical labs, which is inclusive of commercial life sciences R&D operations including pre-commercial biotech firms as well as medical laboratories, has seen a modest employment decline since 2015, down 3%. However, this trend for Greater OKC runs counter to a strong growth trend nationally, where employment rose 35% during this period.
 - The agricultural biosciences subsector has a very modest presence in the region, despite it being recognized as a statewide strength for Oklahoma with a specialized industry concentration.⁹ This subsector has shed jobs locally since 2015.

Stakeholder Insights: The Emergence of Biomanufacturing

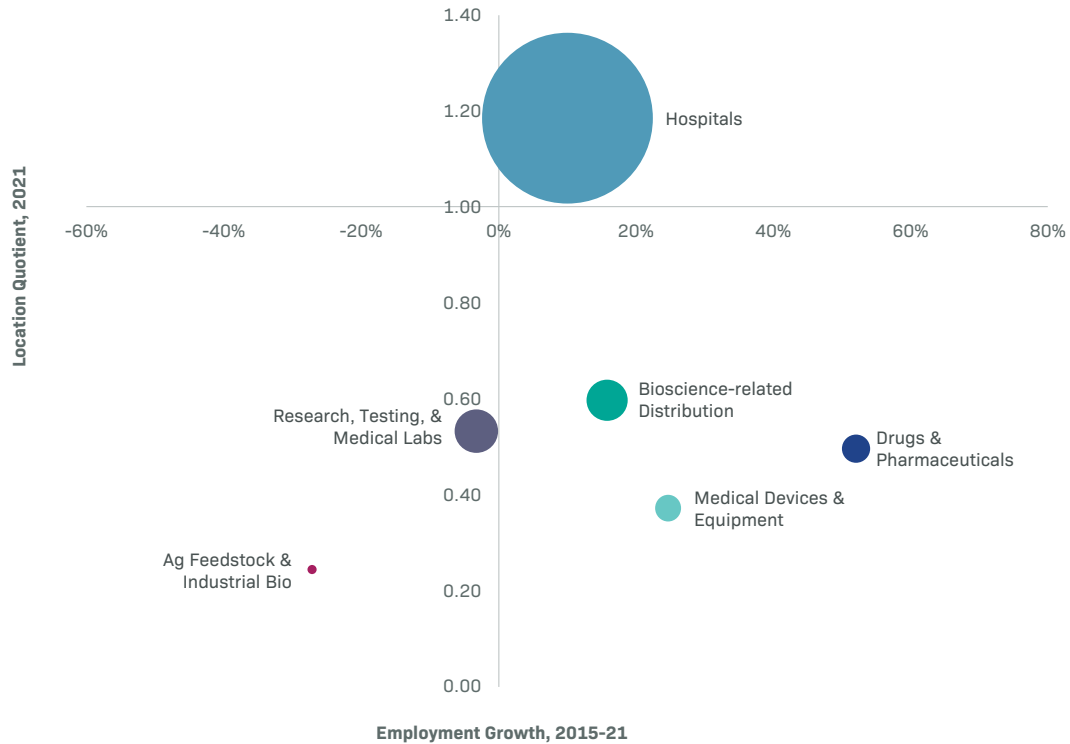
There is a tangible excitement as industry leaders and stakeholders recognize and see the emerging strength, growth, and opportunity in contract manufacturing for biopharmaceuticals as a key focus within a broader growing biosciences industry base. Stakeholders point to the growth and expansion of Cytovance Biologics and investments in Wheeler Bio as a new growth opportunity for Greater OKC.

To support the sector's growth and talent development, the EDA-BBBRC award is funding, in part, a Biomanufacturing Workforce Training Center to be located at the Innovation District.

Despite the exciting growth and momentum, the region remains largely “under-concentrated” in the industrial biosciences subsectors, with a location quotient 48% below the national average. So, while the region is growing, it remains a work in progress to advance the biosciences industry amidst a backdrop of fierce national competition.

⁹ Oklahoma is recognized in TEconomy's biennial national report with BIO as having a “specialized” employment concentration in the agricultural feedstock and industrial biosciences industry subsector statewide.

Figure 3: Greater OKC Region Bioscience Industry: Current Position and Recent Performance Across Subsector Size, Concentration, and Growth, 2021



Source: TEconomy Partners analysis of BLS, CEW data from Lightcast (2022.3)

The region's industry base is involved in innovation-related activities, particularly with respect to patenting of biosciences inventions and venture capital funding of emerging biosciences companies.

- In patenting activity, the leading areas of patent invention in the region assigned to industry from 2015 through 2022 are found in two broad areas of MedTech/HealthTech and therapeutic compounds:
 - MedTech/HealthTech: Digital health devices (82 patents) and surgical and implantable devices (70 patents)
 - Therapeutic Compounds: Receptor/inhibitor compounds (65 patents), antibodies and immunomodulatory compounds (55 patents), and drug delivery compounds (43 patents)
- In venture funding, the leading areas of emerging companies receiving venture investments from 2015 through 2022 are biopharmaceuticals, MedTech, HealthTech, and AgTech.
 - Biopharmaceuticals involve 15 companies receiving approximately \$195 million in venture funding from 2015-2022
 - MedTech involves eight companies receiving approximately \$43 million in venture funding from 2015-2022
 - HealthTech involves four companies receiving approximately \$14 million in venture funding from 2015-2022
 - AgTech involves five companies receiving approximately \$7.5 million in venture funding from 2015-2022

Biosciences Research Reaching Higher Levels with a Diverse Focus

Leading regional universities, including the University of Oklahoma (OU) and Oklahoma State University (OSU), as well as the nonprofit Oklahoma Medical Research Foundation (OMRF), combine to form a more than \$300 million R&D and innovation engine that fuels life sciences and biomedical discovery. This is a substantial base of research activity that compares well to other regions with emerging biosciences clusters such as Phoenix, Portland, Salt Lake City, and Louisville.

Like the long-term growth of the regional industry, bioscience-related R&D expenditures have more than doubled over two decades and since 2015 have grown by 19% to reach \$316 million in 2020. This growth rate, while strong, has lagged behind that of the nation, which has grown by 28%. The region’s research institutions complement each other in their areas of focus, with OU and OMRF highly concentrated in human biomedical innovations and OSU highly concentrated in agricultural sciences. Still, both OU and OSU, together with other research institutions, are active across both human biomedical and agriculture/

animal biosciences with a range of research centers (see callout that follows on the breadth of biosciences-related regional research centers).

A closer examination of research publication fields suggests the diversity of strengths in biosciences research found in the Greater OKC region. Basic biological science fields in areas such as biochemistry and molecular biology, microbiology, cell biology, neurosciences, and immunology are among the largest fields in publication activity, along with many clinical-related medical fields such as oncology, public

Table 1: Top 10 Bioscience-Related Research Publication Fields in Greater OKC Region by Number of Publications and Concentration Relative to U.S. Publications, 2015-2022

Publication Field	Number of Publications	Publication Field	Publications Specialization Relative to US
Biochemistry & Molecular Biology	972	Soil Science	4.05
Oncology	929	Agricultural Engineering	3.85
Microbiology	601	Rheumatology	3.12
Water Resources	578	Agronomy	3.00
Public, Environmental & Occupational Health	556	Water Resources	2.71
Cell Biology	513	Entomology	2.53
Surgery	482	Forestry	2.22
Neurosciences	470	Agriculture; Multidisciplinary	2.21
Immunology	467	Biodiversity & Conservation	2.17
Pharmacology & Pharmacy	461	Veterinary Sciences	1.99

Source: TEconomy Partners’ analysis of Web of Science database.

health, and surgery. At the same time, animal and agricultural-related publication fields in Oklahoma record the highest concentrations relative to national publications, including agricultural engineering, agronomy, and veterinary sciences.

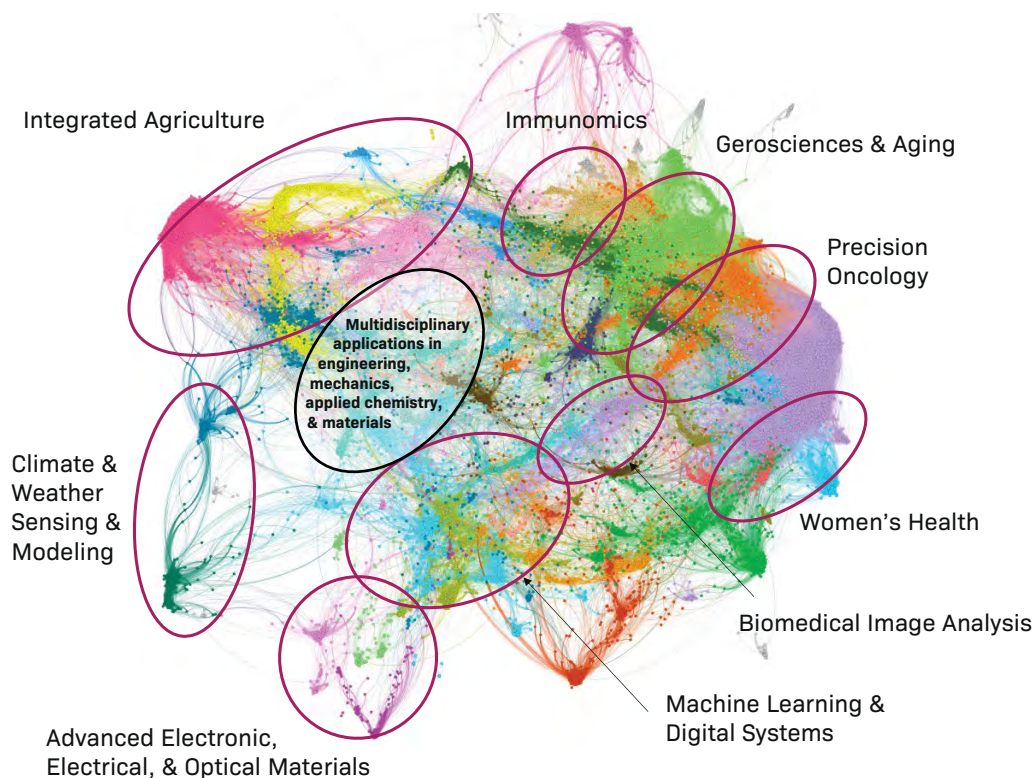
To better understand the distinct and cross-cutting research strengths found across the region's biosciences-related publications, a text-based cluster analysis was undertaken of the more than 20,000 research publications in relevant fields to identify major research themes. This analysis allows for identifying research themes by analyzing the usage of words and phrases using an advanced machine-learning clustering algorithm to offer insights into areas of research concentration that go beyond predetermined, high-level publication field classifications.

Six major bioscience research themes emerge from this clustering analysis as depicted in Figure 4:

- Integrated Agriculture
- Immunomics
- Geosciences & Aging
- Precision Oncology
- Women's Health
- Biomedical Image Analysis

These research themes reflect the combined strengths of regional institutions and offer clearer areas of research strengths found across the region's diverse biosciences research base.

Figure 4: Depiction of Publication Cluster Mapping to Identify Research Themes



Source: TEconomy Partners' analysis of Publication Abstracts from Web of Science Using a Machine-Learning Cluster Algorithm.

