MassBioEd
Massachusetts Biotechnology Education Foundation

The Digest of Biotech Job Trends in Massachusetts

2017

2nd ANNUAL JOB TRENDS FORECAST

About the Digest

The Digest of Biotech Jobs Trends in Massachusetts consists of an on-going series of publications that include *Briefs, 3-Month Job Trends* reports, and an *Annual Jobs Trends Forecast.* The *Briefs* present basic data and analysis on particular aspects of biopharma industry job trends.

The objectives in publishing the *Briefs* is to provide basic information about job listings trends, skills required of candidates, and the prevalence of degree requirements for high trending occupations. The *Briefs* are intentionally limited in commentary. Instead, they are intended to form a basis for additional study on job trends, skill requirements of candidates seeking positions in the industry, and how training and higher education programs can align with industry needs. The *Annual Job Trends Forecast* is intended to provide greater insight based on additional study in these areas.

About the MassBioEd Foundation

MassBioEd engages teachers, inspires students, and guides the life sciences workforce. Our BioTeach program supports Massachusetts teachers as they work to engage students through lab-centered, inquiry-based learning. Our Job Trends initiative identifies workforce needs and illuminates the pathway from the classroom to careers in the life sciences.

Acknowledgements

The research and analysis found in the *Forecast* was conducted by Mark Bruso, Manager of Labor Market Research, under the direction of MassBioEd Foundation Executive Director, Peter Abair. Erica Dickinson, Product Support Manager at Burning Glass provided able assistance to the MassBioEd research team in effectively using data from Burning Glass Technologies. Neena Verma of the University of Massachusetts President's Office provided 2016 graduation data. MassBio, the industry council serving the biopharmaceutical community of the Massachusetts region, provided support for this series and MassBioEd's on-going job trends initiative.

For more MassBioEd job trends analysis, visit MassBioEd.org/job_trends.

Report at a Glance

I. Job Demand

The first section provides a broad overview of the job listings data, which is cut and synthesized by occupation, job type, locale, in-demand skills, employers, and educational minimums.

This information is presented against historical data, illuminating broad-based shifts occurring in the job market in the biopharma industry in Massachusetts.

II. Occupational Forecast

Whereas the first annual *Job Trends Forecast* looked forward over a time-horizon of three years, this year's section on projections looks out to 2022, a full five years from the present, and six years from the latest employment data made available.

This section contains projections for individual occupations, industry sectors, and occupational groups, in the hopes that decision-makers in industry, government, and academia may look forward with a reasonable idea of what the job market landscape will look like when their decisions today are bearing fruit.

III. Supply of Workers

An important and often overlooked area in workforce development is the supply of workers able to fill current and projected openings. Section III highlights graduation data from relevant biotech-related academic programs in order to spotlight occupations and skill-sets that potentially may see deficits in the not-too-distant future.

IV. Industry Pay Snapshot

For the first time, MassBioEd is able to produce granular compensation data for occupations within the biopharma industry. Provided within the fourth section is a flyover of the pay ranges of critical occupations in the industry, as well as comparisons to other biotech hubs in California, North Carolina, and PA/NJ.

V. Annual Employer Survey

The final section looks at the results from our 2nd annual industry survey, which produces data points on employer sentiment that are not readily available from other sources. Examples of topics covered in this year's survey are: time-to-fill openings, expected expansions by functional area, H1-B visas, competitive positions to fill, channels for hiring candidates, and use of temporary workers.

Executive Summary

The Massachusetts biopharmaceutical industry remains in a prolonged period of expansion for which we see no end into 2022. We project that Massachusetts biopharma companies will add 11,600 additional jobs by 2022, at an overall growth rate of 17 percent. The greatest rate of growth within the industry will be in employment associated with employers classified as biopharmaceutical manufacturers, a 32 percent projected increase in this period.

While employment growth and high job demand continue, we do note an easing in the rate of *real* growth in job listings to 6.1 percent in 2016 compared to 9.6 percent in 2015. In addition, while 55 percent of surveyed employers report that it is more difficult to find skilled employees now than three years ago this percentage is significantly lower than the 78 percentage reporting the same level of comparative difficulty in 2016. However, despite these indications, 74 percent of employers in 2017 – up from 52 percent in 2016 – reported that the average time to fill open positions was over 10 weeks. Geographically, the Central and North regions of Massachusetts saw job listings rise at the greatest rates – 35 and 47 percent respectively, outpacing all other areas of the state.

Massachusetts *public* colleges and universities are increasing rates of graduation from biotechnology-related degree programs at a higher rate than national peers. However, the industry's rate of growth in entry level positions currently outstrips the rate of growth of graduates in biotech-related programs from Massachusetts public and private colleges and universities. Associate degree programs are doing the best at meeting demand, increasing the number of graduates in biotechnology-related programs by 60 percent between 2011 and 2015 to meet a 76 percent rise in entry level openings at the associate level.

Massachusetts biopharmaceutical job listings jumped by **6.1 %** in 2016.

11,600 – The forecasted number of new jobs that the industry will need to fill by May of 2022. Biopharma manufacturing-related positions are forecast to increase by **32%**.

82% of employers report that they will increase employment in the next 12 months.

55% of employers report more difficulty in hiring than 3 years ago.

74% of employers reported the average time to fill a position was over 10 weeks, compared to just 52% in 2016.

66% of companies provide paid internships BUT only a small number are publicly listed.

The greatest disparity between graduates and entry level job openings was at the Ph.D. level, with just a four percent increase in graduates from Massachusetts public universities versus a 114 percent increase in Ph.D. entry level job listings between 2011 and 2016.

Career exploration experiences, such as internships, are universally accepted as significant opportunities for students to gain valuable work experience and for companies to nurture and appraise prospective employees. Sixty-six percent of employers reported offering paid internships, but only 266 internship opportunities were listed on public job boards in 2016.

To view or download a copy of the complete 2017 MassBioEd Biotechnology Jobs Trends Forecast or view other job trend reports, visit:

www.massbioed.org/job_trends

MassBioEd, a charitable education non-profit organization, engages teachers, inspires students, and guides the life sciences workforce.

While MassBioEd has a strong focus on providing information about industry job trends, our flagship educational program is BioTeach. We invite you to learn more about our BioTeach program, which supports Massachusetts teachers as they work to engage students through lab-centered, inquiry-based learning focused in biotechnology.

BioTeach provides training for about 150 public high school teachers annually, impacting over 10,000 public high school students. BioTeach's college and career experiential learning opportunities introduce about 1,000 public school science students annually to careers in the life sciences. Through BioTeach, MassBioEd also provides grants for lab supplies and equipment for in-need schools, as well as extensive mentoring for many teachers. BioTeach programming is dependent on funds raised from corporate philanthropy and individual donors.

Learn how you can help at www.massbioed.org.

I. Job Demand

The growth of job listings in the biopharma industry continued in 2016. However, comparative demand for workers in the biopharma industry in Massachusetts declined in 2016 relative to 2015. Year-over-year growth this past year in raw job listings was 7% - in 2015 this number was 33%. When adjusting for increases in Burning Glass Labor Insight's growing ability to detect online job listings, the adjusted, real growth[1] in job listings, a measurement we prefer using, declined to 6.1% in 2016 from 9.6% the year before. Since tracking of these data began in 2010, the share of all Massachusetts listings stemming from biopharma companies has fallen from around 5% to about 3.5% of all listings in recent years.

Figure A1: Listings v. Pct. Of All Listings, Biopharma, MA, 2010 - 2016

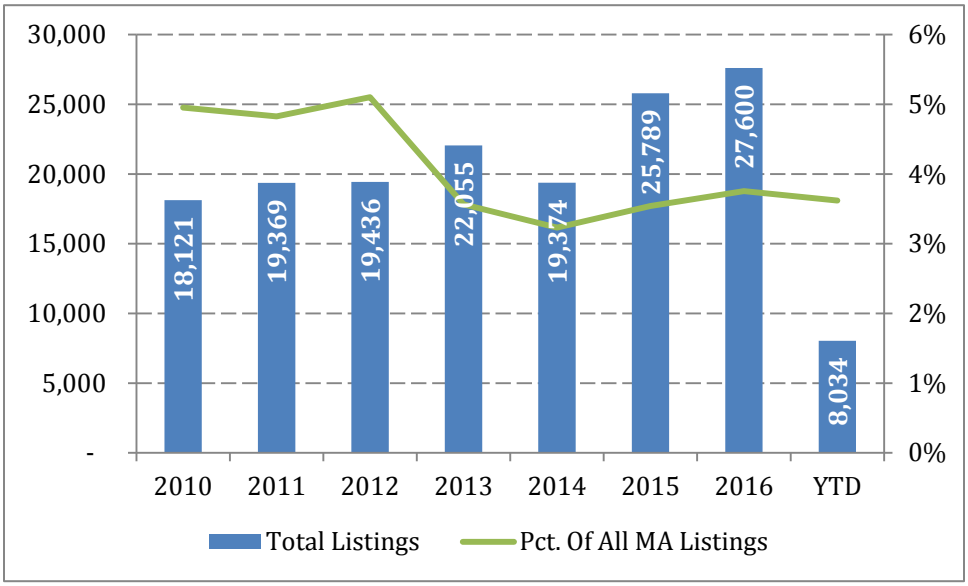


Fig. A2: YoY Growth in Job Listings, Biopharma, MA, 2011 - 2016

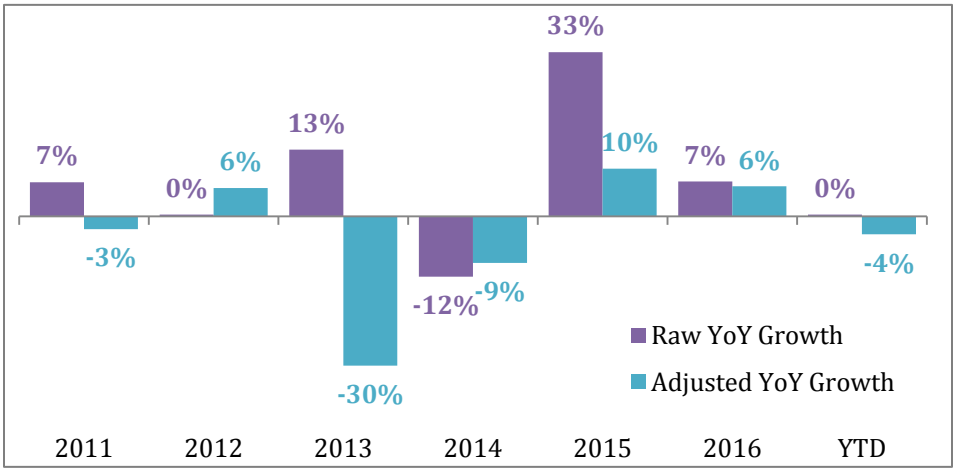
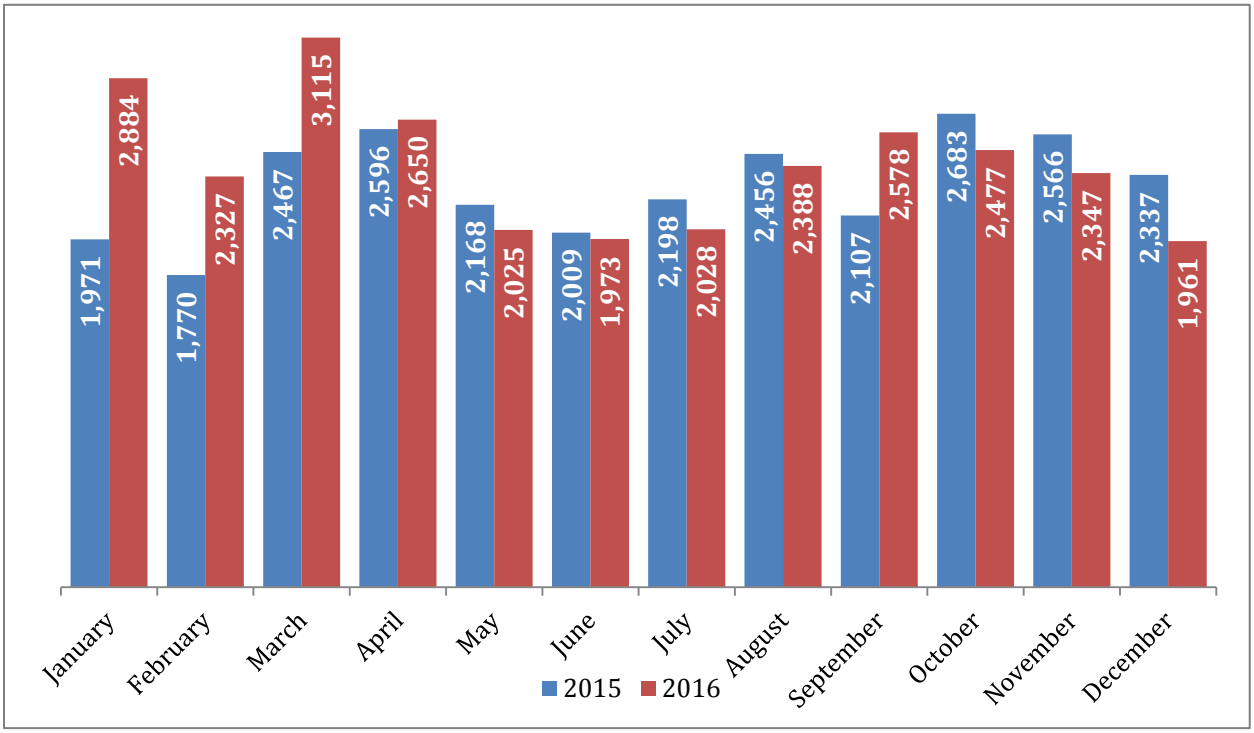


Fig. A1 – Fig. A5 detail the macro-level review of job demand in the biopharma industry from January 2010 through the end of March 2017. While raw year-over-year growth in listings

[1] See Appendix

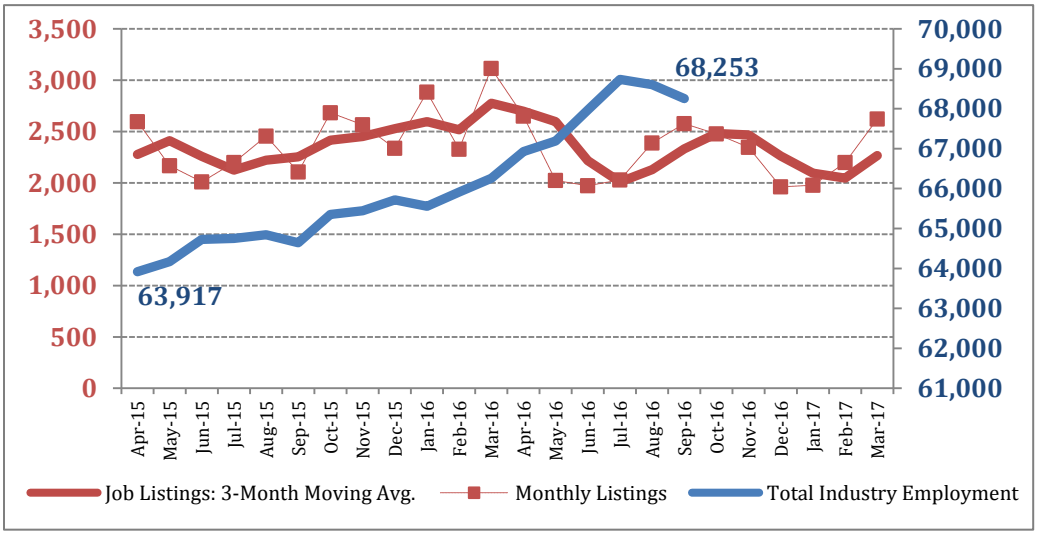
was at a historic high at the time of publication last year, 2016 was more in line with recent norms, where raw growth stood at 7% and adjusted growth was the second highest since

Fig. A3: Monthly Job Listings, Biopharma, MA, 2015 - 2016



2010, at 6.1%. The industry, as a whole, continues to experience growing annual demand for workers. 2017 is on track to surpass 2016's record total for job listings, albeit by a slim margin.

