



BIOTECHNOLOGY IN GEORGIA

Assessing Workforce Challenges and Opportunities

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This report was completed as part of a capstone requirement for the Master of Science degree program at Georgia Institute of Technology's School of Public Policy.

About the Client Priorities:

Our primary client, Georgia Bio, is seeking information on the status of the biotechnology workforce in Georgia. Georgia Bio's relevant areas of interest include difficulty defining the types of jobs in the industry, difficulties finding and retaining suitably qualified candidates for various positions in the industry, and difficulties attracting and keeping leading biotechnology firms in the state. Our secondary client, the NSF Engineering Research Center for Cell Manufacturing Technologies (CMaT), has a particular interest in emerging fields like cell manufacturing. This report includes all of the feedback and input we received from both clients as of April 22, 2019.



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EXECUTIVE SUMMARY

Purpose & Objectives

Georgia has the potential to become a leading state in the fast-growing biotechnology industry. The state has competitive research and educational institutions, yet there is a persistent workforce development problem that hinders advancement. The broad goal is to help inform our client, Georgia Bio, about the challenges and limitations of the biotechnology industry in Georgia. Exploration of these areas, in combination with comparisons to similar state markets should highlight opportunities and unfulfilled needs of the Georgia biotechnology industry. The key questions addressed in the report are:

- What specific opportunities or challenges exist in Georgia to support traditional and emerging areas of the biotechnology industry?
- What policy incentives are other states using to support the biotechnology workforce?

Approach

This study used a mixed-methods approach. After reviewing relevant literature, we examined policies in a set of comparable states to contrast biotechnology industry needs in Georgia with industry needs in other states and conducted qualitative interviews with approximately 25 individuals selected for their roles in Georgia's biotechnology industry or education system. We also collected and analyzed 135 industry job postings to develop a snapshot of the biotechnology job market in Georgia and analyzed publicly available data from the Technical College System of Georgia (TCSG), the University System of Georgia (USG), and the Georgia Department of Education (GaDOE). Collectively, these analyses provide an overview of the biotechnology industry in Georgia and can be used to identify and prioritize efforts, including state government advocacy, to support the industry.

Final Results and Recommendations

State Comparison:

Results from the state comparative analysis show that there are promising opportunities for growth throughout Georgia's biotechnology workforce landscape. To reach the upper echelon and develop a stronger life sciences economy, Georgia should look to comparable states' successful policies and programs used to support a workforce for traditional and emerging areas of biotechnology. Georgia Bio should consider facilitating public-private partnerships between the state of Georgia, technical colleges, public universities, and industries

to create training programs, similar to North Carolina's exemplar program NCBioImpact, for new biotechnology workers. Georgia Bio should continue to promote communication-based efforts to connect colleges with biotech industries and consider working with colleges to develop a curriculum that will provide students with the skills that companies desire. Georgia Bio should lobby the state legislative to build training facilities that specialize in certain areas like bioprocessing or cell manufacturing, and offer companies grants to cover expenses of an employee's training. Finally, Georgia Bio should also work with local leaders to set up their own training programs for new and existing employees.

Industry Evaluation:

Results from the industry evaluation show that internships and cooperative education (co-ops) are needed to prepare recent graduates, at the associate and bachelor's level, to integrate biotechnology classroom knowledge and theory with practical skills developed in professional settings. In addition, it is also imperative to invest in the future of Georgia's biotechnology landscape by building industry awareness in middle school through higher education. To help strengthen Georgia's biotechnology workforce, Georgia Bio should work with their industry partners to initiate industry-led after-school initiatives and industry-led guest speaker events for pre-college students to develop student interest in biotechnology-related fields at an early age.

Education Evaluation:

Results from the education evaluation indicate that the lack of understanding and awareness of students, in particular, pre-college students, provides an opportunity to nurture middle and high school students interest in biotechnology careers. Teacher development is also an area of concern. There are no known teacher development systems in place in Georgia that are designed to produce teachers for the biotechnology sector. Georgia Bio should advocate for the Georgia Department of Education create a Georgia BioTech Career Technology Student Organization (CTSO) that incorporates iGEMS and related initiatives. Georgia Bio should also advocate for the USG to investigate ways to develop biotechnology track teacher education system at the undergraduate and graduate levels. Lastly, Georgia Bio should work to engage technical colleges and universities and advocate for increased attention to providing students with fellowships, internships, and co-ops, to help students learn the in-demand skills required by industry.

Overarching Conclusions:

Georgia's biotechnology industry workforce is both strong and diverse. Industry members are optimistic that the state can stand as a frontline competitor in the nation's biotech market. There are, however, key opportunities to grow and strengthen Georgia's biotech workforce landscape, at least in part through the initiatives identified in this report.

I. INTRODUCTION

Background

The biotechnology industry has been rapidly increasing in prominence in the United States since the field first showed promise in the late 1970s. In the early 2000s, there was a remarkable boom in America's biomedical industry during the race to complete the Human Genome, but excitement dipped when the project ended. By 2012, the United States showed no indication of specializing in one sub-field over except that the environmental sector was underdeveloped (Friedrichs 2018). Total American investment in all types of biotechnology significantly outpaced that of all other developed countries at nearly ten times the amount of the nearest competitor in 2013. In 2012, the biotechnology industry contributed \$324 billion in revenues towards the United States' economy (Carlson, 2016). However, the fact that biotechnology made up only 7.8% of total American business investments – in the middling tier of proportionate spending compared to other developed countries – hinted at some level of restraint (OECD 2013). Over 40,000 people are currently employed at over 3,000 life science firms (Georgia BIO Report).

In 2010, eleven states were offering incentives directly to biotechnology firms, and 34 had applicable tax credits available for R&D (Moretti & Wilson 2013). When states were grouped based on biotechnology workforce, research and development (R&D) funding, and state regulated environment in 2018, Georgia was sorted into the lowest tier (Chao & Myers 2018). In this regard, there is more room for growth in Georgia than other states. Although the biotechnology presence in Georgia is not as ubiquitous as other states such as Massachusetts or New Jersey, the industry is rapidly developing as innovation, technology, and research prosper. Not only is employment in life sciences increasing, but also its contribution to Georgia's GDP (Georgia BIO Report). In 2017 life sciences directly contributed to \$10 billion to Georgia's GDP. This report highlights one aspect of the Georgia life sciences industry - biotechnology. Our goal is to uncover aspects of the biotechnology industry to understand how we can foster further growth in the state of Georgia.

Report Roadmap

This report will proceed in three broad sections. The first section will provide introductory context in the form of a literature review which assesses how "biotechnology" is defined in both practice and theory, the challenges that the discipline currently faces, and the overall status of the industry's workforce. Next, the analysis and results section will present a comparative state evaluation, an industry evaluation, and an education evaluation. The state evaluation will establish the status of Georgia policies in comparison to other

states. This state comparison study consists of both a qualitative descriptive analysis of state biotechnology workforces and a secondary data analysis of the production rates of college graduates with biotechnology-related majors within the selected states. In this way, the policies other states have adopted in support of the biotech workforce can be used to determine what kinds of policies could be appropriate for Georgia. The four states included in the state comparison are North Carolina, Tennessee, Florida, and Washington. Next, the industry evaluation begins the “on-the-ground” portion of the analysis with the results of interviews with local biotech industry personnel and a statewide job posting analysis. The analysis and results section then closes with an education evaluation which, similar to the industry section, consists of the results of interviews with education personnel from local high schools, the TCSG, and the USG, as well as an analysis of secondary data from TCSG, USG, and the GaDOE. Together, the industry and education evaluations offer perspectives on Georgia biotechnology workforce needs, including the perceived and directly-measured status of the workforce talent pool as well as the people and institutions which support it. Following the analysis and results section, the report concludes with a preliminary set of policy and program recommendations.

II. LITERATURE REVIEW

Biotechnology Development

A preliminary review of the current literature indicates that biotechnology is facing challenges worldwide. Finding funding for such an innovative and volatile field is inherently challenging (Kolympiris, et al. 2011). Exacerbating this issue, the talent to workforce pipeline for biotechnology is leaking on both ends in promising regions like Georgia. Industry anecdotes indicate that biotechnology firms are struggling to recruit and hold on to talented workers (Thompson et al. 2018; Liu & Schmid 2009; Georgia Bio 2019). Concurrently, there have been historically low retention and graduation rates for STEM students. Studies from 2003-2009 and 2012, for example, show that less than half of STEM associate degree candidates and STEM-declared bachelor's degree candidates are successfully graduating with STEM degrees (Tanski 2016). The two sides of the equation – education and industry – are conspicuously at odds on these causes of workforce shortages.

Industry professionals point the finger at traditional education programs, claiming that new graduates must be leaving school ill-prepared for what industry work is actually like. Direct supervisors complain that new hires come in lacking the knowledge necessary for their roles. Hiring agents similarly report that job applicants lack multidisciplinary soft skills like business, management, and policy acumen (Thompson et al. 2018; Liu & Schmid 2009; Gunn et al. 2013; Narasimharao 2010). Graduating students seem to confirm this knowledge gap, asserting that they left school feeling misled about and unprepared for the reality of current career prospects in biotechnology (NRC 1998; Fonseca et al. 2013; Narasimharao 2010). Concerningly, on the other end of the equation, teachers, professors, and university career counselors report being unfamiliar with the biotechnology industry. This unfamiliarity means that, not only do educators not know what jobs are available for their graduates, but educators also lack the resources necessary to bridge the knowledge gap in a way that will keep students engaged enough to pursue related career paths (Borgerding et al. 2013; Fonseca et al. 2012; Kidman 2009).

Numerous attempts have been made to address workforce retention. One solution involves adjusting schooling to better reflect non-research science careers, which would incorporate multidisciplinary real-world skills like business, sales, and regulatory knowledge (Gunn et al.; Cramer & Hamilton 2017). Another potential fix involves expanding the talent pool by increasing recruitment and retention of underserved, non-traditional, and foreign-born students (McQuaid 2010; Tanski 2016). A handful of pilot programs across the country have attempted to better prepare more students for biotechnology degrees by expanding recruitment and in-program access to real work experiences, however, the small sample sizes and short time frames of the studies preclude

conclusive results. Additionally, the quality and integration of in-program internships causes significant variation in effectiveness (Cramer & Hamilton 2017).

As disagreements and confusion continue on the individual level, state governments are attempting to use policy to encourage growth. Georgia can gain insight about how to grow its own biotechnology industry by comparing itself with other states that show signs of more development. The Raleigh-Durham region in North Carolina, for example, is the closest major biotechnology hub to Georgia in the Southeast region (Chao & Myers 2018; Moretti & Wilson 2013). Understanding what North Carolina and other similar states with biotech hubs are doing may offer inspiration to policymakers in Georgia. However, while states with a larger workforce, R&D funding, and supportive legislation generally have more robust biotechnology activity, pinning down the details of what will work in Georgia remains difficult (Chao & Myers 2018; Moretti & Wilson 2013). For example, while there is some evidence that subsidies correlate with increased employment and attractiveness to “star scientists,” the rate of return remains unclear (Moretti & Wilson 2013). Similarly, attracting venture capitalist investors has produced inconsistent and limited results (Kolympiris et al. 2011). Prior literature has demonstrated that venture capital investments are higher when venture capital are within a ten-mile proximity to the biotechnology firms. In addition, biotech firms that are older and more established and have also received government funding are more likely to receive funds from more distant venture capitalists (Kolympiris, et al. 2011). Ultimately, addressing Georgia’s biotech workforce challenges is impeded by the ongoing battle about how to accurately define and measure the impact of the field.

Biotechnology Definitions

Biotechnology is challenging to define both in practice and theory. The term has been used to describe an array of groundbreaking activities at the juxtaposition of science and technology. The difficulty in defining biotechnology extends to pinpointing its full economic impact and, therefore, any workforce related challenges (Bud 1991; Carlson 2016). Although individual financial and health contributions often result in top headlines, governments struggle to keep up with the fast-paced advancements to determine an all-inclusive measurement. Similarly, even individual practitioners risk overlooking emerging sub-fields outside of their specialization. The intergovernmental trade organization, the Organisation for Economic Cooperation and Development (OECD) provides the following single definition of biotechnology, narrowed down from an initial eleven:

“[Biotechnology is] the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.” (OECD 2013)

This definition is purposefully broad and unspecific to leave room for everything biotechnology is now and everything it could become in the future. OECD's Directorate for Science, Technology and Innovation pointedly classifies biotechnology as an area of "field convergence," in which multiple fields of study of different origin are blended into one (Friedrichs 2018). If biotechnology were a river, its tributaries would include many existing fields in biology, chemistry, genetics, nanotechnology, and more as filtered through the market and legal practicalities of business and policy. Establishing clear boundaries around the stream of inputs is essential to accurately assess the biotechnology workforce in Georgia.

There are a few favored strategies for simplifying how we think about biotechnology. The first involves dividing and color coding the field based on functionality (Kafarski 2012; Barcelos et al. 2018). With upwards of ten colors, however, the biotechnology "rainbow" can quickly become unwieldy and inconsistent. Biotechnology can be more cleanly divided into six primary areas according to the product output. Listed in order of popularity based on an analysis of relevant patents from 1996-2012, the sub-fields of biotechnology are genetic/molecular, pharmaceutical/medical, industrial, analytic/bioinformatics, agricultural/food, and environmental (Friedrichs 2018). By focusing on the most popular applications, however, American biotechnology can be condensed into medical biotech (drugs and other health-related uses), industrial biotech (non-food products like biofuels and enzymes), and agricultural biotech (modified food and crops) (Carlson 2016).

Biotechnology Measures

There is a wide-open field of opportunities in biotechnology across the United States, but issues pinpointing the definition mean that there are a variety of different approaches to measurement. Three biotechnology sub-industries finally showed signs of coming out ahead in 2016 when researchers experimented with using estimated total revenues to measure economic impact. Economic impact is commonly calculated by using GDP and the US Census Bureau's North American Industrial Classification System (NAICS). Since there is no single NAICS code for all biotechnology-related industries and many codes meld non-biotech and biotech activities together, however, an alternative method has to be used. In a 2016 study in *Nature Biotechnology*, researcher Robert Carlson tried to create a measure of total revenue to estimate economic impact instead. The inputs for total revenue included corporate financial reporting, USDA crop market price and seed usage data, and surveys with private consultants. This method showed that biotech revenues have grown steadily since 1980, peaking at 5.4% of GDP between 2007 and 2011. Notably, the biotech industry did well mid-recession from 2001-2003, which suggests that the industry can still perform well in economic declines. In 2016, American agricultural biotechnology was estimated to contribute \$128 billion in revenue, industrial was estimated at \$105 billion, and medical was estimated at \$91 billion. While the

methods to deduce these numbers are promising, they remain estimates due to a persistent lack of complete, publicly available data. Activities in certain niche sub-sectors or small biotechnology operations within large non-biotech companies were likely overlooked in the struggle to capture the entirety of the field (Carlson 2016).

Another creative method to determine the status of an industry's workforce when other options are unavailable is to investigate current jobs postings. Researchers Helen Liu and Molly B. Schmidt used job posting analysis to estimate the current job opportunities within biotechnology and pharmaceutical companies in their study published in the *Journal of Commercial Biotechnology* in 2009. Specific workforce shortages were addressed by classifying the jobs according to function. Functions included laboratory, non-laboratory, manufacturing, clinical/regulatory, general/administrative, and sales/marketing. According to the job posting analysis, the majority of jobs in large companies were "non-laboratory" while, in smaller and newer companies, job types were more evenly distributed. These Liu & Schmid (2009) results offer a helpful snapshot of the American biotechnology industry. Due to the variation in biotechnology development across the country, however, repeating a similar analysis at the state-level is necessary to develop targeted solutions.

III. STATE EVALUATION

State Comparison Overview

Before diving into the state evaluation section, it is important to note that Georgia is not the primary focus of the research. Instead, the idea of the state comparison is to frame the status of Georgia within the context of the biotechnology industry in comparable states. Additionally, there is no known comprehensive survey that performs a state by state comparison of the biotechnology sector and the related subfields. This makes it difficult to directly make accurate comparisons. This type of comparison, however, can help us begin to understand what other states are doing to bolster their biotech industry and attract talented workers and firms from across the country.

The states – Florida, North Carolina, Tennessee, and Washington – were primarily selected based on client preference, regional proximity, and comparable industry size and growth rate. North Carolina was particularly selected due to the reputation of its biotechnology cluster. The programs and initiatives described are prime examples of the types of positive attributes that can be adapted to attract talented individuals and firms to Georgia. Information in the state comparison section was primarily gathered through secondary analysis of industry associations, governmental reports, and press reports from state biotechnology organizations. These reports provided information on the status of the biotech industry in each respective state. These reports enabled our group to conduct additional on key policies and programs.

Three important trends or themes stood out from our research on the other states. The first trend focused on the types of funding or tax incentives that each state used to grow their biotech industry. The second trend examined the initiatives that were being developed at universities and technical colleges. The final trend consisted of the efforts taken by each state to develop a biotech workforce suited to meet the needs of biotech companies. The state comparison section will conclude with a short, data-driven comparison of the number of bachelor's degrees conferred in each of the selected states. The table below (Table 3.1) provides an overview of key findings that were collected as part of our research biotech policies in other states.

Figure 3-1 State Biotechnology Trends Summary

State	Funding & Tax Incentives	Research Universities	Workforce Development
GA	<ul style="list-style-type: none"> Bio/Med Network – medium to connect investment groups with start-up biotech companies 	<ul style="list-style-type: none"> GRA Eminent Scholars: help lead ground-breaking research projects at the state’s research universities Georgia Centers of Innovation biotech incubators located in biotech clusters Georgia CTSA Research Opportunities & Collaboration Support (ROCS) – promotes collaboration for clinical research among the major colleges in the state 	<ul style="list-style-type: none"> Quick Start Program - provides training to qualified new, expanding, and existing businesses in the state free of charge GA BioScience Training Center – supports training for new life science companies
FL	<ul style="list-style-type: none"> Capital Investment Tax Credit – annual tax credit (up to 20 yrs) to attract companies. To qualify: a company MUST create a minimum of 100 jobs & invest \$25 million in capital costs Qualified Target Industry Tax Refund (QTI) – targets industries seeking to expand existing facilities or build new ones in the state To qualify: a company MUST create a minimum of 10 jobs, pay an average 115% of area wages, & have local support 	<ul style="list-style-type: none"> Universities and technical colleges from across the state have teamed up to form incubators to help young biotech companies University of Florida Innovation Hub: Support biotech companies who build technologies in the university labs University of Florida Sid Martin Incubator: Provides specialized facilities and business support to startup companies 	<ul style="list-style-type: none"> Executives of biotech firms in the state are hesitant with investment money because they do not think potential employees are properly trained for their jobs University of Florida is working to try to close that readiness gap; has the Biotility program which was launched in 2006 <ul style="list-style-type: none"> Offers short courses to professionals and students Program seeks to expand and deepen knowledge on the technical and regulatory details unique to the biotech industry
NC	<ul style="list-style-type: none"> Business and Technology Development Program - make strategic loans to young biotech companies who needed early-stage capital 	<ul style="list-style-type: none"> Faculty Recruiting program – launched by NC Biotechnology Center to attract star research faculty to the state’s public and private universities University Research Funding: fills critical funding gaps needed to support early stage development of university inventions As part of NCBioImpact, technical colleges develop tailored-made training curriculum for biotech companies: Will assist biotech businesses who agree to make a sizable capital investment that will deploy new technologies, create jobs, and enhance the skills of workers 	<ul style="list-style-type: none"> NCBioImpact - public-private partnership that trains workers for biomanufacturing jobs <ul style="list-style-type: none"> Includes training operations in North Carolina’s technical college system NC State and North Carolina Central University have facilities to offer hands-on training for bachelor’s and advanced degree programs These facilities also offer industry specific courses for employed students Offers firm-specific customized training Have centers that train specific areas like bioprocessing and pharmaceuticals
TN	<ul style="list-style-type: none"> TNInvestco – intended to increase the flow of capital to new companies in the early stages of their development INCITE Co-Investment Fund – provides investment funds to biotech companies Angel Tax Credit – passed by the state legislature in 2017 \$1.5 million in credits helped spur \$5.2 million in investment 	<ul style="list-style-type: none"> Has a state-wide network of accelerators that are linked together (an accelerator has been set up in each region of the state) Accelerators attract entrepreneurs to the state and provides support to local biotech companies 	<ul style="list-style-type: none"> Incumbent Worker Training: grant provides funding to businesses to help them provide skills upgrades and process improvement training for existing employees On-the-Job Training Grants: will pay up for the cost of an employee to receive training for a position they have no prior experience in. Memphis BioWorks – offers a free job training program

WA	<ul style="list-style-type: none"> • Biotechnology & medical device manufacturing sales & use tax deferral/waiver <ul style="list-style-type: none"> ◦ Application for this tax waiver must be filed and approved before a building permit is issued ◦ Businesses must maintain a qualified activity at the site ◦ Tax wavier expired in 2017 • Life Science Washington provides biotech companies with resources to national grants programs like National Institute of Health's SBIR/STTR • Life Science Discovery Fund was created in 2005 to help biotech startups <ul style="list-style-type: none"> ◦ Fund was a key way start-up biotech companies could get venture capital funding ◦ Venture capital funding growth in WA outpaced growth across the rest of the country (from 2012-2015) 	<ul style="list-style-type: none"> • University of Washington opened a new Life Sciences building in 2018 thanks to growing demand by students interested in biology: Biology majors doubled over the last 10 years at University of Washington • Biology is the most popular STEM major in the state • State saw a 9.5% change in life science & global health academic R&D (from 2012-2014) • Life Sciences Discovery Fund – supported innovative research and development; fund ended in 2015: Provided 112 grants to universities worth \$106 million • NIH Protein Biotechnology Training Program <ul style="list-style-type: none"> ◦ Students are educated in the applied aspects of biotechnology ◦ Trainees in the program are admitted for graduate studies in academic units like ◦ Chemistry, Bioengineering, and Animal Health ◦ Supported by a grant from the National Institute of General Medical Sciences 	<ul style="list-style-type: none"> • Currently developing a workforce development strategy • A study commissioned by Gov. Inslee highlights that the need to address how the K-12 workforce will be developed • Might want to look to the NIH Protein Biotech Training Program for guidance: Students in the program get state-of-the art training in basic science
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Funding and Tax Incentives

Prior to discussing what Florida, North Carolina, Tennessee, and Washington are doing in these areas, it would be helpful to briefly discuss some of what Georgia is doing. In the area of funding and tax incentives, the Bio/Med Investor Network was set up to help biotech and other bio-science related companies. Bio/Med acts as a medium to connect bioscience companies with investors who can provide them with necessary to grow their businesses. This investor network is supported by Georgia Bio, the Georgia Research Alliance (GRA) and the state research universities. In the university area, the Georgia Centers of Innovation has developed incubators to help foster the growth of biotech companies. These incubators are set-up in the biotechnology clusters of Atlanta, Athens, and Augusta. In the workforce development area, Georgia has the QuickStart program which provides training to qualified new, expanding, and existing businesses in the state free of charge. There is also the Georgia BioScience Training Center which supports training for new life science companies who choose to locate to Georgia.