Broad Mix of Research Centers Focused on Human Biomedical Sciences and Agbiosciences Found in the Region

Key Regional Research Centers Focused on Human Biomedical Sciences

OU Health Sciences Center (OU HSC)	Oklahoma University, Norman	Oklahoma Medical Research Foundation (OMRF)	Oklahoma State University (OSU) and OSU Center for Health Sciences (CHS)
<ul style="list-style-type: none"> • OU Health Stephenson Cancer Center – Oklahoma's only National Cancer Institute-Designated Cancer Center focuses on areas such as cancer biology, cancer prevention and control, cancer therapeutics, gynecologic cancers, tobacco treatment and tobacco regulatory science • OU Health Harold Hamm Diabetes Center – focuses on infant/childhood diabetes, gestational diabetes and obesity, maternal obesity and the infant microbiome, and diabetes and cancer • Oklahoma Center for Geroscience – focuses on healthy aging • Oklahoma Center for Microbial Pathogenesis and Immunity – focus on infections and immune system reactions • Dean McGee Eye Institute • Oklahoma Children's Hospital OU Health • Oklahoma Clinical and Translational Science Institute – unites range of stakeholder groups to address poor public health outcomes 	<ul style="list-style-type: none"> • The Integrative Life Sciences Institute is a transdisciplinary center focused on - eliminating health disparities, transforming therapeutics/ diagnostics, and responding to emergent pathogenic threats • Department of Biology Focus Areas: <ul style="list-style-type: none"> ▪ Strategic Research Initiatives: Biology of Behavior and Geographical Ecology ▪ Core Research Areas: Cell Biology, Genetics and Development; Ecology and Evolutionary Biology; and Physiology and Neurobiology • Department of Chemistry: <ul style="list-style-type: none"> ▪ Center for Structural Biology ▪ Institute for Natural Products Applications and Research Technologies ▪ Center for Bioanalysis ▪ Center for Antibiotic Discovery and Resistance • Galogly College of Engineering <ul style="list-style-type: none"> ▪ Institute for Biomedical Engineering, Science and Technology 	<ul style="list-style-type: none"> • Centers Focused on Autoimmune Disease: <ul style="list-style-type: none"> ▪ Oklahoma Rheumatic Disease Research Cores Center (ORDRCC) ▪ Autoimmunity Center of Excellence (ACE) ▪ Autoimmunity Prevention Center ▪ Oklahoma Sjögren's Syndrome Center of Research Translation (OSSCORT) • Samuel Roberts Noble Cardiovascular Institute – research on topics such as blood function, blood coagulation, inflammation, and sepsis • Oklahoma Nathan Shock Center for Excellence in the Basic Biology of Aging • Other Research Centers: <ul style="list-style-type: none"> ▪ Center for Biomedical Data Sciences ▪ Centers off Biomedical Research Excellence, in Cellular Metabolism and in Developmental Biology ▪ Molecular and Immunologic Analysis of the Pathobiology of Human Anthrax ▪ Oklahoma Shared Clinical and Translational Resources 	<ul style="list-style-type: none"> • Oklahoma Center for Respiratory and Infectious Diseases (OCRID) – focus on focus on the influenza, respiratory syncytial virus, respiratory bacterial and fungal infections, COVID-19, etc. • National Center for Wellness & Recovery – offers solutions that address substance use disorder and provide new discoveries for treating chronic pain • Center for Rural Health - conducts research to identify issues and implement solutions to address rural health care • Center for Health Systems Innovation – works with college of business to support data analytics and improve healthcare delivery innovation • Center for Indigenous Health Research and Policy – focus on eliminating health disparities and improving health and wellness with indigenous communities. • Center for Integrative Research on Childhood Adversity – research-based interventions to interventions to address high rates of adverse childhood experiences in Oklahoma

Key Regional Research Centers Focused on Agricultural and Animal Biosciences

OSU College of Veterinary Medicine	OSU College of Agriculture	Oklahoma University, Norman
<ul style="list-style-type: none"> • The Institute for Translational and Emerging Research in Advanced Comparative Therapy (INTERACT) leads the one-health mission of OSU by bringing together clinician scientists, researchers involved in fundamental discovery, industry and foundations under one roof to conduct parallel investigations in humans and animals. • State of the art laboratory facilities accomplish OSU's mission of service to companion animal, livestock, and human health and well-being, including labs focused on: <ul style="list-style-type: none"> ▪ Comparative Exercise Physiology ▪ Comparative Metabolism ▪ Interdisciplinary Toxicology ▪ National Center for Veterinary Parasitology ▪ Vector-Borne Parasitic Infections ▪ Neurotoxicology ▪ Nanomedicine and Targeted Therapy ▪ Transmission dynamics of vector-borne disease agents (Krull Ewing) 	<ul style="list-style-type: none"> • The Robert M. Kerr Food and Agricultural Products Center (FAPC) offers research laboratories, pilot-processing facilities, and educational programs to engage food and agricultural processors and entrepreneurs with cutting-edge, value-added processing and technologies. • The Biobased Products and Energy Center focuses OSU's multidisciplinary efforts related to Biofuels • The Institute for Biosecurity and Microbial Forensics (IBMF) researches capabilities and provides strategic planning around in microbial forensics as related to plant pathogens, food safety, and plant and food-related microbial forensics and agricultural biosecurity. • The Oklahoma Agricultural Experiment Station system annually accounts for more than a third of OSU's ongoing research projects and 85% of royalty payments from research that come back to the university and fund further studies. • The OSU Institute for Agricultural Biosciences (IAB) research initiative focused on assisting producers through the development of new or improved crops and crop production systems. Located in Ardmore, research at this 33,000-square-foot facility focuses on basic and applied aspects of crop improvement through molecular biology, genetics, plant breeding and crop management. 	<ul style="list-style-type: none"> • The Oklahoma Biological Survey is both a state agency and a department at the university, focused on biodiversity in the state of Oklahoma. • The Center for Earth Observation and Modeling (CEOM) is using geospatial technologies to predict changes in biogeochemical cycles; and to track the dynamics of landscapes and bird migration to explore the ecology and epidemiology of infectious diseases • The Center for Biomass Refining is part of the Center for Interfacial Reaction Engineering, focused on researching thermo-catalytic conversion of biomass to finished products that meet the needs of the fuels and chemical industries in a sustainable manner.

Three Broad Growth Opportunities in the Biosciences for Greater OKC Region Link Region’s Industry Development and Research Capacities

Looking forward, it is important to bring a strategic focus to understanding the opportunities in which the Greater OKC region is well-positioned for future growth in the biosciences across its industry and research assets. This is no different than how the best companies in the world compete. As Hamel and Prahalad in their landmark study, *Competing for the Future*, explain:

“To successfully compete for the future, a company must be capable of enlarging its opportunity horizon. This requires top management to conceive of the company as a portfolio of core competencies ... [that] are the gateways to future opportunities.”¹⁰

From an economic development perspective, core competencies in the biosciences are those focused areas to which the region’s university and industry life sciences base can bring a critical mass of activity. So, the value of the assessment of the Greater OKC region’s bioscience industry development and research capacities reaches beyond simply measuring the performance of these critical elements of biosciences cluster development—together they can inform the likely biosciences growth opportunities in which the region is well-positioned for growth.

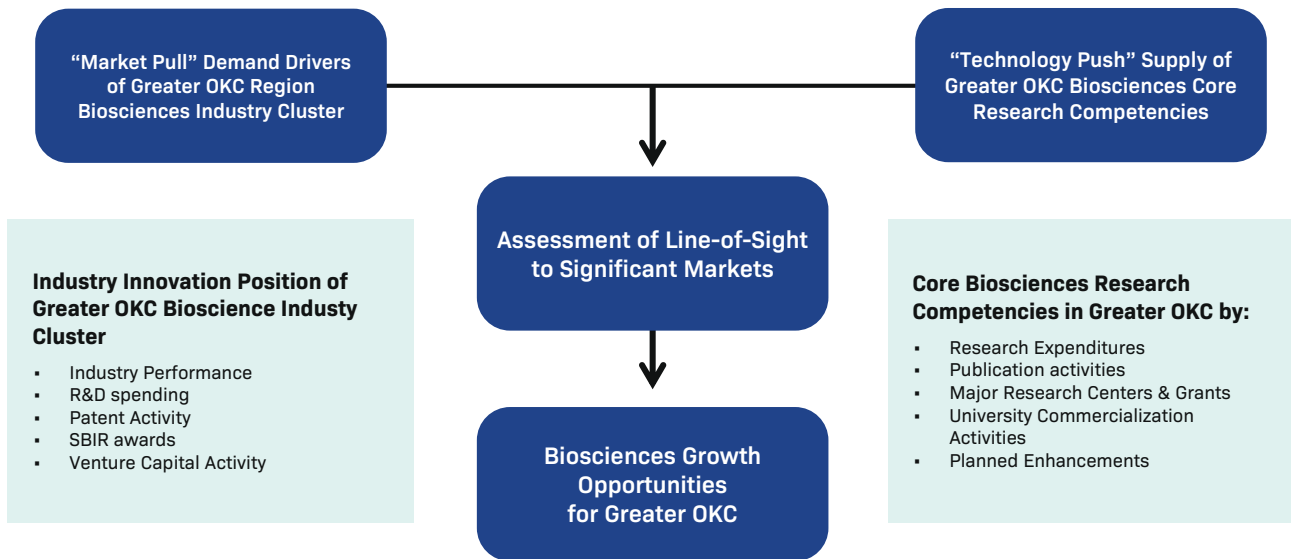
TEconomy has developed a methodology we refer to as a **“line-of-sight assessment”** that aligns the “market pull” of biosciences industry development with the “technology push” of research capabilities at the region’s anchor institutions to identify growth opportunities for the Greater OKC region. The value of this line-of-sight analysis is that it incorporates traditional industry targeting analysis that relies on examining in-depth trends and the competitive

position in industry activities and yet recognizes that this conventional industry target analysis largely sheds light on where an economy has been. *This is helpful but not sufficient to advance target development opportunities in today’s fast-paced global knowledge-based economy.* It is also essential to know where you have the capacity to grow and to leverage the comparative advantage that is provided by an analysis of core research competencies and insights on industry innovation efforts, all with a forward-looking approach to high-growth market opportunities.

This approach to strategic alignment and targeting of high potential growth opportunities in the biosciences for the Greater OKC region is illustrated in Figure 5.

¹⁰ Hamel and Prahalad, *Competing for the Future*, Harvard Business Press, 1994, pp 90 and 217.

Figure 5: Line-of-Sight Assessment for Identifying Strategic Growth Opportunities in the Biosciences for Greater OKC Region



Source: TEconomy Partners, LLC.

What emerges from the line-of-sight assessment are three broad growth opportunity areas in the biosciences for the Greater OKC region that align the region’s biosciences industry development with the research competencies found across its anchor institutions.¹¹ These three growth opportunity areas include:

- **Therapeutics, Diagnostics, and Biomanufacturing** that link the region’s growing basic and clinical biomedical research activities with its fast-growing industry base in biopharmaceutical manufacturing.
- **Medical and Health Technologies** leverages the region’s strengths in healthcare delivery and focus on serving rural communities with its growing base of MedTech and HealthTech companies and emerging technology strengths in areas such as medical imaging and digital health.
- **OneHealth** that recognizes the interconnectedness and opportunities across animal, human, and agricultural health where the region is well-positioned for leveraging its research strengths found at OSU, OU, and OMRF.

Figures 6 through 8 on the following pages present summaries of the intelligence gathered for each of the identified biosciences growth opportunities for the Greater OKC region, focusing on the strengths and assets found in the region, the gaps and barriers identified, and an overall strategic approach to advancing in the years ahead. The strategic approaches are discussed in more detail in the next section on the proposed strategic action plan.

¹¹ For more details and the complete Line-of-Sight Assessment findings, see Appendix on Findings from the Core Competency Analysis, presented to the Advisory Committee on November 2, 2022.

