Bioscience Workforce Educational Needs: Supply and Demand in Georgia

GEORGIA'S ICAPP INTELLECTUAL CAPITAL PARTNERSHIP PROGRAM

Georgia Tech Enterprise Innovation Institute

Bioscience Workforce Educational Needs

Supply and Demand in Georgia

Georgia Tech
Enterprise Innovation Institute
City and Regional Planning Program

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Executive Summary

The Office of Economic Development (OED) of the University System of Georgia (USG) asked Georgia Tech to investigate the extent to which current and future needs of the bioscience industry can be enhanced by the type or level of talent produced by the state's higher educational system. We define bioscience as the manufacturing of pharmaceuticals, medicine, specialized chemicals and food products, equipment, supplies, and instruments as well as bioscience related R&D and laboratory services.

Summary of Findings

- Georgia's higher education system is currently meeting the overall needs of the bioscience industry. The current level of higher education graduates is also sufficient to support a modest expansion of the industry over the next 10 years as projected by the Georgia Department of Labor. Detailed findings follow.

- Georgia's bioscience industry employs around 25,000 workers as of 2006, which reflects a modest 1% decline from 2001 levels. The largest detailed sub-industries in Georgia are medical laboratories (15%), pharmaceutical and medicine manufacturing (13%), and navigational, measuring, electromedical, and control instruments manufacturing (12%). The fastest growing industries are diagnostic imaging centers, R&D in the life sciences, dental equipment and supplies manufacturing, nitrogenous fertilizer manufacturing, and surgical appliance and supplies manufacturing. Some of these industries are fueled by use of the health and elder care services sectors rather than bioscience as it is distinctly conceived.

- Georgia has greatest specializations, compared to national industries, in: artificial and synthetic fibers and filaments manufacturing (including Cellulosic organic fiber manufacturing), ophthalmic goods manufacturing, pesticide and other agricultural chemical manufacturing, and dental laboratories.

- Georgia bioscience industries fared better than the nation in the 2001 to 2006 time frame. Georgia has about 300 more bioscience jobs than it would have had it followed national trends. This is especially true in medical device manufacturing and R&D and testing services.

- Bioscience industries in Georgia are expected to grow by 12% from 2004 to 2014. The fastest growing bioscience sub-industries in Georgia include: (1) Pharmaceutical and medicine manufacturing, (2) testing laboratories, and (3) medical and diagnostic laboratories.

- Averaged over the 2004-2006 time period, Georgia's public and private postsecondary institutions have more than 5,500 graduates in bioscience related programs annually. Nearly 100 postsecondary educational institutions provide bioscience program education, with University of Georgia producing the largest number of bioscience graduates from a public institution. The two largest majors – medical/clinical assistant and biology/biological sciences – account for more than 80% of all graduates.

- Georgia's academic output by program, while sizeable, is lower than one would expect based on the national average, in all but the clinical/technical area. Georgia ranks 10th in overall number of bioscience graduates, 7th in number of clinical/technical graduates, 13th in number of biological science graduates, 16th in biomedical science graduates, 20th in agricultural science graduates, and 25th in medical science graduates.

- In terms of quantities of individual program graduates, Georgia's output is higher than the national average in dairy and poultry science, genetics, bioinformatics, and epidemiology. The state's output is lower than the national average in biomedical/medical engineering, microbiology, biochemistry, and biological and physical sciences.

- Georgia's bioscience occupations are expected to grow faster than the national average - by 20% from 2004 to 2014. The fastest growing occupation in Georgia's future bioscience workforce is medical scientists (38%), followed by food scientists and technologies (30%), medical and clinical laboratory technicians (29%) and technologists (25%), and biomedical engineers (27%).

- There will be an estimated 700 openings in Georgia for bioscience positions over the next 10 years. Two-thirds of these openings are capable of being filled by Georgia's supply of postsecondary graduates. That leaves a modest shortfall of 250 annually, which drops below 160 graduates a year if we remove programs that fall more in the health and elder care service sector. Ninety percent of the unfilled openings are for medical and clinical laboratory technologists, which typically require bachelor's degrees. The medical and clinical laboratory technician occupation, typically served through two-year associates degrees, is estimated to experience no great shortfalls in the next 10 years even though this was the primary area of need in the study conducted by the authors in 2003 (Drummond and Youtie, 2003).

- The good news is that, not withstanding the need for laboratory and clinical technologists, Georgia has enough talent being produced from higher education to support a modest expansion of the bioscience industry.

Recommendations

- Monitor workforce supply and demand for medical and clinical laboratory technologists, including bachelor's-degree and bachelor's-degree-plus-certificate programs. Investigate program best practices and evaluate for appropriateness in University System of Georgia.

- Set broad-based goals for Georgia to become a top five producer of bioscience graduates to determine the extent to which it will be necessary to expand the number of graduates in four of five broad programmatic subareas: agriculture, biomedical engineering, biology, and medical sciences.

- Monitor the need for vaccine and immunotherapy graduates in support of the state's vaccine initiative, The Next-Generation Vaccines and Therapeutics Initiative.

Study Team and Acknowledgements

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Chapter 1. Introduction

The bioscience industry has been a target for many regions including Georgia to create new opportunities for economic development. Since 2004, the report "State bioscience initiatives 2008: Battelle, SSTI, BIO" has been presenting information about bioscience industry employment and R&D activity in US states and metropolitan areas to facilitate technology-based development of the industry (Battelle, 2008). This report defines biosciences as

a diverse group of industries and activities with a common link—they apply knowledge of the way in which plants, animals, and humans function. The sector spans different markets and includes manufacturing, services, and research activities. (Battelle, 2008, p. ES-1).

The Battelle report has become the national standard for examining US, state, and metropolitan area bioscience activity. The report provides a very detailed look at employment, educational initiatives, and R&D on a state by state basis. The 2008 report was published very recently — in June, 2008.

Because of the prominence of the Battelle report, this analysis - sponsored by the Office of Economic Development (OED) of the University System of Georgia (USG) - builds on the report by providing a more indepth analysis of Georgia's talent needs. The value-added of this study, over and above the Battelle report, includes

- Forward looking focus on industry and occupational projections
- Analysis of employment patterns at more detailed industry levels
- Profile of major postsecondary educational programs
- Comparison of supply of postsecondary educational graduates with occupational employment needs to examine the extent of unmet workforce needs by the type or level of talent coming out of the state's higher educational system to service the current and future bioscience cluster.

Definition of Bioscience Industry

The definition of the bioscience industry used in this analysis is consistent with that of the Battelle report (See Table 1.) The Battelle report definition is wide ranging, covering 27 North American Industrial Classification System (NAICS) classes. This definition includes food processing, chemical manufacturing, drugs and pharmaceuticals, medical devices and equipment, and research and testing services.

We can examine the coverage of the Battelle report definition by comparing it to the definition of a Life Sciences cluster used by the Strategic Industries Task Force of the Commission for a New Georgia and the biosciences report developed by the authors in 2003. (Commission for a New Georgia 2004, Drummond and Youtie 2003). The results show considerable overlap in the NAICS classes used in these studies. The Battelle study's definition encompasses those of the Commission and the Drummond and Youtie study. While the Battelle study also includes three food processing classes that are not in the Commission and Drummond and Youtie studies, one could contend that these classes represent the agricultural biotechnology (ag-bio) segment of the biosciences, and therefore, deserve inclusion.

Table 1.1 Battelle Study Bioscience Definition based on Industry Classifications

NAICS	Description
Agricultural Feedstock and Chemicals	
311221	Wet corn milling
311222	Soybean processing
311223	Other oilseed processing
325193	Ethyl alcohol manufacturing[1]
325199	All other basic organic chemical manufacturing[1 2]
325221	Cellulosic organic fiber manufacturing
325311	Nitrogenous fertilizer manufacturing
325312	Phosphatic fertilizer manufacturing
325314	Fertilizer (mixing only) manufacturing
325320	Pesticide and other agricultural chemical manufacturing
Drugs and Pharmaceuticals	
325411	Medicinal and botanical manufacturing[1 2]
325412	Pharmaceutical preparation manufacturing[1 2]
325413	In-vitro diagnostic substance manufacturing[1 2]
325414	Other biological product manufacturing[1 2]
Medical Devices and Equipment	
334510	Electromedical apparatus manufacturing[1 2]
334516	Analytical laboratory instrument manufacturing[1 2]
334517	Irradiation apparatus manufacturing[1 2]
339111	Laboratory apparatus and furniture manufacturing[1 2]
339112	Surgical and medical instrument manufacturing[1 2]
339113	Surgical appliance and supplies manufacturing[1 2]
339114	Dental equipment and supplies manufacturing[1]
339115	Ophthalmic goods manufacturing[1]
339116	Dental laboratories[1]
Research, Testing, and Medical Laboratories	
541380	Testing laboratories[2]
541710	R&D in the physical, engineering, and life sciences[1 2]
621511	Medical laboratories[1 2]
621512	Diagnostic imaging centers[1]

[1]These NAICS classes were included in the definition of Life Sciences cluster in the Commission for a New Georgia (2004) report. The NAICS class Other Professional, Scientific, and Technical Services (541900) was a part of the Commission Life Sciences cluster definition, but not the

Battelle 2008 bioscience report, because it is a miscellaneous category that does not involve bioscience. Likewise, Outpatient Care Centers (621400), also included in the Commission cluster definition but not the Battelle 2008 bioscience report, concerns medical health services rather than bioscience.
[2]Included in Drummond and Youtie (2003).
Source: Battelle, 2008.

