



Leveraging the Phoenix Region's Bioscience Assets for Sustained Economic Growth:

Identifying Growth Opportunities
for the Region and its Bioscience Hubs,
led by the Phoenix Bioscience Core



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CONTENTS

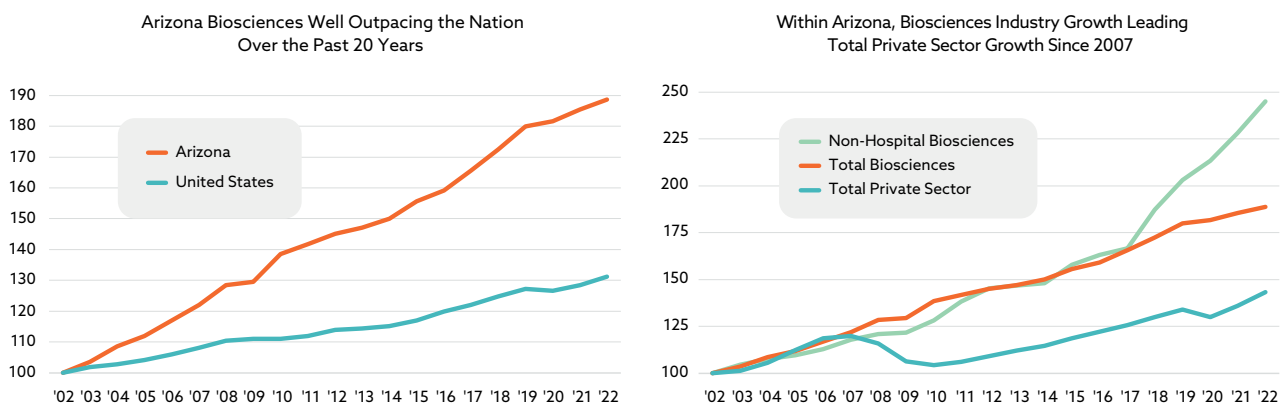
- Introduction and Key Findings 1**
 - Key Findings..... 4
- Setting the Context: A Fast-Growing and Dynamic Regional Bioscience Ecosystem Continues to Evolve, Mature, and Invest7**
- Bioscience Growth Opportunities for the Phoenix Region 11**
 - Precision Oncology and Medicine17
 - Digital Health, WearTech, and Other MedTech..... 26
 - Translational Neuroscience.....35
- Recommended Action Steps to Realize the Bioscience Growth Opportunities for the Phoenix Region43**
- Appendix.....47**

INTRODUCTION AND KEY FINDINGS

Arizona stands out among all states as having one of the nation's fastest growing bioscience industry clusters. Over a two-decade period, the emerging state industry has well-outpaced national growth and has served as a leading growth and innovation driver for the Arizona economy (Figure 1).

Within the state, Greater Phoenix has served as the leading region and growth engine for the bioscience industry.¹ In bioscience industry employment, the Phoenix region has 70.5% of the statewide bioscience jobs and is well outpacing the state's healthy job growth across bioscience industries, with a gain of 9.2% for the Phoenix region from 2019-2022 compared to 4.8% for the state. Additionally, the Phoenix region is a key driver of bioscience innovation and entrepreneurship, with 64% of statewide bioscience venture capital investment, 70% of statewide bioscience patents and 64% of statewide bioscience publications over the 2019 through 2023 period.

Figure 1: Bioscience Industry Employment Growth, Arizona vs. U.S., 2002-22 (Employment Index, 2002 = 100)



Source: Lightcast (Datarun 2024.1); TEconomy Partners analysis.

¹ The Greater Phoenix region is defined in this study to align with the metropolitan statistical area (MSA) definition set by the federal Office of Management and Budget to include Maricopa County and Pinal County.

This dynamic bioscience ecosystem in the Phoenix region is seeing continued corporate and academic research investments and significant efforts at establishing strong and identifiable “places” or physical hubs or nodes for the biosciences in and across the metropolitan region. One long-established strategic effort at placemaking in the region, dating back to 2004, is the Phoenix Bioscience Core, or PBC. Today, the PBC is a unique development found in Downtown Phoenix that brings together an unparalleled set of Arizona’s leading bioscience anchor institutions and collaborators including the state’s three public research universities, several major healthcare systems, genomic research institutes, and a growing number of emerging life sciences companies.² Additional hubs for bioscience development are also advancing across the region in Midtown Phoenix and North Phoenix associated with specific anchor bioscience organizations.

Today, the Phoenix Bioscience Core is a unique development that brings together an unparalleled set of Arizona’s leading biosciences anchor institutions and collaborators, including the state’s three public research universities, several major healthcare systems, genomic research institutes, and a growing number of emerging life sciences companies.

As the Phoenix region’s bioscience industry cluster advances and the broader regional bioscience ecosystem continues to evolve, there is a need to better understand the collection of assets found across the region supporting bioscience development. But rather than simply cataloging the Phoenix region’s wide-ranging bioscience assets, it is critical to identify how these bioscience assets can catalyze growth opportunities for the region.

Advancing industry cluster development in today’s global, knowledge-based economy requires identifying specific niches or market opportunities in which a region can differentiate itself and build specialized expertise to be a world leader. The bioscience industry cluster, in particular, comprises a broad and highly diverse market for goods and services spanning multiple industries and technologies that allow regions to find specific areas of focus aligned to their strengths.

Regional Advantage Requires Defining Distinct Technology and Market Areas of Focus

As Michael Best, a leading scholar chronicling the growth and development of industry clusters across regions, explains in *The New Competitive Advantage* (Oxford University Press):

...industry clusters can be thought of as developing specialized and distinctive technology capabilities, which give them unique global market opportunities. The successful pursuit of these market opportunities in turn reinforces and advances their unique regional technological capabilities. Regional specialization results from cumulative technological capability development and the unique combinations and patterns of intra- and inter-firm dynamics that underlie enterprise and regional specialization.

² The anchor institutions include: Arizona State University, Northern Arizona University, the University of Arizona, Translational Genomics Research Institute (TGen, part of the City of Hope), the International Genomics Consortium, Banner Health, Phoenix Children’s Hospital, Dignity Health, Valleywise Health, the Phoenix VA Health Care System (PVAHCS) Research Space, the NIH National Institute of Diabetes and Digestives and Kidney Disorders’ Phoenix Research Branch; and a growing number of emerging life science companies, including Caris Life Sciences and Exact Sciences.

Most importantly, though, this assessment must look beyond simply the Phoenix region's bioscience industry base to consider also how the region's research drivers are positioning it for growth, and to understand the alignment between industry and research capacities and objectives. More than most other technology-based industry clusters, biomedical industrial development is driven by the ability to catalyze a robust and integral relationship between the industry, clinical care, and academic research and development communities. This integral relationship plays out through a number of synergistic features, including:

- **Biomedical product development is driven by close linkages between industry and academia.** Seventy five percent of the most important therapeutic drugs on the market today had their origins in public sector research conducted in universities, at the National Institutes of Health, or in other non-profit research institutions.³
- **The bioscience industry specifically benefits from close connections to research universities given the unique translational “bench to bedside” research requirements for advancing biomedical development.** The connection between biomedical product advancement and clinical care is not simply one of advancing a supplier and buyer relationship. Advances in biosciences to treat human health require extensive clinical trials to ensure the safety and efficacy of new medical products, which in turn call for close collaborations between industry, researchers, and clinicians.

This study takes stock of the dynamic ecosystem for biosciences using in-depth quantitative and qualitative approaches to consider how the Phoenix region and its bioscience hubs can best be positioned for growth—working to identify specific growth opportunities at the intersection of core research competencies of anchor institutions and bioscience industry drivers. Based on the growth opportunities identified, as well as ecosystem challenges and gaps raised consistently by regional leaders and stakeholders, specific recommendations are offered on types of physical development, marketing outreach, and programming needed to realize those growth opportunities.

Study Objective and Approach:

Assess the Phoenix region's wide-ranging assets supporting biosciences and biomedical development to identify how these assets can catalyze growth opportunities to further advance the Phoenix region's bioscience cluster and its bioscience hubs, led by the Phoenix Bioscience Core (PBC).

This assessment considers the “line of sight” to forward-looking growth opportunities at the intersection of core research competencies of anchor institutions and the region's bioscience industry drivers.

3 Paula Stephan, *How Economics Shapes Science*, Harvard University Press, 2012, page 207.

Key Findings

For the Phoenix region to sustain the continued advancement of its bioscience industry development, it is important to first identify the specific opportunities for which the metropolitan area is best positioned for growth. It is critical then to solicit input and recommendations from regional bioscience stakeholders to identify key development actions necessary to realize those opportunities.

Emerging from the line-of-sight assessment are three growth opportunities in the biosciences for the Greater Phoenix region. These areas demonstrate an alignment of the region's industry development with the research competencies found within and across regional anchor institutions, including those at the PBC. These three opportunity areas include:

- **Precision Oncology/Medicine**—represents an area of specific focus by Arizona over the past 20 years to leapfrog other more established states in bioscience development to be a leader in the emerging genomics revolution that is reshaping the practice of medicine. The Phoenix region has benefitted from substantial investments to possess a significant depth of research assets spanning multiple institutions that has led to a number of high-growth startups in molecular diagnostics able to attract out-of-state industry investment and position the Phoenix region as a fast-growing center for precision molecular diagnostic labs. Today, the industrial focus is primarily oncology diagnostics markets and product innovations, but this area represents a legitimate opportunity to ultimately serve numerous end markets and disease areas.
- **Digital Health, WearTech, and Other MedTech**—represents a dynamic, rapidly emerging area in which the region is seeing strong startup and entrepreneurial activity as well as a cadre of existing, growing medical device companies amidst the broader trend toward the “digital transformation” of healthcare with the ongoing convergence of software, hardware, AI, and regional strengths in microelectronics and the broader tech industry.
- **Translational Neurosciences**—represents a distinctive area of strength for the Phoenix region in biomedical research, clinical expertise and infrastructure, and translational research found across multiple institutions, with significant ongoing investments being made. This is a distinct and differentiated opportunity area for Greater Phoenix in which it stands out nationally and globally is still an emerging one in industry development, with promising innovations among emerging companies.

This portfolio of bioscience growth opportunities for the Phoenix region is exciting. Together, these three opportunities position the region to capture high-growth markets for bioscience development globally. Additionally, these three areas reflect different dynamics in their development trajectory—with precision medicine realizing the fruits of significant past investments and now sustaining a fast-growing industry base in molecular diagnostics testing labs along with a significant base of innovation drivers across industry and research institutions for further advances in molecular diagnostics; while digital health, WearTech and other MedTech is aligned with and leverages the region's considerable assets in microelectronics and tech-driven development; and, finally, translational neurosciences giving the region a distinct and differentiated area of emerging and very promising industry development for the future.

For Greater Phoenix to fully realize these three growth opportunities, the region's bioscience stakeholders identified recommended development actions based on each growth opportunity area's specific competitive strengths and challenges. Still, a number of common themes of ecosystem challenges and corresponding needed development actions emerge from across these growth opportunities, including:

- **While the Phoenix region is widely viewed as business-friendly for bioscience industry development, a more coordinated, proactive regional business development effort is needed to realize the region's bioscience growth opportunities.** There are many positives noted by stakeholders about the business climate for bioscience industry development in the Phoenix region. The region offers a lower cost of doing business compared to well-established bioscience regions across the West Coast, and the region's local government leadership is widely complimented by stakeholders in offering a welcoming and supportive business environment for bioscience industry development. Additionally, many individual healthcare and bioscience research institutions are active in seeking industry collaborations and business development. Still, it is recognized by stakeholders that the Phoenix region has fallen behind others in not having a coordinated, proactive outreach marketing and business development effort for bioscience industry development. This has resulted in few telling the region's bioscience story on a national stage and creating the buzz that attracts the attention of out-of-region investors and industry. In late 2023, the Greater Phoenix Economic Council, which serves as the region's economic development organization focused on attracting and growing businesses, took an important step to address this need by establishing a dedicated business development focus on the biosciences, led by a vice president with expertise in the biosciences.
- **Increased networking and collaboration activities are needed to advance innovation and talent development** within and across these growth opportunity areas, especially given the convergence of technologies taking place to realize these growth opportunities. While the wide geographic footprint of bioscience company locations across the Phoenix region presents a key challenge to overcome, it is the lack of high-quality programming for networking activities that stands out. Among the networking activities needed on a larger scale are bringing peer groups within the biosciences together, creating connections to regional customers, addressing common talent skill shortage needs, and identifying innovation challenges for collaborative efforts. This results in a less robust bioscience community across the Phoenix region, characterized more by silos than active partnerships and collaboration.
- **Shoring up the region's capacity to support scale-up of emerging bioscience ventures in accessing needed business acumen and investment.** The Phoenix region is strong in advancing innovations for the biosciences, but lacking in the required deep business knowledge and lead venture capital investors to scale-up high-growth potential startups. A wide range of activities are identified across the growth opportunities, from developing stronger business mentor networks to advancing regulatory/reimbursement business skills for biosciences to engage lead investors.
- **Leveraging data resources to advance innovation and collaboration activities.** In the age of AI and machine learning, increasingly innovation in the biosciences depends upon access to high-quality data. The Phoenix region would benefit significantly from having increased access to population health databases to spur innovation and collaboration across industry, research institutions and healthcare providers, such as the state's health information exchange data and more specific data collection initiatives such as TGen's MindCrowd initiative.