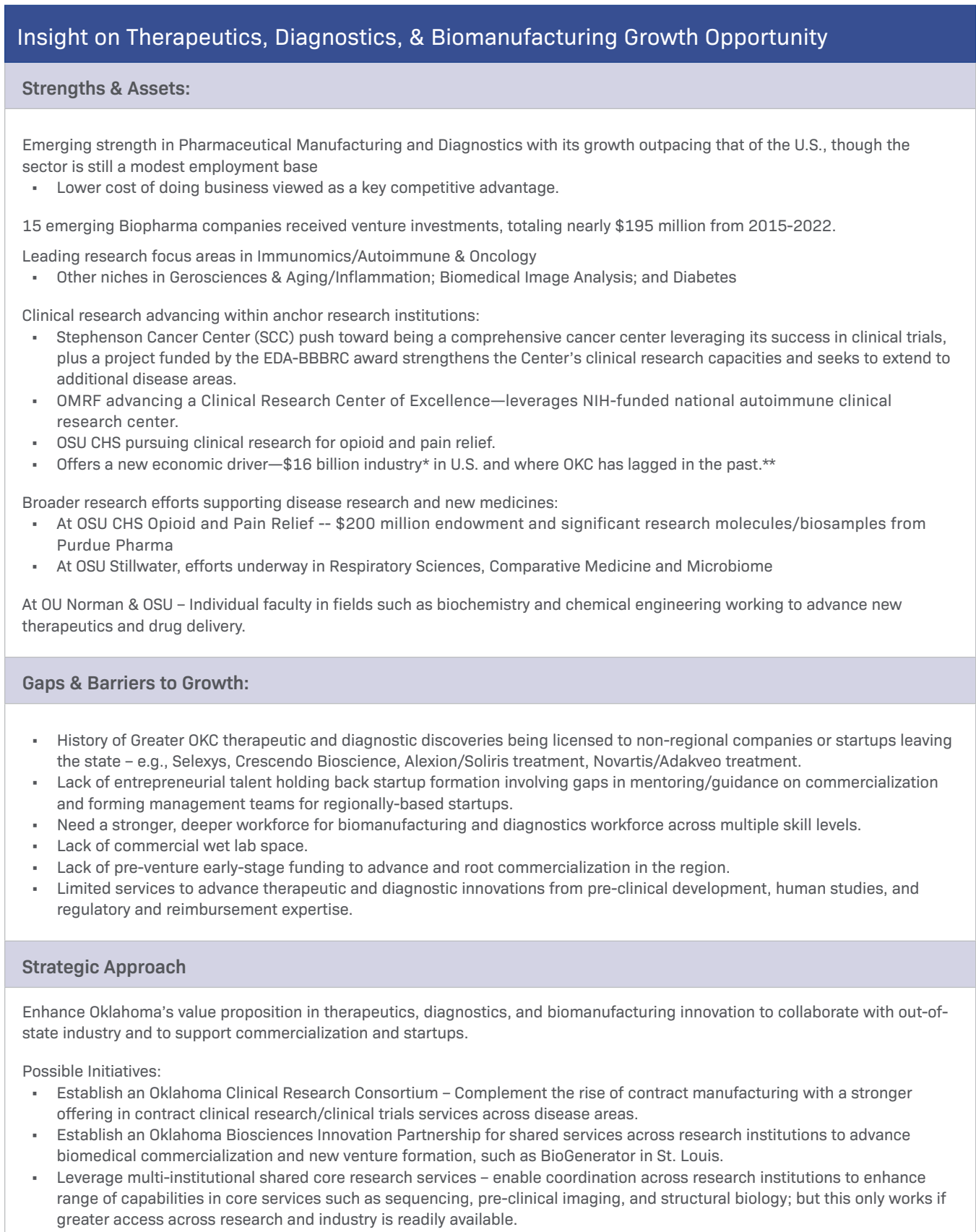
Figure 6: Growth Opportunity Profile—Therapeutics, Diagnostics, & Biomanufacturing*See: <https://www.coherentmarketinsights.com/market-insight/us-contract-research-organizations-market-3179>.**See: <https://catalyst.phrma.org/clinical-trials-impact-state-economies>.

Figure 7: Growth Opportunity Profile—Medical and Health Technologies

Insight on Medical and Health Technologies Growth Opportunity

Strengths & Assets:

Large and highly specialized hospital employment footprint in the region – a critical resource for statewide health care access.

Emerging presence in Medical Devices with growth outpacing the U.S., though still a small and diverse employment base.

- 8 emerging MedTech companies received venture investments, totaling nearly \$43M.

Complemented by a small, but growing Bioscience-Related Distribution industry – suggesting region can be a logistics hub for biosciences.

Leading areas of industry bioscience patenting in the region include:

- 82 patents from 2015-2022 involving patient monitoring, patient management systems and healthcare predictive modeling.
- 70 patents from 2015-2022 involving surgical and implantable devices.

Device trials is a growing area of clinical research between OU's Biomedical Engineering faculty and Stephenson Cancer Center.

- Examples include imaging devices, laser treatment of tumors, brain cancer implantable reservoir.
- Growing efforts for OU-OUHSC collaborations on device prototyping and validation.

Growing connections to academic research capacities at anchor institutions:

- mHealth shared resource at Stephenson Cancer Center has a team of 10 staff working on mobile app development with over 30 contracts to support other cancer centers across the nation.
- Growing strengths and planned future enhancements in biomedical engineering at OU Norman, includes Biomedical Image Analysis in Cancer and Neuro as a key focus area with existing major grants, leading publications theme and growing collaborations with Stephenson Cancer Center.
- OSU Center for Health Systems Innovation at Spears School of Business focused on rural primary care innovations and engaged in health data analytics with access from Cerner to large HIPAA compliant database.

Active Rural Health initiatives underway that utilize health technologies.

- OSU Center for Rural Health and Project Echo – involving rural telehealth network (supported by ARPA grant) and tele-mentoring of community practitioners by specialists, along with rural medical and health education.

Oklahoma Primary Healthcare Extension Program – focused on local health improvement initiatives involving a state hub, four regional extension centers and 70 county health improvement organizations.

Gaps & Barriers to Growth:

- MedTech and HealthTech industry development is nascent and diverse, with little critical mass today to leverage.
- Biomedical engineering talent is growing but is leaving the region for career opportunities.
- Lack of research and development capabilities targeted to advance health technologies involving software/hardware solutions.
- Continued need for mechanisms to engage clinicians and bioengineers, which is well behind top-tier MedTech ecosystems.

Strategic Approach

Leverage Rural Health initiatives as a platform for advancing health technologies.

- Advance statewide networking among rural health provider initiatives, existing health tech companies, and software/hardware companies to identify needs and opportunities for collaboration.
- Coordinate across efforts to create testbeds that can attract companies from across the nation.
- Establish a health technology accelerator focused on rural health solutions.
- Engage research faculty, post-docs, students in OU Biomedical Engineering in Rural Health testbed initiatives to advance prototyping, areas of expertise including patient monitoring, remote device development, and biomedical imaging.
- Leverage technology convergence opportunities, e.g., regional meteorology strengths at OU, OSU in sensing, Doppler technologies for innovative MedTech and HealthTech applications for rural health.

Figure 8: Growth Opportunity Profile—OneHealth

Insight on OneHealth Growth Opportunity
<p>Strengths & Assets:</p> <p>Crop and Animal Production industries are growing in the region, though modest employment base of 1,649.</p> <ul style="list-style-type: none"> ▪ Complemented, integrated with more sizable 4,000 jobs in the Food Processing industry in region. <p>Still, the region’s world-class research strengths found at OSU are truly a statewide resource for a much larger, highly productive agbiosciences industry base.</p> <ul style="list-style-type: none"> ▪ Oklahoma (statewide) recognized in 2022 TEconomy/BIO report with a “specialized” concentration. <p>OSU’s Agricultural and Natural Resources research complex drives a significant base of over \$50M in annual R&D expenditures and many areas of publication specialization.</p> <ul style="list-style-type: none"> ▪ Production Agriculture a key strength: it is a leader in wheat varieties, beef/cattle with a growing emphasis on adapting to climate change with genetic research and precision agriculture. ▪ Food Products involving food safety and preservation, value-added food processing, and support for food innovations and startups via the Food and Agriculture Products Center. ▪ Industrial Biotechnology Innovations involving feedstock development and production, biobased products and materials development, conversion technologies, and value enhancement. <p>OneHealth stands as a major opportunity for connecting agriculture, animal sciences, and human health innovations.</p> <ul style="list-style-type: none"> ▪ OSU brings unique/comparative expertise across animal, human and environment, especially in toxicology and comparative studies. ▪ Already offers key activities in respiratory/infectious diseases across animals and humans (with BSL3 capabilities for pathogen research), as well as comparative medicine focusing on cancer. ▪ Microbiome research is a leading focus area, with 70 faculty members involved and new investments including animal facility for in vivo microbiome research.
<p>Gaps & Barriers to Growth:</p> <ul style="list-style-type: none"> ▪ In past, OKBio primarily focused on human health and did not build connections with agbiosciences and opportunities for OneHealth. ▪ Weak industry connections for Veterinary Medicine on human health. ▪ Addressing joint intellectual property (IP) development across OSU, OUHSC/OU, and OMRP.
<p>Strategic Approach</p> <p>Advance OneHealth as a statewide focus area and connect with broader human health research.</p> <ul style="list-style-type: none"> ▪ Microbiome research is well-positioned to be key focal point for collaborations and provides an opportunity to connect with existing human health research strength in autoimmune research, along with aging and inflammation and GI research. Suggest leveraging and enhancing OSU strengths in probiotics. ▪ Better integrate Veterinary Medicine into human health activities, especially around comparative medicine. Also include development of unique animal models/pre-clinical development capabilities. ▪ Focus on Corporate Innovation Center opportunities by being industry-facing and intentional in building industry relations.

Bioscience Innovation Ecosystem Challenges are Limiting Growth

Although the continued growth and positioning of the Greater OKC region’s biosciences industry and research base offer a strong foundation for continued development, significant gaps, weaknesses, and challenges in the region’s biosciences innovation ecosystem are restricting development. Three primary areas were uncovered:

- **The lack of an effective cluster development organization and “connecting entity”** seen as a trusted broker in the regional (and statewide) biosciences ecosystem; and at the same time, an interrelated lack of systematic collaboration across institutions and regions within the state, resulting in challenging silos.
- **Persistent innovation and commercialization challenges and their intersection in what is often referred to as the “valley of death” for innovative companies** have been identified frequently and consistently as a major weakness and challenge within the regional biosciences ecosystem.
- **Workforce and talent** and key skill sets are misaligned with growing industry demand and raised as a consistent gap, often cited as the greatest challenge facing regional employers.

The following describes, at a high level, each of these challenges in turn, with additional supporting context provided in the following report section on Strategic Recommendations.

There is a strong consensus among stakeholders and regional biosciences leaders that the current incarnation of the state’s bioscience industry association, OKBio, is no longer effective or relevant, and that it has “run its course” and requires an immediate reset or “reboot”. Stakeholders do see the

value in a strong industry development organization and the importance of a highly effective connecting entity and trusted broker in a complex, science-based ecosystem where interconnections and collaborations are tremendously important. Regional leaders are in agreement that a new iteration of OKBio must be an independent organization that engages statewide to leverage all of the biosciences assets throughout Oklahoma.¹² Further stakeholder input and suggestions are considered for organizational design and implementation in the next section of the report on strategic recommendations.

A lack of strategic collaboration is of real concern to stakeholders and industry leaders who recognize that the region is fortunate to have two complementary top-tier (R1) research complexes and major assets in its research universities and academic medical centers, but lament the lack of systematic, intentional collaboration across institutions and even across separate regions of Oklahoma. There is a recognition that the region is defeating itself and not reaching its full potential by consistently operating in silos, and this dynamic needs to change.

“The ‘wins’ I’ve had in startups all came out of partnerships—we must create networks regionally to grow this industry.”

-- Regional biosciences entrepreneur on the need for connectivity, collaboration in the biosciences

¹² These findings and general recommendations are consistent and align closely with those of the Mettise Group, in its recent *OKBio Assessment Study*, completed January 2022.

Of particular concern is the significant “valley of death” experienced in the region between research discovery and commercialization leading to new product development through academic-industry collaborations and high-growth new venture formation. This valley of death is reflected in three key trends found in the Greater OKC region:

- Lagging university technology transfer and commercialization outcomes relative to national averages.
- Limited use of the federal Small Business Innovation Research program by emerging bioscience companies.
- Low level of venture capital funding for emerging startups.

Industry and ecosystem leaders and stakeholders confirmed these persistent innovation and commercialization challenges as a major theme of interviews and group discussions (see sidebar).

Talent and key skill sets have been raised as a consistent gap, often cited as the greatest challenge by regional bioscience industry leaders. The nature of talent concern or demand varies across companies and industry subsectors, but in discussions has included the following consistent themes:

- A lack of “top talent” spanning the Ph.D.-level scientific workforce with experience taking products to market and/or broader industry experience driving innovation and product development in the marketplace.
- Too few experienced managers in the biosciences industry, including those with regulatory expertise who have led emerging companies and/or been through the challenges of the FDA approval process.