In addition to the 27 NAICS classes in the Battelle report, this analysis will show that Bioscience industry is also comprised of 16 occupations (from the Battelle report) and 38 educational programs (from our own analysis). The extent to which educational programs meet the needs of these occupations within the bioscience industries is the primary subject of this report.

History and Approach

The University System of Georgia has partnered with Georgia Tech since 1997 to develop a systematic methodology for assessing the supply of graduates relative to the projected demand for these graduates in the workplace. Previous studies have assessed demand for employees in various occupations at the national, state, and substate regional levels. We have also assembled information on the supply of graduates from both public and private postsecondary institutions in Georgia. We have broadly measured shortfalls across a range of occupations requiring various levels of college education. These studies have pioneered methods for tracking and estimating intra- and inter-state migration of university graduates as they move from their school environment to taking their first job based on the acquisition of matched graduate data from the Georgia Department of Labor. In addition, we have focused on the talent needs of particular occupations identified as important strategic industries by the Commission for a New Georgia such as logistics (2005) and aerospace (2008) (Youtie, et al., 2005; Drummond et al., 2008). Previous studies also have measured the value of higher education based on exploratory education-related measurement approaches. (Drummond and Youtie 1997, Drummond and Youtie 1999, Drummond and Youtie 2001, Drummond and Youtie 2003a). This knowledge is drawn upon to address the distinctive challenge of measuring talent needs in the bioscience industry in Georgia.

Objectives

The aim of this project is to develop a synoptic update of the bioscience analysis conducted by Drummond and Youtie in 2003. More specifically, the objectives are to:

- Extend the Battelle report findings and approach to provide more detailed and indepth information about the bioscience industry, workforce, and educational programs in Georgia
- Determine what jobs, current and future, are involved in this area

- Compare educational profiles of Georgia postsecondary programs with those in other regions to assess any areas of weakness.
- Match future demand for occupations with current supply of graduates in instructional programs to identify significant areas of unmet need for bioscience talent.
- Identify competencies needed to be addressed by underserved instructional programs
- Profile best practice bioscience postsecondary programs outside Georgia based on quantitative results.

Method and Report Organization

Industry Analysis

The industry analysis portrays the size of the bioscience industry as a whole and its subindustry components. The analysis uses employment data from the US Bureau of Labor Statistics's Quarterly Census of Employment and Wages to assess Georgia's competitive position relative to the nation. We report results from the Battelle study to show Georgia's position relative to comparison states. Industry employment projections to 2014 for Georgia are also presented. (Chapter 2)

Academic Supply

The report presents 38 postsecondary educational specializations – i.e., majors – with high relevance to the bioscience industry. The numbers of graduates in these specializations in postsecondary educational institutions in Georgia and across the nation are arrayed to form the basis for assessing Georgia's educational strengths and weaknesses in bioscience programs. We obtained the data from the Integrated Postsecondary Educational Dataset (IPEDS) of the National Center of Educational Statistics (NCES). (Chapter 3)

Projected Demand and Shortfall Analysis

Occupational employment projections in the 2004-to-2014 time period from the US Bureau of Labor Statistics and the Georgia Department of Labor are matched with academic supply figures to identify significant areas of unmet need or shortfalls in Georgia. (Chapter 4)

Recommendations

This section discusses the strengths and weaknesses of the bioscience industry in Georgia. Recommendations for redressing weaknesses are discussed. (Chapter 5)

Chapter 2. Bioscience Industry Analysis

Overview

The Biotechnology Industry Association reports that biotechnology revenues in health care biotechnology nationwide grew from $8 billion in 1992 to $50.7 billion in 2005.[1] By 2006, nationally some 1.3 million employees worked for a bioscience company. Growth from 2001 to 2006 in bioscience employment was 5.7%, faster than the growth of the economy as a whole (3.1%). These statistics suggest that the industry is a significant and growing part of the R&D intensive economy.

This chapter will examine the bioscience cluster as defined in Chapter 1, look at past industry employment trends from 2001 to 2006, and present forecasts of future employment trends to 2014. Georgia's competitive position in the bioscience industries will be measured using basic economic analysis tools such as location quotients and shift share analysis.

A location quotient (LQ) measures a state's relative concentration of a particular industry or specialization in a particular industry. Typically, the percentage of total jobs in an industry in a state is compared to the same ratio for the U.S., to create the LQ. For example, if an industry has 2% of total jobs in a state and that same percentage prevails for the U.S. economy, then the LQ is 1.0 (state percentage divided by the U.S. percentage). Therefore, a location quotient larger than 1.0 indicates the industry is more concentrated in the state than in the U.S.; less than 1.0 indicates just the opposite.

A shift share analysis breaks down employment growth into national share, national industry mix, and regional shift components. These components are used to estimate a region's competitiveness relative to that of the nation. A shift share analysis commonly compares what a state's job growth would have been if it followed national trends to what the job growth actually was. If the actual figure is higher than the national trends, the higher figure represents the state's competitive advantage.

Georgia's Current Bioscience Industry

The Battelle report conducts an analysis of employment size, specialization (LQ), and growth to identify the top bioscience states across each of four subsectors. We have summarized these results in Table 2.1 and also included Georgia's position according to the Battelle report. California is a leader in three

[1] http://bio.org/ataglance/

subsectors; and Massachusetts, Pennsylvania, and New Jersey are prominent in two of the subsectors.

The Battelle report does not situate Georgia among the employment leaders. The report's bioscience subsector analysis of 2001 to 2006 employment changes in Georgia shows that: (1) the state's agriculture and feedstock chemicals subsector declined by 26%; (2) the drugs and pharmaceuticals subsector increased slightly by 3.2%; (3) the medical devices and equipment subsector declined slightly by 4.2%, and (4) the research, testing, and medical laboratories sector grew by nearly 30%.

Georgia has six metropolitan areas that are included among the top 15 metropolitan areas in each of the five bioscience subsectors in the Battelle report based on either total numbers of employees or LQs (i.e. specialization). Atlanta is included because it has large numbers of employees in the medical devices and research/testing/medical laboratory subsectors (represented as "large" in Table 2.1). Five metropolitan areas are included because they have high levels of specialization (that is, higher LQs than other similarly sized metropolitan areas and represented as "specialization" in Table 2.1) in certain subsectors: Augusta (agriculture, drugs and pharmaceuticals), Valdosta (agriculture, research/testing/medical laboratories), Athens (drugs and pharmaceuticals), Albany (drugs and pharmaceuticals), and Warner Robins (research/testing/medical laboratories). Thus, although the state as a whole is not situated among the bioscience employment leaders, certain metropolitan areas are highlighted as having notable levels of activity.

Table 2.1. Georgia's Position Relative to Top Bioscience States

Bioscience Sector	Agriculture Feedstock and Chemicals	Drugs and Pharmaceuticals	Medical Devices	Research, Testing, Medical Laboratories
Top States*	Texas	California	California	California
(by size and	Illinois	New Jersey	Minnesota	Pennsylvania
specialization)	Tennessee	Puerto Rico	Massachusetts	Massachusetts
	Iowa	Pennsylvania		New Jersey
	Ohio	North Carolina		
		Indiana		
		Illinois		
Georgia's Position				
Size	Small size	Small size	Small size	Small size
Specialization	Under-average specialization	Under-average specialization	Under-average specialization	Under-average specialization
Growth	Unchanged growth/Small loss	Moderate growth	Unchanged growth/Small loss	Substantial growth
Metropolitan	Augusta,	Augusta, Athens,	Atlanta (large)	Atlanta (large),

Table 2.1. Georgia's Position Relative to Top Bioscience States				
Bioscience Sector	Agriculture Feedstock and Chemicals	Drugs and Pharmaceuticals	Medical Devices	Research, Testing, Medical Laboratories
areas in top 15	Valdosta (specialization)	Albany (specialization)		Valdosta, Warner Robins (specialization)

Source: Battelle, 2008, pp. ES-4-ES-7.

It can be argued that these broad subsector comparisons are not fine grained enough to portray fully Georgia's bioscience sectors. In this analysis, we breakdown the state's employment into more detailed five- and six-digit NAICS classes. (See Table 2.2.) Five-digit classes are used when there are insufficient numbers of companies at the six-digit level to permit disclosure of employment data. Because the Battelle report only includes a proportion of testing laboratories and R&D facilities performing biological and life sciences functions, we took a percentage (half) of the total employment in NAICS classes 541380 and 541710.

In total these detailed sub-industries accounted for about 25,000 jobs in Georgia in 2006, down by just under 1% since 2001. This job figure is slightly higher than what is reported in the Battelle report (just under 20,000) but within the same order of magnitude.

The largest bioscience sub-industries in Georgia are: Medical Laboratories (15%), Pharmaceutical and Medicine Manufacturing (13%), and Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (12%). Together these three sub-industries comprise 40% of bioscience employment in the detailed subsectors. However, Diagnostic Imaging Centers had the highest growth (70%) in employment from 2001 to 2006, although this growth is also fueled by the strong health and elder care services sector. In addition, R&D in the Life Sciences experienced 30% growth in employment from 2001-2006. In manufacturing, the fastest growing sub-industries were Dental equipment and supplies manufacturing (19%), Nitrogenous fertilizer manufacturing (16%), and Surgical appliance and supplies manufacturing (13%).