Florida

In Florida, BioFlorida, the organization who lobbies on behalf of the state's biotech industry, advocated for tax policies, direct investment, and other state incentives to grow the biotech industry. Florida

Enterprise provides a number of incentives for new biotech companies and for existing one looking to relocate to Florida. One incentive is the Capital Investment Tax Credit (CITC) (BioFlorida, n.d.). This is an annual tax credit up to 20 years that is used to attract and grow capital-intensive industries in the state (BioFlorida, n.d.). To qualify for the tax credit, a company must create 100 jobs at minimum and invest \$25 million in capital costs (BioFlorida, n.d.). Another Florida Enterprise incentive is the Qualified Target Industry (QTI) tax refund (BioFlorida, n.d.). This tax refund targets industries seeking to expand existing facilities or build new facilities in the state (BioFlorida, n.d.). In order to get the refund, a company must create a minimum of ten jobs, pay an average of 115 percent of area wages, and have local support (BioFlorida, n.d.). The state of Florida also offers research & development tax credits that equal ten percent of a company's expenses (BioFlorida, n.d.).

North Carolina

Venture capital was another key to growing the biotechnology industry in North Carolina. Prior to the Great Recession, the state was ranked in fourth in biotechnology-specific venture capital (Easley Jr., 2011). Additionally, the North Carolina Biotechnology Center created a Business and Technology Development Program. This purpose of this program was to make strategic loans to young biotech companies who needed early-stage capital (Easley Jr., 2011). These small, high-risk loans inject cash into funding new startup companies (Easley Jr., 2011). Furthermore, these loans help attract angel investors by signaling a firm's commercial viability. A biotech startup in the state will receive a Company Inception Loan which will provide up \$30,000 for them to conduct market research and develop business plans (Easley Jr., 2011). Once the biotech startup reaches the research-oriented phase, they will become eligible for two rounds federal Small Business Innovation Research Grants (SBIRs) (Easley Jr., 2011). The North Carolina Biotech Center provides a SBIR Bridge loan which allows companies up \$75,000 to maintain tech-development momentum between two rounds of SBIRs (Easley Jr., 2011). If a biotech company has commercial potential, it will become eligible for \$150,000 Small Business Loan (Easley Jr., 2011). Once a biotech company survives the early stages, it may become eligible to receive a \$500,000 Strategic Growth loan to accompany their first round of venture capital financing (Easley Jr., 2011). The North Carolina Biotechnology Center has invested almost \$20 million in North Carolina companies (Easley Jr., 2011).

Tennessee

Tennessee has experienced growth in the biotech industry similar to North Carolina and Georgia. In their 2018 report, Biotechnology Innovation Organization (Bio) stated that Tennessee experienced a job gain of 1,000 to 4,999 jobs between 2001 and 2016 (TEconomy/BIO, 2018). Between 2014 and 2016, the state's bioscience industry experienced a growth of one thousand jobs (TEconomy/BIO, 2018). The sub-sectors that

experienced the most growth during that time span were drugs & pharmaceuticals, medical devices & equipment, and research, testing, & medical laboratories (TEconomy/BIO, 2018).

Research universities have played a vital role in the growth of Tennessee's biotechnology industry. A similar trend can be observed in both Georgia and North Carolina. Additionally, like its neighboring states, Tennessee has emphasized providing funds to biotech startups. In 2009, the state implemented the TNInvestco program. The purpose of the program was to increase the flow of capital to new companies in the early stages of their development (TNInvestco, n.d.). The program allocated \$200 million in tax credits to various venture capital funds with experience developing new startup companies in Tennessee (TNInvestco, n.d.). The venture capital funds would market the tax credits to insurance companies who would purchase the tax credits with capital reserves (TNInvestco, n.d.). Furthermore, the venture funds would use the capital reserves from the insurance companies to help the state's startup companies grow (TNInvestco, n.d.). TNInvestco has helped create 1850 jobs as of 2017 (McGee, 2018). The investment groups involved in the program have allocated over \$130 million to 187 companies (McGee, 2018).

Similarly, in 2011, the INCITE Co-Investment Fund was created. The Fund was part of Governor Bill Haslam's INCITE initiative to foster growth and create knowledge-based jobs by encouraging small business investment (Launch Tennessee, 2019). It was created using \$29.7 million of federal funding that was awarded to Tennessee from the State Small Business Credit Initiative. The fund is administered by Launch Tennessee, a public-private partnership group that focuses on supporting entrepreneurs and the development of high-growth companies in Tennessee. INCITE has awarded \$55 million in investment funds (Waller, 2018). Currently, all \$28.8 million has been invested along with \$88 million in private capital (Launch Tennessee, 2019). Additionally, close to \$60 million in follow-up capital has been invested.

The Tennessee legislature addressed concerns over angel funding by enacting the Angel Tax Credit in 2017 (Waller, 2018). This tax credit program offers a tax credit against Hall income tax for pre-qualified angel investment (Waller, 2018). The Hall income tax is the state's only income tax that is levied on interest and dividends from investment income (Waller, 2018). The legislature allocated \$3 million to the tax credit program in 2017 (Waller, 2018). About \$1.5 million in credits help spur over \$5 million dollars in investment (Waller, 2018). Interestingly, 30 percent of the investors who used the tax credit had not made an investment in the last several years (Waller, 2018).

Washington

Like the other states, Washington state has provided biotechnology companies tax incentives. The most notable tax incentive was a biotechnology & medical device manufacturing sales & use tax

deferral/waiver. In order for biotech companies to apply for this tax waiver, they had to file an application and have that application approved before they were issued a building permit (Department of Revenue, n.d.). Biotech businesses were also required to file an annual tax performance report the year after their project was certified (Department of Revenue, n.d.). Additionally, companies had to file these tax reports for the next seven years (Department of Revenue, n.d.). They also had to maintain a qualified activity at the site of the investment project during that time span (Department of Revenue, n.d.). Sadly, the tax waiver expired in 2017 (Department of Revenue, n.d.). As is the case with the other states, Washington also provided start-up biotech companies with funding. The Life Science Discovery Fund was established in 2005 and was a key source of funding for early-stage biotech and biomedical companies in Washington (Garnick, 2015). Unfortunately, lawmakers eliminated funding for the fund when they passed a budget in 2015 (Garnick, 2015). The end of the fund halted the progress made by early biotech startups in acquiring venture capital funding. In a report published by the Washington Department of Commerce, from 2012 to 2015, Washington state was outpacing the rest of the country when it came to venture capital investment (Commerce Dept, 2016). In the meantime, Life Science Washington, the independent organization who lobbies to the state legislative on behalf of the biotech industry, has been providing biotech companies with information on national grants that they can apply for. One of the grants that organization highlights is the National Institutes of Health (NIH)'s SBIR\STTR Niche Assessment Program grant.

Research Universities

Florida

Florida has made a long-term aggressive commitment to creating a biotechnology cluster within the state. By 2015, the state had invested hundreds of millions of dollars over a decade to grow the segment. The intent is to create a biotechnology cluster, modeled after the cluster in San Diego, CA where the presence of a significant number of high-profile institutes including Scripps, has resulted in the third-largest biotechnology cluster in the nation. Analysis and reports by Battele (2012) and the Sun-Sentinal (Pounds, Marcia H. 2015) indicate frustration with the lack of progress after having made such investments. Despite the lack of return on state incentive for firms to locate in Florida, there have been some mixed successes. For instance, the University of Florida has an Innovation Hub that helps support startup biotech companies whose developed technologies in laboratories at the university (Clearinghouse, n.d.). The school also has the Sid Martin Biotechnology Incubator which is located in Alachua, Florida. This incubator provides specialized facilities and business support to startup companies (Clearinghouse, n.d.).

Florida is now home to more than 1,100 biotech, pharmaceutical, and medical device companies. According to BioFlorida, a membership organization for the state's life science industry, Florida is in the top quintile nationwide for total bioscience industry establishments and there were over 4,000 bioscience and related patents issued within the state between 2009 and 2013.

North Carolina

The homegrown startups are centered around the state's research universities. In North Carolina, most biotech research development clusters are near the state's large research institutions (Easley Jr., 2011). This is important because most biotech startups tend to cluster near the scientists who developed their products and these scientists are typically employed by the research institutions. When the biotechnology industry started growing, the North Carolina Biotechnology Center launched a faculty recruitment program. The faculty recruitment program was launched in 1987 as an annual legislative appropriation to attract star research faculty to the public and private North Carolina universities (Easley Jr., 2011). The program has been very beneficial. The North Carolina Biotechnology Center reports that since 2005, the National Institute of Health has awarded North Carolina \$1 billion annually (NCBIOTECH, 2018).

Tennessee

Tennessee has set up a network of accelerators across the state that are linked together (Life Science Tennessee, 2014). These accelerators allow mentors and investors to network with each other. The accelerators play an important role in attracting entrepreneurs to the state and provides support to local biotech companies (Life Science Tennessee, 2014). The accelerators are also an important vetting tool for new companies and ensuring that venture capital funding is used efficiently (Life Science Tennessee, 2014). The Additionally, colleges like the University of Tennessee and Tennessee have set up a network of stations and extensions services across that state to assist developing agricultural startup companies (Life Science Tennessee, 2014).

Washington

The state of Washington has committed resources to help the state's research universities. Last year, the University of Washington opened the doors to a new \$171 million Life Sciences Building (Holtz, 2018). The university built the new life sciences building due to the demand in biology doubling over the last decade (Holtz, 2018). Over 1,200 students major in biology (Holtz, 2018). It is the most popular STEM major in Washington state (Holtz, 2018). In terms of research, the Washington Department of Commerce reported that the state's life science and global health academic research funding grew by ten percent between 2012 and 2014 (Commerce Dept., 2016). Prior to budgetary cuts, the Life Sciences Discovery Fund played an integral

role in supporting support innovative research & development at the state’s research universities. The fund provided 112 grants to research universities worth \$106 million and helped 40 biotech startups take shape or expand (Garnick, 2015).

Workforce Development

Florida

There is significant frustration in finding qualified R&D employees in Florida. There is a desire to see more talent coming from local universities and training in shepherding new drugs through trial and the approval process. Another frustration is creating an educational system to develop human capital. Interviews of biotech executives by the Sun-Sentinel’s Marcia Heroux Pounds in an article “Push is on to expand area’s biotech workforce” September 4, 2015 reveal revealed frustrations with making unwise public investments on relocation incentives without addressing human capital development needs. The University of Florida has been working hard to try to close the readiness gap. In 2006, they launched the Biotility program. The Biotility program partners with biotech industry leaders to identify current training requirements (Biotility, n.d.). The program offers short courses for professionals and students seeking to expand or deepen their knowledge in technical and regulatory details unique to biotechnology industries (Biotility, n.d.).

North Carolina

North Carolina has also developed a general economic development strategy that focuses on three goals: quality job creation, the development of economically distressed areas, and maintaining economic competitiveness in global markets (Easley Jr., 2011). This economic development strategy for the biotechnology industry consists of supporting homegrown biotech startups and recruiting established companies to the region (Easley Jr., 2011). North Carolina prepares their biotechnology workforce by providing worker training programs. The most recognizable worker training program is NCBioImpact. NCBioImpact is a public-private partnership that trains workers of all backgrounds for biomanufacturing jobs (Easley Jr., 2011). The program is funded by the state of North Carolina, the Golden LEAF Foundation, the North Carolina Biotechnology Center, and the biotech industry (Easley Jr., 2011). The program was launched in 2003 when the Golden LEAF Foundation provided a \$69 million grant (Easley Jr., 2011). The program provides introductory courses, firm-specific customized training, and a 2-year associate degree in applied biotechnology (Easley Jr., 2011). North Carolina’s community colleges help prepare new biotech workers by offering biotech courses (Easley Jr., 2011). Additionally, there are seven centers that train in specific areas like bioprocessing, pharmaceuticals, and bio-agriculture. The state’s community colleges also work with North

Carolina Department of Commerce to develop tailor-made training for biotech companies targeted for recruitment or expansion (Easley Jr., 2011).

Tennessee

The state provides grants to companies to help them develop their workforce. One grant program launched by the state is the Incumbent Worker Training grant. This grant provides funding to businesses to help them provide skills upgrades and process improvement training for existing employees. The goal of this grant program is enable businesses to retain their existing employees. On-the Job Training is another grant program that will pay up for the cost of an employee to receive training for a position they have no prior experience in. Tennessee stands out from the other states (including Georgia) in this area primarily because they have smaller biotechnology organizations in cities offering training. For instance, in Memphis, Memphis BioWorks has a Ready to Work Training Program. This program offers free job training and career placement assistance to residents who live in the Mid-South region of the state and are interested in high-growth careers in bioscience (Memphis Bioworks, n.d.).

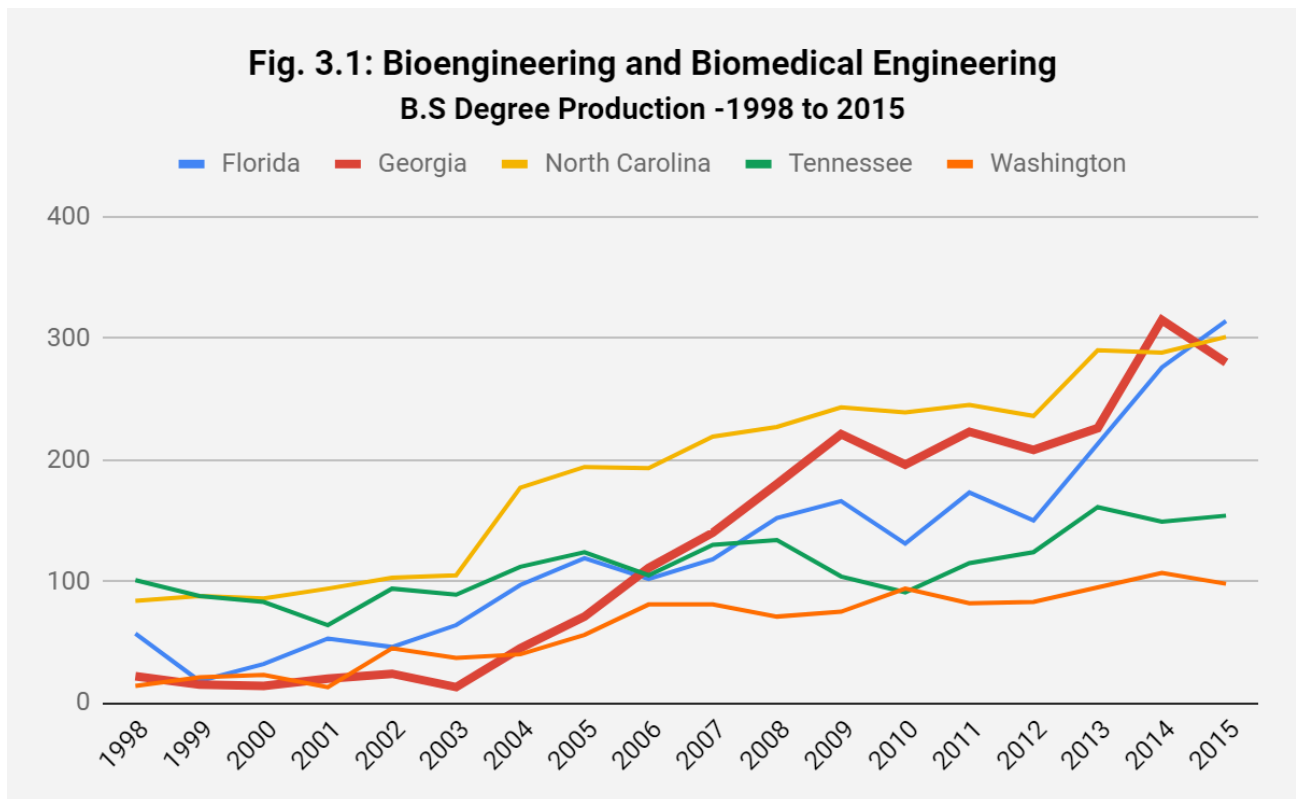
Washington

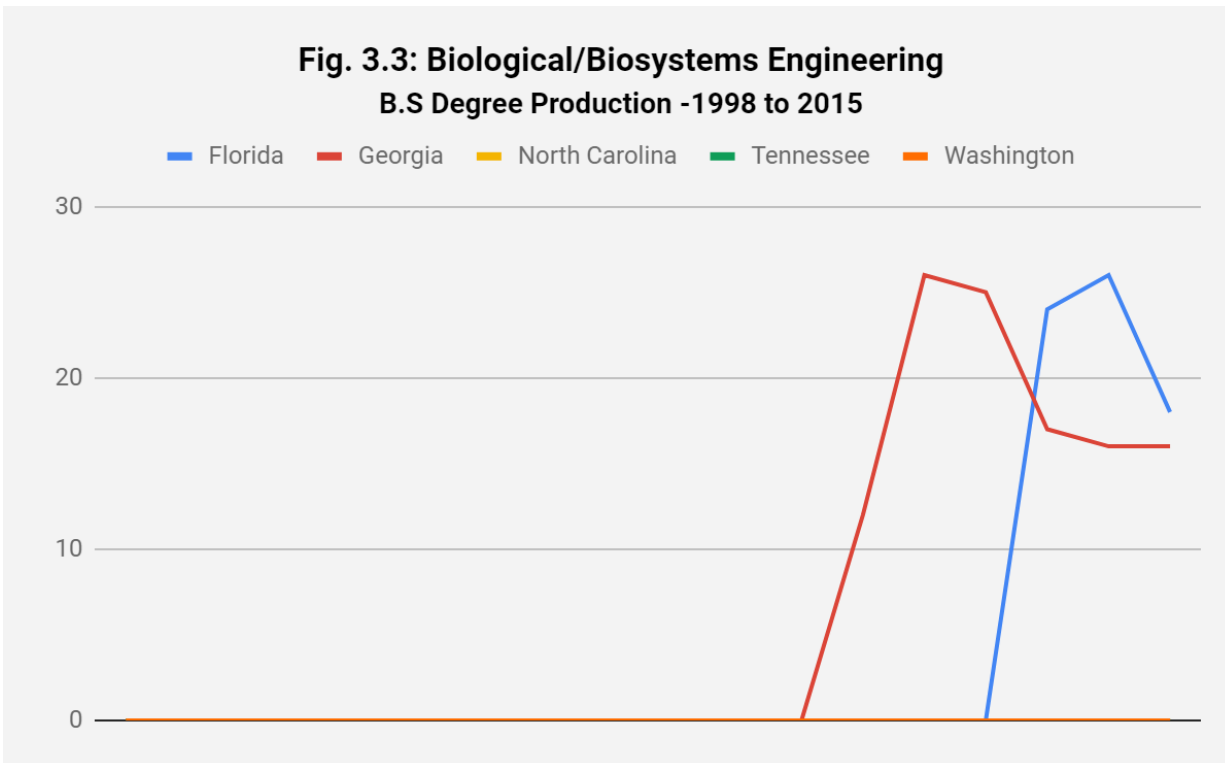
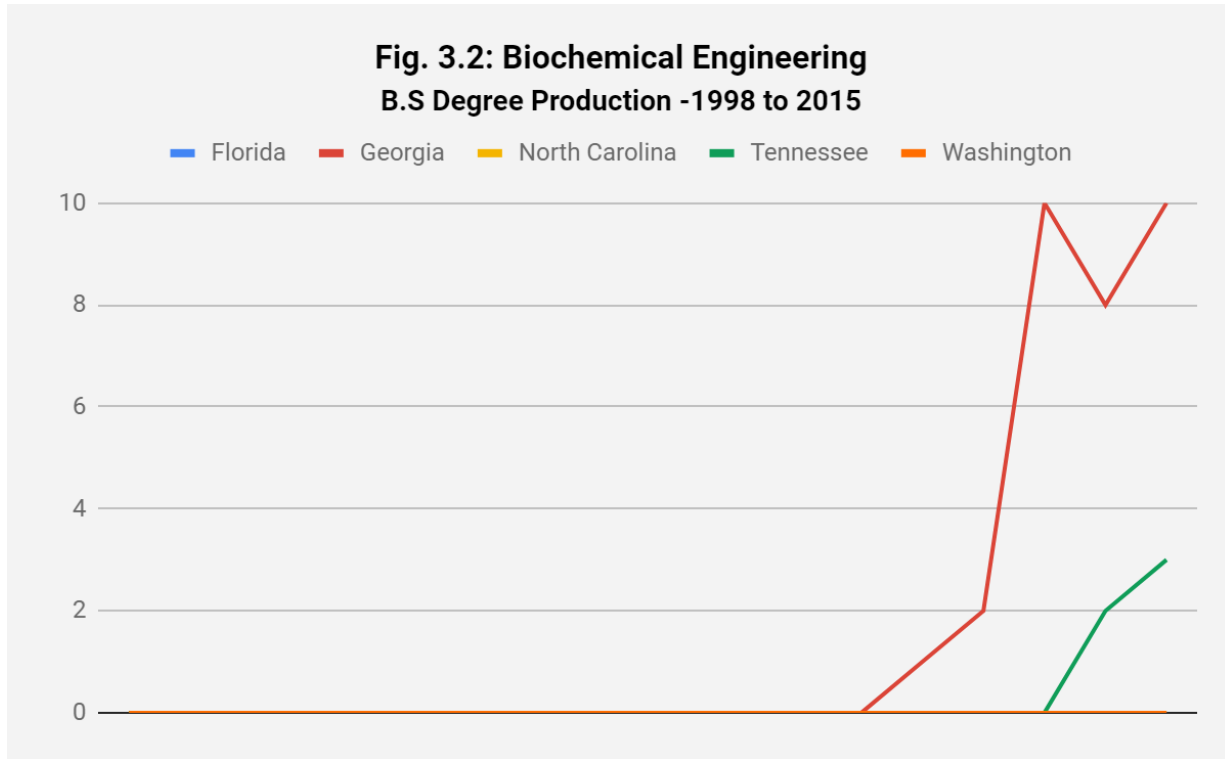
Despite growth in the biotechnology industry, the state of Washington is currently devising a workforce development plan. In 2016, Governor Jay Inslee commissioned a study to examine the industry. The critical information that resulted was surrounding the issue of workforce development. What skills will be needed? How does the workforce development challenge get answered? The report suggested that companies are making decisions about location, and expansion based on whether Washington can develop the workforce needed. The critical issue to be answered by the Governor's reports is how the K-20 workforce is to be developed. Workforce development was identified as a significant risk factor to continued success and growth of the Washington economy.