Stakeholder Insights: Persistent Innovation & Commercialization Challenges

Although recognizing the significant increases in regional biosciences academic and institutional R&D activity, stakeholders maintain that the region is lagging and lacking in biosciences innovation and that regional R&D is too oriented toward basic discovery and lacks commercial-ready or near-ready opportunities. This situation leads to limited deal flow for biosciences commercialization and startups.

At the same time, cluster leaders have been consistently critical of university technology transfer as uneven across institutions and in need of additional tools, resources, and approaches to enhance the situation for commercialization. There is a need for a focus on pre-startup proof-of-concept and technology validation to advance intellectual property.

It is important to acknowledge that discussions with the region’s research universities make it clear that these challenges are being addressed—with OSU advancing new initiatives to deepen mentoring services, leveraging Entrepreneurs-in-Residence (EIRs), and providing further funding resources to startup teams—and with OU reinventing its tech transfer and commercialization programming.

- A lack of biosciences entrepreneurs who have started or are interested in starting companies.
- A strong current demand for Biomanufacturing Technicians in the region’s emerging, fast-growing contract manufacturing space.
- Likewise, there is strong demand for Quality Control and Assurance Professionals in the Biomanufacturing sector with few regional programs developing graduates.
- A lack of technical talent in the region, although companies are increasingly hiring or contracting with the tech workforce remotely.

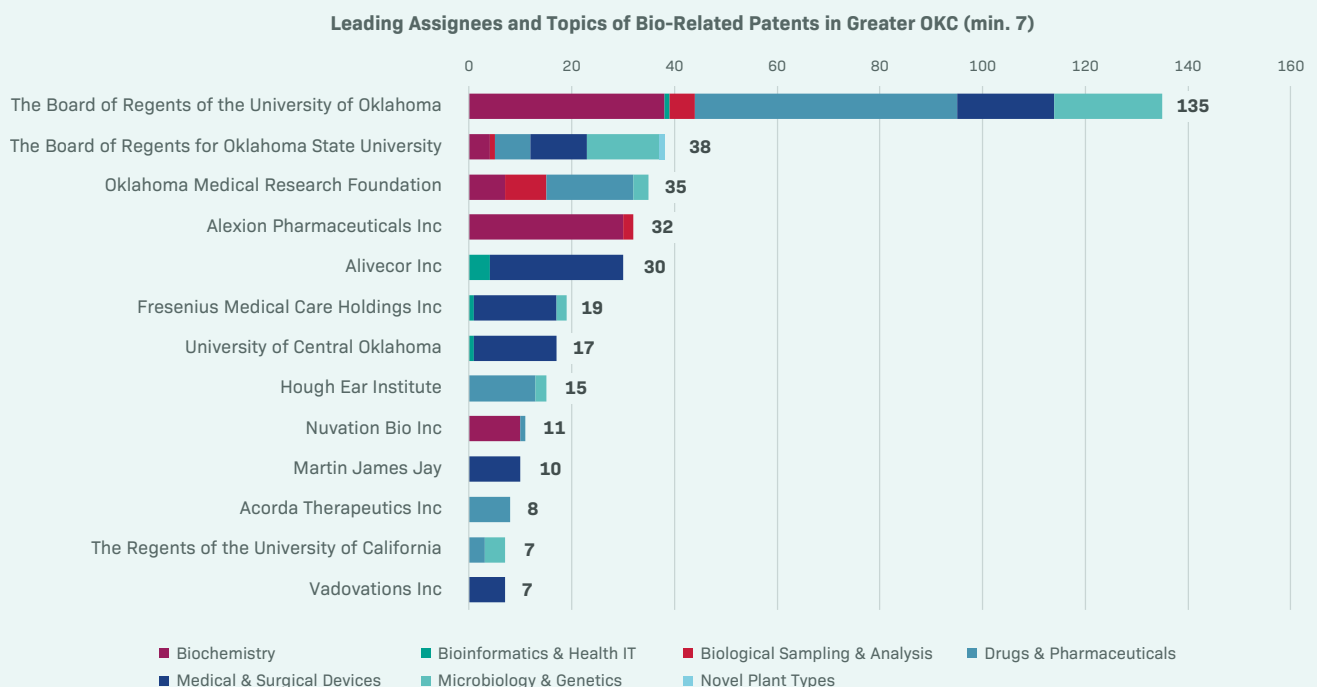
On a positive note, the Greater OKC region has been making significant progress in other bioscience innovation ecosystem trends and capacities, including:

- Increase in bioscience patent innovations.
- Growing capacities in clinical research.

Bioscience-related Patents. The growth in regional biosciences industry activity and extensive bioscience-related R&D activities of OKC’s regional research institutions is translating into tangible innovations. Patent awards protect valuable intellectual property and offer a lens into the outcomes of often years of rigorous scientific research and commercialization pursuits. From 2015 through 2021, 338 patents were awarded and assigned to OKC regional universities, companies, and other entities in bioscience-related patent classes.

Regional patent awards have increased—after averaging almost 80 patent awards per year in bioscience-related technology classes, regional inventors saw awards climb to 128 in 2020 and 148 in 2021. Patent growth has been driven by the two largest regional classes—medical and surgical devices, and drugs and pharmaceuticals. Regional

Figure 9: Leading Assignees and Technology Class Groupings of Bioscience-Related Patents in Greater OKC Region, 2015-21



Source: TEconomy Partners analysis of USPTO data from Clarivate Analytics.

research institutions are driving this activity as the largest cumulative holders of biosciences patents during this recent period (Figure 9). As the industry and innovation ecosystem advances, a key goal for the region will be to see gains in patent awards among private sector firms based in the region.

Clinical trials. A unique context and challenge for life science innovation is the need for clinical testing in humans to demonstrate the safety and efficacy under strict FDA regulatory oversight of investigational therapeutics as well as novel and life-sustaining types of devices. Greater OKC has established itself as a hub of robust clinical trial site activity, operating as a site for more than 2,000 unique trials during the 2015 through 2021 period.¹³

Interventions in trials at Greater OKC sites are largely drugs and biological treatments, and oncology represents the largest disease area accounting for 662 of the 2,078 trials (32%) with a regional site.

This focus on oncology reflects the leading position and growth of Stephenson Cancer Center at OU, which has established itself as a leader in early-stage clinical trials and ranks among the top 10 cancer centers in the nation for accrual of patients to Phase I trials.





A deeper assessment further explored the number of clinical trials with a Greater OKC research institution as a lead sponsor and Principal Investigator (PI)—a key indicator of locally rooted innovations advancing to the clinical research and translational stage. Among the 2,078 trials with a regional site, just 126 or 6% met this criteria, a relatively modest total for regional innovation. A key goal of advancing the cluster strategy will be to advance these local PI-led trials and the biomedical innovations that drive them.

13 Based on TEconomy Partners analysis of clinicaltrials.gov data.

Summary: A Need for Targeted Strategic Interventions

Overall, Greater Oklahoma City demonstrates a mixed performance in the quantitative assessment of its ecosystem position and performance (Figure 10). The biosciences industry is an emerging segment of the regional economy with strong longer-term growth that has matched the national growth rate since 2015. The region continues to experience considerable growth in university biosciences R&D, with increasing opportunities for commercialization and technology transfer.

Figure 10: Summary of the Quantitative Positioning of the Greater OKC Biosciences Industry and Innovation Ecosystem

Ecosystem Element	Measure	Volume	Specialized Concentration?	Trendline Since 2015?	Outpacing US?	Summary Performance, Position
Research	Academic Biosciences R&D	\$316M (2020)	No	Positive	No	 Mixed: making strong double-digit gains, but lagging US
	NIH Funding	\$118M (2021)	No	Positive	No	
Innovation	Biosciences-Related Patents	148 (2021)	No	Positive	N/A	 Lagging: Patent activity predominantly from Univ. not private industry; SBIR funding down from mid-decade peaks
	NIH SBIR Funding	\$4.7M (2021)	No	Down	No	
	Lead Sponsor Clinical Trials	126 (2015-2021)	No	Flat	N/A	
Growth Capital	Venture Capital Funding	\$44M (2021)	No	Flat	No	 Lagging: Low volumes, flat growth while US rising rapidly
Industry	Biosciences Industry Jobs	31K (2021)	Average	Positive	Matching US	 Emerging: Growing, matching US since '15

Source: TEconomy Partners' analysis.

Together, the solid foundation of biosciences industry development and research capacities found in the region point to three growth opportunities in which the region is well-positioned, focusing on Therapeutics, Diagnostics and Biomanufacturing; Medical and Health Technologies; and OneHealth.

However, at the same time, the region is struggling to “take things to the next level” limited by identified gaps, challenges, and weaknesses:

- The lack of an effective cluster development organization and “connecting entity.”
- Persistent innovation and commercialization challenges and their intersection in what is often referred to as the “valley of death” for innovative companies.
- Misalignment with respect to workforce and talent and key skill sets.

The next section addresses these issues with targeted strategic recommendations.

Strategic Recommendations to Meet the Moment for Regional Biosciences Development

The preceding analyses and stakeholder inputs and insights coalesce into a set of strategic priorities for advancing the regional biosciences cluster in Greater Oklahoma City. These priorities were presented to and refined in partnership with the regional focus groups and project Advisory Committee where there was strong agreement on the need for focused investments and interventions.

Four strategic priorities emerge as critical for advancing the region’s bioscience industry and ecosystem, involving:

1. Enhancing connectivity, collaborations, and targeted programming for the overall bioscience ecosystem through a reboot of OKBio.
2. Meeting the biosciences talent challenge.
3. Addressing commercialization challenges that overcome the “valley of death” in biosciences innovation.
4. Seizing and organizing around identified biosciences growth opportunities.

Significant statewide benefits are expected by addressing these strategic priorities to grow the biosciences, given the considerable concentration of overall statewide biosciences research and industry activities found in the Greater OKC region. Other regions of the state are highly interrelated with the Greater OKC region’s biosciences activities, particularly more rural areas where much of the state’s agricultural and food processing industries are located and where healthcare is a pressing need. The Tulsa region also stands out with its own biosciences cluster development that can benefit from increased collaborations with the Greater OKC region around specific growth opportunities and shared ecosystem needs.

1. Enhancing Connectivity, Collaborations, and Targeted Programming through a Reboot of OKBio

Rationale: The emerging regional biosciences ecosystem lacks the ability to systematically foster collaborations across research institutions and establish strong networks across biosciences companies both in the region and across the state. Far too often, the region’s research institutions and biosciences companies operate as silos and miss opportunities for leveraging the collective strengths found locally and statewide.

The result is that the overall biosciences ecosystem in the Greater OKC region is less than the sum of its parts. This has serious consequences for the competitiveness of the region’s biosciences cluster. It limits the region’s ability to pursue targeted bioscience growth opportunities requiring collaborations across research institutions, clinical centers, and industry. It also holds back advancing a higher value business location for bioscience cluster development in the region where the bioscience industry can readily tap the expertise and resources found across the region’s research institutions as well as benefit from close business-to-business relationships.

Critical to the success of technology-based clusters is having a “cluster hub.” According to The Brookings Institution in its 2018 study *Rethinking Cluster Initiatives*, a cluster hub serves as the “driver of the cluster, pushing the local economy towards a shared vision, acting as a thought leader and convener, coordinating existing assets, ensuring a collaborative environment, managing its own programs and initiatives to fill important gaps in the system, and strengthening and championing the case for the cluster locally and in targeted markets.”¹⁴ An example featured by Brookings of a best practice as a cluster organization is BioSTL, which has led the St. Louis plant and life sciences cluster initiative. In its in-depth case study of St. Louis as a best practice, Brookings noted some of the critical elements in the success

Stakeholder Insights:

Across stakeholders and industry leaders there is a recognition that the region is defeating itself and not reaching its full potential by consistently operating in silos and this dynamic needs to change.

of the St. Louis Plant and Life Sciences Cluster Initiative:¹⁵

- Created a primary venue for setting the strategic vision of the cluster and fostering a “**collaborative, trustful environment**” through the efforts of BioSTL.
- Took a **broad approach from the very beginning**, with parallel strategies focused on every major area of need: capital, talent, facilities, and networks.
- Made significant progress on each front over the past 15 years, largely because it had a “**comprehensive approach and patient support including philanthropic capital.**”

The role of BioSTL is not unique. Across the nation, a key lesson from regions that have successfully advanced biosciences development is the

14 Donahue et. al., *Rethinking Cluster Initiatives*, The Brookings Institution, July 2018, page 31.

15 Ryan Donahue, *Rethinking Cluster Initiatives: Case Study of St. Louis Agriculture Technology*, The Brookings Institution, July 2018.