Table 2.2. Bioscience Industry Employment in Georgia: 2006 and Change from 2001				
Industry Class (NAICS)		2006	Change	% Change
31122[1]	Starch and Vegetable Fats and Oils Manufacturing	661	-310	-31.9%
32519[1]	Other Basic Organic Chemical Manufacturing	1048	-285	-21.4%
32522[1]	Artificial and Synthetic Fibers and Filaments Manufacturing	1198	-266	-18.2%

Table 2.2. Bioscience Industry Employment in Georgia: 2006 and Change from 2001				
Industry Class (NAICS)		2006	Change	% Change
325311	Nitrogenous fertilizer manufacturing	186	25	15.5%
325312	Phosphatic fertilizer manufacturing	120	-59	-33.0%
325314	Fertilizer (mixing only) manufacturing	204	-80	-28.2%
325320	Pesticide and other agricultural chemical manufacturing	532	-132	-19.9%
32541[1]	Pharmaceutical and Medicine Manufacturing	3271	112	3.5%
33451[1]	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	2981	-982	-24.8%
339111	Laboratory apparatus and furniture manufacturing	22	-3	-12.0%
339112	Surgical and medical instrument manufacturing	761	-157	-17.1%
339113	Surgical appliance and supplies manufacturing	2389	269	12.7%
339114	Dental equipment and supplies manufacturing	198	32	19.3%
339115	Ophthalmic goods manufacturing	1732	-53	-3.0%
339116	Dental laboratories	1731	-114	-6.2%
541380[2]	Testing laboratories	1107	107	10.7%
541710[2]	R&D in the physical, engineering, and life sciences	2017	534	36.0%
621511	Medical laboratories	3675	533	17.0%
621512	Diagnostic imaging centers	1467	605	70.2%

[1] Because of suppressed values, we aggregated this sector to the 5-digit NAICS class.
[2] Estimates of the proportion of employees performing biological and life sciences functions (0.50) were made.
Source: US Bureau of Labor Statistics, Quarterly Census of Employment and Wages.

Table 2.3 presents a competitive analysis of Georgia in these detailed bioscience sub-industries relative to the US. In comparison to national trends, Georgia's bioscience industry is most competitive in the following sub-industries (see Table 2.3):

- Artificial and Synthetic Fibers and Filaments Manufacturing (including Cellulosic organic fiber manufacturing)
- Ophthalmic goods manufacturing

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- Pesticide and other agricultural chemical manufacturing
- Dental laboratories

These industries have LQs above 1.0. Moreover, the first two industries in this list increased their competitiveness from 2001 to 2006 as evidenced by their rising LQs.

The shift share measures in columns 5-7 in Table 2.3 suggest that many of Georgia's bioscience sub-industries fared better than the nation. Comparing the column labeled "Mix" with that labeled "Local," one can see that 11 of the 19 local bioscience sub-industries have positive values versus 7 of the 19 national mix industries. Georgia has about 300 additional bioscience jobs because of the distinctive attributes of the state's economy than the state would have had it followed national trends.

Table 2.3. Bioscience Competitiveness

Industry Class (NAICS)		LQ06	LQ01	National	Mix	Local
31122[1]	Starch and Vegetable Fats and Oils Manufacturing	0.81	1.16	1	(32)	(279)
32519[1]	Other Basic Organic Chemical Manufacturing	0.85	0.97	1	(136)	(150)
32522[1]	Artificial and Synthetic Fibers and Filaments Manufacturing	1.30	1.12	1	(439)	172
325311	Nitrogenous fertilizer manufacturing	0.83	0.57	0	(34)	59
325312	Phosphatic fertilizer manufacturing	0.54	0.75	0	(15)	(44)
325314	Fertilizer (mixing only) manufacturing	0.85	1.07	0	(29)	(51)
325320	Pesticide and other agricultural chemical manufacturing	1.14	1.14	0	(136)	4
32541[1]	Pharmaceutical and Medicine Manufacturing	0.38	0.38	2	100	10
33451[1]	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	0.23	0.28	2	(307)	(677)
339111	Laboratory apparatus and furniture manufacturing	0.05	0.05	0	(2)	(1)
339112	Surgical and medical instrument manufacturing	0.23	0.29	1	8	(166)
339113	Surgical appliance and supplies manufacturing	0.91	0.78	1	(76)	343
339114	Dental equipment and supplies manufacturing	0.43	0.34	0	(8)	40
339115	Ophthalmic goods manufacturing	1.86	1.76	1	(161)	107
339116	Dental laboratories	1.16	1.31	1	93	(209)

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Table 2.3. Bioscience Competitiveness						
Industry Class (NAICS)		LQ06	LQ01	National	Mix	Local
541380[2]	Testing laboratories	0.51	0.47	1	26	80
541710[2]	R&D in the physical, engineering, and life sciences	0.24	0.19	1	138	395
621511	Medical laboratories	0.87	0.85	2	441	90
621512	Diagnostic imaging centers	0.78	0.62	1	297	307

[1] Because of suppressed values, we aggregated this sector to the 5-digit NAICS class.
[2] Estimates of the proportion of employees performing biological and life sciences functions (0.50) were made.
Source: US Bureau of Labor Statistics, Quarterly Census of Employment and Wages.

Bioscience Industry Projections

We can also examine how employment is forecast to change in the future in this cluster in Georgia and the nation as a whole. Using data from the US Bureau of Labor Statistics (BLS), we report forecast employment for base year 2004 and projected year 2014. (See Table 2.4) Forecasts are at the four-digit NAICS level.

An employment increase of nearly 12% is projected for the overall bioscience industry in Georgia – higher than the overall projections of 5% for the US. The fastest growing bioscience sub-industries in Georgia projected to increase employment by 20% or more include: (1) Pharmaceutical and medicine manufacturing, (2) Testing laboratories, and (3) Medical and diagnostic laboratories. Testing laboratories also are expected to be more competitive than the nation, though their LQs will decline by 2014. The shift share measures in columns 7-9 suggest that employment in the bioscience industries will decline at the national level (refer to the column labeled "Mix") but generally will fare better in Georgia (refer to the column labeled "Local"). Forty percent of the growth in Georgia's bioscience cluster will occur because of gains in the overall national economy, while the other 60% will be the result of Georgia's distinctive capabilities.

Table 2.4. Future Bioscience Industry Employment in Georgia: 2004 and 2014							
Industry Class (NAICS)		% Change	LQ04	LQ014	National	Mix	Local
3112	Grain and oilseed milling	4%	0.95	1.08	75	-300	290
3251	Basic chemical manufacturing	-3%	1.10	1.18	210	-875	555
3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	-1%	1.03	1.19	140	-714	548
3253	Pesticide, fertilizer, and other agricultural chemical manufacturing	-12%	1.16	1.22	58	-316	119
3254	Pharmaceutical and medicine manufacturing	23%	0.45	0.41	169	637	-26
3345	Navigational, measuring, electromedical, and control instruments manufacturing	-8%	0.26	0.23	147	-281	-92
3391	Medical equipment and supplies manufacturing	2%	0.83	0.77	331	-254	57
5413	Testing laboratories	20%	9.10	8.12	1725	6841	-1730
5417	Scientific research and development services	-5%	0.26	0.21	181	175	-539
6215	Medical and diagnostic laboratories	20%	0.90	0.86	237	563	163

Source: Georgia Department of Labor and US Bureau of Labor Statistics, industry employment projections.

Chapter 3. Academic Supply

Introduction

The Battelle report highlighted several distinctive postsecondary educational programs in the biosciences in Georgia. These include University of Georgia's certificate programs in clinical trials design and management and pharmaceutical and biomedical regulatory affairs in its College of Pharmacy, and the joint program of the Athens and Gwinnett Technical Colleges creating a Georgia Bioscience Technology Institute for training biomanufacturing and other bioscience specialists. These are but a few of the offerings throughout the public and private higher educational systems in Georgia. This chapter examines system-wide offerings of the state's public and private postsecondary educational institutions to supply graduates for openings in the bioscience.

The academic major or primary field forms the basis for any analysis of the supply of bioscience graduates. Academic majors or primary fields of study that lead to degrees or certificates are constructed around what is called the classification of instructional programs (CIP). CIPs are hierarchically structured to organize similar fields of study into the same major grouping. This classification system has more than 1300 CIPs. Thus, one challenge is simply to cull this list to those CIPs that are most directly related to bioscience.

This chapter reports information on graduates (or "completions" in educational studies nomenclature) by CIP for all public and private postsecondary institutions in the country. The number of graduates by program in these CIPs for 2004, 2005, and 2006 is extracted to produce and report a three-year average. This data comes from Integrated Postsecondary Education Data System (IPEDS), National Center for Education Statistics, US Department of Education.

Bioscience Educational Program Definition

The definition of bioscience education programs in this analysis is guided by the Battelle report's five categories of higher education bioscience degrees by discipline: agriculture, food, and nutrition science; biological sciences; biomedical sciences and engineering; medical and veterinary sciences; and other life science clinical/technical fields. The Battelle report does not specify the particular CIPs within these broad categories, however. This study uses the following criteria to identify CIPs that are relevant to the bioscience industry.

- Biomedical sciences and engineering: CIPs beginning with 14
- Biological sciences: CIPs beginning with 26 plus 30.0101 (Biological and Physical Sciences)

- Medical and veterinary sciences: CIPs beginning with 51 that include the words/stems *science* or *clinical* or *laboratory*, *nutrition* and *science*, and *food* and *science*
- Agriculture, food, and nutrition science: CIPs beginning with 01 that include the words/stems *science*, *bio* and *science*, *bio* and *engin* plus 30.19.01 (Nutrition Sciences)
- Life science clinical/technical fields: all technicians or assistants in the previous four categories.

In addition, we selected adjacent CIPs that were related to the programs extracted through above search term strategy. This process yields 70 bioscience programs that are listed in Table 3.1.

