

Cell and Gene Therapy and Connected Health Workforce Analysis

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1. Introduction

In 2019, the CEO Council for Growth, University City Science Center, and University City District's West Philadelphia Skills Initiative convened a partnership to leverage their resources and networks on an initiative to support and grow the Philadelphia region's cell and gene therapy and connected health industries. The stimulus for this partnership arose from a need, identified by various stakeholders, to understand the growth of and gaps in the cell and gene therapy and connected health workforce in Greater Philadelphia. Econsult Solutions, Inc. (ESI) was hired to provide an independent assessment of the future workforce and talent needs of the industries.

To determine the scope of the cell and gene therapy and connected health sectors in the eleven-county region, ESI used LinkedIn Talent Insights and Burning Glass Labor Insights to determine both the labor market supply and demand, respectively, for the cell and gene therapy and connected health sectors in Greater Philadelphia. Primary research was also conducted through surveys, interviews, and focus groups consisting of professionals with knowledge of the sectors, including academic researchers, industry and human resources experts, and workforce development organizations. Both quantitative and qualitative data and subsequent analysis informed our understanding of the scope of the sectors and identified barriers and opportunities for growth in Greater Philadelphia.

An initial step of the partnership was creating an Advisory Board of professionals to appropriately frame and shape the research, and to provide guidance throughout the project on findings and proposed strategies. The Advisory Board met three times during the course of the project: first to provide an overview of the project and understand the industries in a broad sense, next to participate in focus group discussions, and last to provide feedback on results and takeaways from the survey, focus groups, and interviews.

This report synthesizes the project methodology, analysis, and findings. Section 2 of this report discusses the cell and gene therapy and connected health sectors on a national level. Section 3 reviews the role of Greater Philadelphia as a leader in these industries. Section 4 provides an overview of our quantitative and qualitative methods and analysis. Section 5 discusses the current supply of talent in Greater Philadelphia using LinkedIn and Burning Glass data, and Section 6 outlines potential industry cluster scenarios and calculations for projected growth in the cell and gene therapy industry.

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2. Cell and Gene Therapy and Connected Health in the US

2.1. The Cell and Gene Industry

Revolutionary innovations in the life sciences sector over the past few decades have resulted in significant industry changes across the United States. The Philadelphia region, long considered a hub for medical innovation and expertise, is home to some of the global leaders in health care, particularly in cell and gene therapy.

Cell therapy, gene therapy, and gene editing comprise the next generation of life-enhancing and curative therapies. Briefly, they can be described as innovative approaches to medical research and practice in which cell or gene modifications are used to treat disease.

This sector has the potential to dramatically impact the life sciences industry, with much of the research and commercial activity within the cell and gene therapy sector having concentrated in the Philadelphia region over the last ten years. The first gene therapy approved for a genetic disease by the U.S. Food and Drug Administration (FDA) was developed by researchers at the University of Pennsylvania and the Children's Hospital of Philadelphia (CHOP), while the first FDA-approved cell therapy was developed through collaboration between researchers at the University of Pennsylvania and Novartis.

However, the cell and gene therapy industry faces some challenges on a national and global scale. As a relatively young field, the workforce is not strictly defined, and firms and academic researchers may struggle to find qualified talent with experience in the sector as well as knowledge of regulations, Good Manufacturing Practices (GMP), and commercialization. Moreover, because startups in the U.S. are dependent upon product approval by the FDA, the industry is inherently risky, often with no defined career path and little job security for workers entering the startup world. Lastly, a shortage of manufacturing space for cell and gene therapy production is a universal barrier to scale. Currently, few companies manufacture therapies in-house.

2.2. The Connected Health Industry

Technological advancements coupled with geographic and demographic shifts have begun to influence how practitioners think about delivering health care in a way that is efficient and appropriate for the patient. Connected health, broadly defined, is the application of technology to healthcare. The goals of connected health include increasing efficiency of delivery, reducing costs, improving outcomes, enhancing the patient experience and expanding the patient populations served, among others. Connected health commonly brings to mind remote consultations and patient monitoring through apps and internet-connected devices, but there are countless examples of connected health less apparent to patients. Examples include the use of artificial intelligence to perform initial or complementary analysis of medical images and the data analytics used to identify and monitor the spread of disease or analyze variations in the human genome.

Additionally, connected health has had, and will continue to have, an important role to play in the development of cell therapies, gene therapies, and gene editing. Bioinformatics and statistical tools are

used to improve biological investigations and maintain databases for gene prediction, sequence analysis, and gene expression.¹ Data processing and management are essential to quality control and advancing reliable molecular data.

Once these therapies reach the market, connected health plays an important role in maintaining the integrity of the supply chain and monitoring of the patients who receive these cutting-edge therapies, as they are typically at risk for potentially severe adverse events. Lastly, as availability of these therapies expands, telemedicine visits with the specialists who will identify, treat, and surveil patients – a class of clinicians who are generally in short supply – will likely become an important part of delivery of care.

Connected health technologies will only continue to grow with technological innovations. The mobile health, or mHealth, market is expected to reach \$187 billion globally by 2024.² Greater Philadelphia is primed to capture a significant share of that market as it is home to key academic institutions and hospitals in the industry, including the University of Pennsylvania and Penn Medicine, CHOP, Jefferson Health, and ChristianaCare. The region also benefits from a concentration of large companies at the forefront of connected health innovation, including Merck, Janssen, IQVIA, IntegriChain, and Quil Health. The last is a joint venture between Independence Health Group and Comcast NBC10 Telemundo 62 (Comcast).

The success of the cell and gene therapy and connected health industries is dependent on a workforce with skills in bioinformatics, machine learning, and data analytics. Thus, workforce strategies that target workers with these skills have the potential to benefit both the cell and gene therapy and connected health sectors.

¹ Mount, D.W. & Pandey, R. (2005). Using bioinformatics and genome analysis for new therapeutic interventions. *Molecular Cancer Therapeutics*. DOI: 10.1158/1535-7163.MCT-05-0150

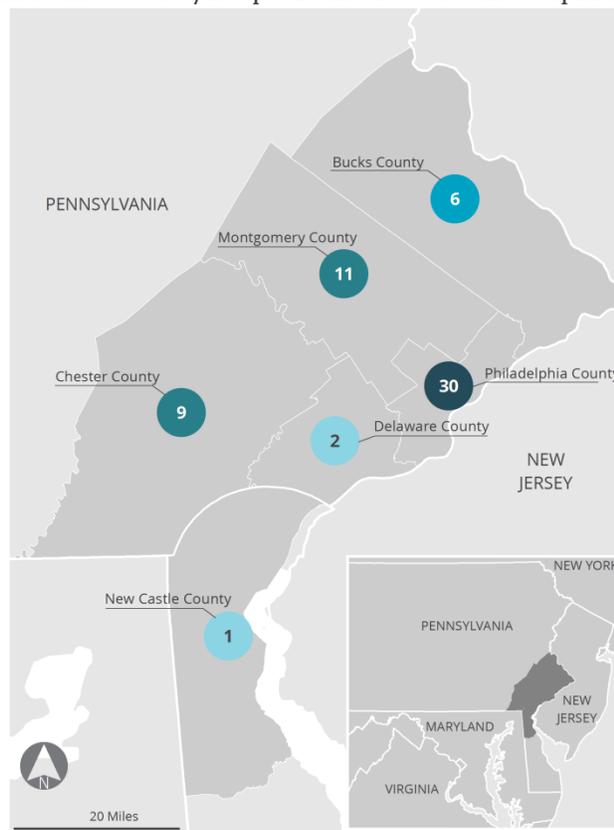
² Market Research Engine (2018). *Mobile Health Market – Global Industry Analysis, Trends and Forecast 2018-2024*. <https://www.marketresearchengine.com/reportdetails/mobile-health-market>.

3. Greater Philadelphia as a Leader in Healthcare Innovation

The Philadelphia region has historically been a hub of life sciences research and development and manufacturing, with a strong legacy of pharmaceutical industry dominance. Over the last twenty years, the cell and gene therapy and connected health sectors have flourished in Greater Philadelphia. One of the world leaders in cell and gene therapy innovation, the region has supported the expansion of this sector through its collaborative relationships among top-tier academic institutions, medical centers, and commercial enterprises.

In the last five years, Philadelphia-area researchers have been awarded nearly \$1 billion in National Institutes of Health (NIH) funding each year. For research specifically related to cell and gene therapy, local researchers have been awarded more than \$240 million in NIH funding in the last five years and funding for cell and gene therapy in the Philadelphia region has grown 36 percent over the past five years.³ During 2018-2019, there was roughly \$800 million in venture capital invested in cell and gene therapy companies in the region.⁴

Figure 3.1: Cell and gene therapies companies, CMOs, and universities/hospitals in Greater Philadelphia



Source: ArcMap (2019), Econsult Solutions (2019)

In addition to the research infrastructure and commercial successes that support growth of the industry, the Philadelphia region also boasts significant human capital resources. The Philadelphia region’s concentration of institutions of higher education is essential to its attractiveness for college students, young professionals, and firms seeking talent. Philadelphia has three Tier I universities within city limits and four within the Metropolitan Statistical Area (MSA), making it one of the cities with the densest concentration of top-tier universities in the country. In total, there are over 100 colleges and universities

³ National Institutes of Health, Research Portfolio Online Reporting Tools (RePORTER), 2018, <https://projectreporter.nih.gov/reporter.cfm>.

⁴ Pitchbook (2019)

in the Philadelphia region.⁵ In 2018, there were approximately 4,000 graduates in biological and biomedical sciences, physical sciences, and science technologies and over 2,000 graduates in computer sciences and information technology, providing a substantial pool of qualified talent for the cell and gene therapy and connected health sectors.⁵

In 2018, there were 14,870 jobs in *biotechnology research and development* and 14,370 jobs in *pharmaceutical manufacturing* in the Philadelphia MSA.⁶ Although not all biotechnology research jobs are in cell or gene therapy development, the biotechnology sector provides a sense of the potential talent pool for cell and gene therapy and connected health firms. Firms in cell and gene therapy are predominantly located in University City and the Navy Yard, with some firms of significant size in suburban Philadelphia. University City, in particular, benefits from a concentration of research organizations, universities, and hospitals, including the University of Pennsylvania, Penn Medicine, Drexel University, The Wistar Institute, the University of the Sciences, and Children’s Hospital of Philadelphia (CHOP).

Likewise, the Philadelphia region is at the vanguard of the connected health industry, with a unique workforce possessing knowledge of health care systems as well as skills in software development, data analysis, and bioinformatics. In the Philadelphia region in 2019, there were 739 professionals with the skills *connected health, digital health, telehealth or mobile health*. Moreover, the number of jobs in this industry in the Philadelphia region has grown roughly 35 percent in the last year alone, from around 548 professionals in 2018 to 739 professionals in 2019.⁷

⁵ The Integrated Postsecondary Education Data System (IPEDS) (2018)

⁶ Bureau of Labor Statistics (2018)

⁷ LinkedIn Talent Insights (2019)

4. Existing Conditions and Future Perceptions

4.1. Industry Survey Development and Objectives

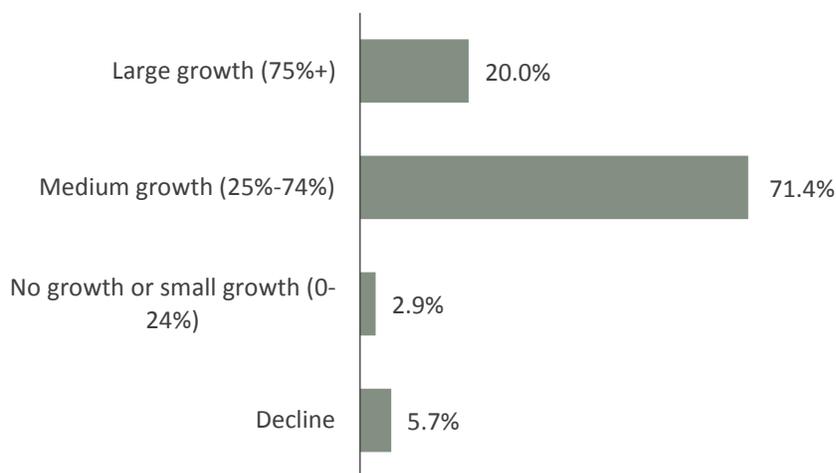
To understand the existing conditions and potential future talent needs of the cell and gene therapy and connected health industries, ESI developed an online survey tool that was shared with industry experts, researchers, HR professionals, and academic curriculum developers. The survey link was included in several relevant partner newsletters as well as shared directly with respondents to attain a broad, inclusive sample.

Developed with guidance from our project partners, the survey focused on the current workforce, potential future workforce, and barriers to industry growth in Greater Philadelphia. Survey questions were targeted based on a respondent's industry and job title. Twenty-four percent of respondents worked in an organization in the cell and gene therapy industry, ten percent worked in connected health, and eighteen percent worked in higher education or an academic/health care research institution. Almost 30 percent of respondents represented an organization other than a cell and gene therapy company, connected health company, or an academic/health care research institution. Other respondents included those from government, biopharma, data analytics, talent innovation, and management consulting firms. The following sections provide an overview of key findings and implications from our survey results.

4.2. Cell and Gene Therapy Insights

Those with knowledge of the cell and gene therapy sector were asked what level of growth they anticipated in the Philadelphia region in the next three to five years. The majority of respondents (71 percent) anticipated medium growth, defined as 25 percent to 74 percent growth. Twenty percent of respondents anticipated large growth, defined as 75 percent growth or greater.

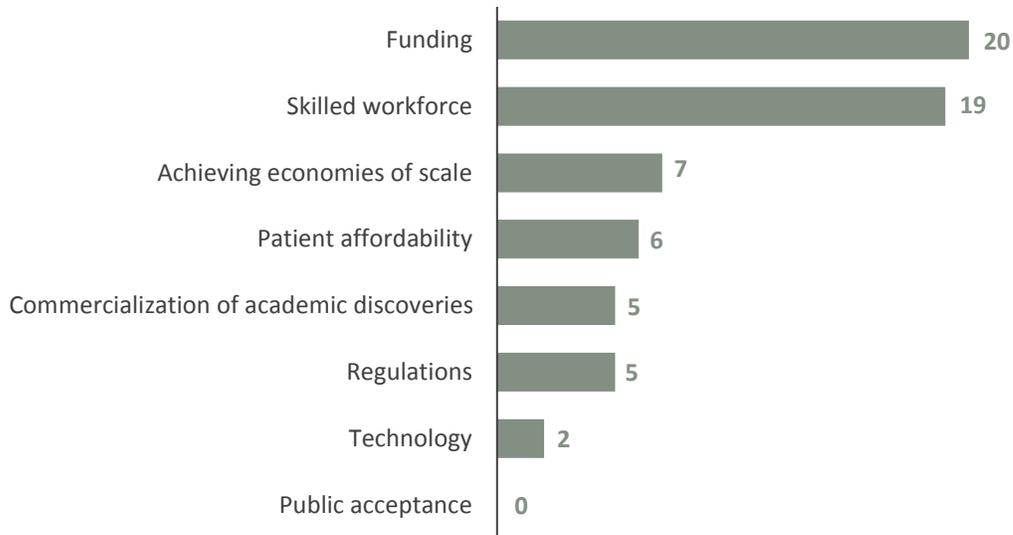
Figure 4.1: Anticipated cell and gene therapy sector growth in the Philadelphia region in the next 3-5 years, (n=35)



Source: Econsult Solutions (2019)

When asked to rank the largest barriers to growth in the cell and gene therapy sector in the Philadelphia region, respondents identified funding and skilled workforce as two of the largest. Of 27 respondents, 74 percent identified *funding* as either the first or second largest barrier to growth, while 70 percent identified *skilled workforce* as the first or second largest barrier to growth. *Commercialization, achieving economies of scale, and technology* were frequently identified as one of the top three.

