

Assessing Washington's Life Science and Global Health Workforce Dynamics:

Enhancing Connections and Addressing the Skills Gaps to Ensure Future Growth

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TECONOMY PARTNERS LLC

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Executive Summary

Washington has built and maintained a sizable and dynamic life science industry and global health sector that represents both the power and promise of innovation. The industry employs approximately 30,000 workers in high-quality jobs that are leveraging a billion-dollar research base to advance innovations in medical devices and biopharmaceuticals, including areas such as ultrasound imaging, animal health, and cancer immunotherapies. At the same time, the state has a unique position as a leading hub of global health research and non-profit organizations.[1]

Washington Industry Snapshot

Life Sciences Industry Highlights, 2015:

- **Employment:** 29,997
- **Average Wages:** $84,156
- **Job Growth, 2001-15:** 15%
- **Job Change, 2011-15:** -1%
- **Notable Strengths:** Strong, above-average concentration in Research, Testing, and Medical Labs subsector; leader in Global Health.

The economic benefits of the life science industry's size and high-quality jobs across a broad range of occupational skill levels is amplified by the fact that the industry has a broad geographic footprint across the state and is not as sensitive to economic downturns given the consistent demand for medical care and life sciences innovation even in times of economic recession. The life sciences and global health represent the rare combination of innovation and economic benefits within a state, which explains why the competition for this industry among states, regions, and nations is so intense.

But the industry in Washington faces challenging headwinds and workforce issues are a top concern. As documented in TEConomy's 2017 study for the Governor's Life Science and Global Health Advisory Council,[2] after a decade of strong gains, the life science industry in Washington faces a "Future at Risk" with recent stagnation in terms of job gains, patent activity, and industrial R&D relative to the U.S. and peer states. And while industry leaders cite challenges such as affordability of office and wet lab space, as well as the availability of investment capital, the most common recurring theme and concern raised by Washington's C-suite executives is the availability of skilled talent, both now and into the future.

The state is not alone in this life science and global health workforce challenge, however, there are unique talent and workforce competitiveness issues and challenges specific to Washington. One of the most significant is the intense competition for an IT workforce that coincides with the continued high-growth position of companies like Amazon and

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1 *The life science industry employment figure includes significant overlap with the global health sector, though there are additional jobs in global health in Washington that cannot be isolated through federal industry classifications. The Washington Global Health Alliance has estimated employment and other impacts of the sector in a recent Landscape Study available at: https://www.wghalliance.org/resource/washington-global-health-landscape-study/.*

2 *TEConomy Partners, "Life Science and Global Health: Future at Risk," prepared for the Washington Life Science and Global Health Advisory Council, February 2017.*

Microsoft, and other large corporations headquartered in Greater Seattle. Similarly, the strong demand for engineering talent in medical devices must compete with a major aerospace industrial complex with similar skills needs. Exacerbating these challenges are limited connections between the life sciences and global health industry and Washington's colleges and universities for this highly sought-after IT and engineering talent.

At stake for Washington is the competitiveness of its life science industry and global health sector. Companies are making location decisions regarding expanding regional and national hubs, sites for headquarters and research operations, and are working through their own calculations regarding limiting factors for growth, with talent continually among the factors under consideration. Amidst this high-stakes environment, this study examines the talent situation and dynamics for Washington's life sciences industry and global health sector.

About this Study

By mid-2016, the building challenges and concerns facing Washington's life science industry and global health sector had coalesced to such a point that the state's Department of Commerce, through its designated Industry Sector Lead and with the support of Governor Inslee, commissioned this study to develop a comprehensive baseline assessment and strategy for meeting Washington's current and future life science and global health workforce needs. To meet the goals of the study, the project addresses several key questions:

- *What workforce skills will be needed?*
- *What capacity does Washington have now to engage broader population groups and offer the needed range of educational and training efforts?*
- *Where are the major gaps in the workforce system relative to key demands for the life science and global health workforce?*
- *What should we do?*

TEConomy Partners, LLC (TEConomy) was selected to lead this study in partnership and in close consultation with a selected group of public and private industry and educational stakeholders that formed the Washington Life Science and Global Health Workforce Panel.[3] The study leverages both quantitative analytical and qualitative approaches focused on both "primary" and "secondary" occupational groups critical to the industry to assess the demand for and supply of industry talent.

Key Findings

Across the array of occupations critical for the industry, the assessment identified eight groups to be in "high demand" by the life sciences and global health industry in Washington. This high-demand designation is based on these eight occupational groups enjoying strong recent job growth along with projections of continued growth based on both state occupational forecasts as well as industry-specific surveying and outreach done for this study in which these occupations were consistently identified as in-demand from employer interviews and regional focus groups (see Figure ES-1). On the workforce supply side, the industry is connecting with some specific in-state postsecondary programs,

3 *For a complete listing of Workforce Panel members please see the Appendix.*

though on a limited scale. For these and other reasons detailed below, there are clear "misalignments" in the workforce ecosystem causing challenges for employers to find, recruit, and hire qualified candidates.

Figure ES-1: Talent and Skill Gaps, where are Interventions Needed?

Occupational Group	Identified as "High Demand"	Identified Misalignments
Agricultural, Food and Nutrition Scientists and Techs		
Biological Scientists and Technicians		✓ (Sr. Scientists)
Life Science-related Engineers	✓	✓
Life Science Managers		✓
Medical and Clinical Laboratory Technicians	✓	✓
Quality Assurance/Control		
Regulatory Affairs	✓	✓
Bioinformatics/Biostatistics	✓	✓
Secondary — Business & Financial		✓
Secondary — Chemists & Chemical Techs		
Secondary — Engineers & Eng. Techs	✓	✓ (Engineers)
Secondary — Health Technicians		
Secondary — Information Technology	✓	✓
Secondary — Office & Administration		
Secondary — Skilled Production	✓	✓ (Assembly)
Secondary — Marketing & Technical Sales Rep	✓	✓
Secondary — Transportation		

One challenge that Washington faces is a critical skill shortage in broader occupations that are in high demand by other industries in Washington, particularly in engineering and IT occupations. So, despite strong growth in new graduates and a high presence of these occupations in the existing workforce, they represent a key barrier to growth for the life sciences and global health industry in Washington.

- In engineering occupations, recent hiring has been strong, with 237 engineers hired by the life sciences industry in the last year, representing 20 percent of the engineering employment base of surveyed companies, and employers surveyed expect to continue to ramp-up hiring over the next 2 years alone, reflecting the state's strengths in medical devices. Washington's colleges and universities are graduating nearly 1,600 in the degree fields aligned to industry needs; however, the life sciences are not the only advanced manufacturing industry competing for this base of new graduates.
- In IT occupations, the life science industry hired 205 workers over the last year, and expects to triple that over the next 2 years. Across all industries, the state is facing substantial deficits in the specific IT talent in demand by the

life sciences industry (e.g. software developers, computer hardware engineers, computer support) of more than 3,300 between annual projected job openings and new degree graduates.

- To a lesser extent, Washington's life sciences industry is also experiencing skill shortages in marketing professionals and skilled production for assemblers for precision device manufacturing for which they need to compete with other industries.

In more life sciences-specific occupations, there are also critical skill shortages, reflecting a lack of talent generation in Washington.

- Medical and clinical lab techs, a very large and fast-growing workforce of more than 8,000 in Washington, is expected to see nearly 400 job openings per year while related degree graduates only number 105.
- In regulatory affairs, industry survey respondents report hiring 20 professionals in the last year, but the expectation for the next two years is to hire 127 additional professionals, a major boost in expected hiring, and talent managers are having difficulty finding them, most often conducting national searches.
- Bioinformatics and biostatistics expertise is also in high-demand with industry reporting 35 hires in the last year, and expectations are to hire 85 professionals in the next 2 years. As with regulatory expertise, many recruiters are having difficulty finding talent in Washington and are searching nationally.

Complicating the ability of life science and global health industry to compete for talent is the fact that it is generally "disconnected" from the state's postsecondary institutions and students, as well as its existing education and workforce training programs as evidenced by:

- A lack of awareness of the life sciences and global health as both a key industry and economic driver for Washington and a career option for young people;
- Limited industry-university connections for recruiting and hiring, even for top university life sciences talent;
- The limited scale of internship programs that connect the industry with local colleges and universities;
- Existing state education and workforce programs that do not explicitly connect with the industry.

Although generally positive, Washington's life science companies have a mixed "performance" engaging diverse populations that are typically under-represented in the life sciences and STEM-related fields.

- Washington's life science employers are faring better at engaging women in the industry than the nation and at least meeting their overall average composition across the state economy; from a gender perspective, the life sciences are much more diverse than other large manufacturing and IT sectors in Washington.
- Since 2000, the industry has increased its overall share of women employed by four percentage points.
- In terms of employment of racial minorities in the life sciences, Washington is lagging the U.S.; however, the industry employment share is reflective of the state's population, which is already underrepresented in terms of racial minorities.
- Since 2000, the overall trend in the industry's employment of racial minorities has increased, with the share rising from 16 percent to 22 percent during this period, signaling progress in inclusion.

Strategic Recommendations to Better Align Washington's Life Science and Global Health Talent Needs and Ensure its Future Competitiveness

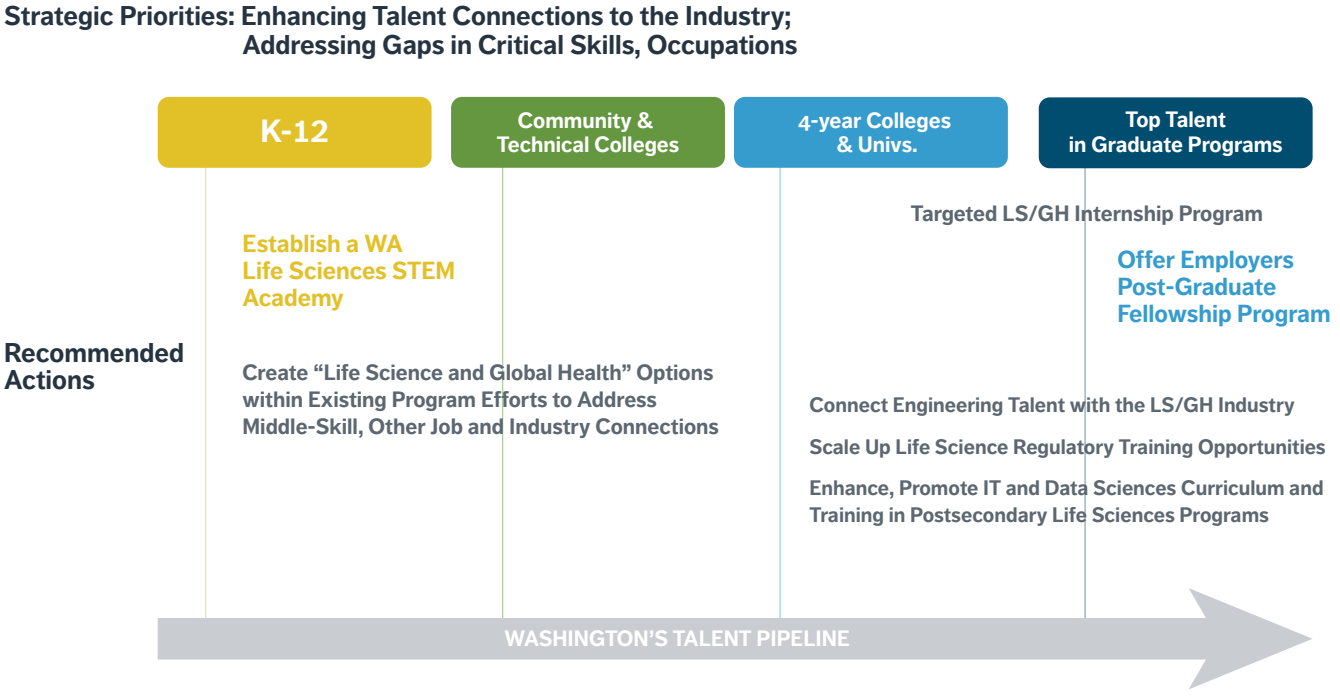
While the critical skill shortages faced by Washington's life science and global health industry are significant, they are not beyond the reach of solutions through a set of targeted, focused initiatives to better align supply with demand for identified occupations and skill sets, and to more broadly create better talent connections to the industry. These findings support two strategic priorities for intervention, with focused proposed actions presented in the report to support each:

1. **Enhancing Talent Connections to the Life Sciences and Global Health** – Washington needs to connect its existing workforce education and training programs to the industry. Where these programs and initiatives exist, there must be a life science and global health "option" or avenue for engagement to boost both industry and career awareness, and connect to talented individuals and talent-generating institutions.

2. **Addressing Critical Gaps for Specific Occupations and Skill Sets** – the assessment finds gaps in a number of aforementioned life science and global health occupational groups where supply and demand are misaligned, primarily in high-skilled fields. Most of these are also in high-demand, with industry needs only growing, which amplifies the current need. Specific actions are recommended to address key gaps in the primary life science occupations, some of which will also enhance connections with secondary occupations.

In considering these needs, an additional context is critical – an effective talent strategy will address the major components of the education and talent pipeline. Figure ES-2 below maps out the recommended actions across this continuum.

Figure ES-2: Strategic Priorities for Washington and Recommended Actions Across the Talent Pipeline



The recommendations depicted in Figure ES-2 are organized within each of the two strategic priorities below and detailed within the main report.

Strategic Priority: Enhancing Talent Connections to the Life Sciences and Global Health

- Action 1: Establish a Hands-on Washington Life Sciences STEM Academy
- Action 2: Develop a Targeted Life Sciences and Global Health Postsecondary Internship Program
- Action 3: Create "Life Science and Global Health" Options within Existing Washington Program Efforts to Address Middle-Skill and Other Job and Industry Connections
- Action 4: Offer Employers Post-Graduate Fellowships to Train, Recruit, and Retain Top Life Sciences Talent

Strategic Priority: Addressing Critical Gaps for Specific Life Science and Global Health Occupations and Skill Sets

- Action 5: Connect Engineering Talent at Washington's Colleges and Universities with the Life Sciences Industry
- Action 6: Scale Up Life Science Regulatory Training Opportunities at Postsecondary Institutions from Certificates to Professional Masters
- Action 7: Emphasize, Enhance, and Promote IT and Data Sciences Curriculum and Training in Postsecondary Life Sciences Programs and Consider IT Apprenticeships for Industry Needs

Many of these recommended strategies and actions require relatively few resources and several could simply leverage existing state programs or initiatives to re-position them with a life sciences and global health focus. Recognizing the importance of the industry to Washington's economic and innovation ecosystem, it is in the state's best interests that industry stakeholders come together in an intentional effort to address these challenges.

I. Introduction

Representing the promise and power of innovation, Washington's life science industry and global health sector is simultaneously saving and improving lives around the world while reaping significant economic benefits across the state. Washington is home to a sizable industrial life sciences industry and billion-dollar research base that has a deep history and has further emerged over the last decade plus to reach approximately 30,000 high-quality jobs that are advancing innovations in medical devices and biopharmaceuticals and research and technology breakthroughs in areas such as ultrasound, animal health, and cancer immunotherapies. At the same time, the state has a unique position as a leading hub of global health research and non-profit organizations.

But the industry in Washington faces challenging headwinds. As documented in TEConomy's 2017 study for the Governor's Life Science and Global Health Advisory Council,[1] after a decade of strong gains, the life science industry in Washington faces a "Future at Risk" with recent stagnation in terms of job gains, patent activity, and industrial R&D relative to the U.S. and peer states. And while industry leaders cite challenges such as affordability of office and wet lab space, as well as the availability of investment capital, the most common, recurring theme and concern raised by Washington's C-suite executives is the availability of skilled talent, both now and into the future.

The state is not alone in this life science and global health workforce challenge. In a recent survey of pharmaceutical executives by Pricewaterhouse Coopers (PwC), talent tops the list of innovation challenges, ahead of other critical areas such as speed to market of innovative ideas, establishing an innovative culture, and finding the right partners for collaboration.[2] Nearly three in five biopharmaceutical executives report that "finding and retaining the best talent to make innovation happen" is a challenge for their company, higher than the average for respondents across all industries.

In manufacturing more broadly, which includes life science subsectors such as medical devices and biopharmaceuticals, U.S. firms are seeing first-hand a major "skills gap." In their third assessment of the skills gap in U.S. manufacturing, the Manufacturing Institute and Deloitte find the gap is widening, with an estimated 60 percent of those positions likely to go unfilled from 2015 to 2025, largely due to lack of STEM-related skills in the workforce.[3]

There are, however, unique talent and workforce competitiveness issues and challenges specific to Washington. One of the most significant is the intense competition for an IT workforce that coincides with the continued high-growth position of companies like Amazon and Microsoft, and other large corporations headquartered in Greater Seattle. Similarly, the

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1 *TEConomy Partners, "Life Science and Global Health: Future at Risk," prepared for the Washington Life Science and Global Health Advisory Council, February 2017.*

2 *PwC, Managing Innovation in Pharma, see: http://www.pwc.com/gx/en/pharma-life-sciences/assets/pwc-managing-innovation-pharma.pdf. Includes results and analysis from the PwC Global Innovation Survey.*

3 *The Manufacturing Institute and Deloitte, The Skills Gap in U.S. Manufacturing 2015 and Beyond, 2015.*

strong demand for engineering talent in medical devices must compete with a major aerospace industrial complex with similar skills needs. Exacerbating these challenges are limited connections between the life sciences and global health industry and Washington's colleges and universities for this highly sought-after IT and engineering talent. These and other competitive talent challenges and insights are examined herein.

At stake for Washington is the competitiveness of its life science industry and global health sector. Companies are making location decisions regarding expanding regional and national hubs, sites for headquarters and research operations, and are working through their own calculations regarding limiting factors for growth, with talent continually among the factors under consideration. Amidst this high-stakes environment, this study examines the talent situation and dynamics for Washington's life sciences industry and global health sector.

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- *What should we do?*

Project Objectives & Key Areas of Focus

Objective: A comprehensive baseline analysis and strategy for meeting Washington's current and future life science and global health workforce needs.

Special emphasis on ***diversity and middle skill jobs***

Addressing Key Questions:

- What workers (Demand)?
- What capacity (Supply)?
- What are the gaps?
- What should we do?

The Department requested the study include a particular emphasis on the needs and supply for middle-skilled occupations (i.e. those jobs that require more than a high school diploma but less than a 4-year college degree), as well as how to generate broader diversity among population groups that may be underrepresented in the industry.

TEConomy Partners, LLC (TEConomy) was selected to lead this study in partnership and in close consultation with a selected group of public and private industry and educational stakeholders that formed the Washington Life Science and

Global Health Workforce Panel.[4] The Workforce Panel has played a key role in this study by helping to guide the project with respect to the types of data to be collected, key organizations and individuals to interview and to survey, key issues and questions to pursue, interpretation of results and ultimately, to provide guidance on strategic interventions.

TEConomy is a national thought-leader in life sciences workforce development with studies prepared for the Pharmaceutical Research and Manufacturers of America (PhRMA) and the Biotechnology Innovation Organization (BIO), and has a track record in identifying and designing comprehensive workforce assessment and development strategies for capturing state and regional growth opportunities, including for Arizona, Connecticut, Indiana, Maryland (Prince George's County), and Oregon. TEConomy was formed in the fourth quarter of 2015 as an independent company, transitioning the complete staff and capabilities of the Technology Partnership Practice (TPP) from Battelle Memorial Institute. As one of the nation's leading technology-based economic development consulting organizations, TEConomy is particularly recognized as a national leader in advancing life sciences strategies and assessing their economic impacts. Well over 20 state and regional life science strategic assessments and roadmaps have been completed by the Principals of TEConomy, and TEConomy also works closely on major national and international reports tracking life sciences industry development; talent, workforce, and STEM education issues; and economic impacts with both BIO and PhRMA.

Setting the Context: Life Sciences and Global Health as an Economic and Workforce Driver in Washington though Industry is Facing Headwinds

The industrial life sciences are impressively diverse and include a whole range of companies engaged in advanced manufacturing, research activities, and technology services, and all with a common thread in their application of life sciences knowledge and how living organisms function. Both nationally and across the states, for more than a decade, the principals of TEConomy have partnered with BIO on biennial assessments of the industry, and have developed a definition that spans five major industry subsectors presented in Figure 1.

Washington Industry Snapshot

Life Sciences Industry Highlights, 2015:

- **Employment:** 29,997
- **Average Wages:** $84,156
- **Job Growth, 2001-15:** 15%
- **Job Change, 2011-15:** -1%
- **Notable Strengths:** Strong, above-average concentration in Research, Testing, and Medical Labs subsector; leader in Global Health.

Figure 1: Defining the Life Science Industry, the TEConomy/BIO Major Subsectors[5]

4 *For a complete listing of Workforce Panel members please see the Appendix.*

5 *For a detailed NAICS-based industry definition, see the Appendix to this report.*

Washington's life sciences industry and global health sector are distinct, but closely linked, and represent overlapping and highly interrelated sectors in Washington. As defined in the recent Landscape Study developed by the Washington Global Health Alliance,[6] much of Washington's global health industries overlap with the research, testing, and medical labs subsector of the life sciences, but also reach beyond to include key university departments, selected hospitals, and religious and other grant-making organizations.

What distinguishes life sciences from global health is how they focus on human health and innovation. Life sciences focuses more on a disease model and advancing novel innovations for disease prevention, diagnosis, and treatment, while global health aims to improve population health and health equity involving broader interventions than simply biomedical treatments, as well as improvements in environmental, infrastructure, and societal conditions that impact the health of populations. In addition, the life sciences sector extends beyond health and biomedical applications to include the agricultural biosciences and far-reaching industrial biosciences technologies and applications.

Washington's Large and Leading Global Health Sector

Taking root over the past 40-50 years, Washington's position as a leading hub in global health has led to the innovation and dissemination of global health solutions across the world. Organizations such as the Fred Hutchinson Cancer Research Center, PATH, Center for Infectious Disease Research, Infectious Disease Research Institute, World Vision, Global Good, SightLife, the Gates Foundation and many others, combined with the University of Washington's Department of Global Health and Washington State University's Paul Allen School for Global Animal Health, have grown to form a significant cluster, with an epicenter in Greater Seattle that works each day to save millions of lives around the world. The Washington Global Health Alliance, established nearly a decade ago, is playing a key role in bringing together the organizations, executives, and key stakeholders in the sector across Washington to coordinate and leverage their combined influence and unique requirements as a cluster.