Table 3.1. Bioscience Postsecondary Educational Programs

CIP	Description	Category
01.0307	Horse Husbandry/Equine Science and Management	Agriculture sciences
01.0901	Animal Sciences, General	Agriculture sciences
01.0905	Dairy Science	Agriculture sciences
01.0907	Poultry Science	Agriculture sciences
01.0999	Animal Sciences, Other.	Agriculture sciences
01.1001	Food Science.	Agriculture sciences
01.1099	Food Science and Technology, Other.	Agriculture sciences
01.1101	Plant Sciences, General.	Agriculture sciences
01.1102	Agronomy and Crop Science.	Agriculture sciences
01.1103	Horticultural Science.	Agriculture sciences
01.1199	Plant Sciences, Other.	Agriculture sciences
01.1201	Soil Science and Agronomy, General.	Agriculture sciences
01.1202	Soil Chemistry and Physics.	Agriculture sciences
01.1203	Soil Microbiology.	Agriculture sciences
01.1299	Soil Sciences, Other.	Agriculture sciences
14.0301	Agricultural/Biological Engineering and Bioengineering.	Biomedical sciences
14.0501	Biomedical/Medical Engineering.	Biomedical sciences
26.0101	Biology/Biological Sciences, General.	Biological sciences
26.0102	Biomedical Sciences, General.	Biological sciences
26.0202	Biochemistry.	Biological sciences
26.0203	Biophysics.	Biological sciences
26.0204	Molecular Biology.	Biological sciences
26.0205	Molecular Biochemistry.	Biological sciences
26.0206	Molecular Biophysics.	Biological sciences
26.0210	Biochemistry/Biophysics and Molecular Biology.	Biological sciences
26.0299	Biochemistry, Biophysics and Molecular Biology, Other.	Biological sciences
26.0308	Plant Molecular Biology.	Biological sciences

Table 3.1. Bioscience Postsecondary Educational Programs		
CIP	Description	Category
26.0401	Cell/Cellular Biology and Histology.	Biological sciences
26.0406	Cell/Cellular and Molecular Biology.	Biological sciences
26.0407	Cell Biology and Anatomy.	Biological sciences
26.0499	Cell/Cellular Biology and Anatomical Sciences, Other.	Biological sciences
26.0502	Microbiology, General.	Biological sciences
26.0503	Medical Microbiology and Bacteriology.	Biological sciences
26.0504	Virology.	Biological sciences
26.0505	Parasitology.	Biological sciences
26.0506	Mycology.	Biological sciences
26.0507	Immunology.	Biological sciences
26.0599	Microbiological Sciences and Immunology, Other.	Biological sciences
26.0801	Genetics, General.	Biological sciences
26.0802	Molecular Genetics.	Biological sciences
26.0803	Microbial and Eukaryotic Genetics.	Biological sciences
26.0804	Animal Genetics.	Biological sciences
26.0805	Plant Genetics.	Biological sciences
26.0806	Human/Medical Genetics.	Biological sciences
26.0899	Genetics, Other.	Biological sciences
26.1101	Biometry/Biometrics.	Biological sciences
26.1102	Biostatistics.	Biological sciences
26.1103	Bioinformatics.	Biological sciences
26.1199	Biomathematics and Bioinformatics, Other.	Biological sciences
26.1201	Biotechnology.	Biological sciences
26.1309	Epidemiology.	Biological sciences
26.9999	Biological and Biomedical Sciences, Other.	Biological sciences
30.0101	Biological and Physical Sciences.	Biological sciences
30.1901	Nutrition Sciences.	Biological sciences
51.0000	Health Services/Allied Health/Health Sciences, General.	Medical sciences
51.0501	Dental Clinical Sciences, General (MS, PhD).	Medical sciences
51.0599	Advanced/Graduate Dentistry and Oral Sciences, Other.	Medical sciences
51.0801	Medical/Clinical Assistant.	Clinical/technical
51.0802	Clinical/Medical Laboratory Assistant.	Clinical/technical
51.1004	Clinical/Medical Laboratory Technician.	Clinical/technical
51.1005	Clinical Laboratory Science/Medical Technology/Technologist.	Clinical/technical
51.1010	Cytogenetics/Genetics/Clinical Genetics Technology/Technologist.	Clinical/technical
51.1099	Clinical/Medical Laboratory Science and Allied Professions, Other.	Medical sciences
51.1608	Nursing Science (MS, PhD).	Medical sciences
51.2006	Clinical and Industrial Drug Development (MS,	Medical sciences

Table 3.1. Bioscience Postsecondary Educational Programs		
CIP	Description	Category
	PhD).	
51.2009	Industrial and Physical Pharmacy and Cosmetic Sciences (MS, PhD).	Medical sciences
51.2501	Veterinary Sciences/Veterinary Clinical Sciences, General (Cert.)	Medical sciences
51.2509	Comparative and Laboratory Animal Medicine (Cert.)	Medical sciences
51.2599	Veterinary Biomedical and Clinical Sciences, Other (Cert.)	Medical sciences
51.9999	Health Professions and Related Clinical Sciences, Other	Medical sciences

Source: Classification of Instructional Programs, National Center for Educational Statistics.

Georgia's Bioscience Graduates

Averaged over the 2004-2006 time period, Georgia has more than 5,500 graduates in bioscience related programs annually. These graduates are spread across 33 of the 70 bioscience programs/majors as shown in Table 3.2.[2] The two largest programs/majors – which account for 83% of graduates — are:

- 51.0801. Medical/Clinical Assistant (3328 graduates)
- 26.0101. Biology/Biological Sciences, General (1241 graduates).

Table 3.2. Georgia Bioscience Graduates		
CIP Code	CIP Title	Georgia Graduates[1]
01.0901	Animal Sciences, General	61
01.0905	Dairy Science	9
01.0901	Animal Sciences, General	61
01.0905	Dairy Science	9
01.0907	Poultry Science	12
01.1001	Food Science	34
01.1102	Agronomy and Crop Science	12
01.1103	Horticultural Science	4
01.1201	Soil Science and Agronomy, General	6
14.0301	Agricultural/Biological Engineering and Bioengineering	36
14.0501	Biomedical/Medical Engineering	76
26.0101	Biology/Biological Sciences, General	1,241
26.0102	Biomedical Sciences, General	50
26.0202	Biochemistry	52
26.0204	Molecular Biology	4
26.0210	Biochemistry/Biophysics and Molecular Biology	2

[2] An analysis of the remaining programs that do not register graduates from Georgia institutions suggest that they all overlap with existing programs at Georgia higher educational institutions.

Georgia Tech
Enterprise Innovation Institute
City and Regional Planning Program
School of Public Policy

Table 3.2. Georgia Bioscience Graduates		
CIP Code	CIP Title	Georgia Graduates[1]
26.0401	Cell/Cellular Biology and Histology	17
26.0407	Cell Biology and Anatomy	1
26.0499	Cell/Cellular Biology and Anatomical Sciences, Other	1
26.0502	Microbiology, General	38
26.0801	Genetics, General	29
26.1102	Biostatistics	9
26.1103	Bioinformatics	22
26.1201	Biotechnology	7
26.1309	Epidemiology	62
26.9999	Biological and Biomedical Sciences, Other	26
30.0101	Biological and Physical Sciences	33
30.1901	Nutrition Sciences	11
51.0801	Medical/Clinical Assistant	3,328
51.1004	Clinical/Medical Laboratory Technician	87
51.1005	Clinical Laboratory Science/Medical Technology/Technologist	47
51.1099	Clinical/Medical Laboratory Science and Allied Professions, Other	3
51.1608	Nursing Science (MS, PhD)	4
51.2501	Veterinary Sciences/Veterinary Clinical Sciences, General (Cert)	4
51.9999	Health Professions and Related Clinical Sciences, Other	184
	Total	5508
Bioscience Program Categories		
Agricultural, Food, and Nutrition Science		137
Biological Science		1603
Biomedical Science and Engineering		112
Medical and Veterinary Science		195
Other Clinical/Technical		3462

[1]Average number of graduates from 2004-2006.
Source: Author analysis of IPEDS data, National Center for Educational Statistics

Georgia's bioscience programs are offered in nearly 100 institutions across the state. (See Table 3.3.) Georgia Medical Institute, Advanced Career Training, and University of Georgia have the largest number of graduates. University of Georgia also has the most programs (15) followed by Emory University with six.