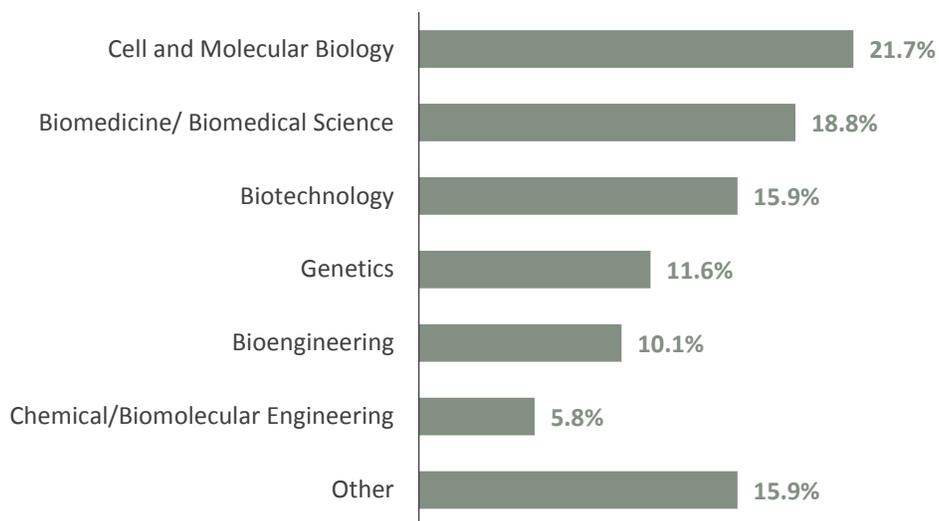
Figure 4.2: Count of respondents who ranked the following as first or second largest barriers to growth, (n=27)



Source: Econsult Solutions (2019)

In terms of workforce composition, 22 percent of respondents identified Cell and Molecular Biology as a dominant field of study of employees working in the primary business function of their organization, 19 percent of respondents selected Biomedicine/Biomedical Science as a dominant field, and 16 percent selected Biotechnology. Other fields that respondents specified include Immunology, Virology, Medicine, Computer Science/Data Analytics, and Pharmacology/Toxicology.

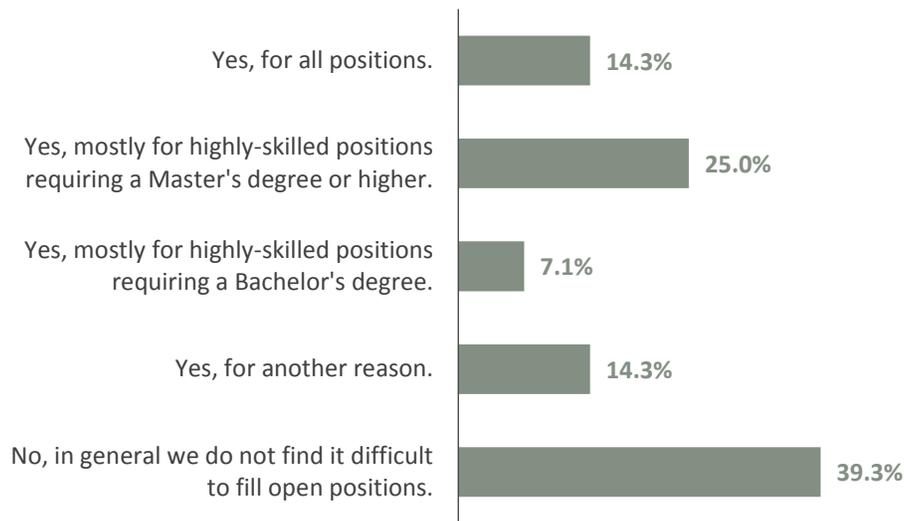
Figure 4.3: Dominant fields of study of employees working in the primary business function of your organization, (n=26)



Source: Econsult Solutions (2019)

When asked if they found it difficult to fill open positions in their organization, 39 percent of respondents shared that they did not find it difficult to fill open positions. However, 25 percent found it difficult to fill open positions mostly for those requiring a master’s degree or higher and 14 percent found it difficult to fill all open positions, regardless of degree level. Fourteen percent of respondents specified another reason why it was difficult to fill open positions; written responses showed that respondents found it difficult to find people with specific experience related to cell and gene therapy, and that it was difficult to recruit experienced technology and engineering candidates to Philadelphia, particularly from the pool of experienced candidates living in the surrounding suburbs.

Figure 4.4: Assessment of difficulty filling open positions at your organization, (n=28)

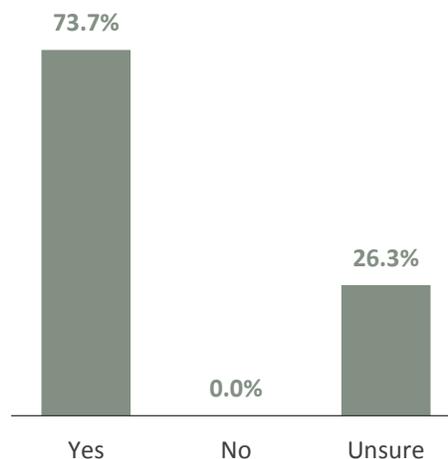


Source: Econsult Solutions (2019)

4.3. Connected Health Insights

For those respondents with knowledge of the connected health sector, the majority (74 percent) believe that there will be a future need for workers in the connected health sector in Philadelphia. This suggests that industry experts anticipate some level of growth of the connected health industry in the region.

Figure 4.5: Belief that there will be a future need for connected health workers, (n=38)



Source: Econsult Solutions (2019)

Respondents were asked two open-ended questions about the types of connected health positions that will have a greater need in the future, as well as the skills that will be important in order to fill roles in

the connected health sector. Positions identified include customer implementation, sales development representatives, information/data specialists, product managers, software engineers, social workers/home health aides, registered nurses with connected health experience, and health care-related IT positions. Skills identified include experience with/knowledge of cyber security, telemedicine, machine learning and programming, project management, data analytics, digital health and health systems, biomedicine, informatics, and ethics.

4.4. Qualitative Analysis and Implications

From November to December 2019, ESI conducted four focus groups:

1. Cell and Gene Therapy Business and Industry
2. Human Resources
3. Community Colleges
4. Connected Health Business and Industry

The focus groups ranged in size from 6 – 15 participants. In addition to the four key informant focus groups, ESI conducted one-on-one interviews with nine industry and workforce experts.

Results from the survey described in Sections 4.1 – 4.3 were used to inform and develop the focus group guides and interview questions. The research question, *‘What are the future workforce needs of the cell and gene therapy and connected health sectors in the Philadelphia region?’*, was used to frame and guide the focus group discussion.

Value Proposition and Talent Risk Threshold at Startups

Focus group participants described the characteristics of job candidates that they typically hire, and qualities that prepare that person for the fast-paced, uncertain startup world. For cell and gene therapy startups, there is no guarantee of therapy approval or commercialization, making early-stage

“We have young people come in - they’re often looking for career paths. We’re not offering career paths. We’re offering education, a chance to try something new. We’re offering skills that you may not get at other places.”

— Cell and Gene Therapy Focus Group Participant

startups inherently risky in terms of job security and career paths. Prospective talent must have a high-risk tolerance to succeed within startups, and often must be willing to take roles without a defined career path. As we heard from cell and gene therapy focus group participants, small startups are not offering structured, mature career paths, but they do offer the opportunity to work and learn in a desirable, growing industry. To attract talented workers, they must be able to explain their distinct value proposition offered by working in an emerging, fast-growing industry. They might not offer the stability and structure of a job in the pharmaceutical industry, but the cell and gene therapy sector is uniquely positioned to offer excitement, originality, and a desirable, exclusive skillset.

Hiring Trends and Talent

Currently, because of the number of small startups in the region, firms are predominantly hiring workers with bachelor's degrees or higher, with a significant portion of the workforce having PhDs. Early-stage startups are focused on hiring highly educated workers because they are often dependent on a very

“What I hear from my colleagues upstairs is that the education that students are getting, no matter what level it is, whether it’s those that are high school, finishing an AS degree, finishing a bachelor’s degree, master’s degree, finishing a PhD, they’re not finishing being ready to take on the positions. Even in just in the lab, specific things that we’ve heard are QA, QC, important documentation, there’s just a lot that they have to learn in onboarding.”

— HR Focus Group Participant

limited workforce, sometimes two to three people, who have experience with therapy development, Good Manufacturing Practices, and knowledge of regulations to get therapies developed and approved. Early-stage startups generally are not yet focused on the diversity of talent needed to commercialize and go to scale. Focus group participants noted that it is often difficult to find qualified candidates fresh out of college, as new graduates tend to lack the

lab experience and regulatory understanding necessary to succeed in this industry. Further, some participants expressed difficulty in attracting and retaining talent.

A positive feedback loop is beginning to establish itself in the Philadelphia region around the cell and gene therapy workforce; that is, attracting more firms provides more job opportunities and thus attracts more talent from outside the Philadelphia region, which in turn makes Philadelphia even more desirable to relocating firms. We heard from our discussions that having multiple firms, meaning more potential job opportunities, is crucial to persuading talent to relocate to Philadelphia. And while small startups tend to hire versatile, experienced PhDs, as firms grow, so will job opportunities for a diverse workforce reflecting multiple education and skill levels. Presently, aside from workers with a scientific research background, this industry will require workers with backgrounds in finance, information technology, legal services, human resources, and general operations.

Attracting and Retaining Talent in the Philadelphia Region

The Greater Philadelphia region has much to offer to support the development and growth of the cell and gene therapy industry: the historical strength and success of the pharmaceuticals industry, a high concentration of research institutions, an established life sciences industry, and a comparatively low cost of living. However, the focus group discussions identified a potential gap in the reach of current life sciences promotion efforts.

While the cell and gene therapy and connected health sectors have an existing

shared messaging platform in the region, there is an opportunity to expand upon and broaden the audience, including prospective and experienced talent, research organizations, and companies.

“What we have is the second largest concentration of high-level institutions in the country in Philadelphia. It is remarkable to me that people don’t recognize that there are very, very few cities that have three R1s within two square miles of each other. That’s just an unprecedented amount of talent.”

— Cell and Gene Therapy Focus Group Participant

Furthermore, developing and strengthening a unified messaging framework will assure students in the region that they do not need to relocate in order to find innovative, exciting opportunities.

Building on Pharma Strengths

The Philadelphia region's pharmaceutical companies are an exceptional source of resources, talent, and knowledge. Those with experience in the pharmaceutical industry have skills that mirror those necessary for success in the cell and gene therapy industry, including knowledge of commercialization, product development, quality assurance and quality control regulations, regulatory requirements and Good Manufacturing Practices. These skills present an advantage for those with experience in the pharmaceutical industry to smoothly transition to the cell and gene therapy industry. However, we heard in the focus group discussions that pharmaceutical professionals that do make the switch to the cell and gene therapy industry still need some level of training in order to fully prepare for the position.

"There's an element of retraining. A lot of people who have done biopharma understand a lot of manufacturing processes. You have to invest in training them and bringing them up to speed. Like everybody said, we're all finding it harder to hire than we would like."

— Cell and Gene Therapy Focus Group Participant

Going to Scale: Manufacturing Barriers

Space and manufacturing at scale were both commonly cited by focus group participants as major barriers to growth and commercialization. This barrier is not unique to the Philadelphia region, and is an industry concern nationally and globally. Currently, many companies rely on contract manufacturing organizations or contract development and manufacturing organizations (CMOs/CDMOs) for therapy production; CMOs, because of their size and responsibilities, have workforce needs that are distinct from therapy startups. Roles like manufacturing technicians may increase in demand as technological innovations allow for growth in therapy manufacturing. Our discussions confirmed that there will likely be significant advances in terms of manufacturing over the next few years. Improvements in therapy technology and automation will likely alter future manufacturing footprints. In addition, participants believe that there will be an evolution to manufacturing on-site, which will reduce the space requirement and create efficiencies as firms move to commercialization.

"Manufacturing at scale and getting the cost of goods down is absolutely a barrier."

— Cell and Gene Therapy Focus Group Participant

Future Potential: Collaboration Opportunities

“I think the other thing that is important is this concept around work-based experiences that are embedded into these [education] programs. Not only internships but the apprenticeships and the pre-apprenticeship models that the state is starting to fund. I think that those obviously, if they’re built into the programs, make it a lot easier for the students to be employed at the end of that process.”
— Community College Focus Group Participant

In focus group discussions with deans, faculty, and administrators at community colleges, participants felt strongly that there was often a disconnect between industry perceptions and the reality of the quality of resources and training available at community colleges. Community colleges across the region have existing programs for hands-on lab training and manufacturing technicians, and are actively developing

biotech curricula. Community colleges recognize the importance of relationship-building in order to provide the best opportunities and training for their students; some colleges work with industry professionals when developing a new curriculum, or bring industry professionals in to teach a course.

Involving the cell and gene therapy industry up front will allow for tailored learning opportunities as well as a sustainable network of future opportunities for students. We heard from both industry and community college participants that work-based experiences, co-ops, and apprenticeships were crucial to adequately preparing students to enter the field. Additionally, there is the potential to expand awareness of local opportunities among students, faculty, and career services professionals, both in community colleges as well as four-year universities. One such example of a successful collaboration in the region is the Biomedical Technician Training Program, a joint effort between The Wistar Institute and Community College of Philadelphia to train community college students for careers as research assistants and technicians.

Growth Fields and Skills

Unsurprisingly, data science and data analytics were mentioned by nearly all focus groups as fields with significant potential for growth in the cell and gene therapy and connected health industries. While there is a large and growing demand for employees with these types of skills in a variety of industries, participants expressed that it was often difficult to find qualified people for these roles. Because these types of positions in data analysis, machine learning, and bioinformatics are quickly becoming standard in nearly every field, this is an area in which there is an urgent need to build and retain a pipeline of talent in the Philadelphia region.

“Huge growth field, machine learning, bioinformatics. It’s really, really hard to find good people and build those teams.”
— Cell and Gene Therapy Focus Group Participant

Patient-Centered Technology: Connected Health

“We do have an opportunity to build on some successes that we’ve had to create a talent pool. If you create a talent pool, that really helps drive some of the innovation. I think we do have a nice opportunity here. The question is whether it gels or not. Unfortunately, you really don’t know.”

— Connected Health Focus Group Participant

The focus group discussion among professionals in the connected health industry echoed some of the concerns regarding workforce from the cell and gene therapy focus group. The connected health industry can benefit from workers with backgrounds in health care, data science, and software development. Although the connected health field is rapidly evolving,

making it difficult to predict future workforce needs, this convergence of the leading-edge digital world and the traditional health care world means leveraging talent from a multiplicity of fields, including data analysis, machine learning, and bioinformatics. These types of positions are at the intersection of connected health and cell and gene therapy; a focus on attracting and retaining this talent could yield an exponential benefit to the region.