According to the 2015 Washington State Global Health Landscape Study, the state's global health sector today is large, growing, and has a substantial impact on the state's economy, as well as impacting millions of lives worldwide. The study found an extensive innovation ecosystem that includes 168 individual global health organizations employing 12,620 with average wages exceeding $71,000 annually, and with $5.8 billion in funding and revenues, largely from federal and philanthropic grants. In turn, these direct economic impacts are yielding an overall economic impact of 32,800 jobs and $9.4 billion in business revenues across Washington, and each global health job was found to support an additional 2.6 jobs in the state. And the sector is growing, with employment increasing by 4.4 percent per year from 2009 to 2013, four times the rate of the overall economy.

6 *Washington Global Health Alliance and Community Attributes Inc., Washington State Global Health Landscape Study, August 2015.*

The life sciences and global health play key roles in Washington's economy, with outsized benefits, including:

- **High-wage, high-impact jobs.** Average annual wages for Washington workers in the life sciences exceeded $84,000 in 2015, 49 percent more than for the state's entire private sector ($56,539). In global health, wages averaged $71,129 in 2013. And, for every one job directly generated by the life science sector in Washington, another 3.8 jobs are created across the state's economy.

- **Middle- and high-skills job generator.** While the popular image of life sciences and global health industry jobs is primarily scientists and engineers, this is not always the case. Production workers, technicians, and other middle-skill occupations represent a majority of the jobs generated by the manufacturing subsectors within the industrial life sciences, typically requiring some post-high-school education and training, but not necessarily a four-year college degree or higher. Specifically, in the major manufacturing components of Washington's life sciences sector—drugs and pharmaceuticals, and medical devices—which together represent about one-quarter of sector jobs, more than 60 percent of these jobs are among middle-skill groups.

- **A growth driver during recessions:** In the recessions of both 2001–2002 and 2007–2009, the life sciences and global health sectors provided Washington with a much-needed source of new job growth.

- **Broad Geographic Footprint.** The life sciences and global health sectors are also more geographically distributed across Washington than many other innovation-led industries.

From 2001 through 2011, Washington's life science industry—which incorporates much of the global health sector—recorded a decade of strong employment growth, supported by targeted state policies (see Figure 2). In fact, this high-wage jobs growth outpaced the nation and other private sector job growth in Washington. However, in recent years, the industry has faced challenges and headwinds which were detailed in the Governor's Life Science and Global Health Advisory Council[7] report. Since 2011, and at a time when the nation and other peer states have been making larger gains, Washington has seen a decline in life science industry jobs and lagging measures of industry innovation. This stagnation coincides with the elimination of state R&D tax incentives, the Life Science Discovery Fund, and the Washington Global Health Fund.

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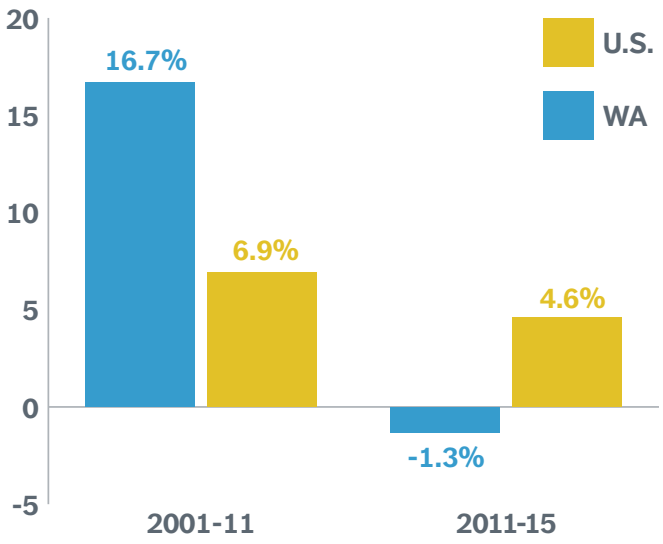
7 Ibid.

Figure 2: Washington's Life Science Industry Employment Trends, 2001-11 vs. 2011-15



Source: TEConomy Partners analysis of BLS, QCEW data; enhanced file from IMPLAN.

This is a critical time for this large state industry that for so long has driven innovation and high-quality job generation in both the industrial life sciences and in global health. Industry representatives are expressing key needs for talent and challenging workforce dynamics to return to a growth path. In order to work toward meaningful solutions for the industry's next phase in Washington, this study will focus on the assessment of these needs and dynamics.

II. Workforce Assessment Approach: Occupational Framework and Methodology

Occupational Framework

Advancing life sciences innovation and successfully delivering it to a highly competitive market requires the right blend of talented, educated, and skilled individuals working together with a common purpose. As the most R&D-intensive industry in the nation, the life sciences are characterized by a unique set of workforce and talent requirements as well as a highly regulated operating environment that adds additional and unique complexity. These characteristics include:

- The array of specialized knowledge needed across the industry;
- The broad mix of industries spanning R&D, services, production activities, and complex supply and distribution chains; and
- The diversity of occupations employed across the industry.

Complicating things further, the demands for talent and skill sets are a moving target, with shifts occurring across the varied skill levels. At the high-skilled end of the continuum, employers increasingly want employees with multi-disciplinary skill sets and the ability to function in a more collaborative, "team science" environment. Among middle-skilled workers, an increasing emphasis and need for math and computer skills characterizes today's advanced manufacturing environment. Lower-skilled workers face threats from increasing automation.

At the industry's core are highly skilled scientific and technical talent—scientists, engineers, technicians, and managers who are the forefront of life science and global health innovation development, and who have specific life science experience, education, and backgrounds. But at the same time, the industry requires a whole range of additional personnel to compete within an advanced, knowledge-driven industry in key functions that are not necessarily specific or unique to the life sciences such as business development and marketing, information technology, and skilled production. The challenge for life science firms regarding this latter group is they must compete for this talent base against a range of other industries.

Based on these two distinct groupings of talent needs and their corresponding demand and supply characteristics, a key delineation has been drawn and a detailed assessment undertaken for this study to separate these groups into:

1. **"Primary" life science and global health occupations** which identifies and groups detailed occupations where the principal function and activities are directly or primarily related to the industrial life science and global health industry (non-clinical). The following five groupings were formed:[8]
    - Agricultural, Food and Nutrition Scientists, and Technicians
    - Biological Scientists and Technicians
    - Life Science-related Engineers
    - Life Sciences Managers
    - Medical and Clinical Laboratory Technicians

2. **"Secondary" life science and global health occupations** includes the many detailed occupations that play a significant and disproportionally important role (based on their industry concentrations) in the life sciences and global health yet are not primarily life science-related in function or in name.[9] These occupations are critical to the industry yet span a number of other industries in Washington. Forty-three occupations were identified and assembled into ten larger groups, including:
    - Business & Financial (e.g. accountants and auditors, marketing specialists)
    - Chemists & Chemical Technicians
    - Engineering & Engineering Technicians (e.g. electrical, industrial, mechanical engineers)
    - Health Technicians (e.g. orthotists and prosthetists)
    - Information Technology (e.g. application software developers)
    - Management (e.g. engineering, industrial production management)
    - Office & Administrative (e.g. customer service reps, shipping/receiving clerks)
    - Skilled Production (e.g. assemblers and fabricators, chemical equipment operators)
    - Technical Sales Reps
    - Transportation (e.g. truck drivers, machine feeders and offbearers)

Conducting industry-specific analyses of occupational data does have limitations. For example, in some cases, the federal occupational classification system does not include enough detail to parse out key occupations for the life sciences such as regulatory affairs, quality assurance/control, or bioinformatics/biostatistics. As these are critical to the industry, TEConomy has conducted an industry survey of Washington companies which includes questions and data collection regarding these occupations.

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8 For a full listing of the detailed occupations in both the Primary and Secondary occupations and how they are defined across these groupings see the Appendix.

9 For a discussion on the "Staffing Patterns" driven assessment approach used by TEConomy to identify detailed Secondary occupations for the industry see the Appendix.

Analytical Approach

Answering the key questions posed in this study requires a multi-faceted and fact-based approach that utilizes both quantitative and qualitative information and is representative of the industry and its key occupations in Washington. Examining the demand and supply for life science and global health talent, the study brings these findings together to assess their alignment, or lack thereof, in order to understand where strategic interventions are necessary.

Demand Assessment. The approach to assessing the demand for life science and global health-related talent in Washington incorporates the following:

Quantitative Approach:

- Occupational Employment Statistics data to assess employment levels and recent trends using data from the U.S. Bureau of Labor Statistics and Washington Employment Security Department (ESD);
- Occupational Employment Projections to assess projected annual demand for employment including both new job openings and replacement needs using data from the Washington ESD;
- Industry "Staffing Patterns" data to identify key occupations that are not clearly life science-related (for secondary occupations) using data from the Washington ESD;
- Demographics of the workforce employed in life sciences to assess industry diversity using data from the U.S. Census Bureau's American Community Survey;
- Industry Employer Survey, administered by TEConomy, to assess the occupational mix of Washington companies and their recent and expected hiring, as well as existing job openings and expected future needs.

Qualitative Approach:

- Industry Employer Survey to assess the emerging skill needs and technology areas specific to the life science industry that are critical to remaining competitive in the future; hiring trends; and future workforce needs;
- Individual Interviews and Regional Focus Groups across industry, academia, workforce, and training providers, and other key Washington stakeholders to gain a more in-depth perspective of workforce needs and challenges that inform strategic priorities and actions.

Supply Assessment. The approach to assessing the supply for life science and global health-related talent in Washington incorporates the following:

Quantitative Approach:

- Postsecondary Graduates across key degree fields to assess the supply of life science-related talent generated by Washington institutions using data from the National Center for Education Statistics.

Qualitative Approach:

- Industry Employer Survey to assess recruitment dynamics, education, and experience requirements of candidates;
- Individual Interviews and Regional Focus Groups across industry, academia, workforce, and training providers, and other key Washington stakeholders;
- More detailed educational program offering review, career awareness, and guidance activities, engagement with industry on meeting skill needs, and use of industry-driven certificates.

The demand assessment will ultimately yield a set of occupations identified as being in "*high demand*" across the industry in Washington which will then be aligned with the findings regarding the supply of talent to highlight areas most in need of interventions.

III. The Demand for Life Science and Global Health Workers in Washington

The demand assessment for life science and global health workers involves considering the current position, recent trends, and future projections from employers. One perspective for this assessment of demand is available from the occupational surveys conducted by the Washington ESD across all employers in the state. With these occupational data, though, it is hard to examine solely for life science employers and requires the split between primary life sciences occupations and secondary occupations involving many industries. However, even with the split, this data provides the most comprehensive context of occupational size, concentration, and trends in Washington.

To gain more specific insights from just the life sciences industry and global health sector, and in order to better understand the talent dynamics, challenges, and issues they face today, TEConomy undertook its own survey of life science employers augmented by one-on-one interviews with life science companies as well as regional focus group meetings with life science employers and key stakeholders. The life science industry workforce survey by TEConomy gauges the demand for workers in key life science and global health occupations including those that lie outside standard classifications yet are critical to the industry, such as for quality assurance and quality control, regulatory affairs, and bioinformatics, with respect to:

- The existing employee base;
- Recent hires (over the last year);
- Current vacancies; and
- Expected new hires (over the next two years).

To further the project objectives and goals, the survey also asks questions regarding:

- Demographics of existing workforce (to assess industry and occupational diversity);
- Degree of difficulty/ease finding qualified candidates;
- Recruitment geography (where Washington-based employers are searching for talent);
- Education and work experience requirements (a focus in the Supply section of the report);
- Emerging technology areas important for educational curriculum, incumbent worker training (a focus in the Supply section of the report);
- Major workforce-related challenges for employers.

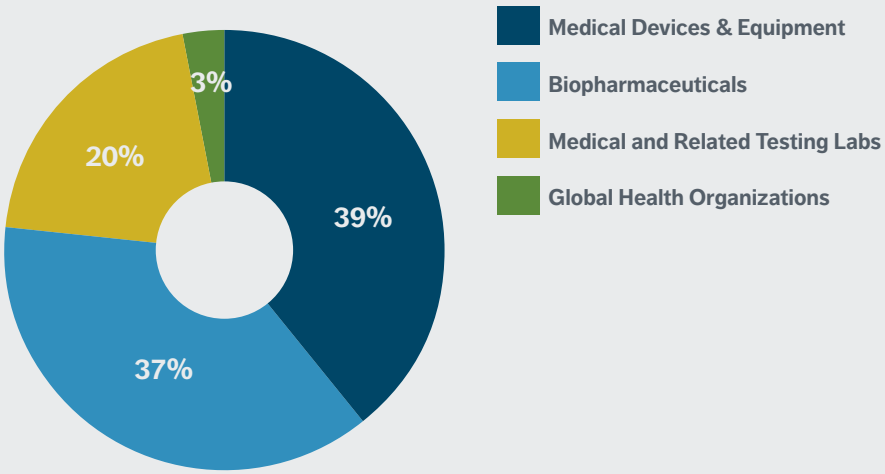
Details about the survey response are provided in the text box.

Washington Industry Survey: Response Overview

Survey distributed in March 2017 to Department of Commerce Mailing List, and to Workforce Panel

25 Life Science/Global Health Companies fully completed survey

- Responding companies employ more than 6,100 in Washington currently and have hired more than 1,400 over the last year.
- Response represents approximately one-fifth of industry jobs.
- Of note, there is significant overlap between the biopharmaceuticals subsector and global health as numerous biotechnology/life sciences R&D organizations are considered part of both, but most have self-identified in the survey as part of life sciences R&D.



Assessing Demand: Recent Performance

Consistent with Washington being one of our nation's leading life science industry states that is experiencing challenging headwinds, it stands as "specialized" overall in its primary occupational workforce, but has declined in employment (see Table 1). This designation is based on the occupational location quotient (LQ), which represents the share of these jobs in Washington relative to that for the nation.[10] At 1.18, the LQ for Washington means the state is 18 percent more concentrated in primary occupational employment compared with the national average. Two of the four primary groupings in Washington have a highly specialized concentration—biological scientists and technicians, and life science management.

Table 1: Employment Metrics for Primary Life Science and Global Health Occupations in Washington, 2015

Primary Life Science Occupation Groups	WA Employment, 2015	WA Location Quotient, 2015
Total, Primary Occupations	20,510	1.18
Biological Scientists and Technicians	9,510	1.59
Medical and Clinical Lab Technicians	8,060	0.93
Life Sciences Managers	1,780	1.54
Agricultural, Food and Nutrition Scientists and Technicians	740	0.66
Life Science-related Engineers	420	0.84

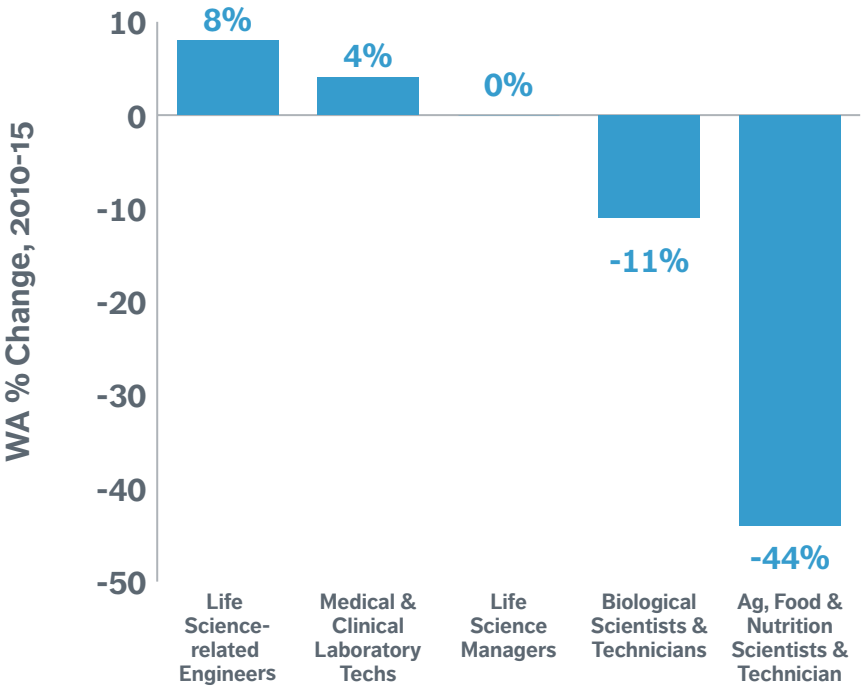
Source: TEConomy Partners analysis of Bureau of Labor Statistics, Occupational Employment Statistics.

Reflecting the performance of the life science industry during the economic recovery, Washington's demand for primary occupations has been mixed, with stronger demand seen increasing jobs for life science-related engineers and for medical and clinical lab technicians (where growth has outpaced that for the nation). Strong growth among biomedical engineers, up 22 percent in Washington since 2010, has driven growth in the engineering group. Among medical lab technicians, job gains have been driven by growth in the two largest components—medical and clinical lab technicians and technologists.

The net employment decline among biological scientists and technicians can be attributed to job losses in its larger components including medical scientists, biological scientists ("all other", a catch-all classification), and among biological technicians. Industry leaders point to the loss of two key Seattle-based companies during this period—Amgen, which closed its Seattle R&D operations in 2015, and Dendreon, which filed for bankruptcy and was sold in late 2014 and early 2015, that has driven down scientific employment. Despite these job losses, Washington experienced strong gains within this category among biochemists and biophysicists, and more modest recent growth among microbiologists and epidemiologists.

10 *State (or regional) location quotients (LQs) measure the degree of job concentration within the state relative to the nation. A state with a LQ greater than 1.0 is said to have a concentration in the occupation. When the LQ is significantly above average, 1.20 or greater, the state is said to have a "specialization" in the occupation.*

Figure 3: Employment Trends for Primary Life Science & Global Health Occupations in Washington, 2010-15



Source: TEConomy Partners analysis of Bureau of Labor Statistics, Occupational Employment Statistics.

Within the primary groupings are several detailed primary occupations with a specialized concentration in Washington, at least 20 percent or more than the national average (Location Quotient > 1.20), including:

- Epidemiologists
- Medical Scientists
- Biological Technicians
- Agricultural Engineers
- Natural Sciences Managers
- Dental Laboratory Technicians
- Biological Scientists (All Other)

Secondary Occupations. The recent strong performance of the industry's "secondary" occupations reflects the overall strength of the Washington economy during the economic expansion and high demand for labor among a broad range of the state's advanced industries. During the 2010 through 2015 period, total occupational employment in Washington rose nearly 11 percent, and seven of the ten occupational groupings key to the life sciences and global health have outpaced this overall state growth (see Figure 4).

Based on the location quotients presented in Table 2, four of these groups can be considered state specializations in Washington: information technology, engineering and engineering technicians, business and financial, and a very small group of specialized health technicians.

The state's strong specialization in IT jobs reflects the industry and talent strengths in Washington that not only serve the IT-specific industry, but represent a key function across other areas including the life sciences, banking, healthcare, aerospace, and others. IT jobs most critical to the life sciences and included in this analysis include software developers, both in applications as well as in systems development; computer hardware engineers; and computer support positions. It is likely no surprise to those who understand Washington's current and historical strengths in software development that relative to the nation, the state has three times the concentration in software applications developers.

Secondary engineering occupations are another deep and varied strength in Washington, with broad-based and strong job growth and specializations in industrial, electrical, and mechanical engineering. The state's medical device manufacturers, who utilize these types of engineers to a great degree, must compete against other large advanced manufacturing sectors in Washington, particularly in aerospace manufacturing for this expertise and talent base. Within this engineering grouping is a large segment of workers in engineering technician jobs which represent a key segment of middle-skilled workers in positions that typically require an Associate's degree for entry. Industrial engineering technicians play key roles in the state's electromedical device production.

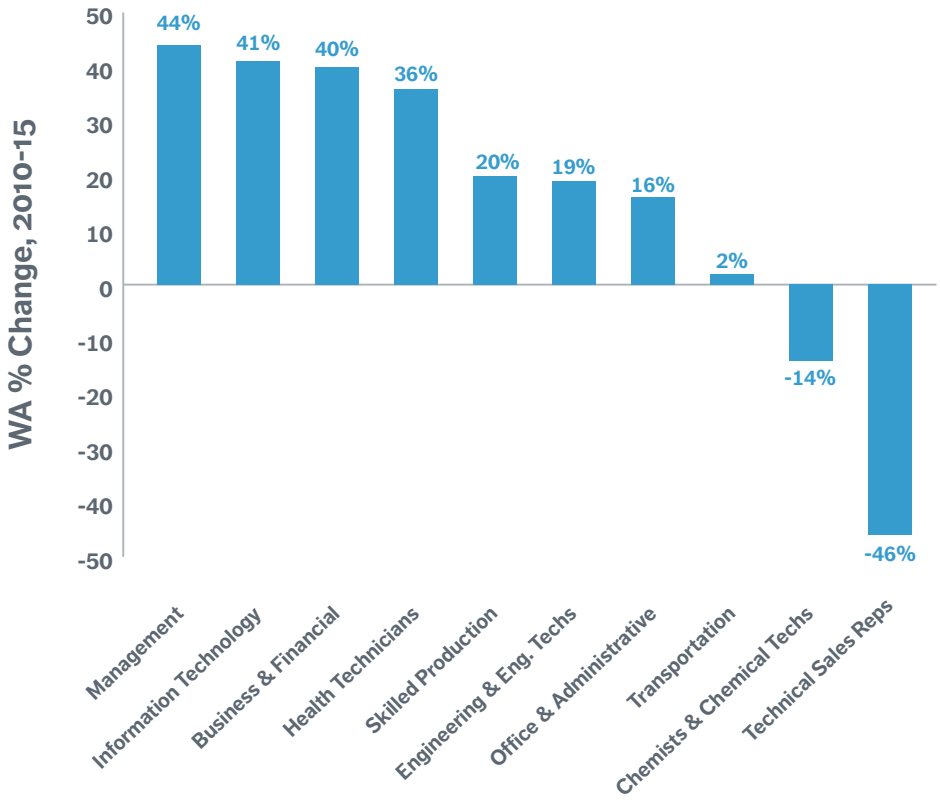
Skilled production workers vital to the industrial life sciences in Washington include chemical equipment operators, and packaging and filling machine operators in the biopharmaceutical subsector. In medical device manufacturing, examples include dental and ophthalmic lab technicians, medical appliance technicians, and molding and casting machine operators. Reflecting the state's strengths in manufacturing overall and recent strong demand, these and other skilled production jobs vital to the life sciences have grown by 20 percent since 2010.