The growth of placemaking at the bioscience hubs developing across the Phoenix region is particularly important for advancing the bioscience ecosystem to address these common development issues. These bioscience hubs not only offer facilities geared toward the needs of bioscience companies and research centers, but also stand out because they are ideal settings to form communities anchored by a university, research institute or healthcare system, focused on innovation, entrepreneurship, education and training, and collaboration for individuals and enterprises of all sizes and growth stages. Moreover, bioscience hubs can offer resources for proactive marketing and hosting of innovation centers that can attract business mentors and venture capital investors from within and outside of the region.

Among the growing bioscience hubs in the Phoenix region, the PBC stands out to regional stakeholders, given its extensive developed footprint and the broad range of leading bioscience anchor institutions and collaborators—which will soon include the new ASU medical school—as being ideal in developing more value-added services for networking, proactive outreach marketing and addressing the region’s capacity to support the scale-up of emerging bioscience ventures. More importantly, PBC is well-situated to help anchor and raise the visibility of the biosciences across the region for a much larger and diverse bioscience innovation community involving Downtown Phoenix with its growing ASU campus, nearby research and medical centers including those in Midtown, and its proximity to the airport and its growing base of molecular diagnostics labs.



SETTING THE CONTEXT:

A Fast-Growing and Dynamic Regional Bioscience Ecosystem Continues to Evolve, Mature, and Invest

Greater Phoenix continues to experience rapid growth in its bioscience industry, increasing its employment base in the industrial, non-hospitals segments by 26% since 2019 and growing at two times the rate of the national industry (13%).

Its growth has been broad-based and diversified in recent years, with job gains seen across each of the major subsectors of the bioscience industry (sidebar) and fueled by a strong concentration of college- and university-led talent development in a leading U.S. metro region. Today, the regional industry employs more than 97,000 Arizonans across over 2,300 individual business establishments (Figure 2).

The industry in Greater Phoenix continues to emerge and mature alongside other major regional clusters, including semiconductor and microelectronics manufacturing, aerospace and defense, and others, and it has not yet reached a significant and “specialized” level of concentration overall. Just one of the five major industry subsectors has an

What are the bioscience areas of focus for the Phoenix Region? Defined in this study to include:

- Drugs, Pharmaceuticals & Diagnostics
- Medical Devices & Equipment
- Research, Testing & Medical Labs
- Bioscience-Related Distribution
- Hospitals
- Digital Health/Health Tech*

** Comparable employment metrics for Digital Health are not available because, unlike the majority of the bioscience industry, this sector cannot be isolated from broader IT industries under federal NAICS classifications.*

above-average employment concentration relative to national averages—in bioscience-related distribution, where Phoenix is 6% more concentrated in its employment base relative to U.S. averages.⁴

Among its major industrial bioscience subsectors, Greater Phoenix is seeing strong emergence in most, with the following double-digit employment growth rates seen from 2019 through 2022 and all significantly outpacing the strong job growth seen nationally:

- Pharmaceutical and Diagnostics Manufacturing: up 35.9% in Phoenix region compared to 12.5% nationally.
- Medical Devices and Equipment Manufacturing: up 28.5% in Phoenix region compared to 6.7% nationally.
- Research, Testing, and Medical Labs: up 26.5% in Phoenix region compared to 21.5% nationally.
- Bioscience-related Distribution: up 20% in Phoenix region compared to 10.4% nationally.

As the industry has grown, venture capital funding to regional bioscience companies has seen significant increases in recent years. From 2014 through 2018, investments in Greater Phoenix bioscience-related companies averaged nearly \$67 million in VC and Angel funding annually. In the 2019 through 2023 period, that figure averaged nearly \$186 million with steady deal flow of more than 43 deals per year for the bioscience sector. The region stands out in its higher concentrations of funding in MedTech (aligned with the medical device subsector) and in HealthTech or digital health.

Figure 2: Greater Phoenix Bioscience Industry Summary Metrics, 2019-22



Source: TEconomy Partners' analyses of Lightcast and PitchBook data.

The Phoenix region also has robust research and development activities in the biosciences as indicated by publications, patent awards, and clinical trials activities. In NIH funding—the gold standard of biomedical research—Phoenix-based research organizations received 270 awards, totaling \$148 million in FY 2023. Since 2019, these bioscience research efforts generated more than 15,000 publications with Phoenix region-based authors. Additionally, nearly 5,000 bioscience patents were awarded to Phoenix region inventors across universities, research institutes, hospital systems and industry. Clinical trials activities are also substantial across the Phoenix region, with 2,533 active clinical trials with sites in the region. Nearly 10% of the clinical trials taking place in the Phoenix region were led by principal investigators based in the region, suggesting strong leadership capacity across research organizations and healthcare systems in clinical trials.

⁴ 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.

There are also significant developments and investments taking place to increase the bioscience research capacity in the Phoenix region. As a result of a major new initiative and call to action by the Arizona Board of Regents (ABOR)—dubbed *AZ Healthy Tomorrow*—to grow the state’s healthcare workforce, the establishment of two new medical schools in Arizona have been announced by ASU and by NAU, with significant implications for Greater Phoenix.⁵

- **ASU will launch its new medical school** with plans to integrate clinical medicine, biomedical science, and engineering. The university will expand its partnership with the Mayo Clinic and grow its nursing workforce. At the same time, ASU Health is creating a school for public health technology and initiating a “health observatory” to monitor public health. Operating in the Phoenix region, the new medical school will have positive implications for research, talent development, and industry partnerships.
- **NAU is designing its new College of Medicine** with a focus on preparing primary care physicians to practice in the state’s rural, underserved, and indigenous communities. NAU Health will further grow the nursing workforce with the establishment of a College of Nursing as well as allied health fields, which are expected to address needs in the Phoenix region.
- Also under the *AZ Healthy Tomorrow* initiative, **UArizona plans to double its number of medical school graduates and grow its partnership with Banner Health** to create a fully integrated academic medical center.

Helping to create a home for the bioscience innovation community across the region, there are a number of innovation-based placemaking developments across the region associated with key bioscience research organizations. The oldest and best established is the **Phoenix Bioscience Core or PBC**. Originally known as the Phoenix Biomedical Campus, it was established in 2004 on a 30-acre city-owned site as an initiative between the City of Phoenix, Arizona State University, University of Arizona, and the Arizona Board of Regents to expand medical education and research in the Phoenix metropolitan area. It has grown into a 1.7 million square-foot innovation district development with bioscience-related research, academic, clinical, and industry facilities with the potential to reach 6 million square feet at build out.

In addition to the established PBC, new bioscience and biomedical focused place-based developments have been launched:

- In 2023, Mayor Gallego announced that Park Central and Midtown Phoenix have been designated as a “Bioscience Hub” for the region. Referred to as the **Phoenix Medical Quarter**, the hub brings together the new Virginia G. Piper Creighton University Health Sciences Campus; a significant expansion of the Dignity Health St. Joseph’s Hospital and Medical Center Campus by Barrow Neurological Institute (BNI)—one of the world’s leading neuroscience hospitals in the world—opening its state-of-the-art Barrow Neuroplex and Ivy Brain Tumor Center; and other bioscience-related entities, including the WearTech Applied Research Center.

5 For more on ABOR’s *AZ Healthy Tomorrow* initiative, see: <https://www.azregents.edu/azhealthytomorrow>.

- **Discovery Oasis** represents an additional biomedical innovation hub adjacent to Mayo Clinic’s existing campus in north Phoenix. Announced by Mayo in 2021, Discovery Oasis represents a 120-acre development envisioned as a collaborative “biotechnology corridor” to advance medical innovation. The site wraps around the Mayo Clinic Hospital campus and ASU’s Health Futures Center where existing collaborations between the two research anchors are expected to be enhanced by the development. Mayo plans to incorporate research facilities, offices, and site amenities to co-locate companies and to encourage collaboration and convergence.

Altogether, the Phoenix region has all of the elements for growing a robust bioscience ecosystem. Its bioscience industry base is growing and reaching critical mass, it is active in venture-backed bioscience startups, its bioscience research and development activities are substantial and it is advancing the placemaking infrastructure critical for enhancing the deep partnerships across industry, universities, academic medical centers, and other biomedical research institutions to advance and commercialize promising research and scientific breakthroughs.



BIOSCIENCE GROWTH OPPORTUNITIES FOR THE PHOENIX REGION

As the Phoenix region's bioscience industry cluster advances and the broader regional bioscience ecosystem continues to evolve, there is a need to better understand the collection of assets found across the region supporting bioscience development. But rather than simply cataloging the Phoenix region's wide-ranging bioscience assets, it is critical to identify how these bioscience assets can catalyze growth opportunities for the region.

A dynamic, high-growth industry across a diversified base is certainly an ideal situation. However, the broad-based growth across a fast-moving ecosystem can prove challenging to identify and organize around specific growth opportunities for which the region is best and uniquely positioned. The region and its numerous active players in the biosciences can and should benefit from understanding how they are best positioned for future growth that strategically targets innovation-led growth opportunities in bioscience development.

Advancing industry cluster development in today's global, knowledge-based economy requires identifying specific niches or market opportunities in which a region can differentiate itself and build specialized expertise to be a world leader. The bioscience industry cluster, in particular, comprises a broad and highly diverse market for goods and services spanning multiple industries and technologies that allow bioscience regions to find specific areas of focus aligned to their strengths.

More than most other technology-based industry clusters, biomedical industrial development is driven by the ability to catalyze a robust and integral relationship between the industry, clinical care, and academic research and development communities. This integral relationship plays out through a number of synergistic features, including:

- **Biomedical product development is driven by close linkages between industry and academia.** Seventy five percent of the most important therapeutic drugs on the market today had their origins

in public sector research conducted in universities, at the National Institutes of Health, or in other non-profit research institutions.⁶

- **The bioscience industry specifically benefits from close connections to research universities given the unique translational “bench to bedside” research requirements for advancing biomedical development.** The connection between biomedical product advancement and clinical care is not simply one of advancing a supplier and buyer relationship. Advances in biosciences to treat human health require extensive clinical trials to ensure the safety and efficacy of new medical products, which in turn call for close collaborations between industry, researchers, and clinicians.

For the Phoenix region to sustain the continued advancement of its bioscience industry development, it is important to first identify the specific opportunities for which the metropolitan area is best positioned for growth. It is critical then to solicit input and recommendations from regional bioscience stakeholders to identify key development actions necessary to realize those opportunities.

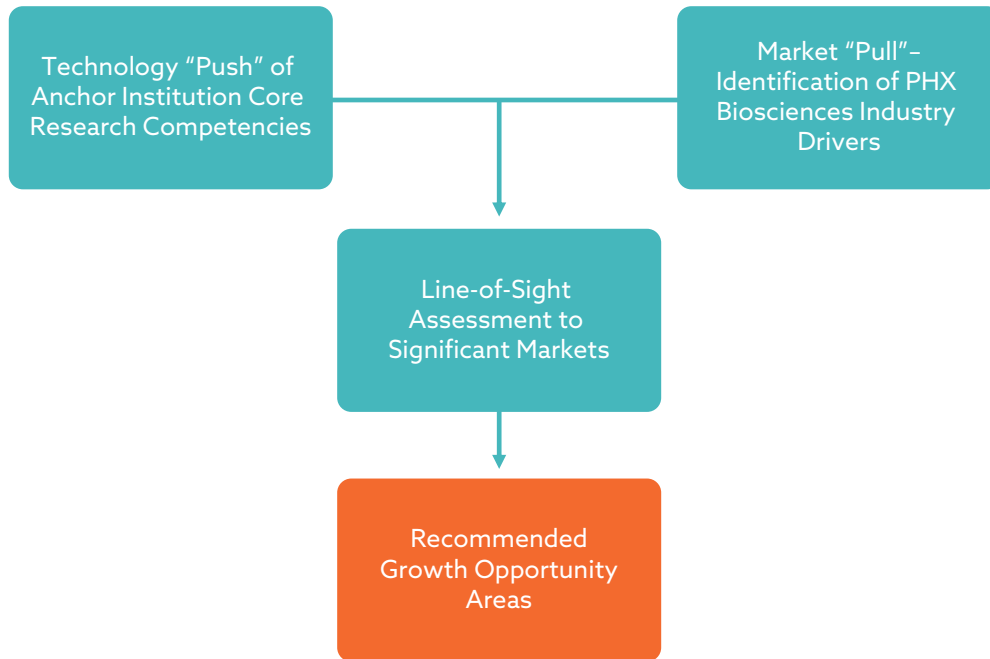
The Approach: A Line of Sight to Growth Opportunities

TEconomy has developed a methodology we refer to as a “*line-of-sight*” assessment to identify these likely growth opportunities for Greater Phoenix, the PBC, and to inform other place-based developments in the region. The approach considers and seeks to align both the “*market pull*” of bioscience industry development and the “*technology push*” of industry-facing research capabilities and competencies at the region’s anchor institutions to identify growth opportunities unique to the Greater Phoenix region.

The approach leverages and incorporates traditional industry targeting analysis—detailed examinations of trends and the sector’s competitive position in its size, relative concentration, and growth—yet it recognizes that this largely illuminates where the regional industry has been. Examinations of the recent past are useful, but not sufficient for understanding forward-looking growth opportunities. It is therefore essential to understand where the region has the capacity to grow and to leverage its comparative advantages by leveraging core research competencies and insights on industry innovation activities and investments. All of this must take a forward-looking perspective toward high-growth market opportunities. This approach to strategic alignment and targeting of high potential growth opportunities in the biosciences is shown in Figure 3.