Fig. A4: Monthly Employment v. Listings, Biopharma, MA, Past 2 Years



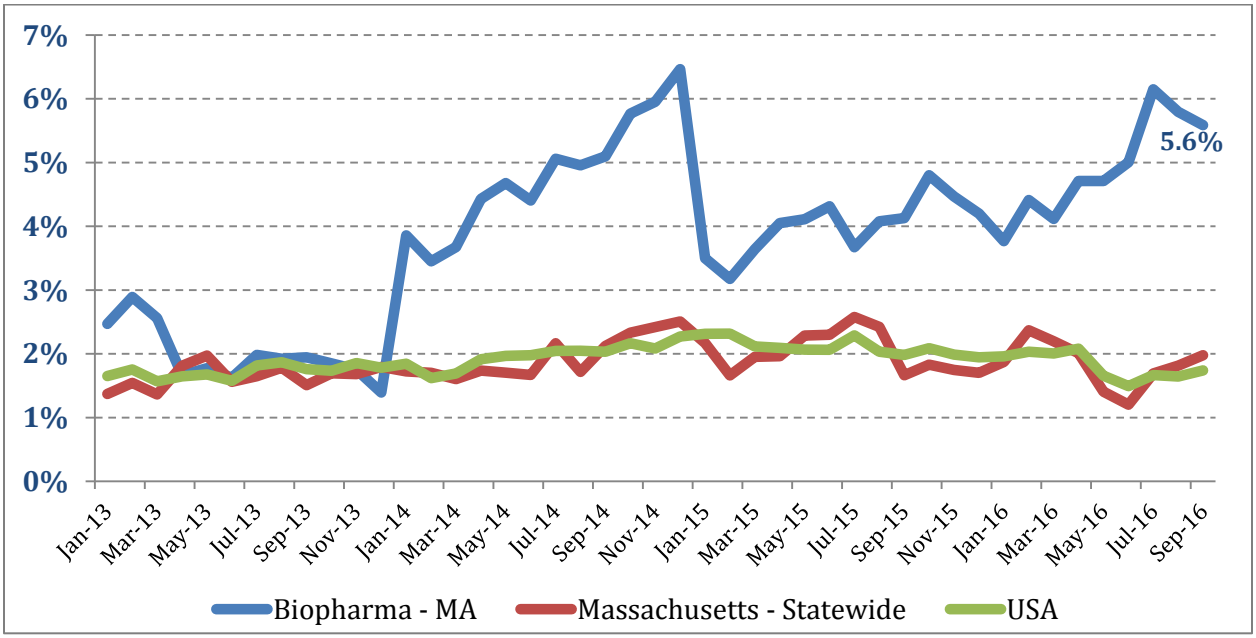
While annual job listings have continued to increase, monthly listings have fallen behind on a year-over-year basis in seven of the final eight months in 2016, as

shown in Fig. A3. The reduction of demand since May of 2016 may be a harbinger of industry easing in hiring.

Fig. A4 is a side-by-side comparison of employment and listings in the industry in the past two years, taken from the Q1 Industry Job Market report. In it, you will see a decrease in employment starting in July 2016 and lasting until September 2016, the latest month for which employment data is available. This is mere months after the slowdown in job listings for new workers. It is too early to say definitively that the decrease in employment is an enduring trend or not, or whether the decrease in job listings will remain on its trajectory.

Notwithstanding the downturn in job listings and employment in recent months, the industry has experienced a prolonged expansion in the post-recession economy. Beginning in January 2014, the pace of employment growth in biopharma in Massachusetts, in comparison to the statewide and nationwide economy, began to take off. As shown in Fig. A5, the rolling year-over-year increase in employee headcount in the industry has exceeded the two aforementioned categories in each of the past 33 months, with a growth rate of 5.6% in the most recent month – September 2016.

Fig. A5: Rolling 12-Month Growth Rate of Employment, 2013 - 2016



Generally speaking, employment and listings have steadily grown in recent years, yet show signs of decreasing in recent months. The ensuing pages will look at a more granular level the occupations and occupational groups that have seen the greatest increases and decreases in demand, as well as comparing differences across regions both inside and outside of Massachusetts.

Biopharma STEM Openings, 2016

All	HS/Voke	439	4%
	Associate	307	2%
	Bachelor's	7,874	64%
	Master's	1,119	9%
	Ph.D.	2,555	21%

Entry Level	HS/Voke	153	5%
	Associate	119	4%
	Bachelor's	2,218	71%
	Master's	200	6%
	Ph.D.	454	14%

0 to 2 Years	3 to 5 Years	6 to 8 Years	9-Plus Years
34%	40%	15%	11%

For job listings of STEM occupations within the biopharma industry in 2016, the vast majority required possession of at least a four-year degree (94 percent). For entry level openings – jobs requiring two years or less of experience – that rate drops to 91 percent. There are stark divides between entry level openings and job openings regardless of experience required. Whereas 30 percent of all STEM openings required a graduate degree of some sort, entry level STEM openings only required them 20 percent of the time.

Just over one-third of STEM openings were deemed "entry level" in 2016, which is less than the economy-wide rate of between 40 – 45 percent. STEM positions, by their very nature, require higher levels of education and experience than many positions found outside the biopharma industry.

Fig. A6: Top 30 Occupations by Job Listings, 2016

2016	2015	Rank +/-	Occupation	2016	2015	Change +/-	Pct. Change
1	1	--	Medical Scientist	2,462	1,924	+538	28%
2	2	--	Researcher / Research Associate	1,298	1,037	+261	25%
3	3	--	Administrative Manager	871	761	+110	14%
4	5	+1	Chemist	843	591	+252	43%
5	4	-1	Chemical / Process Engineer	832	700	+132	19%
6	6	--	Biologist	674	578	+96	17%
7	10	+3	Healthcare Administrator	491	454	+37	8%
8	7	-1	Sales Representative	485	572	-87	-15%
9	11	+2	Quality Control Analyst	468	432	+36	8%
10	12	+2	Marketing Manager	463	429	+34	8%
11	13	+2	Business Development / Sales Manager	436	426	+10	2%
12	9	-3	Office / Administrative Assistant	410	477	-67	-14%
13	21	+8	Laboratory Technician	400	299	+101	34%
14	8	-6	Project Manager	388	552	-165	-30%
15	14	-1	Medical Director	378	372	+6	2%
16	17	+1	Program Manager	376	329	+47	14%
17	18	+1	Biostatistician	367	329	+38	12%
18	23	+5	Clinical Research Coordinator / Manager	345	292	+53	18%
19	19	--	General Manager	312	318	-6	-2%
20	20	--	Compliance Manager	292	315	-23	-7%
21	15	-6	Software Developer / Engineer	272	353	-81	-23%
22	24	+2	Quality Inspector / Technician	265	281	-16	-6%
23	16	-7	Product Manager	264	334	-70	-21%
24	32	+8	Biological Technician	262	200	+62	31%
25	25	--	Quality Control Systems Managers	258	259	-1	-1%
26	22	-4	HR / Labor Relations Specialist	228	293	-65	-22%
27	29	+2	Technical Writer	226	229	-3	-1%
28	26	-2	Financial Manager	223	249	-26	-10%
29	41	+12	Laboratory Technologist	211	120	+91	76%
30	30	--	Business / Management Analyst	207	215	-8	-4%

Methodology: For calculating occupational totals and monthly total of job postings MassBioEd used the following method – for non-STEM positions, the MassBio percentage for each NAICS code. For STEM positions – all postings within 3254, MassBio percentage used for 5417, and the Burning Glass Filter: Biotech for the remaining NAICS codes of 622, 6113, 6215, 3345, and 5413. All *Medical Scientist, Biochemist, Microbiologist, Biomedical Engineer, Biological Technician, Chemical Technician, and Quality Control Analyst* openings were counted, regardless of NAICS code.

Sales Representative and *Medical/Pharmaceutical Sales Representative* were combined into one BGTOCC for tabulation.

Fig. A7: Top 30 Fastest Growing Occupations by Job Listings, 2016

2016	2015	Rank +/-	Occupation	2016	2015	Change +/-	Pct. Change
50	121	+71	Operations Manager / Supervisor	109	32	+77	242%
91	129	+38	Data Scientist	55	26	+29	112%
85	119	+34	Market Research Analyst	60	32	+28	85%
29	41	+12	Laboratory Technologist	211	120	+91	76%
34	53	+19	Account Manager / Representative	176	101	+75	75%
97	122	+25	Cyber / Information Security Engineer / Analyst	50	30	+20	67%
35	50	+15	Natural Science Research Manager	169	103	+66	64%
48	71	+23	Data / Data Mining Analyst	115	73	+42	58%
47	68	+21	Production Plant Manager	120	77	+43	55%
4	5	+1	Chemist	843	591	+252	43%
79	99	+20	Computer Scientist	67	48	+19	40%
65	80	+15	Nursing Assistant	87	63	+24	37%
69	87	+18	Supply Chain / Logistics Manager	78	57	+21	36%
68	86	+18	Computer Support Specialist	78	58	+20	35%
13	21	+8	Laboratory Technician	400	299	+101	34%
61	75	+14	College / University Administrator	90	67	+23	34%
93	108	+15	Account Executive	54	40	+14	34%
44	55	+11	Medical Assistant	130	98	+32	33%
24	32	+8	Biological Technician	262	200	+62	31%
86	102	+16	Buyer / Purchasing Agent	58	45	+13	29%
1	1	--	Medical Scientist	2,462	1924	+538	28%
57	73	+16	Industrial Engineer	93	73	+20	27%
2	2	--	Researcher / Research Associate	1,298	1037	+261	25%
53	65	+12	Financial Analyst	101	82	+19	24%
42	46	+4	Mechanical Engineer	137	111	+26	23%
31	35	+4	Regulatory Affairs Specialist	206	168	+38	23%
39	40	+1	Validation Engineer	150	122	+28	23%
63	74	+11	Chemical Technician	88	72	+16	22%
73	85	+12	Electrical Engineer	72	60	+12	20%
5	4	-1	Chemical / Process Engineer	832	700	+132	19%

Methodology: For calculating occupational totals and monthly total of job postings MassBioEd used the following method – for non-STEM positions, the MassBio percentage for each NAICS code. For STEM positions – all postings within 3254, MassBio percentage used for 5417, and the Burning Glass Filter: Biotech for the remaining NAICS codes of 622, 6113, 6215, 3345, and 5413. All *Medical Scientist, Biochemist, Microbiologist, Biomedical Engineer, Biological Technician, Chemical Technician, and Quality Control Analyst* openings were counted, regardless of NAICS code.

Sales Representative and *Medical/Pharmaceutical Sales Representative* were combined into one BGTOCC for tabulation.

Fig. A8: 30 Fastest Declining Occupations by Job Listings, 2016

2016	2015	Rank +/-	Occupation	2016	2015	Change +/-	Pct. Change
72	42	-30	Recruiter	72	119	-47	-39%
88	56	-32	Fundraising Manager	57	94	-37	-39%
94	63	-31	Auditor	53	85	-32	-37%
76	49	-27	CIO / Director of Information Technology	71	104	-33	-32%
37	28	-9	Production Worker	167	241	-74	-31%
96	70	-26	Surveillance Officer / Investigator	51	73	-22	-30%
14	8	-6	Project Manager	388	552	-165	-30%
33	27	-6	Systems Analyst	179	243	-64	-26%
21	15	-6	Software Developer / Engineer	272	353	-81	-23%
64	45	-19	Computer Systems Engineer / Architect	88	114	-26	-23%
26	22	-4	HR / Labor Relations Specialist	228	293	-65	-22%
23	16	-7	Product Manager	264	334	-70	-21%
78	60	-18	Maintenance Technician	70	87	-17	-19%
77	59	-18	Bookkeeper / Accounting Clerk	71	87	-16	-19%
56	44	-12	Communications / PR Manager	94	116	-22	-19%
67	52	-15	Network Engineer / Architect	84	102	-18	-18%
36	31	-5	Executive Assistant	169	205	-36	-18%
43	36	-7	Phlebotomist	131	156	-25	-16%
80	69	-11	Database Administrator	65	77	-12	-16%
8	7	-1	Sales Representative	485	572	-87	-15%
12	9	-3	Office / Administrative Assistant	410	477	-67	-14%
70	61	-9	Retail Store Manager / Supervisor	75	87	-12	-13%
45	37	-8	Production Supervisor	127	146	-19	-13%
87	79	-8	Office Manager	57	65	-8	-12%
90	82	-8	Training and Development Manager	55	62	-7	-11%
28	26	-2	Financial Manager	223	249	-26	-10%
38	33	-5	Attorney	154	171	-17	-10%
55	51	-4	IT Project Manager	94	102	-8	-8%
20	20	--	Compliance Manager	292	315	-23	-7%
60	54	-6	Engineering Manager	91	98	-7	-7%

Methodology: For calculating occupational totals and monthly total of job postings MassBioEd used the following method – for non-STEM positions, the MassBio percentage for each NAICS code. For STEM positions – all postings within 3254, MassBio percentage used for 5417, and the Burning Glass Filter: Biotech for the remaining NAICS codes of 622, 6113, 6215, 3345, and 5413. All *Medical Scientist, Biochemist, Microbiologist, Biomedical Engineer, Biological Technician, Chemical Technician, and Quality Control Analyst* openings were counted, regardless of NAICS code.

Sales Representative and *Medical/Pharmaceutical Sales Representative* were combined into one BGTOCC for tabulation.