Table 2: Employment Metrics for Secondary Life Science and Global Health Occupations in Washington, 2015

Secondary Life Science Industry Occupational Groups	WA Employment (All Industries), 2015	WA Location Quotient, 2015
Office & Administrative	252,080	0.91
Information Technology	81,430	1.37
Management	59,590	0.91
Business & Financial	51,980	1.19
Skilled Production	43,000	0.83
Engineering & Eng. Techs	28,450	1.26
Transportation	18,720	0.93
Technical Sales Reps	4,650	0.64
Chemists & Chemical Techs	2,540	0.79
Health Technicians	190	1.24

Source: TEConomy Partners analysis of Bureau of Labor Statistics, Occupational Employment Statistics.

Figure 4: Employment Trends for Secondary Life Science & Global Health Occupations in Washington, 2010-15



Source: TEConomy Partners analysis of Bureau of Labor Statistics, Occupational Employment Statistics.

Within the secondary groupings are 11 detailed occupations with a specialized concentration in Washington at least 20 percent or more than the national average (Location Quotient > 1.20), including:

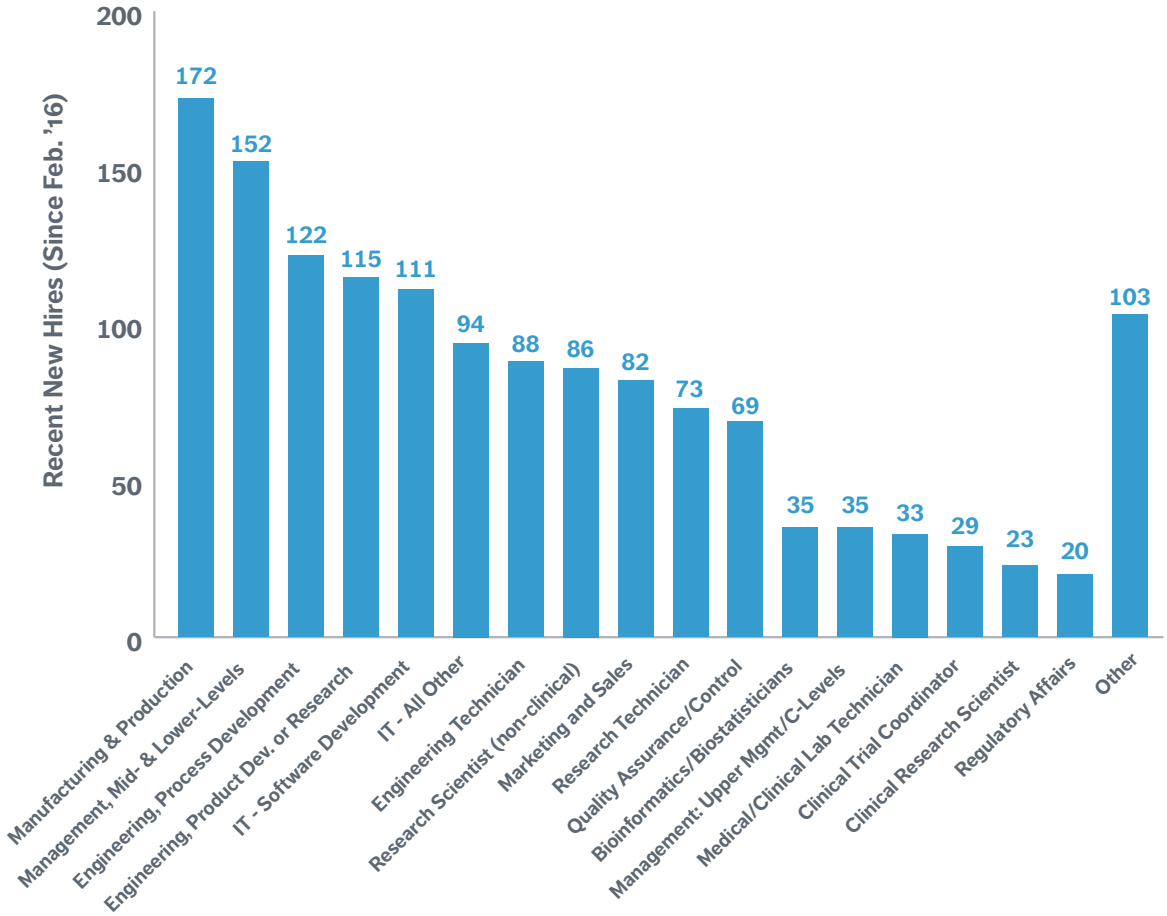
- Software Developers, Applications
- Industrial Engineering Technicians
- Purchasing Agents (Except Wholesale, Retail, and Farm Products)
- Electrical Engineers
- Software Developers, Systems Software
- Industrial Engineers
- Market Research Analysts and Marketing Specialists
- Production, Planning, and Expediting Clerks
- Sewing Machine Operators (which have a role in medical device manufacturing)
- Orthotists and Prosthetists
- Engineering Managers

Recent Performance: Life Science and Global Health Employers' Survey

Despite overall industry employment stagnation during the economic expansion, hiring over the last year among industry employers that completed the survey has been strong. Over the last year, industry hiring totaled more than 1,400 across both new jobs added and replacements, and the composition of new hires generally reflects the overall occupational structure of these organizations (Figure 5). There are several areas where new hiring as a share of total employment exceeded the industry average of 20 percent. These occupational areas with especially strong recent hiring include:

- Research Technicians
- Bioinformatics/Biostatisticians
- Engineering (both Process Development and Product Development/Research focused)
- Engineering Technicians
- IT – Software Development
- Manufacturing and Production
- Marketing and Sales

Figure 5: Recent Hires of Life Science and Global Health Companies in the Last Year*



**Survey was conducted in March 2017 and question asked about hires since February 2016.*

Assessing Demand: Growth Projections

It is critical for a robust demand assessment to not only look backward to assess the recent demand for life science and global health occupations but also to look toward the future. To meet this need, Washington's Employment Security Department develops both short- (5-year) and longer-term (10-year) projections of occupational demand. To more specifically profile the dynamics of expected annual demands, the Department breaks down the projected annual job openings into two categories—demand driven by "replacements" and that driven by new growth.

Key Findings:

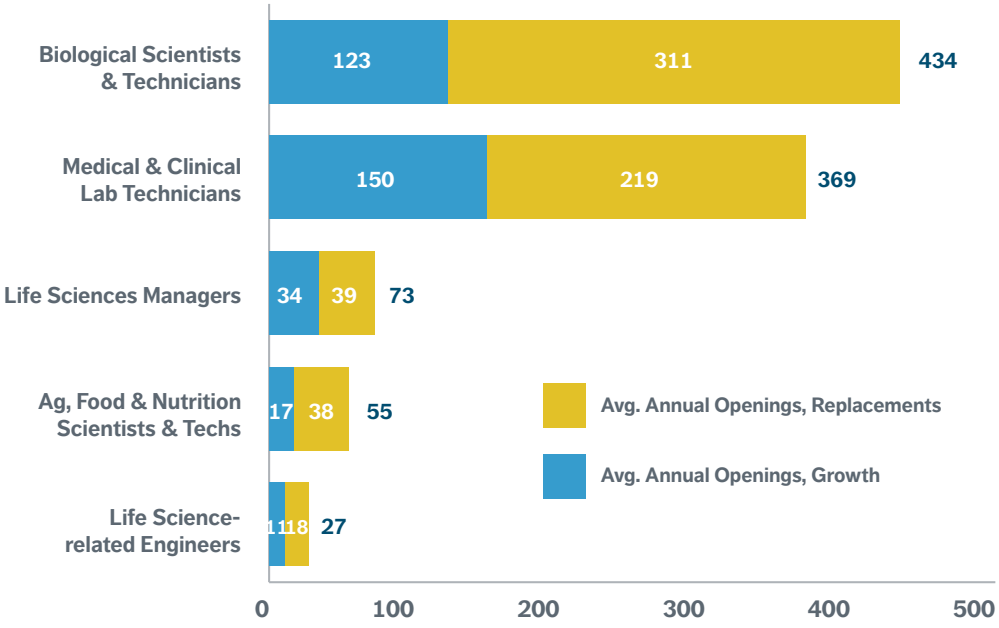
Two of every three annual job openings *in Washington's primary life science and global health occupations will be generated by "Replacements" of retiring workers, or those changing occupations.*

Four of five primary occupations *are expected to be in "high demand" relative to the overall economy.*

Based on Washington's ESD Occupational Projections

Primary Occupations. The most current 10-year projections span the 2014-24 period, with estimates of the breakdown in replacements versus growth openings published for each of the 5-year periods in-between. For the overall Washington economy, ESD projects annual demands for job openings will be strongly tilted toward replacement needs during the 2019-24 period, with 65 percent of openings generated by workers retiring or otherwise leaving their jobs, and 35 percent generated through net job growth. These same breakdowns play out for the primary life science occupations, with nearly two of every three of the nearly 1,000 annual job openings expected to come from replacement needs. Projected annual job openings are presented in Figure 6.

Figure 6: Washington Primary Life Science & Global Health Occupations: Projected Annual Employment Needs, 2019-24



Source: TEConomy Partners analysis of Occupational Employment Projections, Washington State Employment Security Department/LMPA.

Relative to Washington's overall employment outlook, primary life science occupations are expected to be in high demand. Looking out 10-years, expectations are for four of the five groups to exceed the overall growth rate of 17 percent (Table 3).

Table 3: Employment Growth Projections for Primary Life Science & Global Health Occupations, 2014-24

Occupational Group	Projected Empl. Growth, 2014-24
All Occupations	17%
Agric., Food & Nutrition Scientists & Technicians	23%
Life Sciences Managers	21%
Life Science-related Engineers	20%
Medical & Clinical Lab Technicians	19%
Biological Scientists & Technicians	13%

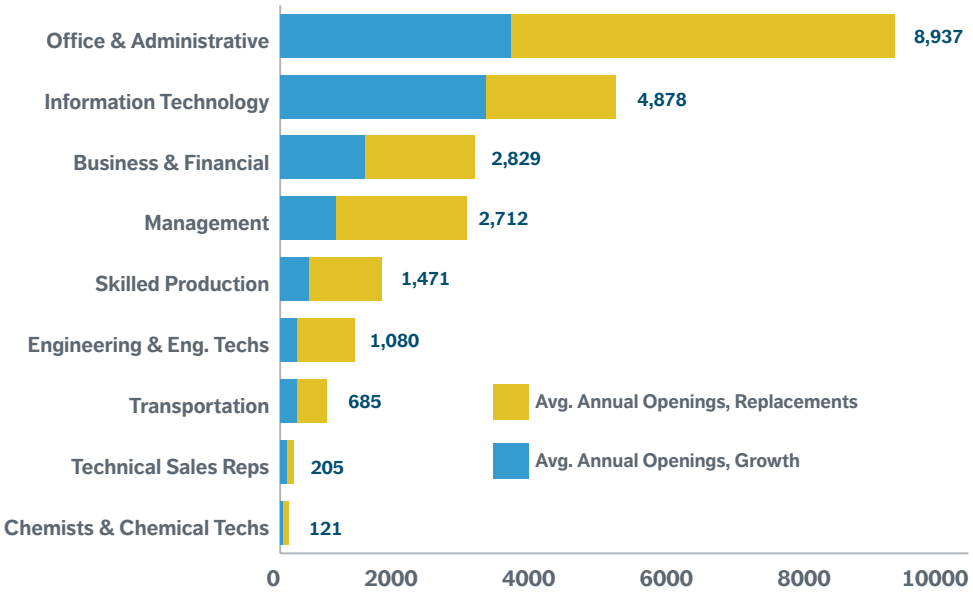
Source: TEConomy Partners analysis of Occupational Employment Projections, Washington State Employment Security Department/LMPA.

Within the broader groupings, ten detailed occupations can be considered "high-growth" in their 10-year employment projections exceeding the overall average:

- Agricultural and Food Science Technicians
- Soil and Plant Scientists
- Biochemists and Biophysicists
- Biomedical Engineers
- Natural Sciences Managers
- Medical and Clinical Laboratory Technicians
- Medical and Clinical Laboratory Technologists
- Medical Appliance Technicians
- Ophthalmic Laboratory Technicians

Secondary Occupations. The 2019 to 2024 outlook for those secondary jobs that are most critical to the life sciences and global health finds projected growth driven more by new job creation compared with the overall economy, with 41 percent of job openings coming from net new jobs. Across all industries, not just the life sciences, these occupations are expected to see nearly 23,000 Washington job openings, on average (see Figure 7).

Figure 7: Washington Secondary Life Science & Global Health Occupations: Projected Annual Employment Needs, 2019-24



Source: TEConomy Partners analysis of Occupational Employment Projections, Washington State Employment Security Department/LMPA.

Four out of the ten secondary occupational groupings are expected to outpace the overall economy during the full, 10-year projection period (Table 4).

Table 4: Employment Growth Projections for Secondary Life Science & Global Health Occupations, 2014-24

Occupational Group	Projected Empl. Growth, 2014-24
All Occupations	17%
Information Technology	34%
Health Technicians	27%
Technical Sales Reps	24%
Business & Financial	22%
Chemists & Chemical Technicians	16%
Transportation	16%
Office & Administrative	15%
Management	15%
Skilled Production	12%
Engineering & Eng. Technicians	7%

Source: TEConomy Partners analysis of Occupational Employment Projections, Washington State Employment Security Department/LMPA.

Sixteen of the detailed occupations underlying the broader secondary groups are expected to see stronger-than-average growth in Washington over the 10-year projection period, including:

- Accountants and Auditors
- Market Research Analysts and Marketing Specialists
- Computer Hardware Engineers
- Computer Network Support Specialists
- Computer User Support Specialists
- Software Developers, Applications
- Software Developers, Systems Software
- Chemists
- Orthotists and Prosthetists
- Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products
- Customer Service Representatives
- Receptionists and Information Clerks
- Weighers, Measurers, Checkers, and Samplers, Recordkeeping
- Assemblers and Fabricators, All Other
- Electrical and Electronic Equipment Assemblers
- Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders

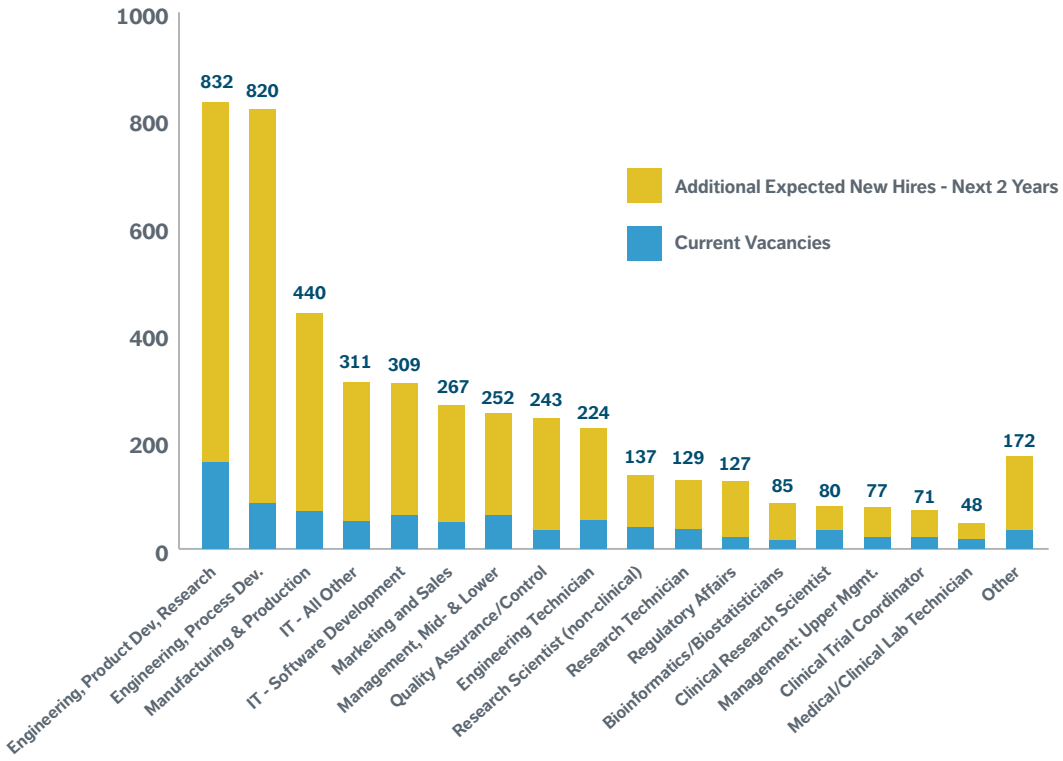
Expected Future Hiring: Life Science and Global Health Employers' Survey

Industry survey respondents were asked about their current vacancies and hiring expectations across the occupations over the next two years (Figure 8). Several occupations stand out with a combined current and expected demand that exceeds the industry average of 63 percent of their current base. Occupations with especially strong expected demand and future hiring needs include:

- Engineering (both Process Development and Product Development/Research focused)
- Regulatory Affairs
- Bioinformatics/Biostatisticians
- Manufacturing and Production
- Marketing and Sales

In particular, the combined current and expected demand for engineers is especially significant with the industry, primarily medical device manufacturers, expecting to hire 1.4 times the current base of engineers in just two years' time. This expectation reveals a very strong need for engineering talent at a time when employers are consistently reporting difficulty in finding qualified candidates to fill engineering positions, which was also echoed in interviews, surveys, and the regional focus groups. An additional situation is arising in the expected needs for personnel with regulatory affairs expertise, with employers expecting to hire more than 100 percent of their current base in the coming two years, and in another occupational area for which employers are challenged in sourcing qualified candidates.

Figure 8: Current Vacancies and Expected New Hires During the Next 2 Years



Whether in the survey and/or from interviews and the regional focus groups, life science and global health employers in Washington are consistently identifying several occupation and skill areas as either "somewhat difficult" or "very difficult" to find qualified candidates. These include:

- Research Scientists
- Bioinformatics/Biostatisticians
- Engineering (both Process Development and Product Development/Research focused)
- IT (both Software Development and other positions)
- Marketing and Sales
- Regulatory Affairs
- Management (all levels)
- Medical and Clinical Lab Technicians

Selected quotes from industry employers and hiring managers regarding key skill sets amplify these and other talent challenges they face today, many of which reflect the themes presented in the next section (see text box).

From a quantitative perspective, both the recent and projected future demand for occupations and corresponding skill sets for the life sciences and global health are key inputs to the demand assessment. But what is the qualitative, on-the-ground perspective from Washington's companies and research organizations on the demand for talent and other related issues and challenges? The next section of the demand assessment turns to the insights gleaned from the survey, interviews, and focus groups with corporate leadership and other stakeholders.

Employers & Hiring Managers Speak Out on Their Greatest Talent Challenges

Theme—Rising Competition in Key Occupations and Skill Areas:

"Information technology, engineering, and modeling/theory competition [is] increasing."

"Competition makes it extremely difficult for a startup to find affordable, qualified people."

"Our challenge has been with the ability to compete on salary with large employers like Amazon and Microsoft."

"Rising information technology salaries exceeding scientific salaries creating imbalance in a scientific organization."

"Experienced engineering, software, technical - large amount of competition."

"Our ability to attract and retain employees in this expensive and competitive Puget Sound labor market."

Theme – Need for Industry-specific Experience and Interest:

"People in data science and software need to understand the vertical markets. And most of them don't."

"Having experience in the medical device arena is challenging. Attracting quality candidates for roles in a highly competitive labor market can be a significant barrier."

"The lack of talented individuals attracted to a medical device product. We are growing...our barrier to this is finding qualified talent that would fit into our culture."

Theme—Difficulty Finding Qualified Candidates in Key Skill Areas:

"Our search for clinical operations, regulatory affairs, and QA/QC personnel has been the most difficult, with many of the most qualified applicants coming from out of state."

"Finding qualified, experienced regulatory people and senior management." [Is greatest workforce challenge]

Theme – Disconnect with Washington's Colleges & Universities:

"Locating and recruiting interns is challenging because of arcane university processes that leave the process to the student and recruiting organization through tools like job boards. University departments should be actively leveraging external opportunities as part of their curriculum in [an] effort to both place students and better prepare them for employment... Attempts in working with educational institutions [have] not been effective or efficient."

Theme—Difficulty recruiting based on perceived lack of career opportunities in Seattle:

"Attracting high caliber candidates from other metropolitan areas - Boston, NE, Bay area, and San Diego. Seattle is becoming less attractive due to rising cost of living and candidates have concerns about health of biotech industry in Seattle."

"Ability to attract new talent to Seattle, given the lack of a biotech "footprint" here and a relatively small number of other biotech companies."

"Getting people to relocate to Seattle [which lacks] biotech presence"

Surveys, Interviews, and Focus Groups: Demand Challenges, Themes, and Insights

The preceding quotes from industry regarding their greatest talent- and workforce-related challenges speak volumes regarding the highly competitive talent situation not only in an advanced industry, which requires highly specialized and often experienced talent, but also in a state and region (much of the industry is concentrated in Seattle and Puget Sound more broadly) where the competition is stiff and increasing. A number of these and other themes that were raised consistently across employer interviews, surveys, and focus groups are reflected in the key themes summarized in Figure 9. These themes span industry-specific as well as situational challenges in the state labor market, as well as the demand for specific skills and expertise.