6 Paula Stephan, *How Economics Shapes Science*, Harvard University Press, 2012, page 207.

Figure 3: Depiction of the Approach to Line-of-Sight Assessment



Areas where the Phoenix Region and the Phoenix Bioscience Core have real, differentiating potential.

The line-of-sight assessment examines and combines many measures to gauge the depth and breadth of capacities found in Greater Phoenix and the PBC across bioscience innovation that span academic research, technology development, major research centers and institutes, clinical excellence and thought leadership—organized under the technology push concept. In addition, it utilizes industry positioning and innovation indicators spanning detailed employment metrics, identification of leading companies, patent awards, venture capital investments in emerging companies, and other related measures—organized under the market pull concept (Figure 4).⁷

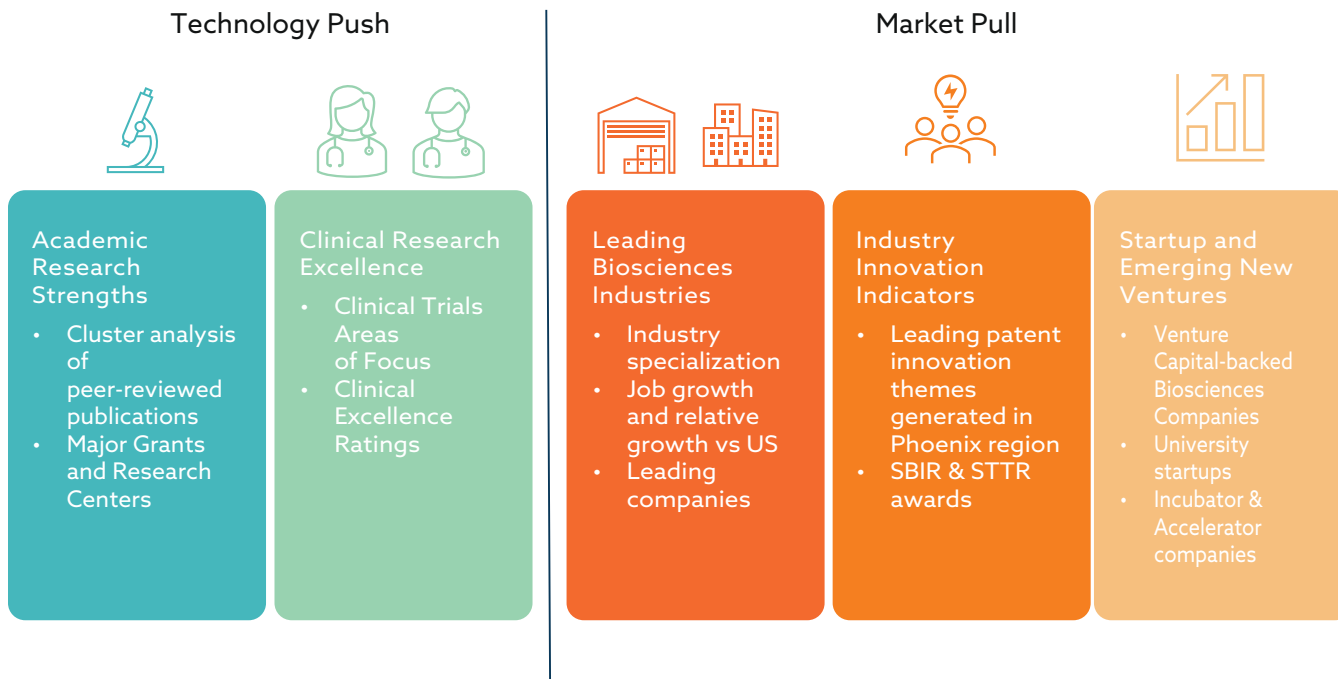
The line-of-sight assessment considered regional quantitative measures and trends over a 4- to 5-year period dating back to 2019 and included the assessment of robust activity across the Greater Phoenix bioscience ecosystem to include:

- More than 15,000 bio-related research publications with at least one Greater Phoenix author.
- Nearly 5,000 patent awards with at least one Greater Phoenix inventor.
- More than 2,500 active clinical trials with sites in the region.
- And many other industry and ecosystem related data inputs.

⁷ For a detailed discussion of the quantitative analyses and findings developed for this effort, see the separate Technical Appendix to this report.

This approach recognizes the unique dynamics of bioscience industry and ecosystem development, which requires deep and highly collaborative industry partnerships with university, academic medical center, and other biomedical institutions to advance and commercialize promising research and scientific breakthroughs.

Figure 4: Key Measures for Quantitative Line-of-Sight Assessment for Greater Phoenix Biosciences



Source: TEconomy Partners, LLC.

To capture ground truths and to understand the forward-looking investments and institutional partnerships driving the regional ecosystem, a qualitative component to the analysis is critical—namely, meeting with key leaders and stakeholders to vet and inform identified bioscience growth opportunities. The project and its findings have been informed and guided by a dedicated leadership Advisory Committee with representatives from Greater Phoenix research, industry, and economic development organizations.⁸ Altogether, more than 40 regional bioscience leaders and stakeholders were consulted to guide this effort.

These group and one-on-one discussions further yielded important strategic insights for ecosystem development, specifically where the region has strengths and opportunities to leverage for future growth, but importantly gaps and areas of weakness where attention is required to ensure a high-functioning innovation ecosystem for industry development.

8 The full roster of Advisory Committee members is included in the Appendix to this report.

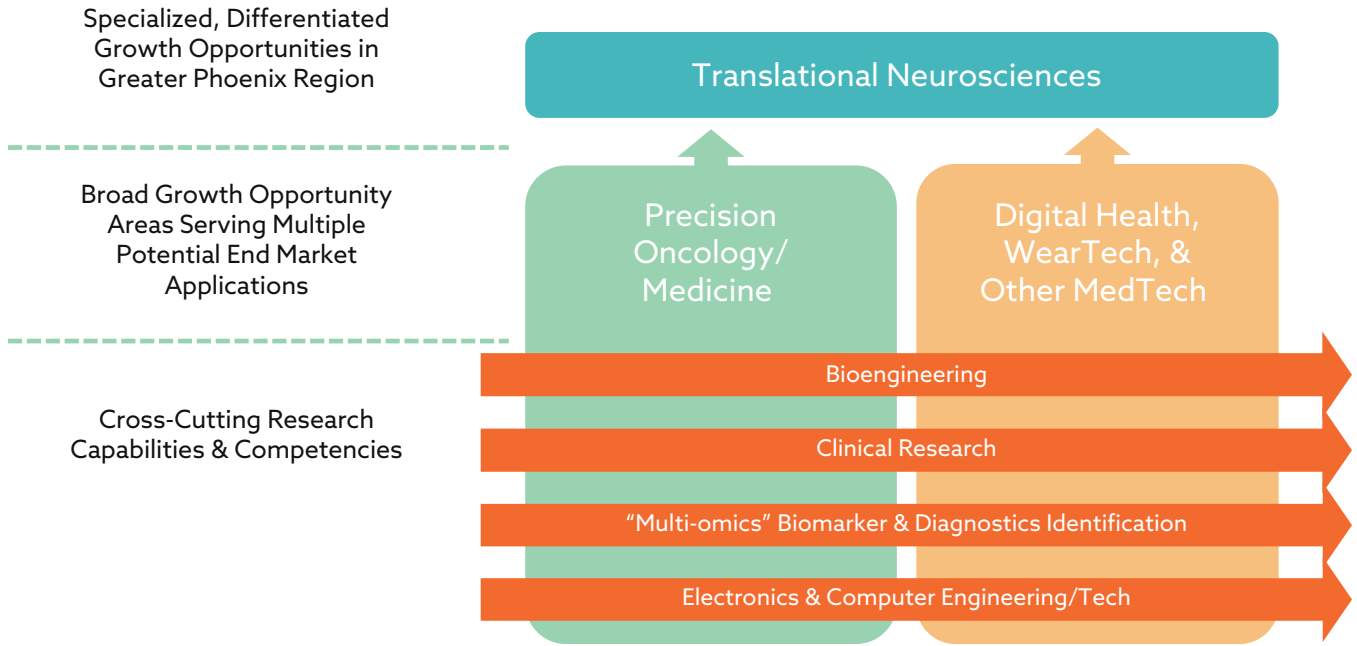
Three Growth Opportunities Identified for Greater Phoenix

Emerging from the line-of-sight assessment are three growth opportunities in the biosciences for the Greater Phoenix region. Depicted in Figure 5, these three areas demonstrate an alignment of the region's industry development with the research competencies found within and across regional anchor institutions, including those at the PBC. These three opportunity areas include:

- **Precision Oncology/Medicine**—represents an area of specific focus by Arizona over the past 20 years to leapfrog other more established states in bioscience development to be a leader in the emerging genomics revolution that is reshaping the practice of medicine. The Phoenix region has benefitted from substantial investments to possess a significant depth of research assets spanning multiple institutions that has led to a number of high-growth startups in molecular diagnostics able to attract out-of-state industry investment and position the Phoenix region as a fast-growing center for precision molecular diagnostic labs. Today, the industrial focus is primarily in oncology diagnostics markets and product innovations, but this area represents a legitimate opportunity to ultimately serve numerous end markets and disease areas.
- **Digital Health, WearTech, and Other MedTech**—represents a dynamic, rapidly emerging area in which the region is seeing strong startup and entrepreneurial activity as well as a cadre of existing, growing medical device companies amidst the broader trend toward the “digital transformation” of healthcare with the ongoing convergence of software, hardware, AI, and regional strengths in microelectronics and broader tech industry.
- **Translational Neurosciences**—represents a distinctive area of strength for the Phoenix region in biomedical research, clinical expertise and infrastructure, and translational research found across multiple institutions, with significant ongoing investments being made. This is a distinct and differentiated opportunity area for Greater Phoenix in which it stands out nationally and globally, but it is still an emerging one in industry development, with promising signs among emerging companies.

The graphic in Figure 5 places these in important context for the region. Today, the opportunities in precision medicine and in the digital transformation of healthcare are, in part, supporting the region's highly focused and specialized opportunity in translational neurosciences (discussed in the following section). Yet both of these opportunity areas represent competencies and foundational technology platforms from which a number of differentiated potential end markets can be served. So, for example, while in precision medicine in Greater Phoenix today, the initial and primary focus of industry has been in oncology, this represents a broad growth opportunity area in which to ultimately serve multiple end markets with innovations in diagnostics. In this important context, these two opportunity areas for Greater Phoenix are especially “evergreen.”

Figure 5: Overview of Three Growth Opportunities Identified for Greater Phoenix



Source: TEconomy Partners, LLC.

The following section presents an overview and profile of each opportunity area, summarizing how they align across the region's research and technology strengths and growing industry base, while also strongly connecting to the strengths and competencies of anchor institutions found at the PBC. Both market opportunities as well as specific recommended development opportunities to catalyze growth have been identified through both the quantitative analyses and via important input from regional leaders and stakeholders.

Precision Oncology and Medicine

What is the opportunity?

The Human Genome Project, launched in October 1990 and completed in April 2003, generated the first sequence of the human genome and heralded the genomics revolution that is reshaping the practice of medicine.⁹ Today, advancements in genomics are transforming medicine from being an inexact science of detection and treatment to one of prediction, prevention and strategic intervention or what is more popularly referred to as “precision” medicine. Rather than relying on a one-size-fits-all approach to treatment, precision medicine takes into account factors such as a patient’s genetics, environment, and lifestyle to deliver more targeted and effective care. This approach has the potential to revolutionize healthcare, providing patients with more precise diagnoses and treatments, reducing healthcare costs, and improving patient outcomes.¹⁰

One of the main applications of precision medicine already advancing in healthcare is the use of molecular diagnostic testing to diagnose and monitor disease, detect risk, and decide which therapies will work best for individual patients. These molecular diagnostics use a variety of techniques to analyze biological markers found in the DNA and RNA of patients based on tissue, blood and other biological samples that have clear, evidence-based association with specific diseases.

Today, molecular diagnostics represents both a large and fast-growing segment of the medical marketplace. For 2021, BCC Research estimated that the global market for molecular diagnostics reached \$17.6 billion and projected it would grow at a fast-paced compound annual growth rate of 19.3% to reach approximately \$42.6 billion by 2026. This makes molecular diagnostics one of the fastest growing segments of laboratory testing. The two largest areas of molecular diagnostics were for detecting infectious diseases, such as testing for COVID and flu, at \$7.3 billion in 2021 and for genetic profiling of a growing range of cancer tumor types, often used as a companion diagnostic based on bone marrow, blood and tissue samples to guide specific treatments for a patient, at \$4.2 billion in 2021.¹¹

As the University of Arizona’s Center for Applied Genetics and Genomic Medicine explains: “The field of molecular diagnostics has expanded rapidly since the sequencing of the human genome. Technological advances are now enabling physicians and scientists alike to identify genes and mutations underlying disease much faster and more accurately than we could in 2003, when we first decoded the genome. New and established companies are entering into this increasingly competitive field to diagnose human disease in ways that were never before possible. Now, physicians can order whole genome sequencing on a pediatric patient with an undiagnosed condition, sequencing drug metabolism genes to understand how their patients could respond to certain prescription medications, or use genetic data to guide cancer prevention strategies in high-risk patients.”¹²

Key market drivers for the growth of molecular diagnostics include the growing incidence of diseases, especially with aging populations found across the world, combined with sustained high levels of research

9 For more information on the Human Genome Project, see <https://www.genome.gov/human-genome-project>

10 Becatti and Cho, “Insights in Molecular Diagnostics and Therapeutics, 2022,” *Frontiers in Molecular Biosciences*, May 5, 2023, page 1

11 BCC Research, *Molecular Diagnostics: Technologies and Global Markets*, May 2022

12 See <https://precisionhealth.uahs.arizona.edu/molecular-diagnostics>

into the molecular basis of diseases. Additionally, there are significant pressures to contain rising health care expenditures and better target treatments using precision medicine.