Table 3.3. Georgia Institutions by Number of Bioscience Graduates			
Institution	**Graduates[1]**	**Programs**	**Institution Type**
Abraham Baldwin Agricultural College	9	2	Public
Advanced Career Training-Atlanta Campus	507	1	Private For Profit
Agnes Scott College	11	3	Private Non-profit
Albany State University	23	1	Public
Albany Technical College	14	1	Public
American Professional Institute	56	1	Private For Profit
Andrew College	2	1	Private Non-profit
Appalachian Technical College	13	1	Public
Armstrong Atlantic State University	78	3	Public
Athens Technical College	30	1	Public
Atlanta Medical Institute	12	2	Private Non-profit
Atlanta Metropolitan College	1	1	Public
Atlanta Technical College	29	2	Public
Augusta State University	31	1	Public
Augusta Technical College	34	1	Public
Berry College	36	2	Private Non-profit
Brenau University	5	1	Private Non-profit
Brewton-Parker College	3	1	Private Non-profit
Career Education Institute-Marietta	94	1	Private For Profit
Career Education Institute-Norcross	142	1	Private For Profit
Central Georgia Technical College	80	2	Public
Chattahoochee Technical College	12	1	Public
Clark Atlanta University	41	2	Private Non-profit
Clayton State University	49	2	Public
Coastal Georgia Community College	5	1	Public
Columbus State University	46	2	Public
Columbus Technical College	26	1	Public
Coosa Valley Technical College	28	1	Public
Covenant College	11	2	Private Non-profit
Dalton State College	29	2	Public
Darton College	13	3	Public
Dekalb Technical College	20	2	Public
DeVry University-Georgia	3	1	Private For Profit
East Central Technical College	12	1	Public
East Georgia College	1	1	Public
Emmanuel College	4	1	Private Non-profit
Emory University	182	6	Private Non-profit
Flint River Technical College	20	1	Public
Fort Valley State University	40	3	Public
Gainesville State College	4	2	Public
Georgia College and State University	36	1	Public
Georgia Institute of Technology-Main Campus	174	3	Public
Georgia Medical Institute	635	2	Private For Profit
Georgia Medical Institute-Atlanta Downtown	303	1	Private For Profit
Georgia Medical Institute-Dekalb	165	2	Private For Profit

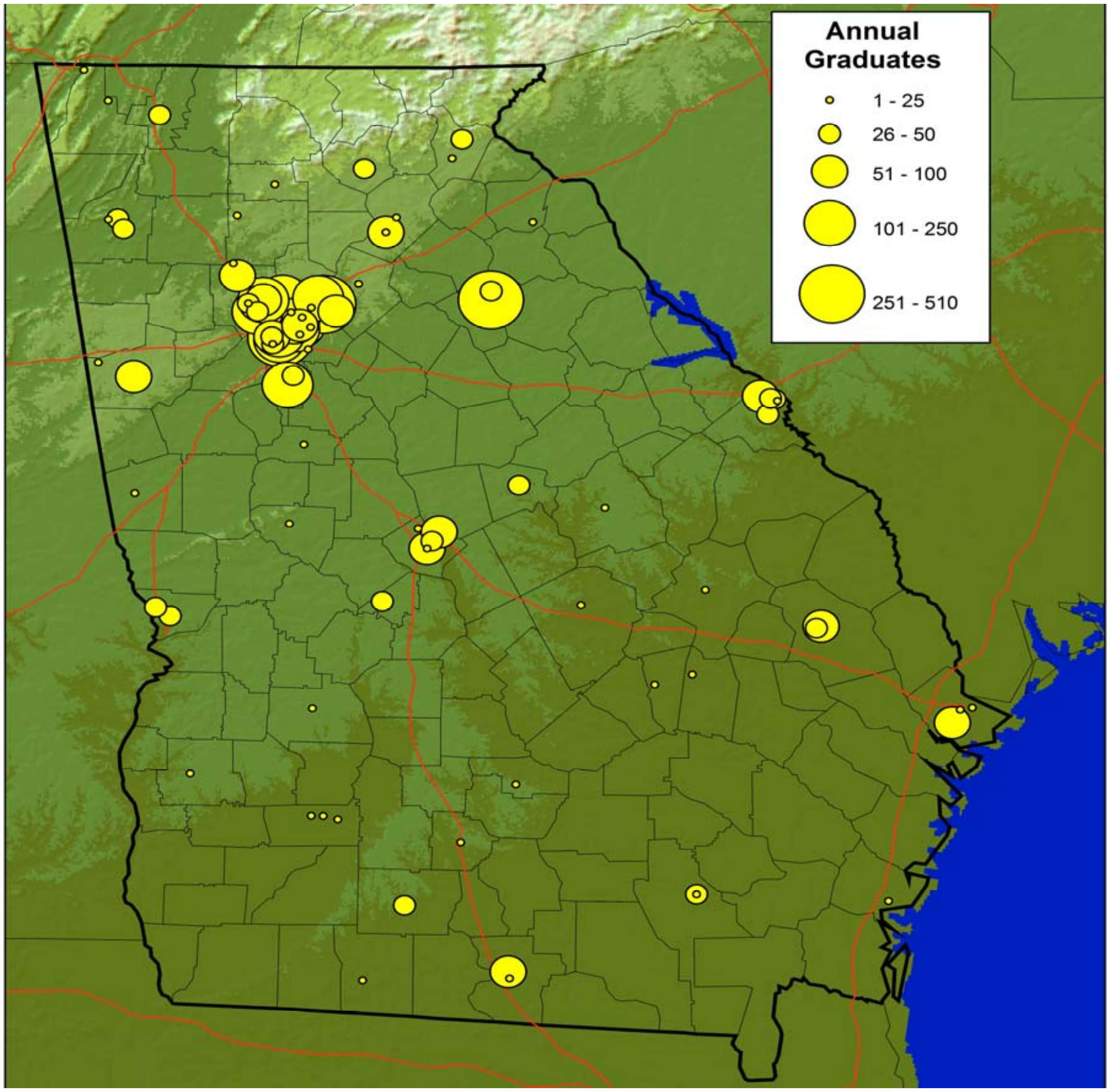
Table 3.3. Georgia Institutions by Number of Bioscience Graduates			
Institution	**Graduates[1]**	**Programs**	**Institution Type**
Georgia Medical Institute-Marietta Campus	119	1	Private For Profit
Georgia Perimeter College	3	2	Public
Georgia Southern University	89	2	Public
Georgia Southwestern State University	12	2	Public
Georgia State University	216	2	Public
Griffin Technical College	20	2	Public
Gwinnett College	60	1	Private For Profit
Gwinnett Technical College	21	1	Public
Heart of Georgia Technical College	13	1	Public
High-Tech Institute-Atlanta	132	1	Private For Profit
Kennesaw State University	66	3	Public
LaGrange College	16	3	Private Non-profit
Lanier Technical College	53	2	Public
Life University	33	2	Private Non-profit
Macon State College	4	3	Public
Medical College of Georgia	36	5	Public
Medix Schools	146	2	Private For Profit
Mercer University	30	2	Private Non-profit
Morehouse College	27	1	Private Non-profit
Morehouse School of Medicine	6	2	Private Non-profit
Moultrie Technical College	42	1	Public
North Georgia College & State University	49	1	Public
North Georgia Technical College	33	2	Public
North Metro Technical College	14	1	Public
Northwestern Technical College	12	1	Public
Ogeechee Technical College	32	1	Public
Oglethorpe University	8	1	Private Non-profit
Okefenokee Technical College	27	2	Public
Paine College	9	1	Private Non-profit
Piedmont College	6	1	Private Non-profit
Reinhardt College	14	1	Private Non-profit
Ross Medical Education Center	79	2	Private For Profit
Sandersville Technical College	4	1	Public
Sanford-Brown Institute	171	1	Private For Profit
Savannah River College	58	1	Private For Profit
Savannah State University	14	1	Public
Savannah Technical College	12	1	Public
Shorter College	10	1	Private Non-profit
South Georgia Technical College	16	1	Public
Southeastern Technical College	22	2	Public
Southern Polytechnic State University	3	1	Public
Southwest Georgia Technical College	20	2	Public
Spelman College	53	2	Private Non-profit
Swainsboro Technical College	15	1	Public
Thomas University	4	2	Private Non-profit

Table 3.3. Georgia Institutions by Number of Bioscience Graduates			
Institution	**Graduates[1]**	**Programs**	**Institution Type**
University of Georgia	426	15	Public
University of West Georgia	54	1	Public
Valdosta State University	54	1	Public
Valdosta Technical College	24	2	Public
Waycross College	2	1	Public
Wesleyan College	6	1	Private Non-profit
West Georgia Technical College	16	1	Public
Westcentral Technical College	20	2	Public
Westwood College-Northlake	15	1	Private For Profit

[1]Average number of graduates from 2004-2006.
Source: Author analysis of IPEDS data, National Center for Educational Statistics.

A map of large programs is shown in Figure 3.1. The map indicates that programs are available throughout the state though they are concentrated in the Atlanta area.

Figure 3.1. Map of Bioscience Programs at Postsecondary Educational Institutions in Georgia



Note: circles represent the location of institutions with bioscience programs and are proportionally sized based on the average number of graduates in the 2004-2006 time period.
Source: Author analysis of IPEDS data from the National Center for Educational Statistics

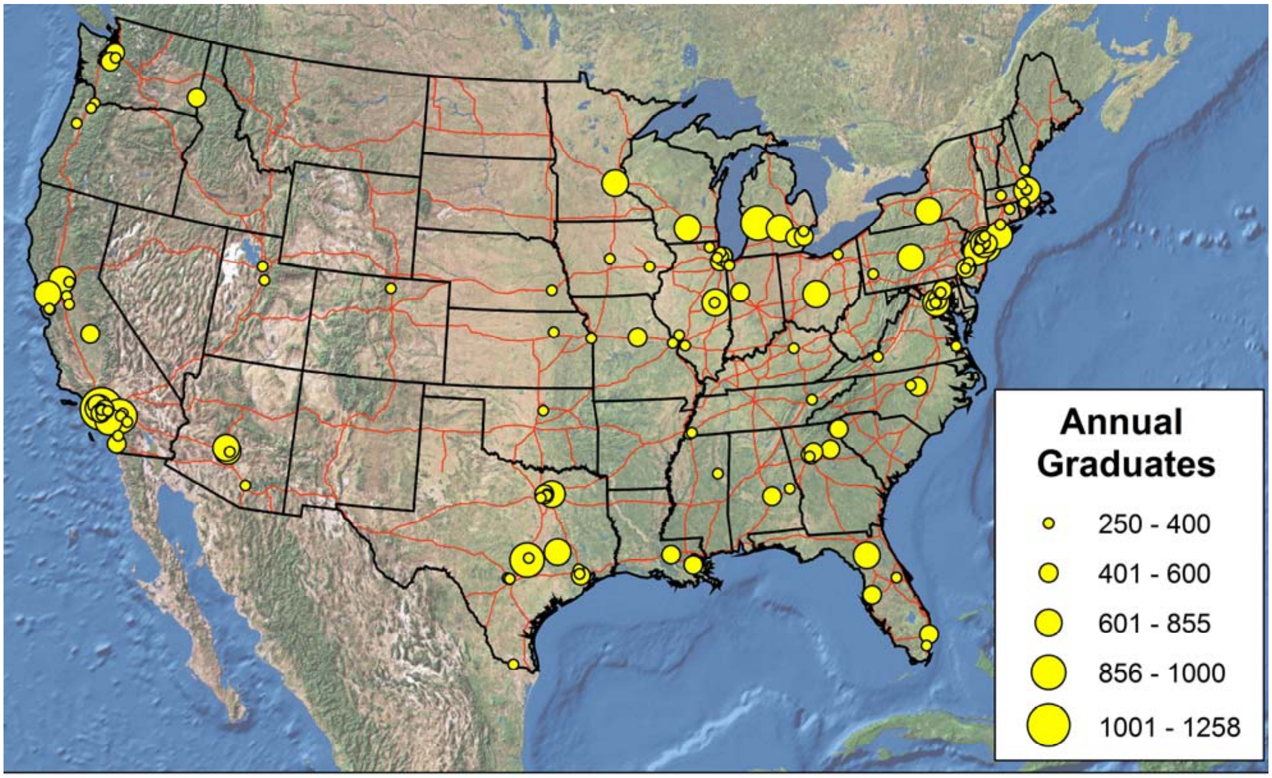
Georgia's Relative Position in Bioscience Education