North Carolina Biotechnology Center: A Pioneer in Leading Statewide Biosciences Development

The PhRMA study on best practices in state biosciences development efforts points to the North Carolina Biotechnology Center (NCBiotech) as a model for other states. NCBiotech was formed by the State of North Carolina just as biotechnology was revolutionizing the industry in 1984 as a private, nonprofit organization.

The PhRMA study and biennial impact assessments by TEconomy have found NCBiotech has implemented a comprehensive set of programs that fuel long-term economic and societal benefits to North Carolina through support of biotechnology research, business, education, and strategic policy statewide. Through the sustained efforts of NCBiotech over the last nearly four decades, North Carolina has become one of our nation's top bioscience industry states.

The portfolio of programs NCBiotech offers include monthly networking forums and an annual in-state biotech conference; assistance aimed at connecting early-stage companies with larger corporations, venture financiers, angel investors, and university licensing offices; business loans for early-stage companies; support for collaborative research projects; listings of available commercial wet-lab space; workforce development programming; and more.

Additionally and importantly, NCBiotech operates as key connective tissue in the ecosystem, and plays a lead role in organizing around federal and other funding and cluster-building opportunities.

establishment of dedicated organizations to support and sustain networking and collaboration among academic, industry, nonprofit, and public sector groups and organizations, as well as ensuring key program services addressing specific needs for advancing the biosciences cluster are advanced in collaboration with other economic development, workforce development, and entrepreneurial support organizations. A study commissioned by PhRMA on best practices in state-level biosciences efforts found that “having a dedicated [biosciences] development entity in the state has been found to be one of the most critical components in states with a robust biopharmaceutical presence.”¹⁶

16 Pharmaceutical Research and Manufacturers of America (PhRMA), *Driving Innovation and Economic Growth for the 21st Century: State Efforts to Attract and Grow the Biopharmaceutical Industry*, Prepared by TEconomy Partners, LLC, December 2016, page 24.

The following action is recommended to address the need for a renewed, reinvigorated cluster hub and development organization.

Action 1.1: Reboot OKBio to be the independent cluster hub for advancing the biosciences sector, serving not just the Greater OKC region but all regions of the state. The organization should embrace a broad concept of the biosciences industry and its varied stakeholders, inclusive of agricultural biosciences and healthcare.

Consider anchoring a physical presence for the cluster hub at the Oklahoma City Innovation District as a centralized, strategic location ideal for collaboration and co-located with key regional biosciences organizations and assets, including the Biomanufacturing Workforce Training Center. Stakeholders have suggested that the organization consider a name change and branding update. For purposes of this strategy, the new organization is referred to herein as OKBio.

Although recognized to have run its course in its existing form, OKBio maintains an active membership of over 25 biosciences companies, branded events, an affiliation with the national BIO organization and sponsorships from a variety of statewide stakeholders, including tapping administrative, leadership, and other support from i2e – and so offers foundational assets to leverage in forming a reinvigorated and transformed cluster hub.

This transformation is further supported by the recent EDA Build Back Better Regional Challenge award in support of the Oklahoma Biotech Cluster Initiative (OBIC). As part of this effort, EDA has provided matching funds totaling \$3M to form a cluster hub ensuring inclusive and broad-based governance and accountability across project activities of OBIC. The expectation is that the hub will address key crosscutting needs, such as coordination and collaboration, and over time support strengthening statewide bioscience cluster hub activities to more fully engage stakeholders across industry, academia, economic development, and communities.

The rebooted OKBio organization in its role of enhancing connectivity, collaborations, and targeted programming will have a role to play across all of the other strategic priority areas as well as housing the cluster hub efforts needed by the OBIC as set out in the BBBRC award.

Meeting the strategic need will call for a variety of functions and leadership by OKBio, for example and consideration:

- **Strategic Development:** A primary responsibility of OKBio will be to create, lead, update, and continuously refine a biosciences strategy and unified vision for the State of Oklahoma. Central to this is the ability to identify challenges facing the state's biosciences ecosystem and respond through facilitated solutions. OKBio should be comprised of strategic visionaries who focus on collaborating across sectors to bring together the necessary partners needed to create and drive solutions. OKBio leadership will often serve as a face for the industry, representing it through collaborations with other states or industries (energy, aerospace, defense) as needed.
- **Data Repository and Tracking:** A critical function for state bioscience associations is acting as a repository for information and data relevant to the biosciences ecosystem. This includes tracking progress across the types of metrics and measures seen throughout this Roadmap, as well as those recommended for tracking outcomes associated with each strategic priority area. OKBio should play this role and ideally would develop an automated dashboard of key metrics for the statewide industry and ecosystem. At the same time, there is a need for and associated role to play in marketing and branding the region, in part by highlighting success stories and touting key companies, institutions, and others making progress across Oklahoma.

- **Ecosystem Concierge Services:** As the “front door” for the state’s bioscience industry, it is expected that a key function of OKBio is to offer concierge services that act as a connector and convener across the ecosystem.

- Examples of activities that could be included under a concierge system include: establishing a job-sharing and workforce recruitment tool for the biosciences industry; leading an internal and external marketing, messaging, and communications campaign; acting as a thought leader and repository for information and data relevant to the biosciences ecosystem; advancing statewide engagement by ensuring that the entire state’s populations feel represented by and connected to OKBio (e.g., Tulsa and other OK regions, Rural Oklahoma, Tribal and Community Partners).

- **Advocate on Behalf of the Biosciences**

Industry: It is expected that advocacy efforts would begin with informal relationship-building with the state’s legislature, including an in-person presence with the legislature; educating leaders about the industry and its innovation ecosystem; and assisting with messaging on policy issues critical to the industry’s success. There is a role for OKBio to stay attuned to and “mine” information on problem areas the industry is facing, with an understanding of what matters most for biosciences companies considering moving to, remaining in, or expanding within the region.

- **Convening Targeted Programming Around Key Challenges and Strategic Priorities:** There is a role for OKBio to identify programming areas and targeted activities needed that align with strategic priorities, to lead organizing efforts, and facilitate delegation and assistance to the right partners to implement. Central to this is organizing and hosting “working groups” for strategic initiatives and continuing to refine evolving industry and technology verticals and opportunities.

Examples of working groups and collaborative networks that could or should be facilitated by OKBio include those focused on other strategic priorities:

- Workforce and talent development
- Overcoming tech development and commercialization challenges
- Seizing and organizing around identified biosciences growth opportunities
 - Therapeutics, Diagnostics, and Biomanufacturing
 - Medical and Health Technologies
 - OneHealth
- **Acting as a Facilitator for Regional Funding Efforts, as Needed:** For significant state and federal funding opportunities (e.g., CHIPS, NSF Programs, etc.), there are opportunities for OKBio to not only identify said opportunities but to begin to build and organize the necessary strategic alliances to compete for and ultimately receive funding.

Key Measures to Track Strategy Performance and Outcomes into the Future:

Over time track macro, high-level performance across biosciences-specific measures of the region and statewide for Oklahoma:

- Level and growth of industry employment, business establishments, and wages
- Level and growth of industry sales/output
- Level and growth of industry productivity, measured as value-added per worker

Track more micro, performance type measures related to OKBio; for example:

- Levels of concierge service assistance provided
- Assistance with state bioscience-related economic development recruitment, expansion activities of companies
- Regional biosciences grant and other funding awarded to cluster organizations and consortia

2. Meeting the Biosciences Talent Challenge

Rationale: Talent is arguably the most critical element in advanced industry development. This is particularly true for the science-based and tech-driven biosciences industry that deploys an outsized concentration of highly skilled, STEM-related talent that requires postsecondary and advanced degrees and often years of specialized experience requirements.¹⁷ At the same time, the industry has a strong demand for middle-skills workforce to fill critical roles such as lab technicians and biomanufacturing associates who typically require some combination of applied associate degrees in science or certifications or stackable, industry-recognized credentials. In a growth mode, regional bioscience industry leaders cite talent dynamics among their top, if not most significant, challenges for continued growth and development in Greater OKC.

The aforementioned talent and skill shortages in regional biomanufacturing stem from the growth of established contract manufacturing firms such as Cytovance Biologics and Avara Pharmaceuticals and emerging firms such as Wheeler Bio, that, combined with others in the contract manufacturing and development sector for large molecule biopharmaceuticals, had more than 200 unique job postings during the last two years alone.¹⁸ The region, to its credit, has prioritized addressing the emerging demand for the biomanufacturing workforce through the federal BBBRC project funding, with two key investments expected to come online in the near- to mid-term—the OU Bioprocessing Core Facility and the Biopharmaceutical Workforce Training Center to be located at the Innovation District. The former will focus on high-skilled engineering talent and the latter on developing skilled technician talent needed for biomanufacturing.

In a growth mode, regional bioscience industry leaders cite talent dynamics among their top, if not most significant, challenges for continued growth and development in Greater OKC.

Despite the targeted biomanufacturing workforce investments underway, industry and ecosystem leaders point to top scientific, entrepreneurial, management, and other talent needs across the ecosystem. As the regional cluster continues to grow, these dynamics and the need for greater scale and diversity in talent development must be regularly revisited to adjust the focus of workforce investments, curriculum, academic programming, and K-12 student engagement.

The following actions are recommended to address both current and expected future talent gaps within the regional biosciences ecosystem:

Action 2.1: Target post-doctoral researchers and graduate students in bioscience-related fields for entrepreneurial development.

- Post-docs and graduate students represent an important pool of top research and scientific talent and are at a key inflection or decision point in their academic and career tracks, and therefore offer prime candidates to engage in entrepreneurial programming and exposure to opportunities in technology commercialization and business development.

¹⁷ See: TEconomy Partners, LLC and Coalition of State Bioscience Institutes (CSBI), *2021 Life Sciences Workforce Trends Report: Taking Stock of Industry Talent Dynamics Following a Disruptive Year*.

¹⁸ Based on TEconomy's analysis of Lightcast Job Posting Analytics database (2023.1) for 2021 through 2022.

Georgia Tech's TI:GER Program: Encouraging Graduate Student Involvement in Innovation

Founded in 2012, TI:GER (Technology Innovation: Generating Economic Results,) represents a best practice program to encourage graduate students to be involved in technology commercialization activities. TI:GER is a transdisciplinary program that combines classroom instruction, innovation projects, team activities, and real-world experience into a comprehensive and practical education. Hosted at the Georgia Tech School of Business, TI:GER is the educational program for the Creative Destruction Lab (CDL-Atlanta), which is a global milestone-based mentoring program for science-based startups. Through this program, TI:GER participants—consisting of Georgia Tech MBA students, Emory Law students, and Ph.D. students from Georgia Tech's engineering, computing, and science colleges—work to translate ideas into successful technology innovations. Program features include:

- **Hands-on Exposure to Technology Commercialization:** Courses expose students to leading thinkers and practitioners in the areas of technology commercialization and include guest speakers, a business lab, retreats, and workshops. The TI:GER program is the educational program for CDL-Atlanta, which is a global technology-innovation program at Georgia Tech's Scheller College of Business. The courses in the TI:GER program prepare Georgia Tech MBA and Ph.D. students to work with CDL-Atlanta ventures.
- **Active Mentorship and Alumni Base:** Each TI:GER team is paired with a business mentor, an attorney mentor, and professors from Emory Law and Georgia Tech. The TI:GER Industry Advisory Board (composed of lawyers, investors, inventors, and executives) provides expertise and guidance as well. TI:GER has an active network of corporate executives, entrepreneurs, investors, consultants, lawyers, and more than 1,000 TI:GER alumni who support students during and after the program.
- **Supporting Student Outcomes and Talent Attraction and Retention:** Since 2002, students have joined TI:GER because they benefit from a competitive advantage in landing jobs and advancing their careers in technology innovation. Hosted at the center of Technology Square in Atlanta, the TI:GER office is across the street from more than 30 corporate innovation centers and more than 100 startups.
- **Results:** More than 1,000 alumni across Georgia Tech and Emory have participated in this program. A very high share of participating students ends up working in areas related to technology commercialization. More than \$140K in prizes have been won by TI:GER teams in business plan competitions. Meanwhile, \$6.6 million has been raised by TI:GER alumni companies.