But despite being a high-growth market, the competitive landscape for molecular diagnostics is challenging. BCC Research explains it is a highly fragmented and competitive market, characterized by the presence of many global, regional and local providers catering to the demands of specific patient pools suffering from chronic diseases. Success places a strong emphasis on novel product launches applying the latest in scientific advances, along with expanding into untapped disease areas and patient pools. So, companies face the challenge of high research costs for new product development along with the marketing costs to reach new pools of patients. There is also a growing focus on strategic collaborations by larger companies for product development and expansion into new markets for patients.¹³

In the U.S., there are also mounting regulatory challenges. Until a recent FDA ruling, molecular diagnostic tests have existed in a nebulous regulatory space, receiving "enforcement discretion" from the FDA, which meant the FDA took a light touch in regulating and mostly let them be. Instead, the Clinical Laboratory Improvement Amendments (CLIA) program administered by the Centers for Medicare and Medicaid Services certified tests for use. Importantly, however, CLIA only assessed a test's reproducibility, not its accuracy for detecting disease. This is now changing significantly with a May 6, 2024 ruling by the FDA that all future laboratory-developed tests (LDTs) will need to meet the same standards as medical devices. So new tests will have to prove accuracy for detecting underlying disease as well as track and report adverse events. The ruling will take effect July 5, 2024, but the new standard will be phased in over four years to give laboratories time to comply. Existing assays will be largely exempt, but it is expected they will comply to maintain a competitive edge. Over time, it is expected that this higher regulatory oversight will become the gold standard applied by other nations.¹⁴

Why Greater Phoenix and the PBC?

Arizona business, university and community leaders recognized the transformative potential of the genomics revolution in reshaping the practice of medicine in the early 2000s. These statewide leaders came together and intentionally focused on investing in raising the state's capacities in genomics and innovations in molecular diagnostics in the early 2000s, just as Arizona's Bioscience Roadmap was beginning as a means to leapfrog other states that had a long history of advancing the bioscience industry and enabling Arizona to become a national leader. Most notably, Arizona leaders secured support to attract the Translational Genomics Research Institute (TGen) and the International Genomics Consortium (IGC) to the Phoenix region.

Twenty years later this intentional strategy to invest in genomics and innovations in molecular diagnostics has paid off, with significant assets found across research and industry activities statewide, including in the Phoenix region. The initial thrust of these efforts has been in advancing cancer-related molecular diagnostics, but the Phoenix region is now well-positioned to serve broader disease area needs for innovations in molecular diagnostics.

¹³ BCC Research, op. cit.

¹⁴ See FDA ruling at <https://www.federalregister.gov/documents/2024/05/06/2024-08935/medical-devices-laboratory-developed-tests> and further explanation by a disease association at <https://www.alzforum.org/news/community-news/fda-will-regulate-diagnostic-tests-yes-those-alzheimers-too>

In technology push, there are now significantly more research centers beyond TGen and IGC. Here's a snapshot of the activities taking place across this growing base of research activities:

- **TGen** is now a well-established research organization in the use of advanced genomic technologies to unravel the genetic components of common and complex diseases, including cancer, neurological disorders, infectious disease and rare childhood disorders, and developing methods of early detection. TGen is now an affiliate of City of Hope and continues to serve as a Phoenix-based, nonprofit medical research institute led by its Collaborative Sequencing Center, offering whole genome, exome, and RNA sequencing—keeping pace with next-gen sequencing advances and Center for Translational Mass Spectrometry for biomarker identification to verification. In recent years, TGen has been advancing AI-enabled tools for optimizing clinical care with close collaboration with Dell's clinical precision medicine efforts. TGen also has an active commercialization effort and has been involved in numerous startups.
- **IGC** also remains active as a non-profit organization with proven capabilities in biospecimen repository services that has enabled it to be in the vanguard for bringing genomics to diagnostics and therapies (personalized medicine) through the building of large biorepositories with public databases housing the mechanisms that drive cancer, resources that are free of intellectual-property restriction and readily available to all scientists to accelerate the discoveries and entrance into the practice of medicine. In this regard, IGC played a key role in The Cancer Atlas Project supported by the National Cancer Institute. It has also led to the formation of a number of highly impactful molecular diagnostic startups.
- **ASU's Virginia G. Piper Center for Personalized Diagnostics** involves a multidisciplinary proteomics approach with focus on cancer, infectious diseases, autoimmune, spinal cord and wound healing injuries and Duchenne muscular dystrophy. The Center, part of ASU's Biodesign Institute, focuses on identifying predictive biomarkers and understanding the molecular underpinnings of human diseases and advancing new platform technology tools for detecting biomarkers using proteomics both for research and clinical applications. It applies high-throughput methods to detect genes targeted by messenger RNA that are enabled by one of the world's largest collection of full-length genes for humans and other model organisms and pathogens. Faculty affiliated with the Center are active in commercialization and have advanced several startups.
- **Mayo Clinic-Phoenix** has research centers that include the Clinical Immunology and Immunotherapeutics Program and the Epidemiology and Genetics of Lung Cancer Research. Among its leading NIH center grants are: an NIH Program Project Grant in Molecular Diagnosis, Prognosis and Therapeutic Targets in Lymphoma; an NIH Specialized Program of Research Excellence in Multiple Myeloma; and NIH Cooperative Center Grants for High-Throughput Immunoproteomics for Cancer Biomarker Discovery with ASU and Quantifying Multiscale Competitive Landscape of Clonal Diversity in Glioblastoma.
- **Phoenix VA, one of the largest sites for Million Veteran Program** with 30,000 consented patients, focuses on advancing personalized treatments that leverage electronic health records and genomic information.
- **Phoenix Children's Hospital Institute of Molecular Medicine Lab** is focused on pediatric cancers, including neuroblastomas.

- **UArizona's operations in Phoenix are advancing a new Center for Advanced Molecular and Immunological Therapies (CAMI)** focused on use of precision medicine for cell- and gene-based therapies.

Together, these research organizations are having a demonstrated impact in advancing the technology push capabilities for the Phoenix region in precision medicine. The topic modelling analysis of research publications with at least one Greater Phoenix author finds four topics areas aligned with genomics and molecular diagnostics, including:

- Specialized cancer diagnosis and treatment regimens
- Oncogenomics and diagnostic biomarker detection
- Metabolomics and proteomics
- Precision medicine applications in multiple non-cancer disease areas

At a high level, genomics and applications of molecular diagnostics for precision medicine as a unified theme emerges as a leading area in bioscience research publications in the Phoenix region, accounting for 5% of all regional research publications.

The emphasis on cancer found across research centers involved in advancing genomics and molecular diagnostics in the Phoenix region is also supported by a strong focus on cancer across clinical trials and clinical excellence in the region. Not only is cancer the leading area of clinical trials activities in the region, but there is also a strong emphasis on early-phase clinical trials for cancer. This reflects a focus on innovative, novel clinical trials for cancer and is supported by key assets, including a dedicated Phase I Clinical Trials facility at Honor Health's Virginia Piper Cancer Center and a unique brain tumor bank at BNI for Phase 0 trials on aggressive brain tumors.

Closely aligned with the technology push from the Phoenix region's research focus in precision medicine has been the rise of industry-led market pull assets in the Phoenix region. The Phoenix region today has a highly specialized and fast-growing base of industry base associated with precision medicine and the application of molecular diagnostics:

- In the Medical Lab Industry, Phoenix has 7,116 jobs with an 89% higher level of industry concentration than the nation and a 24% job growth rate from 2019 to 2022.
- In the In-Vitro Diagnostic Substance Manufacturing Industry, Phoenix has 1,085 jobs, and stands at more than double the national level of industry concentration. In the 2019-2022 period, this industry grew by an impressive 106% in its employment base.

Additionally, this is an active area of patent innovation for the Phoenix region across industry and research institutions. Two of 11 key themes from a cluster analysis of the region's bioscience patents since 2019 are in novel biomarker detection and diagnostics, with a focus on oncology and immunology, and in targeting drug delivery of cancer immunotherapies.

Of the three major molecular diagnostics companies found in the Phoenix region, two involved acquisitions of startups from Phoenix's research organizations:

- Caris Life Sciences—then known as Caris Diagnostics—came to the Phoenix region in 2007 after acquiring Molecular Profiling Institute, a spin-off from TGen and IGC that brought the first commercial test for gene expression into cancer. Caris has continued to focus on measuring protein aberrations to enable early cancer detection assays, discover novel drug targets and characterize protein differences in each patient’s tumor. Its most recent product advancements include developing a proprietary AI platform, with AI algorithms trained on more than a decade of patient profiling data, to improve predictions of patient responses to cancer treatments, such as immunotherapy or chemotherapy, based on their personalized molecular profile. The company is also working towards advancing more universal diagnostic profiling tools encompassing a broad range of diseases. While headquartered in Dallas, Phoenix remains an important and growing location for the company, including all of its laboratories for clinical testing and research and development.
- Exact Sciences acquired two IGC startups involved in cancer diagnostics. One is Paradigm Diagnostics, Inc. that offered a comprehensive genomic profiling test for patients with advanced, refractory, or recurrent cancer, allowing physicians to better understand a patient’s tumor profile and more effectively recommend targeted therapies or clinical trials. The other was Viomics, Inc., which provides extensive sequencing capabilities and expertise in identifying unique biomarkers that indicate the presence of cancer in solid tissue and blood. Together, these two startups provided Exact Sciences a differentiated late-stage therapy selection test and deep competencies in sequencing and biomarker discovery, extending Exact Sciences’s lab testing and research and development capabilities. While having many locations across the nation, Exact Sciences is expanding its clinical testing laboratories in the Phoenix region near the airport.

The fact that both Caris Life Sciences and Exact Sciences not only remained in the Phoenix region after acquiring local startups, but are continuing to expand in the Phoenix region, reflects the region’s competitiveness as a location for the molecular diagnostics industry.

A third molecular diagnostics company operating in the Phoenix region is Castle Biosciences, a Houston-headquartered company whose primary laboratory operations and research and development center are based in Phoenix. Castle principally is focused on proprietary laboratory-developed tests for cancer-related diagnostics. In 2020, Castle doubled its laboratory operations in the Phoenix region.

More generally, over the years molecular diagnostics has been an active area of new startup activity in the Phoenix region. The successful startups of Molecular Profiling Institute, Paradigm Diagnostics and Viomics led to Caris and Exact Sciences operations in the Phoenix region; an additional 16 molecular diagnostics startups were identified as having received venture capital funding or SBIR awards over the 2019-2023 period.

Figure 6: Summary of Technology Push and Market Pull Associated with Precision Oncology and Medicine

Summary of Technology Push: Greater Phoenix Industry-Facing Core Research Competencies

Research Publication Themes:

- Specialized cancer diagnosis/treatment regimens
- Oncogenomics and diagnostic biomarker detection
- Metabolomics & Proteomics
- Precision medicine applications in multiple other therapeutic areas

Major Grants & Research Centers:

- TGen's advanced genomic technologies
- Mayo Clinic-Phoenix - numerous major NIH center-related grants, research centers
- ASU's Virginia G. Piper Center for Personalized Diagnostics
- UArizona advancing CAMI
- International Genomics Consortium
- Phoenix VA—Million Veteran Program
- Phoenix Children's Hospital Institute of Molecular Medicine Lab

Clinical Research Excellence:

- Cancer a leading area of clinical trials activity, with 1,416 active trials, nearly 30% in early phase clinical trials, reflecting a focus on innovation
- Clinical excellence:
 - Mayo Clinic-Phoenix, ranked 24th nationally in Cancer Care
 - High-performing cancer subspecialty rankings: Banner (Boswell, Gateway, University) and St. Joseph's

Summary of Market Pull: Demand Drivers of Greater Phoenix Bioscience Industry and Associated Innovation Activities

Industry Position & Assets

- Industry strengths in Medical Labs, In-Vitro Diagnostic Substance Manufacturing—high specialization, outpacing nation
- Several leading, growing molecular diagnostics companies with focus on personalized cancer diagnostics:
 - Caris Life Sciences
 - Castle Biosciences
 - Exact Sciences

Market Opportunities for Greater Phoenix and the PBC

The ongoing regional activities in precision oncology/medicine are now well-grounded through molecular diagnostics as a proven growth opportunity for the Phoenix region. There are several features that stand out for the Phoenix region's continued growth in molecular diagnostics, including:

- **A primary focus today in cancer diagnostics.** As one of the leading disease areas for molecular diagnostics, Phoenix is well-positioned to continue to grow its industry base given its strong activities in cancer diagnostics across its established company base and ongoing scientific and clinical research activities.
- **Phoenix is well-positioned to become a leading region in “centralized laboratory operations” for molecular diagnostics.** Molecular diagnostics is one of the fastest growing segments of medical laboratory activities. Many molecular diagnostics tests require centralized labs to process and analyze the biospecimens collected. As demonstrated by the continued growth of lab activities by leading molecular diagnostics companies in Phoenix, the region's ability to handle logistics through its airport and its lower cost of doing business combined with its access to a base of scientific and technical talent makes it a very competitive location.
- **Focus on innovations in molecular diagnostics.** The many research centers and companies in Phoenix focusing on emerging “platform” technologies for advancing molecular diagnostics, together with the convergence with data sciences, especially AI tools and engineering, positions the Phoenix region to continue to be an active player for innovations in molecular diagnostics, including leading to a steady base of new startups.