Special Note

The number of jobs that an organization will post will rise and fall according to that organization's business plan. A high number of listings in one year and a small number of listings by the same organization in another year may reflect a number of different factors, including that the organization met its hiring goals in keeping with its business plan in one period of time and as a result has fewer listings in a subsequent quarter.

A rise or fall in the number of job listings in one year should not be used as a barometer of an organization's health. We provide these listings for the more basic purpose of showing which companies influenced talent supply and demand in hiring in 2016.

Fig. A9: Top Employers by Job Listings, 2016

Company	Total Listings	YoY growth
Sanofi Genzyme	2,934	23%
Biogen	1,926	-9%
Pfizer	1,487	32%
Takeda Pharmaceuticals	1,284	-20%
Vertex Pharmaceuticals	988	29%
Merck & Company	897	118%
Novartis	730	-37%
Bristol-Myers Squibb	338	29%
Quest Diagnostics	336	-5%
Charles River Labs	315	39%
Alnylam	274	158%
Shire	266	62%
Amgen	241	-56%
PerkinElmer	223	76%
Parexel	208	164%
Sunovion	201	72%
Ironwood Pharmaceuticals	199	363%
Danaher Corporation	161	189%
AbbVie	156	-11%
Astrazeneca	144	-14%
Non-Profits, Universities & Health Care Orgs	**Total Listings**	**YoY growth**
Massachusetts General Hospital	996	177%
Dana Farber Cancer Institute	353	-12%
Harvard University	341	25%
Boston Children's Hospital	293	36%
Boston University	265	75%
Cardinal Health	200	56%
UMass Medical School	198	-13%
Beth Israel Deaconess Medical Center	138	-13%
MIT	93	8%
Harvard Medical School	91	-13%

Regional Breakdown

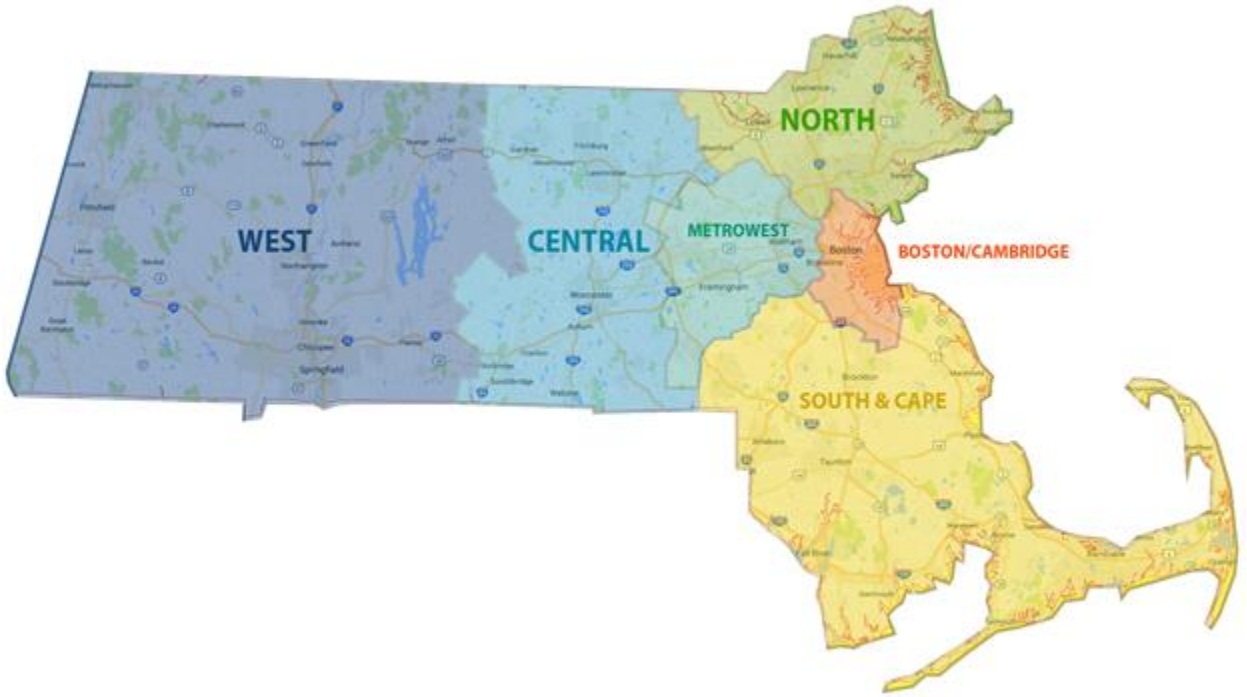


Fig. A10

Region	2015	Share	2016	Share	% Chg.
West	401	**1.6%**	334	**1.3%**	-17%
Central	1,247	**5.1%**	1,678	**6.4%**	+35%
Metrowest	4,114	**16.8%**	4,537	**17.4%**	+10%
North	1,970	**8.0%**	2,887	**11.1%**	+47%
Boston/Cambridge	16,027	**65.4%**	15,642	**60.1%**	-2%
South & Cape	739	**3.0%**	942	**3.6%**	+27%

Four of the six regions across Massachusetts saw significant growth in year-over-year job listings in 2016. The *Western* part of the state was the only place to see a significant drop in listings. The *Cambridge/Boston Core's* total job listings flattened, actually falling slightly by 2 percent.

As a share of all job listings, the *North* and *Central* regions were the biggest gainers, earning an increased share of 3.1 and 1.3 percentage points last year, respectively. The Boston/Cambridge area saw a drop-off of over five percentage points over that same time period.

The shift away from Boston's core to its outlying regions last year warrants continued monitoring to determine whether this is an ongoing trend or a momentary easing in hiring in the Boston/Cambridge core.

Fig. A11

Below are the **top ten employers**, by job listings, in 2016

Boston/Cambridge	Listings	Metrowest	Listings
Biogen	1,657	Sanofi Genzyme	743
Sanofi Genzyme	1,624	Biogen	269
Takeda Pharmaceuticals	969	Shire	203
Massachusetts General Hospital	939	Quest Diagnostics	195
Pfizer	799	PerkinElmer	164
Vertex Pharmaceuticals	735	Astrazeneca	118
Novartis	712	Sunovion	110
Merck & Company	338	Parexel	95
Harvard University	327	Cardinal Health	82
Dana Farber Cancer Institute	298	Astellas	71
Northeast	**Listings**	**South & Cape**	**Listings**
Pfizer	622	Merck & Company	101
Merck & Company	412	Sanofi Genzyme	46
Charles River Labs	186	Cardinal Health	42
Parexel	100	Quest Diagnostics	40
Cardinal Health	52	Covance	39
Flexion Therapeutics	42	MobilexUSA	31
Quest Diagnostics	34	Southcoast Health System	28
Life Technologies	27	Medtronic	28
Danaher Corporation	27	Life Technologies	27
Amgen	23	Cape Cod Healthcare	23
Central	**Listings**	**West**	**Listings**
Sanofi Genzyme	337	Baystate Health	57
Bristol-Myers Squibb	300	Pfizer	21
UMass Medical School	160	Takeda Pharmaceuticals	14
AbbVie	115	Smith College	12
Danaher Corporation	91	Holyoke Medical Center	11
Charles River Labs	85	UMass Amherst	10
Laboratory Corporation of America	51	Sanofi Genzyme	9
UMass Memorial Healthcare	32	Quest Diagnostics	8
IDEXX Laboratories	23	Lancaster Laboratories	8
Pfizer	20	Agilent Technologies	6

Comparison to Other Biotech Hubs

The Cambridge biotechnology supercluster around Kendall Square is recognized as the highest concentration of R&D professionals in the world. As a leader in top-end scientific talent, both Cambridge – and Massachusetts as a whole – must be aware of how the region stacks up against other biotech hubs across the nation. Remaining competitive in this sphere is the key to the continued strength of Massachusetts as the preeminent destination for drug discovery and drug development.

Below is a dashboard of tables relating the labor market indicators for STEM positions (experience, education, job types, pay) in five leading biotech R&D locales in 2016 – Boston/Cambridge, the Research Triangle, San Diego, the Bay Area, and Pennsylvania/New Jersey[2]. All five are considered important places where life-saving therapies creation takes place.

Fig. A12

Minimum Degree	Boston/ Cambridge	Research Triangle	San Diego	Bay Area	PA/NJ
Associate or less	8%	12%	**13%**	9%	9%
Bachelor's	64%	**70%**	67%	68%	65%
Master's	10%	8%	7%	8%	**12%**
Ph.D.	**18%**	10%	12%	15%	14%

Boston/Cambridge open job postings in 2016 were the most stringent of the five clusters, with the lowest concentration of jobs requiring less than a four-year degree as well as the highest share of jobs requiring a graduate degree of some kind. Ph.D. holders were desired at the highest rate of the five areas.

Fig. A13

Required Experience	Boston/ Cambridge	Research Triangle	San Diego	Bay Area	PA/NJ
0 to 2 Years'	29%	27%	**33%**	26%	27%
3 to 5 Years'	40%	**46%**	42%	42%	44%
6 to 8 Years'	17%	16%	15%	**18%**	16%
9-Plus Years'	**15%**	11%	10%	14%	14%

The five epicenters were more alike than not in their experience requirements. Whereas economy-wide some 40% of jobs are earmarked for entry level candidates (those with less than two years of relevant experience), biopharma companies tend to have less demand for those workers.

Of the five clusters, Boston/Cambridge demanded slightly more years of experience of its workers, having the second-lowest number of jobs for those with five years or less of

[2] Five Counties: Mercer, NJ; Middlesex, NJ; Somerset, NJ; Chester, PA; and Montgomery, PA

experience and tied for the highest level of listings for those with other six years of experience.

Fig. A14

Listings by Occupation Group, 2016	Boston/ Cambridge	Research Triangle	San Diego	Bay Area	PA/NJ
Management	31%	26%	26%	30%	**35%**
Life, Physical, and Social Science	**24%**	16%	**24%**	20%	20%
Computer and Mathematical	11%	**13%**	11%	12%	11%
Healthcare Practitioners and Technical	9%	**14%**	11%	8%	7%
Architecture and Engineering	**8%**	**8%**	7%	**8%**	6%
Business and Financial Operations	5%	**6%**	**6%**	**6%**	**6%**
Office and Administrative Support	3%	3%	3%	**4%**	2%
Sales and Related	2%	2%	**3%**	**3%**	2%
Production	2%	3%	2%	3%	**4%**

Fig. A14 illustrates the job categories for job listings in the five biotech clusters in 2016. Boston/Cambridge had the highest rate of openings in the *Life, Physical, and Social Science* and *Architecture and Engineering* positions in 2016. With high rates of listings for STEM positions, as well as high levels of education needed to fill these roles, Boston is unique among its peers in the types of employees sought in 2016. Generally speaking, its employers required a field of candidates with more experience, higher levels of education, and more of a STEM-related academic background than other biotech hubs across the United States.

While the labor market is able to pull talent from outside Massachusetts to fill some of these positions, there remains the need for the Commonwealth to continue to groom and produce workers to fill these openings as the industry's expansion continues apace.

A subsequent section will discuss the supply of workers in Massachusetts, focusing specifically on the ability of institutions of higher education in the state, both private and public, to meet the demand for a graduates with biotech-related academic backgrounds. The industry has expanded by one-third in the past decade, and the rate of growth has shown no obvious signs of abating. Thus, it is important the education system continues to align programs to help Massachusetts maintain itself as the top biotechnology R&D hub in the United States.

II. Projections

The 2016 *Annual Job Trends Forecast,* using what was then the most recent employment data (May 2015), attempted to project employment growth by occupation and industry sector through May 2018, a three-year timeframe that was, in reality, looking ahead only two years. This year's edition is by design, different. Using employment data from May 2016, we are projecting growth in jobs through May 2022, a full five years. The logic behind extending the time horizon is to give workers, students, policymakers, and academic program managers an estimate of future growth, as they make long-term decisions in the present.

A trade-off in projecting outward over a longer period of time is the accuracy of making such a projection. Keeping that in mind, this year projections provide a mid-point, as well as a low- and high-forecast that encompass a range that presents 95% likelihood of the outcome. This is done to provide a distribution of outcomes, as well as what we deem as the likeliest projected employment growth.

The first step was analyzing trends specific to the seven industry sectors that make up the biopharma industry in Massachusetts, examining the relationship between select inputs to employment numbers since 2010 and modeling that relationship moving outward to 2022. The next step was to drill down into the occupational mix of each sector and look at the historical trends therein. After applying the mix of occupational groups to each sector's projected employment total for 2022, we were lastly able to define the growth of individual occupations between 2016 (the base year) and 2022. For more details on our methodology, please see the Appendix.

Fig. B1: Forecasted Employment Growth, 2016 - 2022

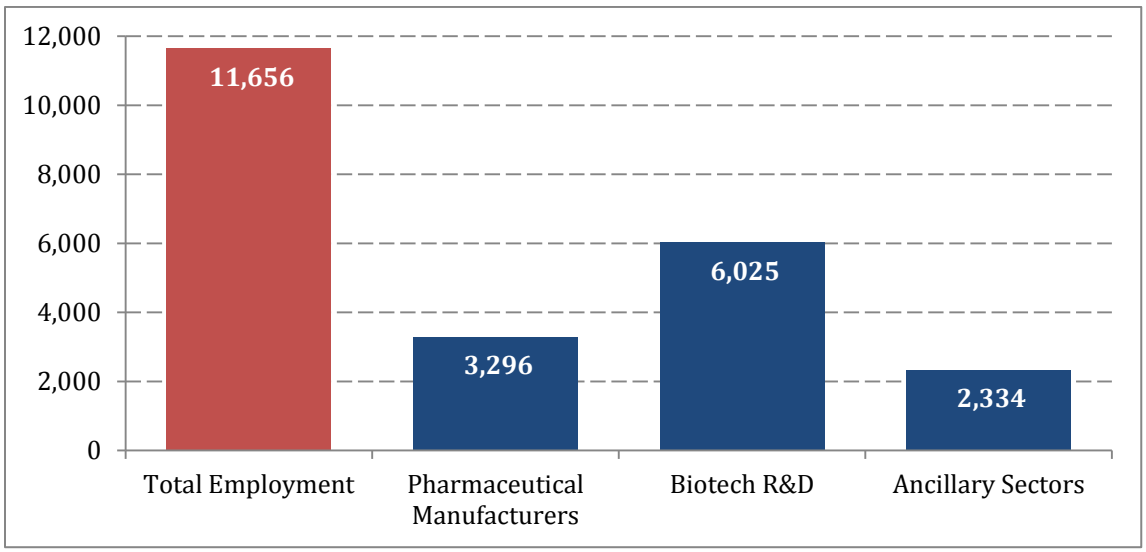
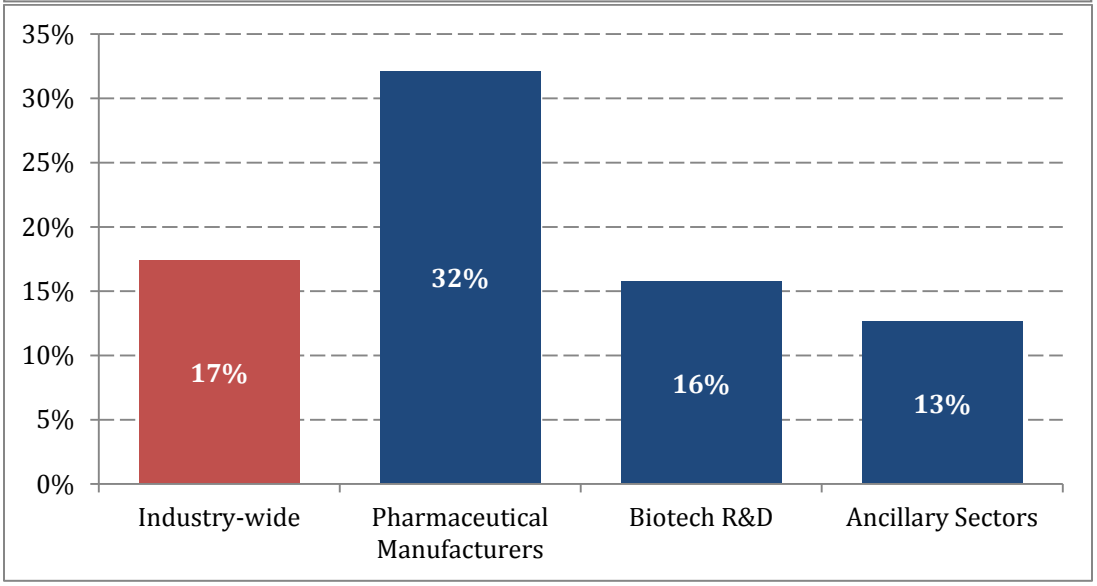