Nationally there are about 186,000 bioscience graduates. Not surprisingly, California, Texas, New York, and Illinois have the largest number of graduates. These four states comprise 36% of bioscience graduates, slightly more than one would expect based on their population.[3] Georgia ranks 10th in terms of number

[3] These four states comprise nearly 31% of US population according to the Population Division, U.S. Census Bureau's annual estimates for the 2004-2006 time period.

of bioscience graduates. Figure 3.2 presents a map of higher educational institutions with 250 or more bioscience graduates. Several Georgia institutions are prominent in this map.

Figure 3.2. Map of Large Bioscience Educational Programs at Postsecondary Educational Institutions



Note: circles represent the location of institutions with bioscience programs and are proportionally sized based on the average number of graduates in the 2004-2006 time period.
Source: Author analysis of IPEDS data from the National Center for Educational Statistics

Georgia's relative position in bioscience graduates can be examined by using an LQ that compares Georgia's proportion of bioscience graduates in its total graduate population averaged annually from 2004-2006 to the same proportion for the US. Table 3.4 presents this LQ analysis for the top states with 3000 or more bioscience graduates. LQs are shown at the broad bioscience program level (see Table 3.1 for a listing of the programs included in each category). Georgia's greatest competitiveness is in the clinical/technical category, and it is relatively weaker in the other four, and some say more bioscience (as opposed to health and elder care) centric categories.

Indiana is most competitive in relative quantities of agriculture science graduates, Illinois in relative quantities of biological sciences graduates, Louisiana in relative quantities of biomedical science graduates, and New Jersey and Arizona in relative quantities of medical science graduates. These findings provide support for a focused strategy in producing bioscience graduates. States such as Illinois, Arizona, and Florida have great strength in one particular area. Georgia also falls into this category.

There is also support for a broad-based strategy in producing bioscience graduates. It is insightful to review the concentrations of bioscience graduates in these five categories in the states with the largest quantities of bioscience graduates. Table 3.4 shows that many of the states in this list meet, if not exceed, the national average in multiple categories.

- Seven states – California, Texas, Pennsylvania, Michigan, Massachusetts, Missouri, Maryland – have LQs above 1.00 in three categories.
- Five states – Ohio, New Jersey, Indiana, North Carolina, and Louisiana – have LQs above 1.00 in four categories.
- Virginia has an LQ above 1.00 in all five categories.

Table 3.4. Competitiveness of Top US States Based on Numbers of Graduates in Broad Bioscience Program Categories

State	Average Annual Graduates[1]	LQs				
		Agriculture sciences	Biological sciences	Biomedical sciences	Medical sciences	Clinical/technical
California	27,653	0.52	1.16	1.07	0.64	1.51
Texas	15,857	0.96	1.09	1.02	0.54	1.69
New York	13,402	0.86	0.88	1.19	1.45	0.86
Illinois	10,195	1.16	2.01	0.78	0.39	0.72
Florida	8,834	0.92	0.51	0.62	1.21	0.92
Pennsylvania	8,765	0.95	1.21	1.31	1.54	0.84
Michigan	7,015	1.19	0.90	1.41	0.87	1.33
Ohio	6,333	1.10	0.83	1.75	1.02	1.25
New Jersey	5,857	0.95	1.22	1.55	2.12	1.34
Georgia	5,508	0.66	0.78	0.78	0.53	1.28
Massachusetts	5,265	0.70	1.27	1.73	1.54	0.80
Virginia	4,611	1.08	1.43	1.12	1.35	1.06
Arizona	4,251	0.38	0.38	0.61	2.11	1.01
Indiana	3,734	1.79	1.05	0.99	1.03	1.32
Washington	3,609	0.71	0.74	0.63	0.99	1.04
North Carolina	3,461	1.45	1.10	1.52	1.56	0.39
Missouri	3,379	1.42	1.09	1.31	0.41	0.72
Maryland	3,316	0.73	1.33	1.95	1.68	0.68
Louisiana	3,221	1.53	1.67	2.04	0.87	1.45

[1]Average number of graduates from 2004-2006.
Source: Author analysis of IPEDS data, National Center for Educational Statistics.

The findings in Table 3.4 can be interpreted by analyzing Georgia's national ranking in producing bioscience graduates within the five program categories. Table 3.5 provides this ranking.

Table 3.5. Rankings of Numbers of Graduates in Broad Bioscience Program Areas				
Program Category	Current Rank[1]	Current Number Graduates[1]	Additional Numbers Needed to Achieve Rank:	
			10th	5th
Agriculture sciences	20	137	94	215
Biological sciences	13	1,603	300	2,193
Biomedical sciences	16	112	57	146
Clinical/technical	7	3,462	0	529
Medical sciences	25	195	367	686

[1]Current rank means average annual number of graduates 2004-2006.
Source: Author analysis of IPEDS data, National Center for Educational Statistics.

The table shows that Georgia ranks 10th among all states in the overall number of bioscience graduates. Since Georgia is the 9th largest state in terms of population, an overall bioscience ranking of 10th means that the number of bioscience graduates nearly proportional to the state's population. However when we compare Georgia's ranking in the five individual categories, Georgia ranks in the top ten states only in the clinical/technical category.

In the other four categories Georgia's ranking varies from a low of 25th for medical sciences, to a high of 13th for biological sciences. To put these lower rankings in perspective, the rightmost two columns of Table 3.5 show the number of additional graduates the state would need to produce in order to achieve category rankings of 10th and 5th. In other words, if Georgia wished to achieve top five states in any of the other subcategories, the state would need to double, or more than double, the number of graduates in each of the four areas. Setting a more modest target of a ranking of 10th would require at least a 50% increase in three of the four categories: agricultural sciences, biomedical sciences, and medical sciences. Although the present level of bioscience graduates is, in general, adequate for the state's current needs, if the state were to set ranking among the top five states in one or more of the five subcategories as a goal, it would be necessary to increase very substantially the size of the state's higher educational bioscience programs.

The analysis moves next to the more detailed program level. Table 3.6 arrays Georgia's bioscience program graduates against the national distribution of graduates in bioscience programs. Compared to the nation, Georgia has a higher concentration of graduates, and therefore is more specialized, in the programs highlighted in Table 3.6. The Georgia institutions with the most graduates in these programs are:

- 01.0905. Dairy science - University of Georgia

- 01.0907. Poultry science - University of Georgia (also at Abraham Baldwin Agricultural College)
- 26.0801. Genetics, General - University of Georgia
- 26.1103. Bioinformatics - Georgia Institute of Technology
- 26.1309. Epidemiology - Emory University

Table 3.6. Competitiveness of Georgia's Bioscience Postsecondary Programs

CIP	Description	LQ
01.0901	Animal Sciences, General	0.55
01.0905	Dairy Science	2.19
01.0907	Poultry Science	2.65
01.1001	Food Science.	1.16
01.1102	Agronomy and Crop Science	0.58
01.1103	Horticultural Science	0.13
01.1201	Soil Science and Agronomy, General	0.64
14.0301	Agricultural/Biological Engineering and Bioengineering	1.31
14.0501	Biomedical/Medical Engineering	0.65
26.0101	Biology/Biological Sciences, General	0.99
26.0102	Biomedical Sciences, General	1.17
26.0202	Biochemistry	0.41
26.0204	Molecular Biology	0.13
26.0210	Biochemistry/Biophysics and Molecular Biology	0.11
26.0401	Cell/Cellular Biology and Histology	1.05
26.0407	Cell Biology and Anatomy	1.12
26.0499	Cell/Cellular Biology and Anatomical Sciences, Other	0.07
26.0502	Microbiology, General	0.74
26.0801	Genetics, General	2.80
26.1102	Biostatistics	0.75
26.1103	Bioinformatics	2.27
26.1201	Biotechnology	0.23
26.1309	Epidemiology	2.68
26.9999	Biological and Biomedical Sciences, Other	0.31
30.0101	Biological and Physical Sciences	0.11
30.1901	Nutrition Sciences	0.33
51.0801	Medical/Clinical Assistant	1.30
51.1004	Clinical/Medical Laboratory Technician	0.93
51.1005	Clinical Laboratory Science/Medical Technology/Technologist	0.69
51.1099	Clinical/Medical Laboratory Science and Allied Professions, Other	0.08
51.1608	Nursing Science (MS, PhD)	0.04
51.2501	Veterinary Sciences/Veterinary Clinical Sciences, General (Cert.)	0.34
51.9999	Health Professions and Related Clinical Sciences, Other	0.81

[1] Average number of graduates from 2004-2006.