5. Existing Workforce Needs in Greater Philadelphia

5.1. Current Conditions in the Cell and Gene Therapy Sector

To identify the current supply of firms and talent in the Philadelphia region, ESI used the LinkedIn Talent Insights data portal to pull reports for a predetermined list of cell and gene therapy companies, biopharma companies, CMOs, research organizations, and academic research institutions/hospitals in the region.⁸ If the firm or institution has a LinkedIn page, the LinkedIn Talent Insights report pulls a variety of data, including number of employees, new hires, attrition rate, tenure, employee locations, titles, skills, and education. There were a few small cell and gene therapy companies (16.7 percent) that did not have LinkedIn pages, and thus were excluded from the analysis. Additionally, there may be some employees who do not have LinkedIn pages, and thus would be missing from the data. LinkedIn estimates that approximately 90 percent of professionals have LinkedIn pages and are captured in their Talent Insights portal, so these are generally appropriate estimates for the purposes of this analysis. Please see Appendix A for a complete list of companies included in the analysis.

Although not all employees work directly in life sciences (e.g., some work in IT, administration, HR, etc.), we have included the total number of employees at cell and gene therapy companies and CMOs in the

“In life sciences research, honestly, I don’t know where else people would want to go besides Philadelphia.”

— Cell and Gene Therapy Focus Group Participant

region in order to capture the scope of the industry and because these operational and administrative positions are dependent upon the existence of the cell and gene therapy industry. However, for biopharmaceutical companies, research organizations, and research hospitals/universities, which are generally much larger and more expansive in terms of the type of work conducted, we selected only those employees with skills in *genetics, gene therapy, cell therapy, immunology, or cell biology*. It is also important to note that LinkedIn skills are normally self-identified, so there may be self-selection bias in the count of employees with these skills.

At the end of 2019, there were approximately 4,900 total employees working in the Greater Philadelphia region at cell and gene therapy companies, CMOs, biopharma companies, research organizations, or research hospitals/universities in the cell and gene therapy fields. The average one-year growth of employees at these companies or organizations is roughly 56 percent, with that average skewed heavily by the significant growth from cell and gene therapy companies (112 percent). These organizations averaged 15 new hires over the past year, with most of the hires coming from biopharma companies in Greater Philadelphia (see Figure 5.1).

⁸ Biotech Company Database (2019). Retrieved February 24, 2020 from <https://biopharmguy.com/biotech-company-directory.php>.

Figure 5.1: Total employees and average growth in the cell and gene therapy industry in Greater Philadelphia

	Number of		Average 1Y Growth	Average 1Y Hires
	Firms	Total Employees		
Biopharma	6	1,815	-3.0%	32
CMO	14	1,059	8.5%	17
Cell and Gene Therapy Company	29	939	112.3%	11
University/Hospital	8	1,023	2.4%	13
Research Organization	2	96	19.9%	9
Total	59	4,932	56.0%	15

Source: LinkedIn Talent Insights (2019)

In terms of educational breakdown of employees in the cell and gene therapy industry, approximately 40 percent of employees have a PhD, 27 percent have a bachelor's degree, and 20 percent have a master's degree. There is some differential in educational attainment by industry category; for example, a majority of

"You can't come in as an associate and rise to the level of being a scientist without going back for that education. It's never going to happen. That's something that's different about the space. There's no leapfrog. Our scientists truly sit in one spot and they carry PhDs."

— HR Focus Group Participant

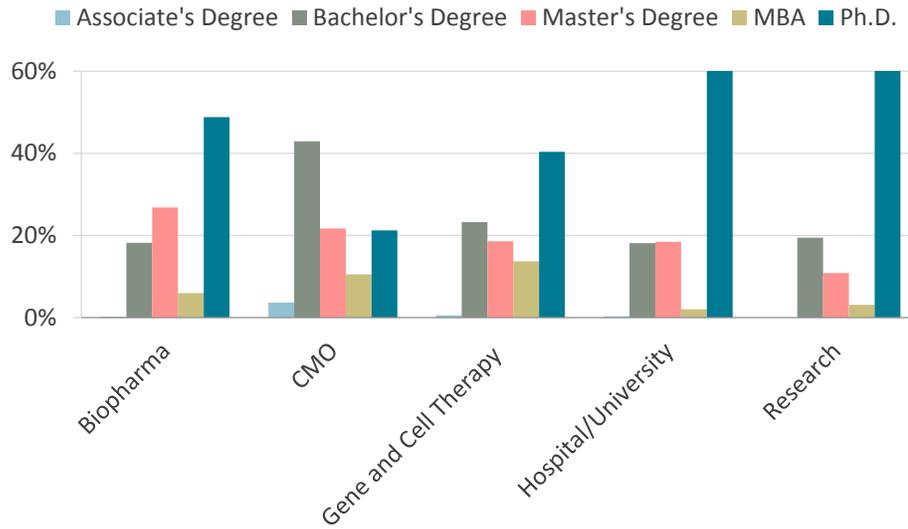
employees in universities/hospitals hold a PhD, while the majority of employees in CMOs have a bachelor's degree (see Figures 5.2, 5.3). This aligns with our focus group findings; small startups in particular need employees that are able to wear many hats—from experience with academic research and lab training to GMP and business operations, and that often means hiring talent with PhDs. This has potential implications for identifying appropriate workforce attraction and retention strategies for different types of organizations. While CMOs may find success in recruiting those with associate's degrees from The Wistar Institute's Biomedical Technician Training Program, for example, therapy startups are more likely to be pursuing workers with PhDs.

Figure 5.2: Educational attainment of employees by industry, 2019

	Average % with Associate's Degree	Average % with Bachelor's Degree	Average % with Master's Degree	Average % with MBA	Average % with PhD
Biopharma	0.2%	18.2%	26.8%	6.0%	48.8%
CMO	3.6%	42.9%	21.7%	10.5%	21.3%
Cell and Gene Therapy Company	0.6%	23.2%	18.6%	13.7%	40.4%
Hospital/University	0.3%	18.1%	18.5%	2.0%	61.0%
Research Organization	0.0%	19.5%	10.8%	3.1%	66.6%
Total	1.2%	26.6%	19.9%	10.2%	40.4%

Source: LinkedIn Talent Insights (2019)

Figure 5.3: Educational attainment of employees by industry, 2019



Source: LinkedIn Talent Insights (2019)

5.2. Current Conditions in the Connected Health Sector

In 2019, there were 739 professionals with skills in *connected health, digital health, telehealth, or mobile health* in Greater Philadelphia, a 35 percent increase over the past year. The talent pool is relatively stable, with approximately 16 people with these skills leaving the Philadelphia region in the past year and 11 people entering the Philadelphia region, with New York City and the Boston metro area being the top competitor regions.

The top organizations in Greater Philadelphia employing this talent include Penn Medicine, CHOP, and Merck. There is an evident overlap between employers in connected health and employers in the cell and gene therapy sector (see Figure 5.4).

Figure 5.4: Top employers of professionals with connected health skills, 2019

Employer	Professionals	1Y Growth
Penn Medicine, University of Pennsylvania Health System	19	+11.8%
Children's Hospital of Philadelphia	18	-14.3%
Merck	14	+16.7%
Johnson & Johnson	13	-18.8%
University of Pennsylvania School of Medicine	12	0.0%
University of Pennsylvania	11	+10.0%
Comcast	10	0.0%
GSK	9	0.0%
ChristianaCare	8	+14.3%
Thomas Jefferson University Hospitals	8	+14.3%

Source: LinkedIn Talent Insights (2019)

The workforce in Greater Philadelphia with connected health skills is educated primarily at the University of Pennsylvania, Temple University, Drexel University, and Penn State University. Schools outside of the region that have graduates working in Philadelphia include the University of Michigan, Cornell University, Johns Hopkins University, and Boston University.

The majority of people with these skills hold a bachelor’s degree or higher, with 19 percent with an MBA and roughly 25 percent with a PhD. Unlike the cell and gene therapy sector, connected health employers tend to be larger, more established organizations, and thus hire a more diverse mix of education levels.

Figure 5.5: Educational attainment among connected health professionals in Greater Philadelphia, 2019

Educational Attainment	Total professionals
Associate's Degree	0.7%
Bachelor's Degree	34.9%
Master's Degree	20.4%
MBA	19.3%
PhD	24.5%

Source: LinkedIn Talent Insights (2019)

The top programs of study among professionals with skills in connected health are Marketing, Biology, and Business Administration and Management. As noted in our focus group discussions, those with backgrounds in Computer Science will continue to find roles within connected health organizations. Overall, professionals with connected health skills come from a variety of fields, with over 90 different programs listed among these professionals.

Figure 5.6: Top programs of study among connected health professionals in Greater Philadelphia, 2019

Program of study	Professionals	% of Total
Marketing	68	6%
Biology, General	58	5%
Business Administration and Management, General	57	5%
Psychology	54	5%
Health/Health Care Administration/Management	54	5%
Economics	42	4%
Finance, General	38	3%
Registered Nursing/Registered Nurse	34	3%
Computer Science	32	3%
Medicine	29	2%

Source: LinkedIn Talent Insights (2019)

Growing skills among these professionals include customer experience, digital health, and artificial intelligence. These growing skills were echoed by our focus group participants, who identified machine learning, artificial intelligence, and user experience as highly desirable skills for the future of connected health.

“In terms of some of the skills I think are required, I think the engineering and IT side are certainly important. Machine Learning seems to be becoming in my field in terms of how to apply those techniques to medical applications.”

— Connected Health Focus Group Participant

Growing position titles include Project Manager, Consultant, Digital Specialist, and Program Manager.

Figure 5.7: Top growing skills among connected health professionals in Greater Philadelphia, 2019

Growing Skill	1Y Growth	Professionals
Customer Experience	+140.0%	47
Digital Health	+120.0%	359
Artificial Intelligence (AI)	+87.5%	44
User Experience (UX)	+33.3%	45
Machine Learning	+30.0%	40
Salesforce.com	+21.4%	67
Telehealth	+21.2%	207
Healthcare Industry	+21.1%	48
Agile Methodologies	+19.4%	49
Life Sciences	+18.0%	131

Source: LinkedIn Talent Insights (2019)

6. Scenarios and Projections for Regional Cell and Gene Therapy Growth

6.1. Talent Supply and Demand Analysis

“You’ve got all these entities in Philadelphia. I know one thing, what’s important to do is to create a buzz around this cell and gene therapy, the potential of this region being the cell and gene therapy focus in the country. There should be some kind of concerted effort to say, Philadelphia’s open for the life science business. Really attract talent, innovators to come to Philadelphia to work.

— Cell and Gene Therapy Focus Group Participant

To determine the gaps in cell and gene therapy workforce supply in Greater Philadelphia, ESI utilized labor insight data from Burning Glass Technologies (Burning Glass), a market analytics software company, to capture demand for cell and gene therapy workers through recent job postings by firms in the Philadelphia region. Using a sample of cell and gene therapy companies, CMOs, and biopharma companies in the Greater Philadelphia region, ESI collected data on job

titles, programs of study, and skills listed in job postings from 2016 to 2019. This sample identifies and informs the top skills in demand by employers in cell and gene therapy in the region.

Due to the small size of most cell and gene therapy firms in the region, the majority did not have job postings data; therefore, these demand-side data comes from five firms with a presence in the Philadelphia region: Adaptimmune, Amicus Therapeutics, Century Therapeutics, Inovio Pharmaceuticals, and Spark Therapeutics. As startup growth in the cell and gene therapy industry is dependent on FDA approval, data from larger companies with approved therapies (like Spark Therapeutics) provide useful insights into future workforce trends and potential workforce demand strategies as more startups in the region grow and commercialize.

The sample also included two CMOs (Wuxi AppTec and Frontage Laboratories) and five biopharma companies (Merck, Roche, Amgen, GSK, and Novartis). In order to select only those within biopharma working in the cell and gene therapy sector, the biopharma data were filtered to include only those job postings with skills including at least one of the following: *genetics, gene therapy, cell therapy, immunology, or cell biology*. From all job postings, ESI aggregated the data into the top ten job titles, programs, and skills desired during the aforementioned time period.

The top job title within the cell and gene therapy sector in Greater Philadelphia was *Laboratory Technician*, with 264 postings (32 percent) for this position during the time frame. The next most posted job title was *Clinical Manager* with 97 postings (12 percent), followed by *Quality Assurance Specialist* with 94 postings (11 percent). In terms of workforce supply of these positions, in the Philadelphia region in 2019, 84 LinkedIn members had *Laboratory Technician* as a current job title AND included at least one of these skills in their profile: *genetics, gene therapy, cell therapy, immunology, or cell biology*. Additionally, there were 41 LinkedIn members with the job title *Clinical Manager* and 48 with the title *Quality Assurance Specialist*.

In order to capture LinkedIn members with similar job titles, we included additional searches for some of the job titles in Figure 6.1: Laboratory Technician also includes those with the title Medical Laboratory Technician and Microbiology Laboratory Technician, Clinical Manager also includes Clinical Project Manager and Clinical Research Manager, Development Associate includes Business Development Associate, Development Assistant, and Business Development Specialist, Operations Specialist includes Business Operations Specialist, Operations Supervisor, Operations Manager, and Operational Specialist.

Figure 6.1: Top 10 job titles from job postings by cell and gene therapy organizations in Greater Philadelphia, 2016-2019, and LinkedIn members by job title and skillset, 2019

Job Title	Number of Postings	Percent	Number of LinkedIn Members
Laboratory Technician	264	32%	84
Clinical Manager	97	12%	41
Quality Assurance Specialist	94	11%	48
Development Associate	92	11%	11
Intern	49	6%	12
Biologist	49	6%	23
Operations Specialist	48	6%	36
Scientist	52	6%	407
Associate Scientist	45	5%	132
Manufacturing Associate	42	5%	18
Total	832		84

Source: Burning Glass Technologies (2019), LinkedIn Talent Insights (2019)

During the same time period, the top program of study desired by Greater Philadelphia firms was *Biology/Biological Sciences*, with 800 postings (28 percent) mentioning this program of study. The next most desired program of study was

“When you’re hiring manufacturing, you need people with prior biologics experience. Quite honestly, we’re looking at engineering programs.”
 — HR Focus Group Participant

Business Administration and Management with 416 postings (15 percent), followed by *Chemistry* with 311 postings (11 percent). Interestingly, one of the top three programs of study by job posting was not in the life sciences, suggesting that as cell and gene therapy firms grow, their workforce needs expand beyond those with a specific background in the biotechnology sector (see Figure 6.2). Aside from degrees in the life sciences, focus group participants mentioned engineering as well as MBA programs in the region from which they are recruiting talent.

On the supply side, the number of LinkedIn professionals (with at least one of the five skills: *genetics, gene therapy, cell therapy, immunology, or cell biology*) with one of the top programs of study listed in job postings is shown in Figure 6.2. With the exception of *Business Administration, General Engineering, and Computer Science*, there is adequate supply of professionals in the Philadelphia area with the desired programs of study.

Figure 6.2: Top 10 programs of study from job postings by cell and gene therapy organizations in Greater Philadelphia, 2016-2019, and number of LinkedIn Professionals

Program	Number of Postings	Percent	LinkedIn Professionals
Biology/Biological Sciences, General	800	28%	933
Business Administration and Management, General	416	15%	276
Chemistry	311	11%	1,268
Immunology	305	11%	593
Cell/Cellular and Molecular Biology	253	9%	350
Molecular Biology	248	9%	1,122
Engineering, General	221	8%	-
Computer Science	127	4%	109
Virology	97	3%	160
Bioengineering and Biomedical Engineering	74	3%	514
Total	2,852		

Source: Burning Glass Technologies (2019)

“I would say soft skills are a little more important than hard skills. For us, it's being able to function in a team. Entrepreneurial. Get it done. Good communication. Communication, communication, communication, so important.”