Fig. B2: Forecasted Growth Rate of Industry Sectors, 2016 - 2022

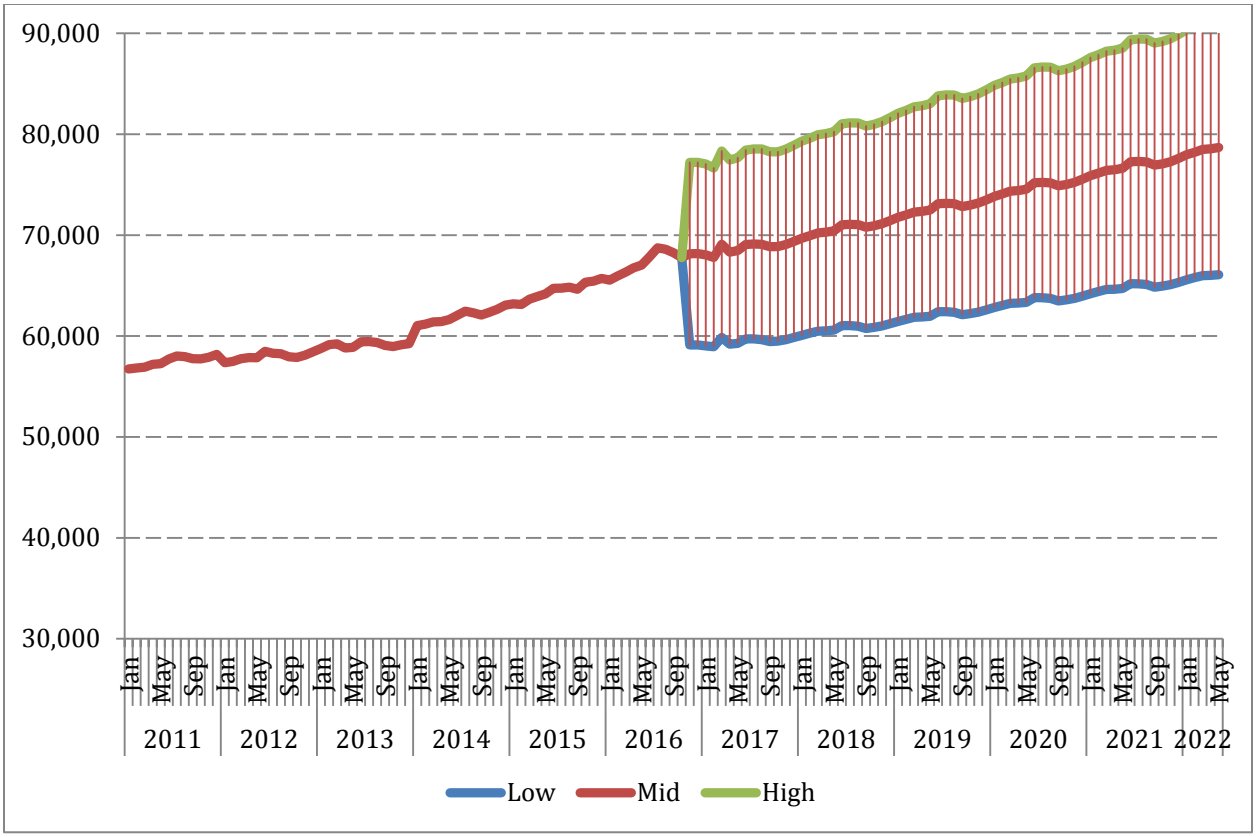


MassBioEd is projecting the biopharma industry will expand by 17% by 2022, which is in-line with recent history. Between the base year of 2016 and 2022, the estimate for total number of new employees in the industry is forecasted to top 11,600. Of the three main sectors, Biotechnology R&D (NAICS Code 54171) projects to grow by approximately 6,000 workers, followed by Pharmaceutical Manufacturers (NAICS Code 3254) at nearly 3,300. The remaining five ancillary sectors are projected to grow by 2,334 net new workers.

Buoyed by relocations of global giants to Massachusetts in recent years and FDA approval of therapies discovered and developed in Massachusetts, biomanufacturing is projected to grow by nearly a third in the six-year period analyzed. Positions more highly concentrated in this sector are likely to grow at a much faster rate than the industry average as well.

The ancillary sectors - made up of biopharma employment at research hospitals, universities, testing laboratories, and laboratory instrument manufacturing – presented the smallest growth both by total projected increase in workers and growth rate at 2,334 and 13%, respectively.

Fig. B3: Forecasted Industry Growth, Upper & Lower Bounds, 2016 - 2022



The range of expected outcomes shows the inherent difficulty in projecting six years into the future. Exogenous factors not included in MassBioEd's models – i.e. unforeseen economy-wide shocks – are not possible to predict. Based on the industry's recent trajectory, however, it is safe to assume that if the factors contributing to the growth of the industry in recent years hold then the expected employment numbers should be close to the red line in Fig. B3, away from the extremes.

The mid-point projections of the models forecast growth in line with recent years, with a May 2022 industry employment at about 78,600. As this is the most likely number of workers in the industry five years from now, we based our individual occupational projections off of this number. The following section explores the projections for critical occupations.

Fig. B4: Projected Growth for Top STEM Occupations, by 2016 Employment

Occupation	May 2016 Workers	May 2022 Workers	Change +/-	Pct. Change
Medical Scientists, Except Epidemiologists	9,110	10,182	+1,072	11.8%
Biological Technicians	5,190	5,798	+608	11.7%
Biochemists and Biophysicists	2,820	3,365	+545	19.3%
Biomedical Engineers	1,610	1,849	+90	5.6%
Natural Sciences Managers	1,607	1,878	+270	16.8%
General and Operations Managers	1,555	1,830	+275	17.7%
Chemists	1,305	1,617	+312	23.9%
Chemical Technicians	1,240	1,479	+239	19.3%
Microbiologists	1,160	1,387	+227	19.6%
Mechanical Engineers	967	1,155	+188	19.4%
Compliance/Regulatory Affairs Officers	957	1,149	+192	20.1%
Phlebotomists	911	1,094	+182	20.0%
Industrial Engineers	894	1,115	+221	24.7%
Laboratory Technicians	863	988	+125	14.5%
Laboratory Technologists	861	971	+109	12.7%
Biological Scientists, All Other	852	1,058	+206	24.2%
Electronics Engineers, Except Computer	837	987	+150	18.0%
Software Developers, Systems Software	819	1,013	+194	23.7%
Electrical Engineers	780	935	+156	20.0%
Sales Representatives	724	886	+162	22.4%
Industrial Production Managers	652	844	+192	29.5%
Medical and Health Services Managers	639	720	+81	12.7%
Quality Control Analysts	620	684	+64	10.3%
Architectural and Engineering Managers	616	748	+133	21.6%
Accountants and Auditors	610	697	+54	8.8%
Computer and Information Systems Managers	518	612	+93	18.0%
Statisticians	495	601	+106	21.5%
Engineering Technicians, Except Drafters, All Other	418	493	+75	17.9%
Industrial Engineering Technicians	408	547	+138	33.9%
Mechanical Engineering Technicians	338	402	+64	19.0%
Quality Control Technicians	317	431	+114	36.1%
Chemical Engineers	220	263	+43	19.5%
Materials Scientists	177	224	+47	26.4%
Computer Programmers	139	173	+35	24.9%
Technical Writers	118	154	+36	30.7%

Fig. B5: Projected Fastest-Growing Occupations, 2016-2022, by Pct. Growth*

Occupation	May 2016 Workers	May 2022 Workers	Change +/-	Pct. Change
Electrical and Electronic Equipment Assemblers	112	159	+46	41.1%
Still Machine Setters, Operators, and Tenders	570	777	+207	36.3%
Quality Control Technicians	317	431	+114	36.1%
Team Assemblers	168	228	+60	35.6%
Industrial Engineering Technicians	408	547	+138	33.9%
Paralegals and Legal Assistants	66	88	+22	33.2%
Technical Writers	118	154	+36	30.7%
Public Relations Specialists	147	191	+45	30.4%
Maintenance and Repair Workers, General	423	548	+126	29.7%
Industrial Production Managers	652	844	+192	29.5%
Social Science Research Assistants	121	154	+33	27.0%
Lawyers	281	356	+75	26.8%
Materials Scientists	177	224	+47	26.4%
Economists	78	98	+20	25.7%
Sales Reps, Wholesale and Manufacturing, Except Technical and Scientific Products	60	75	+15	25.2%
Shipping, Receiving, and Traffic Clerks	346	433	+87	25.1%
Environmental Scientists and Specialists	151	189	+38	25.1%
Security Guards	178	222	+45	25.1%
Computer Programmers	139	173	+35	24.9%
Janitors and Cleaners	276	344	+69	24.9%
Industrial Engineers	894	1,115	+221	24.7%
Receptionists and Information Clerks	127	158	+31	24.3%
Biological Scientists, All Other	852	1,058	+206	24.2%
Couriers and Messengers	227	282	+55	24.1%
Chemists	1,305	1,617	+312	23.9%
Software Developers, Systems Software	819	1,013	+194	23.7%
Computer Systems Analysts	356	437	+81	22.7%
Software Developers, Applications	468	573	+105	22.5%
Sales Representatives	724	886	+162	22.4%
Stock Clerks and Order Fillers	114	139	+25	22.3%
Data Entry Keyers	87	107	+19	22.1%
Database Administrators	114	139	+25	21.8%
Architectural and Engineering Managers	616	748	+133	21.6%
Statisticians	495	601	+106	21.5%
Computer User Support Specialists	271	329	+58	21.5%

*with over 50 employed professionals in 2016

Fig. B6: Projected Largest Increases in Employment, 2016-2022

Occupation	Change +/-	Annual Growth Rate
Medical Scientists, Except Epidemiologists	+1,072	1.9%
Biological Technicians	+608	1.9%
Biochemists and Biophysicists	+545	3.0%
Chemists	+312	3.6%
General and Operations Managers	+275	2.8%
Natural Sciences Managers	+270	2.6%
Chemical Technicians	+239	3.0%
Microbiologists	+227	3.0%
Industrial Engineers	+221	3.7%
Registered Nurses	+219	1.6%
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, etc.	+207	5.3%
Biological Scientists, All Other	+206	3.7%
Software Developers, Systems Software	+194	3.6%
Industrial Production Managers	+192	4.4%
Compliance Officers	+192	3.1%
Mechanical Engineers	+188	3.0%
Phlebotomists	+182	3.1%
Executive Secretaries and Executive Administrative Assistants	+179	2.8%
Sales Representatives	+162	3.4%
Electrical Engineers	+156	3.1%
Electronics Engineers, Except Computer	+150	2.8%
Industrial Engineering Technicians	+138	5.0%
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	+137	2.7%
Architectural and Engineering Managers	+133	3.3%
Financial Managers	+131	2.8%
Maintenance and Repair Workers, General	+126	4.4%
Laboratory Technicians	+125	2.3%
Customer Service Representatives	+123	3.1%
Quality Control Technicians	+114	5.3%
Office Clerks, General	+113	3.0%
Marketing Managers	+113	3.1%
First-Line Supervisors of Office and Administrative Support Workers	+113	2.7%
Laboratory Technologists	+109	2.0%
Statisticians	+106	3.3%
Software Developers, Applications	+105	3.4%

III. Supply of Workers

More so than other biopharma clusters – as discussed previously – the Boston/Cambridge metropolitan area, and Massachusetts as a whole, require higher levels of educational attainment of candidates for openings. Looking forward, research and development activities – primarily centered on Cambridge and Boston – will take up the lion's share of employment and job openings. However, biomanufacturing has grown at a rate far surpassing other sectors within the biopharma industry here in Massachusetts. It is forecast to continue doing so through 2022, at a rate of expansion of that almost double that of R&D.

As is always the case, our institutions of higher education play integral roles in developing new talent that is needed to sustain the robust growth experienced in the state in the past decade-plus. Historically, two-thirds of all industry jobs are in STEM professions. Over 11,600 new jobs are anticipated to be added to the payrolls of biopharma companies between 2016 and 2022. Not considering those leaving their jobs, the industry, or retiring; there will be a significant need for community colleges and universities to produce graduates with the technical skills, competencies, and know-how to drive growth and innovation in the coming years. What follows is a continuation of our overview of the educational landscape as conducted in last year's report, updated with new data.