Washington State University has partnered with the National Institute of Health to develop the NIH Protein Biotechnology Training Program. This program offers state-of-the art training in basic science relevant to biotechnology and educates students in the applied aspects of biotechnology (NIH Protein Protein Biotechnology program, n.d.). Students who enter the program are admitted for graduate studies through one of the school's participating academic units (NIH Protein Protein Biotechnology program, n.d.). Students are then nominated for a traineeship (NIH Protein Protein Biotechnology program, n.d.). Trainee positions supported by a grant provided by the National Institute of Medical Sciences (NIH Protein Protein Biotechnology program, n.d.).

B.S. Degree Conferral in Selected States

The production of B.S. degrees in the relatively new engineering fields of Bioengineering and Biomedical Engineering, Biochemical Engineering, Biological/Biosystems Engineering, was examined. The states of Florida, Tennessee, Washington, and North Carolina was compared with Georgia. Georgia's Bioengineering and Biomedical Engineering programs started to significantly increase output in 2003 and until recently has slightly outpaced the comparison states. The Biochemical Engineering and the Biological/Biosystems Engineering programs are much smaller but are significant producers.





Note the change in vertical scale from relative to Fig. 3.1

KEY TAKEAWAYS: STATE COMPARISONS

Financing and Tax Incentives

- Each state uses a different set of incentives to grow their respective biotech industry
- NC prefer grants, funds, and loans; TN also relies on funds and loans
- FL relies on grants but use tax credits attract companies
- Venture capital is crucial to growing biotech industry in each state

Technical Colleges and Universities

- The formation of incubators plays a crucial role in start-up biotech firms securing the necessary capital to grow their businesses

Workforce Development

- Firms are reluctant to make investments in states that have weak workforce development initiatives

IV. INDUSTRY EVALUATION

Interviews with Industry Personnel

To understand the biotechnology industry in Georgia, a total of 15 qualitative interviews with key hiring managers and biotechnology educators in the state were conducted from March 2 - 13, 2019. Specific questions were asked to interview respondents in regard to biotechnology workforce needs, qualification requirements, industry demographics, and the reason these firms were attracted to Georgia. The intent of these interviews was to answer the following questions (Reference Appendix B for the full set of interview questions):

- What are the demographics of the current biotechnology workforce in Georgia?
- What are the workforce challenges that biotechnology firms in Georgia face?
- Are there specific opportunities or challenges for Georgia to support a workforce for emerging areas of biotechnology (e.g. cell manufacturing)?

The purpose of answering these questions was to find industry trends that exist among biotechnology firms in Georgia. The goal of these interview questions was to understand industry needs and challenges. The interview process was conducted through the narrative research approach. Interviews were conducted via phone and detailed notes were transcribed throughout the interview to ensure accuracy of the participants information.

Industry Personnel Selection

Correspondence between interviewers and interviewees was first initiated by email. A total of 33 industry personnel were contacted from the client's contact database throughout the duration of the study. Response rates were limited. In addition, the given time frame for the study limited the number of individuals contacted. Once the respondents confirmed their willingness to participate in a 30- to 60-minute dialogue, interviewers contacted them via phone to conduct the interview. A wide variety of interview respondents were represented from various positions and companies within the industry. The following respondents were interviewed: human resource managers, research and development directors, manufacturing directors, talent directors, program managers and safety officers, lab managers, medical communications directors, validation managers, regulatory affairs and quality assurance directors, and government affairs directors.

Interview Analysis

Industry personnel expressed that many variables attracted their companies to Georgia. The anticipated university relationships, partnerships, and support from local municipalities, connections to a broad range of expertise from a variety of life science and engineering disciplines, and the state capital's strong bioscience workforce made Georgia an appealing state to start a biotechnology firm. Moreover, access to a major airport for transportation needs, the state's strong pharmaceutical and public health presence, and the ability to purchase inexpensive land were also factors that attracted their companies to Georgia. Industry personnel stated that the current age demographic for biotech employees in Georgia ranges from approximately 20 - 60 years-of-age. They also mentioned that the gender demographic is roughly half-and-half for the male to female ratio for the majority of the biotech-related positions. However, the field of medical writing is skewed more towards males. Also, the regulatory affairs field is skewed more towards females.

In regard to ethnicity, biotech employees were reported to be disproportionately Caucasian. A majority of the industry respondents mentioned they had vacant biotech-related positions available in their companies. Moreover, many of the industry personnel interviewed stated that their company had plans to increase either their technician or technologist positions over the next few years. Based on interview responses, it takes approximately 1 - 6 months to complete the hiring process for jobs in biotechnology or life sciences (Table 4.1). Hiring for entry-level positions usually takes less time in comparison to senior level positions. There are, however, some exceptions, where the process can proceed to roughly six months. Many respondents stated that when positions require more experience and specialized expertise, they took longer to fill. A senior level engineer or manufacturing manager may take between three and six months to fill. Many companies expressed that they used a professional recruiter to fill these positions.

Table 4.1: Timeframe to Hire

Time to Hire	Number of Respondents	Percent of Total Respondents
<1 Month	2	13.3%
1 - 3 Months	6	40%
4 - 6 months	6	40%
No response	1	6.7%

For the most part, industry personnel felt that certifications for biotech-related positions were considered to be a preference rather than a requirement. However, some respondents mentioned that certification requirements were dependent on the job. Industry staff seemed to prefer certifications for regulatory affairs positions. Many personnel also listed Six Sigma as a preferred certification. Industry respondents also mentioned that the preferred or required education level for their employees is dependent upon the position level. For example, technicians are usually required to either have a High School Diploma, GED, or associate degree. Whereas people hired for quality control, quality assurance, and engineering positions need to have completed secondary education in a STEM discipline. In terms of recruiting, the majority of the industry employees mentioned that they only use external recruiters for extremely specialized positions. Aside from more specialized positions, most companies have internal recruiting teams to seek out local talent.

During the hiring process, industry personnel stated that their potential job candidates expressed interest in positions that give them the opportunity to grow in their careers, supply adequate work-life balance, provide employment stability and flexibility, offer generous benefit packages and income, and supply intellectual stimulation. Respondents also stated that potential candidates had expressed their desire to help people and contribute to patients' overall health and wellbeing.

When hiring new candidates, industry personnel stated that they are looking for job candidates who possess the following characteristics: integrity, kindness, strong work ethic, and teachability. Industry employers mentioned that they are seeking individuals who have strong critical thinking and analysis skills, can self-start and problem solve, can work with multidisciplinary teams, and are willing to learn continuously. They should also be adept in the subject matter they plan to work with.

The biotechnology and life sciences industry are complex and rapidly evolving. Although the sector holds excellent commercial and societal promise, it is also filled with many challenges and risks. Respondents had mixed responses in regard to the opportunities and challenges that the Georgia biotechnology industry faces. However, many common themes emerged from the human resource, talent acquisition, and direct supervisory personnel.

Challenges

Human Resources and Talent Partners

Human resource (HR) and talent personnel expressed concern with recruiting local talent. Many respondents stated the majority of the biotechnology companies are not located in the South, aside from the Research Triangle situated in North Carolina. Therefore, companies in Georgia find themselves "buying talent"

from the Northeastern and Western states instead of growing it locally. Notably, respondents also mentioned that they tend to have trouble hiring individuals who have medical or research and development expertise, marketing and business skills, and regulatory skills.

A majority of the respondents reported that the frequency of staff turnover depends on position type and individual life circumstances. The HR respondents stated that, overall, bio-life science employee retention rates are average or below average at their companies. However, some of the respondents stated that there is higher than average turnover rates in their companies for individuals who work as pharmaceutical sales representatives. Many of the respondents acknowledged that it can be difficult for individuals to find biotechnology or life science-related jobs in Georgia. Therefore, respondents reported that once individuals do secure a position at their companies, they usually do not leave. When workforce reduction does occur, it is generally due to sickness, poor market conditions, interests in promotions that are unattainable, retirement, or relocation for family reasons. Individuals also leave positions that are not permanent. Selective biotech employees are brought on for "start-up" and temporary jobs and move on once the project is complete to find a more secure position. However, overall, employment retention was reported to be better for companies that offered comprehensive benefit packages.

Also, HR and talent personnel highlighted concerns around hiring individuals that are either overqualified or underqualified for biotech-related positions. The magnitude of the issue is mainly contingent upon the type of job. However, respondents mentioned that it is common for individuals applying for managerial roles to be overqualified for positions. This is because individuals often downsize roles when the job market is weak, and companies tend to look for candidates who can occupy positions within the next two levels. Georgia is also not as established in comparison to other states in the Northeast and Western regions. Therefore, it is not uncommon for biotechnology companies throughout the country to hire local candidates that are underqualified. Moreover, many candidates apply for front-line supervisor roles but do not have the proper educational qualification requirements to satisfy the position.

From a human resources perspective, respondents stated that any legislation that seeks to mandate benefits and pay rates will always be problematic for biotechnology companies. Moreover, when legislative guidance related to mandatory training requirements and overtime is not consistent across states, it can be difficult for companies to streamline complexities around employee relations. Additionally, in the pharmaceutical industry, discussions relating to marijuana legislation are also concerning to biotech companies from an occupational safety perspective. Personnel mentioned that marijuana policies raise safety issue concerns in the event of potential employee impairment. Some HR respondents also indicated that public perception of biotechnology companies could be a barrier to biotechnology companies in addition to legislative

acts. The demonization of "Big Pharma" from news media paints a poor public image and can cause losses for the company.

Moreover, respondents expressed concerns related to education and training preparation from higher-education life science and engineering programs in Georgia. Many life science degree programs provide students with robust technical skills. However, they don't equip recent graduates with the proper interpersonal skills needed to work successfully in a corporate environment. Recent graduates and interns usually understand essential job functions and have the appropriate technical skills to be successful in industry positions. However, frequently, they enter into the biotech industry lacking the proper communication and technical writing skills necessary to satisfy many of the biotech-related positions.

Lastly, interviewees reported that recent graduates could not often work in diverse teams cross-collaboratively to accomplish industry projects. HR personnel stated that conversations with recent graduates related to business etiquette are often needed. Respondents also emphasized that academia seems to focus specifically on medical devices and R&D opportunities. Yet, the manufacturing arm of biotechnology is not as much of a focus in the academic setting as it should be. As a result, students are apprehensive about applying for manufacturing-related positions that they view to be more "mundane" or "laborious." For example, HR personnel reported that recent graduates, especially from engineering disciplines, were frequently unwilling to consider jobs in manufacturing. Selective engineering graduates are reluctant to take on positions that do not have "engineering" explicitly listed in the position title.

Directors, Managers, and Direct Supervisors

Similar to HR personnel, managerial personnel have mixed feelings towards recent college life science graduates. Direct supervisors, specifically manufacturing, program managers, and safety officers, seemed to be reasonably pleased with the talent coming from life science university programs such as the University of Georgia (UGA), Georgia Tech (GT), Emory, and Georgia State University (GSU). However, similar to the HR and talent personnel's statements, managers and direct supervisors expressed concerns about hiring local talent for more specific and specialized positions. One of the respondents specifically mentioned that Georgia did not have enough talented biotech workers, nor enough biotech firms compared to New Jersey, New York, or California. For example, respondents said they often need to recruit outside of Georgia for regulatory affairs, quality management, and clinical positions.

Compared to HR and talent personnel, managerial personnel had mixed responses in regard to issues with retention rates. They expressed that although they sometimes find it difficult to retain quality employees at lower-level manufacturing and laboratory entry-level positions, retention rates are still not as much of a problem as recruitment. Many individuals in the biotechnology and life sciences space are very dedicated and

driven to their line of work. Therefore, they are continually seeking meaningful work that provides work-life balance, flexibility, security, and financial stability. The majority of the interviewees reported that their companies are very responsive to these employee values, which limits attrition rates altogether. Also, they acknowledged that certain industry positions, such as medical technical writers, receive substantially higher pay than most academic jobs. As a result, employees don't frequently leave industry to enter into academia. They did mention, however, that when employees go, it usually is because they wish to transfer from manufacturing positions to R&D positions.

Additionally, direct supervisors reported that the majority of the candidates interviewing for positions are underqualified. Therefore, they stated that they have to take the time to train and educate new employees on company protocols and procedures. Direct supervisors often do not have the luxury of taking extended periods to ensure a candidate can perform at the anticipated level. Managerial staff also mentioned that candidates with limited experience tend to apply for more senior-level roles in which they do not qualify. Many of the individuals applying for entry-level postings are underqualified, specifically recent college graduates who do not have a lot of work experience. Managers and direct supervisors have reported that many of the entry level engineers that apply to their positions are under-qualified in terms of industry experience. Most biotechnology companies are looking for individuals with bachelor's or master's and three years of experience for entry-level positions. Respondents have mentioned that college graduates are unfamiliar with the medical device process. Most graduates are familiar with medical device design from their coursework, but lack understanding in terms of development, testing, troubleshooting, and complying with FDA regulations.

Furthermore, college graduates are not familiar with the latest medical devices in the industry nor who is developing these devices. One of the questions respondents were asked was, "If you could tell a college department what you want from a recent college graduate, what would it be?" Most respondents stated that they are looking for strong technical knowledge, which should be their foundation, but are also looking for candidates with strong soft skills. Respondents indicated they look for candidates that have experience working on a team, have strong interpersonal skills, strong negotiation skills, and understand team dynamics. Most candidates lack the industry experience that develops not only students' understanding of the latest technology, but also soft professional skills.

Managerial staff also expressed concerns related to education and training preparation from higher-education life science and engineering programs in Georgia. They acknowledged that students gain valuable training from graduate programs, such as the proper technical and laboratory skills, the ability to read detailed research, and the ability to report findings to various audiences. Respondents expressed that undergraduate programs, however, do not prepare students as much as they would like. Several respondents expressed that

undergraduate students did not have sufficient laboratory skills or medical device knowledge to perform the necessary functions of their work. Respondents also mentioned that both graduate and undergraduate students are ill-prepared when it comes to their regulatory affairs, six-sigma, and financial skill sets. Recent graduates often lack the softer skills needed to manage difficult clients and work in a business setting. In addition, directors stated that academic curricula in life science graduate programs are theoretical and technical. However, higher education in the life sciences lacks application. Recent graduates do not receive the proper applied training. As a result, industry personnel have to spend an immense amount of time training them. Direct supervisors voiced that spending industry resources on training interns is not necessarily a beneficial long-term investment, mainly because interns who are hired at biotechnology companies do not always stay there. They may find jobs at different companies and transfer intellectual property with them. Moreover, recent graduate students fall short when it comes to their ability to tell a "compelling" scientific story. Respondents emphasized that it is not enough for employees to solely regurgitate scientific information or findings. The information must be synthesized into everyday language and presented in an engaging format that appeals to various audiences.

Opportunities

Human Resources and Talent Partners

Although there are many challenges for Georgia to support a workforce for emerging areas of biotechnology, there are also specific opportunities that can be addressed in terms of workforce, education, and training. As mentioned previously, project management and interpersonal skills are critical for recent life science graduates entering into the biotech industry space. Recent graduates need to have a fundamental background in the subject matter they are working with. However, they should also be willing to continuously learn, develop the critical thinking skills necessary to work in a regulated environment and connect with colleagues from diverse backgrounds. Academic institutions should continually emphasize the importance of internships and co-ops to help address gaps in students' industry skills. These project-based experiences will not only expand students' horizons, but they will also learn the necessary skills to work in a regulated environment successfully.

In terms of academia, respondents stated that degree programs place a hyper-focus on technical competencies and R&D; however, as reported previously, they seem to neglect to emphasize the importance of manufacturing, regulatory knowledge, interpersonal skills, business skills, negotiation skills, troubleshooting, and leadership skills. Academia should do more knowledge sharing to make sure manufacturing is appealing to students. They should also continue to require students to complete writing and communication classes to foster leadership, presentation, and writing skills needed to be successful in the industry sector. Interviewees

also emphasized that biotechnology companies need to start making their presence known in both primary and secondary schools, so students are aware of the industry from a very young age. This presence will foster potential interest in life science disciplines early on and will give children and students the ability to start building their institutional portfolio to align with company requirements. Moreover, biotechnology companies should make it a priority to broaden their net presence in and outside of rural areas throughout Georgia to recruit additional talent.

Finally, many HR staff reported that their companies offer generous benefit packages such as health, dental, compensation for commercial relocation costs, competitive 401K matching, maternity and paternity leave, and disability. However, fewer companies reported offering benefits outside of the traditional box, such as tuition reimbursement, college savings plans, and transportation reimbursement. For biotech companies to attract and retain a continual flow of adept and educated bioscience workers in the state of Georgia, they should consider offering generous and non-traditional benefit packages to employees to incentivize employees not to relocate. Transportation reimbursement benefits could be extremely beneficial for entry or lower-level biotech employees who work in rural locations.

Directors, Managers, and Direct Supervisors

Direct supervisors and managers suggested it might be useful to allow manufacturing employees to participate in assignments off-site to keep them in positions. If possible, individuals in manufacturing jobs should be encouraged to work on temporary detail at either international or domestic sister-plant locations. Giving employees the opportunity to work off-site energizes employees and gives them a newfound appreciation for their line of work. According to direct supervisors, individuals are more willing to stay in manufacturing positions if they continue to be intellectually challenged and stimulated.

Both human resource respondents and direct manager and supervisors expressed a positive sentiment concerning the growth of the biotechnology industry in Georgia. Positions at all levels from manufacturing, sales, clinical, quality control, research and development, and others are expected to grow in the upcoming years. Managerial personnel stated that Georgia has the potential to serve as the next great biotechnology "hub" in terms of innovation and development. To continue to foster growth throughout the state, Georgia legislators should look to thriving surrounding biotechnology state clusters throughout the nation for advice on how to attain rapid growth. The positive sentiment toward growth could be hindered if companies do not receive adequate funding for the right infrastructure. Companies could relocate to Northeastern regions if they don't receive the proper resources and government assistance in Georgia. Therefore, Georgia governments need to be engaged from the venture capital process to the manufacturing process. Selective state governments throughout the U.S. have done a great job of implementing effective financial subsidies, such as tax incentives

and state-sponsored incubators. Thus, managerial personnel acknowledge that Georgia should not try to "reinvent the wheel." Instead, legislatures should continue to invest in resources to evaluate effective financial subsidies used in surrounding biotechnology powerhouse states.

In regard to academic curricula, direct supervisors agreed with HR and talent acquisition personnel in the sense that institutions should continue to mandate that students fulfill specific writing, communication, and business course requirements. Moreover, directors specifically expressed it would be helpful if graduate programs would build in more flexibility to allow students to attend training and networking sessions outside of the university. Some of the biotechnology companies interviewed are already offering this assistance. According to Directors, academic faculty tend to train their graduates to fulfill research positions at universities. Faculty often focus their efforts on laboratory and research initiatives, while neglecting industry-led initiatives. Academic faculty should allow their graduate students the opportunity to leave laboratories early to seek out career development seminars and events to broaden their job prospects after graduation.

Finally, academic institutions should mandate that graduate students in life science programs fulfill either a fellowship, internship, or co-op as a graduation requirement. Direct supervisors stated that graduate students spend a fair amount of time conducting individual work, such as completing their theses and dissertations. These particular projects don't prepare students to work effectively in a cross-collaborative setting. Moreover, post-doc programs don't provide a solution to this problem, mainly because they still focus on basic academic research. If students are required to complete a fellowship or co-op at the graduate level, they will have the opportunity to gain practical training while they study.

Job Posting Analysis

Selection Criteria

To achieve a preliminary overview of the biotechnology workforce landscape in Georgia, we analyzed current job postings for biotechnology jobs in the state. This analysis aimed to assess current industry needs for workers in the biotechnology. More specifically, we were interested in finding trends in types of job listings and desired training and skill sets. A sample of 135 biotech-related job advertisements was collected from professional social networking and company websites to gather information about job titles, desired skills, and preferred training qualifications for Georgia biotechnology jobs. This portion of the research intended to answer the question, "What employee skills and qualifications do biotechnology industries in Georgia desire?"

For consistency, job advertisements were selected from only two professional social networking sites: LinkedIn and Indeed. To minimize biases and adhere to best standardization practices, the advertisements were

also chosen by using the following keyword strings: "biotechnology"; "biotechnology," & "agricultural technician"; "biotechnology," & "biomanufacturing," & "biopharmaceutical," & "bioengineering," & "biology."; and "biotechnology," & "agriculture." These search strings were selected based on the literature analysis with the intent to ensure all sub-industries were included. Job advertisements were also selected by filtering "Georgia" as the location of interest within networking and company sites. Job advertisements were chosen from the following locations: Greater Atlanta, Greater Athens area, Greater Augusta Area, Greater Columbus area, Greater Savannah area, and Greater Valdosta area. Jobs were also coded based on whether or not the companies had headquarters and local offices in Georgia, outside of Georgia (but still domestic), or internationally.

Advertisements were only chosen if they had been posted within four months of the search date to ensure relevancy. Furthermore, job postings were selected throughout the project to give the most accurate and up-to-date overview of vacant positions during the period of the study. Each selected posting, from both company websites and professional social networking sites, was collected between February 13–March 10, 2019. Finally, job advertisements pulled from professional social networking sites were cross-checked on the companies' official website to certify the postings were both legitimate and up-to-date.

Categorization of Job Openings

Job postings were captured electronically and manually categorized by job function, industry type, degree level, and skills and requirements using Google Forms, Google Sheets, and Microsoft Excel. The biotechnology industry was categorized into three sub-industries based on the results of the literature review: medical biotechnology, agricultural biotechnology, and industrial biotechnology. Advertisements were assigned to the medical biotechnology category if they were involved with the industrial and manufacturing sectors and processes to help identify, prevent, and treat human diseases. Advertisements were assigned to the agricultural biotechnology category if they were involved with improving plants, microorganisms, and animals to help enhance new crops and livestock. Lastly, advertisements were assigned to the industrial biotechnology category if they were involved with the use of biological resources to produce chemicals, materials, and energy required for the development of industrial goods.

Each employment opportunity was sorted into one of 8 categories based on job function. The job function categories were laboratory; manufacturing; general and administrative; legal and regulatory; clinical; sales and marketing; business; and engineering (Table B1). When possible, jobs were categorized based on their job title. When the function was not clear from the job title or description; however, categorization was completed based on further investigation of the posting on networking and company

The degree level category was divided into seven different subsets: Associates, Bachelors, Master of Science ("Master's"), Master in Business Administration (MBA), Doctorate, and high school diploma/General Education Diploma (GED). Associate, bachelors, and doctoral degrees were not defined and differentiated by degree type; however, "Masters" and "MBA" were delineated based on degree focus. Job postings were categorized into the "Masters" group if the position required a science, technology, engineering, and math (STEM) related degree. Conversely, advertisements were categorized into the "MBA" group if the position explicitly stated a degree requirement for a Master's in Business Administration. Postings were tagged multiple times if the job description had more open-ended degree requirements. For example, positions with job descriptions that included statements such as "bachelor's degree required; master's degree preferred," or "bachelor's degree with some years' experience, or master's degree with some years' experience" were counted twice for both the bachelor's and master's subsets. The categorization process also allowed for descriptive coding in the "Certification/other" subset. Therefore, specific certification names were recorded to provide more detailed information for the degree requirement portion of the analysis.