Situational Assessment and Development Actions to Catalyze Growth

Regional leaders and stakeholders have offered a robust situational assessment and suggested targeted development actions to catalyze growth in the precision oncology/medicine growth opportunity.

Situational Assessment from Stakeholders

Phoenix regional leaders and stakeholders in precision medicine offered key strengths and challenges facing the region:

Strengths:

- **Growing base of researchers in Precision Medicine**—Major research activities found at TGen, ASU and Mayo Clinic that are linking genomics expertise with data sciences (AI/ML) and engineering provide the region with scientific talent and ideas to help sustain existing companies, create new startups and attract outside industry investment and collaborations.
- **Growing base of existing precision diagnostics companies in the region**—many of whom came to the region based on acquiring a precision diagnostics startup and have continued to expand upon that footprint.
- **Sustained pipeline for future startups in molecular diagnostics**—The active commercialization efforts across research centers promise an ongoing pipeline of 3 to 5 startups of precision medicine focused molecular diagnostics companies each year across a diverse base of activities from new clinical

applications of precision medicine, point-of-care diagnostics, next-gen sequencing applications, and whole-exome testing using both tissue and blood-based analogues.

- **Rise of innovative talent generation programs for precision medicine and molecular diagnostics in collaboration with industry**—Stakeholders noted that ASU is a strong partner in working with Phoenix-based molecular diagnostics companies to address their talent needs, including:
 - ASU Molecular & Cellular Biology Ph.D. program is collaborating with industry to prepare students for industry team-based science.
 - ASU College of Health Solutions M.S. program in biomedical diagnostics is a one year program for gaining insights into a growing industry that is at the center of health care innovation and personalized medicine.

Challenges:

- **Lack of robust life science venture investment community for precision medicine and molecular diagnostics**—Phoenix remains a fly-over region for bioscience venture capital investment. This requires Phoenix diagnostics startups to rely upon “strategic investors” such as instrument suppliers, customers, technology providers, and drug companies to raise needed capital. It also means that they need to seek exits more quickly than if they had access to later stage rounds of venture capital.
- **Lack of deep knowledge of regulatory and reimbursement issues relating to molecular diagnostics**—There is a concern that the Phoenix region is missing the talent base of regulatory science expertise that is needed to keep pace with FDA’s new requirements for molecular diagnostics. This translates into few mentors to help startups address key issues such as reimbursement and developing “quality of evidence,” which are critical business issues facing the molecular diagnostics industry.
- **Region’s struggle to keep pace in generation of well-trained bioscience workforce**—Despite having innovative, collaborative university-based talent programs, the Phoenix region is not generating sufficient numbers of technicians as well as Ph.D. and master’s level graduates to meet the needs of existing precision diagnostics companies. This requires companies to have to bear the costs of relocation to attract the needed workforce.
- **Lack of lab-ready spaces in the Phoenix region**—Molecular diagnostics companies require higher-cost wet lab facilities both for their centralized medical labs to process biospecimens and their research and development activities. Given that the Phoenix region does not have the legacy as a major biopharmaceutical hub, Phoenix has few lab-ready facilities, and so companies must fully bear the higher costs of building out their own wet lab spaces.
- **Mixed views on the ability of the region to tap local hospitals for biospecimen bank development**—The advancement of innovations in precision medicine and molecular diagnostics requires having

access to biospecimen banks for development, testing and validation. In the past, the Phoenix region was able to meet the needs for NIH's Cancer Genome Atlas Program, but in more recent years this did not work as well for the NIH SeroNet effort. It seems that overall capacity is available only on-demand to meet specific research projects that can support coordinators.

Recommended Development Actions by Stakeholders:

- **Promote Phoenix as a place for locating diagnostic/biological centralized labs**—Today, the business development efforts to recruit businesses to Phoenix do not have a focus on targeting the centralized labs of molecular diagnostics companies, despite the region's proven competitiveness as a location for molecular diagnostic labs. A campaign that features how existing companies have grown in the region, together with featuring the region's competitive advantages, would seem to make very good sense for business development efforts for the region.
- **Create a statewide testing/demonstration network among healthcare systems for precision medicine diagnostics**—This would involve a systematic approach for working with healthcare systems across Arizona to advance in a timely fashion needed biospecimens across the diverse populations found in Arizona, which could then be applied for developing novel molecular diagnostics and for the testing and validation needed to address quality of evidence for regulatory approval and reimbursement. Such a statewide capacity for meeting research and development needs for biospecimens could also attract larger clinical studies to maintain diagnostic banking and testing infrastructure.
- **Advance more regulatory affairs training and education opportunities**—This would address a key challenge for the Phoenix region, and could include workshops, mentoring or more formal education offerings, such as a Ph.D. in regulatory science like found at the University of Southern California (see <https://mann.usc.edu/program/doctorate-in-regulatory-science/>).
- **Promote innovation and industry networking to drive future opportunities for commercializing innovations in molecular diagnostics, promoting industry-research center partnerships and talent generation/attraction/retention.** Of particular value would be creating a research-industry network focused on tapping the expertise of universities and non-profit research organizations on basic research questions, such as how to use AI for advancing diagnostic testing and digital pathology, as well as peer networks of CEOs to create more strategic collaborations on common issues, such as talent generation and attraction, as well as to offer peer CEO counseling to emerging ventures.

Digital Health, WearTech, and Other MedTech

What is the opportunity?

Digital health innovations and integration hold tremendous promise for addressing some of healthcare's most significant and intractable global challenges. These challenges include record-high costs, sizable workforce shortages, significant inequities in care, and ever-growing demand amidst increasing incidence of chronic disease. Yet, despite widespread integration and massive multi-billion dollar investments, the World Economic Forum finds that digital health "has yet to deliver on its promise," and that healthcare systems remain "extraordinarily complex and fragmented."¹⁵ The healthcare sector is leveraging powerful digital tools but often implementing "point solutions" which address a specific aspect of an overall patient experience, but not the seamless or end-to-end transformation long envisioned.¹⁶ It is clear that while well underway, there is progress to be made and innovative solutions to be more fully leveraged in this digital transformation.

Greater Phoenix is well positioned to make a significant contribution to this global demand for innovative digital integration and the transformation of healthcare. The region's strengths as a leading hub for healthcare, biosciences, and microelectronics manufacturing are converging around distinct growth opportunities in Digital Health, WearTech, and other MedTech and are supported by key assets and expertise that span both the regional research and industry base. Greater Phoenix has an exciting opportunity to contribute to solving global challenges in healthcare via digital innovations.

Medical treatments and the delivery of healthcare are being transformed through the ongoing integration of a wide range of digital technologies, driven by innovations aimed at enhancing the efficiency, accessibility, and quality of care. This spans a broad and impressive array of innovations, including implementing and leveraging electronic health records (EHRs), mobile health (mHealth) applications, AI-enabled personalized treatment planning, robotic surgery and process automation, 3D modelling and printing for medical devices, clinical decision support and predictive patient risk management, wearable biosensors and remote patient monitoring, and much more. Digital tools and MedTech breakthroughs enable healthcare providers to offer more precise, timely, and personalized care to patients.

The market for digital health technologies and applications is significant and growing rapidly on a global scale. BCC Research recently forecast the global market for digital health technologies to grow by a compound annual growth rate of 17% to reach \$385 billion by 2026, with the largest share of the market in North America.¹⁷ This market forecast defines digital health technologies to span digital health systems (EHRs, E-prescribing), mHealth applications including wearables, tele-healthcare including remote monitoring, and health analytics.

The high-growth market for digital health technologies is being driven by a number of factors on a global scale.¹⁸ Key factors driving demand include the prevalence and increased incidence of chronic diseases globally related to aging populations, greater longevity of those living with chronic conditions, unhealthy lifestyles and diets, and lack of physical activity. Consumer demand and expectations for a

¹⁵ World Economic Forum and Boston Consulting Group, "How to ensure digital transformation in healthcare reaches its potential," January 2024.

¹⁶ Ibid.

¹⁷ BCC Research, "Global Market for Digital Health Technologies," December 2021.

¹⁸ Ibid.

single, integrated healthcare experience with respect to their individual EHR, payment, scheduling, and messaging portal are driving requirements for technology integration by healthcare providers. Advances in cognitive computing, using computerized models to simulate human thought and to leverage near instantaneous processing of enormous amounts of data to answer specific questions and to make recommendations for care, represent the opportunity to leverage the digitization occurring today to further improve care efficiency and quality.

While no one region or institution has the capacity to address all of these digital technologies and associated innovations at the scale required for global healthcare markets, this research effort finds Greater Phoenix has distinct strengths and niches to contribute important and meaningful solutions in the ongoing digital transformation of healthcare. Specifically, these niches for the region include:

- **Digital Health**, also often referred to as HealthTech, encompasses technology-enabled healthcare products and services such as mobile health, health information technology, wearable devices, telehealth, population health management, and other technologies noted above.
- **WearTech** includes wearable electronic devices and software to collect data on and monitor biometric indicators such as weight, heart rate, and more.
- **MedTech**, also referred to as medical technology, includes the use in therapeutic care settings of technologies, devices, equipment, and health information systems enabling disease detection and monitoring, more effective treatments, and less invasive medical procedures.

Why Greater Phoenix?

The Greater Phoenix region has distinctive research, clinical, and industrial strengths and assets that are converging around the digital transformation of healthcare—summarized in Figure 7.

Regional researchers are advancing a strong focus on WearTech, MedTech, and other medical device innovations, with sizable clusters of research publication activities focused in neurostimulation and other neurosciences, cardiovascular interventions, rehabilitation, and implantable devices. This is reflective of a region with combined research strengths and competencies in bioengineering and in electronics and computer engineering, primarily at ASU. In particular, ASU has numerous grants related to WearTech, devices and implants, robot-aided rehabilitation, and other related areas. Recognizing both significant research activity and translational opportunities, ASU and regional partners have launched the **WearTech Applied Research Center** (see callout below).

The medical device and equipment sector in Greater Phoenix has grown by an impressive 28% since 2019, four times the growth seen nationally (7%), and it stands at nearly 6,000 jobs today across the metro region.

At the same time, regional research and economic development leaders are seeing an overall **industry “resurgence” in MedTech and medical device manufacturing**, particularly in connection with the use of microelectronics, given the major investments taking place in the region around semiconductors. The overall medical device and equipment sector has grown by an impressive 28% since 2019, four times the

growth seen nationally, and stands at nearly 6,000 jobs today across the Phoenix region. In addition to large, well-established regional medical device companies operating in the region, such as BD, Medtronic, and WL Gore, a strong cadre of emerging Greater Phoenix MedTech and device companies are seeing significant levels of VC investment, with an outsized 25% share of all funding to regional bioscience companies occurring in this space since 2019 and totaling \$188 million over the 5-year period to 2023. Examples of VC-backed companies receiving later stage venture capital investments include GT Medical Technologies, Nectero Medical, and Verve Medical.

There are key assets and initiatives advancing MedTech applied research and business formation and acceleration in Greater Phoenix, including:

- **The Mayo Clinic and ASU Alliance for Health Care, an ongoing collaboration between the two leaders in research, education, and innovation, has established the MedTech Accelerator** in Greater Phoenix to advance early-stage medical device and health care technology companies. The Accelerator leverages the institutional expertise and networks of the two institutions and provides an entrepreneurial curriculum and personalized business development planning to advance and accelerate these promising companies. The program utilizes subject-matter experts and mentors to develop strategies and to connect throughout the Phoenix ecosystem across business, research, and clinical areas. Accelerator companies are developing technologies spanning software, AI, neuro-related sensing, diagnostics, and regenerative medicine, to name some prevalent themes, and are able to license Mayo Clinic intellectual property. Mayo Ventures often invests in Accelerator companies and the firms have combined to raise significant follow-on funding. More than 30 companies from around the world have participated in the Accelerator program, and some have established a local presence in the region following its completion.
- **Phoenix Children’s Hospital is collaborating with ASU’s Image Processing Applications Laboratory to operate the Cardiac 3D Print Lab.** The Lab produces patient-specific 3D printed models resulting in an accurate representation of an individual patient’s anatomy that can be used for surgical planning, medical education, and family consults. To-date the Lab has collaborated with more than 15 institutions across six countries, including with UArizona College of Medicine, using heart models for teaching future doctors and surgeons. The Lab has developed models for numerous organs and body parts including brains and blood vessels, as well as medical devices.
- **A strong, active base of device-related clinical trials and innovation is ongoing in the region,** with 316 studies active or recruiting across regional hospitals and health systems. Among these is a significant base of trials led by regional research institutions as principal investigators or key collaborators—more than one in ten. This is reflective, in part, of regional institutions’ strong ratings of clinical excellence in MedTech-related areas including rehabilitation, orthopedics, and cardiology. Interview discussions with healthcare systems leadership corroborates these activities, with a strong focus and recognized importance of advancing MedTech and digital health innovations across the region.