Fig. C1: Annual Growth in Graduates (Public) + Listings, 2010 - 2016

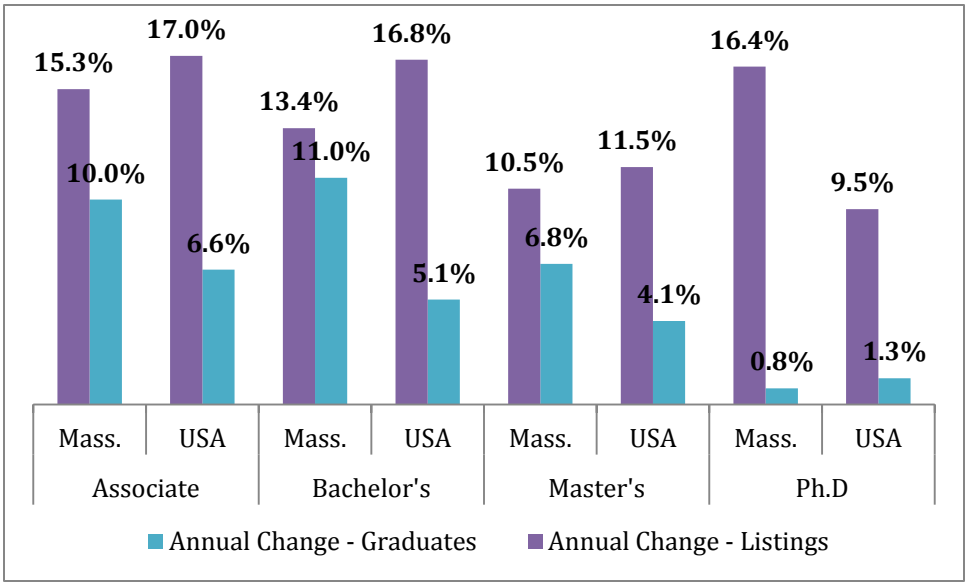


Figure C1 provides an overview of the annual changes in graduates of biotech-related academic programs[3] at **public institutions** of higher education in both across the US and in Massachusetts between 2011 and 2016 (2015 for Associate degree).

[3] See Appendix for list of academic programs considered "biotech-adjacent"

At the associate, bachelor's, and master's level, Massachusetts *surpasses* the rate of growth of biotech-related graduates from public colleges and universities nationwide. However, the state lags behind the rate of producing graduates in those programs at the Ph.D. level, even though the region requires the highest rate of doctorates as a portion of their total job openings. Inversely, the annual growth rate of entry level openings requiring a Ph.D. was the only level of educational attainment that Massachusetts experienced a faster rate of growth than the rest of the country.

The following four tables contain data on the number of graduates and entry level openings in the industry and in industry-related academic programs between the base year (2011) and the most recent year in which data was available (2015 or 2016). Private universities outpaced public universities in the number of graduates at every level, with the exception of Associate degrees. *However, the only level in which private universities had a faster rate of growth since 2011 was at the Ph.D. level*. In recent years, public universities have responded more forcefully to increases in demand for biotech jobs by increasing the number of graduates at their institutions at a faster rate.

Fig. C2

Associate - Massachusetts	Graduates – Public	Graduates – Private	Graduates – All	Entry Level Openings
2011	199	10	209	122
2015	320	14	334	215
Change	+121	+4	+125	+93
Pct. Change	61%	40%	60%	76%
Bachelor's - Massachusetts	**Graduates - Public**	**Graduates – Private**	**Graduates – All**	**Entry Level Openings**
2011	929	2,709	3,638	1,582
2016	1,567	3,669	5,236	2,971
Change	+638	+960	+1,598	+1,389
Pct. Change	69%	35%	44%	88%

One use of this data is to compare the relative rates of growth between job openings and graduates, as not every graduate from these programs enters the job market, let alone enters into a position at a life sciences company. By comparing the differences in rates of growth as proxies for supply and demand, one can make judgements on whether higher education is meeting the demand for new workers.

At every level, higher education (publics and privates combined) did not keep pace with the growth in entry level openings that their graduates would qualify to fill. Two-year programs did the best in keeping pace with the growth in entry level job listings, with 60 percent growth compared to 76 percent growth in job listings. Growth in graduates from 4-year programs was precisely half that of the growth in entry level STEM openings at biopharma companies in Massachusetts. However, there was a significant difference in the rates of growth between public and private universities – public institutions were able to

increase their graduates from these programs by 69 percent, private institutions by 35 percent.

Fig. C3

Master's - Massachusetts	Graduates - Public	Graduates – Private	Graduates – All	Entry Level Openings
2011	120	665	785	184
2016	167	927	1,094	303
Change	+47	+262	+309	+119
Pct. Change	39%	39%	39%	65%
Ph.D. - Massachusetts	**Graduates - Public**	**Graduates – Private**	**Graduates – All**	**Entry Level Openings**
2011	126	1,071	1,197	243
2016	131	1,432	1,563	520
Change	+5	+361	+366	+277
Pct. Change	4%	34%	31%	114%

Both public and private universities grew their master's graduates at the same rate, but growth in openings still far outpaced that of graduates. One stark difference occurred in Ph.D. programs. Public universities increased the total number of graduates in the academic programs by only 5 in five years, while private universities increased theirs by 361, or 34 percent, within the same period of time. This growth pales in comparison for the increasing demand for doctorates with less than two years' experience at biopharma companies, which increased by 114 percent in just a half-decade.

We caution against making a one-to-one comparison of raw growth in listings and the increases in graduates. For one, Burning Glass' Labor Insight software program has increased its ability to find and adequately de-duplicate job listings it finds online, and companies may adjust how many open positions they list online – making year-over-year comparisons of job listings an imperfect way of understanding growth. And as mentioned previously, not every graduate from these academic programs enters into biopharma companies – some may continue their schooling, some may leave Massachusetts entirely, some choose not to enter the job market, or some may enter into another industry which competes for the same talent pool as the biopharma industry.

From our recent *2017 Life Science Entry Level Jobs Report* is Fig. C4, which using data from Burning Glass, discerns the share of all entry level openings for specific occupations that are located at biopharma companies. These positions are ones graduates of bachelor's degree programs would qualify for upon graduation.

Fig. C4

Bachelor's Academic Program Type	Biopharma Share of All Entry Level Listings in MA
Biological/ Life Science	54%
Biochemistry, Biophysics, & Molecular Biology	48%
Medical Science	61%
Biostatistics, Bioinformatics, and Computational Biology & Statistics	61%
Chemistry	38%
Bioengineering and Biomedical Engineering	71%
Manufacturing / Industry Engineering	18%
Chemical Engineering	50%

These academic program types developed by Burning Glass, cluster similar majors into broader categories and then aggregate job listings for which they would qualify.

Most majors found in these academic program types are considered "biotech-related" and appear in the graduation data in this section. It is not possible to do a one-to-one comparison, as these data stem from two entirely different sources. Plainly, the share of jobs at biopharma companies varies by academic program type at the bachelor's level. Life science companies account for about 50%-70% of all the openings graduates from programs we deem "biotech-related" qualify for after graduation, assorted industries account for the rest.

Universities by Graduates in Biotech-Related Programs

MassBioEd consistently looks at biopharma employers with the most open job listings at a given time as a way to communicate to job seekers and institutions of higher learning where the majority of open jobs are located. Conversely, we now list the top colleges and universities by 2016 graduates in biotech-related programs.

Fig. C5

Grads, Publics, 2016	Bachelor's	Master's	Ph.D.	Total
UMass Amherst	597	42	52	691
UMass Lowell	160	92	17	269
UMass Boston	200	10	7	217
UMass Dartmouth	122	6	0	128
Bridgewater State	111	0	0	111
Salem State	104	0	0	104
Worcester State	98	9	0	107
UMass Medical	0	4	55	59
Westfield State	51	3	0	54
MCLA	44	0	0	44
Framingham State	41	0	0	41
Fitchburg State	39	1	0	40
Grand Total	**1,567**	**167**	**131**	**1,865**

The aim is to inform emerging companies that may lack relationships with area colleges to learn which local institutions of higher education are graduating students with a biotech background in significant numbers.

The tables in this section are broken up by private and public institutions, as well two-year and four-year schools.

In the public university sphere, UMass Amherst, the largest public university in the Commonwealth, has the largest number of graduates in biotech-related programs, spread across three levels. They have the most at the bachelor's level by almost 400 graduates over the next university, yet are second to UMass Lowell and UMass Medical in turning out Master's and Ph.D. graduates in 2016, respectively.

Fig. C6

Grads, Privates, 2016	Bachelor's	Master's	Ph.D.	Total
Boston University	389	217	101	707
Northeastern	513	149	34	696
Harvard	227	138	176	541
Tufts	204	203	46	453
MIT	151	56	176	383
MCPHS	323	41	1	365
Boston College	264	8	25	297
WPI	253	22	11	286
Brandeis University	139	57	19	215
Williams College	100	0	0	100
Holy Cross	95	0	0	95
Mount Holyoke	93	0	0	93
Clark University	62	17	11	90
Stonehill College	80	0	0	80
Smith College	76	4	0	80
Suffolk University	74	0	0	74
Emmanuel College	68	0	0	68
Assumption College	61	0	0	61
WNEC	61	0	0	61
Wellesley College	59	0	0	59
Grand Total	**3,669**	**927**	**600**	**4,996**

Boston University and Northeastern, separated by mere miles, are neck and neck in 2016 graduates, with a difference of only 11 graduates. Northeastern has far and away the most bachelor's graduates of private universities (2nd to UMass in the state), while BU leads Tufts by 14 in Master's graduates. Meanwhile, Harvard awarded a Ph.Ds. in biotech-related programs to 176 people this past year, the same number as MIT. Together, Harvard and MIT accounted

Grads, Community Colleges, 2011-2015	2015	2014	2013	2012	2011	Total
Bunker Hill Community College	65	58	34	37	38	**232**
Middlesex Community College	47	52	36	49	32	**216**
Springfield Technical Community College	31	31	32	29	31	**154**
Mount Wachusett Community College	20	17	35	19	29	**120**
Quinsigamond Community College	21	25	23	16	14	**99**
Roxbury Community College	25	17	19	17	20	**98**
Holyoke Community College	44	10	6	10	4	**74**
Massachusetts Bay Community College	15	10	15	16	13	**69**
Quincy College	29	16	14	5	4	**68**
Bristol Community College	11	11	6	15	7	**50**
North Shore Community College	5	7	26	4	2	**44**
Cape Cod Community College	4	1	2	2	5	**14**
Northern Essex Community College	3	0	0	0	0	**3**
Grand Total	**320**	**255**	**248**	**219**	**199**	**1,241**

Fig. C7

for half of all biotech-related Ph.Ds. awarded in Massachusetts in 2016.

While 2016 data is not yet available for community college graduates, we look to the historical graduation numbers between 2011 and 2015. Fig. C7 explores the growth of biotech-related graduates from two-year schools in Massachusetts.

The importance of Community Colleges cannot be understated. Outside of certificate programs (not listed above) they train workers to fill technician roles, primarily in biomanufacturing settings. As seen on the previous page, the top two by sheer number of graduates since 2011 are situated in the backyard of the hub of the industry – Bunker Hill and Middlesex Community Colleges. As a cohort, community colleges have increased the number of graduates by 60% since 2011. Since that base year both Holyoke Community College and Quincy College have improved their market share of all grads at this level the most, by 11 percent and 7 percent, respectively.

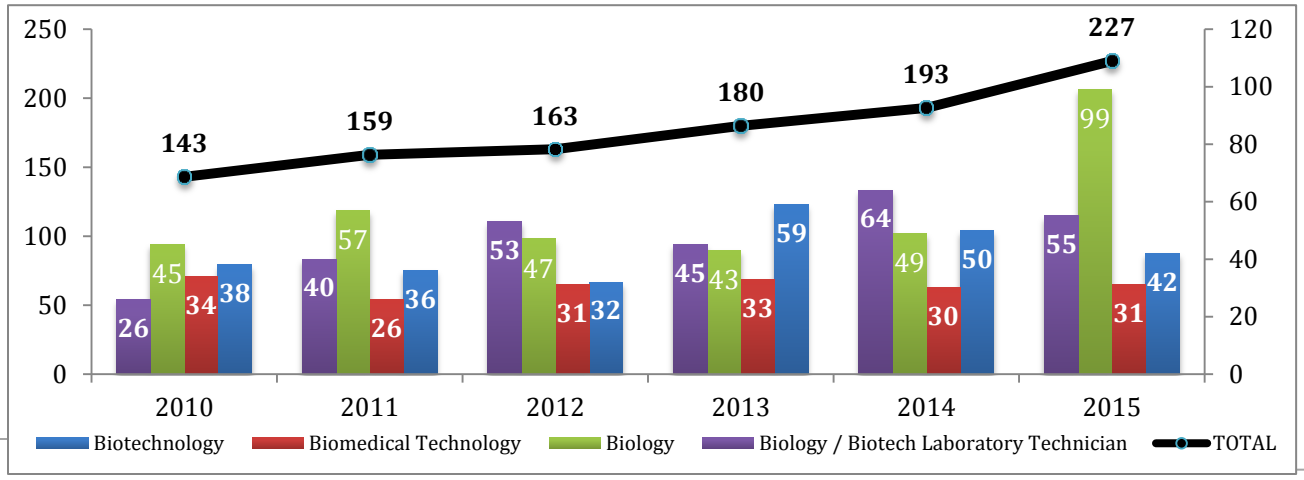
Growth of Core Academic Programs

Up to this point, we have looked at yearly graduates of all biotech-related programs from Massachusetts' institutions of higher learning. Some of these programs, however, are more critical to the industry than others. This section will spotlight specific majors at all educational levels, mapping out their year-over-year trajectory since 2010.

Fig. C4 lists academic program types and the relative importance of the biopharma industry in hiring graduates from said programs. We will look to majors from the academic program types for which our industry has an outsized share.

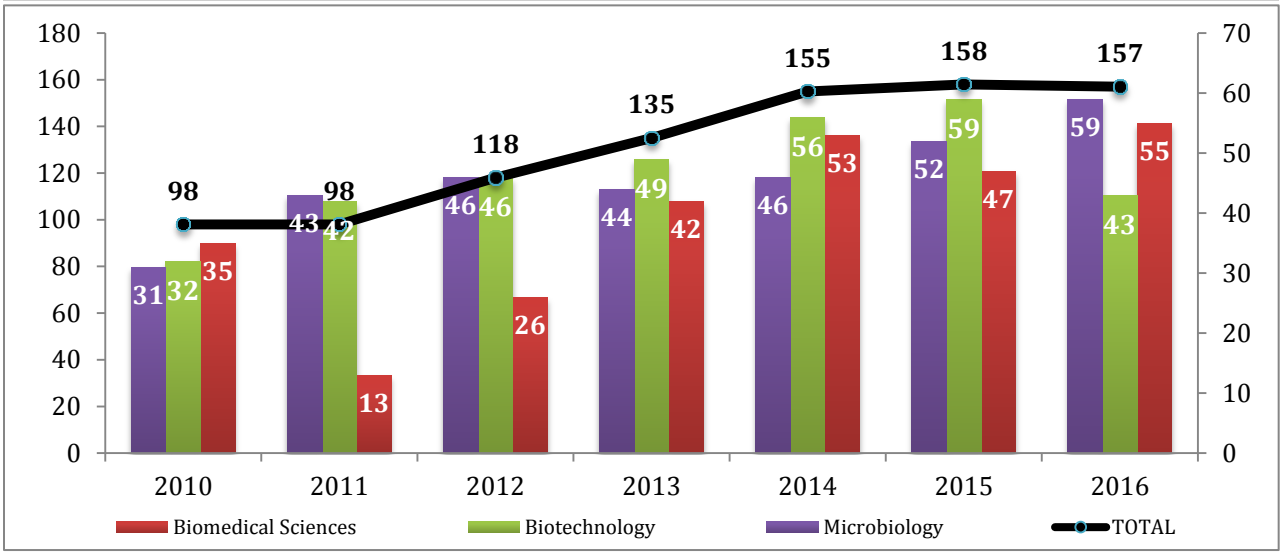
Fig. C8 illustrates the changes since 2010 of four key associate degree programs: those categorized as *Biotechnology, Biology, Biomedical Technology,* and *Biology / Biotechnology Technician.* The steady growth since 2010 spiked in 2015, attributable solely to an increase of 50 graduates coming out of two-year *Biology* programs. Specialty programs like *Biotechnology* and *Biomedical Technology* have largely graduated the same number of graduates since 2010.