— Cell and Gene Therapy Focus Group Participant

The top skills listed in job postings from 2016 to 2019 were *Current Good Manufacturing Practices (cGMP)* with 1,159 postings (14 percent), *Good Laboratory Practices (GLP)* with 1,077 postings (13 percent), and *Biotechnology* with 831 postings (10 percent). In focus group discussions, we heard that regardless of a

potential employee’s program of study, firms hope to hire candidates with some knowledge of or experience with cell and gene therapy processes and practices (see Figure 6.3). While not captured in the LinkedIn data, soft skills like entrepreneurial spirit and a team mentality were repeatedly mentioned in focus groups as something that could set apart a potential candidate. On the supply side, there is a shortage of individuals in the Philadelphia area with skills in *Current Good Manufacturing Practices (cGMP)*, *Good Laboratory Practices (GLP)*, *Gene Therapy*, and *Batch Records*.

Figure 6.3: Top 10 skills from job postings by cell and gene therapy organizations in Greater Philadelphia, 2016-2019, and number of LinkedIn professionals with those skills

Skill	Number of Postings	Percent	LinkedIn Professionals
Current Good Manufacturing Practices (cGMP)	1,159	14%	145
Good Laboratory Practices (GLP)	1,077	13%	952
Biotechnology	831	10%	4,533
Gene Therapy	780	10%	233
Project Management	748	9%	60,082
Good Manufacturing Practices (GMP)	744	9%	2,188
Batch Records	711	9%	112
Quality Assurance and Control	710	9%	10,745
Scheduling	704	9%	1,652
Immunology	662	8%	1,480
Total	8,126		

Source: Burning Glass Technologies (2019), LinkedIn Talent Insights (2019)

From the top ten skills in demand among the sample of cell and gene therapy companies, CMOs, and biopharma companies in the Greater Philadelphia region, ESI isolated the gaps in supply by comparing the demanded skills with the region’s supply of those skills gathered from LinkedIn Talent Insights. For each skill identified as “in demand” by cell and gene therapy organizations, we used Burning Glass to collect data on the number of times that skill was mentioned in a job posting in the Philadelphia metro area in 2019. We also used Burning Glass to capture the total number of job postings in the same region over the same time period in order to get the proportion of overall demand for a particular skill.

Using the same skills identified through Burning Glass, we gathered data on the number of LinkedIn profiles in Greater Philadelphia that mention each skill and calculated a proportion of total employment based on U.S. Bureau of Labor Statistics data. Certain skills identified in the top ten are not explicitly related to the cell and gene therapy industry (e.g., GMP, quality assurance and control, project management). In these instances, we queried a subset of those profiles that also included “biotechnology.” For example, for project management, we queried “project management AND biotechnology”, as indicated in the figure below.

A ratio of supply and demand was used to detect gaps in workforce supply; in the figure below, the skills with a ratio equal to or greater than one are considered to be meeting the region’s demand, whereas a ratio less than one indicates that the

current workforce is not meeting the industry’s demand. Gene therapy, batch records and biotechnology, and scheduling and biotechnology skills in the Philadelphia region are currently not meeting industry demand. However, these are relatively narrow skills compared to skills like QA/QC

“These students, every certain number of years, are going to have to have professional development, because this industry is rapidly changing. If we put them out with a narrow skill set, they’re not going to be employed 5 to 8 years out because the needs in these labs are going to change.”

— Community College Focus Group Participant

or immunology, where supply can come from a variety of fields. It is also difficult to identify relevant skills in a nascent and rapidly evolving industry like cell and gene therapy; from focus group discussions,

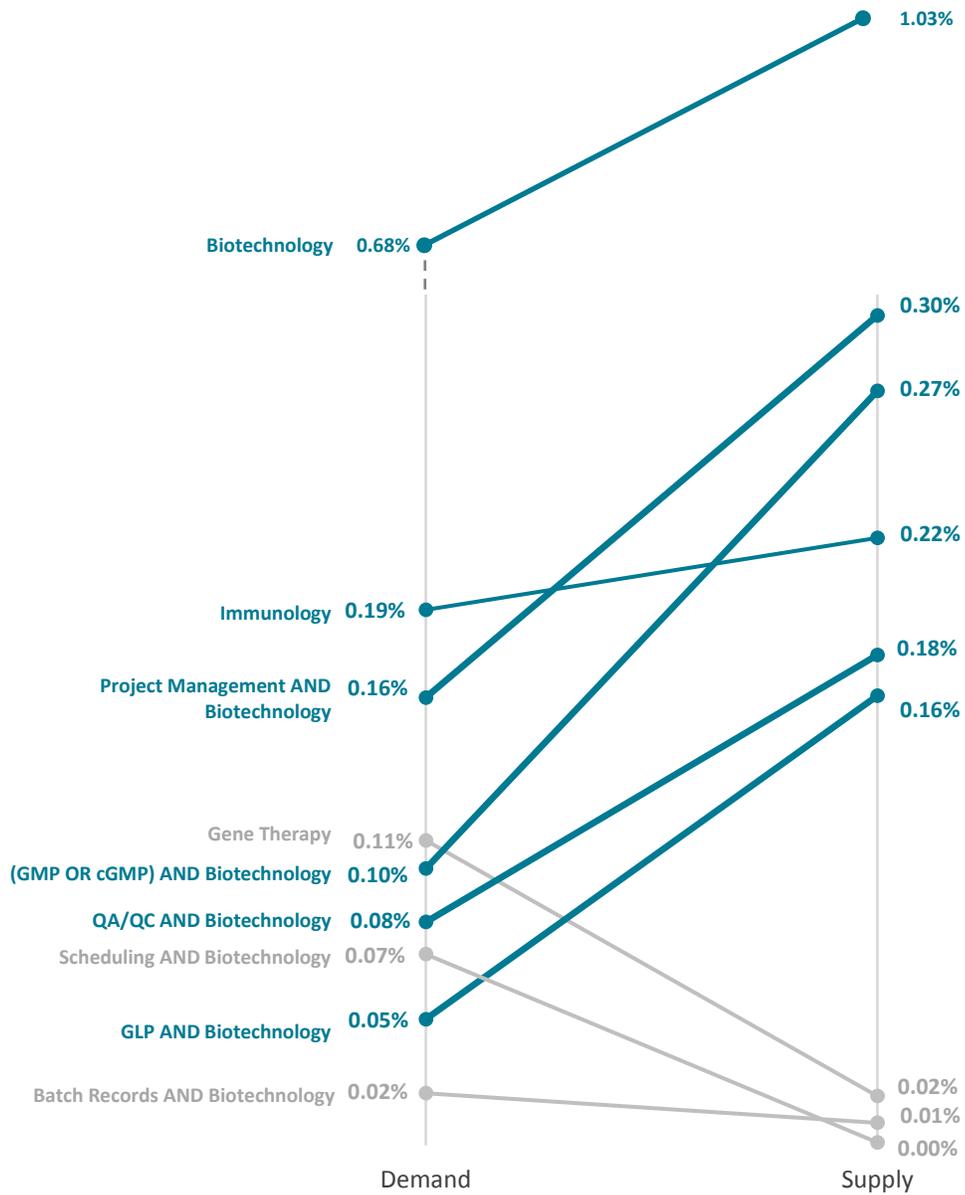
academic institutions are already thinking about how to update their curricula to prepare students to meet the demand of an emerging industry.

Figure 6.4: Skills supply/demand analysis among cell and gene therapy companies, CMOs, and universities/hospitals in Greater Philadelphia

Skill	Demand - % of Job Postings with Skill	Supply - % of Employees with Skill	Ratio
GLP AND Biotechnology	0.05%	0.16%	3.57
cGMP OR GMP AND Biotechnology	0.10%	0.27%	2.73
QA/QC AND Biotechnology	0.08%	0.18%	2.20
Project Management AND Biotechnology	0.16%	0.30%	1.85
Biotechnology	0.68%	1.03%	1.50
Immunology	0.19%	0.22%	1.13
Batch Records AND Biotechnology	0.02%	0.01%	0.43
Gene Therapy	0.11%	0.02%	0.16
Scheduling AND Biotechnology	0.07%	0.00%	0.01

Source: LinkedIn Talent Insights (2019), Burning Glass Technologies (2019), Bureau of Labor Statistics, Econsult Solutions (2019)

Figure 6.5: Skills supply/demand analysis among cell and gene therapy companies, CMOs, and universities/hospitals in Greater Philadelphia



Source: LinkedIn Talent Insights (2019), Burning Glass Technologies (2019), Bureau of Labor Statistics, Econsult Solutions (2019)

6.2. Attrition and Movement of Workforce within Philadelphia

“When you look at the challenges, it’s been, can you convince people to take that leap of faith and how do you attract, motivate and retain people. At the same time, there is this war for talent that’s coming into Philadelphia, so the retention of the talent is important. At the same time, you’re going through a natural evolution very quickly on talent that was excellent at one stage of an organization, is not the talent that will take you through to the next stage. That ability for your organization to see that and to maneuver around it is critical.”

— HR Focus Group Participant

An important component of the workforce assessment is a comprehensive understanding of workforce retention and attrition. To attract talent willing to relocate from another competitive region, it is necessary to know from what regions we are currently successful in attracting talent, and to what regions we are losing potential talent. Based on the proportions of our sample, we selected five cell and gene therapy companies, one pharmaceutical company, two CMOs, and two universities/hospitals and examined their

departures and hires over the last twelve months.

For departures and hires within Greater Philadelphia, only Inovio Pharmaceuticals and Adaptimmune had a negative net change within the past year, with a net loss of 30 employees and 4 employees, respectively.⁹ The other select cell and gene therapy companies, biopharmaceutical companies, CMOs, and university/hospitals within the region experienced positive employee growth in the past year, with a total net increase of 178 employees.

Figure 6.6: Departures and hires for select organizations in Greater Philadelphia, 2019

Category	Name	Departures	Hires	Employees	Net Change
Cell and gene therapy Company	Adaptimmune	29	25	142	-4
Cell and gene therapy Company	Amicus Therapeutics	7	35	83	+28
Cell and gene therapy Company	Inovio	43	13	77	-30
Cell and gene therapy Company	Spark Therapeutics	29	98	349	+69
Cell and gene therapy Company	Tmunity	6	21	46	+15
Biopharma	Novartis*	1	4	20	+4
CMO	Frontage Laboratories	28	39	180	+11
CMO	Wuxi AppTec	61	85	283	+24
University/Hospital	CHOP*	32	46	384	+14
University/Hospital	Penn Medicine*	13	26	178	+13

*Skills include at least one of the following: Genetics, Gene Therapy, Cell Therapy, Immunology, Cell Biology

Source: LinkedIn Talent Insights (2019)

⁹ The net loss from Inovio Pharmaceuticals is due in part to layoffs in July 2019 of approximately 80 employees due to the termination of a Phase 1/2 study. Source: Pagliarulo, N. (2019). Inovio cuts staff, research to buy time. Biopharmadive. Retrieved February 24, 2020 from <https://www.biopharmadive.com/news/inovio-cuts-staff-research-to-buy-time/558949/>.

Regarding the types of industries from which the cell and gene therapy sector attracts talent, most hires are coming from universities/hospitals, pharmaceuticals, research, and biotechnology. Cell and gene therapy companies saw the most departures to the biotechnology and pharmaceuticals industries in the past year, while university/hospitals saw the most departures within universities/hospitals. The university/hospitals industry experienced the greatest net change (+168 hires) with a total of 219 hires and 51 departures in the past year.

Figure 6.7: Departures and hires by industry for select organizations in Greater Philadelphia, 2019

Industry	Cell and gene therapy Companies		Biopharma		CMOs		University/Hospitals		Total Departures	Total Hires	Net Change
	Departures	Hires	Departures	Hires	Departures	Hires	Departures	Hires			
University/Hospitals	5	47	15	82	2	37	29	53	51	219	+168
Research	4	5	6	60	0	4	1	9	11	78	+67
Pharmaceuticals	27	51	142	184	39	23	6	6	214	264	+50
Biotechnology	34	45	66	62	18	7	3	4	121	118	-3

Source: LinkedIn Talent Insights (2019)

6.3. Comparative Analysis of Competitive Regions in the U.S.

Qualitatively, focus group participants could effortlessly identify what sets Philadelphia apart from other regions dominating in the cell and gene therapy sector. To remain competitive, the region also needs quantitative data to identify labor supply shortages and comparative advantages to other regions.

In order to understand how Philadelphia fits into the overall landscape of the cell and gene therapy sector within the United

States, ESI utilized LinkedIn Talent Insights to compare the Greater Philadelphia region to its largest competitors nationally: Boston, San Francisco, New York City, Washington, D.C.-Baltimore, San Diego and Raleigh-Durham-Chapel Hill. These competitor regions were identified and selected based on industry knowledge and an exploratory analysis of LinkedIn Talent Insights and Burning Glass data. The talent demand analysis within each of these metropolitan areas is based on LinkedIn users' self-reported skills. A user was included in the analysis if any of the following skills were included in their profile: *genetics, gene therapy, cell therapy, cell biology, immunology, and biotechnology*. *Biotechnology*, as it includes a broad subset of the population, was included as a skill here in order to accurately identify the potential labor pool, regardless of whether or not someone is currently working within the cell and gene therapy sector. These skills were selected based on focus group analysis, local survey results, and skill demand analysis from Burning Glass.

“Philadelphia’s an easy place to relocate people to, if they’re willing to leave out of Boston, out of San Francisco, out of other major cities, because of what it does offer. You do have a city where a story is starting to really launch itself. It is more affordable in many, many ways. Cambridge can become tiring for people. At the same time, Philly is a very rooted city. So is Boston. You’re trying to get to people that are transient and that can be hard to find.”

— HR Focus Group Participant

Labor Supply

There are currently over 32,000 professionals in the Greater Philadelphia area with the basic skillset identified for entry into the cell and gene therapy sector. While the over-the-year growth of professionals with these skills locating in Philadelphia (3.2 percent) lagged its regional competitors, the average salary (\$97,533) for individuals with the skillset needed for the cell and gene therapy sector is currently higher than all other locations once adjusted for differences in regional cost of living. This analysis identifies another unique value proposition of the Philadelphia region: its relatively low cost of living while still providing all the amenities and accessibility associated with living in a large city.

Figure 6.8: Total talent, growth, demand, and compensation within each region, 2019

	Professionals	Over the year growth	Job posts	Hiring demand	Average Compensation	Adjusted for Regional Price Parity
San Diego	20,574	+4.6%	736	Very high	\$95,900	\$82,672
Greater Boston	70,518	+4.5%	3,815	Very high	\$93,300	\$83,453
San Francisco Bay Area	69,362	+4.2%	2,915	Very high	\$123,400	\$96,406
New York City Metropolitan Area	72,177	+4.1%	2,043	Very high	\$104,500	\$85,446
Washington DC-Baltimore Area	38,703	+4.1%	812	Very high	\$87,700	\$74,071
Raleigh-Durham-Chapel Hill Area	21,821	+4.1%	852	Very high	\$82,400	\$86,555
Greater Philadelphia	32,169	+3.2%	727	Very high	\$102,800	\$97,533

Source: LinkedIn Talent Insights (2019)

Regional Talent Gain and Loss

The number of professionals with the aforementioned skillsets grew slightly in Greater Philadelphia in 2019, with 797 professionals leaving the region, and 825 professionals entering the region. This growth is slightly less than that in Greater Boston, the San Francisco Bay Area, and Raleigh-Durham-Chapel Hill. San Diego, Washington, D.C.-Baltimore and New York City experienced a net loss of this talent in 2019.