Translating Applied Research into Innovative Companies and Products: The WearTech Applied Research Center

Recognizing the applied research strengths and associated commercial opportunities with respect to wearable health and performance solutions, ASU has partnered with the Partnership for Economic Innovation (PEI) to establish the WearTech Applied Research Center in Midtown Phoenix. Located at the Park Central Phoenix biomedical hub and launched in 2019, the Center provides an engineering lab and community space “for innovation teams bringing disruptive IP to life.” While not a formal accelerator program, the WearTech Center aims to address gaps in translational dynamics—in particular for funding—for early-stage companies with a pilot product and university collaboration, but not quite ready for full commercialization or formal VC funding. In addition, the Center works with large, established regional MedTech companies advancing specific innovation projects in the wearables space.

Once a WearTech project has been accepted into the program, the Center provides assistance at the research, prototyping, and validation stages, assembling teams and providing access to resources and strategic partnerships with a focus on commercialization outcomes. This assistance can include connecting companies to clinical validation assets.

According to WearTech leadership, the overall scale and quality of projects continue to grow and the Center is engaging additional universities as collaborative partners beyond ASU, including UArizona and GCU. The latest cohort of projects included approximately 20 that have seen \$1.6 million awarded in funding. Research funding is matched one-to-one by the Arizona Commerce Authority (ACA). Five projects from the ARC are now on the market.

While **Digital Health** is harder to delineate from an industry classification perspective, and therefore challenging to quantify as its own distinct sector, Greater Phoenix is seeing strong, outsized investments in emerging innovative companies in the space. In fact, nearly one in three dollars invested in regional bioscience companies by VC firms since 2019 have been in digital health. The cumulative investment in Greater Phoenix digital health companies has totaled \$240 million from 2019 through 2023. Examples of VC-backed Digital Health companies receiving later stage venture capital funding include AdviNow, eVisit, evolvedMD, Safe Health Systems, and Salucro Healthcare Solutions.

- **Phoenix Children's recently launched a partnership with Coplex**, a leading venture studio, with the goal of forming six new digital health startups over their first three years. The partnership is intended to leverage Phoenix Children's long-recognized expertise in developing digital health and data innovations, including creation of data tools for managing complex care, predictive algorithms that advance treatment, and unique tools that enhance the patient and family experience in a hospital setting.
- **ASU's Health Entrepreneurship Accelerator Lab (HEALab)** is an interdisciplinary initiative between Entrepreneurship and Innovation, Edson College of Nursing and Health Innovation, College of Health Solutions, and New College of Interdisciplinary Arts and Sciences, with a co-working space on the Downtown Phoenix campus and additional programming on the West campus and ASU Online, with a mission to provide an array of resources for innovators who are interested in bringing their health-related business ventures to market.

Figure 7: Summary of Technology Push and Market Pull Associated with Digital Health, WearTech, and Other MedTech

Summary of Technology Push: Greater Phoenix Industry-Facing Core Research Competencies

Research Publication Themes:

- Device-focused clusters of research:
 - Neurostimulation devices
 - Cardiovascular devices
 - Rehab—adaptive gait, balance
 - Implantable devices

Major Grants & Research Centers:

- Numerous NSF Grants involving ASU in WearTech, Devices & Implants, Robot-aided Rehab, etc.
- Cardiac 3D Print Lab at Phoenix Children's Hospital
- Simulation Lab at St. Joseph's Hospital and Medical Center

Clinical Research Excellence:

- Active base of device-related trials:
 - 316 active or recruiting studies
 - 36 by Phoenix research institutions as PIs or key collaborators.
- Numerous hospitals highly rated in key MedTech fields (Rehabilitation, Orthopedics, Cardiology)
- Discussions with healthcare systems raise importance of MedTech and Digital Health innovations taking place in the region.

Summary of Market Pull: Demand Drivers of Greater Phoenix Bioscience Industry and Associated Innovation Activities

Medical Devices & Equipment at nearly 6,000 jobs, has grown 28% since 2019 vs. 7% national growth.

- Outsized shares of regional bio-related VC investments since 2019:
 - Medical Devices 25% (\$188M)
 - Digital Health 32% (\$240M)
- Significant Incubator, Accelerator, Applied Research Assets:
 - Mayo Clinic's MedTech Accelerator
 - WearTech Applied Research Center
 - HonorHealth Research Institute's new Center of Innovation and Innovation Fund
 - Phoenix Children's partnership with Coplex (Venture Studio) to launch new digital health startups
 - ASU Health Entrepreneur Accelerator Lab

Market Opportunities for Greater Phoenix and the PBC

The ongoing regional development activities in the digital transformation of healthcare, driven significantly by the industrial “market pull” in the region, are already serving as a growth opportunity in the three key areas outlined here.

- **Digital health companies are taking multiple forms in Greater Phoenix**, all relevant to growth markets in the broader context of healthcare and biomedical innovations and enhancement of health services delivery to patients. A cadre of VC-backed software-as-a-service tools in service of innovative clinical health services, patient engagement, and healthcare management for processing claims, handling billing, etc. is taking form across the Phoenix region.

Digital health companies in the region are seeing strong convergence with technology advancement across AI and Machine Learning, data exchange and storage tools, and remote data capture tools and therefore it is critical to maintain and enable collaborative partnerships between the regional tech and electronics community and those advancing digital applications specific to healthcare and biomedical markets.

- **WearTech innovations** are diverse, though the WearTech Applied Research Center is seeing some thematic focus around neuro-related wearables and sensing related to concussion detection, fall prediction, diagnostics, and others that are leveraging AI analytics platforms. In addition, the Center is seeing product and technology development in exoskeletons, including for enhancing worker capabilities, as well as worker safety devices. It should be expected that applications in wearables and WearTech will be diverse, ultimately leveraging regional strengths not only in bioengineering, but in broader digital health, given that these WearTech innovations involve cyber-physical systems requiring cloud-based software tools and database solutions.
- **Neuro-Related MedTech** is a growth area for the region that leverages the strengths profiled herein, but also the region’s deep strengths and expertise in translational neurosciences, representing its own distinctive growth opportunity for Greater Phoenix. Regional innovations are advancing out of biomedical research institutions and universities in neuro-surgical devices and tools, neuro-imaging tools, neuro-modulation, deep-brain stimulation devices, and implantable devices. This opportunity is well aligned with Phoenix’s position as a national leader in neurosciences research and clinical excellence.

Situational Assessment and Development Actions to Catalyze Growth

Regional leaders and stakeholders have provided key insights on the situational assessment and suggested development actions to catalyze growth in the opportunities around the digital transformation of healthcare.

Situational Assessment from Stakeholders

Strengths:

- **The region's broader tech-industry strengths offer the high-quality technical talent needed for advancing digital health and MedTech innovation.** Leaders cite the existing base of IT companies and tech professionals across the region as a key asset. At the same time, they point to the close proximity of sizable cohorts of quality talent in biomedical engineering at ASU and note that GCU is on the rise in engineering and software engineering talent development. In addition, stakeholders point to the soon-to-be presence of three state medical schools with a strong presence in the region as well as existing research assets advancing and recruiting in talent in the biomedical, digital, and engineering fields. In addition, regional bioscience leaders consistently highlight the relative ease with which companies are able to recruit in and hire talent from outside of the region, citing the great climate and helpful business and government community.
- **Innovative startups are emerging from regional research institutions and health systems,** either directly or in a collaborative capacity and serving as a strong base from which to grow the entrepreneurial ecosystem as research is translated and commercialized. These include companies emerging from BNI in neuro-related MedTech, from Mayo Clinic and ASU and their accelerator and applied research center activities, and others.
- **Active efforts are underway to expand and leverage patient data to drive innovative health solutions** including those related to population health solutions. These include efforts of Contexture, a health information exchange—representing the largest HIE organization in the Western U.S.—focused on adding data elements to develop intelligence on social determinants of health, and now forming a regional HIE with Colorado. In addition, the Phoenix VA is an active site for the Million Veteran Program, leveraging the VA's EHR system with the third-largest cohort in the nation, with 30,000 consented veterans.

Challenges:

- **Stakeholders report a lack of industry connectivity, including the lack of an industry networking organization to bring the community together, as a key challenge for ecosystem enhancement and development.** Regional MedTech and digital health companies are dispersed geographically, spanning Phoenix, Tempe, Mesa, Chandler, and other communities, creating a dynamic where many companies and corporate leaders are unaware of each other and making it difficult to leverage the benefits of industry clustering.
- **Challenge of engaging with the region's largest MedTech companies.** Several of the largest MedTech companies with a presence in the region are not headquartered in Greater Phoenix and therefore represent branch plant operations without key decision-makers for corporate innovation and partnerships located in the region. This makes it a challenge to engage and leverage these companies

in regional economic development initiatives, for example, collaborating with emerging MedTech ventures or participating in statewide and regional innovation initiatives.

- **Emerging regional digital health companies find healthcare systems are open to collaborating with them on developing and piloting innovations, but then find it is difficult to get them to purchase solutions as “first customers.”** This creates a dynamic where companies face the challenge of having to go outside of the region for their first healthcare customers and makes the Phoenix region less attractive as a place to scale their emerging businesses.
- **Digital health leaders find Phoenix is at times limited or still emerging in its entrepreneurial ecosystem maturity and resources, particularly in access to capital.** While Angel investing is available and happening, there exists a key gap for pre-revenue startups in accessing seed and Series A investments in the \$1 to \$5 million range. A concern is voiced that often those emerging regional companies with a strong idea and capitalization are pulled out of the region for their next funding round.
- **Advancement of population health innovations and collaborations with emerging digital health startups is held back in Arizona.** Currently, the ability to use HIE data in Arizona collected by Contexture to advance digital health innovations for population health applications, particularly to train AI models using machine learning approaches, is limited and would require legislation to enable its use—unlike approaches in other states and regions.

Recommended Development Actions by Stakeholders

Regional leaders and stakeholders were asked to share ideas and thoughts about addressing the challenges raised and to seize opportunities for advancing this growth opportunity area.

In Digital Health and WearTech:

- **Launch proactive and value-added industry networking activities and events** to build awareness and connect industry leaders with others across the regional industry, including economic development, academic, place-making and other leadership and ongoing initiatives. Phoenix would benefit from having a J Labs type innovation collaboration center given the growing convergence of Digital Health with MedTech via AI and data analysis, software engineering, imaging and sensing technologies, etc. A unique aspect for the Phoenix region would be bringing together semiconductor companies—most notably Intel and TSMC—with life sciences around innovations in diagnostics that involve developing novel chips for biosensing, molecular profiling and other applications.
- **Establish a First Customer Program for health innovations** to address procurement challenges of emerging digital health companies and to ensure a more complete and robust ecosystem for growing the sector. First customer programs are highly valuable for small innovative companies to increase their chances of success with respect to market validation, providing feedback and improving the product or service, demonstrating proof of concept, building credibility in the market, generating revenues, and attracting investors.
- **Enhance and broaden the resources and programming of the WearTech Applied Research Center by implementing accelerator-type wraparound services.** Today the WearTech Center is advancing

innovation, making clinical connections, and providing some limited, early access to capital for promising research and other valued services, but the Center is not providing a full suite of traditional business acceleration services, such as deep mentorship and coaching from experienced entrepreneurs, office space and essential business resources (administrative, legal, etc.), facilitating customer engagement, proof-of-concept funding, etc.

- **Seek legislation and develop testbed capabilities to use Arizona's Health Information Exchange for innovation and research purposes.** A key initiative for the region and the State of Arizona going forward is to unlock the value of its HIE data to fuel population health innovations and collaborations with digital health companies and the state's healthcare systems. This requires allowing Contexture to make available its population health databases to advance the commercialization of new digital health tools and to establish collaborative approaches that engage health entrepreneurs and innovation-focused health companies to address needs for population health solutions by the state's healthcare systems. This effort should emphasize offering testbeds and co-location spaces that can further attract and retain digital health entrepreneurs to the state and the Phoenix region.

In MedTech:

- **Address need for small-batch manufacturing capability for early-stage MedTech companies and for specialty device manufacturing.** These capabilities are key for agile, efficient product development and commercialization, particularly for cost-effective market testing and validation and mitigating risk associated with larger-batch production commitments. Small-batch production allows emerging companies to produce needed units for clinical trials, regulatory submissions, and early market introduction without committing to full-scale production before receiving necessary approvals. Further, high-quality small-batch production provides a foundation for scaling up and can demonstrate to investors the ability to do so.
- **Recruit in or establish regional Medical Device Design Houses.** Stakeholders indicate there is a gap in regional capabilities for MedTech device production, going out of the region to access design houses—firms that focus on the development and design of medical devices, providing a range of key services to go from initial idea or concept to market-ready products.
- **Address a regional gap in MedTech entrepreneurial education and programming.** Best practices in advancing MedTech entrepreneurship at colleges and universities tend to “co-mingle” three key areas of expertise among medical students, engineering students, and business/MBA students. Stakeholders indicate this is not occurring at regional universities but has been impactful at other institutions with a focus on MedTech entrepreneurship, such as the University of California at Irvine.
- **Deepen regional engagement and touchpoints for medical device and MedTech companies that are attracted to regional programs such as the Mayo Clinic-ASU MedTech Accelerator.** Today, these companies are spending time in the region to advance innovation, but few are remaining here to establish an operational footprint. Ensure the region is demonstrating the full value of a Phoenix-based MedTech ecosystem for attraction/recruitment.