Fig. C8: Graduates of Crucial Biotech-Related Associate Degree Programs, MA, 2010 - 2015



At the Bachelor's degree level, we categorize critical academic programs into three graphs, one for programs with a small number of graduates, one for larger programs, and one for *Biology* majors, which account for a large portion of all graduates in biotech-related programs. The first chart looks at graduates from *Biomedical Sciences, Biotechnology,* and *Microbiology,* which all have fewer than 60 graduates per year since 2010.

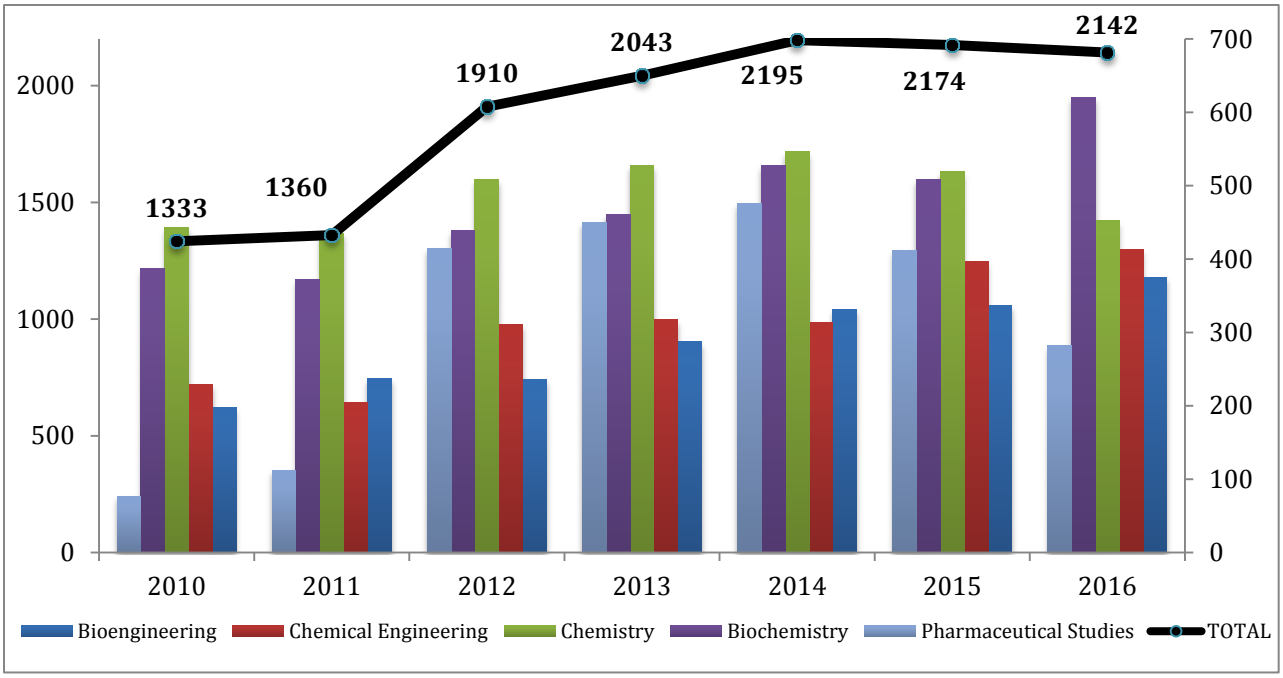
Fig. C9: Graduates of Small Biotech-Related Bachelor's Degree Programs, MA, 2010 - 2016



Since 2010, the number of graduates from *Biotechnology* and *Microbiology* programs rose steadily, and after a nadir in 2011, *Biomedical Sciences* has recovered nicely and grown at a healthy clip since that year.

Fig. C10 on the following page shows the vital bachelor degree programs for the biopharma industry with a large number graduates. Academic programs located in this graph include majors categorized as *Bioengineering, Chemical Engineering, Chemistry, Biochemistry,* and *Pharmaceutical studies.* All of these academic programs have direct applications in the life sciences, are are included in a separate graph due to the scale of their graduate numbers.

Fig. C10: Graduates of Large Biotech-Related Bachelor's Degree Programs, MA, 2010 - 2016



Assorted *Pharmaceutical studies* - encompassing such fields as *Pharmacy, Pharmaceutical Administration, Pharmaceutics and Drug Design, Medicial & Phamaceutical Chemistry*, and *Pharmacy Policy & Regulatory Affairs* - grew nearly threefold between 2010 and 2016, starting with 76 in 2010 and reaching a high of 476 in 2014 before declining to 282 in 2016. The group grew by over 60% during thise time, with only *Chemistry* falling below that growth rate – at 2%.

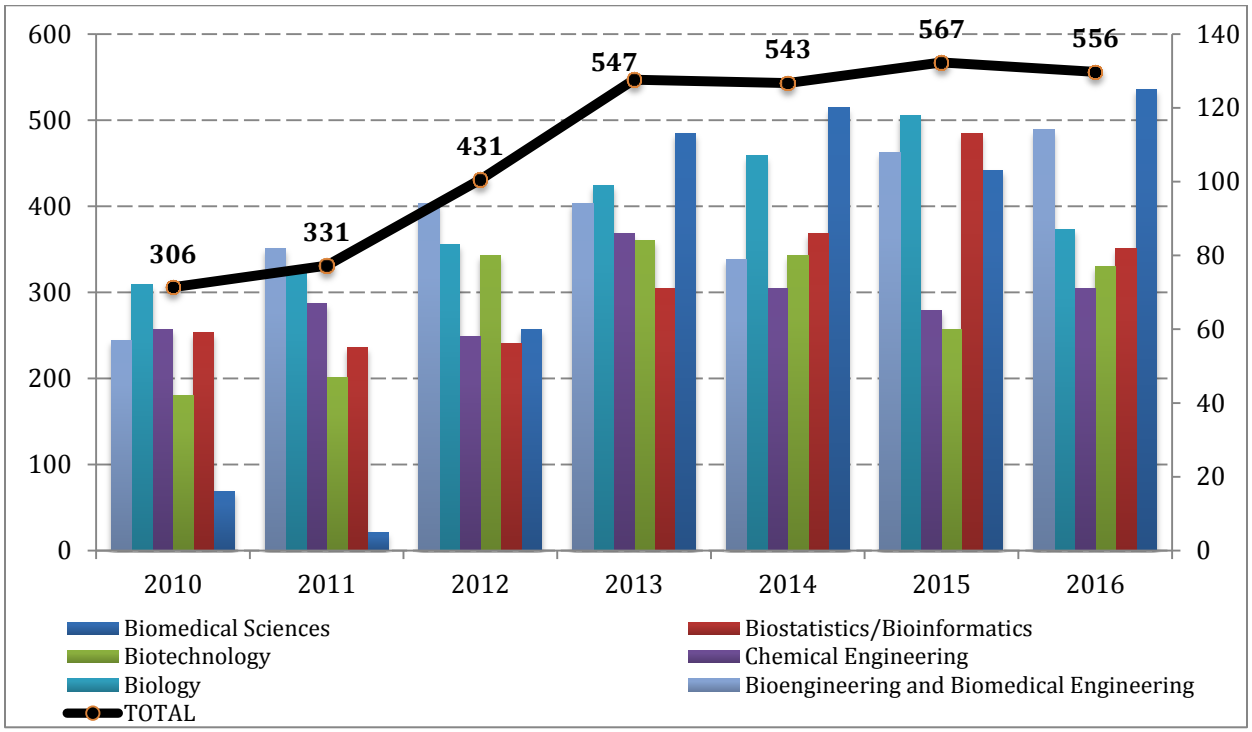
Fig. C11

Bachelor's Degree Graduates	2010	2011	2012	2013	2014	2015	2016
Biology	1,851	1,855	1,955	2,032	2,218	2,186	2,340

Included separately due to its sheer size is the *Biology* major, which has sustained impressive growth since 2010 – rising by nearly 500 graduates, an improvement of 26%.

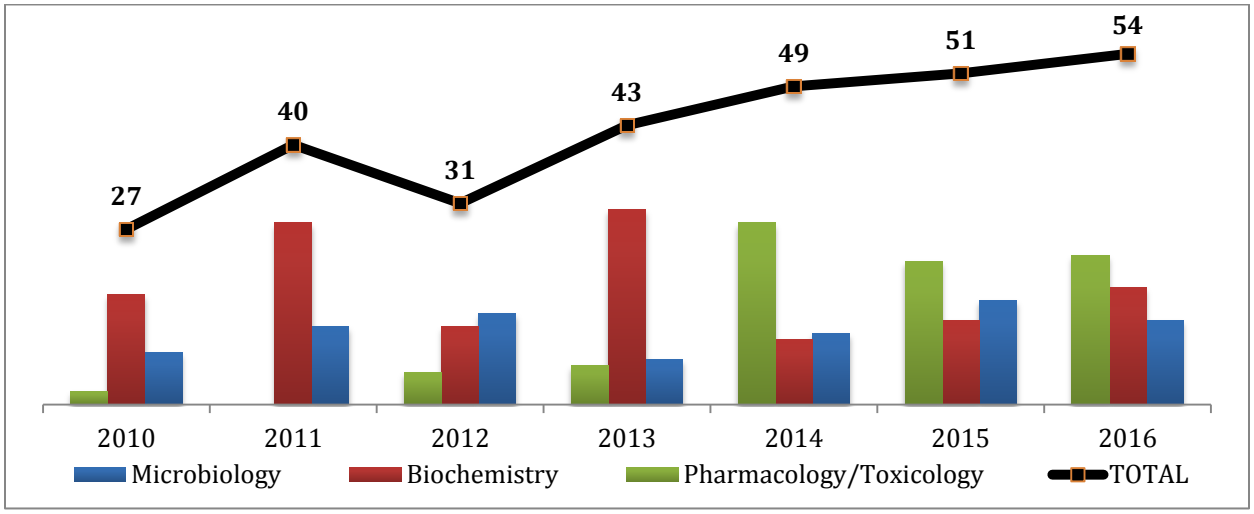
At the Master's level we focus on a select group of academic programs that have obvious applications at biopharma companies – *Biomedical Sciences, Biotechnology, Biology, Biostatistics, Chemical Engineering,* and *Bioengineering* are in the first grouping; *Microbiology, Biochemistry,* and *Pharmacology/Toxicology* are in the second.

Fig. C12: Graduates of Large Biotech-Related Master's Degree Programs, MA, 2010 - 2016



Master's in these fields experienced rapid growth between 2010 and 2013, perhaps a result of many people going back to school as the Great Recession was at its peak. However, since 2013, degrees conferred in these fields has plateaued at approximately 550 per year, even as job listings requiring these degrees have accelerated.

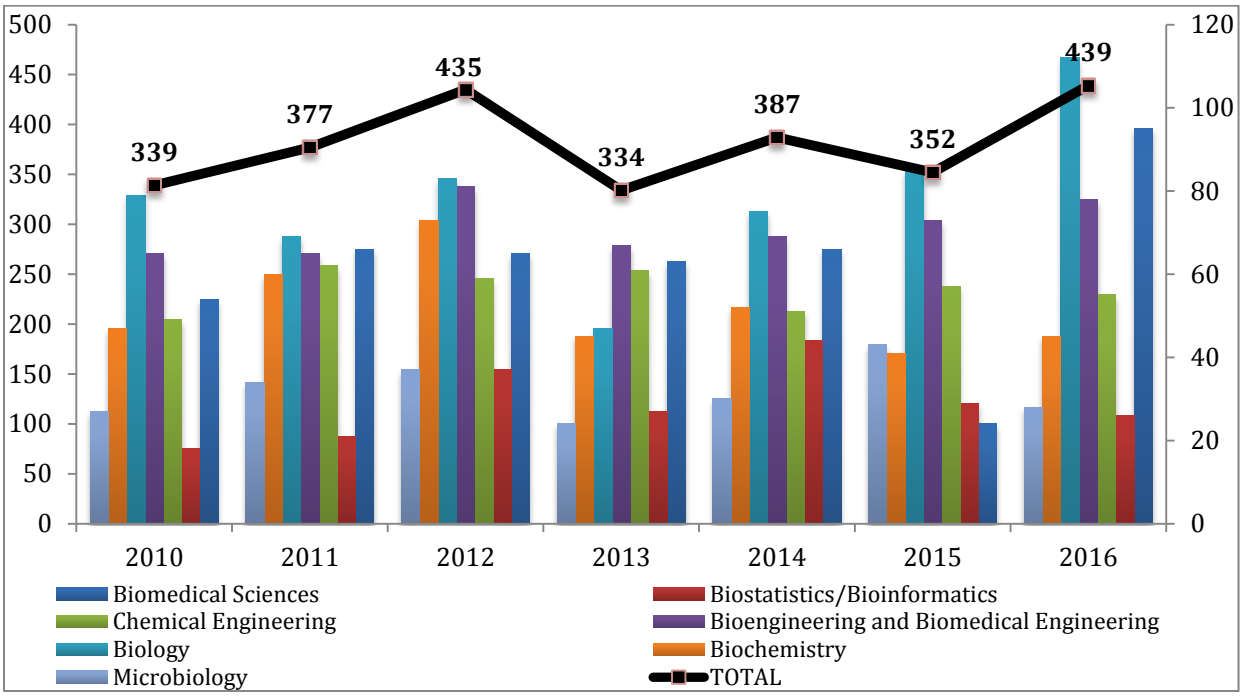
Fig. C13: Graduates of Smaller Biotech-Related Master's Programs, MA, 2010 - 2016



Although only constituting a small sliver of overall graduates, these programs are traditional feeders into the life sciences industry and have been increasing in numbers in recent years from local institutions of higher learning.

At the doctoral level, the programs we look to are generally in the same fields as they were at the Master's level.