Figure 6.9: Total cell and gene therapy talent lost and gained by region, 2019

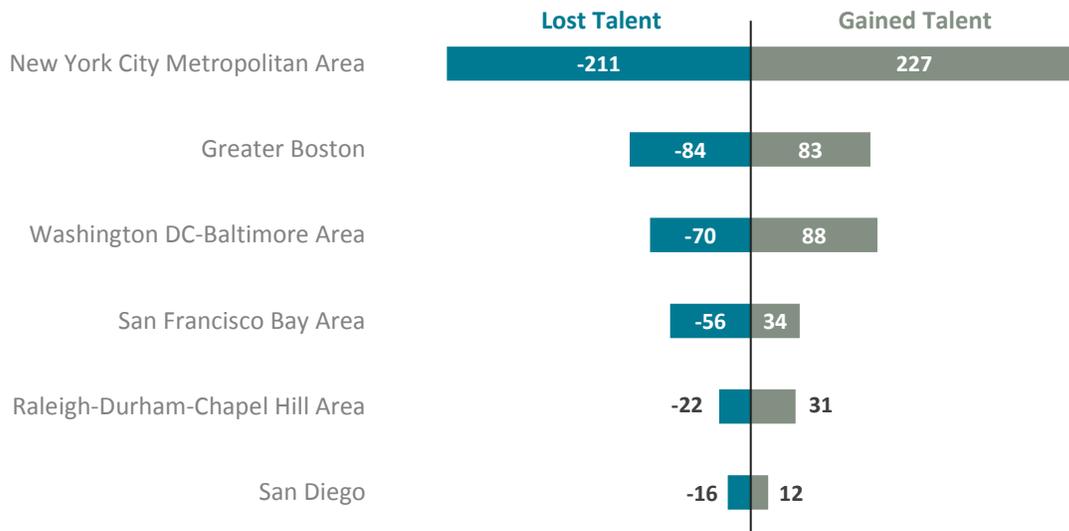
Region	Total Talent Lost	Total Talent Gained	Ratio
Greater Boston	1,660	2,062	1.24
San Francisco Bay Area	1,798	2,053	1.14
Raleigh-Durham-Chapel Hill Area	597	645	1.08
Greater Philadelphia Area	797	825	1.04
San Diego	346	345	-1.00
Washington DC-Baltimore Area	1,215	1,112	-1.09
New York City Metropolitan Area	2,204	1,940	-1.14

Source: LinkedIn Talent Insights (2019)

Of the 797 professionals with one of these skills who left the Philadelphia region in 2019, 211 went to the New York City metro area, 84 went to Greater Boston, and 70 went to Washington, D.C.-Baltimore. Of the 825 professionals who moved to the Philadelphia region, 227 came from the New York City metro

area, 83 came from Greater Boston, and 88 came from Washington, D.C.-Baltimore. From the figure below, Greater Philadelphia experienced notable net gains in talent from Washington, D.C.-Baltimore, Raleigh-Durham-Chapel Hill, and New York City, and a net loss of talent to San Francisco and San Diego. Not shown below, the Philadelphia region also experienced a net gain from State College, PA, Chicago, IL, Atlanta, GA, Detroit, MI, and Dallas, TX, and a net loss of talent to Seattle, WA, Denver, CO, Madison, WI, and Houston, TX in 2019.

Figure 6.10: Greater Philadelphia's largest talent gains and losses within the cell and gene labor pool, by region, 2019



Source: LinkedIn Talent Insights (2019)

New Graduate Labor Supply

When considering priority regions for attracting talent to Greater Philadelphia, it is useful to look at the total number of recent graduates with these skills in each region. In absolute numbers, Greater Boston has the largest number of LinkedIn professionals with these skills with a graduation date between 2016 and 2020, followed closely by the San Francisco Bay Area and the New York City metro area. There are approximately 2,889 recent graduates with these skills living within Greater Philadelphia; however, it is important to note that this number only captures those individuals that have self-identified as having one of a limited set of skills, and does not capture the totality of qualified graduates in the region (see Figure 6.11).

Figure 6.11: Recent graduates within the cell and gene labor pool located in each region, 2016-2020

	Recent Graduates
Greater Boston	8,181
San Francisco Bay Area	7,414
New York City Metropolitan Area	6,545
Washington, DC-Baltimore Area	4,147
Greater Philadelphia	2,889
Raleigh-Durham-Chapel Hill Area	2,542
San Diego	2,291

Source: LinkedIn Talent Insights (2019)

The schools with the largest number of graduates working in the Philadelphia region are the University of Pennsylvania, Temple University, Drexel University, the University of Delaware, and Penn State University. Schools outside of the region with a significant number of recent graduates working in the Philadelphia region include Johns Hopkins University, Cornell University, University of Pittsburgh, Northeastern University, and Duke University. For a complete list of universities with recent graduates in Greater Philadelphia, see Appendix B.

Regarding departures from the Philadelphia region, 140 recent graduates from the Philadelphia region are currently working in Greater Boston: 68 from the University of Pennsylvania, 36 from Rutgers University, and 36 from Penn State University. More significantly, 1,098 recent graduates from the region are currently working in the NYC metro area: 720 from Rutgers University, 172 from the University of Pennsylvania, 66 from Penn State University, 37 from Temple University, 44 from the University of Delaware, 43 from Drexel University, and 16 from the University of the Sciences.

Regional Value Proposition Importance

“In our recruitment, how do we start advertising [Philadelphia’s success] because we’re not finding that that is one of the attractions yet. We’re starting to push that as our messaging a bit more - the reasons to come to Philadelphia or what the benefit to being in this area is.”

— HR Focus Group Participant

In 2018, LinkedIn asked users of its site to rank employers’ value propositions by importance. Those with the aforementioned skillset in Greater Philadelphia ranked their top three value propositions as *excellent compensation and benefits, good work-life balance, and challenging work*. As explored in the focus group discussions, one of the challenges of attracting workers to the cell

and gene therapy industry was how to explain a startup’s value proposition. While compensation and benefits might not be competitive in absolute terms with more expensive cities like New York or San Francisco, Philadelphia’s attractiveness is strengthened by its cost of living (as seen in Figure 6.8). Further, because Philadelphians value *challenging work*, startups here have an opportunity to stress to potential employees an exciting work experience and the prospect of gaining a unique and desirable skillset.

Interestingly, while *excellent compensation and benefits* and *good work-life balance* were ranked as either first or second within all regions, *colleagues and culture that inspire employees to do their best* was consistently ranked in the top four for all regions. This information can prove to be beneficial to attract talent from other regions to Philadelphia (see Figure 6.12).

Figure 6.12: Value proposition importance within the cell and gene therapy labor pool by region, 2018

Value proposition by importance	Philadelphia	New York	Raleigh-Durham	San Francisco	Boston	Washington, DC	San Diego
Excellent compensation and benefits	1	1	2	1	1	1	1
Good work-life balance	2	2	1	2	2	2	2
Challenging work	3	6	7	8	5	4	7
Colleagues and culture that inspire employees to do their best	4	3	3	3	3	3	4
Flexible work arrangements	5	9	5	9	7	6	8
Open and effective management	6	5	4	4	4	5	3
Job security	7	10	9	11	11	8	12
Role that meaningfully impacts the company's success	8	4	6	7	6	10	5
A company with a purposeful mission	9	8	8	6	10	7	6
Employees have influence over their tasks and priorities	10	11	12	10	9	11	9
Convenient commute to work	11	7	10	5	8	9	11
An industry-leading company with high caliber talent	12	12	15	12	12	15	10
Opportunity for rapid advancement within the company	13	14	14	14	14	13	13
Inclusive workplace for people of diverse backgrounds	14	13	11	13	13	12	15
Investment in comprehensive and ongoing employee training	15	15	13	15	15	14	14

Source: LinkedIn Talent Insights (2019)

Growing Skills

Although this analysis focused only on six particular skills within the cell and gene therapy workforce, there is a deeper pool of talent in Philadelphia with other skills that are necessary to commercialize, including data analysis, machine learning, programming, and information technology. The fastest growing skills among LinkedIn professionals in Greater Philadelphia with a gene and cell therapy skillset include Biology, Troubleshooting, Data Analysis, and Analytical Skills. In this usage, Troubleshooting is defined as the logical, systematic process of identifying and resolving errors or faults within a software or computer system. Comparison regions like New York City, Boston, and Raleigh-Durham-Chapel Hill are experiencing similar trends.

As confirmed by our focus group discussions, these growing skills in data analysis present a huge opportunity for

“In particular, we’re looking at how AI and analytics are going to be at the cross section of everything from precision medicine to work in labs to almost any field you could imagine. That’s where we’re putting a lot of our strategic planning and a lot of our investments these days.”

— Cell and Gene Therapy Focus Group Participant

Philadelphia to secure a foothold in the emergent data science field and attract and retain qualified talent that can support a variety of industries. Focus group participants in both the cell and gene therapy group and connected health group identified data analysis and similar skills including machine learning, information technology, and bioinformatics as in-demand skills in the industry. Creating and nurturing this talent pool will help drive innovation in the Philadelphia region in both the cell and gene therapy industry and the connected health industry (see Figure 6.13).

Figure 6.13: Fastest growing skills within the cell and gene therapy labor pool, by region, 2019

<i>Skills</i>	<i>YOY Growth</i>	<i>Skills</i>	<i>YOY Growth</i>
Philadelphia		San Francisco	
Biology	16.3%	Python (Programming Language)	+20.4%
Troubleshooting	11.6%	Biology	+16.6%
Data Analysis	8.4%	Troubleshooting	+13.0%
Analytical Skills	7.6%	R	+11.4%
Real-Time Polymerase Chain Reaction	7.1%	Data Analysis	+8.8%
New York City		Boston	
Biology	+16.9%	Biology	+17.2%
Data Analysis	+9.5%	R	+12.8%
Analytical Skills	+8.8%	Troubleshooting	+11.3%
Analytics	+7.8%	Analytics	+9.9%
Flow Cytometry	+6.6%	Analytical Skills	+9.8%
Raleigh-Durham-Chapel Hill		Washington, DC-Baltimore	
Biology	+15.7%	R	+13.7%
Troubleshooting	+9.9%	Biology	+12.7%
Analytical Skills	+9.6%	Troubleshooting	+12.6%
Data Analysis	+9.1%	Databases	+9.0%
Aseptic Technique	+8.2%	Data Analysis	+7.8%
San Diego			
Biology	+23.3%		
Technical Support	+15.9%		
Troubleshooting	+15.5%		
R	+14.0%		
Analytical Skills	+14.0%		

Source: LinkedIn Talent Insights (2019)

6.4. Critical Uncertainties and Scenario Development

From focus group discussions, interviews, and survey data, ESI developed four potential scenarios for the future of the cell and gene therapy industry. Focus group discussions probed participants about critical uncertainties of the growth potential of the industry; the range of those uncertainties was then used to frame the scenario matrix.

“Space [is a barrier]. Ability to grow. For your development pathway, you need to know that you’re going to be able to grow into the next facility that you need at each stage.”

— Cell and Gene Therapy Focus Group Participant

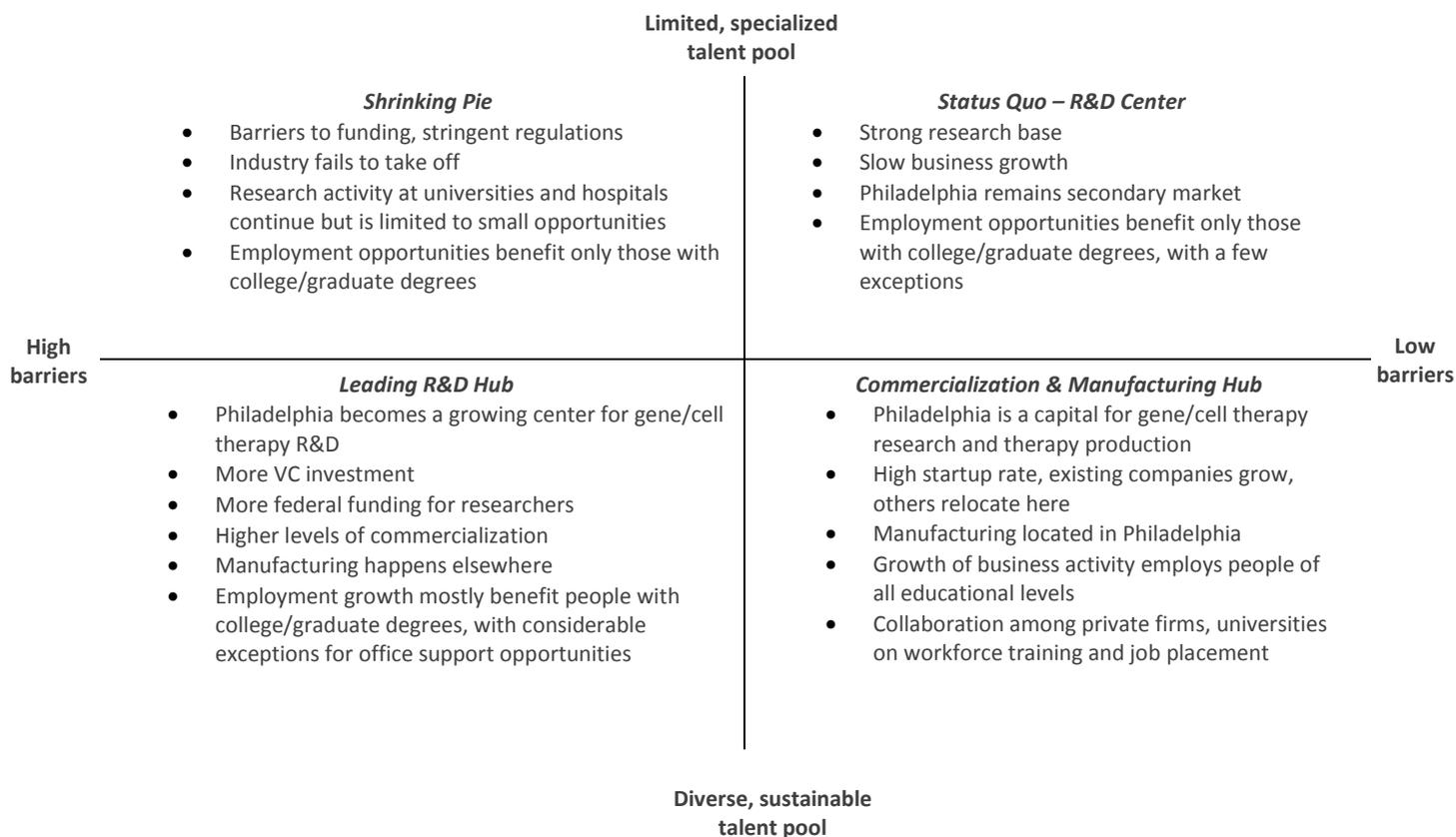
as significant barriers to success in the industry. While the region benefits from legacy pharma space in the Philadelphia suburbs, participants expressed concern about attracting their workforce out of the city. Relatedly, participants voiced difficulty in attracting and retaining qualified talent, in particular therapy manufacturing labor and data analytics and programming labor. The first uncertainty presents a range of scenarios based on the presence of barriers – from low barriers to high barriers. The second uncertainty creates scenarios based on the availability of talent in the region – resulting in a limited, specialized talent pool or a diverse, sustainable talent pool.

Our research identified two priority critical uncertainties: 1) contextual or environmental barriers to industry growth, including regulations, infrastructure, and funding, and 2) workforce development, attraction, and retention. Focus group participants identified space and the ability to manufacture at scale

“That’s a problem in Philadelphia. If you have a bunch of startup companies, all of whom are looking for the same leadership talent. Then you’re basically cannibalizing the success in your region because not enough people are attracted.”