- Establish a Post-Doctoral Entrepreneurship Program within regional universities with an intentional focus in biosciences business development. Key facets of the program, such as that implemented at Georgia Tech (see the callout), should include: a competitive selection

process for those interested in commercializing technologies; collaboration, training, and mentoring through the university business, innovation, and tech transfer programming arms on disclosed, university-managed technology opportunities.

Action 2.2: Invest in specific, targeted postsecondary programming in areas of demonstrated industry need including in biomanufacturing quality control/assurance (QC/QA) and in biotechnology programs for lab technicians and other applied industry roles.

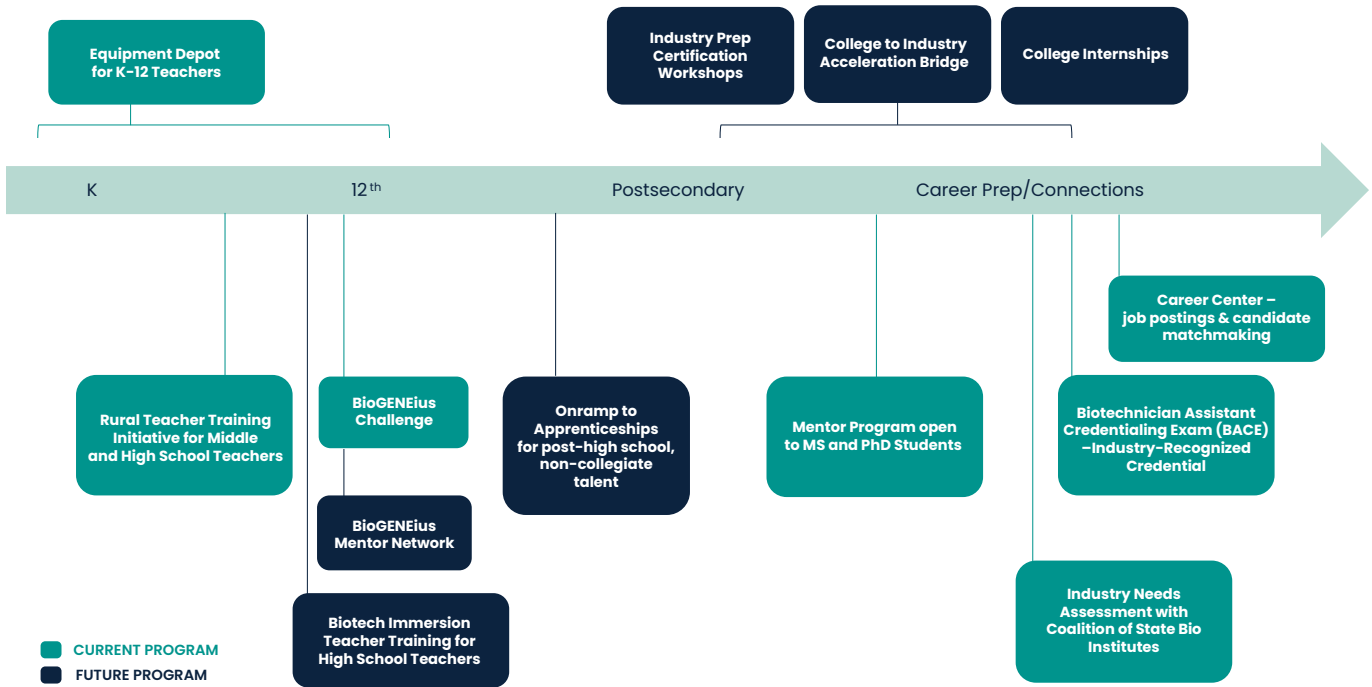
- Growth in the biomanufacturing sector is driving a strong demand for QC/QA professionals. As the sector grows, these professionals are increasingly needed to work alongside manufacturing associates across the highly regulated and sophisticated GMP production environment, playing a key role in testing of both material inputs as well as intermediate and final products to ensure the identity, purity, and activity of the product or batch. In an environment that is increasingly leveraging digital technologies, QC/QA professionals are a key link in this transformation with data and analytical tools aimed at increasing efficiency and flexibility and lowering costs.
- Today, employers cite just one existing regional postsecondary program with “some” relevant QC curriculum elements from which to recruit—namely, the UCO Chemistry Department.
- Employers further report that OSU is developing an associate degree in QC. This program should be supported and appropriately scaled to meet regional needs. Following best practices, the program should utilize an industry advisory board for curriculum development and industry experiential learning, and career awareness opportunities.
- Several employers lament the loss of a regional postsecondary Biotech program, an important foundational degree program for which students are better connected to the industry in an applied framework and approach as opposed to more basic research or career orientations toward healthcare or academia.

Action 2.3: Bolster biosciences career awareness and connections to engage K-12 students, early college students, and parents about the wide array of career opportunities in the growing regional biosciences industry.

- Career awareness is vital to the biosciences in meeting its workforce and talent demands, and a common challenge even in leading biosciences hubs where students are unaware of the varied roles required across the cluster—from production and logistics to quality control to lab technicians, scientists, software developers, data scientists, engineers and more. The industry has numerous on-ramps for career opportunities.
- OKBio should work with regional bioscience companies, educators, and other ecosystem partner organizations to promote career awareness across multiple approaches spanning community events, classroom visits, company tours, lab and other equipment donations for class experiments, mentoring, internships, senior projects and capstones, and other creative approaches.

Georgia’s BioEd Institute represents one example of engaging K-20 students, teachers, and parents in an impressively varied set of approaches and initiatives as shown in Figure 11. The BioEd Institute is an Office of the Center for Global Health Innovation associated with Georgia Bio, focused on strengthening the state’s life sciences workforce pipeline through a broad set of targeted “classroom-to-career” initiatives that span all educational levels and align with industry needs.

Figure 11: Examples of Career Awareness and STEM Education Initiatives of the Georgia BioEd Institute, 2020-2023



Source: TEconomy Partners, LLC for Georgia Bio, *The Georgia Life Sciences Industry Trends and Impacts Report, 2022*.

Illinois BIO: Supporting STEM Education and Biosciences Career Awareness

As Illinois' biosciences industry organization, iBio has a three-part focus of government affairs, community development, and STEM education programs. Funded through iBio's 501c3 affiliate, the EDUCATE program includes a range of programs for students in grades 3-12:

- **The Stellar Girls program** introduces girls to STEM concepts through weekly hands-on after-school activities, where students interact with STEM professionals and learn about STEM careers, apply STEM skills to real-world problems, and employ critical thinking skills.
- **STEM Girls Camp** is a 5-day STEM Summer camp for 3rd-8th grade girls, with programming that includes hands-on activities, sessions with STEM professionals, and field trips to biosciences companies.
- **iBIO STEM Kits** offers at-home STEM exploration activities for kids in grades 3-8 at home. Each kit includes the materials needed, printed activity instructions in English and Spanish, STEM Hero profiles, and links to instructional videos.
- **The BioGENEius Challenge** is among the world's most prestigious high school science competitions focused on original research in biotechnology.
- **Results:** Roughly 2,100 girls have participated in the Stellar Girls program, with more than two-thirds from lower-income households, and two-thirds are from underrepresented minorities. Participants report significantly higher interest rates in STEM.

Key Measures to Track Strategy Performance and Outcomes into the Future:

- Track alignment of annual industry employment projections in high-priority, high-demand occupations or roles against the regional workforce training and education graduate cohorts in key fields/programs for biosciences companies relative to their expressed needs and workforce gaps.
- Monitor and track job opening trends across the six major bioscience industry subsectors to understand who is hiring; for what skills/roles; and overall trends in volumes to understand real-time demand dynamics for employers and where interventions and additional investments are needed.

3. Overcoming Tech Development and Commercialization Challenges through Collaborations and Partnerships

Rationale for intervention: Considered together, Greater Oklahoma City’s research institutions have levelled up their biosciences research base—over two decades, the volume of annual R&D expenditures in bio-related fields has increased by more than 2x, and since 2015 have increased R&D expenditures by 19%. This is a significant achievement, but the recent pace of growth has lagged behind that of the United States overall and is not translating into the commercialization outcomes one would expect from a biosciences research complex of this magnitude.

The “valley of death” between research discoveries and new product development is a significant barrier to high-growth new venture formation in the region. Despite the sizable research base, the region’s level of “translation into innovation” is quite low. Since 2010, the annual average number of NIH-funded Federal Small Business Innovation Research (SBIR) Awards, a key metric for product innovation by emerging small businesses, averaged just seven per year for the region, with no year having more than 10. Additionally, the average annual number of VC deals in biopharmaceutical-related companies since 2010 stands at just slightly over three per year and funding at \$15 million per year, far below national levels when viewed on a normalized basis.

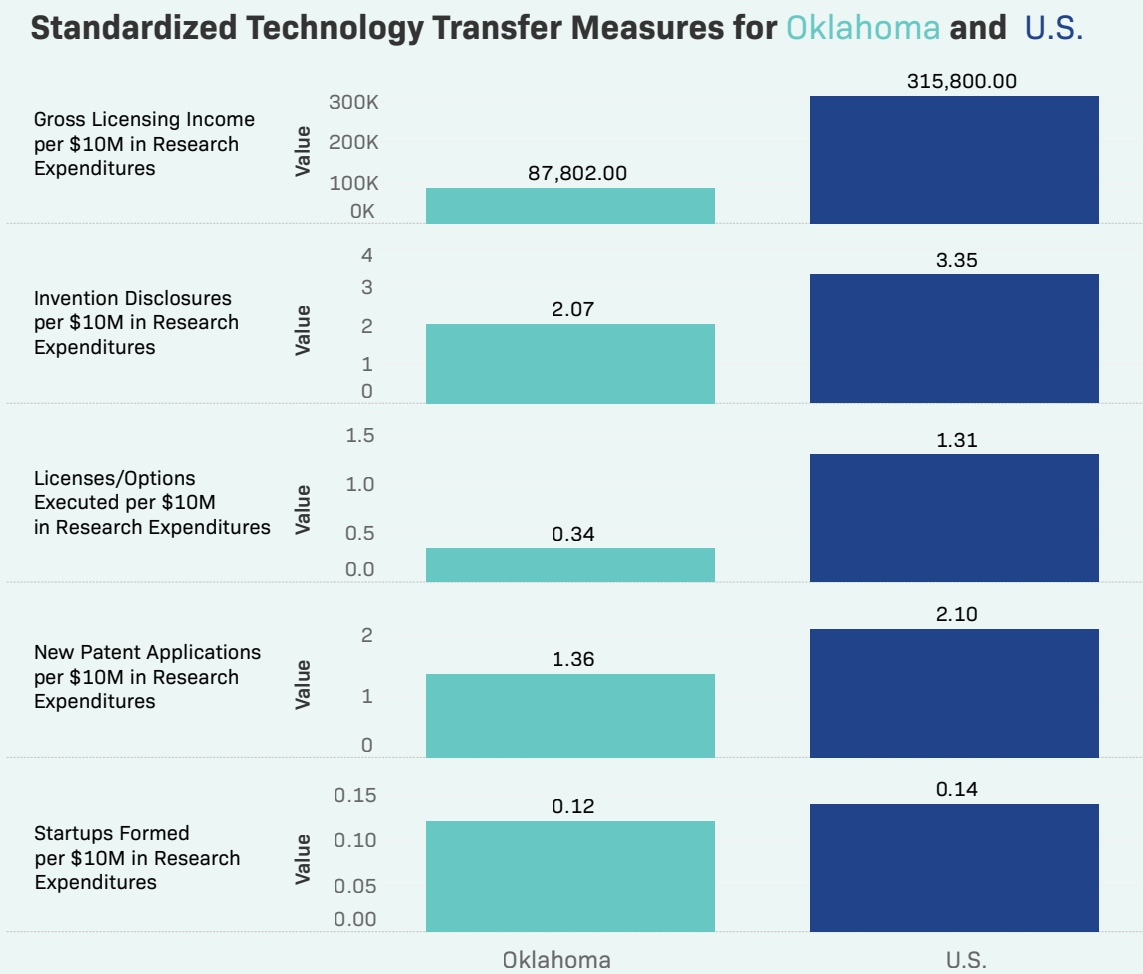
Based on an analysis of data from PitchBook, SBIR.gov, NSF’s HERD survey, and administrative data from OMRF, the Greater OKC region has generated, on average, 0.7 VC deals per \$100M in academic R&D versus a national average of 1.3 deals. Similarly, the region has generated 1.5 SBIR awards per \$100M in academic R&D compared against a national average of 2.8.