Source: Integrated Postsecondary Education Data System, National Center for Educational Statistics.

On the other hand, Georgia lacks a competitive advantage in nearly 20 bioscience programs. The LQs associated with these programs are all noticeably below 1.00, the national average. In terms of specific programs, there are four programs with LQs below 1.00 that have some quantity of graduates and appear fundamental to the biosciences (which we present along with a brief description of the program from the National Center for Education Statistics, 2002):

- 14.0501 Biomedical/Medical Engineering: prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of biological and health systems and products such as integrated biological systems, instrumentation, medical information systems, artificial organs and prostheses, and health management and care delivery systems.
- 26.0502 Microbiology, General: focuses on the scientific study of unicellular organisms and colonies, and subcellular genetic matter and their ecological interactions with human beings and other life.
- 26.0202 Biochemistry: focuses on the scientific study of the chemistry of living systems, their fundamental chemical substances and reactions, and their chemical pathways and information transfer systems, with particular reference to carbohydrates, proteins, lipids, and nucleic acids.
- 30.0101 Biological and Physical Sciences: either a general synthesis of one or more of the biological and physical sciences, or a specialization which draws from the biological and physical sciences.

It could be argued that bringing these programs up to an LQ of 1.00 – the national average – could help the state meet its aspirational goals for bioscience by increasing its talent base of graduates. This position is a tenant of the economic development strategy to “lead with talent” in advance of current demand in emerging industries such as bioscience. Some observers maintain that this can be a risky strategy because at an early point in the economic development trajectory there may be too many graduates for the number of open positions. To assist the “lead with talent” strategy, we have calculated the number of graduates needed to meet national benchmarks in selected bioscience instructional programs with LQs of less than 1.00. These examples are as follows.

- Biological and Physical Sciences currently averages 33 graduates annually, and would need another 272 graduates to be at the national average
- Biochemistry averages 52 graduates annually, and would need 74 graduates to be at the national average
- Biomedical/Medical Engineering averages 76 graduates annually, and would need another 41 graduates to be at the national average
- Microbiology currently averages 38 graduates, and would need another 13 graduates to be at the national average

Of course, one cannot look at the numbers of graduates in these programs solely in isolation. It is important to compare them to industry needs to gauge shortfalls of talent. This analysis is the subject of the next Chapter.

Chapter 4. Demand and Supply for Bioscience Occupations

Because the bioscience industry is knowledge intensive, its ability to expand depends in part on having the right talent available to support this expansion. The USG has examined the extent to which mismatches between the demand for knowledge workers and the supply of university graduates exist in various occupations for more than 10 years. Supply-demand analysis can be used to help address large gaps between supply and demand arising when industry structure transforms, consumer tastes change, demand for products or services shifts, and/or technological advances occur. Labor mobility restrictions, rapid pace of change, and regional industrial concentrations can challenge industries on the rise to find the skills they need. Because of the lead time necessary in developing or expanding educational programs, it can be helpful to foresee potential gaps in demand for various types of jobs.

This chapter uses long-term projections of employment in occupations in the bioscience industry and links these projections to present levels of graduates from bioscience major fields of study in the state's postsecondary educational institutions. Long-term projections draw on models of standard demographic, business, and economic trends. These projections can be used to identify any long-range mismatches between projected demand for certain types of workers and current supply of graduates. It does not take into account any changes that may occur in demand as a result of new and highly successful economic development business recruitment strategies which may expand the cluster in unexpected directions. We cannot pinpoint the extent to which out-of-state labor may migrate to Georgia to fill open positions in bioscience firms. Some number of Georgia graduates also leaves the state for other employment locations; Drummond and Youtie (2001) found that 72% of graduates in the 1993 to 1997 time period were found in the Georgia workforce database in 1998;[4] however, this information is too dated to incorporate into the current study.

The analysis does give us an initial look at any long-range employment disparities in the bioscience industry that could limit Georgia's economic development recruitment strategy.

What is a Bioscience Occupation?

Analyses of occupational talent needs typically begin from the Standard Occupational Classification (SOC) system. The SOC system was published by the Office of Management and Budget (OMB) in 1999 and is utilized by the US Bureau of Labor Statistics for portraying all occupational employment

[4] The results of this analysis are judged to be too dated – more than 10 years old – to validly include in this analysis.

information for current periods and 10 year projections. The SOC classifies all workers into more than 800 occupations. To facilitate classification, occupations are combined to form 23 major groups, 96 minor groups, and 449 broad occupations. Each broad occupation includes detailed occupation(s) requiring similar job duties, skills, education, or experience.

The Battelle report specifies a bioscience occupation as one of 16 SOCs. (See Table 4.1.)[5]

Table 4.1. Bioscience Occupations

SOC Code	SOC Description	Typical Training/ Degree
Agricultural, Food and Nutrition Scientists and Technicians		
19-1011	Animal Scientists	Bachelor's
19-1012	Food Scientists and Technologists	Bachelor's
19-1013	Soil and Plant Scientists	Bachelor's
19-4011	Agricultural and Food Science Technicians	Associate's
Biological Scientists and Technicians		
19-1022	Microbiologists	Doctoral
19-1041	Epidemiologists	Master's
19-1042	Medical Scientists, Except Epidemiologists	Doctoral
19-1029	Biological Scientists, all other	Bachelor's
19-4021	Biological Technicians	Associate's
Biomedical and Biochemical Scientists and Engineers		
17-2031	Biomedical Engineers	Bachelor's
19-1021	Biochemists and Biophysicists	Doctoral
Medical and Clinical Laboratory Technicians		
29-2011	Medical and Clinical Laboratory Technologists	Bachelor's
29-2012	Medical and Clinical Laboratory Technicians	Associate's
51-9081	Dental Laboratory Technicians	Long-term on-the-job training
51-9082	Medical Appliance Technicians	Long-term on-the-job training
51-9083	Ophthalmic Laboratory Technicians	Moderate-term on-the-job training

Source: Battelle (2008) and author analysis.

Occupational Forecasts

The Georgia Department of Labor provides 10-year forecasts from 2004 to 2014 for nearly 780 occupations, including the 16 occupations listed in Table

[5] The authors observed the Battelle report used the code 19-1010 which is a major category rather than an occupational code, so this analysis substituted the occupational code 19-1012.

4.1. Here we compare the Georgia forecasts with those provided by the US Bureau of Labor Statistics.[6] Table 4.2 shows that employment in these 16 bioscience occupations is expected to rise by 20% for Georgia compared to 13% for the nation. The fastest growing occupation in Georgia's future bioscience workforce is Medical Scientists (38%), followed by Food Scientists and Technologist (30%), Biomedical Engineers (27%), and Medical and Clinical Laboratory Technicians (29%) and Technologists (25%). Georgia is more specialized than the US in its concentration of Epidemiologists (LQ greater than two). Of Georgia's growth, about half is expected to be driven by the distinctive features of its local economy, with the other half expected to be driven by the national economy.

Table 4.2. Georgia Bioscience Occupational Projections: 2004-2014

SOC	Description	Employment 2014	% Growth 2004-2014	LQ 2014
19-1011	Animal Scientists	63	19%	0.38
19-1012	Food Scientists and Technologists	262	30%	0.72
19-1013	Soil and Plant Scientists	371	11%	0.77
19-4011	Agricultural and Food Science Technicians	719	16%	0.93
19-1022	Microbiologists	320	14%	0.59
19-1041	Epidemiologists	308	16%	2.15
19-1042	Medical Scientists, Except Epidemiologists	601	38%	0.20
19-4021	Biological Technicians	830	0%	0.32
19-1029	Biological Scientists, all other	767	-2%	0.91
17-2031	Biomedical Engineers	132	27%	0.27
19-1021	Biochemists and Biophysicists	86	4%	0.13
29-2011	Medical and Clinical Laboratory Technologists	6335	25%	1.20
29-2012	Medical and Clinical Laboratory Technicians	5624	29%	1.15
51-9081	Dental Laboratory Technicians	2474	12%	1.59
51-9082	Medical Appliance Technicians	220	20%	0.58
51-9083	Ophthalmic Laboratory Technicians	1123	7%	1.29

Source: Georgia Department of Labor and the US Bureau of Labor Statistics

Shortfall Analysis

The shortfall analysis compares projected annual openings to the annual number of graduates that Georgia's postsecondary educational institutions (averaged over the 2004 to 2006 timeframe). Annual openings come from the 10-year growth forecasts and take into account net replacements of workers transferring from other occupations or leaving the workforce. Graduates of each program

[6] The BLS occupational forecasts are for base year 2006 and projection year 2016.

are distributed to related occupations by calculating an allocation factor for each program-to-occupation relationship based on the SOC-CIP Crosswalk. The method followed for linking supply and demand involves multiple rounds of matching.[7]

Looking at annual openings, there will be an estimated 770 openings in Georgia for bioscience positions in the next 10 years. Of these, 250 positions are not likely to be filled. (See Table 4.3.) Seven of the 16 occupations have shortfalls. The largest shortfalls are associated with the medical and clinical laboratory technologist occupation which typically requires a bachelor's degree. There are also some modest shortfalls projected for the dental laboratory technician and ophthalmic laboratory technician occupations, although these two occupations are strongly tied to on-the-job training in the health and elder care industries rather than the biosciences per se. If we take away occupations more in the health and elder care domain than in the bioscience domain, that reduces the shortfall to 158 positions.