— Cell and Gene Therapy Focus Group Participant

Figure 6.14: Four scenarios for the cell and gene therapy industry in Philadelphia



Source: Econsult Solutions (2019)

“Automation is going to be a big factor, actually. It will bring the cost of goods down, make things more reproducible. [Currently] there are a lot of individual tests that are all done with different techniques and different timing. There’s a lot of innovation that needs to go into making this a really streamlined and efficient process.”

— Cell and Gene Therapy Focus Group Participant

Our discussion and following projections will focus on the two scenarios framed by a diverse, sustainable talent pool: *Leading R&D Hub* and *Commercialization & Manufacturing Hub*. The *Leading R&D Hub* scenario is proportionate with current levels of growth in the industry in Greater Philadelphia. Conditions necessary for this scenario’s success include the adoption or

support of growth-oriented business practices, which leads to increased commercialization of research, and a growth-oriented business environment, which in turn incentivizes startup growth and attracts established businesses to the region. Technological advancements in therapy development will also accelerate the growth of the industry. A growth scenario focused on research and development implies that most startups remain small and may not succeed at commercialization, either in the region, or at all. Relatedly, manufacturing happens elsewhere in this scenario, limiting the potential for manufacturing technician positions to grow in the Philadelphia region.

The *Commercialization & Manufacturing Hub* scenario envisions an environment in which there are few to no barriers for startups in terms of regulations, funding, or infrastructure, and the Philadelphia region has succeeded in attracting and retaining a diverse, well-qualified talent pool. In this scenario, the Philadelphia

region continues to grow as a dominant location for cell and gene therapy research and production in the U.S. This scenario results in a high startup rate, exponential growth for existing companies, and an abundance of firms as well as an accomplished workforce relocating to and growing in the region. In contrast to the previous scenario discussed, the *Commercialization & Manufacturing Hub* scenario presupposes that therapy manufacturing will locate within the Philadelphia region, and this growth will employ people from a multiplicity of educational levels and fields of study. The realization of this scenario is dependent upon well-defined collaboration among private firms, universities, and other organizations on workforce training and job placement in the region.

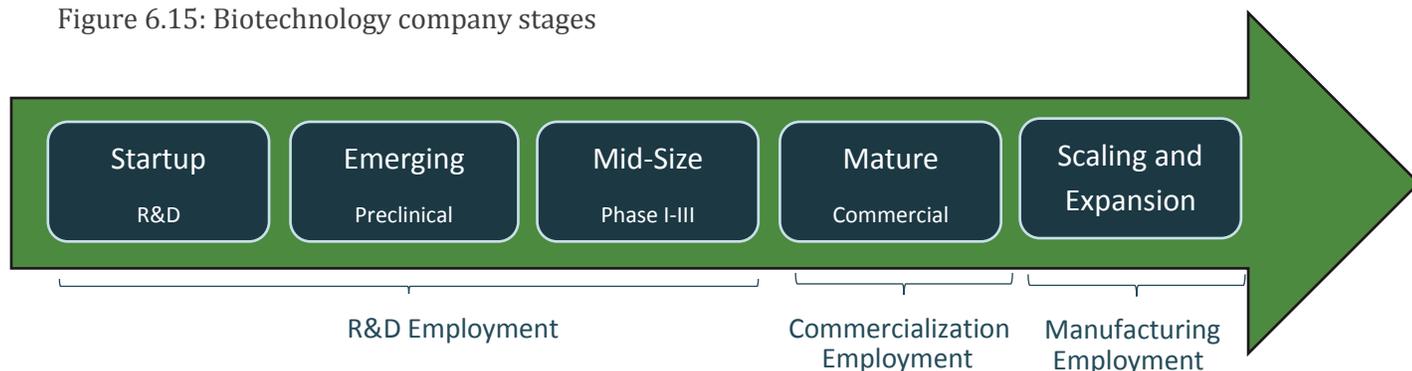
“The most difficult hires in manufacturing, that’s a huge problem for the region, we’re all competing with each other for manufacturing talent. I think any company that wants to succeed in manufacturing needs to hire more than they need and have good training programs.”

— Cell and Gene Therapy Focus Group Participant

6.5. Projections for the Future of the Industry

The nascent, yet complex, nature of the cell and gene therapy sector creates challenges for projecting future employment growth. As illustrated above, there are numerous critical uncertainties and barriers that will affect not only the growth of the sector within Philadelphia but for the nation as a whole. In order to conceptualize the two scenarios depicted above, projections were based primarily on three factors: a) growth of R&D employment from expanding divisions within biopharmaceuticals and hospitals as well as new start-ups (stages: startup, emerging, and mid-size) and b) anticipated FDA approvals within the cell and gene therapy sector in the United States over the next ten years (stage: mature) and c) growth in the manufacturing sector (stage: scaling and expansion).

Figure 6.15: Biotechnology company stages



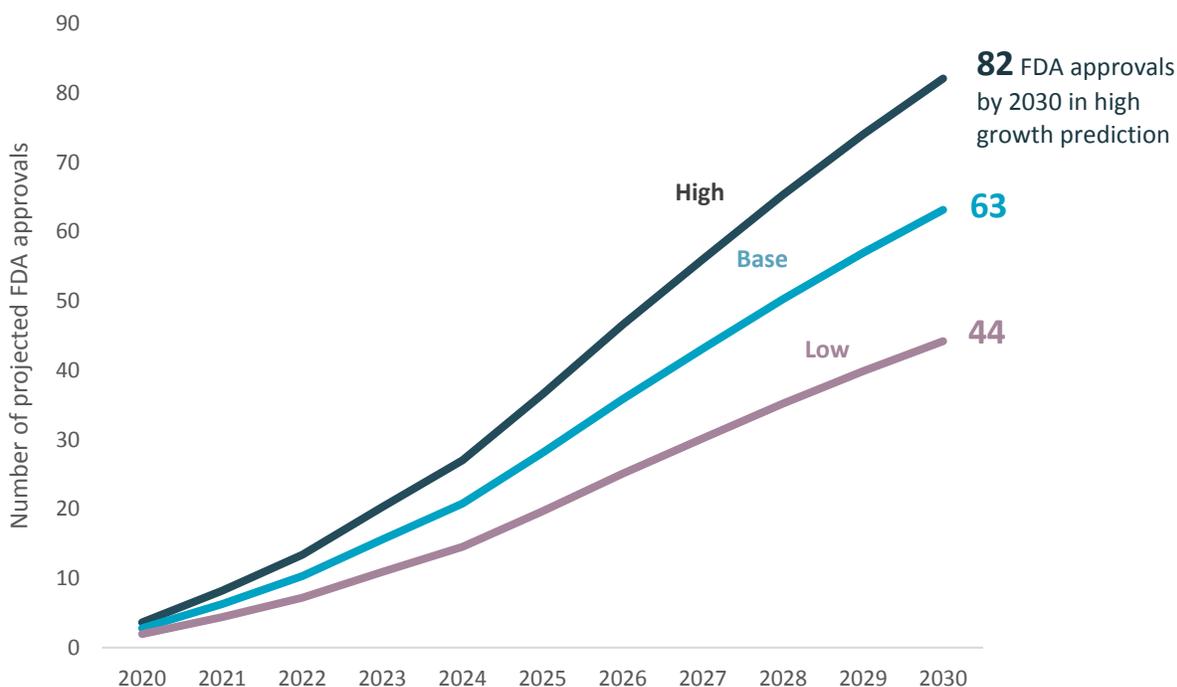
National Employment Growth based on FDA Approvals

Scott Gottlieb, the former United States Food and Drug Administration (FDA) Commissioner anticipated that by 2020, the department would receive more than 200 Investigational New Drug (IND) applications per year in addition to the 800 trials then on file as of January 15, 2019.¹⁰ With this volume of potential therapies in the pipeline, Commissioner Gottlieb predicted, based on the current clinical success rates, that by 2025, the FDA will be approving 10 to 20 cell and gene therapy products per year. Using these predictions, coupled with the methodology produced by the Center for Biomedical Innovation of the Massachusetts Institute of Technology (MIT) within their work *Estimating the Clinical Pipeline of Cell and Gene Therapies and Their Potential Economic Impact on the US Healthcare System*, ESI estimated the following ranges of FDA clinical trial approvals.¹¹

¹⁰ U.S. FDA (2019). Statement from FDA Commissioner Scott Gottlieb, M.D. and Peter Marks, M.D., Ph.D., Director of the Center for Biologics Evaluation and Research on new policies to advance development of safe and effective cell and gene therapies. Retrieved February 24, 2020, from https://www.fda.gov/news-events/press-announcements/statement-fda-commissioner-scott-gottlieb-md-and-peter-marks-md-phd-director-center-biologics_

¹¹ Quinn, C., Young, C., Thomas, J., Trusheim, M., & the MIT NEWDIGS FoCUS Writing Group. (2019). Center for Biomedical Innovation, Massachusetts Institute of Technology. <https://doi.org/10.1016/j.jval.2019.03.014>.

Figure 6.16: Projected, cumulative FDA approvals for cell and gene therapy sector, 2020-2030



Source: Econsult Solutions (2019)

The baseline predictions produced by MIT analyzed a snapshot in time of the FDA’s cell and gene therapy clinical pipeline using a Monte Carlo simulation to predict the probability of any given trial’s progression to the next phase, ultimate approval, and subsequent commercialization. However, since these estimates used only the existing pipeline, additional INDs were not factored into the projections. In order to include the additional INDs anticipated by the FDA, the projections above incorporated approvals starting in 2025 based on an additional 100 (low), 150 (mid), or 200 (high) therapy INDs added to the pipeline each year. For consistency, these additional approvals resulting from new INDs were based on MIT’s success rates and not Commissioner Gottlieb’s anticipated 10–to–20 approval range. This method arrives at a more conservative approval estimate, with the high prediction averaging 7.46 approvals per year, the mid-range prediction averaging 5.74 approvals per year, and the low prediction averaging 4.02 approvals per year.

To translate these approvals into employment, SEC filings were used to understand the progression of known commercialized companies’ employment over time from their R&D phases (Startup, Emerging, and Mid-Size) to their employment after FDA approval (Mature). Since the majority of the companies that have received FDA approval have yet to reach their last stage of development (Scaling and Expansion), employment estimates were based on the “Mature” stage of development. The table below displays the potential employment growth due to anticipated FDA approvals over the next ten years within the United States.

Figure 6.17: Employment growth in cell and gene therapy sector based on projected, cumulative FDA approvals, United States, 2020-2030

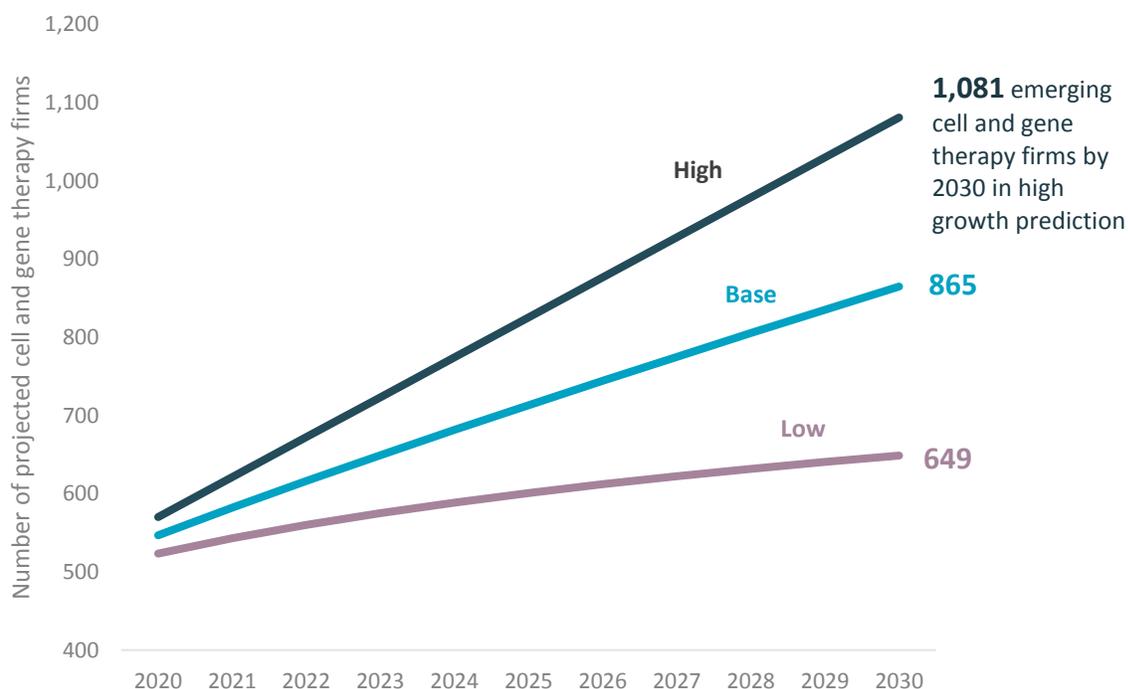
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High	1,147	2,580	4,218	6,388	8,518	11,518	14,672	17,658	20,579	23,324	25,861
Mid	882	1,985	3,245	4,914	6,552	8,860	11,286	13,583	15,830	17,941	19,893
Low	617	1,389	2,271	3,440	4,586	6,202	7,900	9,508	11,081	12,559	13,925

Source: Econsult Solutions (2019)

National Employment Growth based on Additional R&D Growth

In order to reasonably estimate the employment growth resulting from additional firms, hospitals, and established biopharmaceutical companies entering into the cell and gene therapy sector (R&D employment in Figure 6.15 above), projections were based on the North American growth rate of regenerative medicine companies in North America from 2015 to 2019.¹² Estimates were based on both linear and log-based projections of the previous five-year growth rate. The max, min, and average of the linear and log-based projections were used as each year’s high, mid-range, and low projections (see Figure 6.18 below).

Figure 6.18: Projected, cumulative emerging cell and gene therapy firms, 2020-2030



Source: Econsult Solutions (2019)

¹² Alliance for Regenerative Medicine

Based on SEC filings and regional company data, employment estimates were based on the composition of those companies considered to be in the Startup, Emerging, or Midsize stage of development. The table below displays the potential employment growth due to rising departments and firms within the cell and gene therapy sector over the next ten years within the United States.

Figure 6.19: Employment growth based on projected business openings and expansions, cell and gene therapy sector, United States, 2020-2030

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High	14,253	15,530	16,808	18,085	19,363	20,640	21,918	23,195	24,473	25,750	27,028
Mid	13,669	14,554	15,406	16,233	17,040	17,831	18,608	19,375	20,132	20,881	21,623
Low	13,085	13,577	14,004	14,380	14,717	15,021	15,299	15,555	15,792	16,012	16,218

Source: Econsult Solutions (2019)

Aggregate National Employment Growth

The employment estimates from the two preceding sections (Figure 6.17 and Figure 6.19) combine to create an overall employment estimate for the United States over the next ten years, depicted in the following table (Figure 6.20).