The Region Lags in Biosciences “Translation into Innovation”

The Greater OKC region has generated, on average, 0.7 VC deals per \$100M in academic R&D vs. a national average of 1.3 deals; the region has generated 1.5 SBIR awards per \$100M in academic R&D vs. a national average of 2.8.

In addition, the region’s two major research universities underperform compared to national averages in technology transfer metrics. When combined and normalized per \$10M in R&D expenditures, OU and OSU together lag the nation in key measures from invention disclosures to licensing activity and income, patents, and startups (Figure 12). It is important to acknowledge that these metrics include fields beyond the biosciences; however, the majority of regional university R&D is in bio-related fields.

Figure 12: Technology Transfer Metrics for Greater OKC Research Universities vs. U.S. Averages, 2020



Source: TEconomy Analysis of Association of University Technology Managers (AUTM) Licensing Activity Survey.

Note: AUTM survey is voluntary and only includes Oklahoma data from the University of Oklahoma (systemwide) and Oklahoma State University.

Concerns about the performance and function of regional tech development and commercialization dynamics are top-of-mind to many regional biosciences leaders, cited consistently in interviews and group discussions. And while it must be recognized that regional players have acknowledged this ecosystem gap and are working to address it, including through new, dedicated university programming and through the federal BBBRC award, which included funding for the Oklahoma Biotech Startup Programs at OU’s Tom Love Innovation Hub, deeper and more intentional bio-focused resources are needed.

Unlike incumbent innovation hubs with more complex commercialization frameworks on both the East and West Coasts, a key constraint to increasing local bioscience velocity is a lack of translational resources, which limits the development of new biosciences products. With the continued success of programs at the OU Stephenson Cancer Center and clinical and other biomedical research advancing across institutions, the region has a once-in-a-generation opportunity to advance industry-facing infrastructure intentionally supporting new industry collaborations and new firm formation.

The following actions are recommended to address technology development and commercialization challenges through collaborative regional approaches.

Action 3.1: Consider establishing an Oklahoma Clinical Research Consortium to leverage the emerging activities and investments across the region’s anchor research institutions and to complement the rise of contract manufacturing with a stronger position in clinical research and clinical trials services across disease areas. The Consortium should include industry representatives, academic institutions, and hospitals and health systems with clinical trials sites.

- Numerous institutions are advancing clinical research including SCC with its BBBRC project enhancements aiming to double its clinical trials capacity and translational research; OMRF is advancing a Clinical Research Center of Excellence leveraging its NIH-funded national autoimmune clinical research center; OSU Center for Health Sciences has a major effort underway pursuing clinical research for opioid and pain relief.
- Each of these institutions has significant assets to leverage from research infrastructure, patient populations, tissue repositories and biospecimens, and other capabilities to form strategic partnerships and from which to inform each other’s efforts.
- Clinical Research Consortia can take on different forms and functions (see, for example, callout box on OneFlorida+ Clinical Research Network), but at their core, they typically work in collaboration to address and support the needs of clinical research leaders and partners to:
 - Improve and expand clinical research workforce development by informing curriculum, demonstrating career paths, offering experiential learning opportunities (e.g., internships), and increasing awareness of career opportunities
 - Increase awareness of market trends and opportunities
 - Share best practices on patient recruitment, accruals

The OneFlorida+ Clinical Research Network: A Consortium Dedicated to Improving Clinical Trials

The OneFlorida+ Clinical Research Network is a best practice example of how a consortium of researchers, clinicians, patients, and stakeholders can address the biggest health challenges and serve as a resource for the region in improving health, health care, and health policy. Led by University of Florida Health, this consortium is a partnership of 11 health systems based out of academic health centers, community health systems, and clinics in the state of Florida.

To support research aimed at addressing pressing health care needs, key elements of OneFlorida's research infrastructure include:

- **The Data Trust** is a centralized data warehouse containing regularly updated, high-quality healthcare data. Legal agreements for data use have been negotiated with all partners, reducing administrative burdens. Scientists and clinicians use the Data Trust for various research activities, such as hypothesis generation, cohort discovery, prep-to-research activities, participant enrollment, observational studies, research workflow, and study data collection.
- **The Practice-Based Research Network (PBRN)** allows researchers to conduct clinical trials and interventional studies with patients who have already consented to participate.
- **The Front Door** is a centralized access point for researchers to submit data queries, formulate hypotheses, and apply to use the network's research infrastructure.
- **The Informatics for Integrating Biology and the Bedside (i2b2)** cohort discovery tool provides access to a curated dataset of 16 million patient records dating back to 2012, allowing researchers to identify patient populations and trends over time.
- **The Citizen Scientist program** allows community members with an interest in health research to work alongside scientists and offer lay perspectives and insights.
- **Workforce development and sharing best practices:** The Miami Clinical and Translational Science Institute (CTSI) has a major focus on workforce development, and OneFlorida+ allows for expertise to be shared across the state's colleges of medicine. For example, Miami CTSI's network for clinical research professionals offers peer-to-peer networking and mentorship opportunities through workshops and training programs that enhance career development. The program has grown to include more than 2,000 professionals across the University of Miami. In addition to various certification programs, the school also offers a master of science in Clinical and Translational Investigation, a structured educational program that offers trainees of diverse cultural and educational backgrounds formal graduate training in the principles and practice of translational science and clinical research.
- **Results:** In total, the Data Trust houses data on 17.2 million unique individuals dating from January 2012 through March 2021, including HER, claims, and other data sources. It is estimated that the consortium's partners serve roughly 50% of the state's population, including approximately 5.5 million unique patients in both 2019 and 2020. Several retrospective studies have utilized the Data Trust, including studies on hypertension, obesity, sickle cell disease, stillbirth, hepatitis C, opioid use disorder, and adults with multiple chronic conditions. Researchers have also used the Data Trust to develop computable phenotypes, including resistant hypertension, type 1 diabetes mellitus, and transgender and gender nonconforming individuals.

Action 3.2: Establish an Oklahoma Biosciences Innovation Partnership to establish integrated commercialization services across research institutions to advance biomedical commercialization and new venture formation.

- Regional ecosystems with multiple research universities and/or biomedical research institutions such as Greater OKC can leverage and benefit from pooling integrated commercialization services. Biosciences and other advanced industry ecosystems as varied as Greater St. Louis and Georgia have established and seen strong impacts from working across universities to enhance business acumen and resources in tech commercialization.
- Typical models, such as that implemented by the St. Louis Biogenerator (see callout box) combine to deploy some combination of the following resources and programming across a set of multiple research institutions:
 - Establish or utilize an existing privately funded, nonprofit entity focused on the formation and early growth of sustainable bioscience companies
 - Offer integrated commercialization-to-venture investment services, including:
 - Entrepreneurs in Residence (EIRs) to provide commercialization guidance to university faculty and entrepreneurs/inventors, and in some cases join the team to provide management support during early development stages
 - Advise on establishing a company, accessing capital including SBIR awards, connecting to local business services, etc.
 - Proof-of-concept funding grants to enable de-risking technology as well as regulatory guidance and considerations, prototyping, conducting key lab experiments, and conducting market studies
 - Access to lower-cost collaborative lab and/or office space
 - A venture investment fund to invest in the most promising new startups to advance to key milestones and position them for follow-on funding

The St. Louis BioGenerator: An Integrated Commercialization Model

The BioGenerator stands out as a best practice because it has recognized importance and high value of linking together direct access to Entrepreneurs-in-Residence and other proven C-level talent with focused efforts to de-risk technologies. These integrated commercialization services are critical for ensuring the viability of startups and positioning them for realizing their growth potential and ability to generate follow-on investments as they reach key milestones.

The BioGenerator is a privately funded, nonprofit 501(c)(3) organization established in 2003 to facilitate the formation and early growth of successful, sustainable bioscience companies in the greater St. Louis region. The BioGenerator is an affiliate of BioSTL—a regional biosciences cluster organization—and is located in the CORTEX Innovation District.

The BioGenerator offers a range of integrated commercialization-to-venture investment services:

- **Entrepreneurial Mentoring/Guidance:** At the earliest stage, the BioGenerator deploys over a dozen Entrepreneurs in Residence (EIRs) as part-time contractors who provide commercialization guidance and advice to university faculty and entrepreneurs. The EIRs work with the entrepreneur/inventor to establish a company, formulate a development plan, access sources of funding, and connect to professional services including lawyers and accountants. In some instances, EIRs will provide management support during initial company formation and are encouraged to take one or more companies forward as the CEO or other key management position.
- **De-Risking Technology:** The BioGenerator complements the efforts of its team of EIRs, typically before a company is formed or at the very earliest stages after its formation, with proof-of-concept grants to pay for early de-risking of technologies involving patent reviews, regulatory guidance, small market studies, prototyping, or conducting key lab experiments. As a new company is launched, the BioGenerator has a venture investment arm to invest in promising new companies to take them through technical and business milestones that would position them for next-stage investors.
- **Access to Lab Space:** Additionally, the BioGenerator offers access to flexible, low-cost collaborative laboratory spaces and helps startups with pursuing non-dilutive grants, such as federal SBIRs.
- **Results:** The St. Louis BioGenerator has supported more than 150 technology commercialization efforts with proof-of-concept funding and has made \$31 million in venture investments in more than 50 startups coming through their commercialization efforts that have generated \$2.4 billion in follow-on investments.

Action 3.3: Establish a multi-institutional shared biosciences core research services program to enhance a range of capabilities such as sequencing, pre-clinical imaging, structural biology, animal models, etc.

- To function as intended, the shared resources must be accessible to both researchers and industry.

Action 3.4: Stand up a health technology accelerator focused on rural health solutions—both of which are strengths in Greater OKC as well as a core mission and strength of OSU-CHS in and around Tulsa and represent a major need for the State of Oklahoma’s rural population.

- The initiative should leverage numerous key assets, initiatives, and tech development strengths identified during this planning effort, including:
 - A leading area of bioscience-related patenting in the region with more than 80 patents since 2015 in areas including patient monitoring, patient management systems, and predictive healthcare monitoring
 - mHealth, a shared resource at SCC that has a team of ten working on mobile app development with over 30 contracts to support other cancer centers across the nation
 - OSU CHS Innovation at Spears School of Business focused on rural primary care innovations and engaged in health data analytics with access from Cerner to a large HIPAA-compliant database
 - Active Rural Health initiatives underway that utilize health technologies including OSU Center for Rural Health and Project Echo, and Oklahoma Primary Healthcare Extension Program
 - The establishment of Canopy HealthTech, a philanthropic, multi-institutional program aiming to accelerate “the translation of intellectual property at Oklahoma universities into commercially viable virtual health technologies.” Recognizing this new organization and its potentially highly-synergistic mission as well as the potential for overlap, the Chamber and OKBio should coordinate closely as efforts in this space progress.