Table 4.3. Annual Openings, Graduates, and Shortfalls

Occupation[1]	Annual Openings	Graduates	Shortfall	Common Education/Training
Medical and Clinical Laboratory Technologists	260	117	143	Bachelor's degree
Dental Laboratory Technicians	80	26	54	Long-term on-the-job training
Ophthalmic Laboratory Technicians	30	0	30	Moderate-term on-the-job training
Medical Appliance Technicians	10	4	6	Long-term on-the-job training
Agricultural and Food Science Technicians	20	14	6	Associate degree
Medical and Clinical Laboratory Technicians	250	244	6	Associate degree
Food Scientists and Technologists	10	7	3	Bachelor's degree
Soil and Plant Scientists	10	10	0	Bachelor's degree
Biological Scientists, All Other	30	30	0	Bachelor's degree
Medical Scientists, Except Epidemiologists	30	30	0	Doctoral degree
Microbiologists	10	10	0	Doctoral degree
Biological Technicians	10	10	0	Associate degree
Animal Scientists	0	0	0	Bachelor's degree

[7] The process begins by applying an allocation factor, which is defined as the number of openings in the occupation divided by the total number of openings in all occupations related to the program. Once all programs are allocated, the number of graduates coming from all related programs is summed for each occupation. For some occupations the number of allocated graduates may exceed the number of openings. When this is the case the "excess" graduates are then re-assigned to their original programs, in proportion to the size of the program. The process is repeated until the largest number of "excess" graduates is less than ten.

Table 4.3. Annual Openings, Graduates, and Shortfalls				
Occupation[1]	Annual Openings	Graduates	Shortfall	Common Education/Training
Biochemists and Biophysicists	0	0	0	Doctoral degree
Biomedical Engineers	10	10	0	Bachelor's degree
Epidemiologists	10	10	0	Master's degree

[1]Projections for job openings in the Agricultural and Food Scientist occupation were not available.
Source: Author analysis of data from the National Center for Educational Statistics; Georgia Department of Labor.

Table 4.4 presents descriptions of competencies required in these bioscience centric-occupations.

Table 4.4. Bioscience-centric Occupations with Largest Shortfalls and their Specific Competencies	
Occupations	Competencies
Medical and Clinical Laboratory Technologists and technicians	Perform crucial laboratory testing in the detection, diagnosis, and treatment of disease. Technologists perform complex chemical, biological, hematological, immunologic, microscopic, and bacteriological tests. Technicians may prepare specimens and operate automated analyzers, for example, or they may perform manual tests in accordance with detailed instructions.
Dental Laboratory Technicians	Fill prescriptions from dentists for crowns, bridges, dentures, and other dental prosthetics.
Ophthalmic Laboratory Technicians	Make prescription eyeglass or contact lenses.
Medical Appliance Technicians	Construct, fit, maintain, and repair braces, artificial limbs, joints, arch supports, and other surgical and medical appliances.
Agricultural and food science technicians	Work with related scientists to conduct research, development, and testing on food and other agricultural products. Agricultural technicians are involved in food, fiber, and animal research, production, and processing. Food science technicians assist food scientists and technologists in research and development, production technology, and quality control.
Food Scientists and Technologists	Use their knowledge of chemistry, physics, engineering, microbiology, biotechnology, and other sciences to develop new or better ways of preserving, processing, packaging, storing, and delivering foods.

Source: US Bureau of Labor Statistics, Occupational Outlook Handbook, 2008-09 Edition.

These shortfall numbers are moderately sizeable but not enormous. One interpretation of the analysis is that the greatest is bottlenecks have to do with laboratory work, although some of this deficit results from shared health care needs. The good news is that, not withstanding the need for laboratory and clinical technologists and technicians, Georgia has enough talent being produced from higher education to support an expansion of the bioscience industry.

Chapter 5. Recommendations

Introduction

This study has presented industry, academic, and occupational analyses of the bioscience industry in Georgia. These analyses are presented relative to the Battelle report which has become the standard for studying the size and needs of the industry from a technology-based economic development perspective. By and large, the study shows that Georgia's higher education system is currently meeting the overall needs of the bioscience industry. The current level of higher education graduates is also sufficient to support a modest expansion of the industry over the next 10 years as projected by the Georgia Department of Labor.

Strengths and Opportunities

Georgia's bioscience industry has several strengths. The overall industry is moderately sized and relatively stable, undergoing only a modest decline in the last five years. Georgia's strong local economy has buoyed this industry, especially in medical device manufacturing and bioscience R&D and testing services. Future growth is projected for some sectors of ag-bio, pharmaceutical and medical device manufacturing, and testing and diagnostic laboratories. On the academic side, the state turns out more than 5,500 bioscience graduates and is competitively stronger than the national average in the broad clinical/technical category and particular ag-bio science programs. Georgia's higher education institutions have been innovative in their introduction of new programs including certificate programs at University of Georgia's College of Pharmacy and joint biomanufacturing and laboratory technicians program at Athens and Gwinnett Technical Colleges. On the occupational side, employment in bioscience occupations is expected to have somewhat higher growth in Georgia than in the nation. And the concentration of epidemiologists in the state is also a strength. With modest shortfalls predicted for bioscience occupations, the talent produced from higher education in Georgia supports a modest expansion of the bioscience industry.

But Georgia's biosciences industry and talent situation also faces challenges. The lack of positioning of the state as a bioscience leader in any of the subsectors in the Battelle report, and lack of significant growth of the bioscience industry in the last five years are concerns. Low LQs in many of the bioscience sectors, including manufacturing and in R&D and testing services, suggest the state is not at pace with national trends in these industries. On the academic side, while Georgia produces a sizeable number of graduates, the state has not kept pace with the nation or other states with similar magnitudes of bioscience graduates. This weakness suggests that Georgia will be challenged to pursue a "lead through talent" bioscience development strategy. Also competition for graduates from the health and elder care services sector presents a challenge for the future, especially for future medical and clinical laboratory technologists.

Recommendations

Monitor workforce supply and demand for medical and clinical laboratory technologists. Investigate program best practices and evaluate for appropriateness in University System of Georgia.

Attention should be given toward addressing modest future shortfalls in the medical and clinical laboratory technologist occupation. (Refer to Table 4.4 for competencies associated with this occupation.) Georgia has some programs directly serving this occupation – clinical laboratory science/medical technology/ technologist – at Medical College of Georgia and Georgia Southern University, as well as Morehouse School of Medicine and Thomas University. In the 2003 bioscience study conducted by the authors (Drummond and Youtie, 2003), the medical and clinical laboratory technician occupation, typically served through two-year associates degrees, was identified as an important area of shortfall. Georgia is now served by some 60 institutions that offer medical and clinical assistant and clinical/medical laboratory technicians programs at the associate's degree level. These results suggest that shortfalls can be addressed through enhanced programmatic activity.

We recommend monitoring and providing support for modest increases in bachelor's-degree and bachelor's-degree-plus certificate programs in the medical and clinical laboratory technologist area. Best practice examples should be investigated and evaluated for appropriateness. Examples of large programs in clinical laboratory science outside of Georgia include:

- Bachelor of Science in Clinical Laboratory Science / Medical Technology, University of Michigan-Flint, Nancy Gouin PhD, 810-762-3174 http://www.umflint.edu/hsa/med_tech/index.htm
- Louisiana State University, Louann Lawrence, PhD 504-568-4276 http://alliedhealth.lsuhsc.edu/clinicallaboratory/
- Temple University (pre-master's certificate programs), refer to Table 5.1.

Set broad-based goals for Georgia to become a top five producer of bioscience graduates in agriculture, biomedical engineering, biology, medical science programs

This study has suggested that Georgia's higher educational system could set a broad-based goal to become a top five producer of bioscience graduates by increasing the quantity of graduates in the agriculture sciences, biological sciences, biomedical sciences, and medical sciences. This type of increase certainly will require more faculty per student and additional course offerings. An example of a large program in each of these areas is shown in Table 5.1.

Table 5.1. Examples of Bioscience Programs and Practices		
Area/Program	Practice	Contact
Agriculture sciences University of Tennessee Plant Sciences Program	Offers PhD concentrations in crop sciences, horticulture, plant improvement and biotechnology	Robert Auge, PhD http://plantsciences.utk.edu 865-974-7324
Biomedical sciences MIT/Harvard	Large number of faculty per student, diverse courses	Martha L. Gray, PhD http://hst.mit.edu 617-253-4418
Biological sciences Rutgers University-New Brunswick/Piscataway	Graduate program in Microbiology and Molecular Genetics	Andrew K. Vershon http://lifesci.rutgers.edu/~mmg 732-445-5086
Medical sciences Temple University	Multiple pre- and post-certificate programs in translational areas, drug delivery, risk analysis, manufacturing, etc.	Peter H. Doukas, PhD http://www.temple.edu/pharmacy_qara/index.html 267-468-8560

Monitor the need for vaccine and immunotherapy graduates in support of the state's vaccine initiative

The state of Georgia has created an initiative to advance its position in the emerging vaccines and immunotherapy technologies, The Next-Generation Vaccines and Therapeutics Initiative. The vaccine and immunotherapy area draws on multiple fields and Georgia has educational programs that feed these fields, including in microbiology, biology, chemistry, biomedical engineering, and the like. It is recommended that the state reinforce its focused strategy by monitoring the need for more vaccine and immunotherapy programs as the initiative moves forward.

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