Skills and requirements was divided into 12 broad categories: communication and writing skills; legal and regulatory skills; computer and technical literacy skills; production (engineering or laboratory) skills; statistical analysis skills; teamwork and customer service skills; problem solving and self-starting skills; business and marketing skills; quality assurance skills; education and training skills; leadership and management skills; and manual labor dexterity skills (Table B1). This portion of the coding process also allowed for multiple assignments, so various skill sets were tagged for each job post accordingly.

Results

Industry Profile

Sub-Industries, Job Functions, and Company Location

As mentioned previously, job openings were classified by industry types. The postings were divided into medical, agricultural, and industrial biotechnology sub-industries. Of the total job postings ($n=135$), 105 postings were medical, 28 were agricultural, 3 were industrial, and 3 were unknown (Fig. 4.1). The data shows that medical biotechnology comprised the majority of the job openings. These figures seem to be representative of and consistent with Georgia's current biotechnology workforce. Both agricultural and industrial industries comprised the minority of the job openings. Job openings were also classified by the primary function of the position (refer back to Table B1 in Appendix B for a detailed explanation of function categorizations). Jobs with multiple functions were coded for every relevant function, resulting in some job

postings being double or triple coded. A breakdown of job postings by function is displayed in Figure 4.2. Results show there was an even spread across job functions.

Fig. 4.1: Total Job Postings by Sub-Industry

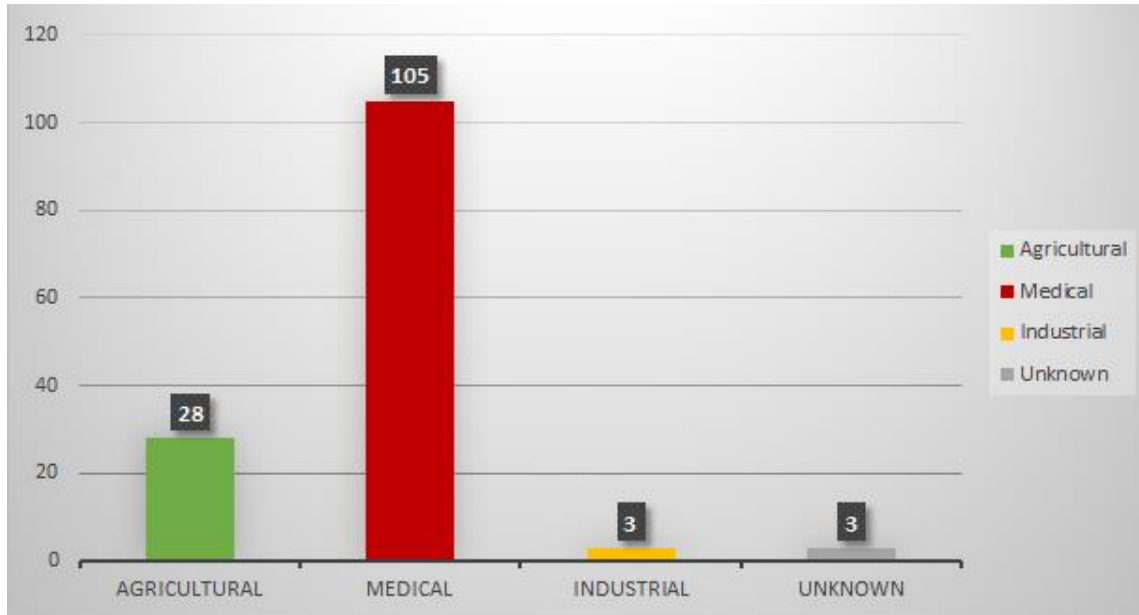
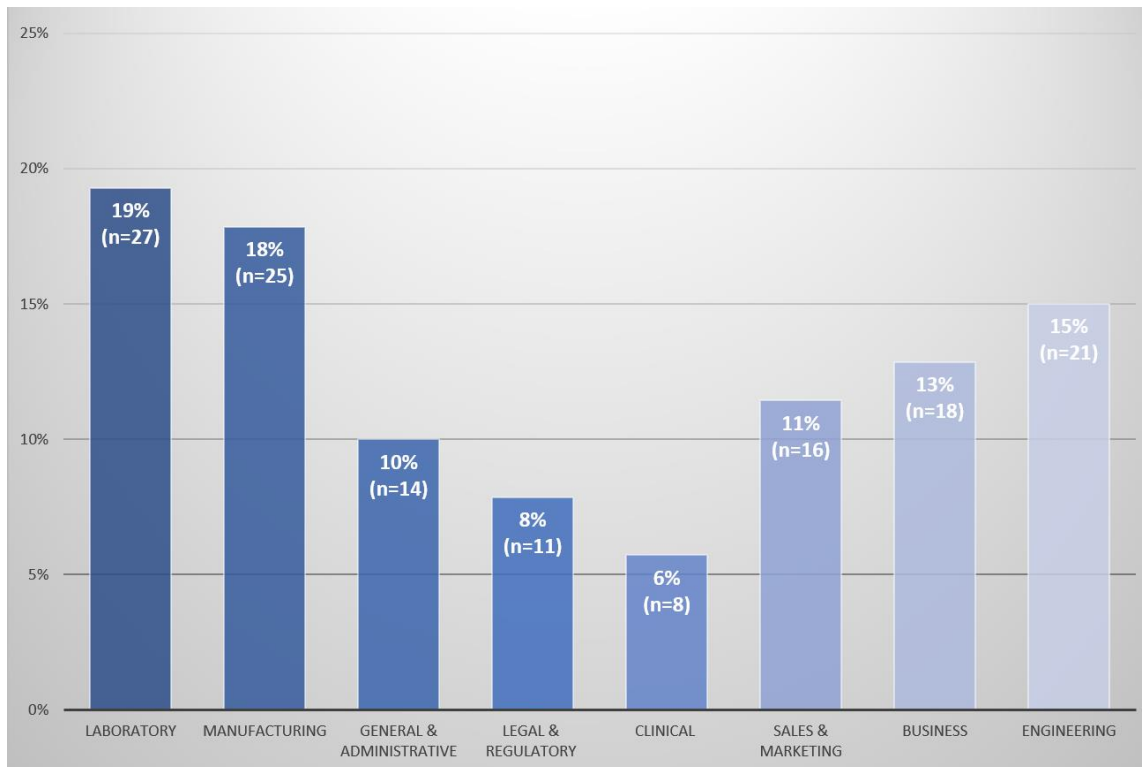
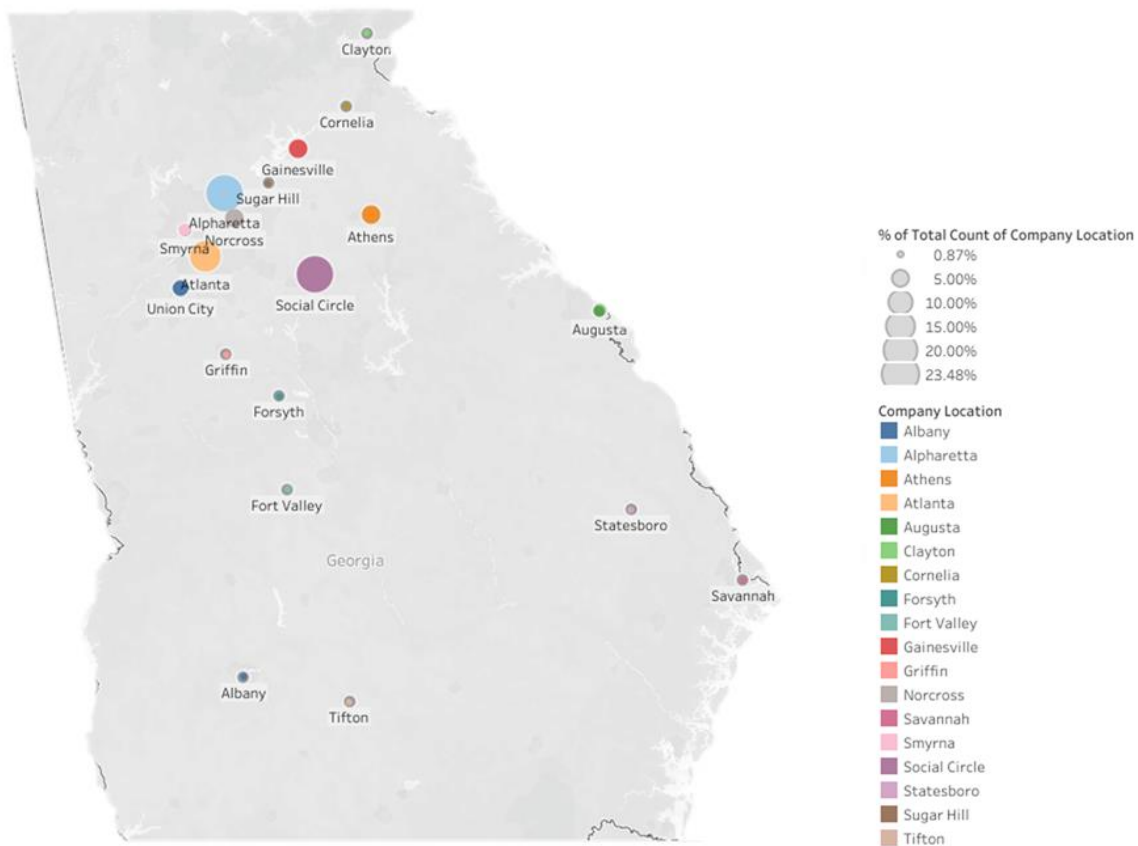


Fig. 4.2: Percent of Total Job Postings by Job Function



Job posts were classified by the location identified on the job ad and mapped (Fig. 4.3). Of the 135 postings most were found in Alpharetta (21%), Social Circle (21%), Atlanta (15%), Athens (5%), Gainesville (5%), and Norcross (5 %). Of the 135 posts 5 % were unknown. All other cities were identified in less than 5% of the job posts. Detailed percentages by city are broken down in the Appendix B, Table B2.

Fig. 4.3: Total Job Postings by City



We also identified the location of each biotechnology companies' headquarters. As demonstrated in Figure 4, most of the biotechnology companies were located in Georgia. International companies make up 33% of the biotechnology industry in Georgia. Twenty-three percent (23%) of the companies we surveyed are headquartered in other states across the United States. Last, we were unable to identify 1% of the biotechnology company sample (Fig. 4.4). To gain further insight, the set of job postings with Georgia-headquartered companies was also broken down by sub-industry. Of the 135 total companies in our job search that had Georgia headquarters, 75% were in the medical biotech industry and 20% were in the agricultural industry, and 2% were in the industrial industry (Fig. 4.5).

Fig. 4.4: Location of Headquarters

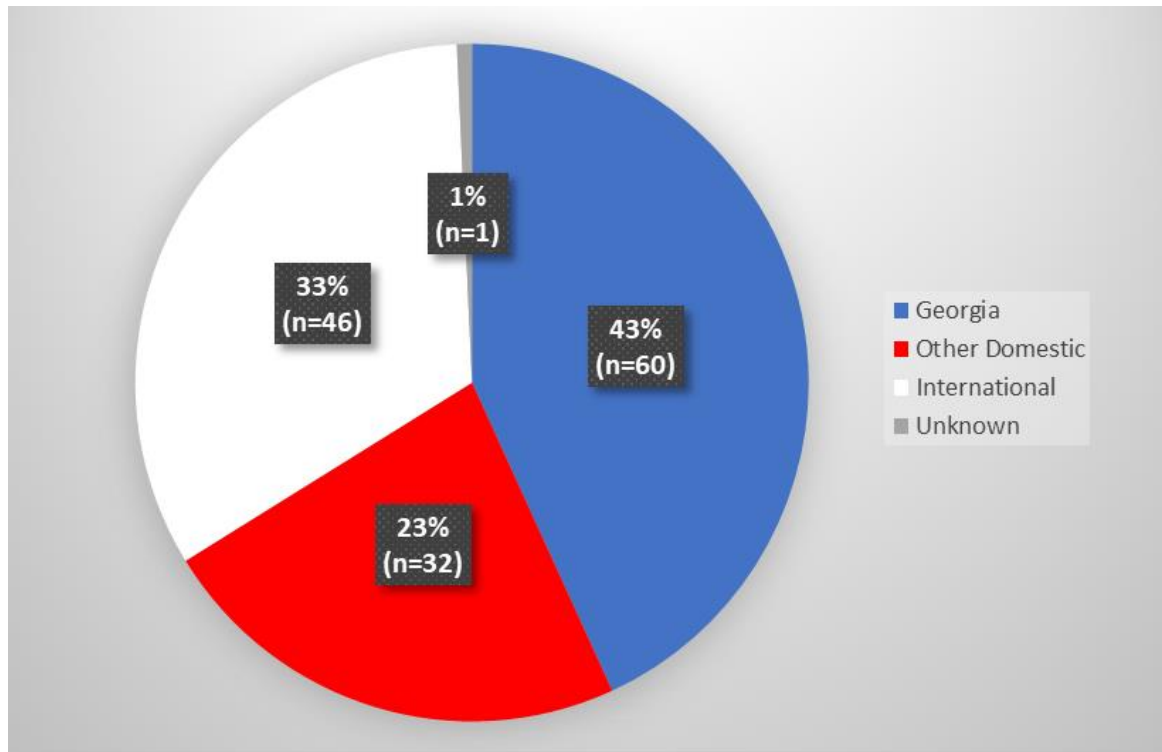
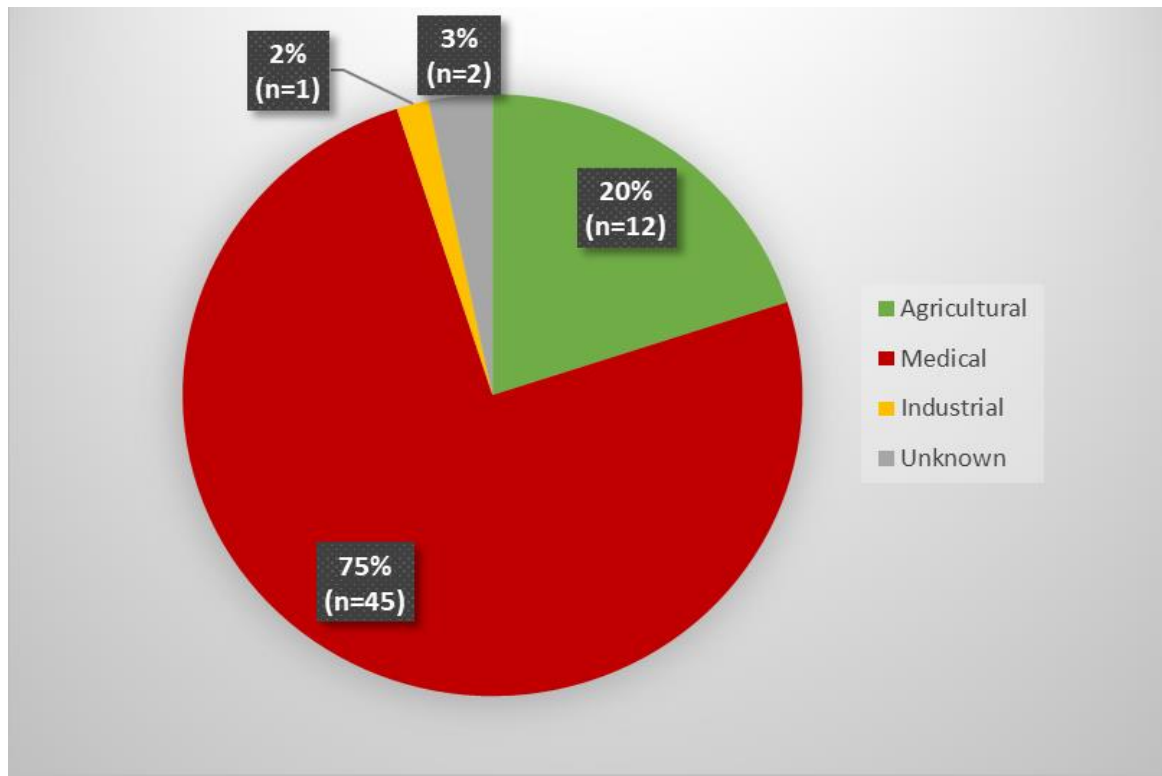
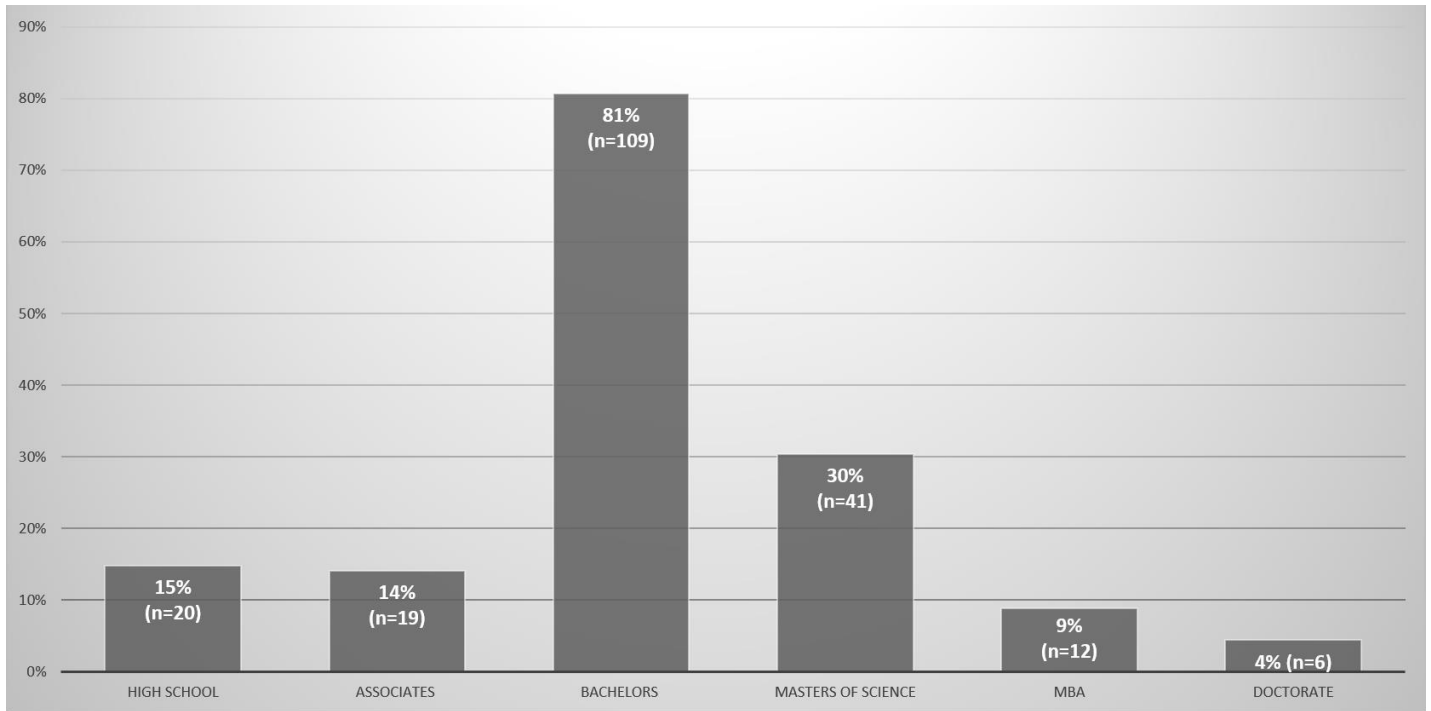


Fig. 4.5: Companies with Georgia HQs by Sub-Industry



Desired Degree Level

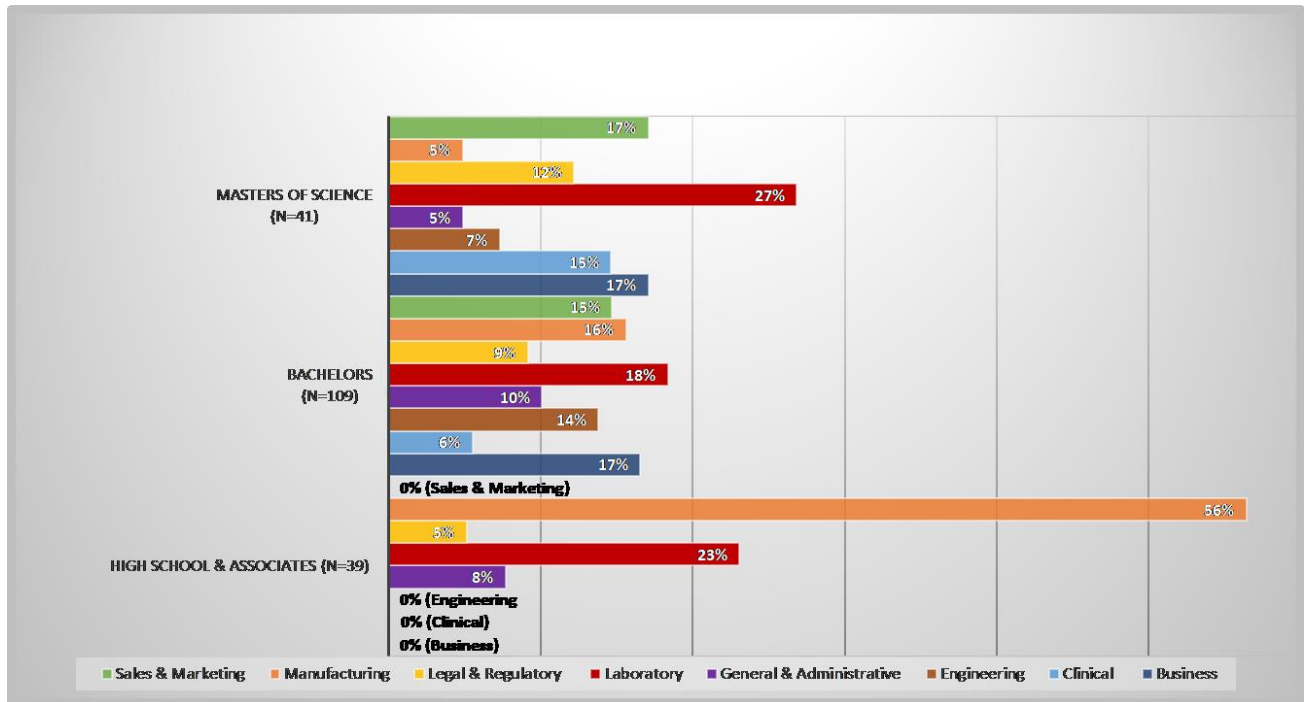
Fig. 4.6: Percent of Total Job Postings by Desired Degree Level



As mentioned previously, the job openings were collected and categorized based on degree type. Job openings were classified based on the desired degree level listed within each posting. Of the total sample of job postings ($n = 135$), 81% desired a bachelor's degree, 30% required a Master of Science degree, 14% desired an associate's degree or high school diploma/GED, 9% required a Master of Business Administration (MBA), and 4 % desired a Doctorate degree (Fig. 4.6). The desire for a bachelor's degree compromised the majority of the job postings, where the desire for doctorate degrees represented the minority of the postings. More listings indicated that candidates should have a Master of Science degree than an MBA degree.