Translational Neuroscience

What is the opportunity?

Neurological disorders are placing a tremendous strain on societies worldwide. Recent research finds that brain disorders represent the second-leading cause of death behind only heart disease, and they represent the leading cause of disability globally—and the prevalence of these disorders has increased rapidly in recent decades.¹⁹ Despite these sobering trends, Deloitte reports that in the latter half of the 20th century, innovations in neuroscience “essentially stalled,” with few new drugs reaching the market in the last four decades.²⁰ In addition, many therapeutics in the market today often only slow disease progressions, not recover lost brain function. Treatments are limited by our limited understanding of the biological foundations of brain disorders and a lack of early-stage diagnostics to detect disease before it progresses to advanced stages. Clearly, advancing both basic, foundational neuroscience research and its translation into new treatments and interventions is critical for global health and well-being.

Translational neuroscience is focused on bridging the gap between basic neuroscience research and applications and treatments in the clinic. It requires the translation of research findings and insights into diagnostics, devices, treatments, and prevention for neurological and psychiatric diseases and disorders, with the ultimate goal of improving the understanding of the brain and developing treatments to address symptoms, to improve the quality of life of patients, and to arrive at cures.

The fast-rising and global nature of neurological disorders has made research and the market for effective diagnosis and treatments a leading priority in the biosciences. Deloitte estimates that the global market for neurosciences, inclusive of diagnostics solutions, drug therapies, and non-drug therapies (e.g., behavioral and digital health) reached \$612 billion in 2022 and is expected to increase to nearly \$721 billion by 2026, with over half of revenues generated in North America.²¹ While the projected compound annual growth rate is modest overall (4.2%), the components vary; for example, digital health interventions in neuropsychiatry (28% CAGR) and the molecular diagnostics areas (18% CAGR) are expected to see a much faster growth rates compared to lower-growth in behavioral health.

Neurosciences advances will be needed well into the future, as researchers seek to better understand what some refer to as the most complex structure known to humanity—the brain. The steady expected demand for translational neurosciences and their resulting treatments point to strong market returns and viability as a high-growth market of focus. BCC Research cites several major, global initiatives underway in the neurosciences as their own, significant market drivers, including initiatives launched by the United Nations and World Health Organization to raise awareness and to scale up services related to mental illness and neurological and substance-abuse disorders, particularly in low- and middle-income countries. Numerous strategic and funded research initiatives have been introduced globally to investigate new treatment modalities and to develop new therapeutics for neurological disorders, including by the U.S. National Cancer Institute, Phoenix’s own Barrow Neurological Institute, the Pediatric Brain Tumor Foundation, the National Institute for Health Research in the UK, and others.²²

19 Deloitte Insights, “Sizing the Brain: Segmentation and growth factors of the global neuroscience market,” February 2023.

20 Ibid.

21 Ibid.

22 BCC Research, “Neurology Market: A BCC Research Overview,” August 2019.

As in other translational research areas in biomedical fields, translational neuroscience requires strong interdisciplinary talent and collaborative approaches to succeed that span neuroscientists, clinical researchers, physicians, and other healthcare professionals, as well as advanced research equipment and infrastructure. This section presents the numerous ways in which the Phoenix region is utilizing collaborative approaches and bringing world-class talent and research assets forward to contribute to diagnosing and treating neurological diseases and disorders.

Why Greater Phoenix and the PBC?

Greater Phoenix stands out in the breadth, depth, and excellence of research and translation in the neurosciences, with significant assets and expertise located across the region, including at the PBC. The region has long focused on key investments, building its depth of expertise over decades with its highly collaborative consortium-focused approach to advancing Alzheimer's research and treatments, its foresight in advancing key assets such as the brain donation program and brain bank at Sun City, the world-class BNI advancing treatments and translation of its research and clinical excellence, as well as new initiatives just underway. Translational neurosciences represents for the Phoenix region a distinct and differentiated opportunity area in which it stands out nationally and globally. Findings from the quantitative analyses of both the technology push and market pull associated with translational neurosciences are summarized in Figure 8.

As noted above, the region is home to several world-class research centers, consortia, and other assets, including the following:

- **Barrow Neurological Institute (BNI) at Dignity Health St. Joseph's Hospital** in Phoenix is a global leader in research, education, and treatment of brain and spinal diseases, injuries, and conditions. Leveraging one of the nation's largest neurosurgery departments, BNI performs nearly 6,000 brain and spine surgeries and treats more than 58,000 patients in total each year. The Institute is very translational in its activities and closely aligned with numerous leading clinical areas. BNI actively collaborates across the regional ecosystem, partnering with other institutions, such as TGen with its complementary strengths in genomics, proteomics, etc., with ASU on a joint bioengineering and neuroscience Ph.D. program, with HonorHealth on clinical trials, and others.
- **The Arizona Alzheimer's Consortium** represents a long-standing and leading model of statewide university and non-profit research collaboration established to make a transformational difference in the fight against Alzheimer's disease and related disorders. Today, the Consortium represents a high degree of collaboration and includes more than 150 researchers and staff from seven organizations, as well as four affiliated organizations. In addition to addressing the unmet needs of patients and caregivers and educating state residents about the disease, the Consortium is focused on finding effective treatments to halt the progression and prevent the onset of Alzheimer's. Its major research themes include early detection, study, and prevention of Alzheimer's disease, brain aging, and emerging roles of blood-based biomarkers to enhance early diagnosis and develop therapies. Since 2001, the Consortium has been funded by a highly competitive NIH Center grant, which has enabled the funding of deeper research infrastructure for key scientific cores. The Consortium is led by Banner Health and its Banner Alzheimer's Institute.

- **Banner Alzheimer’s Institute (BAI)** is a leader in both groundbreaking Alzheimer’s disease research and clinical care services in the Phoenix region and across Arizona. BAI offers an array of innovative programs and services that span access to clinical neuropsychologists evaluating brain function and recommending strategies, the Banner Neuro Wellness program offering community-centric wellness activities and support, continuing education programs for healthcare professionals, the Alzheimer’s Prevention Initiative, and memory care centers of excellence. At the same time, BAI is deeply involved in translational research and deep collaborations across the region and state, including leading the Arizona Alzheimer’s Consortium, advancing clinical trials, and partnering with ASU in a strategic research alliance—the **ASU-Banner Neurodegenerative Research Collaborative** to advance the scientific study, treatment and prevention of Alzheimer’s, Parkinson’s and other neurodegenerative diseases. The ASU collaboration includes the launch of a new research center on ASU’s Tempe campus.
- **TGen brings a focus in neurosciences research through its Neurogenomics Division, based at the PBC.** The Division has a focus on prediction and prevention for both common and rare neurological disorders, working to advance blood-based biomarkers, enhanced testing including cognitive screening, leveraging big data and its institutional expertise in genomics research. TGen is advancing its **MindCrowd initiative**—a unique online research project that partners with UArizona, ASU, and others to identify the factors that affect the brain’s functioning as we age. Launched in 2013, MindCrowd is a free online memory and attention test to gauge personal cognitive performance that is now available on smartphones. Data now spans about 500,000 participants, including valuable associated genomics data with insights about how health, medical, and lifestyle factors affect cognition across the lifespan.
- **The University of Arizona College of Medicine-Phoenix has recently established a new Translational Neurosciences Department**, aiming to blend basic research and clinical medicine to understand and model CNS-related diseases and leverage innovative technologies to develop new treatments. Based at the PBC, the university has recruited James Bibb, Ph.D. to chair the department.
- Regional research excellence leverages unique research capabilities, assets, and infrastructure such as:
 - **The Brain and Body Donation Program at Banner Sun Health Research Institute**—the world’s largest around Parkinson’s and Alzheimer’s Disease and a shared resource for biomarker development.
 - **The Neurogenetics Lab at Phoenix Children’s Hospital** studying the molecular and cellular basis of cerebral palsy and other movement disorders with a goal of developing personalized medicine approaches for new therapies.

These research institutions and assets combine to yield significant research outputs in the region’s technology push capabilities in translational neuroscience. The topic modelling analysis of research publications with at least one Greater Phoenix author and aligned with the institutions most closely associated with or adjacent to the PBC finds a critical mass of thematic areas related to neurosciences. At a high level, translational neurosciences as a unified theme emerges as the second leading in research publications, accounting for 8% of all regional research publications and behind only oncology as a unified thematic area.

The publication themes span numerous conditions as well as associated focus in translational outcomes, including:

- Neurodevelopmental conditions and biomarkers
- Neurostimulation devices
- Traumatic brain injury and other nerve injuries
- Neurodegenerative conditions and staging diagnostics

To further illustrate, within the neurodegenerative conditions and staging diagnostics cluster of publications, the leading conditions spanned Alzheimer's disease, multiple sclerosis, myelopathy, and others. Stakeholder discussions corroborate the broad base of conditions for which regional institutions are focusing translational research, which in addition to those noted above, further include strengths in ALS, Parkinson's, stroke, cerebrovascular, and brain tumors.

The ongoing neurosciences research in the Phoenix region is supported by and translated through robust clinical trials activities, as well as demonstrated clinical excellence across the region. Today, there are 341 active or actively recruiting clinical trials with a focus on central nervous system (CNS) treatments. Among these, an impressive 46 or 13% have been initiated by a Greater Phoenix research institution as the principal investigator or a key collaborator, signaling the strong and active innovation thrust of the region. Further, BNI is nationally recognized as a national leader for its Neurological Surgery Residency Program.

The translational neurosciences opportunity area is still emerging in its "market pull" and industry development across the region, though its presence can be seen via patent innovations and among a cadre of emerging, VC-backed companies present in the region. Among the patent innovation themes identified are neuro/electro-stimulation devices, with the following companies patenting technologies: Soovu Labs, Endostim, Nocira, Medtronic, Paradromics, and Vmas Solutions. Another thematic area from the patent analysis is in wearable impact detection sensors, with companies involved including Force Impact Technologies, Cranial Technologies, and Intel. Among the Venture-backed companies are CND Life Sciences and Nocira.

While translational neurosciences represents an embedded application rather than a distinct industry sector, the opportunity area is primed to leverage key dynamics of regional industry growth, including medical devices, medical labs, and hospitals—all demonstrating growth in the region and providing enabling capacities for startups and for advancing emerging research.

Figure 8: Summary of Technology Push and Market Pull Associated with Translational Neurosciences

Summary of Technology Push: Greater Phoenix Industry-Facing Core Research Competencies

Research Publication Themes:

- Neurodevelopmental conditions and biomarkers
- Neurostimulation devices
- Traumatic brain injury and other nerve injuries
- Neurodegenerative conditions and staging diagnostics

Major Grants & Research Centers:

- Arizona Alzheimer's Consortium
- ASU College of Health Solutions Translational Teams
- ASU-Banner Health Neurodegenerative Research Collaborative
- Banner Alzheimer's Institute with Sun Health Research Institute
- Barrow Neurological Institute
- Neurogenetics Lab at Phoenix's Children's Hospital
- TGen Neurogenomics Division
- UArizona-COM Phoenix New Translational Neurosciences Department

Clinical Research Excellence:

- Active base of central nervous system (CNS) clinical trials, with 341 active or recruiting studies, 46 by Phoenix-based research institutions as PIs or key collaborators
- Two top rated "global" hospitals in neurosurgery:
 - St. Joseph's/BNI
 - Mayo Clinic-Phoenix
- BNI ranked #2 in nation for its Neurological Surgery Residency Program; national leader in brain tumor surgeries.

Summary of Market Pull: Demand Drivers of Greater Phoenix Bioscience Industry and Associated Innovation Activities

Industry Position & Assets

- Represents an embedded application rather than a distinct industry, but growing base of:
 - Medical devices, medical labs, and hospitals in the region, providing capacity for startups and for advancing emerging research.
- Innovative neuro companies seen in:
 - Patent activity—neuro/electro stimulation devices; wearable impact detection sensing.
 - VC-backed companies

Market Opportunities for Greater Phoenix and the PBC

The ongoing regional activities in translational neurosciences point to three distinct opportunities for focused industry and market development today and into the future. Importantly, two of these areas align and overlap with the prior growth opportunities as neuroscience-related applications have been an initial and integral focus of both the MedTech and precision medicine strengths of the region to-date.

- **Neuro-Related MedTech** products and solutions are being actively advanced and are leveraging both the region's translational neurosciences and digital health and MedTech strengths and expertise. As evidenced by the focus of regional patent awards, VC-backed companies, and conversations with regional leaders, neuro-related MedTech innovations are advancing out of biomedical research institutions and universities in neuro-surgical devices and tools, neuro-imaging tools, neuro-modulation, deep-brain stimulation devices, and implantable devices.
- **Neuroscience-related applications in precision medicine** are being advanced out of the continued and expanding research focus on developing novel blood- and fluid-based biomarkers for neurodegenerative and neurodevelopmental diagnosis as well as genomic-based, cognitive, and imaging-related diagnostic approaches. In new areas of research, regional researchers are turning to leveraging patient-derived stem cells for regenerative approaches to treating neurological conditions and partnering with industry on clinical research and new treatment approaches.
- **Clinical trials and research** can serve as a market and economic driver in their own right, leveraging the unique clinical research infrastructure and capabilities of the region, including at the PBC. The region's assets in translational neurosciences—from its unique brain bank to its imaging and large animal facilities and its active base of clinical trials—serve as a center of gravity for industry and other institutions aiming to advance clinical research. The region's two top-rated hospitals in neurosurgery (St. Joseph's/BNI and Mayo Clinic) represent further assets to leverage for market development, with patients coming into the region for surgery and consultations. In addition, there is a new and increasing emphasis by regional institutions as well as the NIH and major biopharmaceutical companies globally on studying typically underrepresented population groups, including rural populations in the region and state.