Figure 6.20: Employment projections based on commercialization and R&D employment, cell and gene therapy sector, United States, 2020-2030

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
High	15,399	18,110	21,025	24,473	27,880	32,158	36,589	40,853	45,052	49,074	52,889
Mid	14,551	16,538	18,650	21,147	23,592	26,691	29,895	32,958	35,963	38,822	41,516
Low	13,702	14,966	16,275	17,820	19,303	21,223	23,200	25,063	26,873	28,571	30,144

Source: Econsult Solutions (2019)

Philadelphia Scenario Employment Projection: Leading R&D Hub

The *Leading R&D Hub* scenario is proportionate with current levels of growth in the industry in Greater Philadelphia. Conditions necessary for this scenario's success include the adoption or support of growth-oriented business practices, which lead to increased commercialization of research, and a growth-oriented business environment, which incentivizes startup growth and attracts established businesses to the region. A growth scenario focused on research and development implies that most startups remain small and may not succeed at commercialization. Relatedly, manufacturing happens elsewhere in this scenario, limiting the potential for manufacturing technician positions to grow in the Philadelphia region.

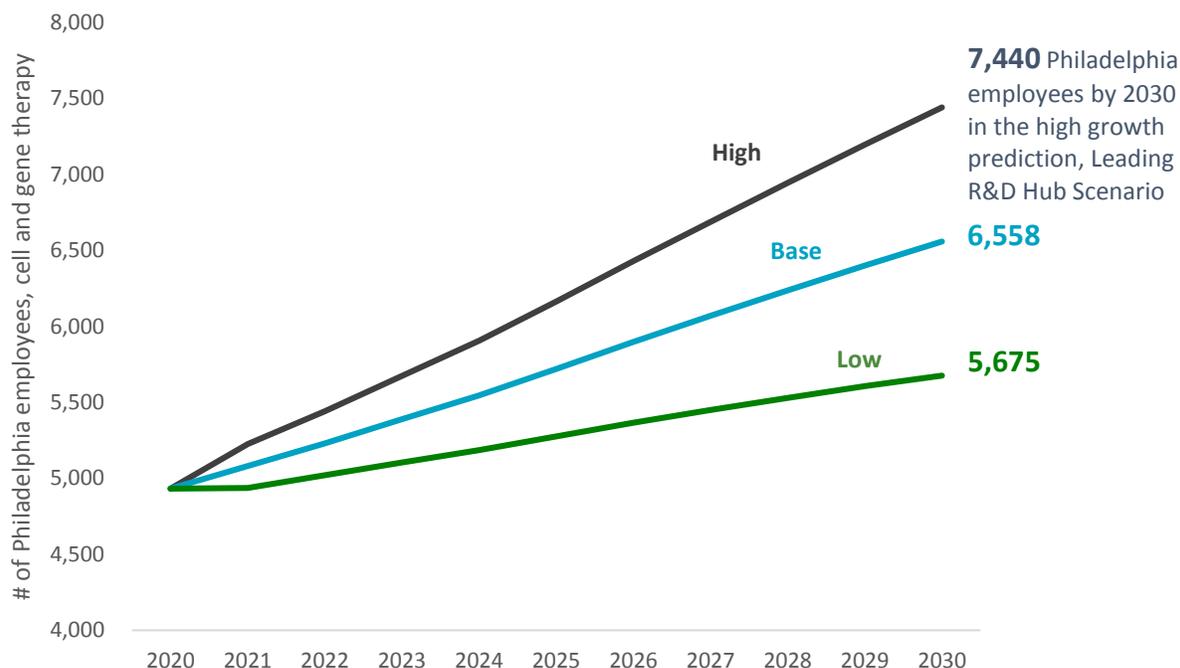
The employment projections for the *Leading R&D Hub* scenario are based on the assumption that five percent of FDA approvals over the next ten years will include a Philadelphia-based firm and that twenty percent of hospital, biopharmaceutical, and start-up

"I don't think that there's a lot of forethought [from startups] about what that talent pipeline can be. Then when it happens, it's like they're in a panic. Now all of a sudden, they just have to hire as many people."

— Community College Focus Group Participant

employment growth will occur within the region. These proportions are equivalent to the area's current scale within the national sector. The employment projections detailed in the previous section are based primarily on the growth of firms engaged in R&D and those going to commercialization based on FDA approvals. From these assumptions and calculations, the mid-range prediction yields a 34.9 percent growth in employment over the next ten years. The high estimate projects a 53.9 percent growth over the same time period while the low prediction anticipates a 16 percent increase in employment.

Figure 6.21: Projected Philadelphia employment growth, Leading R&D Hub scenario, 2020-2030



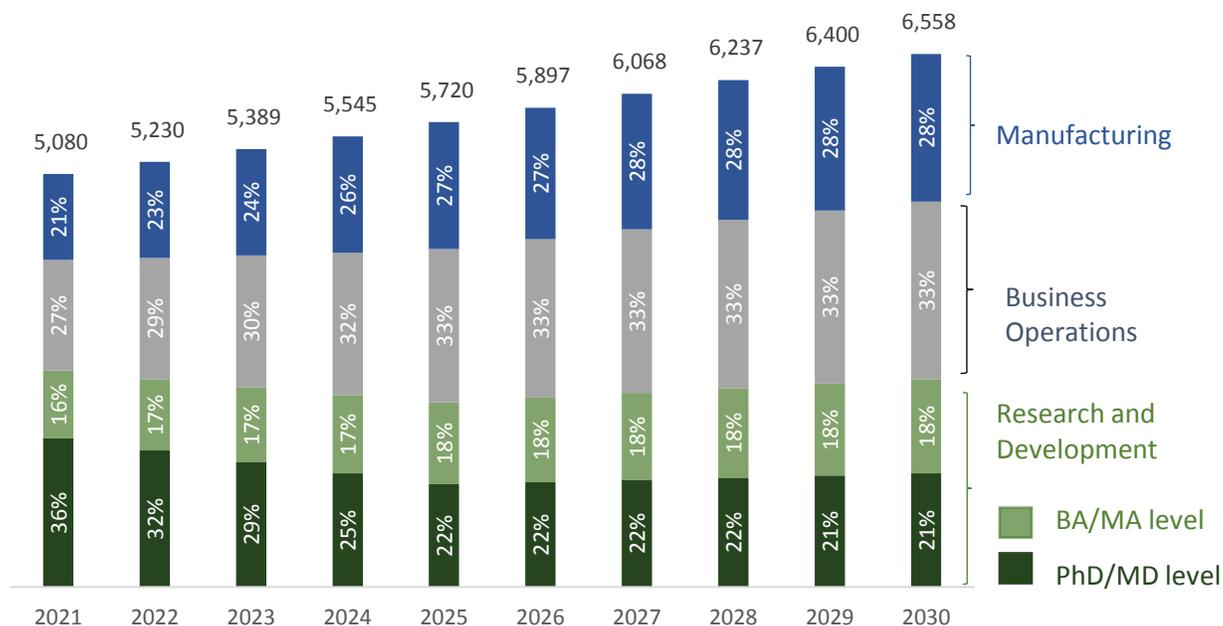
Source: Econsult Solutions (2019)

The employment composition projections within this scenario are based on SEC filings of cell and gene therapy firms that have disclosed the structure of their workforce and experienced growth over time. For employment derived from predicted start-up growth in Philadelphia, a six-year period was used to simulate the change of employment composition within firms as they grow. For employment derived from anticipated approvals, composition was based on the sixth year proportions of the modeled start-up firm.

Given these data, within the *Leading R&D Hub* scenario it is projected that those working in research and development, while remaining fairly stable over the ten-year period, will make up a smaller portion (39 percent) of the overall employment within the industry. Furthermore, the percentage of individuals with advanced degrees (PhD and MD), while still a significant portion of the overall workforce compared to other industries (21 percent), would decline (-15 percentage points) while those with bachelor's or master's-level education would increase (+2 percentage points) in both percentage and numeric terms, as a portion of the total industry (18 percent). Furthermore, as firms grow, the need for business operations professionals—such as HR professionals, accountants, business managers, and IT professionals—also increases. It is projected that the percentage of employment within these fields would increase 5 percentage points, from 27 to 33 percent over the ten-year period.

Lastly, employment in manufacturing is anticipated to increase from 21 percentage points to 28 percentage points. While the previous two groupings of employment would typically employ individuals with an educational attainment level of a bachelor's degree or greater, employment in manufacturing could potentially employ individuals with a sub-baccalaureate degree.

Figure 6.22: Projections by type of employment (base prediction), Leading R&D Hub scenario, 2020-2030



Source: Econsult Solutions (2019)

Philadelphia Scenario Employment Projection: Commercialization and Manufacturing Hub

The *Commercialization & Manufacturing Hub* scenario envisions an environment in which there are few to no barriers for startups in terms of regulations, funding, or infrastructure, and the Philadelphia region has succeeded in attracting, developing, and retaining a diverse, well-qualified talent pool. In this scenario, the Philadelphia region continues to grow as a dominant location for cell and gene therapy research and production in the U.S. This scenario results in a high startup rate, exponential growth for existing companies, and an abundance of firms as well as an accomplished workforce relocating to the region. In contrast to the previous scenario discussed, the *Commercialization & Manufacturing Hub* scenario presupposes that therapy manufacturing will locate within the Philadelphia region, and this growth will employ people from a multiplicity of educational levels and fields of study. The realization of this scenario is dependent upon well-defined collaboration among private firms, universities, and other organizations on workforce training and job placement in the region.

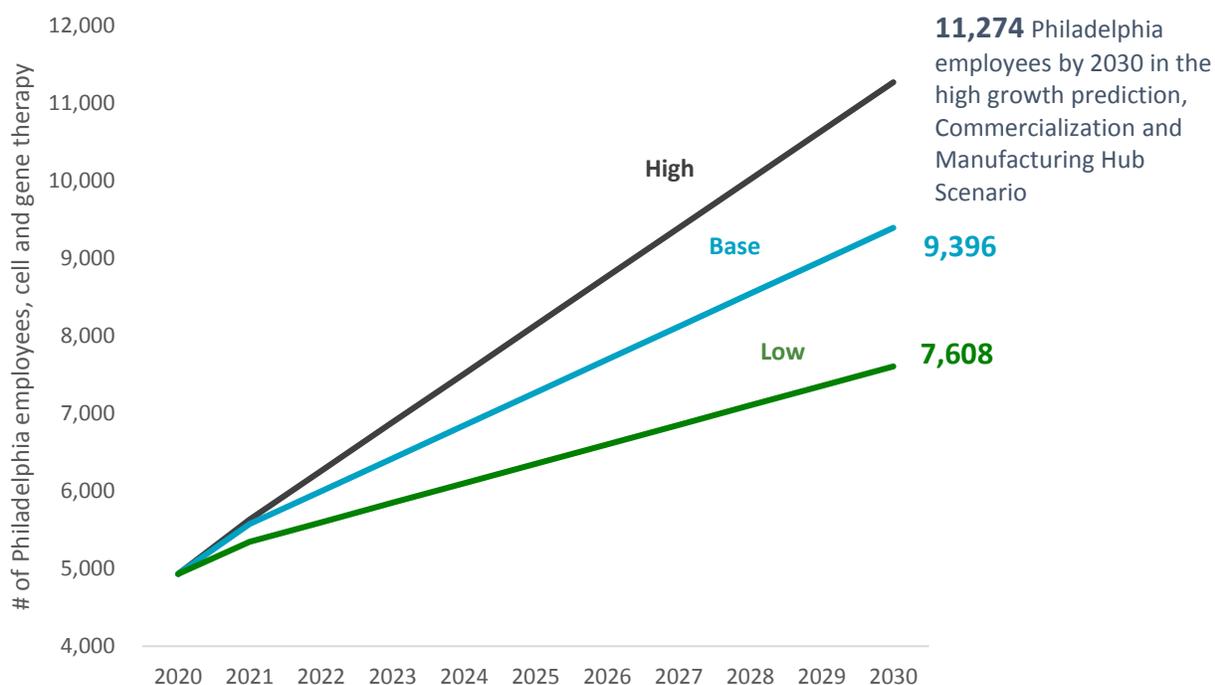
“If all these startups reach fruition and they get their products approved by the FDA, they’re going to need a lot of technicians. We could be at that point in a few years where they are coming to us.”

— Community College Focus Group Participant

The employment projections for the *Commercialization & Manufacturing Hub* scenario are based on the assumption that fifteen percent of FDA approvals over the next ten years will include a Philadelphia-based firm and that twenty percent of

hospital, biopharmaceutical, and start-up employment growth will occur within the region. Notably absent from the national projections and *Leading R&D Hub* scenario is employment growth based on therapies that have gone to scale (the “Scaling and Expansion” level of development). This potentially large segment of employment growth was omitted from these projections as there is not a current benchmark in which to produce estimates nationally. Nevertheless, the Philadelphia region has the potential to become a central location for cell and gene therapy manufacturing. Therefore, within this scenario, in addition to a higher proportion of employment growth based on FDA approvals, an additive manufacturing estimate was included. These estimates are based on recent growth patterns from firms that are currently planning for manufacturing expansion. The low estimate includes one large manufacturing operation opening in the Philadelphia region in 2021 and growing through 2030, the mid-range estimate includes an additional plant opening in 2023, and the high estimate adds a third large manufacturing firm in 2026. Based on these assumptions and calculations, the mid-range prediction yields a 94 percent growth in employment over the next ten years. The high estimate projects a 136 percent growth over the same time period while the low prediction anticipates a 56 percent increase in employment.

Figure 6.23: Projected Philadelphia employment growth, Commercialization and Manufacturing Hub scenario, 2020-2030



Source: Econsult Solutions (2019)

The employment composition projections within this scenario are similarly based on SEC filings of cell and gene therapy firms that have disclosed the structure of their workforce and experienced growth over time. In addition to the employment based on new start-up firms and FDA approvals, this scenario also includes employment based on large-scale manufacturing firms locating in Philadelphia.

Within the *Commercialization and Manufacturing Hub* scenario, the overall baseline sector projections are higher for each employment type when compared to the *Leading R&D Hub* scenario. However, as a proportion of total employment,

manufacturing is anticipated to increase from 25 to 33 percent of the total sector. Should this growth occur, it is expected that sub-baccalaureate technicians would be needed to fill many of these manufacturing positions. Employment in

“They want an entry-level technician. They don’t want someone necessarily with a four year or master’s degree. They want somebody that is going to do fairly routine work but do it well. That’s what [the industry] really needs as it progresses.”

— Community College Focus Group Participant

key business operations, largely unchanged from the *Leading R&D Hub* scenario, is expected to increase 6 percentage points from 28 percent in 2021 to 34 percent in 2030.

Additionally, it is projected that those working in research and development within the sector, while remaining fairly stable over the ten-year period, will make up a smaller portion (34 percent) of the overall employment within the industry. Furthermore, the percentage of individuals with advanced degrees (PhD and MD) would decline in a similar proportion to the *Leading R&D Hub* scenario (-13 percentage points) while those with bachelor’s or master’s-level education would mildly increase as a proportion of the total industry (16 percent).

Figure 6.24: Projections by type of employment (base prediction), Commercialization and Manufacturing Hub scenario, 2020-2030



Source: Econsult Solutions (2019)

7. Conclusion

The Philadelphia region benefits from a concentration of existing resources for success in the cell and gene therapy and connected health industries. The region boasts the first FDA-approved cell therapy and the first FDA-approved gene therapy approved for a genetic disease, as well as leading innovations in connected health. The cell and gene therapy and connected health sectors in Greater Philadelphia can strengthen their collaborative workforce development efforts and leverage legacy pharmaceutical industry resources and talent to maintain the region's position as a leader in the industries.

As the cell and gene therapy and connected health sectors grow and develop, it will be important to ensure that the region is able to meet the workforce needs of new and expanding companies and institutions. The region is building from a strong base of talent and knowledge. The key to success will be building on those efforts, working collaboratively, and staying flexible to meet the needs of a dynamic and changing ecosystem.