Master of Science

We identified 41 job openings that required or preferred a Master of Science degree in a STEM field. This sample size was above 30, which indicates that it is more representative sample. The top job functions of those openings requiring, or preferring MS degrees was laboratory jobs (27%). The second and third highest job functions were business (17%) and sales and marketing (17%). The lowest job functions requiring MS degrees were engineering (7%), general and administrative (5%), and manufacturing (5%) (Fig. 4.7).

Fig. 4.7: Job Function by Degree Level

Bachelors

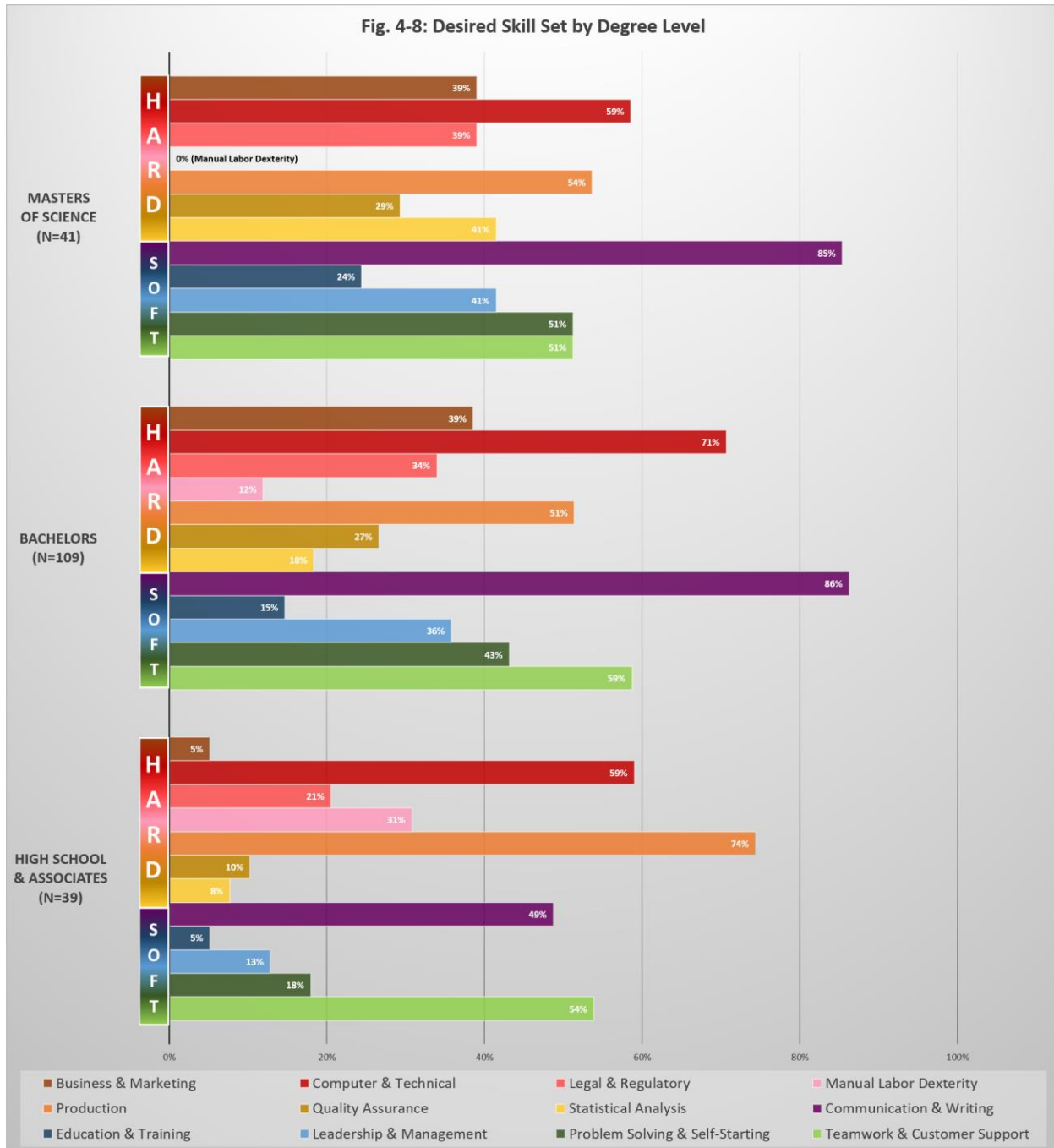
There were 109 job openings that required or preferred a bachelor's degree which amounted to 81% of all listings (Fig. 4.6). This sample was the largest out of all of the degree categories classified. Of the total job postings classified as desiring a bachelor's degree, the top three job functions categorized were Laboratory (18%), Business (17%), and Manufacturing (16%) (Fig. 4.7). The bottom three job functions were Clinical (6%), Legal and Regulatory (9%), and General and Administrative (10%) (Fig. 4.6). A diverse range of skill sets were reported for job postings that desired a bachelor's degree (Fig. 4.8). From our job search, the top three job skills recorded were communication and writing (86%), computer and technical (71%), and teamwork and customer support (58%). The bottom three skill sets reported were for manual labor and dexterity (12%), education and training (15%), and statistical analysis (18%).

Associates and High School/GED

Thirty-nine, or 29% of the job openings of the job openings required or preferred an associate's or high school diploma/GED (Fig. 4.6). Of the total job postings classified as desiring an associate's degree or high school diploma/GED, the most frequently reported job function was manufacturing (56%) (Fig. 7). The second most frequent job function laboratory (23%), followed by general and administrative (8%) and legal and regulatory (5%). Engineering, business, sales and marketing, and clinical job functions were the least

reported, all at 0% (Fig 4.7.) Of the total job postings that require an associate's or high school diploma/GED, manual labor dexterity (74%), computer and technical (59%), and teamwork and customer support (54%) were the most desired skill sets (Fig. 4.8). The bottom three skills reported were for quality assurance (10%), statistical analysis (8%), business and marketing and education and training (5%) (Fig. 4.8).

Fig. 4.8: Desired Skill Set by Degree Level



Desired Skills

Desired skill sets were grouped together by hard and soft skills for visual clarity and ease of interpretation (Fig 4.8.) (Reference Appendix B, Table B3 for hard and soft skill set definitions). The degree level results in Figure 4.8 suggest common themes in relation to desired skill set by degree level. Many of the positions require scientific skills and knowledge paired with the interdisciplinary knowledge of communications, business, regulatory, and interpersonal skills. The desire for communication and writing skills were the highest among all degree types (Appendix B, Fig. B1). Teamwork and customer service support, along with computer/technical skills, were also highly valued for all degree types. Production skill sets, which include laboratory and engineering abilities, were highly desired among all degree types. For lower-level degree types, the desire for manual labor dexterity skills was higher in comparison to higher-level degree types. The need for manual labor abilities became non-existent from the master's to the doctoral level. Moreover, there was more desire for legal and regulatory skills for the higher degree levels in comparison to the lower degree levels. However, the desire for legal and regulatory affairs skills still reported approximately 47% and above for all degree levels. These percentages suggest that the ability to work in a regulated environment is imperative for job positions with various degree requirements.

In addition, there seemed to be more desire for statistical analysis skills as the degree level increased. Skills related to providing oversight, such as leadership, management, education, and training, were also desired more for higher-level degree types in comparison to lower-level degree types. Positions that require a doctorate degree reported low desire for leadership and management skills. These figures suggest that positions that require a doctorate degree may value skills related to research and development over skills related to employee oversight.

By Sub-Industry

Sub-Industry: Industrial Biotechnology

Three jobs were identified as industrial biotechnology jobs (Fig. 4.1). This is a very small sample size which may skew the results of the job skills requirements by industry. Of these openings all of the jobs looked for communication and writing skills (100%), computer and technical skills (100%), and business and marketing (100%). The following skills were all identified in 33% of the industrial job postings: Leadership and management, education and training, quality assurance, problem solving and self-starting, teamwork and customer support statistical analysis, production, legal and regulatory. Manual labor and dexterity was not identified for any of the job postings (Fig. B1).

Sub-Industry: Agricultural Biotechnology

Of all of the open job postings only 28 jobs were identified as agricultural biotechnology jobs (Fig. 1). This is a very small sample size which may skew the results of the job skills requirements by industry. The top three skills in the agricultural biotechnology jobs were communication and writing skills (79%), computer and technical skills (75%), teamwork and customer support (64%), and Production (50%). The lowest three skills were identified: education and training (7%), leadership and management (18%), and manual labor and dexterity (18%) (Fig. B1).

Sub-Industry: Medical Biotechnology

A diverse range of skill sets were reported for job posting categorized within the medical biotechnology industry. Skill sets from each category were reported for this industry. None of the skillset categories were reported non-existent. Of the total number of job postings categorized under the medical biotechnology industry, 103 jobs were identified as medical biotechnology jobs (Fig. 1). The top three reported skill sets were communication and writing (84%), computer/technical (65%), and production (52%). The lowest three reported skill sets were manual labor dexterity (12%), education and training (15%), and quality assurance (20%) (Fig. B1). These figures suggest that a combination of both soft skills and hard scientific-related skills are important in the medical biotechnology industry sector in Georgia.

*By Function***Function: Engineering**

Fifteen percent (n = 21) of job postings were identified as engineering jobs (Fig. B2). Of these job openings the top three skills identified were production (91%), communication and writing (81%), and computer and technical (71%) (Appendix B, Fig. B2). The lowest count of skills of engineering jobs were manual labor (10%), statistical analysis (15%), and educational and training, (19%).

Function: Business

We identified 18 business jobs in the data, a 13% representation of the total jobs (Fig. B2). Of these job openings the top three skills identified were computer and technical skills (94%), communication and writing (94%), and business and technical (83%). The lowest count of skills of engineering jobs were education training (11%), statistical analysis (11%), and quality assurance (6%). None of the business jobs requested skills in manual labor and dexterity.

Function: Sales & Marketing

There were 16, or 11%, sales and marketing jobs in the job listing data (Fig. B2). Of these job openings the top three skills identified were business and marketing skills (100%), computer and technical skills (88%), and

communication and writing (93%). The lowest count of skills of engineering jobs were statistical analysis (6%), production (6%), and education and training (19%). None of the sales and marketing jobs requested skills in manual labor and dexterity or quality assurance.

Function: Clinical

Only 6% (n = 8) jobs had clinical functions (Fig. B2). Of these job openings the top three skills identified were communication and writing (75%), statistical analysis skills (50%), and business and marketing, teamwork and customer support, and production were all tied at (38%). The lowest count of skills of engineering jobs were leadership and management (13%), quality assurance (13%), and problem solving and self-starting (13%). There were no clinical jobs requested skills in manual labor and dexterity.

Function: Legal & Regulatory

Eleven, or 8% of jobs had legal and regulatory functions (Fig. B2). Job postings classified under the Legal and Regulatory job function desired a combination of both soft and hard skill sets. However, the desired hard skill sets were less technical than some of the other job functions. Moreover, this job function reported less desire for manual labor-related, analytical, and customer relations skills. Of the total job postings that were categorized under the Legal and Regulatory job function, the top three desired skills were legal and regulatory (100%), quality assurance (52%), and communication and writing (73%). The bottom three desired skills were manual dexterity (0%), education and training (18%), and business and marketing and statistical analysis (27%).

Function: General & Administrative

There were 14, or 10% of the jobs that were general and administrative jobs in function (Fig. B2). Job postings classified under the General and Administrative job functions valued interpersonal skills over technical skills. However, information technology (IT) skills were highly desired under this job category. Of the total job postings that were categorized under the General and Administrative job function, the top three desired skills were communication and writing (93%), teamwork and customer support (86%), and computer/technical (71%). The bottom three desired skills were statistical analysis and manual dexterity (0%), education and training, production, and legal and regulatory (7%), and quality assurance (21%).

Function: Laboratory

There were 28 laboratory jobs identified in the job opening data. Job postings classified under the Laboratory job function desired hard technical skills over interpersonal and employee oversight-related skills. However, similar to many other job categories, job postings labeled in the Laboratory category did report a high percentage of desire for communication and writing skills. Of the total job postings that were categorized under the Laboratory function, the top three desired skills were production (100%), communication and

writing (68%), and computer/technical (54%). The bottom three desired skills were business and marketing (0%), education and training (7%), and leadership and management (18%).

Function: Manufacturing

The job postings were 18% (n = 25) manufacturing (Fig. B2). Job postings classified under the manufacturing job function desired a combination of both soft interpersonal skills and technical and applied hard skills. Of the total job postings that were categorized under the manufacturing function, the top three desired skills were communication and writing (84%), production and computer/technical (68%), and manual dexterity and teamwork and customer support (44%). The bottom three desired skills were education and training (4%), statistical analysis (12%), and leadership and management, quality assurance, business and marketing, and problem-solving and self-starting (20%).

Limitations

The industry-related modes of inquiry were subject to limitations. For the job posting analysis, we are unable to know how representative this population size is of the total biotechnology job posts in Georgia because the job posts are continually being posted and taken down. For example, digital health was not coded for as a biotech sub industry in this study because it was difficult to define as a stand-alone enterprise. We felt that coding for medical biotechnology was a sufficient representation of the sub industry. However, we do recognize that not coding specifically for digital health as a separate biotech sub industry might not be completely representative of the entire biotechnology workforce landscape in Georgia. Moreover, we recognize that the lower reporting for the agriculture sub industry could also serve as a limitation in terms of not being fully representative of the entire Georgia biotechnology workforce landscape. Although we included “agriculture” terminology in our keyword search strings, it is possible that agriculture biotechnology uses different hiring mechanisms to search for employees or utilizes different keyword tags within their advertisements.

Second, we are not able to verify the reliability of the job posts. Although a job posting may be on a career website or a company website, they are not updated frequently so the company may have closed the application period even though the post is still up. A second factor that may bias our results is that we did not code for work experience in the quantitative analysis of the job openings. We felt that the skills and education required were sufficient to address the gaps in the biotechnology workforce indicated by the client. A third factor that may skew our results is that we double counted education when a job posting reported that the required bachelor's degrees but might have preferred a master's degree for example. We felt that coding for every permutation would have confused our analysis, so we decided to double count the degrees preferred or

required. A second factor that may threaten reliability is the classification of job posts as ‘biotechnology jobs.’ Last, we acknowledge there may be human error in inputting and interpreting the job posts. There could be posts that we have misclassified as agriculture, medical, or industrial biotechnology or job posts that we have misclassified amid the skills section.

For the industry personnel interviews, the most pertinent limitations were the lack of time allocated for the study and the limited response rate from interviewee candidates. Due to the limited time frame of the study, we were confined in our ability to reach out to extremely large interviewee applicant pools. Moreover, the restricted response rate also inhibited us from obtaining strong statistical power for our study. Finally, the industry personnel interviewed for the study were direct contacts from the client’s contact bank. The industry respondent contact pool lacked interviewees from the agricultural biotechnology sector. Therefore, selection bias could be a potential limitation for the industry interview portion of the study.

KEY TAKEAWAYS: INDUSTRY

The industry personnel interviews show:

- There is perceived growth in the Georgia biotechnology industry landscape.
- Internships and cooperative education programs are critical for students to gain experience working in a regulated environment.

The job posting analysis shows:

- Demand and opportunity for work in the biotechnology industry in Georgia
- The industry is multidisciplinary and seeks skills beyond laboratory and scientific acumen such as communication, writing, problem solving, leadership, etc.

V. EDUCATION EVALUATION

The goal of the education evaluation is to gain insight into how the Georgia educational ecosystem is supporting the biotechnology sector. Using 8 qualitative interviews with key educators and educational leaders, and reviewing data from TCSG, USG, and GaDOE, we seek to identify the broad themes, strengths, weaknesses, and opportunities in the world of biotechnology workforce development. Interviews sought to understand their perceptions on the impact of their efforts on industry, and the issues in the area of recruitment, retention, graduation, and placement of biotechnology degree candidates. Notably, there are a few limitations to the education overview. Given the low number of schools that offer the biotechnology pathway (>5%), it is difficult to estimate how many students in total would be interested in the program if offered more broadly. Additionally, all interview results must be taken with a grain of salt because those interviewed were inherently speaking in the self-interest of their respective institutions.

The public education system in Georgia consists of 2,301 public schools providing K-12 education in a system with oversight by the Georgia Department of Education (GaDOE). Upon high school graduation, students may pursue additional training through local technical colleges that comprise the Technical College System of Georgia (TCSG) or through one of the 26 units of the University System of Georgia (USG). Well known units of USG include the University of Georgia, Georgia Institute of Technology, and Georgia State University. A brief introduction to each of the systems assessed is given next and will be followed by the results of the interviews and the data analysis.

Education Systems Background

Georgia Department of Education (GaDOE)

GaDOE provides a system of 17 Career Clusters aligned to the National Career Cluster Framework. Within each cluster is a career pathway that a student can choose to study while in high school. To complete a career pathway, a high school student can take a structured sequence of three specialized courses. Tucked within the Healthcare Cluster, there is Biotechnology Research and Development pathway. This pathway offers three courses; Introduction to Healthcare Science; Essentials of Biotechnology; and Applications of Biotechnology. The Career Cluster system is the primary component of the CTAE (Career, Technical and Agriculture Education) ecosystem.

In order for a student to graduate high school, 23 high school credits must be earned, many in state mandated areas. Of those 23 hours, 3 must be in a CTAE pathway, a modern language, or the fine arts. GaDOE has over 120 CTAE pathways defined, ranging from veterinary science to marine engine technology to aircraft

maintenance. The choice of pathways that are offered in a high school is not determined by the state, but by the local school district. Typically, the district arrives at the determination based on several factors which may include local industry interest, student interest, funding availability, and teacher supply. It is possible for a school to offer no CTAE pathway at all and only offer languages or fine arts.

The question of why the Biotechnology career pathway is put inside the Healthcare Cluster is answered by examining all other clusters. It fits other clusters less well. The placement of this pathway creates potential issues in how teachers are recruited to teach biotechnology in high school. It is not uncommon for school administrators and leadership to lump together things that seem alike. The result is that teachers in nearby fields, such as the allied health courses, are asked to teach biotechnology classes when they have no effective training in that area. The lack of availability of well-trained biotechnology teachers impedes the deployment of the Biotechnology pathway on a broader scale. The CTAE / CTE Biotechnology pathway is not unique to Georgia. It has been adopted by many states including and not limited to Florida, North Carolina, Washington, Kansas, Ohio, Oregon, Maryland, Minnesota, Virginia, New Jersey, and Massachusetts.

The Technical College System of Georgia (TCSG)

The Technical College System of Georgia (TCSG) provides a unified system of technical education, adult education, and customized business and industry training. Their students include students entering from high school, adult education students, and Move On When Ready (MOWR) students that are jointly enrolled in high school that wish to move on from high school and enter technical or career training. TCSG works closely with Georgia's system of College and Career Academies to provide career training and MOWR opportunities. The Technical College System of Georgia has four units that participate in biotechnology degree production. The institutions are Athens Technical College, Atlanta Technical College, Central Technical College, and Gwinnett Technical College.

The University System of Georgia (USG)

USG is composed of 26 higher education institutions including four research universities, four comprehensive universities, nine state universities and nine state colleges. The five most significant USG contributors to the biotechnology workforce include Georgia Institute of Technology, University of Georgia, Augusta University, Kennesaw State University, and Fort Valley University. USG institutions provide programs that lead to baccalaureate, master's, and doctoral degrees.

The need for engineers spans across most disciplines of engineering. Significantly, the production of Bioengineering and Biomedical Engineering, Biochemical Engineering, and Biological/Biosystems

Engineering Bachelor's Degrees consumes nearly 10% of all the 3,110 degrees conferred in engineering in the USG system. Georgia Tech and the University of Georgia dominate the production of Bioengineering and Biomedical Engineering, Biochemical Engineering, and Biological/Biosystems Engineering degree programs. Kennesaw State University used to have a biotechnology degree program but closed the degree program due to low production numbers, and insufficient recruitment.

Interviews with Educational Personnel

Interviews were conducted with educators and leaders at high school, TCSG, and USG institutions. The Technical College System of Georgia has four units that participate in biotechnology education, and they all were interviewed. The institutions are Athens Technical College, Atlanta Technical College, Central Technical College, and Gwinnett Technical College. The USG institutions interviewed included Georgia Institute of Technology, University of Georgia, and Kennesaw State University. One public school district was interviewed about high school initiatives. The opening questions for the interviews can be found in Appendix A.

Results

The number of graduates of TCSG programs is low, but the students that do graduate are described as doing quite well. Some companies typically do not hire associate degree holders, but in spite of their hiring policies, interviews reveal that companies hire Atlanta Tech graduates with A.S. degrees with excellent success. Atlanta Tech estimates that half of their graduates go on to pursue a B.S. degree, with the remainder going straight into industry. The numbers of Atlanta Tech graduates is relatively small, averaging about ten students a year. The sources of incoming candidates at Atlanta Tech is approximately 50% adult career changers, the remainder being new high school graduates. Central Georgia Technical College estimates that nearly all students at this time are adult career changers.

The Athens program is the oldest biotech training in the state. They provide a two-year program, training people to work in a biotechnology manufacturing area. About half of the students go on to get a four-year degree. About 85 students are enrolled, but some students are just taking a class in the area. The program graduates about ten students a year. In the 'heyday' the program graduated approximately 18 students a year. The program tends to be broad, but most students are in microbiology or analytical chemistry settings. The recent trend has been toward biomanufacturing. Local industry is reported to have hiring needs in the hundreds of people. Athens Tech can only provide a small number of candidates. All the respondents at USG and TCSG see biotechnology and bioscience as existing at the intersection of science and business. Bioscience was

described as an applied not pure science. It was stated that students should have a strong sense of the business component of the industry in addition to the scientific and engineering knowledge and skill sets.

Challenges

Issues in Student Recruitment, Retention, and Graduation

There was one theme that dominated the discussion across all interviews, including high school, TCSG, and USG interviews. The interviews with the program chairs were remarkably consistent on the issue of student recruitment. The largest challenge in recruitment is educating students, and their primary career influencers, parents and teachers. The widespread consensus is that people do not understand what a career in biotechnology looks like. There is little understanding of the depth and breadth of possibilities. Anecdotes given by the respondents indicated that students were drawn into the field because a friend, teacher, or mom, guided their decisions. There was a clear message that there was a need to find ways to educate students, and their primary career influencers, parents and teachers, about the career opportunities that exist in biotechnology.