Regional Focus Groups

Life science and global health industry stakeholders, representing employers as well as higher education and workforce training partners, were invited to a series of regional focus groups to discuss key project findings and to provide more perspectives on key trends, specifics on demands and skill gaps, education and workforce programs/ initiatives that are working well, and what should be done. Focus groups were held in:

- *Vancouver, WA with a broad-based life sciences industry and education focus*
- *Spokane, WA with a broad-based life sciences industry and education focus*
- *Bothell, WA with a focus on medical device manufacturing*
- *Seattle, WA with a focus on biopharmaceuticals*
- *Seattle, WA with a focus group of life science graduate students and post-docs from the University of Washington*
- *Seattle, WA with a focus on health information technology*

Figure 9: Common Themes and Insights from Industry Interviews, Surveys, and Regional Focus Groups

Broad Industry-related Talent Challenges & Concerns	Demand for Specific Occupations, Skill Sets, Technology Areas	Broader Labor Market & Competitive Challenges in Washington

• Major challenge for industry in Washington around industry and career "Awareness"
• Many companies recruiting out of state; often limited connections with local colleges/universities
• Intern programs limited, often not large-scale
• Unique nature of search for niche individual expertise
• University students having difficulty connecting with the industry
	• Strong demand & difficulty sourcing/hiring in:
	  • Senior Scientific (PhD), Clinical
	  • IT & Data Sciences, Bioinformatics
	  • Engineering, particularly QA for medical device mfg.
	  • Regulatory expertise
	  • Clinical lab scientists
	  • Functional support particularly in Marketing & Sales
	• General: Nature of jobs changing with shifts toward "Team Science"; increasing multi-disciplinary collaborations
	• Uneven STEM and "Soft Skills" development
	• Technical talent that understands and has experience in the industry
		• Highly competitive talent market in WA in Advanced Industries – e.g. boom in Technology sector leading to increased competition for talent, driving up wages
		• Challenges for medical device firms to leverage talent, skills from aerospace industry
		• Aging workforce reflected in large number of "replacement" needs projected into the future
		• Challenges getting candidates to relocate to Seattle citing limited scale of regional cluster and therefore limited additional career opportunities, cost of living.

The common themes and insights include perspectives on both the demand and the supply for talent. Therefore, some of the items above, such as career awareness, recruitment dynamics, and internships, will be addressed in the supply section of the report.

Life sciences industry, technology, and research trends are shifting the high-demand skills sets and nature of industry jobs. Findings from recent industry workforce studies reveal employer preferences are shifting with respect to preferred and ideal candidates that reflect industry and related technology trends such as:

- **The genomics revolution and applications in molecular diagnostics and personalized medicine are driving vast amounts of data collection** and in turn, biopharmaceutical companies in particular, need technical expertise in the analysis and management of large clinical data sets. In a recent workforce and talent study by TEConomy for Indiana's health and life sciences industry, industry consistently identified the need for health and bioinformatics talent across the biomedical research and clinical trials enterprise.[11] Bioinformatics degree programs, particularly

11 *TEConomy Partners and Battelle Technology Partnership Practice, Indiana's Health and Life Sciences Talent and Workforce: Developing Strategies to Compete in a Global Economy, May 2016.*

at the graduate levels, are increasing in the United States to meet this demand, but education and training at other degree levels are also placing greater emphasis on analytical capabilities. Many companies in both Indiana and Washington are conducting national searches for bioinformatics talent.

- **Regulatory and quality assurance and control expertise remains critical for biopharmaceutical and medical device companies,** though much of this is not learned in a formal academic setting or degree program but rather on the job. Washington's medical device employers, many of whom are manufacturing small, intricate implantable devices or defibrillators that simply cannot fail, face tremendous challenges in finding workers with the knowledge and experience to oversee quality control and industrial production in a highly regulated environment.

- **The demand for STEM-related talent is rising and competition is increasing, even in non-STEM related industries.** TEConomy has engaged with PhRMA on assessments of U.S. STEM education in the context of biopharmaceutical industry competitiveness and found the poor performance of U.S. students in achievement and proficiency is translating into major competitive challenges for the industry as it competes internationally.[12] Talent gaps are widening, particularly when STEM-related skills and educational backgrounds are highly valued by non-scientific industries like finance and insurance.

Additional studies find life sciences companies are emphasizing a broader need for workers in the following capacities[13][14]:

- Top scientific and engineering talent and broad STEM education backgrounds but supplemented with multidisciplinary skill sets, for example, life sciences with business expertise or engineering with computer sciences training;
- A scientific orientation toward development and real-world applications rather than simply basic research;
- Strong communications and management skills, including the ability to work among and across teams.

In conversations with life science and global health industry leaders in Washington, these in-demand characteristics were raised consistently. In addition, there is an increasing emphasis on "Team Science", an approach to research that utilizes and leverages cross-disciplinary teams and collaborations, and represents a cultural shift in the scientific community that can require a scientist used to working alone to adapt. And as in other places, this represents a difficult challenge in Washington for both research scientists and their managers as they adapt.

Looking across the valuable quantitative and qualitative insights shared by Washington's life science and global health employers, a summary of occupational findings is shown in Figure 10 that informs the full demand assessment and key gaps for potential strategic interventions, particularly after also evaluating the supply side of the talent equation.

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12 TEConomy Partners, Enhancing Today's STEM Workforce to Ensure Tomorrow's New Medicines: Biopharmaceutical Industry Partnerships with U.S. Colleges and Universities, June 2017.

13 CSBI, Life Sciences Workforce Trends Report 2014.

14 Kathy Nugent and Avi Kulkarni, Nature Biotechnology, "An interdisciplinary shift in demand for talent within the biotech industry," September 2013.

Figure 10: Industry Survey Results Regarding High-Demand Occupations and Skills and Difficulty in Hiring

Occupation/Skill Areas	Survey: Strong Recent Hiring	Survey: Strong Expected Hiring	Interviews & Survey: Difficult to Find Qualified Candidates
Research Scientists			✓
Research Technician	✓		
Bioinformatics/Biostatisticians	✓	✓	✓
Engineering	✓	✓	✓
Engineering Technicians	✓		
IT – Software Development	✓		✓ (All IT areas)
Mfg. & Production	✓	✓	
Marketing & Sales	✓	✓	✓
Regulatory Affairs		✓	✓
Medical/Clinical Lab Techs			✓
Management			✓

Regional Industry Demand Drivers

For talent in the life sciences and global health, workforce focus groups provided valuable insights into unique regional demand drivers (see Figure 11). In the Greater Puget Sound area, including both Seattle and Bothell, the varied industry strengths of Washington are concentrated and were evident in the discussions. Bothell has a strong concentration of industrial life sciences manufacturing, especially within medical devices where numerous larger firms are located including the concentration of companies in ultrasound technologies such as: Philips, which develops and manufactures imaging equipment as well as defibrillators and oral healthcare products; EKOS, a BTG Company and pioneer in developing and producing ultrasounds treatments for vascular thrombosis (blood clots); and Physio Control, a leader in external defibrillators and monitors and EMR products and services. However, Bothell is also home to drug and pharmaceutical companies including Seattle Genetics, a high-growth biotech company specializing in antibody-based therapies for treating cancer; and CMC Biologics, a contract manufacturer serving the biotech and biopharma sector's production needs. Bothell has also benefitted from its close proximity to Seattle's life sciences ecosystem offering manufacturing space, a regional campus of the University of Washington, though it stands out on its own with its historic position and concentration of the state's legacy and continued strength in ultrasound technologies.

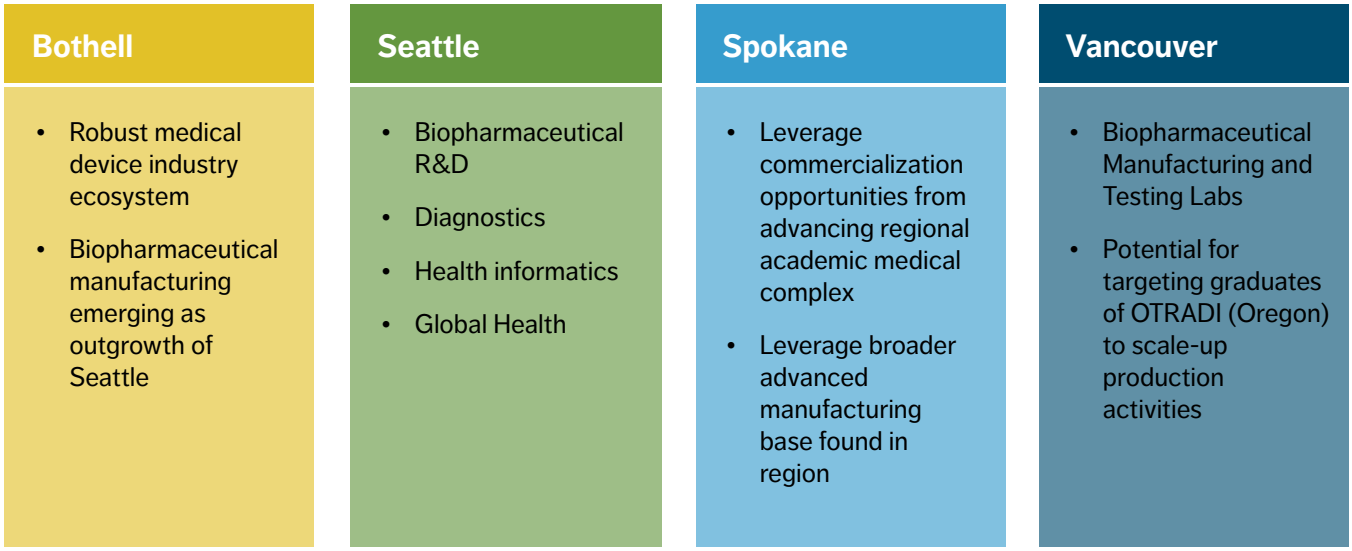
As a centerpiece of its "Vision 2030" strategy, the Spokane metro area is focusing intensely on economic development opportunities in the life sciences and healthcare as a primary economic driver. Greater Spokane Incorporated, the region's lead business development organization, is spearheading the effort to envision and execute on a strategy that builds upon the region's largest economic driver—healthcare—and is focused on key components including: expanded

undergraduate and graduate medical education (including the new WSU Medical School); health and life sciences research, commercialization and business development; and community health care.[15] Current strengths in the region's advanced manufacturing base that could be leveraged for opportunities in the life sciences, particularly within medical device manufacturing, include aerospace, as well as industry strengths in agriculture and related technologies that could be leveraged to drive opportunities in the agricultural biosciences.

Vancouver is targeting the life sciences as a key opportunity area for regional economic development and has seen an increased presence in the life sciences as new growth firms have moved in to the area from Portland focused in biopharmaceutical manufacturing and testing laboratories. The potential for "spillover" effects in the industry, from Oregon's Knight Foundation Cancer investments to targeting graduates of Oregon's OTRADI Bioscience Incubator on Portland's South Waterfront are being seen by regional economic developers. For example, AbSci, a leader in protein production technologies working to reduce costs in the biopharmaceutical industry, graduated from the Incubator and relocated to Vancouver, and is adding employees.

The geographic footprint of the life sciences and global health in Washington extends even beyond these areas with industry concentrations and demand for workers in the tri-cities region in research, testing, and medical labs; in Pullman with broad research strengths including in global health; and in Northwest Washington in the agricultural biosciences and in medical devices.

Figure 11: Regional Life Science & Global Health Opportunities Driving Demand



15 *For more information on GSI's Vision 2030 Strategy see: https://greaterspokane.org/vision-2030/.*

Assessing Demand: Identification of "High-Demand" Occupations in Washington

Taken all together, the quantitative and qualitative information and insights gathered provide an assessment of the demand for each occupation and skill area in Washington. Working across the assessment in Figure 12, those occupational groups that meet or exceed key thresholds across at least three or four assessment areas can be considered to be in "high-demand" by the life sciences and global health industry in Washington. This designation will help to inform the alignment of supply and demand later in the report, and to help identify areas of potential intervention.

Based on the assessment, eight occupational groups can be considered in "high-demand", and they span the primary occupations as well as the survey- and interview-specific categories (those that are not identified in the federal classification structure), as well as several of the secondary groups.

Figure 12: Summarizing the Demand Assessment

Major Occupational Groups	High Growth (WA>US)	Projected High Growth (Occ > WA Avg)	Industry Survey: Strong Recent Hiring	Industry Survey: Strong Expected Hiring	Industry Interviews & Focus Groups: Consistently Identified as In-Demand	"High-Demand" Occupations
Primary LS/GH Occupations:						
Agricultural, Food and Nutrition Scientists and Techs		✓				
Biological Scientists and Technicians			✓ (Techs)		✓	
Life Science-related Engineers		✓	✓	✓	✓	*High-Demand*
Life Sciences Managers		✓				
Medical and Clinical Laboratory Technicians	✓	✓			✓	*High-Demand*
Survey & Interview-Specific LS/GH Occupations:						
Quality Assurance/Control	n/a	n/a			✓	
Regulatory Affairs	n/a	n/a		✓	✓	*High-Demand*
Bioinformatics/Biostatistics	n/a	n/a	✓	✓	✓	*High-Demand*
Secondary LS/GH Occupations:						
Business & Financial	✓	✓				
Chemists & Chemical Techs						
Engineering & Eng. Techs	✓		✓	✓ (Engs.)	✓	*High-Demand*

Major Occupational Groups	High Growth (WA>US)	Projected High Growth (Occ > WA Avg)	Industry Survey: Strong Recent Hiring	Industry Survey: Strong Expected Hiring	Industry Interviews & Focus Groups: Consistently Identified as In-Demand	"High-Demand" Occupations
Health Technicians	✓	✓				
Information Technology		✓	✓		✓	*High-Demand*
Management	✓					
Office & Administrative	✓					
Skilled Production	✓		✓	✓	✓ (Assembly)	*High-Demand*
Marketing & Technical Sales Reps		✓	✓	✓	✓	*High-Demand*
Transportation						

Note: High-growth occupations are those where the growth rate during the economic expansion exceeded that for the nation. Projected High-Growth Occupations are those whose 10-year projected growth rate exceeds that for the overall Washington economy. Strong Recent Hires are those where recent hiring was above-average relative to the employment base reported. Strong Expected Hiring occurred where expectations are to hire an above-average share of workers relative to their employment base.

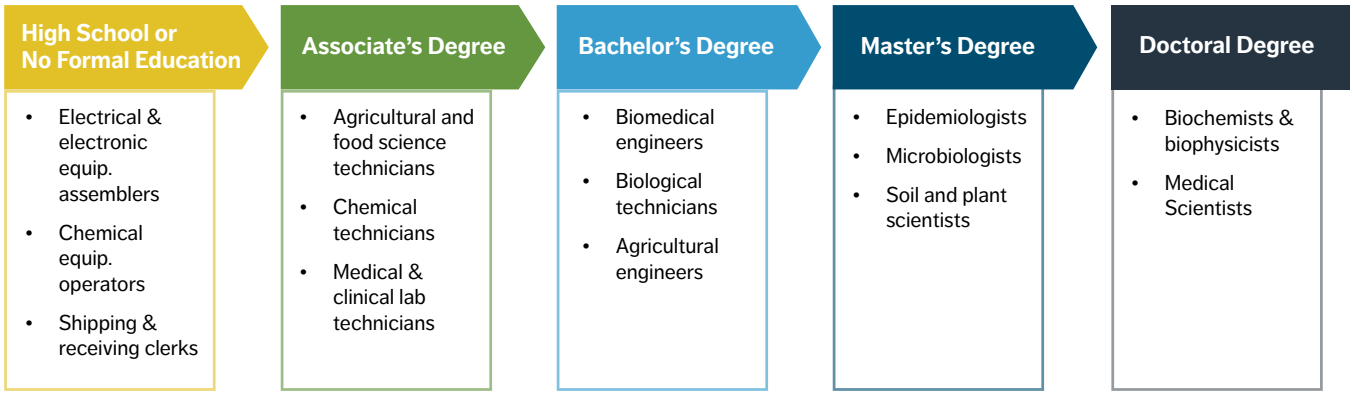
Despite meeting just two categories in the formal assessment, Regulatory Affairs has been designated high-demand due to the consistent and vocal demand expressed by numerous life science and global health companies; unfortunately, the current federal occupational classification system does not allow for isolating this occupation/skill set in the data assessment.

IV. The Supply of Washington's Life Science and Global Health Workforce

While the life science and global health workforce in Washington includes talent and expertise that is "imported", the primary source for developing and maintaining a robust talent pool is via the state's own workforce, and an education system that spans public and private institutions. This study's principal focus on the supply side of the talent equation is on those postsecondary programs most closely aligned with the industry's occupational and skill needs. However, the study also recognizes key education, workforce, and training programs that target the state's K-12 and secondary students and young adults, and may offer avenues for raising industry and career awareness and improving connections with the future life sciences workforce.

As an economic development driver which creates jobs that span the low, middle, and high-skilled continuum of education and skill requirements, life sciences and global health offer a unique value proposition. As illustrated in Figure 13, the industry includes jobs such as chemical equipment operators or shipping clerks that often require little to no formal education for entry; middle-skill jobs such as medical lab technicians that typically require an Associate's degree; and higher-skilled jobs such as biomedical engineers which can require a bachelor's or higher degree.[16]

Figure 13: Examples of Educational Requirements to Enter Life Sciences and Global Health Occupations

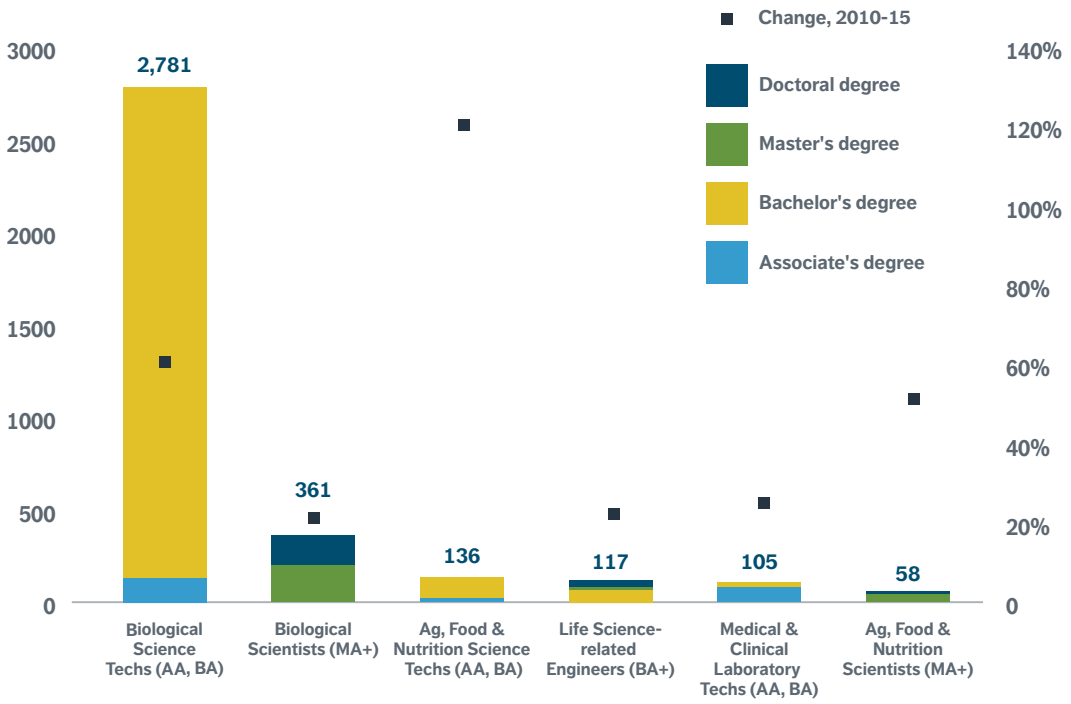


16 *Educational requirements for entry are based on U.S. Bureau of Labor Statistics, Occupational Employment Projections office.*

Talent Supply for Primary Life Sciences Occupations

Since 2010, Washington's colleges and universities have increased degree graduates in all primary occupational degree areas. For the levels and disciplines most relevant for primary life science and global health occupations, the degree counts and composition for Washington are presented in Figure 14, which represents the most recent annual snapshot (2015) of graduates from state colleges and universities. In addition, the recent growth of these degree groups aligned to occupations is shown by the square in the graphic (aligned with the right axis), showing that rise across all fields since 2010. Certain fields such as biological science technicians and agricultural, food and nutrition technicians, are at the associates and bachelor's levels based on entry requirements; while the scientist occupations typically require at least a master's degree for entry.

Figure 14: Washington Degree Graduates in Fields Most Closely Aligned with Primary Life Science and Global Health Occupations, 2015 and Increase, 2010-15



Degree graduate totals align with levels of degree generally required. Occupation to Degrees crosswalk developed by the National Crosswalk Service Center. Management occupations are not included due to inability of crosswalk to effectively map degrees to "managers".

Source: TEConomy analysis of Postsecondary Degree data from National Center for Education Statistics, IPEDS Database.

Highlights of recent growth in postsecondary life sciences degree areas include:

- The largest degree fields related to biological technician jobs have seen strong growth at the bachelor's level, particularly in biology (up 34%); biochemistry (up 38%), and molecular biology (up 76%);

- Among graduate degrees for biological scientist positions, one area of modest increase has been in biostatistics;

- In engineering, bioengineering has seen a slight increase at the bachelor's and above level but the distribution has shifted by level, with an increase in bachelors and doctoral degrees but a decline at the master's level. Graduate degrees in agricultural engineering have increased from just two in 2010 to 19 by 2015, which is consistent with other degree increases in ag, food, and nutrition.

In terms of numbers of graduates, the largest degree fields and leading Washington-based institutions are shown for each primary group in Figure 15. The institutions vary in their areas of focus most closely aligned with industry needs, with the larger public institutions including the University of Washington and Washington State University, playing key roles in the science and engineering fields, and several technical colleges with graduates for technician roles. As Washington's land-grant university, WSU has focused strengths in animal and food science as well as in agricultural engineering, a program which has grown at the graduate levels.