Projections for the future of the cell and gene therapy industry in the Philadelphia region indicate that while growth is expected, there may be significant fluctuations in that growth dependent on the local infrastructure available and the regulatory ecosystem in which therapy development and production occurs. Regardless of the magnitude of growth, these industries will require sustained efforts at workforce development and retention in order to maintain a stable pool of qualified talent from which to draw in the region.

While the New York City, Washington, D.C.-Baltimore, and Boston metropolitan areas are the region's chief competitors for top talent, the Philadelphia region is uniquely positioned to promote its distinct value proposition to potential workers. Philadelphia benefits from a concentration of research institutions, a lower cost of living, and laudable successes in the cell and gene therapy and connected health sectors. However, in order to sustain and build momentum in these fields, the region needs to take an active role in regional workforce development. Strategic partnerships can continue to build on current successes and nurture new relationships among private firms, universities, community colleges, and workforce development organizations to create a viable, capable labor pool for the cell and gene therapy and connected health sectors.

8. Appendix

About Econsult Solutions, Inc.

This report was produced by Econsult Solutions, Inc. (“ESI”). ESI is a Philadelphia-based economic consulting firm that provides businesses and public policy makers with economic consulting services in urban economics, real estate economics, transportation, public infrastructure, development, public policy and finance, community and neighborhood development, planning, as well as expert witness services for litigation support. Its principals are nationally recognized experts in urban development, real estate, government and public policy, planning, transportation, non-profit management, business strategy and administration, as well as litigation and commercial damages. Staff members have outstanding professional and academic credentials, including active positions at the university level, wide experience at the highest levels of the public policy process and extensive consulting experience.

Appendix A: LinkedIn Talent Insights Companies, Greater Philadelphia, 2019

Category	Name	Employees	1Y Growth	1Y Hires	% of Employees
Biopharma	GSK*	1,269	+3.4%	122	14.4%
Biopharma	Novartis*	70	+1.4%	6	0.7%
Biopharma	Merck*	598	+2.6%	44	29.0%
Biopharma	Roche*	10	-9.1%	1	0.2%
Biopharma	Amgen*	4	-42.9%	2	0.2%
Biopharma	Janssen*	588	+9.5%	76	24.3%
Cell and Gene Therapy	Adaptimmune	142	0.0%	25	40.1%
Cell and Gene Therapy	Aevi Genomic Medicine	11	-35.3%	0	91.7%
Cell and Gene Therapy	Amicus Therapeutics	83	+59.6%	35	14.3%
Cell and Gene Therapy	Aro Biotherapeutics	14	+40.0%	6	77.8%
Cell and Gene Therapy	AUM Lifetech	3	+200.0%	2	60.0%
Cell and Gene Therapy	Bioquark	6	0.0%	0	60.0%
Cell and Gene Therapy	Cabaletta Bio	24	+300.0%	19	85.7%
Cell and Gene Therapy	Carisma Therapeutics	22	+144.4%	16	78.6%
Cell and Gene Therapy	Century Therapeutics	23	+666.7%	20	74.2%
Cell and Gene Therapy	Excision Biotherapeutics	1	0.0%	0	25.0%
Cell and Gene Therapy	Express Cells	2	+100.0%	1	66.7%
Cell and Gene Therapy	Fibrocell	32	+28.0%	9	84.2%
Cell and Gene Therapy	Flowmetric	14	+40.0%	4	56.0%
Cell and Gene Therapy	Formula Pharmaceuticals	1	0.0%	0	100.0%
Cell and Gene Therapy	Geneos Therapeutics	5	+150.0%	4	83.3%
Cell and Gene Therapy	Gyroscope Therapeutics	5		5	10.0%
Cell and Gene Therapy	Immunome	21	+16.7%	6	84.0%
Cell and Gene Therapy	Imvax	6	+50.0%	2	75.0%
Cell and Gene Therapy	Inovio	77	-28.7%	12	36.3%
Cell and Gene Therapy	Limelight Bio	13	+44.4%	4	86.7%
Cell and Gene Therapy	MBF Therapeutics	3	0.0%	0	60.0%
Cell and Gene Therapy	Passage Bio	9		9	50.0%
Cell and Gene Therapy	Psioxus Therapeutics	1	-66.7%	0	1.4%
Cell and Gene Therapy	Scout Bio	3	+200.0%	2	42.9%
Cell and Gene Therapy	Spark Therapeutics	349	+27.8%	98	76.5%
Cell and Gene Therapy	Spirovant Sciences	6	+500.0%	6	60.0%
Cell and Gene Therapy	Swan Bio	13	+225.0%	10	65.0%
Cell and Gene Therapy	Tmunity	46	+70.4%	21	80.7%
Cell and Gene Therapy	Verve Therapeutics	4	+300.0%	3	19.0%
CMO	Abzena	36	+16.1%	9	17.9%
CMO	Accupac	131	+9.2%	18	72.8%
CMO	Alliance Contract Pharma	16	+6.7%	3	88.9%
CMO	Alliance Pharma	57	+11.8%	14	42.2%
CMO	American Regent	30	+15.4%	8	7.3%
CMO	Axcentria Pharmaceuticals	14	+7.7%	2	77.8%
CMO	BioPharmaSpec	4	-20.0%	0	23.5%
CMO	Emergent BioSolutions	20	+66.7%	11	1.4%
CMO	Frontage Laboratories	180	+9.1%	38	51.4%
CMO	Lyophilization Technology	23	-4.2%	2	88.5%
CMO	PCI Pharma	196	+3.2%	30	16.9%
CMO	Recro Pharma	26	-27.8%	1	40.6%
CMO	Viant Medical	43	+16.2%	10	5.5%
CMO	WuXi AppTec	283	+9.3%	85	8.6%
Hospital/University	CHOP*	441	+5.8%	58	88.0%
Hospital/University	Drexel*	130	-2.3%	18	89.7%
Hospital/University	Temple*	223	-0.9%	16	82.3%

Cell and Gene Therapy and Connected Health Workforce Analysis
 March 13, 2020

Category	Name	Employees	1Y Growth	1Y Hires	% of Employees
Hospital/University	Penn Medicine*	243	+11.5%	41	88.4%
Hospital/University	Jefferson University Hospitals*	128	+5.8%	15	85.9%
Hospital/University	ChristianaCare Health System*	22	+15.8%	4	73.3%
Hospital/University	Rowan University*	56	-8.2%	0	88.9%
Hospital/University	Rutgers University*	26	+13.0%	7	5.3%
Research Organization	The Wistar Institute*	70	+2.9%	9	87.5%
Research Organization	Coriell Institute*	26	+36.8%	9	89.7%

*Skills include at least one of the following: Genetics, Gene Therapy, Cell Therapy, Immunology, Cell Biology

Source: LinkedIn Talent Insights (2019)

Appendix B: Universities with Recent Graduates Working in Greater Philadelphia

Schools	Professionals	Recent grads
University of Pennsylvania	1,944	316
Temple University	1,839	238
Drexel University	1,515	236
University of Delaware	1,300	187
Penn State University	1,982	132
Drexel University College of Medicine	348	95
Thomas Jefferson University	296	86
Villanova University	1,059	83
Rowan University	315	74
Thomas Jefferson University Hospitals	689	72
University of the Sciences in Philadelphia	695	71
West Chester University of Pennsylvania	684	69
University of Pennsylvania School of Medicine	367	63
Rutgers University	928	58
The Wharton School	542	57
Saint Joseph's University	637	46
Fox School of Business at Temple University	269	41
Philadelphia College of Osteopathic Medicine	120	36
The Johns Hopkins University	341	35
Lehigh University	447	34
Temple University - Lewis Katz School of Medicine	238	34
Ursinus College	301	29
Arcadia University	210	29
La Salle University	391	27
Cornell University	379	27
Wilmington University	120	25
University of Pittsburgh	393	24
Northeastern University	128	24
Montgomery County Community College	200	23
Rutgers University - Camden	197	21
Duke University	166	20
Delaware Valley University	309	19
Harvard University	190	18
Widener University	255	16
Kutztown University of Pennsylvania	176	15
University of Florida	165	15
University of Maryland	243	14
Syracuse University	113	14
Cabrini University	147	13

Schools	Professionals	Recent grads
Stockton University	134	13
Community College of Philadelphia	110	13
Northwestern University	105	13
Boston University	149	12
Stanford University	116	12
University of Wisconsin-Madison	175	11
Columbia University in the City of New York	135	11
North Carolina State University	132	11
Albright College	114	11
Brown University	99	11
Saint Joseph's University School of Business	196	10
University of North Carolina at Chapel Hill	191	10
The Ohio State University	182	10
Bucks County Community College	142	10
Carnegie Mellon University	117	10
Delaware County Community College	106	10
University of Michigan	212	9
Drexel University's LeBow College of Business	181	9
Princeton University	160	9
Penn State Great Valley	152	9
University of Rochester	128	9
Georgetown University	103	9
Rochester Institute of Technology	93	9
Gwynedd Mercy University	215	8
Bloomsburg University of Pennsylvania	193	8
University of Phoenix	174	8
University at Buffalo	111	8
University of California, Los Angeles	105	8
Massachusetts Institute of Technology	190	7
University of Virginia	173	7
Purdue University	171	7
University of Illinois at Urbana-Champaign	135	7
University of Massachusetts Amherst	115	7
New York University	112	7
Temple University - James E. Beasley School of Law	99	7
Gettysburg College	91	7
University of California, Berkeley	170	6
Millersville University of Pennsylvania	158	6
Michigan State University	148	6
Eastern University	131	6

Schools	Professionals	Recent grads
Lafayette College	113	6
Stony Brook University	108	6
The Johns Hopkins University School of Medicine	106	6
Franklin & Marshall College	98	6
Yale University	163	5
Bucknell University	149	5
Rider University	138	5
Philadelphia University	136	5
University of Connecticut	134	5
Immaculata University	159	4
Virginia Tech	143	4
The College of New Jersey	134	4
Shippensburg University of Pennsylvania	130	4
University of Minnesota	116	4
The George Washington University	115	4
University of Mumbai	104	4
West Virginia University	94	4
East Stroudsburg University of Pennsylvania	125	3
Harvard Medical School	98	3
Muhlenberg College	93	3
University of Scranton	161	2

Source: LinkedIn Talent Insights (2019)

Appendix C: Best Practices in the United States

There are several existing, successful programs or initiatives across the U.S. working on developing the cell and gene therapy workforce as well as sharing resources across institutions and organizations.

California

The California Life Sciences Association (CLSA) is a life sciences advocacy and businesses leadership organization in California and works to influence public policy and grow the state's life sciences sector. Within CLSA, the California Life Sciences Institute is a nonprofit created to support education, entrepreneurship, and career development in the life sciences. The Institute provides networking connections, professional development workshops, and career search assistance, as well as learning opportunities and lab resources for students from kindergarten through post-graduate.¹³

Maryland

Bridges to Biotech is a Fellows Program for PhD students and postdoctoral fellows to gain additional training and networking experience in the biotech industry. The fellowship program is a collaborative effort among the University of Maryland School of Medicine, Johns Hopkins University, the National Institutes of Health, and the Maryland Department of Commerce.¹⁴ The Maryland Department of Commerce identifies companies in Maryland interested in hosting a fellowship session and serving as mentors to the students. This program not only prepares students and postdoctoral fellows for entry into the biotech workforce and exposes them to a variety of professional opportunities; it also connects firms with a sustainable pool of qualified talent.

Massachusetts

The Massachusetts Biotechnology Council, or MassBio, is a nonprofit with an extensive member network of life sciences companies, universities, and other organizations focused on life sciences education and policy advocacy in Massachusetts.¹⁵ MassBio provides entrepreneur mentorship, shares resources and funding opportunities with its members, and has a careers page where members can post job opportunities. A separate organization founded by MassBio, MassBioEd, was created with the intention of developing the talent pipeline for life sciences in Massachusetts, with a particular focus on high school students. The first program developed at MassBioEd was BioTeach, which provides high school teachers and students with lab equipment and life sciences curricula to build student interest in the life sciences and prepared them for the workforce.¹⁶

New Jersey

BioNJ is the life sciences association in New Jersey, and has initiatives related to public policy, education and networking, and workforce solutions for the biotechnology industry in the state.¹⁷ BioNJ has worked

¹³ California Life Sciences Association. (2020). Innovation. <https://califesciences.org/innovate/>.

¹⁴ Winters, Amanda. (2018). Bridges to Biotech: preparing tomorrow's workforce today. <https://open.maryland.gov/blog/bridges-to-biotech-preparing-tomorrows-workforce-today/>.

¹⁵ MassBio. (2020). About MassBio. <https://www.massbio.org/about>.

¹⁶ MassBioEd. (2020). Educators. <https://www.massbioed.org/educators>.

¹⁷ BioNJ. (2019). About BioNJ. <https://bionj.org/about-bionj>.

with the state on a variety of tools to attract and retain biotech companies, including the Garden State Life Sciences Fund, the Business Retention and Relocation Assistance Grant program, and the Angel Investor Tax Credit.¹⁷ BioNJ also creates networking opportunities and provides career support for pharma, biotech, medical device technology, clinical operations, and medical diagnostics through its Talent Services Network.

New York

NewYorkBIO is the life sciences trade association for the state of New York. The organization supports talent development, access to capital for startups, and state funding for lab space in New York City and the state. NewYorkBIO works with the governor's office on talent recruitment and retention initiatives and a proposed mentorship program for early-stage entrepreneurs. There are also programs focused on biotech development within New York City. LifeSciNYC is a 10-year, \$500 million initiative by the mayor's office to grow the city's life sciences industry through tax incentives, policy proposals, and capital investments.¹⁸ One of the initial focuses of LifeSciNYC is on expanding the city's R&D infrastructure for sustainable, long-term growth. Furthermore, the New York City Economic Development Corporation (NYCEDC) has created a life sciences fund, partnering with venture capitalists to invest in life sciences startups in the city.¹⁹

North Carolina

NCBioImpact is a biotechnology training program that developed out of a workforce need assessment in North Carolina. The program includes the development of an 82,500 square foot facility with classrooms and lab space at North Carolina State University, an initiative connecting the state's community colleges, and a program at North Carolina Central University in Pharmaceutical Science.²⁰ The North Carolina Biotech Center establishes networks between private companies and university researchers, and connects entrepreneurs to potential funders. Additionally, they host a jobs network for bioscience professionals and manage a biotech jobs board that aggregates job opportunities with universities, private firms, and other life sciences organizations across the state.

Texas

The Texas Health care & Bioscience Institute is an advocacy organization working to influence health policy and regulatory legislation in the state to create an attractive business environment for companies in the life sciences.²¹ Texas also leverages the influence and connections at its academic institutions in attracting and developing the biotech sector. The Austin Technology Incubator, affiliated with the University of Texas at Austin, supports local entrepreneurs by facilitating access to capital and developing robust business teams. Since its inception in 1989, the Austin Technology Incubator has

¹⁸ LifeSciNYC.(2020). NYCEDC. <https://www.lifesci.nyc/state-industry>.

¹⁹ NYCEDC. NYC Early-Stage Life Sciences Funding Initiative. <https://edc.nyc/program/nyc-early-stage-life-sciences-funding-initiative>.

²⁰ NCBioImpact (2019). About Us. http://www.ncbioimpact.org/about_us.html.

²¹ Texas Healthcare & Bioscience Institute. About. <https://www.thbi.com/about>.

worked with more than 300 member companies, resulting in 10 IPOs and more than 50 mergers and acquisitions.²²

²² Austin Technology Incubator. (2019). ATI History. The University of Texas at Austin. <https://ati.utexas.edu/about/>.

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