The interviews remarks on the issue of student recruitment resonated with a 2005 era research report called “The Extraordinary Women Engineers Project (EWEP).” The EWEP report was commissioned by the American Association of Engineering Societies (AAES), the American Society of Civil Engineers (ASCE), and WGBH Educational Foundation. The findings of the report revealed the issues in recruiting young women to the engineering profession. The EWEP identified that significant problem in recruiting students to engineering careers is that students and the adults that influence student’s choice of career do not know what an engineering career looks like and do not know how to identify with an engineering career. The interviews revealed a nearly identical statement about biotechnology careers. There is a strong desire to establish initiatives that educate prospective students and career influencers about biotech and bioscience careers.

The most discussed, and most needed area of attention was the area of developing and cultivating interest, motivation, and academic capacity in pre-college students. For many years, in other STEM fields, there has been substantial attention to the issue of how to influence the career development path of elementary through high school students. There are activities in the K-12 STEM formal in class, and informal after-school initiatives that can inform thinking about building biotech/bioscience workforce and post-secondary opportunities. In the STEM fields of computer science and engineering, pre-college activities such as coding camps, and robotics, has been influential in developing student career interest in the STEM fields of engineering and computer science. Existing state initiatives such as the CTSO (Career and Technical Student

Organization) provide teacher support and cocurricular engagement in engineering and computer science fields and dwarf similar efforts in biotechnology.

The iGEMS initiative was consistently cited in all interviews as an opportunity to develop student interest in biotech and bioscience fields. iGEMS is a team-based engineering biology competition designed to engage high school and college level students. There are 6,000+ students on about 340 teams. Participants in the iGEM synthetic engineering biology competition come from schools compete all over the world. They compete by making synthetic organisms, make genetic code, learn laboratory technique, and use research tools. It is competitive and is attractive, especially amongst peers. Some participants have the chance to go to MIT in Cambridge, Massachusetts. Compared to the world's largest out of school initiative, the FIRST Robotics Competition with over 615,000+ students on 72,000 teams, iGEMS is relatively small. Efforts to grow and support programs such as iGEMS provide an opportunity to engage students with the same success as other STEM engagement initiatives.

Consistent with the experience the TCSG chairs have in program recruitment, it is observed that Masters' applicants have a little but no deep understanding of biotech and is further lacking necessary laboratory skillsets. Some students have gained their first knowledge of biotechnology because of interest in brewing, and others due to a condition that may have affected a family member, such as a relative who is dependent on insulin. University master's level graduate programs suffer from the same fate as students entering TCSG. There is little public understanding of the biotech industry and the nature of the careers that exist.

Issues in State and Federal Policies

Athens Tech experience highlights how small decisions have the potential to derail efforts to recruit students. In 2007, a \$ 1.9M U.S. Department of Labor grant provided for a full-time outreach person that worked in schools during the school year, to recruit students and nurture student interest in biotech/bioscience careers. During the summer, the person trained teachers. This was the 'heyday' of recruitment and teacher training. Athens Tech had the funding to do what they needed to do in this area. Funding for lab equipment is currently adequate, but the missing link is the outreach, education, and recruitment component. After the DOL grant ended, most of the external engagement collapsed, except for faculty outreach on Fridays. Administrative decisions now require faculty to be on campus on Friday, and now external engagement has collapsed. Recently, Athens Tech lost their website about biotech/biotech due to another set of administrative decisions. Over time, the external engagement decayed to zero, and to fully reinforce the decay, now the website it dismantled.

Atlanta Tech's program was started with a \$ 4.8M Federal Department of Labor grant that created up the initial program. Some of the funds were able to be used to perform outreach and education to pre-college students. The Federal DOL grant has now expired. Another grant was used to enable career changers that held H1B grants to move into the biotech/bioscience workplace. This initiative was not for incumbent workers. The Move On When Ready (MOVR) is a dual enrollment initiative for high-school students allowing dual enrollment in high school and a TCSG or USG institution, was viewed very favorably.

Federal grants are often intended to start programs at the state and local level with the goal of state adoption when the Federal grant ends. The Athens and Atlanta Tech experience illustrated how workforce development startup efforts decay when the state fails to adopt and further develop these initiatives. Currently, the Technical Colleges are very resource constrained on the issue of engaging feeder high schools. There is a significant difficulty, and little support in the way of meeting with and guiding administrators and science leads on how to move forward. Complicating the issue is the delivery of curriculum at the high school level, in terms of courses offered and teacher training. It is the respondent's perception that at the high school level teachers for aligned directions were pulled out of nursing and allied health pathways.

The Athens and Atlanta Tech schools have an open admission model. Incoming candidates must meet a minimum score on the Compass exam. The gatekeeper course tends to be general chemistry. Athens developed a laboratory calculation class because incoming students are not prepared for math in chemistry. Athens and Atlanta spend effort on standard and learning support classes to prepare students for the biotechnology curriculum. Many students are not adequately prepared in the subject areas of English, math, reading, the basic 3R's. Students often have deficiencies and need to be elevated and need to be able to function. It is a steep learning curve for some students. Once students get to chemistry and pass it, they are then on a conveyor belt to success. The issue is getting the right type of student in the classroom.

Teacher Supply for High Schools

According to the USG Datamart, there are no teachers produced with a specific biotechnology emphasis, nor any known defined biotechnology undergraduate degree program anywhere in USG. Some states, such as Florida, have programs available to chemistry and biology teachers that allows the teacher to earn a biotech teaching credential. The 'Bionetwork' of North Carolina Community Colleges reports that they offer professional development for teachers. There is no identified undergraduate biotech teacher degree program that we have found. Interviews with Georgia high school and TCSG educators indicate that biotechnology teachers are acquired on an ad-hoc basis, by recruiting someone from industry, or by drafting existing teachers from fields that seem nearfield or similar to bio-something. The typical victim is said to be

often pulled the allied healthcare fields in the Healthcare cluster. One interview indicated attempts to draft the school nurse to teach biotechnology.

Opportunities

The University of Georgia (UGA) support the biotechnology area in a couple of different ways. First is through technology development, and secondarily by providing workforce development. The technology development efforts tend to incubate companies that spin out of faculty laboratories. UGA provides an innovation gateway that provides incubator, product licensing, patent, contract, and (IP) intellectual property protection support. The gateway also provides space to new companies in incubation.

Workforce development efforts include education and training, which can include experiential learning. Some pathways require internships. There is a MS in Regulatory Affairs (MS RS) that is operated out of the College of Pharmacy and a Master of Biomanufacturing and Bioprocessing (MBB) in the Biomedical and Health Sciences Institute at UGA. The MS RS focuses on Quality Control, FDA and DGMP guidelines, and other pertinent regulatory areas. The MBB is a Master's of Bio Manufacturing/Bioprocessing, plus business classes that prepare candidates for the industry. The MBB has been in place since 2010 and has produced 34 graduates, with six currently in the program, and there are plans to increase the enrollment. Enrollment standards are typical of a university level master's program, which require a GRE examination and statement of purpose leading to an admissions evaluation of the fitness of the candidate. UGA has a 'Young Dawgs' program that intakes high school students into the laboratories as workers during the summer and after school. 'Young Dawgs' is an initiative to engage students and nurture interest in the biotechnology universe.

Located at Georgia Tech, The Georgia Advanced Biomanufacturing Center (GABC) is a multi-university collaboration. Members include Georgia Tech, University of Georgia, TCSG and Augusta University. The goal is to create an ecosystem that will help grow and attract biotechnology and bioscience firms to the area, by creating an international center of excellence. The State of Georgia provided a \$ 5M grant (bond) for equipment and other tasks. The effort entails a planning phase, including working with the economic development authorities to better understand issues in workforce development, innovation, and commercialization.

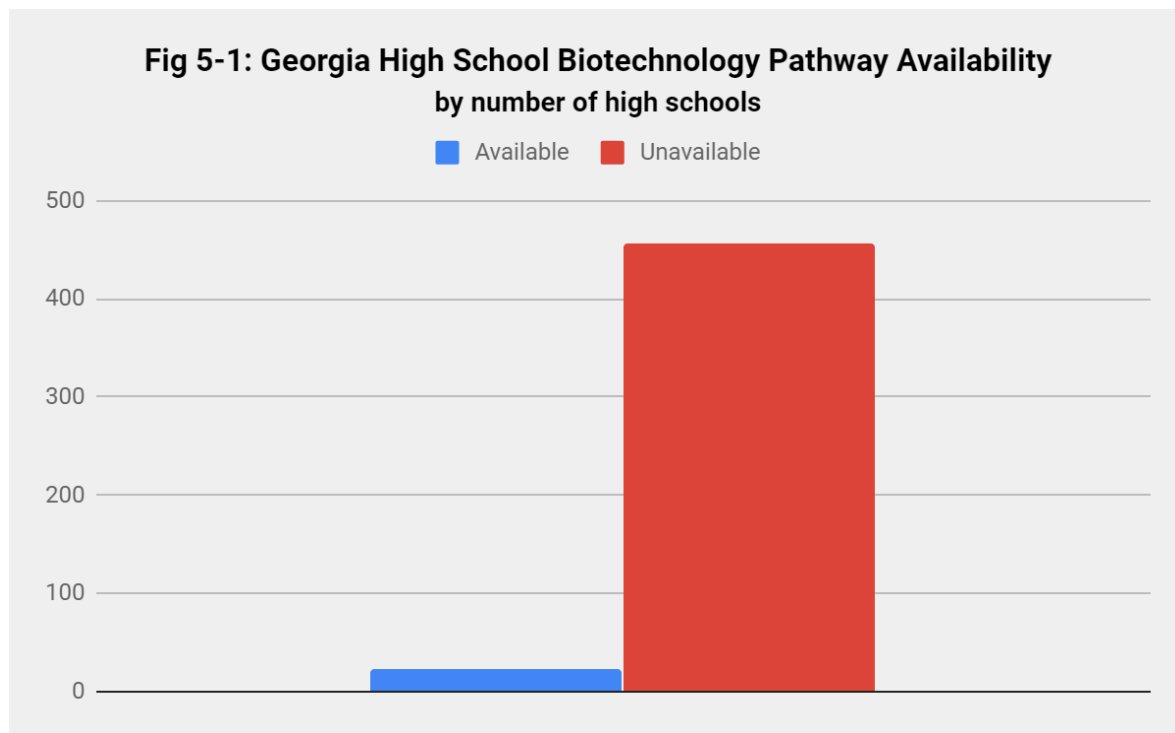
Goals include moving the needle on what is state of the art in biotechnology, their initial thrust is to work with TCSG and community colleges. The second thrust is to bring in undergraduate students to work side by side to develop new approaches in manufacturing and automation, helping in the manufacturing of cellular therapy and biologics, with the ultimate objective of helping to drive economic growth. The industry collaborative effort is in a very early stage and is not fully engaged in industry as of this time. GABC is a very

new project. GABC would benefit from letters of support from industry. Ultimately, they project intends to build a GABC tech cluster, a Tech Square Innovation Center that would become a showcase, a playground, to enable the establishing proof of concept, startups, incubators, etc. The vision is to make Georgia an epicenter for biotechnology and bioscience.

Data Analysis

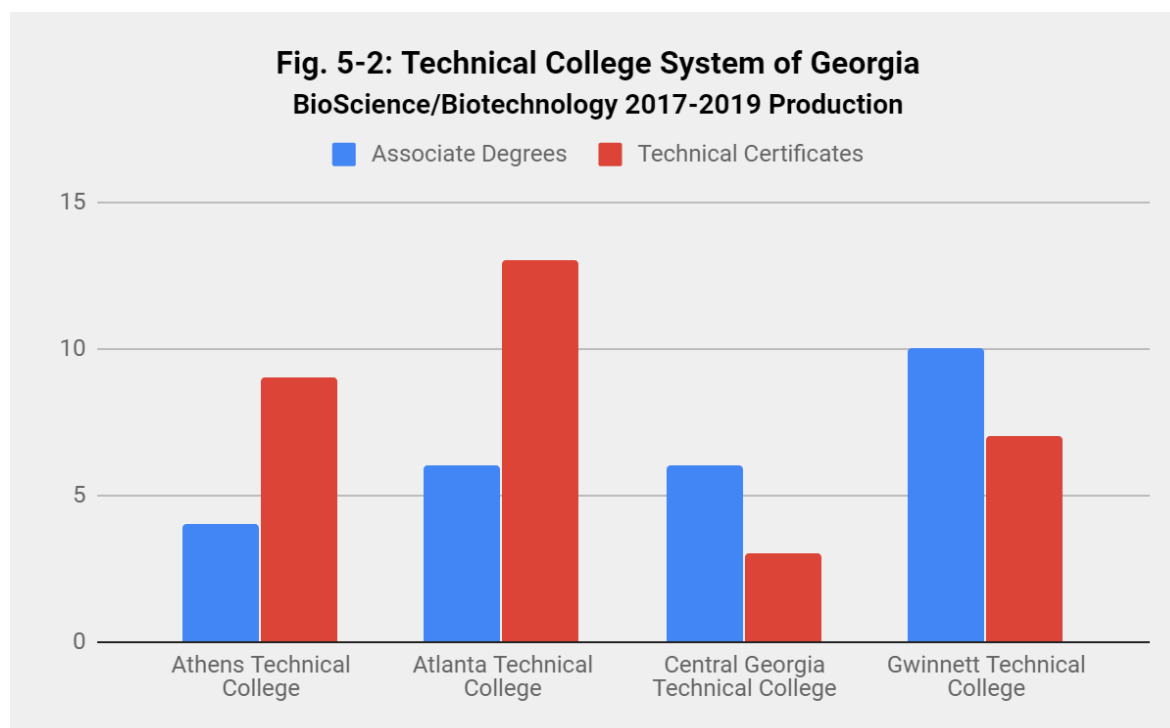
GaDOE - High School Degree Programs

The biotechnology education sector in Georgia is relatively small. During the FY2018 data collection cycle, The Georgia Department of Education reported that only 4.6%, or 22 of the 479 high schools offer the full biotechnology pathway. Of those schools, 28,185 students across 397 schools took the *Introduction to Healthcare Science* which is the introductory course to most of the allied healthcare pathways. The second course in the biotechnology pathway is *Essentials of Biotechnology* which was taken by 357 students in 20 schools. The final and pathway completion course is *Applications of Biotechnology* which was completed by 542 students in 22 schools. For reference, there were 115,927 students in the 12th grade during AY2018. (2018 GaDOE end of year 'L' cycle data collection). The complete CTAE Biotechnology Pathway is available in only 4.6 % of all of Georgia's High Schools (Fig. 5-1). Future research should seek to understand the deployment of the CTAE Biotechnology Pathway across all states.



TCSG – 2-year Technical College Associate Degrees and Certificates

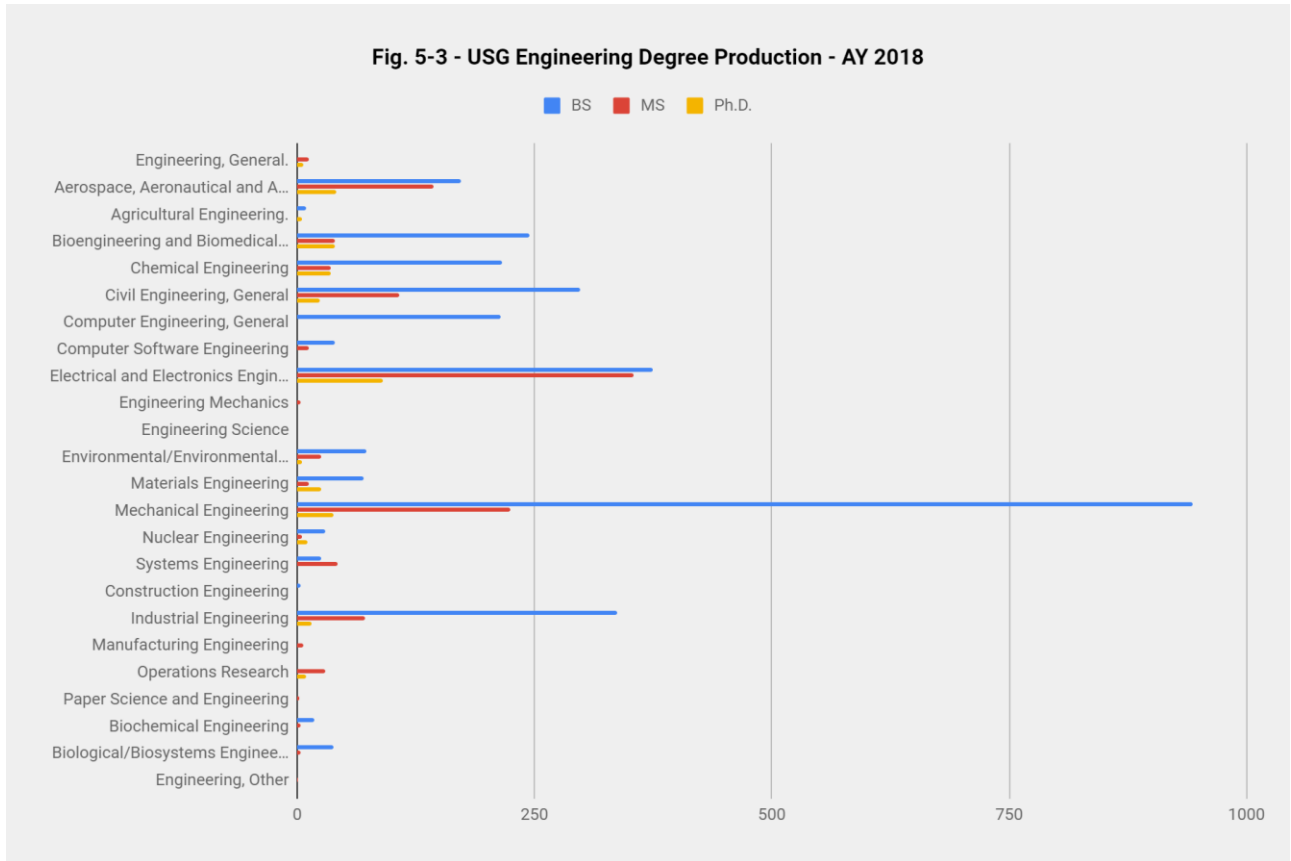
The Technical College System of Georgia (TCSG) data was evaluated to provide a snapshot of bioscience and biotechnology program outcomes. For the academic 2017 - 2018 year, the TCSG production rates for bioscience and biotechnology majors were relatively low (Fig. 11). The entire system, composed of Athens Technical College, Atlanta Technical College, Central Georgia Technical College, and Gwinnett Technical College, awarded a total of twenty-six Associate degrees and thirty-two technical certificates of completion. The Athens Technical College produced four Associate degrees and nine technical certifications of completion. The Atlanta Technical College produced six Associate degrees and thirteen technical certifications. The Central College of Georgia produced six Associate degrees and three technical certificates of completion. The Gwinnett Technical College produced ten Associate degrees and seven technical degrees of completion. Of all of the technical colleges, the Atlanta Technical College awarded the most technical certificate completion. Conversely, the Central Georgia Technical college awarded the lowest number of technical certificates of completion. The Gwinnett Technical College awarded the highest number of Associate degrees. Whereas, the Athens Technical College awarded the lowest number of Associate degrees. *(TCSG Office of Information Technology & Data Resources, for 2016-2018 end of year cycle).*



Total Production by TCSG units for Biotechnology

USG - Baccalaureate, Masters, & Ph.D. Degree Programs

Analysis of publicly available data from USG provides a snapshot of engineering degrees awarded. In 2018, USG units awarded 3,110 BS, 1,138 MS, and 348 Ph.D. degrees in engineering. Of those totals, there were 302 BS, 47 MS, and 40 Ph.D. degrees in the engineering fields of Bioengineering and Biomedical Engineering, Biochemical Engineering, and Biological/Biosystems Engineering. (*USG DataMart, 2018 end of year data collection*)



Total Production for Engineering Degrees by USG institutions FY 2018

The three following degree programs awarded 10% of all USG engineering B.S. degrees:

Table 5.1: USG Degree Production for Bio Specific Fields			
Degree Program	B.S.	M.S.	Ph.D.
Bioengineering and Biomedical Engineering	245	40	40
Biochemical Engineering	18	3	0
Biological/Biosystems Engineering	39	4	0

KEY TAKEAWAYS: EDUCATION

The education personnel interviews and data analysis show:

- Pre-college and college students do not understand biotechnology careers and opportunities
- Only 4.6% of high schools support the Biotechnology CTAE Pathways
- There is no state support for CTSO or co-curricular Biotechnology initiatives, except HOSA.
- There are no known USG teacher development systems for degree, specialist, and certificate programs in biotechnology
- Opportunities for teacher professional development initiatives in Georgia are limited

VI. DISCUSSION

State Comparison Overview

After examining the policies and programs enacted in Florida, North Carolina, Tennessee, and Washington are doing in these areas, it would be helpful to discuss what Georgia is currently doing. Like the other states, in the area of funding and tax incentives, venture capital funding is also crucial to startup biotech companies in Georgia. The Bio/Med Investor Network was set up to help biotech and other bio-science related companies. Bio/Med acts as a medium to connect bioscience companies with investors who can provide them with necessary to grow their businesses. This investor network is supported by Georgia Bio, the Georgia Research Alliance (GRA) and the state research universities.

In the university area, the Georgia Centers of Innovation has developed incubators to help foster the growth of biotech companies. These incubators are set-up in the biotechnology clusters of Atlanta, Athens, and Augusta. While the creation of incubators is a crucial component to the growth of startup biotech for the states (including Georgia), it appears that Tennessee has gone a step further with the creation of their accelerator network. The accelerator network in Tennessee gives venture capitalists a better sense of a start-up's potential. That is, this program helps venture capitalists make wise decisions when it comes to providing the necessary funds for a biotech startup. Like the other states, Georgia has recruited top-notch faculty to their research universities. For example, researchers that are part of the Georgia Research Alliance's Eminent Scholars program lead ground-breaking research projects being conducted at the research universities.

Georgia has the QuickStart program which provides training to qualified new, expanding, and existing businesses in the state free of charge. There is also the Georgia BioScience Training Center which supports training for new life science companies who choose to locate to Georgia. The key difference between the workforce development programs is that Tennessee has metropolitan areas offering job training. In Memphis, Tennessee, the Memphis BioWorks Foundation has a Ready to Work Training program for biotech employees. In this program, Memphis BioWorks offers free job training and career placements for residents who live in the Mid-South region of the state and are interested in information technology and bioscience.