Figure 15: Leading Washington Institutions in Primary Life Science and Global Health Degree Areas

Agricultural, Food and Nutrition Scientists and Technicians	Biological Scientists and Technicians	Life Science-related Engineers	Medical and Clinical Laboratory Technicians
Animal Sciences • WSU Food Science • WSU Plant Sciences • UW	Biology: • UW • WSU • Eastern Washington Univ. Biochemistry: • UW Cellular & Molecular Biology: • UW Physiology: • UW • Seattle Pacific Univ.	Biomedical Engineering: • UW • WSU Agricultural Engineering • WSU	Clinical/Medical Laboratory Assistant: • Wenatchee Valley College • Clover Park Technical College • Renton Technical College Clinical Lab Science/Medical Technology: • UW

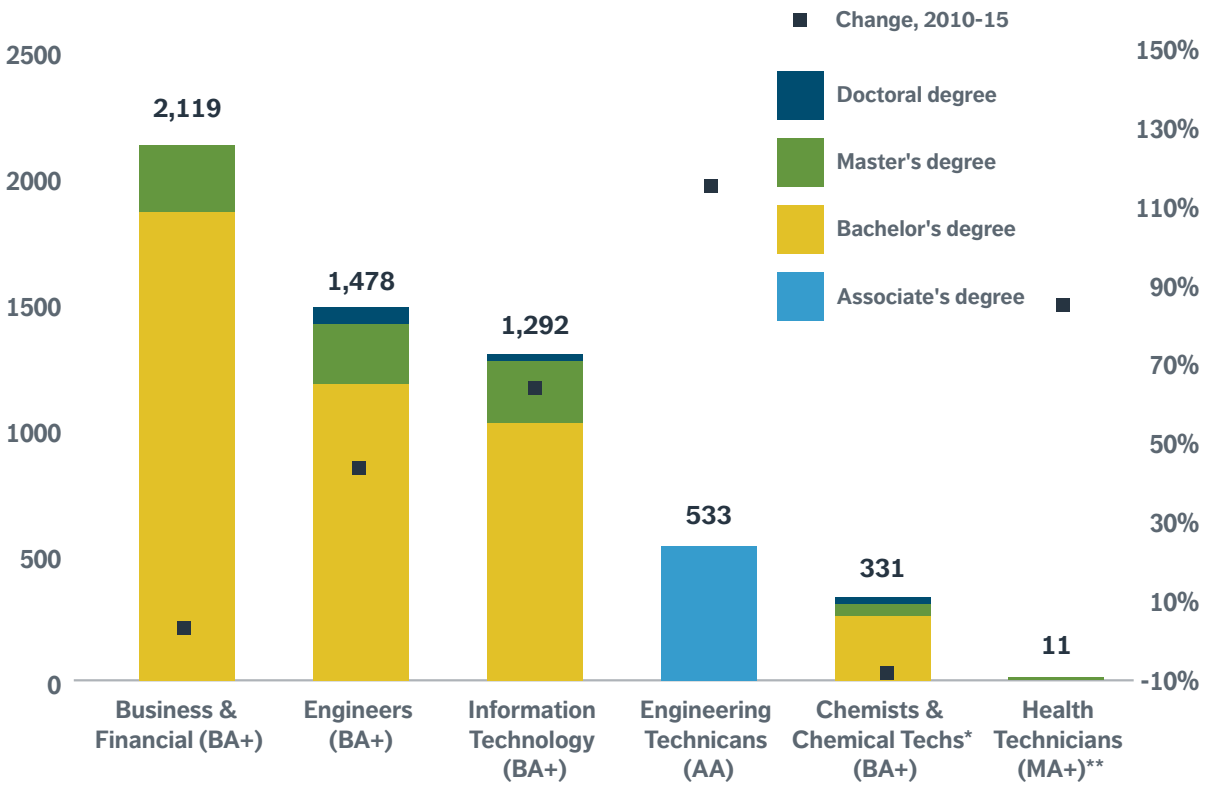
Source: National Center for Education Statistics, IPEDS Database.

Talent Supply for Secondary Life Sciences Occupations

To address secondary talent needs, the life sciences and global health must draw from a whole range of degree graduates, and compete with other advanced industries across relatively large pools of these graduates. The most relevant degree totals are summed and shown in Figure 16 which, similar to primary life science degree fields, shows the state's colleges and universities increasing their degree totals across each major area.

Washington's postsecondary institutions have increased degrees in IT fields that are key to the life sciences by 76 percent just since 2010. These include degrees in more general computer sciences and information technology where UW, WSU, and Central Washington University are among the largest programs (see Figure 16); but also include degrees in life science-specific areas such as medical and bio-informatics which is offered by UW. These degree programs are very important to meeting industry needs, however, they are quite small relative to others—in 2015, biostatistics graduates in all of Washington's postsecondary programs totaled just 23, and medical informatics had just 11 graduates, nearly all at the PhD level. And since 2003, these programs have shown virtually no significant increase in graduates. Clearly, this is an applied area critical to industry in which Washington is falling short.

Figure 16: Washington Degree Graduates in Fields Most Closely Aligned with Secondary Life Science and Global Health Occupations, 2015 and Increase, 2010-15



Degree graduate totals align with levels of degree generally required. Occupation to Degrees crosswalk developed by the National Crosswalk Service Center.

Data not shown for: Office/Admin; Skilled Production; and Transportation as majority of these jobs do not require postsecondary education for entry.

**Note: Chemical technicians combined here with Chemists due to lack of chem-tech degree graduates; **Note: Health Technicians growth set at 100% as no degrees were recorded in 2010. Source: TEConomy analysis of Postsecondary Degree data from National Center for Education Statistics, IPEDS Database.*

A whole range of Washington schools are playing leading roles in key secondary degree areas for the industry, including community colleges such as Spokane Falls which has an orthotics and prosthetics technician program and is also training electrical engineering technicians (see Figure 17).

Figure 17: Leading Washington Institutions in Secondary Life Science and Global Health Degree Areas

Business & Financial	Chemists & Chemical Techs	Engineering & Eng. Techs	Health Technicians	Information Technology
Accounting: • WSU • US • Central Washington Univ. Marketing: • UW • WSU • Western Washington Univ.	Chemistry: • UW • Western Washignton Univ. • Whitworth Univ.	Electrical and Electronics Eng: • UW (Seattle & Bothell) • WSU Mechanical Eng: • WSU • UW • Gonzaga Univ. Industrial Eng: • UW EE Eng. Technology: • ITT Technical • Spokane CC Industrial Technology/ Technician: • Olympic College	Orthotist/ Prosthetist: • UW • Spokane Falls CC	Computer Science: • UW • WSU Information Technology: • UW • Central Washington Univ. Informatics, Medical Informatics: • UW

Source: National Center for Education Statistics, IPEDS Database.

University Hiring Connections with the Life Science and Global Health Industry

For recent recruiting and hiring, life science and global health companies cite specific connections with a number of state colleges and universities. The programs and corresponding institutions listed in Figure 18 were reported by industry hiring managers during interviews and in the survey, and are organized here by industry subsector. Representing the varied locations of the industry throughout the state, the schools have a dispersed geographic context and connections for specific areas of expertise.

University of Washington's Regulatory Affairs Master's and Certificate Programs. One example of an applied program that industry employers cite as excellent and an effective "model" for meeting industry needs is the University of Washington's Regulatory Affairs Master's and Certificate programs.

- A 2-year program for those wanting to work in or advance their career in regulatory affairs, the UW Master of Science in Biomedical Regulatory Affairs curriculum spans the process of taking a medical product—drug, device or biologic—from R&D to market and post-market. Course topics include clinical trials management, product

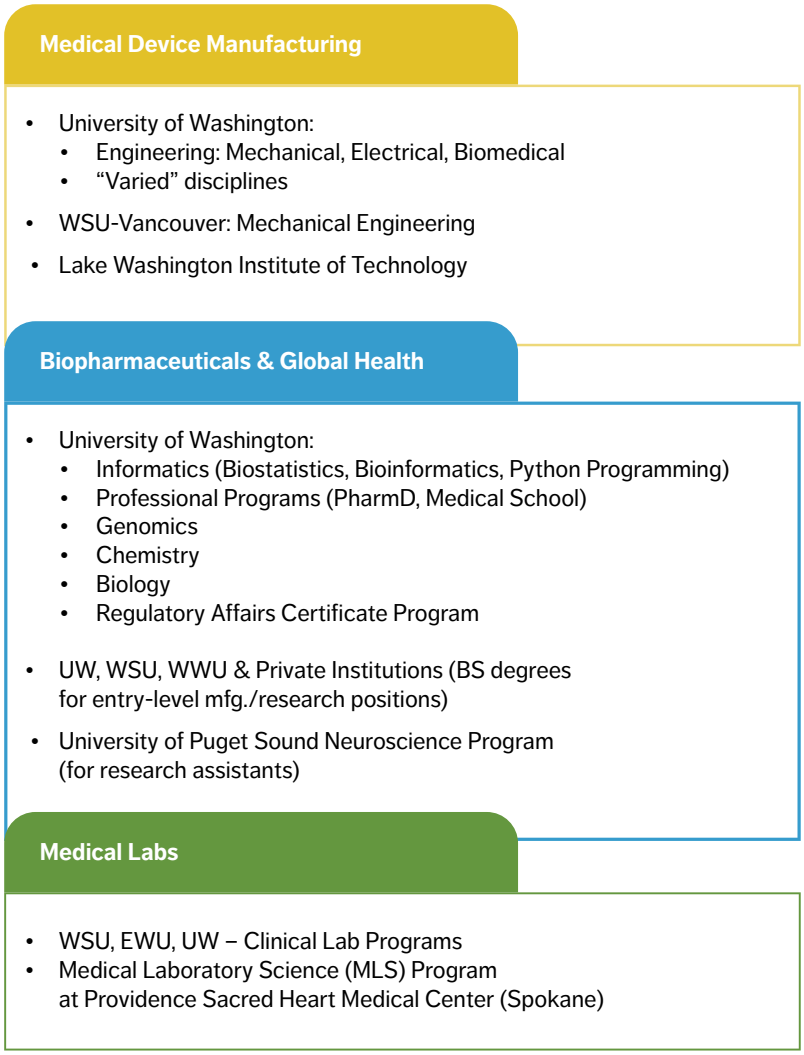
testing, risk management, technical writing, and international regulatory affairs. According to the program materials, graduates are then able to:

- Guide new medical products through regulatory compliance, clinical trials, and quality assurance;
- Understand and access regulations, guidelines, standards, and application procedures used by the U.S. Food and Drug Administration, the International Conference on Harmonisation, and the International Organization for Standardization;
- Identify, analyze, and apply business and economic factors important to regulatory affairs for the pharmaceutical and medical device industries;
- Identify and manage medical risk;
- Write effective, accurate technical documents and reports;
- Be prepared to earn professional certifications, including those from the Regulatory Affairs Professionals Society and the Association of Clinical Research Professionals.

Beginning this year, UW is offering a new option—the Master of Science in Regulatory Affairs Applied — that allows students to develop specialized expertise in an area of biomedical regulatory affairs such as epidemiology, nutrition, global health, statistics, or biostatistics.

Finally, the Certificate program in Biomedical Regulatory Affairs is seen by industry as a particularly flexible and expedient way for existing employees to add regulatory expertise and knowledge. In addition, certificate programs are also an excellent way for professionals to quickly add a highly applicable credential in a short period of time, and the UW program includes opportunities for hands-on experiences with local companies to learn about Good Manufacturing Practices (GMPs).

Figure 18: Industry-reported Recruiting and Hiring Connections with Specific Washington Colleges and Universities



Supply-related Insights and Challenges from Industry Interviews, Surveys, and Focus Groups

Relative to talent challenges in Washington, among the top themes noted by employers are several related to the supply of talent, which includes difficulties connecting with students and graduates and other challenges in recruiting. Added up, these difficulties revealed a broader theme related to challenges for Washington's life science and global health companies and organizations regarding "connections", and the need to enhance those connections.

Challenges for Industry and Career Awareness. Washington's life sciences and global health companies and organizations are facing major challenges differentiating themselves as an industry in Washington in general, and from a workforce and talent perspective, among students as a known, high-quality, and accessible career opportunity in the state. The industry, which stands out in its innovation profile, its sizable job and firms footprint in Washington, and its high-paying jobs that span low-, middle-, and high-skilled areas, is often overshadowed by the state's large and leading aerospace manufacturing sector as well as its headline-grabbing, world-leading technology sector. Among state residents and even legislators, this has led to a general lack of awareness of the industry's importance, as well as its leadership position in life-saving technologies such as ultrasound and cancer immunotherapy, and its status as a world hub for global health.

Moreover, this lack of awareness is affecting the talent pipeline in a negative manner. In nearly every discussion with employers, they continually raise challenges with career and industry awareness among students both in the K-12 levels, and even more alarmingly, with students in the state's colleges and universities. Representatives of both community colleges and 4-year institutions confirm that the vast majority of students entering degree majors such as biology, microbiology, and others are there in a "pre-med" or other health-related education or career track. Students are very aware of health-related fields and careers but not the industrial life sciences or even global health.

Internships Lacking Scale. While some life science and global health companies have established internship programs, and there are industry-student connections for internships, their scale is very limited. The project team was consistently told that internships are often "difficult" to organize, manage, and execute around real, meaningful projects due to time and resource constraints of those industry employees who would provide oversight. At the same time, however, many in industry recognize that these types of direct connections with students and with their schools are critical to developing talent and industry experience for young professionals and recent graduates. The industrial life sciences cite internship connections with UW, WSU, EWU, and Seattle University but these lack scale. Among some of the world-leading global health companies and organizations, internships are so competitive that applicants are fielded from across the U.S., and sometimes the world, and so local interns are crowded out.

Limited Industry-Higher Education Connections in Washington. Despite the recruiting and hiring connections identified by employers and listed previously, many companies interviewed and surveyed are not connecting on a consistent and regular basis for recruiting and hiring Washington graduates. When the industry has a need for a new graduate, connections are said to occur based more on employee referrals or an industry employee's connection to a specific university professor or their lab, but even these instances are limited.

The nature of recruiting for the life sciences also poses some limitations for employers—the relatively unique expertise required in the life sciences and global health means hiring managers and recruiters are often looking for one or two very

Emerging Life Science-related Technology Areas

In addition to specific occupational dynamics, the industry survey asked employers to look ahead and advise colleges and universities on curriculum, and even students on career choices and specializations, by asking about emerging technology areas, specifically:

> **In your business or research area, what are the emerging life science-related technology areas you are expecting to see in the near term (next 5 years) that need to be reflected and/or increasingly emphasized in today's educational curriculum? These could include existing technology areas expected to see increased importance.**

The top answers from employers include:

- Bioinformatics;
- Precision Medicine;
- Biomarkers;
- Regenerative Medicine & Other Stem Cell Therapies; and
- Connected/Digital Health, including Remote Monitoring.

Emerging Skill Sets & Training Needs

The survey asked Washington industry employers:

> **What are the emerging skill sets and training needs you view as critical for your current, incumbent workers?**

Employers report a wide range of items when asked this question about their existing workforce that include:

- Regulatory affairs/expertise related to: regulated lab environments; worldwide medical device regulation; drug/device combination technology and regulation; drug development;
- Machine learning, quantitative analysis, modeling and theory, and artificial intelligence;
- Bioinformatics is huge, but also need people who get the "big picture" across vast sections of these industries due to how complex the research and funding environments are;
- Experience with social media technology;
- Software engineering skills;
- Systems integration, metaphorical thinking, lean process engineering, cross functional experience in the technology and product lifecycle;
- Project Management, including collaborative project management, moving away from top-down management styles to a more networked/teamwork approach;
- Data Management;
- Sales and business acumen;
- Communication skills.

specialized skill sets or experiences, and this does not lend itself to attending career fairs and other large hiring events where employers typically go to hire or recruit en masse. In fact, these niche skill needs and nature of search often lead to companies recruiting on a multi-state regional or even national scale.

Several occupational areas stood out in the survey with a high number of companies reporting they primarily recruit nationally, including for:

- Research scientists (non-clinical)
- Bioinformatics/Biostatistician
- Regulatory Affairs
- Management, all levels

University students cite barriers in connecting with the industry. Interviews and a focus group were conducted with graduate students and post-docs in life science fields and these students voice significant frustration in trying to connect with the industry around career opportunities and connections. The students engaged, particularly those in Seattle, recognize the strong regional industry cluster that is all around them, want to remain in the area for their early-career, and are trying to connect with the industry but face challenges and barriers that include:

- A lack of industry connection among academics, and many frowning upon industry jobs in preference to an academic career track for doctoral students;
- Lack of industry presence on campus and outreach to students;
- Even supportive professors and Principal Investigators have relatively little knowledge of the industry so consequently, student exploration is self-guided;
- Post-docs often told by industry they lack experience though they have strong expertise;
- Barriers to internships or project-based opportunities with industry due to economic arrangements, i.e. the University is paying for their time throughout the year in their respective research labs and teaching assistantships and so an industry internship cannot be arranged due to lack of resources to cover their time in the lab.

Existing State Programs Advancing STEM Education and Workforce Connections

The following are examples of programs in Washington that are working to enhance STEM education and workforce opportunities and connections primarily between students and educational entities, and students and businesses. And while these programs are advancing worthy goals and activities, life science and global health employers interviewed indicate there are little direct or explicit connections with the industry. Indeed, these programs represent opportunities for the industry to connect not only to existing programs but often to the diverse and under-represented populations they serve.

Washington STEM is a statewide non-profit working to advance excellence, equity, and innovation in STEM education by increasing access, interest, and success for students. The initiative focuses on regional and other partnerships across four key initiatives in computer science, early math, science and engineering, and career-connected learning. Washington STEM has three priorities:

- Supporting STEM networks in local communities and creating a “network of networks” to promote and increase the scale of best practices;
- Advancing STEM innovation; and

- Promoting STEM policies and state leadership via recommendations to improve STEM teaching and learning.

Washington State Opportunity Scholarship (WSOS) is designed to help low- and middle-income Washington residents earn their bachelor's degrees in "high-demand" STEM and healthcare fields, and encourages recipients to remain in Washington for work once completed. The program is a public-private partnership between Washington businesses including Boeing, Microsoft, and the State Legislature. Since its inception, WSOS has awarded scholarships to over 5,400 students and is making strong progress in advancing opportunities for diverse populations with:

- 59% of all-time funded scholars are first-generation college students;
- 57% of all-time funded scholars are female;
- 58% of the most recent cohort of recipients identified as students of color;
- More than three-quarters of 2015 graduates are employed in their field or seeking an advanced degree;
- Of graduates working in their field of study, nearly 90% remained in Washington.

Washington's Workforce Development Board is part of the state's workforce system designed to help residents find jobs, re-enter the workforce, or move ahead in their careers. These state programs begin with high school and extend through to apprenticeships, certificate programs and college; however, they do not include a four-year degree. The state's twelve Workforce Development Councils (WDC's) direct federal WIA/WIOA activities, provide employer outreach, and oversee the state's WorkSource employment centers. Each council develops a local strategic plan assessing local employment to coordinate workforce activities throughout their area, and local WDC's are very active and innovative in connecting job seekers with employers and engaging youth. For example, they develop and implement "Sector Strategies" in differing industries including healthcare, manufacturing, and maritime. Unfortunately, they do not currently have strategy for the industrial life sciences. The WDC's are advancing apprenticeship models including emerging models in Washington for healthcare and for IT (described in more detail below), which is another potential opportunity area for life sciences engagement to employ a unique approach to meet industry talent needs.

Washington State Work Study Program is a state-funded and operated program administered by the Washington Student Achievement Council. Providing financial aid to low- and middle-income Washington students, the Work Study program partners with nearly 700 employers and 55 nonprofit institutions across the state and students who qualify get an approved on- or off-campus job to support their education. The state also subsidizes the wages of work study employees so employers benefit from workers at a lower cost—on average, employers match state appropriations by 40 percent. The program is currently funded at $7.8 million annually and serving about 4,300 students, less than half of its size from 2009.

The Governor's YouthWorks Initiative was established in 2013 and designed to match Washington youth with employer mentors in internships and other work-based learning experiences and career planning, and seeks to "re-engage" young people who have dropped out of school or are at-risk of not graduating from high school. Since the program's inception, YouthWorks has doubled the number of participants in internships with local employers, doubled the number of youth matched with employer mentors and tripled the number of youth who designed a specific career plan at YouthWorks sites across the state. Recently, Governor Inslee announced winners of new funding grants for the program that total nearly $2.2 million and highlighted a partnership with ACE Mentorships—an after-school mentoring program for high school students interested in careers in architecture, engineering, and construction management.

V. Industry Demographics and Diversity

The workforce and talent needs and shortages experienced by Washington companies in life sciences and global health are alarming, and represent a limiting factor for those companies making key location decisions and expansion plans. And while the state's universities and colleges are expanding their graduate output in key life sciences fields, limitations remain in the scale of key programs as well as in the need for experienced talent; competition for talent and expertise is fierce in Washington and for expertise sought nationally. To ensure the industry is as inclusive as possible, and that population groups which have traditionally been underrepresented in the life sciences are encouraged to participate, this situation calls for an "all-hands-on-deck" approach to talent generation and sourcing.

Further, underrepresentation has been documented in S&E and "STEM" related fields. In its 2013 report on the presence of women, minorities, and the disabled in science and engineering, the National Science Foundation (NSF)[17] found:

- Relative to their share of the U.S. population, women are less likely than men to:
  - Pursue a postsecondary degree in math, the physical sciences, computer sciences, and engineering;
  - Work as a scientist or engineer relative to their participation in the workforce overall;
  - Work full time as a scientist or engineer;
  - Work as a full-time, full professor with a science, engineering, and/or health-related doctorate degree (women represent fewer than one in four among these professors).

- Relative to their share of the U.S. population, "underrepresented minorities" including three racial/ethnic groups—blacks, Hispanics, and American Indians are less likely than their white and Asian counterparts to:
  - Attend college or to graduate;
  - Graduate with a postsecondary science or engineering degree;
  - Work as a scientist or engineer relative to their participation in the workforce overall.