Fig. C14: Graduates of Crucial Biotech-Related Ph.D. Programs, MA, 2010 - 2016



These core doctorate programs in Massachusetts have experienced swings in the number of annual degrees conferred over the past six years, generally on an upward trajectory. *Biomedical Sciences* (76%), *Biostatistics* (44%), and *Biology* (42%) saw the biggest increases in graduates over that span of time. Below is the table connected to the Fig. C14

Fig. C15

Ph.D. Graduates, MA, All Schools	2010	2011	2012	2013	2014	2015	2016
Biomedical Sciences	54	66	65	63	66	24	95
Biostatistics/Bioinformatics	18	21	37	27	44	29	26
Chemical Engineering	49	62	59	61	51	57	55
Bioengineering and Biomedical Engineering	65	65	81	67	69	73	78
Biology	79	69	83	47	75	85	112
Biochemistry	47	60	73	45	52	41	45
Microbiology	27	34	37	24	30	43	28
TOTAL	**339**	**377**	**435**	**334**	**387**	**352**	**439**

IV. Industry Pay Snapshot

One important metric in analyzing labor markets is compensation. Using ERI's Salary Assessor tool, which aggregates both internal and external salary surveys, MassBioEd is able to provide a sampling of base salary information for key occupations in the biopharma industry in Massachusetts.

We were able to compare the median pay at three levels – **entry level**, **intermediate,** and **senior levels** - with pay for the same positions in the Research Triangle, Bay Area, and Pennsylvania/ New Jersey. In doing so, we hope to illuminate the relative differences in pay for key positions within the industry and view the premium that some locales pay for specific occupations.

Fig. D1: Q1 2017 Median Pay, Massachusetts

Occupation	#	Entry Level	Intermediate	Senior
Medical Scientists	9,092	$ 79,542	$ 94,181	$ 112,720
Biological Technicians	5,110	$ 55,003	$ 62,090	$ 71,469
Biochemists and Biophysicists	2,820	$ 88,029	$ 104,470	$ 124,353
Biomedical Engineers	1,610	$ 85,153	$ 102,108	$ 123,661
Natural Sciences Managers	1,580	--	--	--
Chemists	1,263	$ 71,041	$ 86,887	$ 106,031
Microbiologists	1,240	$ 71,867	$ 87,266	$ 106,052
Mechanical Engineers	949	$ 87,190	$ 102,952	$ 122,937
Compliance Officers	946	$ 71,718	$ 80,700	$ 93,099
Phlebotomists	913	--	--	--
Industrial Engineers	910	$ 76,756	$ 91,224	$ 108,849
Chemical Technicians	910	$ 48,375	$ 55,198	$ 64,186
Laboratory Technologists	860	$ 64,810	$ 73,653	$ 84,877
Laboratory Technicians	860	$ 46,029	$ 51,915	$ 59,703
Biological Scientists, All Other	835	$ 65,418	$ 79,504	$ 96,920
Sales Representatives	710	$ 87,744	$ 104,214	$ 124,083
Industrial Production Managers	643	$ 103,715	$ 118,798	$ 138,745
Medical and Health Services Managers	633	$ 92,954	$ 109,901	$ 130,791
Quality Control Analysts	620	$ 39,761	$ 45,032	$ 51,952
Accountants and Auditors	609	$ 71,529	$ 77,661	$ 87,061
Architectural and Engineering Managers	605	$ 114,468	$ 131,725	$ 154,817
Statisticians	486	$ 82,074	$ 97,084	$ 115,977
Engineering Technicians	412	$ 66,575	$ 74,886	$ 86,664
Industrial Engineering Technicians	405	$ 61,455	$ 70,270	$ 82,157
Quality Control Technicians	303	$ 44,820	$ 51,099	$ 59,400
Human Resources Managers	259	$ 110,981	$ 126,851	$ 148,116
Chemical Engineers	216	$ 90,527	$ 107,579	$ 128,736
Technical Writers	116	$ 70,502	$ 83,966	$ 100,210
Pharmacists	99	$ 112,499	$ 133,184	$ 156,386
Operations Research Analysts	91	$ 72,873	$ 87,232	$ 104,800

Comparison to Research Triangle

Fig. D2

Q1 2017, Boston vs. Research Triangle	Entry	Mid	Senior
Medical Scientists	+13.9%	+12.5%	+11.0%
Biological Technicians	+16.4%	+15.7%	+14.9%
Biochemists and Biophysicists	+13.4%	+11.7%	+10.2%
Biomedical Engineers	+13.9%	+12.1%	+10.5%
Chemists	+15.8%	+14.4%	+13.0%
Microbiologists	+14.6%	+13.4%	+12.1%
Mechanical Engineers	+13.8%	+12.1%	+10.5%
Compliance Officers	+15.3%	+14.9%	+14.1%
Industrial Engineers	+14.6%	+13.4%	+12.1%
Chemical Technicians	+16.9%	+16.3%	+15.6%
Laboratory Technologists	+20.1%	+19.4%	+18.5%
Laboratory Technicians	+22.2%	+21.6%	+20.9%
Biological Scientists, All Other	+15.0%	+14.1%	+13.0%
Sales Representatives	+18.1%	+17.0%	+16.0%
Industrial Production Managers	+12.8%	+11.7%	+10.5%
Medical and Health Services Managers	+12.8%	+11.4%	+10.2%
Quality Control Analysts	+17.3%	+17.6%	+17.4%
Accountants and Auditors	+15.9%	+15.6%	+15.1%
Architectural and Engineering Managers	+11.8%	+10.5%	+9.4%
Statisticians	+10.0%	+8.7%	+7.4%
Engineering Technicians	+14.8%	+14.7%	+14.3%
Industrial Engineering Technicians	+14.7%	+14.8%	+14.6%
Quality Control Technicians	+16.9%	+16.1%	+15.2%
Human Resources Managers	+12.3%	+11.1%	+10.0%
Chemical Engineers	+13.4%	+11.6%	+10.0%
Technical Writers	+15.1%	+14.3%	+13.4%
Pharmacists	+15.7%	+13.7%	+12.1%
Operations Research Analysts	+10.9%	+9.7%	+8.4%

The Boston/ Cambridge metropolitan area typically has a wage premium for core, STEM-related occupations of at least ten percent when compared with those of the Research Triangle in North Carolina. With very few exceptions, the premium dissipates at the upper levels of experience. Although Boston/ Cambridge biopharma companies pay far more to candidates, one has to keep in mind the cost-of-living differences between the two metropolitan areas. Using bankrate.com's *Cost of Living Calculator*, the cost-of-living premium in Boston over both the Raleigh and Durham-Chapel Hill metropolitan areas was **37%** and **28%.** Thus, the wage premiums that workers in Boston and Cambridge experience are completely offset by the cost of living in the area.

In adjusted terms, positions like *Lab Technician, Lab Technologist, and Quality Control Technicians* come close to parity between the two areas, while positions like *Statisticians, Engineering Managers,* and *Operations Research Analysts* fall well short. Perhaps, the differences in pay premiums is a function of relative supply of workers in these locales and demand by local life science companies and other industries competing for the same talent.

Comparison to Bay Area

The Bay Area has the opposite relationship with Boston/ Cambridge, as the cost-of-living is much higher, while the wage premiums across the core occupations is only slightly more,

meaning in purchasing power the wages experienced there are not higher than in the Boston metro area.

Fig. D3

Q1 2017, Boston vs. Bay Area	Entry	Mid	Senior
Medical Scientists	-8.4%	-8.3%	-8.2%
Biological Technicians	-8.2%	-8.7%	-9.1%
Biochemists and Biophysicists	-8.4%	-8.2%	-8.0%
Biomedical Engineers	-6.5%	-6.3%	-6.2%
Chemists	-8.4%	-8.7%	-8.9%
Microbiologists	-8.2%	-8.3%	-8.4%
Mechanical Engineers	-6.4%	-6.3%	-6.2%
Compliance Officers	-6.8%	-6.8%	-6.9%
Industrial Engineers	-6.6%	-6.4%	-6.3%
Chemical Technicians	-7.8%	-8.3%	-8.9%
Laboratory Technologists	-13.2%	-13.4%	-13.5%
Laboratory Technicians	-12.5%	-12.7%	-12.9%
Biological Scientists, All Other	-8.0%	-8.3%	-8.5%
Sales Representatives	-1.8%	-1.9%	-1.9%
Industrial Production Managers	-5.2%	-5.2%	-5.2%
Medical and Health Services Managers	-5.4%	-5.5%	-5.5%
Quality Control Analysts	-6.8%	-7.3%	-7.9%
Accountants and Auditors	-7.1%	-7.2%	-7.4%
Architectural and Engineering Managers	-5.5%	-5.5%	-5.4%
Statisticians	-6.7%	-6.8%	-6.8%
Engineering Technicians	-8.2%	-8.1%	-7.9%
Industrial Engineering Technicians	-8.2%	-8.1%	-8.0%
Quality Control Technicians	-2.6%	-2.9%	-3.2%
Human Resources Managers	-5.2%	-5.2%	-5.2%
Chemical Engineers	-6.4%	-6.3%	-6.2%
Technical Writers	-5.1%	-5.1%	-5.1%
Pharmacists	-13.0%	-12.4%	-11.9%
Operations Research Analysts	-6.5%	-6.7%	-6.9%

All occupations across all levels had lower median pay in Boston/ Cambridge than in the Bay Area. However, the cost-of-living in the Bay Area is **22% higher** than in Boston.

Thus, the wage premiums in these occupations were not enough to offset the higher cost-of-living.

Unlike the relationship between the Research Triangle and Boston/ Cambridge, at the higher levels of experience, there were not great changes in the pay premiums between the two locales (the difference between the two regions remained largely the same across all three levels).

Comparison to Pennsylvania/ New Jersey

Greater wage similarities exist between Boston/Cambridge and Pennsylvania/ New Jersey than that of other areas we examined. MassBioEd found that industry pay for those select occupations was slightly higher in Boston/ Cambridge, with some exceptions.

Fig. D4

Q1 2017, Boston vs. PA/NJ	Entry	Mid	Senior
Medical Scientists	+0.3%	-0.2%	-0.5%
Biological Technicians	+3.4%	+2.7%	+2.1%
Biochemists and Biophysicists	+0.0%	-0.3%	-0.6%
Biomedical Engineers	+3.1%	+2.7%	+2.2%
Chemists	+2.3%	+1.5%	+0.9%
Microbiologists	+0.7%	+0.1%	-0.4%
Mechanical Engineers	+3.1%	+2.6%	+2.2%
Compliance Officers	+3.6%	+3.3%	+2.9%
Industrial Engineers	+0.5%	-0.1%	-0.7%
Chemical Technicians	-6.9%	-7.0%	-7.2%
Laboratory Technologists	+5.6%	+5.3%	+5.0%
Laboratory Technicians	+5.9%	+6.0%	+5.8%
Biological Scientists, All Other	+1.1%	+0.3%	-0.2%
Sales Representatives	+4.5%	+4.0%	+3.6%
Industrial Production Managers	+4.1%	+3.4%	+2.4%
Medical and Health Services Managers	-0.3%	-0.7%	-1.0%
Quality Control Analysts	-7.3%	-8.2%	-9.1%
Accountants and Auditors	+3.6%	+3.4%	+3.1%
Architectural and Engineering Managers	-0.6%	-0.9%	-1.1%
Statisticians	+1.5%	+1.0%	+0.6%
Engineering Technicians	+3.5%	+3.5%	+3.4%
Industrial Engineering Technicians	+3.6%	+3.5%	+3.4%
Quality Control Technicians	+8.0%	+7.0%	+6.0%
Human Resources Managers	-0.6%	-0.8%	-0.9%
Chemical Engineers	-2.1%	+1.4%	+3.8%
Technical Writers	+4.6%	+4.3%	+4.0%
Pharmacists	+5.0%	+4.4%	+3.8%
Operations Research Analysts	+2.1%	+1.3%	+0.8%

For many occupations, the premium received in Boston/ Cambridge was more marked at the lower levels of experience (entry level).

Cost-of-living comparisons, made using bankrate's tool, shows a lower cost-of-living of approximately 15% for the counties examined – Mercer/ Somerset/ Middlesex in NJ and Montgomery & Chester in PA in comparison to Boston/ Cambridge.

In all, after adjusting for cost-of-living differences, it appears as though biopharma workers in Boston/ Cambridge get paid less in real terms, as the occupations in the above chart do not show the 15% increase in earning necessary to cancel out the increases in the cost of living.

As we focused solely on STEM and related core occupations, we hesitate to say that this experience is for all occupations across the industry in these four key hubs. But in the occupations examined, the aforementioned insights were supported by the data.

V. 2017 Employers Industry Survey Results

The 2017 MassBioEd Employer Survey is the second such survey conducted by MassBioEd in concert with MassBio, by which we gain insight on workforce issues from the perspective of human resources professionals in the biopharma industry. Some survey questions will be asked on an annual basis in order to establish benchmarks for data points that are not available from other sources.

This year's survey also includes questions on topical areas of concern for hiring managers and human resources departments in the industry, e.g. H1-B visas, time-to-fill for open positions, educational reimbursement, and channels for sourcing new hires. MassBioEd finds it important to measure these metrics, as pay, listings, and employment data only touch on part of the wider workforce dynamics within the industry.

This year, complete survey submissions increased threefold over 2016, with 150 professionals responding to our survey, giving us robust data on questions about key workforce development issues facing the industry.

The Respondents

Fig. E1

What Type of Organization is Your Company? (n=149)	Response 2017
Research-focused	44%
Manufacturing-focused	6%
Integrated	24%
CRO	9%
CMO	1%
University/ Hospital/ Non-profit-based research	4%
Office-only biopharma company	13%

Of the 149 employer respondents, nearly half were from R&D-centric organizations. Only 6 percent were from biomanufacturing-centric organizations. Integrated companies, meaning those with combined R&D and manufacturing operations, accounted for nearly a quarter of the responses. These were similar to the responses received in 2016. However, R&D-centric organizations responded at a 15 percentage point higher rate this year, while integrated fell to 24 percent this year from 31 percent in 2016.

The size of the respondents' organizations was measured as well. Specifically, we asked participants to estimate the number of employees at their organizations in Massachusetts only.