Industry Overview

We identified common themes upon conducting the qualitative interviews from specialists in the field and quantitative analysis of job opening data. Some of these themes include the growth in the biotechnology sector in Georgia, desired skills and knowledge in the field, and the workforce gaps. In terms of growth in the biotechnology sector, we found both the job posting and industry interview data suggest that Georgia has the

potential to serve as a “biotechnology hub” in the future. The job posting data showed that the medical biotechnology industry comprised the majority of the job openings. These figures seem to be representative of and consistent with Georgia’s current biotechnology workforce, as many respondents mentioned that the state’s life science community is a rich mix of pharmaceutical, biotechnology, medical device, diagnostic, and medical supply companies.

The job postings showed that the majority of the companies with job openings are Georgia-headquartered. The number of job postings in Georgia shows the potential for job growth for Georgians among Georgia-based companies. Regions with low job posting counts could serve as opportunity zones for future biotechnology industry establishments. The qualitative interviews highlighted that the state has all of the resources available to be considered a biotechnology “powerhouse.” However, state decision-makers need to allocate resources to ensure individuals and companies are not lured away to other states. Of the job posts we coded for, we classified more of the job openings as medical biotechnology industry. Although Georgia is not defined as a “hub” for the biotechnology industry, it is experiencing growth as denoted by the interviews and job postings. Industries such as agriculture and the industrial sectors are the less developed sectors in Georgia. The job openings least represented these industries. The lack of job openings was verified from the interviews as well. This indicates that Georgia could potentially do a lot more to encourage the growth of the agricultural and industrial biotechnology industries throughout the state. Another observation was described by a manufacturing supervisor at a leading biotechnology company in Georgia during the industry interviews. The manufacturing supervisor stated, “there was an opportunity at his company for entry-level manufacturing positions to be temporarily transferred from a job site in Georgia to a job site abroad.” The job opening data speaks to the potential for this opportunity at other companies as well given many of the biotechnology companies also have offices overseas.

The second theme identified was the skills and knowledge desired in the industry. Most of the interviewees emphasized communication and writing, problem-solving, team building, technical skills, etc. We verified the desire for these skills through the job opening data as well. However, there was a reasonable degree of variation in skills desired according to job function and degree. From the job openings, we observed as the degree level advances, the more diverse the desired skills are, excluding doctorate and MBAs. This correlation was also expressed by industry personnel. Openings that required a higher degree level, in turn, required a vaster array of skills. The opposite was observed as well. The less advanced the degree, the fewer skills were needed. The final theme we observed was the labor gap in the field. Industry interviewees explained that positions such as quality assurance and advanced engineering positions were difficult to place and had openings. We identified several job openings that sought individuals with engineering experience and quality assurance skills.

Education Overview

The most prominent theme throughout the education interviews was the issue of developing student interest in biotechnology careers. There is a consensus that measures must be taken to educate and influence young students and their primary career influencers, teachers and parents about biotechnology. The next most prominent theme was regarding the development and support of teachers for the high school biotechnology pathway. There are no specific USG biotechnology teacher development programs, and outside of the Georgia Bio's Ed Institute, we do not know of any Georgia based professional development initiatives for biotech teachers. While there was general satisfaction by TCSG and USG units on the issue of funding for laboratories and facilities, there is insufficient support for outreach, recruitment, and other initiatives that would draw students into degree programs. In one case, the TCSG unit dismantled a biotechnology website that was used to educate prospective students about biotech careers. For any program to prosper, there has to be a champion in place as the chair, and the effort has to be supported.

Examining the national data on engineering degree production from 1998 through 2015 demonstrates the rapid growth of support at USG, primarily Georgia Tech. The growth of Bioengineering and Biomedical Engineering at Georgia Tech is strong relative to the comparison states of Washington, Florida, Tennessee, and North Carolina. The program output has dropped noticeably between 2015 and 2018, reason unknown. Biochemical Engineering and Biological/Biosystems Engineering is relatively new to Georgia but does not exist in the four comparison states we selected. Georgia Tech produces a significant portion of those degrees as compared to the full United States, 6 and 16 % respectively.

Industry and Education Key Findings

Multidisciplinary Needs for Biotechnology

Both industry and education interviewees stressed that biotech and bioscience fields are multidisciplinary. The fields are not solely categorized as a pure science. Currently, biotechnology spans across many different disciplines. Educators view biotechnology and bioscience fields at the intersection of science and business while industry personnel value employees that have strong laboratory, technical, and interpersonal skills. Firms desire candidates who have a combination of basic scientific and engineering knowledge coupled with regulatory and business skills. Interviewees stated it is not enough for individuals to only have extensive scientific experience. Candidates must possess adequate interpersonal skills, such as the ability to problem solve and self-starter, write and communicate effectively, and integrate as part of a team. Another observation found in both the interviews and job openings was the diversity of the biotechnology industry itself. Biotechnology job openings in Georgia are not specific to laboratory functions. There are also

various alternative job functions that are also desired throughout the state. Job postings and interviews conclude that the majority of the job openings mined were classified as non-laboratory. These results show that the biotechnology field is complex and ever-evolving.

Biotechnology Education and Training Initiatives in Primary and Secondary Schools

Educational and industry personnel highlighted the need to establish initiatives to educate primary and secondary students about biotech and bioscience careers. Respondents from both sectors emphasized the importance of creating programs to engage students in bioscience at an early age. From an educational perspective, it is imperative that STEM-related courses are introduced and available for students. Additionally, selective industry personnel mentioned that their companies currently make it a priority to broaden their net presence in education systems to foster interest in life science disciplines early on. Furthermore, the job posting evaluation, specifically for desired skill sets by degree type, can be used to help technical college systems assess whether or not their curriculum mirrors the reality of positions that life science majors will obtain.

Need for Applied Training via Internships and Fellowships

Based on our 2019 job posting analysis, various job functions are available to the 58-total number of TCSG graduates (Fig. 12). The types of jobs requesting an associate degree in 2019 are for laboratory, manufacturing, general and administrative, legal and regulatory, and engineering functions. However, based on interviews, graduates need both work and internship experience to be top contenders for industry positions. Moreover, it is also critical that recent graduates have experience working in a regulated environment. Again, this is only a snapshot estimate of demand based on a small sample size of both job postings and graduation data.

Recommendations

State Comparisons

Long-term

Georgia Bio should facilitate dialogue between industry and education partners with the goal of aligning and optimizing workforce education initiatives. By conducting this facilitation, state investments in workforce development initiatives can be maximized, similar to efforts in other states. By lobbying the state legislative, educational partners will be able to gather the resources needed to implement and enhance the hands-on training facilities needed for students to develop and master the skills needed prior to entering the

workforce. Similar to the initiative in Tennessee and Georgia's TCSG training programs that align to the HDCI (High Demand Career Initiative), Georgia should offer companies with grants and incentives that supplant the expenses of an employee's training.

Education

Short-term

Advocates of biotechnology workforce development should request that the Georgia Department of Education create a Georgia BioTech CTSO (Career Technology Student Organization). The creation of a Georgia BioTech CTSO would enhance the ability of Georgia Bio to conduct outreach and education throughout the state. The BioTech CTSO has the potential to address the issue of encouraging student interest in biotechnology careers. The CTSO would also enhance the ability to expand Georgia Bio's teacher professional development activities. The newly created CTSO should support iGEMS and other similar biotechnology initiatives. The CTSO system is an effective way to implement after-school co-curricular activities that nurture and develop middle and high school student interests in careers that align with the identified workforce and economic development goals. Currently, Georgia's CTSO system supports several areas including agriculture, healthcare, technology and engineering, advanced manufacturing, and other disciplines. An alternative to creating a Georgia Bio CTSO is to enhance and support the HOSA (Future Health Professionals) CTSO which aspires to support the CTAE Biotechnology Pathway. Please see Appendix D1 and D2.

Long-term

Given that workforce development is a K-20 process, there are several recommendations. Currently, there is no known university level program at USG that specifically targets K-12 teacher development for the biotechnology community. It is recommended that a biotechnology teacher track program within USG colleges of education be developed and implemented. All levels of biotechnology workforce development programs should provide training in regulation, product development from concept to delivery. Educators should provide opportunities for students to engage in capstone and team projects, to develop basic knowledge, communication, and soft skills. It is recommended that TCSG students perform industry internships before graduation.

Industry

Short-term

There are various actionable items that Georgia Bio can do in the short-term to strengthen the Georgia biotechnology workforce. Short-term recommendations for Georgia Bio are primarily communication-based. As previously mentioned, both the educational and industry interviews highlighted the importance of building biotech and bioscience workforce awareness in primary and secondary schools. Moreover, the job posting analysis highlighted the complexities of the current biotech workforce. Industry members should work collaboratively with educational systems to make their presence known in K–12 academic programs. Again, Georgia Bio should work with their industry partners to initiate and enhance industry-led after-school CTSO initiatives in primary and secondary schools to develop student interest in biotechnology-related fields at an early age. Also, industry-led biotech and life science school initiatives could help educate students on, what has proven to be, a complex and diverse sector. Georgia Bio can also work with their industry liaisons to help coordinate industry “guest speaker” events where industry personnel travel to primary and secondary schools to educate and stimulate student interest in life science degree programs. These guest speaker educational seminars, hosted by the biotechnology industry personnel, will help students align their portfolios to match industry needs at a young age.

Long-term

In addition, there are a variety of process-oriented “long-term” actionable items that Georgia Bio can take to strengthen Georgia’s biotechnology workforce. The industry interviews emphasized the importance of applied learning through fellowships, cooperative education programs, and internships. Georgia Bio has an opportunity to communicate with their industry partners and advocate these types of applied learning programs. As learned from the industry interviews these programs can better prepare college students with the necessary skills needed to join the biotechnology workforce. Georgia Bio can also advocate for applied learning programs to the state legislature through lobbying efforts. Georgia state policy and decision makers should consider incentivizing biotechnology companies to hire graduate students for fellowships and co-ops by offering tax breaks to offset their annual tax liability. Lobbying efforts can convey this message to the Georgia state legislature to ensure biotechnology companies throughout the state are eligible to claim credits for hiring students enrolled in life science programs as interns or fellows.

Georgia Bio should work with state and local leaders, community-based organizations, private sector leaders, advocacy leaders, philanthropic leaders, and schools collaboratively to make sure that Georgian bioscience-majoring students are offered exposure to the workplace and build financial and regulatory skills. A

multi-agency effort is needed to provide financial incentives for state and local communities that adopt innovative approaches to offer biotechnology-related internships and co-ops to youth. More specifically, Georgia Bio should consider partnering with CMaT to help market emerging areas of biotechnology. Georgia Bio and CMaT could also work together to help create opportunities for more internship opportunities in cell manufacturing. In addition, state governments should consider providing stipends to graduate students to complete extended fellowships or co-ops.

Investing resources into incentivizing bioscience internships may serve as a limitation for biotechnology companies. As stated previously, spending resources on training interns is not always a significant long-term investment for companies. Interns who work at companies are not guaranteed to stay at the company. They often shift to a more secure position after graduation and transfer companies' intellectual property along with them. Conversely, internships are also beneficial for firms because they provide employees with the opportunity to assess whether or not an intern will serve as a good future employee. If the intern is an ideal candidate to serve as full-time employee, the transitional hiring process is much more seamless, in comparison to hiring from outside, because they are already integrated into the company. However, industries may want to consider offering co-ops rather than internships. Co-ops differ from internships in the sense that the duration of the experience is longer and more in-depth work is required. If industries are going to spend time and resources training interns, they should ensure that students feel part of their integral team.

Lastly, like NCBioImpact, a public-private partnership should be formed between the state of Georgia, Georgia Bio, technical colleges, public universities, and the industry to create training programs for the new biotech workers. These facilities could offer courses for technical college students or current workers to prepare them for work in the biotech industry. These courses could provide firm-specific training. This multidisciplinary partnership would provide biotech firms in the state an opportunity to stress to technical colleges the skills students need to learn to fill open positions. Additionally, the hands-on training facilities would be a good for bachelor and Ph.D. graduates to get more training before entering the biotech workforce.

Conclusion

The biotechnology and life sciences industry is complex and rapidly evolving. There is, however, an overall positive sentiment towards Georgia's biotechnology pathway to future growth. Although the industry holds great commercial and societal promise, it is also filled with many challenges and risks. This study can help inform Georgia Bio about the challenges and limitations of the biotechnology industry. The industry evaluation identifies the need for individuals with a blend of science, communication and writing, regulatory, and various interpersonal skills. The industry evaluation can be used to help Georgia universities evaluate

whether their current higher-education curricula for life science majors reflects the needs of the jobs they will obtain. The education evaluation highlights challenges related to teacher development, student recruitment, retention, graduation rates, and state and federal policies. The state evaluation provides an informative analysis for associations, such as Georgia Bio, whose mission is to advance the growth of the Georgia's life sciences industry through strategic partnerships. There are various policy options to shape the biotechnology industry. The state comparison delivers an overview of exemplary policies and programs that comparative states are adopting. Georgia Bio can work with their academic and industry partners to improve workforce training programs, increase manufacturing growth, kindle student interest through internships, promote emerging areas of biotechnology, and heighten industry presence in academic institutions. The final report can be used to help guide potential state investments in the biotech.

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APPENDIX A: Interview Questions

Industry Personnel
Workforce/Industry/Employment Questions
<ul style="list-style-type: none"> • What attracted your company to Georgia? Where there any specific legislative acts, policies, or university relationships that affected your company's location choice? • Do you have trouble hiring for biotechnology-related positions? If so, what specific positions lend the most issues in terms of the hiring process? • How long does it usually take for you to hire a qualified "technologist" in life sciences and/or biotechnology? • What is the current gender/ethnicity demographic for your biotech employees? • Are you having trouble with employment retainment? If so, what specific positions lend themselves to the most issues? • Do you have plans to increase your "technician and/or technologist" positions over the next few years? • Do you have any current vacancies for life sciences or biotechnology "technicians or technologists at this time?" If yes, how many full time equivalent life sciences and biotechnology technicians and technologists are you looking for? • What are the most common values and/or expectations that potential employees express during the interview/hiring process? Based on employment satisfaction data from your organization, do you think those values/expectations are being met once they become employees? • Are there certain professional certifications that you require to fill biotech-related positions? • Do you feel that individuals you hire to fill biotech-related positions are either overqualified or underqualified for positions? In what way? • Are you working with an executive recruiter who is tapped into new, qualified talent pools of potential biotech employee candidates to help you find the right people to fill vacant positions? • What types of benefit plans are you offering to your biotech employees? Are you offering benefits outside of the traditional retirement box, such as tuition reimbursement and college savings plans? • Are there any policies that have or could potentially negatively impact your company?
Education and Training Questions
<ul style="list-style-type: none"> • What education levels do your employees have when they are hired? • Do you feel students in higher-ed life science degree programs are being properly trained for the multidisciplinary needs of the ever-changing biotech industry? • What are the most essential biotech company skills students need to learn from their graduate programs before entering into the workforce? • Are graduate programs excluding critical content from their curricula that hinder the education/training preparation for students entering the biotech workforce? • What methods do you use for training your biotech employees? Do you feel those methods were effective? • What knowledge and/or skills do learner employees at your organization need to have to be successful in their jobs? What barriers of success for a company would you say are unique to the Biotech Industry? To Georgia?

Educational Personnel

- How has your state's university system impacted the bio industry?
- Do you value scientific research, business-related skills, or a combination of both when it comes to training your students to graduate?
- Can you give a brief description of your admission and examination process that potential candidates must endure before entering your biotechnology/life sciences graduate programs?
- Is your curriculum designed to educate students through a cross-disciplinary framework? If so, how?
- What are your enrollment percentages in biotech/life science programs at the graduate level? Do you think certain incentives/state policies/etc. influence enrollment percentages?
- What do you think are the most pertinent social factors that increase a students' willingness to enter into a STEM education field?

APPENDIX B: Additional Job Analysis Tables & Figures

Table B1: Job Function Descriptive Table

Table B1: Job Function Descriptive Table		
Category	Category Definition	Examples
Laboratory	The category includes an array of jobs related to the research and development of new biotechnology-related products. Job functions include the culturing of samples, handling hazardous chemicals, and logging scientific information	Conjugation Scientist; Analytical Chemist; Biochemistry Research Scientist; Principal Scientist; Product Development Scientist; Laboratory Automation Technician
Manufacturing	The category includes jobs related to supply chain, packaging, labeling, and quality control.	Manufacturing Tech 2; Manufacturing Operations Associate; Quality Manager - Filing and Packing; Manufacturing Technician I; Manufacturing Supervisor, IG Purification -Dayshift; Manufacturing Operator
General & Administrative	The category includes duties related to customer service relations, logistics, information technology, project management, communications, public relations, and administrative affairs.	End User Services Manager; Onsite Production Services Coordinator; Manager, Technical Transplant Support; Agricultural Technology Specialist; Customer Service Representative; Account Manager; Purchasing & Materials Management Specialist; IT Analyst; Administrative Assistant.
Legal & Regulatory	The category includes positions in regulatory, quality assurance and control, legal counsel, and public affairs to influence policy and administration.	Regulatory Compliance Manager; Agriculture Compliance Specialist; Drug Safety Manager; International Regulatory Affairs and Quality Director; Quality Control Analyst; Quality Assurance Specialist; Manager of Quality and Regulatory Affairs
Clinical	The category includes positions with duties related to clinical trial management and authorization, statistical analysis associated with clinical trials and product development, clinical technical writing, and the evaluation of medical records.	Clinical Research Analyst; Clinical Scientist; Dermatology Collaboration Lead; Clinical Research Manager, On-X Technologies; Pathologist

Sales & Marketing	The category includes duties such as product sales to physicians and outside organizations, brand/product positioning, market analysis, and instituting networking initiatives via trade shows.	Market Access Strategy & Innovation Lead (Immuno); Regional Sales Manager Georgia; Product Brand Director - Immunology In-Office Injection Solution Lead; Payer Value HEOR Lead; Market Analyst
Business	The category includes positions in finance, business development, budgets, accounting, and metrics.	Operational Excellence Lead; Business Project Manager II; Business Systems Analyst; Imm Dermatology District Manager
Engineering	The category includes the responsibility for oversight of operational and troubleshooting support for facility systems, manufacturing, automation, quality assurance, and validation and operations. Duties also include projects related to facility improvement and design and the preparation risk assessment reports and Standard Operating Procedures (SOPs).	Senior Validation Engineer; WWTP Sr. Utilities Technician; Engineer II – Tech Services; Lead Quality Assurance Engineer; Utilities & Facilities Engineering – HVAC; Lead Technical Specialist, Utilities Automation

Table B2: Job Postings by City

City	Number of Job Posts	Percentage of Total
Alpharetta	27	21%
Social Circle	27	21%
Atlanta	19	15%
Athens	7	5.4%
Gainesville	7	5.4%
Norcross	7	5.4%
Union City	5	4%
Kennesaw	4	3%
Augusta	3	2.3%
Duluth	3	2.3%
Smyrna	3	2.3%
Albany	1	0.78%
Clayton	1	0.78%
Cornelia	1	0.78%
Covington	1	0.78%
Decatur	1	0.78%
Forest Park	1	0.78%
Forsyth	1	0.78%
Fort Valley	1	0.78%
Griffin	1	0.78%
Milton	1	0.78%
Roswell	1	0.78%
Savannah	1	0.78%
Statesboro	1	0.78%
Sugar Hill	1	0.78%
Tifton	1	0.78%
Unknown	7	5.4%

Table B3: Job Skill Set Descriptions

Table B3: Job Skill Set Descriptions	
Skill	Description
<i>Hard Skills</i>	<i>Hard skills are learned, technical abilities that are acquired and enhanced through practice, repetition, and education. (Kagan 2019)</i>
Business and Marketing Skills	Knowledge of business intelligence software; awareness of industry trends; ability to provide consultative selling to researchers/scientists, educational institutions, and hospitals; ability to carry out market research to understand customer interests; provide product information and demonstrations to prospective customers; effective negotiation and convincing abilities
Computer/Technical Literacy Skills	IT technical knowledge; understanding of what computer hardware/software can do; website building and management Internet and customer service/search engine knowledge; social media expertise; working knowledge of Microsoft platforms (Excel, PowerPoint, Word)
Legal and Regulatory skills	Combination of scientific, legal, and corporate awareness to make sure products are developed and manufactured in line with industry and government standards; ensure necessary licensing and legal components are all compliant before product is allowed to enter the market place
Manual Labor Dexterity Skills	Ability to lift heavy weight; ability to be active for long periods of time; willingness to work in environment with toxic or caustic chemical exposure.
Production (i.e. Engineering and Laboratory skills)	Bioprocessing: skillset that uses complete living cells or their components (e.g., bacteria, enzymes, chloroplast) to obtain desired products; chemical engineering skill sets; biomedical engineering skill sets; gene therapy; Product characterization ; DNA structure and analysis; performs testing of samples in laboratory ; ensures quality and safety in laboratory setting
Quality Assurance Skills	Systematic skills of managing the quality of products and processes involved in their production.
Statistical Analysis Skills	Advanced understanding of statistical software, analyses, and procedures; bioinformatics
<i>Soft Skills</i>	<i>“Soft skills refer to the cluster of personality traits, social graces, facility with language, personal habits, friendliness, and optimism that mark people to varying degrees (Schultz 2008)</i>
Communication and Writing Skills	Explain findings to decision-makers in a clear and concise way (both written and orally); technical writing skills; ability to adapt presentations to fit the intended audience; update organizations SOP's
Education and Training Skills	Educate, train, interview/hire; conduct product demonstrations; conduct seminars and workshops for clients and/or employees

Leadership and Management Skills	Ability to develop conflict management strategies; combine strategic thinking with efficient time management mentality; excellent interpersonal skills to handle sensitive and delicate tasks
Problem Solving and Self-Starting Skills	Ability to independently troubleshoot, solve difficult problems, and propose solutions related to assay design and execution.
Teamwork and Customer Service Skills	Ability to share information across divisions, while interacting with both scientists and non-scientists; ability to incorporate team members needs into an integrated plan; good interpersonal skills; ability to work with diverse teams