Although evidence from the NSF studied trends indicate progress is modest, women and minorities are gaining ground in certain areas. Among women, there has been an increase in their share of social science and bioscience related college degrees and they are relatively well-represented in these fields; conversely, their share of degrees in math, physical sciences, engineering, and computer science remain low and show little signs of improvement. Among underrepresented minorities, there have been steady gains in their share of science and engineering degrees over the last two decades for this group, with increasing degrees in psychology, social science, and computer science fields.

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17 *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013, National Center for Science and Engineering Statistics; Directorate for Social, Behavioral and Economic Sciences; National Science Foundation.*

Gender composition of the life science industry. Washington's life science industry, which includes significant overlap with the global health sector, exceeds the national representation for women in the life sciences by three percentage points. In Washington, 45 percent of life sciences industry employment is made up of women compared with 42 percent for the U.S. And, Washington's share in the life sciences matches that for the overall private sector while the U.S. overall is 5 percentage points lower than the private sector. In this respect, Washington employers are faring better at engaging women in the industry than the nation and at least meeting their overall average composition across the state economy (see Table 5). Across the major life sciences industry subsectors, this employment composition varies. For example, scientific R&D has the highest share of women employed at 51 percent, while drugs and pharmaceuticals at 35 percent has the lowest.

Compared with other major industries in Washington, such as aerospace manufacturing and computer systems and design services (the largest pure-play IT sector in the state), the life sciences employs a much greater share of women.

The industry survey asked questions regarding the industry composition by gender and largely confirmed the results from the federal data utilized in this analysis though it revealed an even greater share. Companies completing the survey demographic questions reported 51 percent of their employment was currently made up by women.

Table 5: Industry Employment Shares for Women in the Life Sciences and Comparison Industries, WA and U.S., 2015

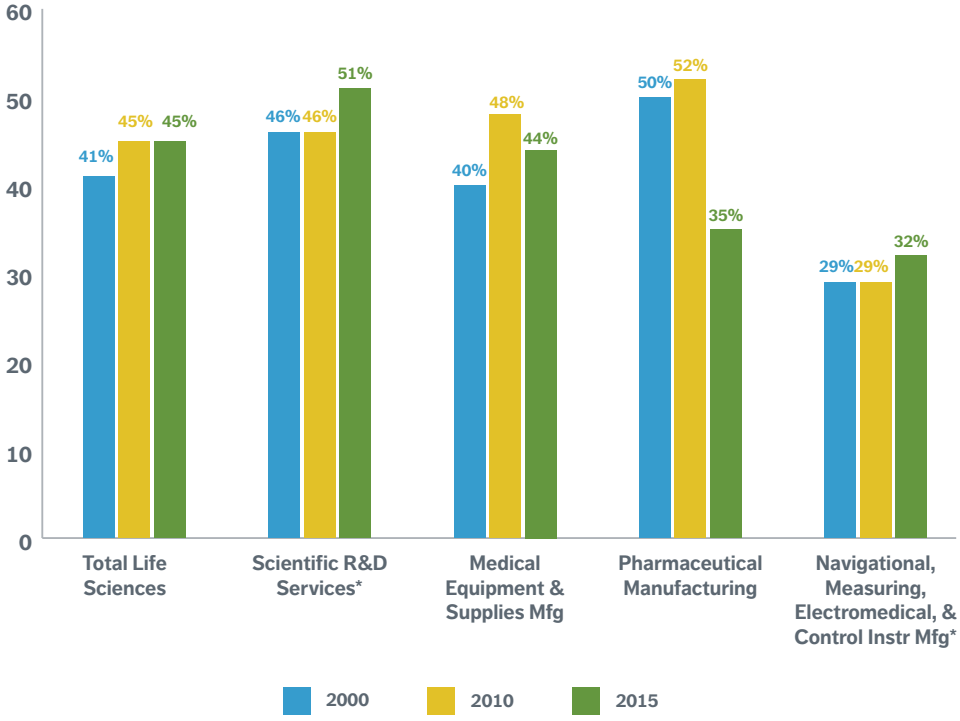
Industry Sector (NAICS Code in Parentheses)	WA % Women, 2015	U.S. % Women, 2015
Total Private Sector	45%	47%
Life Science-related Industries:		
Total, Life Sciences	45%	42%
Pharmaceutical and Medicine Manufacturing (3254)	35%	45%
Medical Equipment and Supplies Manufacturing (3391)	44%	41%
Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (3345)*	32%	29%
Scientific Research and Development Services (5417)*	51%	47%
Comparison Industries:		
Total Manufacturing (31-33)	25%	29%
Aerospace Product and Parts Manufacturing (3364)	24%	23%
Computer Systems Design and Related Services (5415)	24%	27%

Source: TEConomy Partners and Univ. of Baltimore Jacob France Institute calculations based on US Census Bureau, 2015 American Community Survey PUMS data.

**Note: represent industries where only a portion of activity is related to life sciences (e.g. NAICS 3345 contains Electromedical Equip. Mfg, a major industry in WA's life science industry; however, it also includes other non-life science industries. Likewise, Scientific R&D includes life sciences R&D but also other areas.)*

The industry has increased its overall share of women employed since 2000 (see Figure 19).

Figure 19: Trends in the Share of Women Employed in Life Science-related Industries, Washington



Source: TEConomy Partners and Univ. of Baltimore Jacob France Institute calculations based on US Census Bureau, 2015 American Community Survey PUMS data.

**Note: represent industries where only a portion of activity is related to life sciences (e.g. NAICS 3345 contains Electromedical Equip. Mfg, a major industry in WA's life science industry; however, it also includes other non-life science industries. Likewise, Scientific R&D includes life sciences R&D but also other areas.)*

Racial Minorities' Composition of the Industry. Washington is lagging the U.S. in terms of employment of racial minorities in the life sciences; however, this industry employment share is reflective of the state's population, which is already underrepresented in terms of racial minorities. Twenty-two percent of the jobs in Washington's life sciences industry are accounted for by racial minorities, with the national share sitting at 26% (see Table 6). This share is comparable to the composition of employment in overall manufacturing in the state but lower than for the aerospace and systems design sectors.

Table 6: Industry Employment Shares for Racial Minorities in the Life Sciences and Comparison Industries, WA and U.S., 2015**

Industry Sector (NAICS Code in Parentheses)	WA % Non-White, 2015	U.S. % Non-White, 2015
Total Private Sector	23%	26%
Life Science-related Industries:		
Total, Life Sciences	22%	26%
Pharmaceutical and Medicine Manufacturing (3254)	23%	30%
Medical Equipment and Supplies Manufacturing (3391)	21%	25%
Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (3345)*	26%	22%
Scientific Research and Development Services (5417)*	21%	26%
Comparison Industries:		
Total Manufacturing (31-33)	22%	24%
Aerospace Product and Parts Manufacturing (3364)	25%	22%
Computer Systems Design and Related Services (5415)	32%	32%

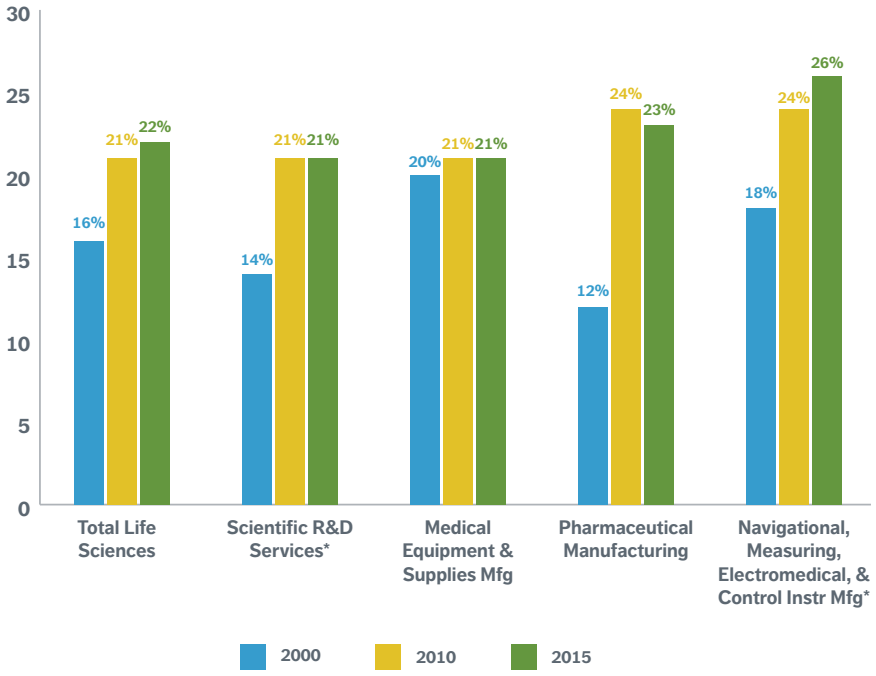
Source: TEConomy Partners and Univ. of Baltimore Jacob France Institute calculations based on US Census Bureau, 2015 American Community Survey PUMS data.

**Note: represent industries where only a portion of activity is related to life sciences (e.g. NAICS 3345 contains Electromedical Equip. Mfg, a major industry in WA's life science industry; however, it also includes other non-life science industries. Likewise, Scientific R&D includes life sciences R&D but also other areas.)*

***Racial minorities include all non-white race categories used by the U.S. Census Bureau.*

Since 2000, the overall trend in the industry's employment of racial minorities has increased, with the share rising from 16 percent to 22 percent during this period.

Figure 20: Trends in the Share of Racial Minorities Employed in Life Science-related Industries, Washington**



Source: TEConomy Partners and Univ. of Baltimore Jacob France Institute calculations based on US Census Bureau, 2015 American Community Survey PUMS data.

**Note: represent industries where only a portion of activity is related to life sciences (e.g. NAICS 3345 contains Electromedical Equip. Mfg, a major industry in WA's life science industry; however, it also includes other non-life science industries. Likewise, Scientific R&D includes life sciences R&D but also other areas.)*

***Racial minorities include all non-white race categories used by the U.S. Census Bureau.*

Industry Efforts to Promote Diversity

To boost efforts to promote inclusion and diversity, the industry survey found Washington's life science and global health employers are using several strategies, the most common approaches utilized include:

- Establishing/advancing a corporate strategy of diversity and inclusion;
- Participating in career fairs/recruiting events targeted toward women, minority groups, veterans, or people with disabilities;
- Partnering with or recruiting from under-represented/minority technical/technology associations (e.g. Women in Bio);
- Promoting STEM Education and related programs aimed at advancing a diverse talent pipeline into the future.

Interviews with industry hiring managers revealed more specific measures including multiple companies that are actively, intentionally recruiting veterans, utilizing veterans-specific career fairs. Also, several companies are active in Seattle's "Women in Bio" chapter, which holds regular events and provides networking opportunities for women in the industry. Finally, Global Health organizations are recruiting heavily internationally, with search efforts well beyond U.S. borders for positions in Greater Seattle which is boosting diversity, and at least one company has close ties to a local refugee organization for recruiting.

In general, companies in the life sciences and global health are meeting statewide averages for employment shares in the life sciences among traditionally under-represented populations. Compared with the nation and other major industries in the state, Washington is better engaging women in the industry, and this situation has been improving over time, at least to a degree. For racial minorities, the industry looks much like the rest of the economy and there is room for improvement but hiring is reflective of the state's population more broadly. There are efforts in place among these companies to improve inclusion though it is difficult to assess their scale and impact.

VI. Aligning Demand with Supply: Identifying Gaps in Growing the Life Sciences and Global Health

The life sciences and global health require an alignment of supply and demand for occupational needs and skill sets that allows for continued industry growth and success. Both the quantitative and qualitative assessments combine to provide insights into where misalignments are occurring and potential interventions are necessary.

One approach to assessing the alignment of each occupational area in the industry framework is to compare, on an annual basis, the annual demand projection for occupations against the number of graduates from Washington's postsecondary institutions. And while this approach is useful for assessing alignment, several caveats must be acknowledged. First, not everyone who graduates from a degree program will enter into a career field that matches one to one. Second, new graduates are certainly not a substitute for experienced workers in skilled occupations. And third, not all graduates will remain in the state following graduation. Acknowledging these caveats, at a high level this approach can reveal imbalances in the supply-demand context where annual local graduates are insufficient for meeting expected demand.

The alignment approach in Table 7 for primary occupations reveals a generally close alignment between projected annual job openings and degree graduates, except for medical and clinical lab technicians where projected demand is well outpacing the supply of new degree graduates. The assessment splits the science and technician groups out in order to better assess varying degree levels required (i.e. scientist positions typically require a master's degree).

Table 7: Primary Occupations – Comparison of Annual Projected Job Openings vs. "Supply" of Total New Higher-Education Degrees Generated

Key Life Science-related Occupational Groups	WA Projected Annual Job Openings, 2014-19	WA Degree Graduates, 2015	Degree Levels Generally Required for Entry
Agricultural, Food & Nutrition Scientists & Technicians:			
Scientists	28	58	*Master's & Higher*
Science Technicians	18	136	*Associate's & Bachelor's*
Biological Scientists & Technicians:			
Scientists	295	361	*Master's & Higher*
Science Technicians	123	2,781	*Associate's & Bachelor's*
Life Science-related Engineers	24	117	*Bachelor's & Higher*

Key Life Science-related Occupational Groups	WA Projected Annual Job Openings, 2014-19	WA Degree Graduates, 2015	Degree Levels Generally Required for Entry
Medical & Clinical Lab Technicians	388	105	*Associate's & Bachelor's*

Notes: Degree graduate totals align with levels of degree generally required. Occupation to Degrees crosswalk developed by the National Crosswalk Service Center.

**Data not included for Management occupations due to inability of crosswalk to effectively map degrees to "managers".*

Source: TEConomy analysis of Occupational Projections data from Washington State Employment Security Department/LMPA; Postsecondary Degree data from National Center for Education Statistics, IPEDS Database.

In secondary occupations, where the industry competes for this workforce with other sectors, the assessment finds gaps in IT and business-related demand versus new supply of graduates (Table 8). The IT occupations most utilized in the life sciences and global health have annual job openings expected at more than 4,600 with degree graduates in Washington of just under 1,300, a significant gap particularly when these graduates are dispersed across numerous industries, and this analysis does not include the attrition of graduates that leave the state to begin their careers elsewhere.

Table 8: Secondary Occupations – Comparison of Annual Projected Job Openings vs. "Supply" of Total New Higher-Education Degrees Generated

Key Life Science-related Occupational Groups	WA Projected Annual Job Openings, 2014-19	WA Degree Graduates, 2015	Degree Levels Generally Required
Business & Financial	2,770	2,119	*Bachelor's & Higher*
Chemists & Chemical Techs*	115	331	*Bachelor's & Higher*
Engineering & Eng. Techs:			
Engineers	828	1,478	*Bachelor's & Higher*
Engineering Technicans	131	533	*Associate's & Higher*
Information Technology	4,643	1,292	*Bachelor's & Higher*
Office & Administrative	9,738	n/a	*No Postsecondary Requirement*
Skilled Production	1,565	n/a	*No Postsecondary Requirement*
Technical Sales Representatives	231	--	*Bachelor's & Higher*
Transportation	817	n/a	*No Postsecondary Requirement*

Notes: Degree graduate totals align with levels of degree generally required. Occupation to Degrees crosswalk developed by the National Crosswalk Service Center.

**Data not included for Management occupations due to inability of crosswalk to effectively map degrees to "managers".*

Source: TEConomy analysis of Occupational Projections data from Washington State Employment Security Department/LMPA; Postsecondary Degree data from National Center for Education Statistics, IPEDS Database.

The supply-demand assessment reveals just how critical this pipeline of postsecondary workers is in meeting the needs of industry, and in a quantitative manner, highlights some of the significant "pain points" communicated by industry in trying

to meet current and future skill needs. In key areas, it is important not only to ensure that state colleges and universities continue to increase degree graduate levels but also to connect young students and recent graduates with opportunities in the industry—the state cannot afford to allow the current lack of connectivity between the industry and students, colleges, and universities to continue on.

In the next section, as the study pivots toward necessary areas for intervention, the findings from this approach must be combined with the areas identified as "high demand" that consider the input from not only a data perspective, but also via employer interviews, surveys, and focus groups. Areas identified as both high demand and with potential misalignment are the primary candidates for necessary strategic intervention (Figure 21).

The concept of "*Identified Misalignments*" includes not only those occupations with gaps identified in the preceding quantitative supply-demand assessment, but also those identified by employers regarding consistent difficulty in hiring and sourcing qualified candidates, and those that require national recruiting.

Figure 21: Talent and Skill Gaps, where are Interventions Needed?

Occupational Group	Identified as "High Demand"	Identified Misalignments
Agricultural, Food and Nutrition Scientists and Techs		
Biological Scientists and Technicians		✓ (Sr. Scientists)
Life Science-related Engineers	✓	✓
Life Science Managers		✓
Medical and Clinical Laboratory Technicians	✓	✓
Quality Assurance/Control		
Regulatory Affairs	✓	✓
Bioinformatics/Biostatistics	✓	✓
Secondary — Business & Financial		✓
Secondary — Chemists & Chemical Techs		
Secondary — Engineers & Eng. Techs	✓	✓ (Engineers)
Secondary — Health Technicians		
Secondary — Information Technology	✓	✓
Secondary — Office & Administration		
Secondary — Skilled Production	✓	✓ (Assembly)
Secondary — Marketing & Technical Sales Rep	✓	✓
Secondary — Transportation		

VII. Strategic Recommendations to Better Align Washington's Life Science and Global Health Talent Needs and Ensure its Future Competitiveness

The workforce challenges faced by Washington's life science and global health industry call for a set of strategic priorities and public-private initiatives and efforts to better align the industry's demand with the needed supply of workers and specific skills and expertise. Like other states, Washington has existing programs and initiatives already in place to advance education and industry-workforce connections; however, the life sciences represent unique and challenging dynamics with respect to talent needs, and these programs are currently not addressing this industry's most pressing challenges. In some cases, an existing program could benefit the industry by extending a "life sciences" focus or interaction of the program. In others, a new organization or program should be advanced to truly address the scale of industry needs.

One challenge that Washington faces is a critical skill shortage in occupations that are in high demand by other industries in Washington, particularly in engineering and IT occupations. So, despite strong growth in new graduates and a high presence of these occupations in the existing workforce, they represent a key barrier to growth for the life sciences and global health industry in Washington.

- In engineering occupations, recent hiring has been strong, with 237 engineers hired by the life sciences industry in the last year, representing 20 percent of the engineering employment base of surveyed companies, and employers surveyed expect to continue to ramp-up hiring over the next 2 years alone, reflecting the state's strengths in medical devices. Washington's colleges and universities are graduating nearly 1,600 in the degree fields aligned to industry needs; however, the life sciences are not the only advanced manufacturing industry competing for this base of new graduates.

- In IT occupations, the life science industry hired 205 workers over the last year, and expects to triple that over the next 2 years. Across all industries, the state is facing substantial deficits in the specific IT talent in demand by the life sciences industry (e.g. software developers, computer hardware engineers, computer support) of more than 3,300 between annual projected job openings and new degree graduates.

- To a lesser extent, Washington's life sciences industry is also experiencing skill shortages in marketing professionals and skilled production for assemblers for precision device manufacturing for which they need to compete with other industries.

In more life sciences-specific occupations, there are also critical skill shortages, reflecting a lack of talent generation in Washington.

- Medical and clinical lab techs, a very large and fast-growing workforce of more than 8,000 in Washington, is expected to see nearly 400 job openings per year while related degree graduates only number 105.

- In regulatory affairs, industry survey respondents report hiring 20 professionals in the last year, but the expectation for the next two years is to hire 127 additional professionals, a major boost in expected hiring, and talent managers are having difficulty finding them, most often conducting national searches.

- Bioinformatics and biostatistics expertise is also in high-demand with industry reporting 35 hires in the last year, and expectations are to hire 85 professionals in the next 2 years. As with regulatory expertise, many recruiters are having difficulty finding talent in Washington and are searching nationally.

Complicating the ability of life science and global health industry to compete for talent is the fact that it is generally "disconnected" from the state's postsecondary institutions and students, as well as its existing education and workforce training programs as evidenced by:

- A lack of awareness of the life sciences and global health as both a key industry and economic driver for Washington and a career option for young people;
- Limited industry-university connections for recruiting and hiring, even for top university life sciences talent;
- The limited scale of internship programs that connect the industry with local colleges and universities;
- Existing state education and workforce programs that do not explicitly connect with the industry.

Although generally positive, Washington's life science companies have a mixed "performance" engaging diverse populations that are typically under-represented in the life sciences and STEM-related fields.

- Washington's life science employers are faring better at engaging women in the industry than the nation and at least meeting their overall average composition across the state economy; from a gender perspective, the life sciences are much more diverse than other large manufacturing and IT sectors in Washington.
- Since 2000, the industry has increased its overall share of women employed by four percentage points.
- In terms of employment of racial minorities in the life sciences, Washington is lagging the U.S.; however, the industry employment share is reflective of the state's population, which is already underrepresented in terms of racial minorities.
- Since 2000, the overall trend in the industry's employment of racial minorities has increased, with the share rising from 16 percent to 22 percent during this period, signaling progress in inclusion.