Situational Assessment and Development Actions to Catalyze Growth

Regional leaders and stakeholders have provided key insights on the situational assessment and suggested development actions to catalyze growth in the opportunities related to translational neurosciences.

Situational Assessment from Stakeholders

Strengths/Regional Advantages:

- **A broad research and translational focus exists today across many neurological conditions involving numerous research institutes, university centers and academic hospital systems** in the Phoenix region. This dynamic allows for a broad range of commercial solutions for patients and a deep set of translational opportunities into the future.
- **The Phoenix region has a demonstrated and proven track record of multi-institutional collaboration in the neurosciences.** As highlighted herein, the region has a long history of collaboration through the Arizona Alzheimer's Consortium, as well as other ongoing or recently initiated efforts.
- Stakeholders recognize the **unique and high-value neurosciences research infrastructure and assets** as a regional strength, including the brain donation and banking program, imaging capabilities and large animal facilities.
- **Strong clinical trials activity, including the significant number with a Greater Phoenix principal investigator.**
- **New investments by regional research universities, including** the establishment of the new UArizona College of Medicine-Phoenix Department of Translational Neurosciences located at the PBC, and the establishment of the ASU-Banner Health Neurodegenerative Research Collaborative in Tempe.

Challenges:

- **Regional research leaders acknowledge and emphasize the longer-term outlook and expectations required for therapeutics development in neurosciences.** As one regional researcher noted in an interview discussion, "Of course we need therapeutics [to treat/prevent neurodegenerative diseases] ... but in this field we are behind cancer by about 20 years." The challenges related to our fundamental understanding of the brain and broader CNS conditions and arriving at safe and effective treatments require patience.
- **Many industry collaborators from large, multinational biopharmaceutical companies with regional institutions are not based in, nor have a sizable presence in the Phoenix region.** This has the potential to create a dynamic where Phoenix-based innovation is further developed or ultimately manufactured outside of the region.
- **Regional leaders point to gaps in the clinical workforce that affect or limit clinical trials activities in the Phoenix region,** notably with respect to physicians and support staff such as clinical research associates.

Recommended Development Actions by Stakeholders

Regional leaders and stakeholders were asked to share ideas and thoughts about addressing the challenges raised and to seize opportunities for advancing this growth opportunity area. For translational neurosciences, it is important to recognize the significant overlap with the prior two areas to catalyze industry and further place-based development—many of the identified development opportunities described in the prior two sections have relevance for advancing both neuro-related MedTech and neuro-focused precision medicine and should therefore be considered in this regard as well.

- **Research Institutions, including BNI, are focused on and investing in forward-looking opportunities around “Challenges of the Brain” and “Brain Health” initiatives.** Recognizing there are still vast areas of basic research to undertake to gain a greater understanding of the human brain, regional institutions are investing in these forward-looking research pursuits, and regional leaders should continue to look for opportunities to collaborate, even in areas not ripe for near-term translation or commercialization.
- **Regional institutions have a significant focus today on serving and better understanding diverse and rural patient populations,** i.e. those that have been traditionally underrepresented in biomedical and clinical research studies. This represents an opportunity and a value proposition where the Phoenix region, and Arizona more broadly, can and should lead on patient diversity and rural healthcare and related innovations, including in the neurosciences. TGen and others are actively investing in mobile, rural health outreach in the neurosciences including bringing sophisticated mobile imaging equipment to rural Arizona communities.
- **In the neurosciences and more broadly, there are opportunities for industry and other researchers to leverage unique, large patient data assets such as MindCrowd,** developed at TGen, for clinical trials recruitment and other applications. MindCrowd and other patient data initiatives represent key assets to leverage for translational research.

RECOMMENDED ACTION STEPS TO REALIZE THE BIOSCIENCE GROWTH OPPORTUNITIES FOR THE PHOENIX REGION

The three growth opportunities identified for the Phoenix region provide a strategic focus to sustain its bioscience growth going forward. For the region to realize the potential of these three growth opportunities, its bioscience stakeholders identified recommended development actions based on each growth opportunity area’s specific competitive strengths and challenges. These recommended actions are summarized in Figure 9 below.

Figure 9: Recommended Action Steps for Realizing Bioscience Growth Opportunities for the Phoenix Region

Growth Opportunity	Stakeholder Recommended Actions to Realize Growth Potential
<p>Precision Oncology/Medicine: Seeks to advance the Phoenix region as a leader in the continuing genomics revolution that is reshaping the practice of medicine through a focus on molecular diagnostics innovations and industry growth.</p>	Promote Phoenix as a place for locating diagnostic/biological centralized labs.
	Create a statewide testing/demonstration network among healthcare systems for precision medicine diagnostics.
	Advance more regulatory affairs training and education opportunities.
	Promote innovation and industry networking to drive future opportunities for commercialization innovations in molecular diagnostics, promoting industry-research center partnerships, and talent generation/attraction/retention.

Growth Opportunity	Stakeholder Recommended Actions to Realize Growth Potential
<p>Digital Health, WearTech, and Other MedTech:</p> <p>Focuses on the digital transformation of healthcare with the ongoing convergence of software, hardware, and AI technologies, building on the region's strengths in tech and microelectronics.</p>	<p>Digital Health and WearTech:</p> <ul style="list-style-type: none"> • Launch industry networking activities and events. • Establish a First Customer Program for health innovations. • Enhance and broaden resources and programming of the WearTech Applied Research Center. • Seek legislation and develop testbed capabilities to use Arizona's Health Information Exchange for innovation and research purposes. <p>MedTech:</p> <ul style="list-style-type: none"> • Address need for small-batch manufacturing capability for early-stage MedTech companies and for specialty device manufacturing. • Recruit in or establish regional Medical Device Design Houses. • Address the regional gap in MedTech entrepreneurial education and programming. • Deepen regional engagement and touchpoints for medical device and MedTech companies that are attracted to regional programs such as the Mayo Clinic-ASU MedTech Accelerator.
<p>Translational Neurosciences</p> <p>A distinctive area of global strength and continued investment for the Phoenix region in biomedical research, clinical expertise and translational research across multiple institutions with an emerging industry base in development.</p>	<p>Seek continued investment by research institutions in forward-looking "Brain Health" opportunities.</p> <p>Focus on serving and better understanding diverse and rural patient population needs and treatments for improved brain health.</p> <p>Leverage unique, large patient data assets, such as MindCrowd at TGen, for clinical trials recruitment and health innovations.</p>

Still, a number of common themes of needed development actions emerge from across these growth opportunities, including:

- **While the Phoenix region is widely viewed as business-friendly for bioscience industry development, a more coordinated, proactive regional business development effort is needed to realize the region's bioscience growth opportunities.** There are many positives noted by stakeholders about the business climate for bioscience industry development in the Phoenix region. The region offers a lower cost of doing business compared to well-established bioscience regions across the West Coast, and the region's local government leadership is widely complimented by stakeholders for offering a welcoming and supportive business environment for bioscience industry development. Additionally, many individual healthcare and bioscience research institutions are active in seeking

industry collaborations and business development. Still, it is widely recognized by stakeholders that the Phoenix region has fallen behind other regions in not having a coordinated, proactive outreach marketing and business development effort for bioscience industry development. This has resulted in few telling the region's bioscience story on a national stage and creating the buzz that attracts the attention of out-of-region investors and industry. In late 2023, the Greater Phoenix Economic Council, which serves as the region's economic development organization focused on attracting and growing businesses, took an important step to address this need by establishing a dedicated business development focus on the biosciences, led by a vice president with expertise in the biosciences.

- **Increased networking and collaboration activities are needed to advance innovation and talent development** within and across these growth opportunity areas, especially given the convergence of technologies taking place to realize these growth opportunities. While the wide geographic footprint of where bioscience companies are located across the Phoenix region presents a key challenge to overcome, it is the lack of high-quality programming for networking activities that stands out. Among the networking activities needed on a larger scale are bringing peer groups within the biosciences together, creating connections to regional customers, addressing common talent skill shortage needs and identifying innovation challenges for collaborative efforts. This results in a less robust bioscience community across the Phoenix region, characterized more by silos than active partnerships and collaboration.
- **Shoring up the region's capacity to support scale-up of emerging bioscience ventures in accessing needed business acumen and investment.** The Phoenix region is strong in advancing innovations for the biosciences but lacking in the required deep business knowledge and lead venture capital investors to scale-up high-growth potential startups. A wide range of activities are identified across the growth opportunities from developing stronger business mentor networks to advancing regulatory/reimbursement business skills for biosciences to engage lead investors.
- **Leveraging data resources to advance innovation and collaboration activities.** In the age of AI and machine learning, increasingly innovation in the biosciences depends upon access to high-quality data. The Phoenix region would benefit significantly from having increased access to population health databases to spur innovation and collaboration across industry, research institutions and healthcare providers, such as the state's health information exchange data and more specific data collection initiatives such as TGen's MindCrowd initiative.

The growth of placemaking at the bioscience hubs developing across the Phoenix region is particularly important for advancing its bioscience ecosystem and addressing these common development issues. These bioscience hubs not only offer facilities geared toward the needs of bioscience companies and research centers, but stand out because they are ideal settings to form communities anchored by a university, research institute or healthcare system, focused on innovation, entrepreneurship, education and training, and collaboration for individuals and enterprises of all sizes and growth stages. The 2018 Association of University Research Park survey of university-affiliated research parks and innovation districts identifies two of the most common success attributes for building an innovation community: offering entrepreneurial services to launch and grow startups and fostering industry, and a robust approach to promoting university collaborations and partnerships.

Moreover, bioscience hubs can offer resources for proactive marketing and hosting of innovation centers that can attract business mentors and venture capital investors from within and outside of the region.

Among the growing bioscience hubs in the Phoenix region, the PBC stands out to regional stakeholders, given its extensive developed footprint and the broad range of leading bioscience anchor institutions and collaborators—which will soon include the new ASU medical school, as being ideal in developing more value-added services for networking, proactive outreach marketing and addressing the region’s capacity to support the scale-up of emerging bioscience ventures. More importantly, PBC is well-situated to help anchor and raise the visibility of the biosciences across the region for a much larger and diverse bioscience innovation community involving Downtown Phoenix with its growing ASU campus, nearby research and medical centers, including those in Midtown, and its proximity to the airport and its growing base of molecular diagnostics labs.

Key Findings on Success Attributes of University-Affiliated Research Parks and Innovation Districts from the 2018 Association of University Research Park survey

Innovation Economy — Launching startups and supporting their growth with entrepreneurial services are a core focus, with 80% of university-affiliated research parks and innovation districts having dedicated space for startups, along with a wide range of entrepreneurial support activities involving networking, mentoring, business planning, and commercialization assistance.

Innovation Culture—Activating industry-university partnerships with their programming, with 80% of university-affiliated research parks and innovation districts having dedicated partnership development staffing to match companies to talent, university expertise, specialized laboratory and testing facilities and university innovation.

AURP Communities of Innovation: A State of the Practice, 2018.



APPENDIX

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Arizona Board of Regents: Regent Gregg Brewster, Chair, ABOR Research and Health Sciences Committee

Arizona State University: Matthew Hulver, Ph.D., Vice President for Research

Banner Health: Michael Kupferman, M.D., Senior Vice President, Physician Enterprise;
President, Academic Division

Barrow Neurological Institute: Robert Bowser, Ph.D., Chief Scientific Officer

City of Phoenix: Claudia Whitehead, Economic Program Manager, Biosciences

Creighton University: Randy Richardson, M.D., Regional Dean, Phoenix Campus

Greater Phoenix Economic Council: Kathleen Lee, Senior Vice President, Regional Initiatives

HonorHealth: Mark Slater, Ph.D., Vice President for Research; CEO, HonorHealth Research Institute

Mayo Clinic: Steven Lester, M.D., Cardiologist, Professor of Medicine; Founder and Chief Medical Officer,
Mayo-ASU MedTech Accelerator

Northern Arizona University: Oaklee Rogers, Ph.D., Associate Dean, College of Health and Human
Services at Phoenix Bioscience Core

Phoenix Bioscience Core: Scarlett Spring, Executive Director

Phoenix Children's Hospital: Stewart Goodman, M.D., Senior Vice President, Research; Chair & Professor, Department of Child Health

Phoenix VA Health Care System Research: Samuel Aguayo, M.D., Associate Chief of Staff for Research

St. Joseph's Hospital & Medical Center, Dignity Health: Julie Riley, Chief Administrative Officer, Vice President of Service Line Operations

TGen: Tess Burlison, Chief Operating Officer

University of Arizona: Karen Taraszka Hastings, M.D., Ph.D., Professor, Basic Medical Sciences; Co-Director, MD/PhD Program; Director, Department of Dermatology, UA College of Medicine-Phoenix

Valleywise Health: Michael White, M.D., Executive Vice President & Chief Clinical Officer

Wexford Science + Technology: Tom Osha, Executive Vice President; Kyle Jardine, Vice President, Market Executive