Fig. B1: Desired Skill Set by Sub-Industry

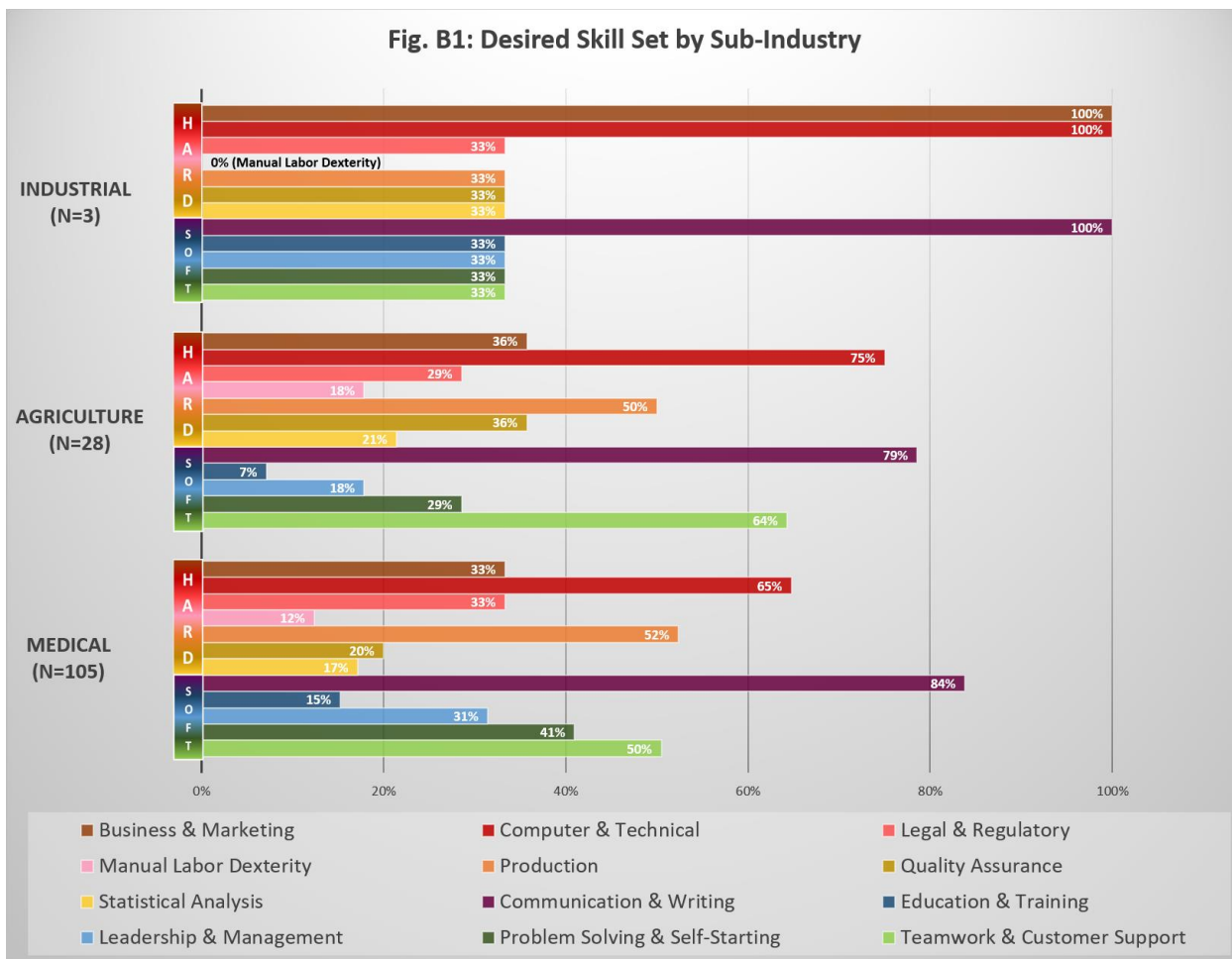


Fig. B2: Desired Skill Set by Job Function (2-parts)

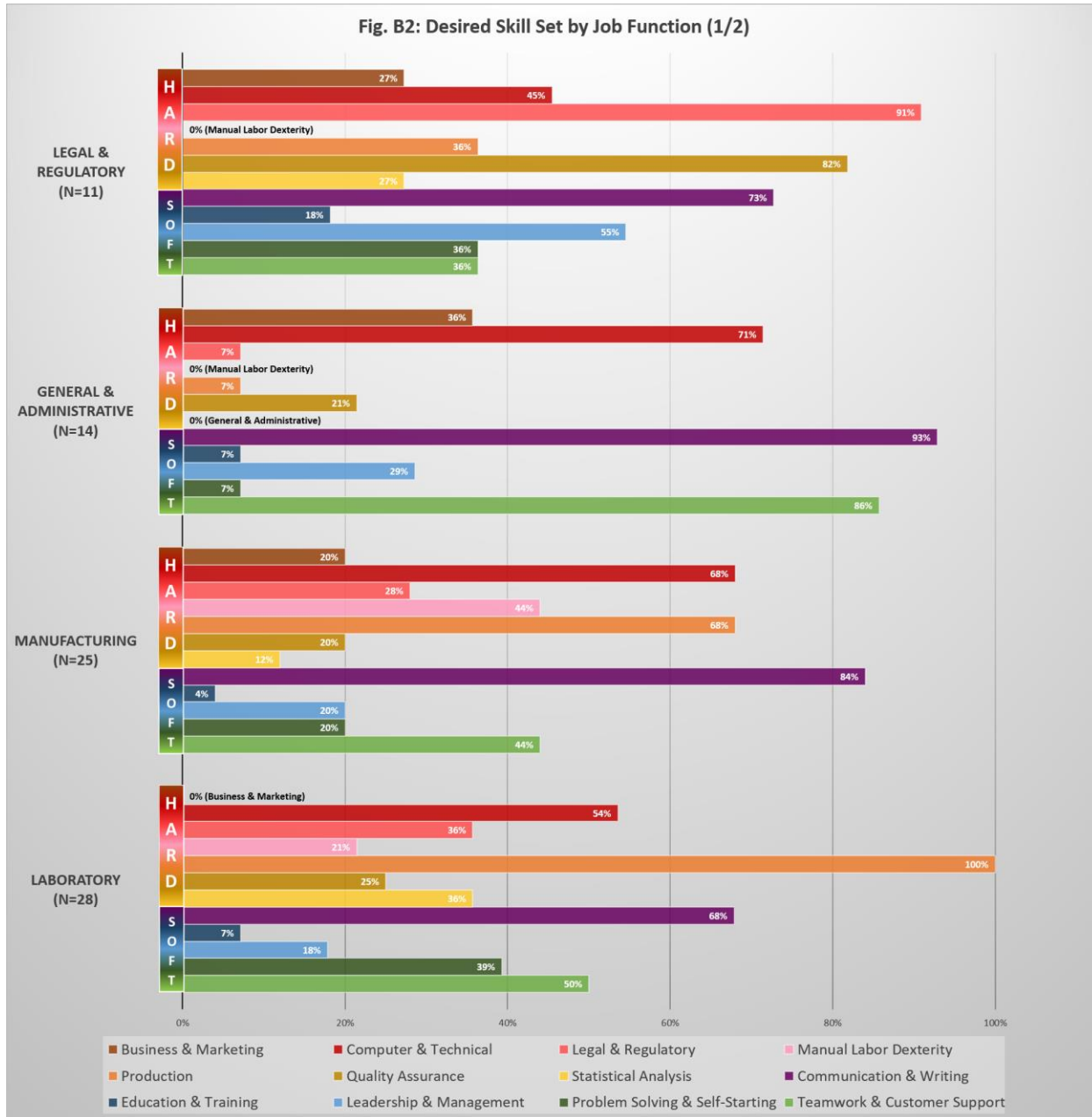
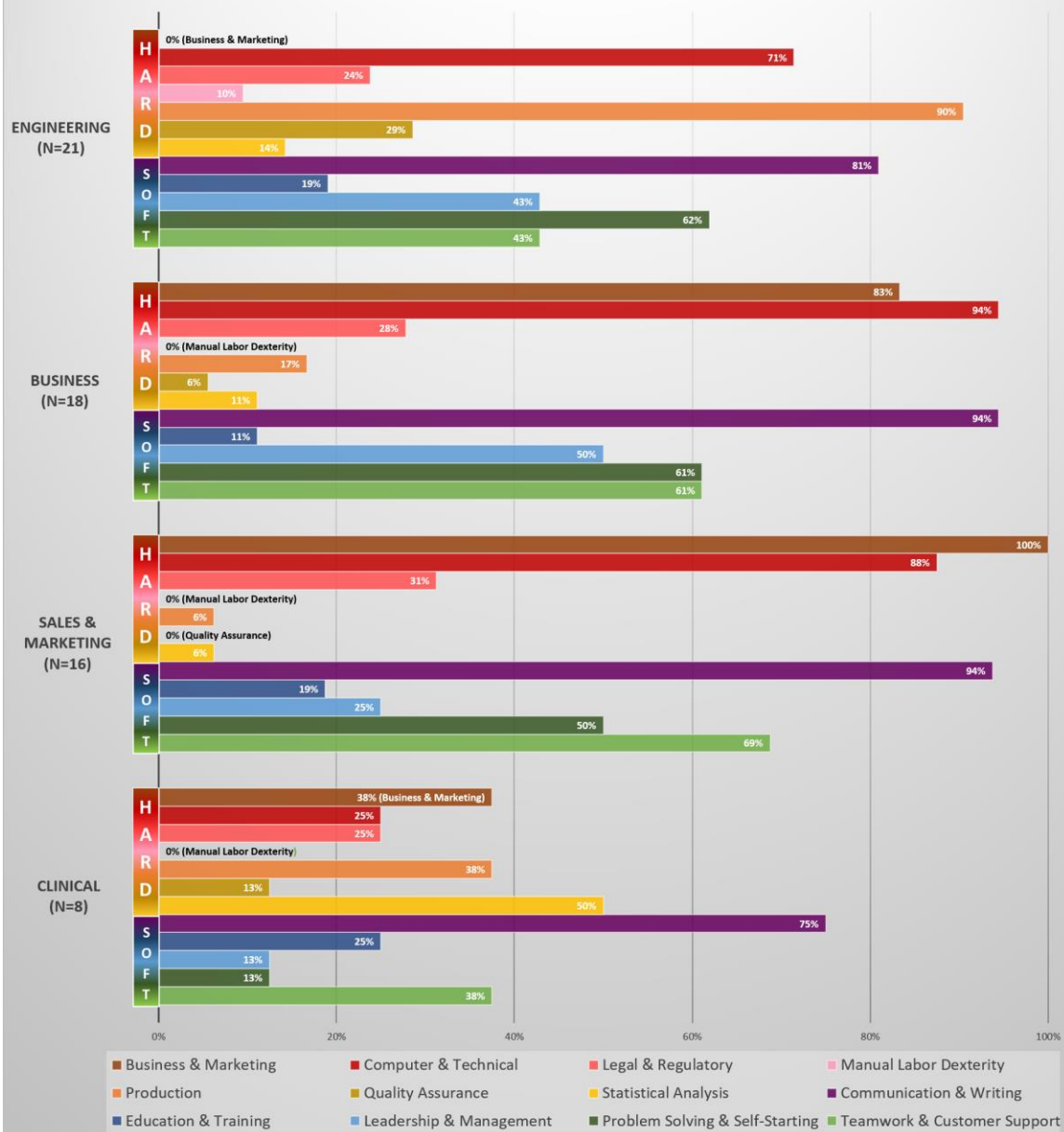


Fig. B2: Desired Skill Set by Job Function (2/2)



APPENDIX C: Degrees Awarded

Table C1: USG Engineering Degrees Awarded

Degree Subject	BS	MS	Ph.D.
Engineering, General.	0	12	7
Aerospace, Aeronautical and Astronautical/Space Engineering.	172	143	41
Agricultural Engineering.	10	0	5
Bioengineering and Biomedical Engineering.	245	40	40
Chemical Engineering	216	35	35
Civil Engineering, General	298	108	24
Computer Engineering, General	214	0	0
Computer Software Engineering	40	13	0
Electrical and Electronics Engineering	375	354	91
Engineering Mechanics	0	4	0
Engineering Science	0	0	0
Environmental/Environmental Health Engineering	73	26	5
Materials Engineering	70	13	26
Mechanical Engineering	944	225	38
Nuclear Engineering	30	5	11
Systems Engineering	25	43	0
Construction Engineering	4	0	0
Industrial Engineering	337	72	15
Manufacturing Engineering	0	6	0
Operations Research	0	29	10
Paper Science and Engineering	0	2	0
Biochemical Engineering	18	3	0
Biological/Biosystems Engineering	39	4	0
Engineering, Other	0	1	0
TOTAL	3,110	1,138	348

Table C2: TCSG Degrees Awarded

TCSG Graduates and Awards Conferred - TES0263 (Filtered for Biotechnology Majors)						
Fiscal Year	College Name	Major Code	Major	Major	Certificates	Degrees
2016	Athens Technical College	BI13	Bioscience	AAS	0	4
	Athens Technical College	BS11	Biological Sciences Laboratory Technician	TCC	9	0
	Athens Technical College	RC11	Bioscience Regulatory Assurance Technologist	TCC	1	0
	Atlanta Technical College	BE61	Bioscience Environmental Laboratory Technologist	TCC	12	0
	Atlanta Technical College	BR41	Bioscience Regulatory Assurance Technologist	TCC	13	0
	Atlanta Technical College	BT13	Bioscience Technology	AAS	0	2
	Central Georgia Technical College	BI23	Biotechnology	AAS	0	5
	Central Georgia Technical College	BLA1	Biotechnology Laboratory Assistant	TCC	5	0
	Gwinnett Technical College	BT13	Bioscience Technology	AAS	0	17
2017	Athens Technical College	BI13	Bioscience	AAS	0	7
	Athens Technical College	BS11	Biological Sciences Laboratory Technician	TCC	10	0
	Athens Technical College	RC11	Bioscience Regulatory Assurance Technologist	TCC	2	0
	Atlanta Technical College	BE61	Bioscience Environmental Laboratory Technologist	TCC	8	0
	Atlanta Technical College	BR41	Bioscience Regulatory Assurance Technologist	TCC	5	0
	Atlanta Technical College	BT13	Bioscience Technology	AAS	0	1
	Central Georgia Technical College	BI23	Biotechnology	AAS	0	5
	Central Georgia Technical College	BLA1	Biotechnology Laboratory Assistant	TCC	5	0

	Gwinnett Technical College	BT13	Bioscience Technology	AAS	0	10
2018	Athens Technical College	BI13	Bioscience	AAS	0	8
	Athens Technical College	BS11	Biological Sciences Laboratory Technician	TCC	4	0
	Athens Technical College	RC11	Bioscience Regulatory Assurance Technologist	TCC	1	0
	Atlanta Technical College	BE61	Bioscience Environmental Laboratory Technologist	TCC	11	0
	Atlanta Technical College	BR41	Bioscience Regulatory Assurance Technologist	TCC	7	0
	Atlanta Technical College	BT13	Bioscience Technology	AAS	0	7
	Central Georgia Technical College	BI23	Biotechnology	AAS	0	5
	Central Georgia Technical College	BLA1	Biotechnology Laboratory Assistant	TCC	3	0
	Gwinnett Technical College	BT13	Bioscience Technology	AAS	0	6
2019	Athens Technical College	BI13	Bioscience	AAS	0	1
	Athens Technical College	BS11	Biological Sciences Laboratory Technician	TCC	2	0
	Athens Technical College	RC11	Bioscience Regulatory Assurance Technologist	TCC	1	0
	Atlanta Technical College	BR41	Bioscience Regulatory Assurance Technologist	TCC	1	0
	Atlanta Technical College	BT13	Bioscience Technology	AAS	0	3
	Central Georgia Technical College	BI23	Biotechnology	AAS	0	2
	Central Georgia Technical College	BLA1	Biotechnology Laboratory Assistant	TCC	4	0
	Gwinnett Technical College	BT13	Bioscience Technology	AAS	0	6

APPENDIX D1: CTSO Implementation

CTSO (Career and Technical Student Organizations) are co-curricular activities that are designed to enrich classroom learning by providing students with the opportunity to participate in after-school career-related activities. CTSO organizations are “not clubs,” but more organized, similar to a sports team.

CTSO organizations are organized as after-school activities in middle and high school by the school leadership, teachers, and students. School district CTAE administrators are the school's point of contact for communicating coordination and budget approvals with the State of Georgia. Typically, the administration of competitions and professional and student development events is conducted by an executive director and/or their assignees located within a non-profit affiliated organization, in this case could be Georgia Bio.

Currently, there are nine CTSO programs in Georgia. They are FFA (Future Farmers of America), FIRST (For Inspirations and Recognition of Science and Technology), SkillsUSA, TSA (Technology Student Association) and HOSA (Future Health Professionals, CTI (Career & Technical Instruction), DECA (formerly Distributive Education Clubs of America), FBLA (Future Business Leaders of America), and FCCLA (Family, Career and Community Leaders of America)..

The HOSA CTSO is intended to align to the following CTAE Pathways.

- Diagnostic Services
- Therapeutic Services-Medical
- Health Informatics
- Physical Medicine
- Therapeutic Services-Emergency
- Biotechnology Research & Development
- Therapeutic Services-Nursing

Note that HOSA targets the Biotech pathway. It is unknown if any Georgia HOSA chapter participates in Biotechnology activities, or the item is listed as a placeholder or aspirational option. Also note that FIRST, TSA, and SkillsUSA have some overlap in certain areas of STEM activities. For example, TSA, SkillsUSA, and FIRST each have robotics competitions. Each system has different optimization.

It may be worth considering supporting and accelerating the Biotechnology area within the HOSA CTSO. If it is deemed that the Biotechnology pathway can better be supported by the creation of a new CTSO pathway, the lead can be taken by Georgia Bio. Georgia Bio would then ask the State Department of Education to implement a Georgia Bio CTSO, and then ask the Georgia Legislature to support the budget request needed by GaDOE to support the initiative. The implementation of a new Georgia Bio CTSO requires an administrative decision by the executive leadership of GaDOE. It does not require legislative approval, nor the State Board of Education approval.

When the state authorizes a CTSO, it provides an information signal to the school districts that the activity is valid, desired, and needed. It also enables funding to flow into schools to support the CTSO team. The funding source is part of state education monies from the general funds and partly from Federal Perkins funds.

In order for a school teacher and the CTSO team to receive the allotment of funds, the teacher and team must agree to a POW, or Program of Work. Each CTSO has their own POW, that is designed and agreed upon by the state CTSO executive leadership and the GaDOE CTAE program office.

The POW has several required areas. They are:

- Operations

- Leadership
- Team Activities
- Professional Development
- Competition Events

The POW is a menu structure, allowing the teacher and team to select options that maximize their utility. A minimum number of activities in each area must be done, as assessed by a points earned for compliance. When the team fulfills their POW, the state funds will be provided for limited team expenses and a teacher stipend.

Please see the next section for an example POW:

APPENDIX D2: Example CTSO Program of Work

APPENDIX D2: *Example* CTSO Program of Work

Example Extended Day Program of Work (POW) for Biotechnology

Operations - *Example*

(Minimum 15 points)

- ____ The Biotechnology Coach shall organize and maintain a local competition team with by serving as the advisor (coach) and shall affiliate (register) with the state and national organization by October 1st.
NOTE: Georgia Biotechnology requires a minimum of 10 members to affiliate on the local level.
Points: 5

- ____ The Biotechnology Coach shall submit a local Plan of Yearly Activities and a Team Budget. The Plan and Budget should be approved by the local system CTAE Director by October 1st.
Points: 5

- ____ The local competition team shall conduct at least five chapter meetings during the school year. (This is a true business meeting with recorded minutes.) A minimum of three career and/or leadership activities should be conducted.
Points: 5

List Activities:

Point 1

Point 1

Point 1

Point 1

Point 1

Leadership - *Example*

(Minimum 15 points)

- ____ The Biotechnology Coach and at least three (3) student leadership team members shall participate in the Georgia Biotechnology Symposium for Leadership Training.

Points: 5

Note: The Georgia Biotechnology Symposium is a one-day conference designed to teach and discuss a wide range of topics to support several areas of interest, including but not limited to:

- Design Processes
- Manufacturing Processes
- Leadership Development
- Community Engagement
- Corporate Partnership Development & Engagement
- Safety Training & Support
- Media & Communications
- STEM Education & Literacy Advocacy
- Public Policy Advocacy

Conference sessions are targeted to Biotechnology students, as well as Biotechnology Coaches. The Biotechnology Symposium(s) are principally hosted at select units of USG, including Georgia Tech, Kennesaw State University, University of Georgia, and Georgia Southern University.

- ____ The Biotechnology Coach coordinates the selection of at least one student leader for the activities of the Georgia Biotechnology team captain or co-captains. The Coach will act as a leadership mentor and provide structured leadership training to the student leader(s). Evidence of student leadership development must be evident in the team's Yearly Plan of Activities and/or other award submissions

Points: 5

- ____ The Biotechnology Coach and at least three (3) student team members shall participate in an advocacy activity/event (e.g. attend a CTSO legislative event, such as CTSO Day at the Capitol, send a letter/email or face-to-face meeting to a local legislator explaining the importance of the Biotechnology Competition and copy the Georgia Biotechnology Director, make a presentation to local administrators, to business/industry personnel, and/or to community groups about the CTSO.

Points: 5

- ____ The Biotechnology team (at least 3 members) will volunteer at a Biotechnology competition event.

Points: 5

While participation in all activities is encouraged, a minimum of 30 points of activities in this section must be completed.

Team Activities - *Example*

(Minimum 20 points)

- ____ The Biotechnology team shall participate in two (2) marketing/public relations activities that are designed to increase awareness of Georgia Biotechnology that you as the advisor will help plan and execute. Submit appropriate materials that includes at least one (1) article with digital photos for submission to the local school newspaper, local paper, and/or school/system website.

Points: 5

- ____ The Biotechnology team and Coach shall attend the Biotechnology competition kickoff event.
Points: 5

- ____ The Biotechnology team shall conduct activities in recognition of CTAE Month that the coach shall help plan and execute. Submit appropriate materials that include at least one (1) digital photo for submission in the Georgia Bio website.
Points: 5

- ____ The Biotechnology Coach shall serve as an event coordinator/planner for the Georgia Biotechnology Symposium.
Points: 5

- ____ The Biotechnology Coach shall serve as an active member of the Georgia Bio Mentor Advisory Council (BMAC).
Points: 5

The Biotechnology Team shall conduct a local/state community service project. List activities below:

Point 1

Point 1

Point 1

Point 1

Point 1

While participation in all activities is encouraged, a minimum of 20 points of activities in this section must be completed.

Biotechnology Teacher Professional Development - *Example*

(Minimum 15 points)

Activities:

- ____ The Biotechnology Coach and team will present/moderate one (1) conference session at a Georgia Biotechnology Symposium. A formal session submission must be presented to and approved by the Georgia Bio CTSO Director one month prior to the event. Conference sessions may be designed around technical and non-technical (leadership) components of a Biotechnology team.
Points: 5

___The Biotechnology Coach shall attend the Georgia Bio Biotechnology Mentor Advisory Council (BMAC) annual meeting.

Points: 5

___The Biotechnology Coach shall attend a Georgia Biotechnology competition scrimmage event and offer assistance to any teams in need.

Points: 5

___The Biotechnology Coach shall attend at least one Technical Enrichment Session held at Georgia Bio.

Points: 5

While participation in all activities is encouraged, a minimum of 15 points of activities in this section must be completed.

Competitive Events/Awards - *Example*

(Minimum *TBD* points)

Biotechnology Competition

___*The Biotechnology Coach and competition team shall compete in TBD competitions*

While participation in all activities is encouraged, a minimum of *TBD* points of activities in this section must be completed.