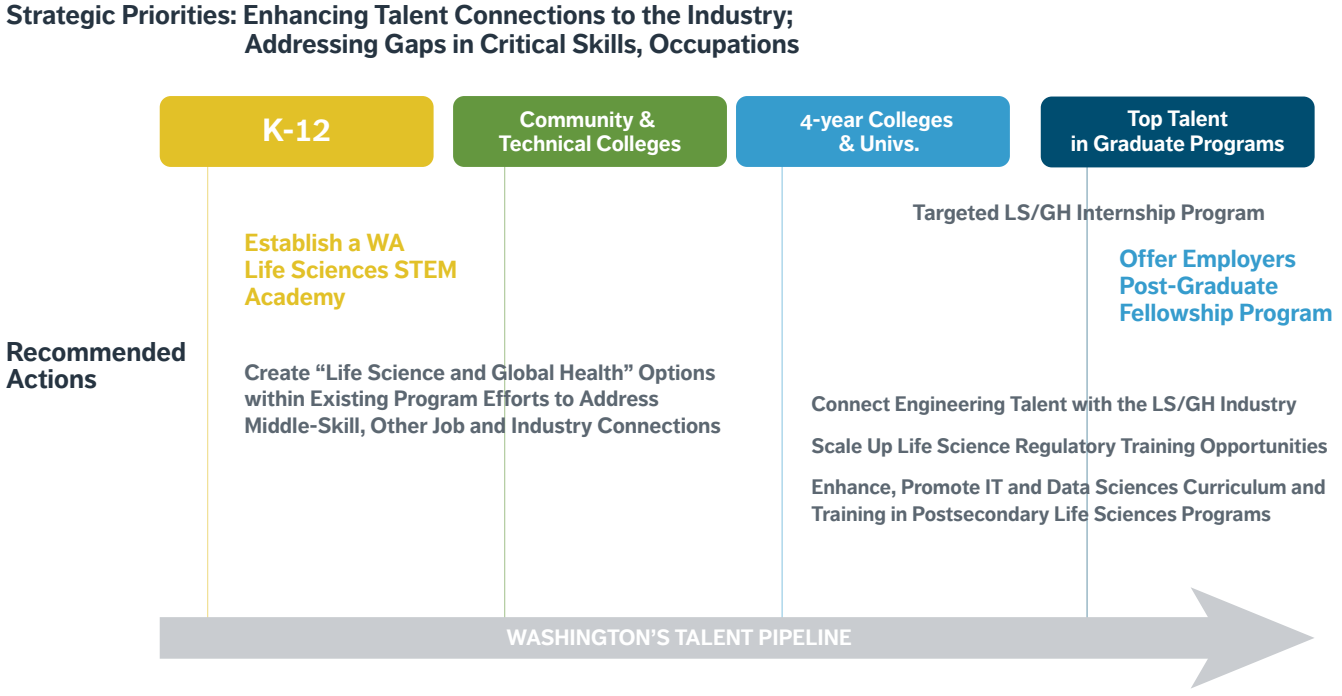
While the critical skill shortages faced by Washington's life science and global health industry are significant, they are not beyond the reach of solutions through a set of targeted, focused initiatives to better align supply with demand for identified occupations and skill sets, and to more broadly create better talent connections to the

industry. These findings support two strategic priorities for intervention, with focused proposed actions presented in this section to support each:

1. **Enhancing Talent Connections to the Life Sciences and Global Health** – Washington needs to connect its existing workforce education and training programs to the industry. Where these programs and initiatives exist, there must be a life science and global health "option" or avenue for engagement to boost both industry and career awareness, and connect to talented individuals and talent-generating institutions.
2. **Addressing Critical Gaps for Specific Occupations and Skill Sets** – the assessment finds gaps in a number of aforementioned life science and global health occupational groups where supply and demand are misaligned, primarily in high-skilled fields. Most of these are also in high-demand, with industry needs only growing, which amplifies the current need. Specific actions are recommended to address key gaps in the primary life science occupations, some of which will also enhance connections with secondary occupations.

In considering these needs, an additional context is critical – an effective talent strategy will address the major components of the education and talent pipeline. Figure 22 below maps out the recommended actions across this continuum.

Figure 22: Strategic Priorities for Washington and Recommended Actions Across the Talent Pipeline



For each of the recommended actions within a strategic priority area, there is included:

- Rationale for the action
- Best practices
- Proposed design of the action
- Resources required

Strategic Priority: Enhancing Talent Connections to the Life Sciences and Global Health

Today, connections between students, academic institutions, and existing education and training programs and initiatives with the life sciences and global health in Washington are very limited and it is a situation that must be reversed in order to help meet the industry's talent needs. Several themes regarding this limited connectivity and gaps have been identified in this study, including:

- A lack of awareness of the life sciences and global health as both a key industry and economic driver for Washington and a career option for young people;
- Limited industry-university connections for recruiting and hiring, even for top university life sciences talent;
- The limited scale of internship programs that connect the industry with local colleges and universities;
- Existing state education and workforce programs that do not explicitly connect with the industry.

Although not necessarily unique to Washington, the degree of disconnectedness is significant and it goes bi-directionally, it is not simply a lack of engagement by state postsecondary institutions or by the industry alone. Both parties, as well as state-funded programs and initiatives, must step forward to ensure progress in meeting talent needs.

Action 1: Establish a Hands-on Washington Life Sciences STEM Academy

Rationale. Industry stakeholders recognize the workforce and talent needs in the life sciences as highly distinct, and distinct enough to necessitate life science-specific approaches and real-world industry context to advancing education, and industry and career awareness. And while Washington is advancing STEM education and other related initiatives and opportunities more broadly, all parties can benefit by incorporating life science industry-specific opportunities for Washington's teachers and students that can ultimately lead to vibrant career connections. Built into this concept should be advancing the industry's demographic diversity to further engage a broader population with new ideas, experiences, and leadership to offer the industry.

Best Practices. Recognizing the critical nature of talent to their knowledge-driven, technology based industry, several state and regional life science industry organizations have prioritized STEM education and workforce development as a distinct function and priority. Understanding that talent needs must be nurtured to not only meet today's demand, but also that for the future, these organizations are engaging at multiple levels of the talent pipeline. Examples of where this has been initiated successfully and comprehensively include:

- The Illinois Biotechnology Industry Organization (iBIO), the state's life science industry association, has established STEM education as a priority with the creation in 2003 of the iBIO Institute and its EDUCATE Center. The Center's

mission is to deliver industry-led STEM education programs to both students and teachers in Illinois, with the goal of inspiring the next generation of innovators as well as helping to improve the United States' leadership in technology education. Recognizing that hands-on, real-world experiences and connections get students excited about science and STEM careers, the EDUCATE Center connects Illinois classrooms with the real world of biotechnology and science-based industry through hands-on lab activities, tours of industry R&D facilities, and interdisciplinary problem-centered learning experiences. Specific Center programs have a focus on diversity and include:

- TalentSparks! Provides intensive teacher professional development workshops designed to assist Illinois' teachers in aligning curricula and implementing Common Core and Next Generation Science Standards (NGSS) through real-world, problem-centered, hands-on learning and connections to experts in STEM fields. Workshops are organized around life sciences sectors. Since 2007, with financial support from Illinois' life sciences industry and a grant from the Illinois State Board of Education, this program has reached over 1,200 teachers and, through them, over 100,000 students. Independent external evaluation shows that TalentSparks teachers and their students significantly improve their knowledge of STEM concepts and careers with average gains of approximately 8 percentage points on science assessments and 11 percentage points on NGSS understanding.

- Stellar Girls is an after-school program developed with support from Astellas USA Foundation and designed to inspire girls in grades 3-8 to enter into STEM careers. Stellar Girls activities exemplify Next Generation Science Standards and Common Core State Standards. Activities are woven into 20 lessons that provide authentic problem contexts and student-centered investigations. EDUCATE staff provide program training during summer professional development sessions. After-school Stellar Girls lessons are led by school instructors or community members, with scientists and engineers from industry and higher education assisting with instruction of select lessons to provide additional insight and career connections to the topics. Serving a diverse student population including high-needs schools, more than 1,400 girls have participated since 2011 with 24 schools and an estimated 475 girls participating in 2016-17. Participants achieve significant gains in science and math content averaging 15 percentage points from pre- to post-test.

- The Biocom Institute, based in San Diego, was founded in 2008 as the non-profit workforce development and STEM education arm of Biocom, Southern California's life sciences trade association. Created to accelerate biosciences talent development and training, the Institute's mission spans K-12 students and teachers in STEM education, innovative industry-vetted professional development initiatives, and programs focused on mentoring veterans in the biosciences. The Institute utilizes a partnership approach across key agencies, bioscience companies, and educational institutions to develop hands-on programs that stimulate interest in life science careers. Also, the Institute offers a Career Center job search portal and professional development opportunities through partnerships, offering cost discounts to its members. Educational partners include: 2Connect which provides hands-on workshops and coaching for improved communication and presentation skills; Biotech Primer; and The Leadership Edge which offers a "Laboratory to Leadership" course. Specific programming of the Institute includes:

- The Biocom Institute Teacher Fellows Program connects K-12 science teachers with life science industry professionals to provide educators with current, first-hand knowledge on what is happening across the life sciences industry today, enabling them to relate real-world examples in the classroom.

- The Biocom Institute Veteran Career Mentoring Program provides mentoring to veterans in the form of industry exposure, introductions, referrals and life science industry-specific knowledge to assist overall networking and job search capabilities. Upon completing the program, veterans should be able to decide if the industry is a good fit from a career perspective. Veterans are matched to business functions they are most interested in from business development, marketing, sales, finance, to scientists, engineers, etc. Up to 30 veterans are paired with life sciences industry professionals who themselves have successfully transitioned from the military.

- Biocom Institute Introductory Life Sciences Experience (ILSE) Program. The ILSE program is focused on providing a "re-entry" path for 40 to 48 out-of-school youth aged 17-24 into a STEM-related career in the life sciences industry. Because the students have yet to complete high school, they face major barriers to career entry and pathway planning. The program provides free classroom instruction and paid internships in biotechnology that include hands-on lab experience and college level courses, as well as work readiness training. Following the internship, the participants receive job placement support and learn about the variety of careers across the life sciences.

- The San Diego Festival of Science and Engineering, a STEM-related program of the Institute that seeks to engage and encourage students to become the STEM innovators of tomorrow.

Program Design. One potential home for the Academy and its programming activities could be within Life Science Washington (LSW), the independent, non-profit trade association that serves the industry through advocacy, collaboration, and facilitating access to capital, all with a focus on supporting and growing the industry. LSW's existing programming includes advancing commercialization in the life sciences, supporting early-stage company mentoring, and monitoring and reporting on industry investment transactions and trends. The organization partners with a customized life sciences training provider in BioTech Primer and hosts a life science-related "Career Center" which connects job seekers with employers.

As an organization dedicated to the industry and well-connected throughout the state, with appropriate resources, Life Science Washington could establish the Academy and prioritize early hires to organize the types of industry-led STEM education-related teacher seminars and after-school programs illustrated in the examples above. As a starting point, the Academy could solicit input on life science-focused STEM program design, and pilot two or three program-related sites as an initial step in partnership with a local school district(s). Washington life science and global health companies could be engaged for either/both funding resources as well as engaging employee volunteers for the programs. The Academy and LSW could partner with the Washington Global Health Alliance on participation from the global health sector.

Other existing organizations and initiatives in Washington active in advancing STEM and life sciences-specific student education and mentoring could also consider taking the lead on this initiative. Washington STEM has an existing

statewide framework and is engaging STEM education and training stakeholders across the state and may consider adding a life sciences area of focus and intentional programming. The Center for Infectious Disease Research, based in Seattle, has established the BioQuest Academy with a mission to "Educate, train and promote college-readiness in all Washington teens including under-represented teens in the science of global infectious disease." Through the Academy, the Center leverages its extensive research as curriculum content for high school students and teachers through a set of interconnected workshops, site visits, and summer programming. Either of these organizations could advance or help to advance in a partnering approach a focused, statewide K-12 Life Sciences STEM Academy.

Potential program activities could include:

- Hands-on industry interactions: arranging tours of life science and global health companies and research laboratories for K-12 students and teachers; training high school science teachers on industry-grade equipment and donating materials for corresponding lab experiments; and bringing industry mentors into the classroom for career discussions. Companies are engaged in these activities all across the U.S. and typically are donating time, resources, and equipment to support such programs. The principals of TEConomy documented these STEM-related educational support activities for PhRMA in a 2014 report as a reference and resource guide.[18]

The program should aim to affect hundreds of Washington teachers and ultimately, thousands of Washington students in grades K-12. Programming with teachers directly has a cumulative ripple effect on their students with new cohorts entering classrooms each year. Once established, an initial mid-term goal should be to reach several hundred teachers across Washington which could indirectly impact tens of thousands of students. Complementing this should be direct programming with students to impact thousands more.

Resources Required. Envisioned as a public-private initiative with financial support provided by state government, philanthropy, and industry partners.

Action 2: Develop a Targeted Life Sciences and Global Health Postsecondary Internship Program

Rationale. Washington has an immediate need for connecting high-skilled, in-state university talent to the industry in several specific occupational groups found to be both high-demand and misaligned including: engineering, IT, regulatory affairs, lab technicians, and bioinformatics/biostatistics.

At the same time, interviews with industry reveal a lack of scale for college internship programs. Washington should develop a targeted life sciences postsecondary internship program that focuses specifically on these misaligned and high-demand skill areas. Based on the size of the industry in Washington, once established, the mid-term goal should be to scale the program to at least 100 interns annually.

There is a recognition that organizing and conducting intern programs at individual companies, whether they are in medical devices or biopharmaceuticals or in global health research, is quite difficult on already busy managers and that

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18 Battelle Technology Partnership Practice, "STEM: Building a 21st Century Workforce to Develop Tomorrow's New Medicines," 2014. Available at: http://phrma-docs.phrma.org/sites/default/files/pdf/stem-education-report-2014.pdf.

an effort to better "formalize" an internship program utilizing a dedicated industry liaison and a pre-programmed "intern in a box" concept could help the industry gain traction. Implementing a more formal industry internship program can help to more tightly connect companies, colleges and universities, and students around career opportunities and industry talent needs. Students who are working toward a bachelor's or master's degree in primary life science fields represent the industry's future workforce and intentional efforts to create connections will pay dividends now and into the future.

Best Practices. Leading life sciences hubs and clusters are advancing components of industry talent development and connections via formal internship programs.

- The Massachusetts Life Sciences Center (MLSC), the state's quasi-public agency leading the implementation of the $1-billion state life science initiative, operates an "Internship Challenge" program that facilitates the placement of students and recent graduates interested in careers in the life sciences in paid internships to expand the talent pipeline and create meaningful connections between students and companies. Internships can be part-time or full-time and can run throughout the year. And MLSC provides a web-based system to facilitate the connection of potential interns and companies. Each company participating commits to providing a dedicated mentor and hands-on learning experience. Per year, MLSC funds up to two interns at participating smaller life science companies, reimbursing up to $17 per hour and a total funding of up to $8,160 per intern. Larger life sciences companies can access the internship web-based system to recruit interns. Since 2009, MLSC has funded more than 3,000 interns at more than 600 life science companies in Massachusetts. Survey results suggest high levels of satisfaction by both students and companies, along with 8 out of 10 students having an increased interest of working in a Massachusetts life sciences company and 6 out of 10 companies using the program to help in identifying future employees.

Program Design. The life science and global health internship program should target high-demand and misaligned occupations in high-skilled job categories that require a bachelor's degree or higher, specifically for: science, engineering (in both primary and secondary fields), regulatory affairs, bioinformatics and biostatistics, and IT. The program should be eligible for current Washington postsecondary students and those who grew up in Washington but may be attending an out-of-state institution. In order to attract the state's top talent, the program should also be highly competitive. Once operational, the mid-term goal (2 to 5 years out) should be to scale this program to at least 100 interns annually.

Based on discussions with industry and educational stakeholders, and the experience of best practice programs, a more formal college internship program for the life sciences and global health requires building relationships with individual companies and understanding that it may take several years to bring a company into the program. With that context, it is recommended to begin by focusing on an initial program first, with one or two companies beginning to customize the experience and training for a life science-specific setting and experience, and to setup the programmatic infrastructure.

The internship program requires at least one initial dedicated industry liaison that can help to design, implement, and monitor the program and facilitate interactions between companies, interns, and state colleges and universities. Working toward the concept of a more standard internship experience is desired by employers, at least on an industry subsector basis (i.e. one for medical devices, one for biopharmaceuticals, etc.) around a concept of an "intern in a box" program design. While there can always be flexibility in the oversight and substance of an intern's experience, industry

employers could begin to frame out relatively standard tasks based on the corporate environment, e.g. research versus manufacturing. To facilitate matching companies and interns and providing additional services, such as ePortfolios and on-line skills development, another key component for this effort to advance is maintaining a web-site with an internship database that can link companies in the program with intern candidates as well as other on-line tools.

Resources Required. Recommendations for this targeted life sciences post-secondary internship effort include scale up to at least 100 interns after 3-5 years. Some form of cost sharing will be needed as an incentive and can be provided on a sliding scale based on the size of the life sciences company.

Start-up and ongoing program operations cost are also to be expected. Up to $250,000 per year is likely to be needed to hire the industry liaison and maintain the on-line database and tools for the program. A one-time cost to design the website is also expected. State and philanthropic sources may be able to support the start-up and supplement ongoing program operations costs.

Action 3: Create "Life Science and Global Health" Options within Existing Washington Program Efforts to Address Middle-Skill and Other Job and Industry Connections

Rationale. There are a number of existing programs and initiatives in Washington aimed at enhancing educational opportunities for diverse populations, advancing STEM education, and connecting students and other young adults with the world of work. Unfortunately, industry interviews and program investigations find little explicit connection to the industrial life sciences and the global health sector. These programs are engaging the right constituencies in innovative approaches to boost industry and career awareness and so integrating more intentionally with the life sciences, and with the opportunity to connect to a large state industry that is generating high-quality jobs is a smart approach. Further, by leveraging existing programs and infrastructure, this type of initiative should require relatively modest resource levels while at the same time, help to aggregate industry engagement. For most of these connections, the focus for the industry would be on developing and attracting middle skilled workforce.

Best Practices. States with recognized life sciences or other industry clusters often intentionally build in cluster-specific workforce approaches to broader education and training programs in order to gain the greatest return on their economic development resources.

- The EARN Initiative in Maryland – standing for Employment Advancement Right Now – supports regionally-based, industry-led workforce development projects to address critical skill gaps needed for available jobs. EARN is oriented towards growing specific industry sectors through industry partnerships that document the need through an initial planning grant and then conducts the training through a follow-on implementation grant. EARN has helped meet training needs in Maryland's strong bioscience industry cluster. For example, two biopharmaceutical sector programs have been funded through the EARN Initiative:

    - BIOTrain, hosted at Montgomery College, began in 2013 and focuses on a number of short courses that address the needs identified by biosciences companies in the County, including drug development, process improvement, and protein purification.

- Biotechnology Baltimore Strategic Industry Partnership brings together a unique partnership of a newly formed molecular biological manufacturing, distribution, and pharmacokinetics company, Baltimore BioWorks, Inc., whose mission is to become the first minority-owned, self-sustaining, vocational biotechnology training company, with a proven non-profit training provider, the BioTechnical Institute, funded largely by foundations and local Baltimore businesses to train minority high school graduates to become laboratory technicians through an intensive nine-week course of lectures, laboratory exercises and internships covering skills such as clean room practices, techniques in cell culture, FDA sanctioned Good Manufacturing Practices (GMP), laboratory safety and Good Laboratory Practices (GLP), cleaning and sterilization, and techniques in molecular biology.

Program Design. Rather than establishing a whole new set of education and training programs or initiatives, this recommendation largely proposes creating life sciences focus and options within existing programs in Washington. If an Intern Coordinator or Liaison is established based on recommended Action #2 above, this individual could take the lead on this effort. The following are examples of potential industry engagement strategies for existing programs:

- Leveraging local Workforce Development Councils for addressing middle-skill needs of the industry and helping to aggregate demand, such as the need among multiple medical device companies in Bothell for assemblers, who often work on a microscopic scale in a high-precision, highly regulated environment. The WDC's are advancing innovative apprenticeships capitalized by federal and state funding and leveraging the "earn and learn" model in technology and in healthcare, and there is receptiveness to piloting a similar program for the life sciences. Further, WDC's have strong youth interactions and with more industry awareness, could help to make industry connections and boost overall awareness. The Worksource one-stop centers often host an "employer for a day" that brings together industry and job seekers. For example, Amazon recently participated at the WDC-Seattle and hired hundreds in one day. While this is certainly not the typical venue for recruiting into a life science company, nor are they typically recruiting en masse, these avenues are available for connecting with lower and middle-skilled workers. Key middle-skill activity and program examples from the WDC's include:

  - Funding by the WDC's is awarded for pre-apprenticeship training, for example in the construction trades and in aerospace, and could be leveraged for production technicians and other manufacturing workers in the life sciences.

  - The Southwest Washington WDC in Vancouver recently funded a Certified Production Technician (CPT) program for high school graduates providing free training to learn core competencies required in manufacturing. Where there is aggregated demand for production workers, for example in Bothell with medical device manufacturers, this type of program could be developed.

- Career and Technical Education (CTE) is a national initiative promoting and supporting middle and high school programs at local levels that provide 21st century academic and technical skills for students. In Washington, CTE explores careers in a range of technology areas, helps students identify career goals and plans, and offers classes at high schools, at skills centers, and at community and technical colleges, applying real-world, hands-on experiences. Ultimately, CTE can connect with apprenticeships, industry certifications, and 2- and 4-year degree

options. Today, the "career clusters" under CTE are designated at the national level and there is not an explicit "life sciences" cluster. However, there are related clusters including in Agriculture, Food, and Natural Resources, which provides opportunities to connect students with the agbiosciences; in Information Technology; and in STEM. For Washington's CTE career connections, each of these areas can and should intentionally connect to the life sciences and global health industry in Washington.

Potential Program Engagement to Enhance Industry Diversity:

- Washington State Work Study Program – engage enrolled, low- and middle-income college students in life sciences jobs; while there are limitations on roles they can fill, industry outreach to academic life science-related departments could yield interest and participation among a typically under-represented student socioeconomic group. Participants are enrolled college students and may qualify for certain middle-skill jobs in the industry. Once engaged, these college students can learn the industry and make connections for a potential position upon graduation, including with industry mentors.

- YouthWorks Initiative – provides an opportunity to engage and mentor and/or offer internships to at-risk high school students for opportunities in the industry. The program can boost industry and career awareness and offer introductions to industry lab or production careers, including the aggregated demand in medical device manufacturing for assemblers.

Resources Required. Since the programs are ongoing, there are limited cost implications. Industry engagement is key to make this integration of life sciences into existing programs happen. This initiative could be a part of the role of the Intern Coordinator or Liaison established under the previous recommendation (Action #2).