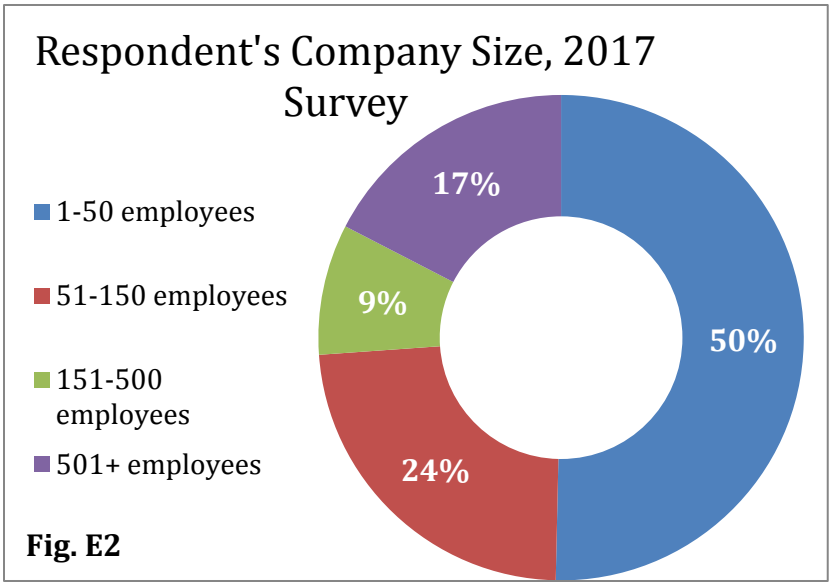


Fig. E2

Precisely half of the responses (n=149) originated from start-ups or small companies with under 50 employees in Massachusetts. Seventeen percent came from companies with a large presence (500+ employees) in Massachusetts, while a healthy proportion of intermediate companies were represented in the sample.

The Responses

82% of companies reported that they planned to increase net employment at their organization in the next 12 months. This result is statistically similar to last year, when the answer was 87%.

57% of respondents reported that their organizations reimburse incumbent worker training and education for all full-time employees. This is in line with findings from a 2013 Human Resource Management survey, which found that 61 percent of companies in the US do so[4].

66% of companies reported offering paid internships or co-ops. 5% offered only unpaid internships, while the remaining 29% did not offer any at all.

74% of companies reported the average length of time it took to fill an open position at their company was over 10 weeks. 52% of respondents from the 2016 industry survey said it took 10 weeks or longer, on average, to fill open positions. The nationwide job openings vacancy average for all industries in January 2017 was approximately 4 weeks[5].

55% of respondents indicated that in comparison to three years ago, it is either more difficult or much more difficult to find qualified talent to fill openings at their organizations. 78% answered the same on 2016's survey.

[4] https://www.shrm.org/hr-today/news/hr-magazine/Pages/0614-tuition-assistance.aspx
[5] DHI Hiring Indicators, http://dhihiringindicators.com/report/

Time-To-Fill Openings

Fig. E3

	ALL	Research	CMO+ Manuf.+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
<9 weeks	26%	25%	20%	27%	36%	21%	8%
10-12 weeks	44%	47%	45%	46%	48%	42%	40%
13-15 weeks	17%	19%	25%	17%	7%	25%	32%
>15 weeks	12%	9%	9%	10%	9%	13%	20%
Sample Size	**149**	**64**	**44**	**78**	**75**	**48**	**25**

Difficulty in Finding Talent (vs. 2014)

Fig. E4

	ALL	Research	CMO + Manuf.+ Integrated	CRO + Research	<50 workers	51-500 workers	501+ workers
Easier	10%	12%	11%	10%	15%	6%	4%
About the same	35%	32%	39%	35%	41%	28%	36%
More difficult	47%	46%	41%	46%	38%	57%	52%
Much more difficult	8%	10%	9%	8%	6%	9%	8%
Sample Size	**141**	**59**	**44**	**71**	**68**	**47**	**25**

H1-B Visas

In comparison to one year ago, do H1-B visa holders account for:

Fig. E5

	ALL	Research	CMO+ Manuf.+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
A higher % of your workforce	5%	5%	4%	5%	5%	6%	4%
A lower % of your workforce	22%	20%	22%	24%	25%	17%	19%
About the same %	38%	42%	31%	41%	41%	45%	19%
I don't know	35%	33%	42%	29%	28%	32%	58%
Sample Size	**150**	**64**	**45**	**78**	**75**	**47**	**26**

Temporary Workers

Is part of your hiring strategy to hire temporary workers and transition them to permanent positions?

Fig. E6

	ALL	Research	CMO+ Manuf.+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
No	50%	52%	44%	56%	55%	43%	50%
Yes	50%	48%	56%	44%	45%	57%	50%
Sample Size	**150**	**65**	**45**	**79**	**75**	**47**	**26**

Worker Training & Education

Does your company reimburse incumbent worker training/education?

Fig. E7

	ALL	Research	CMO+ Manuf.+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
Yes, all FT employees	57%	63%	56%	59%	45%	68%	72%
Yes, only some FT employees	11%	5%	20%	6%	9%	11%	16%
No	20%	25%	11%	24%	34%	9%	4%
I don't know	11%	8%	13%	10%	12%	13%	8%
Sample Size	**148**	**65**	**45**	**78**	**74**	**47**	**25**

When the need for training of incumbent workers arises, what type of organization fulfills those needs?

Fig. E8

	ALL	Research	CMO+ Manuf.+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
College/University	13%	13%	18%	12%	17%	11%	8%
Internally	45%	45%	43%	47%	49%	40%	44%
Vendor/Consultant	42%	42%	39%	41%	34%	49%	48%
Sample Size	**144**	**62**	**44**	**75**	**71**	**47**	**25**

Does your company partner with area universities for customized, in-house training of workers?

Fig. E9

	ALL	Research	CMO+ Manuf+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
Yes, in the past 12 months	21%	28%	20%	24%	22%	23%	17%
Yes, but over a year ago	9%	9%	14%	8%	9%	6%	13%
Not in the past 5 years	60%	52%	57%	59%	64%	62%	46%
I don't know	10%	11%	9%	9%	5%	9%	25%
Sample Size	**147**	**65**	**44**	**78**	**74**	**47**	**24**

Does your company offer internships/co-ops?

Fig. E10

	ALL	Research	CMO+ Manuf.+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
No	29%	25%	18%	28%	36%	26%	12%
Yes, paid	66%	69%	77%	67%	57%	70%	84%
Yes, only unpaid	5%	6%	5%	5%	7%	4%	4%
Sample Size	**147**	**65**	**44**	**78**	**74**	**46**	**25**

Channels for Hiring New Employees

*For **entry level** positions, where do you primarily source your new hires?*

Fig. E11

	ALL	Research	CMO+ Manuf+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
Colleges (directly)	12%	11%	24%	9%	7%	17%	16%
Internally	17%	19%	16%	19%	23%	15%	4%
Internships/Co-ops	11%	9%	9%	8%	12%	11%	8%
Online job boards	43%	50%	31%	52%	39%	45%	52%
Recruiters/Staffing Cos	17%	11%	20%	12%	19%	13%	20%
Sample Size	**147**	**64**	**45**	**77**	**74**	**47**	**25**

*For **non-entry level** positions, where do you primarily source your new hires?*

Fig. E12

	ALL	Research	CMO+ Manuf+ Integrated	CRO+ Research	<50 workers	51-500 workers	501+ workers
Internally	25%	31%	27%	29%	32%	28%	4%
Online job boards	33%	27%	34%	30%	33%	32%	36%
Recruiters/Staffing Cos	42%	42%	39%	42%	36%	40%	60%
Sample Size	**146**	**64**	**44**	**77**	**73**	**47**	**25**

Appendix

Data Sources:

- Burning Glass *Labor Insight* (2010 – 2015 Graduation Data, Job Listings Data)
- MA Dept. of Labor and Workforce Development's *Employment and Wages by Industry and Area* (Industry Sector Employment Data)
- Univ. of Massachusetts' President's Office, Neena Verma (2016 Graduation data via IPEDS Data Center)
- Annual Industry Survey, *SurveyMonkey*
- BLS' *QCEW Data Files* (Employment Data)
- BLS' OES *Research Estimates by State and Industry* (Staffing Composition of Industry Sectors)
- BLS' *Consumer Expenditure Survey* (Consumer Spending on products, by year)
- *iShares* by BlackRock (Biotech Stock Data)
- Evaluate Pharma (BioPharma R&D Spending Data)
- PwC *MoneyTree* (Venture Capital Funding Data)
- Bureau of Economic Analysis' *GDP-by-Industry Data* (final demand for sectors)
- NIH's *RePORT* ("NIH Awards by Location & Organization," NIH awards by sector)
- ERI's *Salary Assessor* software portal (pay data by occupations, regions, etc.)
- Bankrate.com (cost-of-living comparisons)

Adjusted Listings Growth

Burning Glass' Labor Insight tool measures total, de-duplicated job listings. But, due to changing employer job posting habits and improvements in detection of Burning Glass' technology, means that comparing total job listings may not be the best way to measure industry growth year-over-year.

To adjust for this, we measured total industry listings as a percentage of all job listings in a given year within all industries in Massachusetts.

Biotech-Related Academic Programs

Biotech-related programs are academic majors filed under certain CIP codes (the federal academic program classification system) that teach core competencies used by occupations at biopharma companies. The following table is the exhaustive list of what MassBioEd has deemed "biotech-related."

Bioengineering and Biomedical Engineering	Chemical Engineering
Industrial Engineering	Engineering Technology, General
Biomedical Technology/Technician	Electromechanical Technology/Electromechanical Engineering Technology

Instrumentation Technology/Technician	Electromechanical and Instrumentation and Maintenance Technologies/Technicians, Other
Water Quality and Wastewater Treatment Management and Recycling Technology/Technician	Hazardous Materials Management and Waste Technology/Technician
Environmental Control Technologies/Technicians, Other	Manufacturing Engineering Technology/Technician
Industrial Production Technologies/Technicians, Other	Occupational Safety and Health Technology/Technician
Quality Control Technology/Technician.	Industrial Safety Technology/Technician
Hazardous Materials Information Systems Technology/Technician	Quality Control and Safety Technologies/Technicians, Other
Biology/Biological Sciences, General	Biomedical Sciences, General
Biochemistry	Biophysics
Molecular Biology	Radiation Biology/Radiobiology
Biochemistry and Molecular Biology	Biochemistry, Biophysics and Molecular Biology, Other
Cell/Cellular Biology and Histology	Anatomy
Cell/Cellular and Molecular Biology	Cell/Cellular Biology and Anatomical Sciences, Other
Microbiology, General	Medical Microbiology and Bacteriology
Virology	Immunology
Physiology, General	Pathology/Experimental Pathology
Pharmacology	Molecular Pharmacology
Neuropharmacology	Toxicology
Molecular Toxicology	Environmental Toxicology
Pharmacology and Toxicology	Pharmacology and Toxicology, Other
Biostatistics	Bioinformatics
Biomathematics, Bioinformatics, and Computational Biology, Other	Biotechnology
Ecology	Evolutionary Biology
Epidemiology	Neurobiology and Anatomy
Chemistry, General	Analytical Chemistry
Inorganic Chemistry	Organic Chemistry
Biology Technician/Biotechnology Laboratory Technician	Chemical Technology/Technician
Clinical/Medical Laboratory Assistant	Pharmacy Technician/Assistant
Clinical/Medical Laboratory Technician	Clinical Laboratory Science/Medical Technology/Technologist
Pharmacy	Pharmacy Administration and Pharmacy Policy and Regulatory Affairs
Pharmaceutics and Drug Design	Medicinal and Pharmaceutical Chemistry
Industrial and Physical Pharmacy and Cosmetic Sciences	Pharmacy, Pharmaceutical Sciences, and Administration, Other

Industry Projection Methodology

MassBioEd conducted its second annual forecast of industry growth in May 2017. With a base month and year of May 2016 (latest available employment data with staffing patterns), we were able to forecast out through 2022, both by industry size and individual occupations.

The first step was to estimate the size of the industry in May 2022. Each individual sector (3254, 54171, 54138, 3345, 622, 61131, and 6215) was broken out into the highest-digit NAICS code with available OES industry staffing patterns for May 2016, in order to isolate historical trends and contributing factors unique to each sector. A multiple regression was run for each sector, all with auto-regressive terms of the monthly, seasonally-adjusted employment numbers.

For *Pharmaceutical Manufacturers* (NAICS 3254), additional independent variables are the centered moving 12-month average of Venture Capital funding in the Massachusetts Biotech industry (sourced from PwC's *MoneyTree* tool), and the previous 6-month average of industry job listings were found to be statistically significant contributors, with p-values of $2.14x10^{-14}$ and $5.46x10^{-17}$, respectively (any variable with a p-value below .05 was included). All independent variables were then auto-regressed out to May 2022. The resulting Adjusted R-Squared, a measure of the total amount of variance of the dependent variable explained by the independent variables in the equation, was .96.

For *Biotechnology R&D* (NAICS 54171), additional independent variables were centered moving 12-month average of Venture Capital funding in the Massachusetts Biotech industry (sourced from PwC's *MoneyTree* tool), and the previous 6-month average of industry job listings were found to be statistically significant contributors, with p-values of $5.78x10^{-8}$ and $51.43x10^{-8}$, respectively. Following the same methodology as described above, the resulting Adjusted R-Squared value was .91.

For *Testing Laboratories* (NAICS 54138), one additional independent variable was used: the real average monthly output of the NAICS code 5413, where 54138 resides. The p-value for this variable was 0.019. Following the same methodology as described above, the resulting Adjusted R-Squared value was .86.

For *Analytical Laboratory and Instrument Manufacturing* (NAICS 334516), one additional independent variable was used: the real average monthly output of the NAICS code 334516. The p-value for this variable was 0.01. Following the same methodology as described above, the resulting Adjusted R-Squared value was .92.

For *Hospitals* (NAICS 622), two additional independent variables were used: centered moving 12-month average of Venture Capital funding in the Massachusetts Biotech

industry (sourced from PwC's *MoneyTree* tool), and the 12-month centered moving average of NIH funding of Independent hospitals in Massachusetts. The p-values for these variables were .035 and $3.84x10^{-6}$, respectively. Following the same methodology as described above, the resulting Adjusted R-Squared value was .83.

The other two sectors (6215 & 6113) were forecasted using strictly an autoregressive equation, which is essentially a "business-as-usual" approach. The Adjusted R-Squared values were .95 and .97. The resulting estimates of industry populations were completed by applying seasonality to the trend. All industries were then summed to complete the total industry growth projections.

After projecting total industry growth, we then looked to trends in staffing patterns within each sector – i.e. the share of each sector that occupational "families" had from May 2012 through May 2016. These occupational families are best seen as clusters of similar occupations, e.g. Life Sciences, Management, Engineering, etc. that are sources from the Bureau of Labor Statistics *Standard Occupational Code* system.

Next, in order to best predict industrial occupational composition in May 2022, we weighted the average share of each occupational family within each sector of the previous five years (50% of the 2016 average, 35% of 2015, 10% of 2014, and 2.5% each of 2013 and 2012) to derive the estimate.

Next, we applied the percentage change of each occupational family's sector share to each occupation within each occupational family, which resulted in a 2022 share for each occupation in each of the seven sectors of the industry, applied to the aforementioned May 2022 total sector employment projections. They were then summed across sectors and compared against the May 2016 employment totals to come up with the projected growth or decline for all occupations between 2016 and 2022.

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