Key Measures to Track Strategy Performance and Outcomes into the Future:

- Technology transfer metrics presented herein, benchmarked against national averages, and ideally implementing an annual survey to regional research institutions to specifically track bioscience-related commercialization outcomes.
- Key productivity measures on regional R&D translation into innovation—bioscience-related VC, Angel, and SBIR/STTR awards to regional emerging biosciences companies both overall and relative to the institutional R&D base of expenditures.
- Track/monitor the presence of biosciences EIRs within the regional ecosystem and seek to grow it steadily over time.

4. Seizing, Organizing around Identified Biosciences Growth Opportunities

Rationale for intervention: The growth opportunities identified for the Greater OKC region by the line-of-sight assessment offer a strategic focus for targeting economic development efforts to advance the region’s biosciences clusters. Rather than a “field of dreams” approach of simply picking “hot” areas in the biosciences to pursue as economic development targets, the three growth opportunities reflect where the Greater OKC region is positioned for biosciences development based on the existing capabilities and core competencies of its industry development and research activities.

To realize these strategic growth opportunities requires an intentional focus across all elements of the strategic action plan. Figure 13 below crosswalks how key elements of the other strategic priorities align with each of the three biosciences growth opportunities for the Greater OKC region.

Still, to fully realize the potential for each of these growth opportunities, the Greater OKC region will need to go beyond traditional economic development practices that focus on the development needs of individual businesses on a one-by-one basis and establish a means for systematically advancing engagement, partnerships, and collaborations across industry, research,

and support organizations through the use of a dedicated network for each growth opportunity.

A bioscience growth opportunity network is not simply a means for linking academic medical institutions and industry; it is also a means to connect business-to-business relationships and business-to-entrepreneurial development resources, such as serial entrepreneurs and investors. These dedicated networks in the growth opportunity areas can play many roles, from creating a sense of community through meet-up events to offering informational and educational workshops on key topics to technical assistance and problem-solving forums to product innovation and process improvement opportunities. In

Figure 13: Recommended Strategic Approaches to Seizing, Organizing Around Three Growth Opportunities for Greater OKC



any case, networks can build a critical mass of like-minded firms and researchers whose ongoing success will increasingly be driven by collaboration. It can also point the way to identifying the region specific investments in shared-use resources critical for industry development in collaboration with academic medical institutions and industry partners.

BioNexus KC: Catalyzing Innovation in Animal and Human Health

Originally founded in 1999 as the Kansas City Area Life Sciences Institute, the mission of BioNexus KC is to highlight life sciences resources and their value to the community through collaboration and commercialization. BioNexus KC works to create opportunities at the nexus of Human and Animal Health, Urban and Rural Health, Academia and Industry, and, Kansas and Missouri. Key activities of BioNexus KC include:

- **Working Groups Aligned with Areas of Scientific Strength:** A key programmatic element of BioNexus KC is its working groups across four areas of progress that benefit the region's citizens and its economy. BioNexus KC is guided by four areas of scientific strength: animal health, cancer research and care, neuroscience, and health IT and outcomes research. Task forces were created for each cluster driver and work groups for each scientific area.
- **Networking and Events:** Across its key verticals, BioNexus KC supports events to encourage networking in the scientific community. For example, KC One Health Day is an annual regional event that highlights and celebrates the complex connections between humans and animals and the environment. The 2022 event hosted over 100 academic and industry attendees and featured a poster competition for high school, undergraduate, and graduate students to compete for a cash scholarship. Collaborate2Cure is a program providing a platform for scientists, entrepreneurs, students and the community to collaborate and identify solutions to a specific scientific problem. The 2022 Nexus Informatics Conference focused on expanding, sharing, and applying the region's informatics capacities and featured 200 unique attendees and 52 student posters.
- **Supporting R&D:** For two decades, the BioNexus KC Research Grant program has supported researchers through early-stage proof-of-concept-work. The program leverages partnerships with funders and provides applicants the review infrastructure built by BioNexus KC for researchers to generate preliminary data to develop competitive grant proposals for larger funding opportunities.
- **Promoting STEM and Workforce Development:** The Science2Art program is an annual auction where regional scientists display and describe their research through the visual arts: Since 2014, the program has donated nearly \$140,000 to STEAM programs in the region. BioNexus KC is also involved with regional partners to promote STEM learning and build awareness of careers in life sciences among K-12, undergraduate, and graduate students.
- **Startup Funding:** BioNexus is developing the KC Nexus Fund, a privately funded and professionally managed life sciences proof-of-concept fund. The fund will provide funding, industry connections and guidance to early-stage entrepreneurs as they conduct the initial research and/or development needed to validate their technology and its fit in the marketplace.
- **Results:** BioNexus KC has had numerous successes over its 20-year history, including the establishment of the Animal Health Corridor and the attraction of the Department of Homeland Security's National Bio-Agro Defense Facility. The R&D Grants Program has been very successful in attracting follow-on funding: The program has funded \$6.7 million in grants, which has more than 91.8M in follow-won funding for R&D (13:1 ROI).

Action 4.1: Establish an organizational infrastructure for supporting growth opportunity networks, led by OKBio with assistance from site miners at major anchor organizations.

It is proposed that OKBio serves as the facilitator and administrative support organization for advancing each of the growth opportunity networks. OKBio will have the responsibility for forming the networks, organizing a planning committee, and outreach to industry and entrepreneurs.

For the larger anchor organizations such as OU, OSU and OMRF, there is a need for a single point of contact to serve as a “site miner” to access the right people to engage in the varied activities of each growth opportunity network over time. This can include finding experts for information sharing and education workshops, matching of bioscience companies with researchers and key facilities needed to solve specific technical problems, and soliciting broader organization involvement in larger-scale collaborative activities to further the growth opportunity area.

Each growth opportunity network should also strive to identify unmet market/clinical needs and then identify potential solutions that can support the advancement of each growth opportunity area in the Greater OKC region. This would involve:

- **Identifying Problems:** Seek out clinicians, engineers, entrepreneurs, and researchers at the front lines of Healthcare and Technology to identify existing problems.
 - Communicate with the designated front line (ex: hospital clinicians) to identify problems (*role: site miner*)
 - Hold “reverse pitch” events on clinical or other industrial challenges for potential innovative market solutions by regional startups (*role: site miner or program manager*).
 - This can include forming a roundtable discussion with different groups: clinicians/nurses/patients, dentists, public health, animal health/vets, agriculture.
- **Validating Problems:** Once a problem is identified, further investigating/validating the problem and opportunity.
- **Creating Solutions:** Present clinical/industry/health problems in need of technological innovation and technologies with potential yet undefined (ex: clinical) applications and solutions to a “working group” of potential solution providers (a team of universities, research institutions, and industry).
 - Facilitate a roundtable discussion connecting clinicians, engineers, and entrepreneurs who have creative ideas about applying existing or new technologies to solve targeted patient care challenges (*role: program manager*)
- **Determining Commercialization Viability:** Before building or applying the solution, the solution will need a compelling business model to pursue commercialization. The principal of the concept will partner with resources such as i2e and Canopy Health for the proof of concept.

Key Measures to Track Strategy Performance and Outcomes into the Future:

- Over time track the advancement of each growth opportunity with respect to the levels and growth of:
 - Regional startups; venture capital and angel investments (both funding values and deal volumes); federal SBIR/STTR awards related to each area; workforce training and education programs established directly related to targeted skills development.
- More tactically, as the strategies are implemented and advanced, track collaborations and stakeholder engagements and participation in key initiatives; for example:
 - In the therapeutics area: participation in clinical research consortiums; cohorts completing training at the Biomanufacturing Training Center; companies serviced via the Innovation Partnership.
 - In MedTech and HealthTech: tracking establishment of test-beds; partnerships with rural communities; companies served by the HealthTech accelerator; etc.
 - For OneHealth: tracking collaboration on research projects, grant funding, and other opportunities where strategic partnerships cross research institutions and the major expertise areas spanning human and animal biomedical and agricultural sciences.

Conclusion

The timing is ripe to seize the tangible momentum in the regional biosciences cluster. Greater Oklahoma City has seen a significant win for the industry and its innovation ecosystem with major federal funding flowing to strategic biosciences projects, combined with an exciting spirit of collaboration and new leadership across the region. Regional industry and university R&D are growing, with a diverse mix of potential growth opportunities. Numerous activities and investments by regional players are ongoing but require greater connectivity and the region must coordinate around its talent, commercialization, and organizational challenges or it risks missing this key moment for biosciences development.

Appendix

Four interim project update deliverables were presented to the Advisory Committee throughout the project. They represent additional, detailed background that can inform the Strategic Roadmap, its findings, and strategic recommendations. These act as important reference appendices and can be made available by request through the Greater OKC Chamber. These presentations include:

1. Project kickoff and initial industry, innovation ecosystem scan.
2. Identification of regional core competencies and resulting initial line-of-sight to growth opportunities.
3. Regional focus group meeting presentation, establishing a cluster SWOT assessment and the initial identification of strategic priorities, as well as potential strategic recommendations.
4. Presenting the Strategic Roadmap and associated strategic priority areas and specific recommendations.

Project Advisory Committee

The Greater Oklahoma City Chamber and the TEconomy Partners project team would like to thank the project Advisory Committee for their extremely valuable contributions throughout this effort—from attending several in-person meetings and participating in interviews and focus groups to sharing critical insights and helping to shape the Strategic Roadmap. The Committee members include:

Name	Company/Organization
Bill Lance	Chickasaw Nation Dept. of Commerce
Mike Moradi	Cortado Ventures; Sensulin, LLC
Dr. Stephanie Wickham	Cytovance
Christian Kanady	Echo
Jeff Seymour	Greater OKC Chamber
Madison Jackson	Greater OKC Chamber
Rex Smitherman	i2E
Dr. Sean Bauman	IMMY
Katy Boren	Innovation District
Gene Hopper	Mettise
Dr. Craig Shimasaki	Moleculara Labs
Dan Luton	Oklahoma Center for Advancement of Science and Technology (OCAST)
Amy Loftis-Walton	Oklahoma Department of Commerce
Dr. Andrew Weyrich	Oklahoma Medical Research Foundation (OMRF)
Dr. Kenneth W. Sewell	Oklahoma State University (OSU)
John Hanak, JD	Oklahoma University and Oklahoma University Health Sciences Center (OU/OUHSC)
Rick McCune	Presbyterian Health Foundation

Bioscience Industry Definition

Table A-1: Bioscience Industry Definition

Bioscience Industry Subsector	NAICS Code	NAICS Description
Agricultural Feedstock & Industrial Biosciences	311221	Wet Corn Milling
	311224	Soybean and Other Oilseed Processing
	325193	Ethyl Alcohol Manufacturing
	325311	Nitrogenous Fertilizer Manufacturing
	325312	Phosphatic Fertilizer Manufacturing
	325314	Fertilizer (Mixing Only) Manufacturing
	325320	Pesticide and Other Agricultural Chemical Manufacturing
Drugs & Pharmaceuticals	325411	Medicinal and Botanical Manufacturing
	325412	Pharmaceutical Preparation Manufacturing
	325413	In-Vitro Diagnostic Substance Manufacturing
	325414	Biological Product (except Diagnostic) Manufacturing
Medical Devices & Equipment	334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
	334516	Analytical Laboratory Instrument Manufacturing
	334517	Irradiation Apparatus Manufacturing
	339112	Surgical and Medical Instrument Manufacturing
	339113	Surgical Appliance and Supplies Manufacturing
Research, Testing, & Medical Laboratories	339114	Dental Equipment and Supplies Manufacturing
	541380*	Testing Laboratories
	541713*	Research and Development in Nanotechnology
	541714	Research and Development in Biotechnology (except Nanobiotechnology)
	541715*	Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)
Bioscience-related Distribution	621511	Medical Laboratories
	423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
	424210*	Drugs and Druggists' Sundries Merchant Wholesalers
Hospitals & Health Services	424910*	Farm Supplies Merchant Wholesalers
	622110	General Medical and Surgical Hospitals
	622210	Psychiatric and Substance Abuse Hospitals
	622310	Specialty (except Psychiatric and Substance Abuse) Hospitals

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