Action 4: Offer Employers Post-Graduate Fellowships to Train, Recruit, and Retain Top Life Sciences Talent

Rationale. Top scientific, engineering, and other high-skilled, technical talent has been identified across the high-demand and misaligned areas for Washington's primary and secondary life science and global health occupations. Washington's industry must connect these scientists and engineers with recently-completed PhD's who often represent the future entrepreneurs, innovators, managers, and ultimately leaders of the industry.

Many years of schooling and local connections have been invested in this top technical talent and to see it migrate out of the state and to other life sciences hubs such as Boston, or the Bay Area in California, is a painful loss for Washington. Feedback from post-doctoral and current graduate students indicates a disconnect between this top talent cohort and the industry, and among many of these individuals there is a strong desire to remain in Washington and to work in industry rather than academia. Intentionally reinforcing those connections and providing students and recent graduates avenues for their first post-doctoral position in industry is a necessary step to retaining this home-grown talent in the state.

Best Practices.

- The Massachusetts Global Entrepreneur in Residence (GEIR) Program was established in 2014 to attract and retain qualified entrepreneurs and their growth companies in the Commonwealth. The program focuses on developing opportunities for foreign national entrepreneurs to bridge to longer-term residency via the support of and affiliation

with universities and research institutions. The GEIR allows universities to partner with the Commonwealth to establish a program at their institution. Participating universities act as the "sponsor" for filing "cap-exempt" H-1B petitions for graduates with advanced degrees who want to grow their companies in Massachusetts but cannot due to a lack of available H-1B visa slots.

Since the pilot program was launched, the UMass-Boston Venture Development Center and the UMass-Lowell New Venture Initiative have sponsored nearly 25 GEIRs, which has led to the founding of 18 new companies, the creation of 218 new jobs, and the economic investment of $118 million in Massachusetts. In June 2016, Babson College announced it was establishing a GEIR program, the first private institution to do so in Massachusetts. Other colleges and universities are looking to follow suit soon.

- The State of New Jersey's Commission on Science and Technology, the government entity promoting science and technology research and entrepreneurship, developed the Technology Fellowship Program to "promote strong ties between industry and academic institutions" to both advance technology commercialization and to develop and retain top talent. The program, which began in 2005 but is now no longer active, connected early-stage New Jersey technology companies with post-doctoral graduates in a 2-year paid program. Participating companies benefited by having access to the top, highly-skilled talent coming out of universities that they otherwise might not have been able to afford, and the Fellows benefited by gaining valuable industry experience. Benefits also accrued as companies were then connected and building collaborations with university research laboratories. Salaries were funded at $65,000 for year 1 and $75,000 for year 2. The company was required to match $25,000 of the salary the second year of the program. In New Jersey, a leading life sciences state with a very large biopharmaceutical industry cluster, the companies that subscribed to the program were virtually all in the life sciences.

Program Design. Top talent in Washington, especially those that are not pursuing academic careers, needs an entry point to the industry. A post-graduate program could take the form of the New Jersey Technology Fellows program and provide a 2-year opportunity for Washington's post-docs, or alternatively, the program could be designed for a 1-year transition into industry. In Washington, it is vital to not only connect this top talent across the sciences but also in engineering (biomedical, mechanical, electrical, computer) in order to serve the talent needs of the major subsectors in the state—biopharmaceuticals, medical devices, and global health. With a government funding structure, the Department of Commerce and even the Governor's Life Sciences Sector Lead could oversee the program.

Resources Required. This effort would involve some level of state funding with industry cost-sharing. In the case of Massachusetts, each participating industry sponsor (which includes life science companies and their venture capital and other professional services supporters) pays a monthly membership fee depending on space needs; about $5,000 visa/legal fee for each visa; and about $1,389 per month for 8 hour per week wage-related expenses. In the case of the NJ program, there was a match in the second year, but this could be structured to have industry match in all years and at a higher level.

Strategic Priority: Addressing Critical Gaps for Specific Life Science and Global Health Occupations and Skill Sets

The assessment has identified specific high-demand, misaligned talent needs for the industry, primarily within high-skilled areas including: science, engineering (both primary to life sciences and key secondary disciplines), regulatory affairs, bioinformatics and biostatistics, and IT.

While gaps exist between demand and supply, industry representatives point to specific postsecondary education and training programs that are working and should be scaled up, or represent a model for additional initiatives and offerings. Building on the themes of the first Strategic Priority, there are also opportunities and needs to further connect existing academic programs with the industry.

The following recommended actions are intended to address these gaps and better connect and orient university programming with the life sciences industry and global health sector in Washington.

Action 5: Connect Engineering Talent at Washington's Colleges and Universities with the Life Sciences Industry

Rationale. Washington's industry base has a tremendous need for qualified engineers, particularly in the medical device sector which employs a varied set of electrical, mechanical, industrial, and biomedical engineers. Since 2010, state employers have increased employment among biomedical engineers by 22 percent, or 60 jobs. Industry survey respondents indicate an extremely high level of expected hiring over the next two years—more than doubling their current job base with more than 800 expected hires across both product development and research, and process development expertise.

With the exception of biomedical engineering, which is explicitly tied to life science applications, there is often little connection between engineering programs and the life sciences industry. To better address these needs requires an intentional connection between academic engineering programs, at both the undergraduate and graduate levels, and the industry via logical touchpoints such as senior design projects and capstone courses.

Best Practices. Top biomedical engineering programs, such as those at the University of Pennsylvania and Stanford University, are connecting graduate students with clinicians to see first-hand how to translate research and ideas from the bench to the bedside, and their professors are often active partners with the life sciences industry. Such opportunities must also be afforded to students in mechanical and other engineering fields to see viable career paths in the life sciences.

Georgia Tech is offering an innovative (and growing) professional master's degree that combines cross-disciplinary instruction and clinical experiences with industry spanning regulatory affairs and product development—the Master of Biomedical Innovation and Development (MBID) program. The MBID program offers current and aspiring biomedical technology professionals two career-building components in one focused program:

- Collaborative academic instruction in biomedical technology from two top-ranked institutions in engineering and medicine; and
- Practical, hands-on clinical experience in Atlanta's biomedical industry.

The new MBID specifically addresses a gap in current professional biomedical education: the crucial "bench-to-bedside" progression that transforms biomedical research into practical, usable techniques and products for improving patient care. With this unique approach, Georgia Tech graduate students study with experts in clinical practice, engineering design and development, best-practices manufacturing, financial planning, and commercialization, as well as guest lecturers from the diverse healthcare industry.

Program Design. To meet the strong current and expected future job demands and to successfully compete against other advanced manufacturing sectors such as aerospace, connecting top students and recent graduates of engineering programs with local industry opportunities must be a priority. In addition, with concerns about the current and next generation of managerial or executive-level talent, the industry should consider proven ways in which to connect with students that can include all or some mix of the following approaches: senior design projects and capstone courses, professional master's programs, entrepreneurial training for graduate students and/or postdocs, internships, and co-ops.

Relevant to medical devices and other life sciences manufacturing, there are opportunities to improve the alignment of engineering-student design projects, cooperatives, internships, and other experiential learning and professional opportunities with the life sciences. It is critical to connect engineering students who may be outside of biomedical engineering programs— including those in key mechanical or industrial engineering programs—to these opportunities in the life sciences. A unique characteristic of engineering programs is the senior design project undertaken as a capstone, often team-driven project with an applied industry focus (including real deadlines and budgets and often direct interaction with a company) to design and prototype a product, electronic device, or software system. Life sciences and global health organizations in Washington should consider sponsoring or participating in these design projects to expose engineering and other science students to opportunities within the industry.

Resources Required. Since student tuition and institutional resources should drive these efforts, limited funding is required to start-up this effort. However, industry does play a key role in generating student interest.

Action 6: Scale Up Life Science Regulatory Training Opportunities at Postsecondary Institutions from Certificates to Professional Masters

Rationale. Currently, there is high demand for regulatory affairs expertise across all major subsectors of the industry, including biopharmaceuticals, medical devices, and global health, and this demand is expected to grow significantly. In the last year, industry survey respondents have hired 20 regulatory affairs professionals, but the expectation for the next two years is to hire 127 additional professionals, a major boost in expected hiring and talent managers are having difficulty finding candidates, with many often conducting national searches.

Profiled in the "supply" section of the assessment, the University of Washington's Regulatory Affairs Master's and Certificate Programs are well-regarded and serve industry needs with multiple offerings that provide flexibility to employers. In addition, the University is adding an "Applied" version of the Master's program that allows students to develop specialized expertise in an area of biomedical regulatory affairs such as in epidemiology, nutrition, global health, statistics or biostatistics.

Washington must work to scale-up both the UW programs in addition to adding programs to meet industry needs. UW's master's program currently graduates only 18, insufficient for meeting expected demand.

Best Practices. Warsaw, Indiana is home to one of the largest orthopedics device manufacturing clusters in the nation and had significant challenges recruiting in regulatory expertise. Instead, a local small institution, Grace College, partnered with the cluster's industry association, OrthoWorx, to seek to build their own expertise. The Orthopedic Regulatory and Clinical Affairs Program, or ORCA, is offered through its Center of Excellence in Orthopedics. Grace College offers "the nation's only graduate program designed specifically by and for orthopedic regulatory and clinical affairs professionals." The college offers both a graduate certificate and master's level program with an accelerated design to complete in one year. The program is focused on developing a strong foundation and understanding in laws and regulations, particularly of the FDA related to orthopedic products. Specific courses are offered in introductory orthopedics, medical device law, writing for regulatory affairs, managing clinical data, good clinical practices, compliance, and clinical trial management and monitoring.

Program Design. It is recommended to not only encourage the expansion of the University of Washington's regulatory affairs programs but also to add additional educational programs at other institutions in Washington. The continuum offered by UW from certificates through master's is ideal, though it is recognized that adding a certificate program is much more viable and practical for many institutions. Additionally, it is recommended that planning grants be offered to state colleges and universities to develop proposals and approaches for expanding these opportunities. Building-in incentives for colleges and universities to collaborate across institutions is strongly recommended.

Resources Required. Since student tuition and institutional resources should drive these efforts, limited funding is required to start-up this effort. Industry, though, plays a key role in generating student interest.

Action 7: Emphasize, Enhance, and Promote IT and Data Sciences Curriculum and Training in Postsecondary Life Sciences Programs and Consider IT Apprenticeships for Industry Needs

Rationale: IT and bioinformatics/biostatistics occupations and skill sets have been identified as high-demand with the industry expressing consistent need for these skill sets, which overlap with and include needs for "data sciences". In the last year, the companies responding to the survey have hired 240 combined in these areas, and that is just one-fifth of the life sciences industry reporting. Expectations among these same companies are to hire just over 700 in the next two years alone. National recruiting for bioinformatics expertise is proving to be challenging and cannot be relied upon to solve most of the state's needs. In IT, the industry is competing fiercely for talent with Washington's technology and other sectors and the Washington Technology Industry Association (WTIA) is seeing annual demand for jobs that require a computer science degree of approximately 4,000 across the state, with qualified candidates counting fewer than 500.

It must be recognized that Washington is on the leading edge in data sciences at the University of Washington's exceptional eScience Institute, which engages researchers across disciplines, including in the life sciences, "in developing and applying advanced computational methods and tools to real-world problems in data-intensive discovery." With faculty in physics, astronomy, bio-engineering, bioinformatics, data management techniques, and computer science, the Institute helps researchers apply appropriate technologies to their research.

In addition, WTIA is advancing an innovative apprenticeship model as an additional avenue to address talent gaps, described below as a best practice.

Beyond what Washington is already doing and to help address these challenges, Washington should promote and integrate IT and data sciences curriculum into its postsecondary life sciences programs. In addition, the life sciences and global health should consider participating in the innovative apprenticeship model that WTIA has developed and advanced.

Best practices.

The rise of data analytics as a degree option is emerging across universities in the U.S. One of the pioneers, Ohio State, offers an interdisciplinary major where students receive a Bachelor of Science (BS) degree from the College of Arts and Sciences through curricular partnerships with the College of Engineering, the College of Medicine, and the Fisher College of Business. In this unique Ohio State degree program, each student chooses a specialization, and the major to learn how core fundamentals are applied in a particular field.

The data analytics skills developed for students include:

- Computer science principles relating to data representation, retrieval, programming, and analysis.
- Mathematical and statistical models and concepts to detect patterns in data, and to draw inferences and conclusions supported by data.
- Critical thinking skills associated with problem identification, problem solving and decision making, assessing value propositions supported by data, and generating a logical synthesis of information from data.
- Ability to communicate findings and their implications, and to apply them effectively in organizational settings.

Program Design. IT and data sciences are already being integrated into undergraduate life science curriculum, but this integration can and should be expanded. The state's leading public institutions—UW and WSU—currently have courses for undergraduate biology majors in data sciences, but have no combined curriculum tracks or minors offered specifically in bioinformatics or data sciences for biologists. These institutions, and others in the state, should design complementary statewide minor programs in these areas for biology majors. Biology is the largest major field at UW and so the program track could gain significant scale and can leverage exciting opportunities to connect with its medical school and eScience Institute for collaborations and student projects. At WSU, strengths in animal science and the new medical school coming online provide interesting options for unique applications in data sciences for undergraduates as well.

Further, Washington should leverage the strength it has in the eScience Institute. Currently building out tracks for various undergraduate academic departments and majors at UW, the Institute already offers a master's and PhD programs in data science. The Institute should better integrate existing certificate programs for post-bachelor students into the undergraduate curriculum in collaboration with departments at the university, and seek to collaborate with other universities in Washington to advance similar degree options.

The Washington Technology Industry Association represents the technology industry in Washington which is facing severe talent deficits annually. To address these challenges and "grow its own" talent, WTIA has launched an innovative "Apprenti" program utilizing DOL funding ($11 million grant) to create a nationally-registered apprenticeship program with a major focus on diversity, requiring more than 50 percent of participants from diverse populations. The program, which recently launched its initial cohort, screens candidates for key competencies in math, logic, and critical thinking, and then approved applicants can enter into one of nine job classes. They interview with companies; participate in 2-5 months of technical classroom training; have 1 year of paid on-the-job-training with an experienced professional, and then earn a certificate (e.g. a Certified Software Developer). Participants in the program are not solely IT industry firms but include Starbucks, REI, Costco, and others. In fact, this program is open to any company, including the life sciences, and could address needs for data sciences talent development. These private entities are helping to fund "scholarships" with respect to the education component.

Resources Required. Since student tuition and institutional resources should drive these efforts, limited funding is required to start-up this effort. Industry, though, plays a key role in generating student interest.

Appendix

Workforce Panel Members

The project team would like to thank the members of the Workforce Panel, listed here, for their participation and invaluable role in guiding this study.

Panel Member	Organization
John Aultman	State of Washington, Office of the Governor
Jaylene Belcher	Physio-Control (Stryker)
Toby Bradshaw	University of Washington
Marty Brown	State Board of Community and Technical Colleges
Pam Yanchik Connealy	Bill and Melinda Gates Foundation
Deb Doel-Hammond	Allen Institute
Dot Fallihee	Workforce Development Council of Seattle-King County
Dan Ferguson	Allied Health Center of Excellence, Washington State Community Colleges
Sabrina Kamran	University of Washington Science & Engineering Business Association (SEBA)
Kevin Keller	CMC Biologics
Andrea Knapp	Women in Bio; NanoString Technologies
Debbie Krogman	NanoString Technologies
Maura Little	Cambia Grove (Former Washington State Department of Commerce)
Matt Maclean	PATH
Tracy Matthews	BTG
Jennifer Olsen	Resourceful HR
Eleni Papadakis	Washington Workforce Training and Education Coordinating Board
Chris Pawlowicz	Seattle Genetics
Jennifer Peppin	Washington Employment Security Department
Karen Riba	PAML
Jessica Roberto	Life Science Washington
Jennifer Ryan	Novo Nordisk
Marlena Sessions	Workforce Development Council of Seattle-King County
Radi Simeonova	Washington State Department of Commerce
Diane St. John	CMC Biologics
Angela Stevens	Philips
Lori Stewart	Adaptive Biotechnologies
Tina Vlasaty	Washington Global Health Alliance
James Zimmerman	Washington State University

Life Science Industry Definition

Table A-1 presents the industry definition of the life sciences utilized in this report and developed by TEConomy Partners in partnership with the Biotechnology Innovation Organization (BIO). The industries are based on the North American Industry Classification System (NAICS).

Table A-1: Life Science Industry Definition

Life Science Subsector	NAICS Code	NAICS Description
Agricultural Feedstock and Chemicals		
	311221	Wet Corn Milling
	311222	Soybean Processing
	311223	Other Oilseed Processing
	325193	Ethyl Alcohol Manufacturing
	325221	Cellulosic Organic Fiber Manufacturing
	325311	Nitrogenous Fertilizer Manufacturing
	325312	Phosphatic Fertilizer Manufacturing
	325314	Fertilizer (Mixing Only) Manufacturing
	325320	Pesticide and Other Agricultural Chemical Manufacturing
Drugs and Pharmaceuticals		
	325411	Medicinal and Botanical Manufacturing
	325412	Pharmaceutical Preparation Manufacturing
	325413	In-Vitro Diagnostic Substance Manufacturing
	325414	Biological Product (except Diagnostic) Manufacturing
Medical Devices and Equipment		
	334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
	334516	Analytical Laboratory Instrument Manufacturing
	334517	Irradiation Apparatus Manufacturing
	339112	Surgical and Medical Instrument Manufacturing
	339113	Surgical Appliance and Supplies Manufacturing
	339114	Dental Equipment and Supplies Manufacturing
Research, Testing, and Medical Laboratories		
	541380*	Testing Laboratories
	54171*	Research and Development in the Physical, Engineering, and Life Sciences
	621511	Medical Laboratories
Bioscience-Related Distribution		
	423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
	424210*	Drugs and Druggists' Sundries Merchant Wholesalers
	424910*	Farm Supplies Merchant Wholesalers

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

Primary and Secondary Life Science and Global Health Occupational Definitions

The following tables include the detailed occupations and corresponding Standard Occupational Classification (SOC) Codes that make up each grouping across both primary and secondary designations.

Table A-2: Primary Life Science and Global Health Occupations

SOC Code	Definition
Agricultural, Food and Nutrition Scientists and Technicians	
19-1011	Animal Scientists
19-1012	Food Scientists and Technologists
19-1013	Soil and Plant Scientists
19-4011	Agricultural and Food Science Technicians
Biological Scientists and Technicians	
19-1021	Biochemists and Biophysicists
19-1022	Microbiologists
19-1029	Biological Scientists, All Other
19-1041	Epidemiologists
19-1042	Medical Scientists, Except Epidemiologists
19-1099	Life Scientists, All Other
19-4021	Biological Technicians
Life Science-related Engineers	
17-2021	Agricultural Engineers
17-2031	Biomedical Engineers
Life Sciences Managers	
11-9121	Natural Sciences Managers
Medical and Clinical Laboratory Technicians	
29-2011	Medical and clinical laboratory technologists
29-2012	Medical and clinical laboratory technicians
51-9081	Dental Laboratory Technicians
51-9082	Medical Appliance Technicians
51-9083	Ophthalmic Laboratory Technicians

Table A-3: Secondary Life Science and Global Health Occupations

SOC Code	Definition
Management	
11-1021	General and Operations Managers
11-3031	Financial Managers
11-3051	Industrial Production Managers
11-9041	Architectural and Engineering Managers
Business & Financial	
13-1023	Purchasing Agents, Except Wholesale, Retail, and Farm Products

SOC Code	Definition
13-1161	Market Research Analysts and Marketing Specialists
13-2011	Accountants and Auditors
Information Technology	
15-1132	Software Developers, Applications
15-1133	Software Developers, Systems Software
15-1151	Computer User Support Specialists
15-1152	Computer Network Support Specialists
17-2061	Computer Hardware Engineers
Engineering & Eng. Techs	
17-2071	Electrical Engineers
17-2072	Electronics Engineers, Except Computer
17-2112	Industrial Engineers
17-2141	Mechanical Engineers
17-3023	Electrical and Electronics Engineering Technicians
17-3026	Industrial Engineering Technicians
Chemists & Chemical Techs	
19-2031	Chemists
19-4031	Chemical Technicians
Health Technicians	
29-2091	Orthotists and Prosthetists
Technical Sales Reps	
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products
Office & Administrative	
43-1011	First-Line Supervisors of Office and Administrative Support Workers
43-3031	Bookkeeping, Accounting, and Auditing Clerks
43-4051	Customer Service Representatives
43-4171	Receptionists and Information Clerks
43-5061	Production, Planning, and Expediting Clerks
43-5071	Shipping, Receiving, and Traffic Clerks
43-5111	Weighers, Measurers, Checkers, and Samplers, Recordkeeping
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive
43-9061	Office Clerks, General
Skilled Production	
51-1011	First-Line Supervisors of Production and Operating Workers
51-2022	Electrical and Electronic Equipment Assemblers
51-2099	Assemblers and Fabricators, All Other
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic
51-6031	Sewing Machine Operators
51-9011	Chemical Equipment Operators and Tenders

SOC Code	Definition
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders
51-9111	Packaging and Filling Machine Operators and Tenders
51-9198	Helpers--Production Workers
Transportation	
53-3033	Light Truck or Delivery Services Drivers
53-7063	Machine Feeders and Offbearers

Approach to Identifying Secondary Life Science and Global Health Occupations

Critical to competing in a knowledge and innovation-driven industry are key personnel in business, information technology, and skilled production functions—areas of talent for which life science and global health companies and research organizations must compete with other advanced industries—referred to in this study as "secondary" life science and global health occupations.

To identify key "secondary" life science occupations, TEConomy utilized state-specific "Staffing Patterns" data that break down occupational employment by industry. To be included among the secondary occupational groupings in Washington, these occupations:

- Must make up at least 1 percent of employment in key industry segments (where available), including in biopharmaceutical manufacturing and medical device and equipment manufacturing; and,

- The occupational share for the life science and global health industry segments must exceed the share of employment in the broader industry classification (e.g. a greater share of jobs in pharmaceutical manufacturing compared with all of manufacturing), indicating that these occupations play a key role in the production of goods and delivery of services in the industry.


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