GODBE RESEARCH
Gain Insight

# BIOTECHNOLOGY & LIFE SCIENCES CLUSTER RESEARCH

Conducted for work2future

June 2006

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# INTRODUCTION

Godbe Research is pleased to present the results of this labor market study conducted for work2future.

work2future, formerly known as the Silicon Valley Workforce Investment Network (SVWIN), has undertaken a series of labor market studies aimed at understanding the workforce needs of local employers in key industries in order to target and address these workforce needs through the effective and efficient allocation of available resources.

The results of this study are drawn from first hand data provided by biotechnology employers based in the Bay Area region. The data was gathered using a variety of methods, including a focused survey of 59 local biotechnology employers, as well as executive interviews with biotechnology-related education and training providers in the region. The primary research data has been supplemented by secondary research findings throughout the report.

The work2future board has embraced the findings and recommendations set out in this study. Based on these research findings and recommendations, work2future anticipates playing a key role in the development of the local biotechnology industry in the years ahead by providing an actively supportive role. In particular, work2future anticipates:

1. Becoming engaged with employers to assist with the development of biotechnology-specific workforce training programs in order to provide the region with a highly-educated and skilled workforce in the years ahead;

2. Actively developing and making available a series of assessment tools to help guide current and potential biotechnology employees through either the job-seeking or career advancement processes, assisting entry into the industry and the retention and development of key workers;

3. Increasing the awareness levels of local youth and adult populations about the career opportunities which are available to them in the biotechnology industry; *and*

4. Working closely with biotechnology employers to develop successful strategies, including lifelong learning accounts (LiLAs), which will help them to recruit, retain, and retrain valuable employees.

work2future and Godbe Research would like to thank the members of the workforce study's Advisory Panel, whose contributions helped to enrich the content of the study.

Advisory Group:

Ru Weerakoon
Melinda Richter
Janice Shriver
Rob Gamble
Kim Walesh
Javier Vanga
Ray Mcdonald
Jeff Ruster

## Organization of the Report

With a thorough search of existing research and information about the biotechnology industry, Godbe Research compiled a summary of the industry and provided insight into its future direction. By conducting interviews with biotechnology employers and education and training providers, we were able to gather information about current and potential occupational gaps and opportunities for work2future.

The report is organized into the following sections:

- The *Executive Summary* includes a summary of the *Key Findings* from the survey and secondary research, a short description of the project methodology, and the Conclusions and Recommendations for the biotechnology industry based on our research.
- The *Summary of Findings* section offers an industry and occupational analysis based on the research findings. The discussion is organized into the following sections:
    - Industry Analysis
        - Biotechnology Overview
        - Biotechnology Industry Classifications
        - Biotechnology Industry Employment
        - Biotechnology Industry Outlook
    - Biotechnology Workforce Issues and Challenges
        - Employee Development Practices
        - Employee Recruitment Practices
    - Occupational Assessment
    - Biotechnology Education and Training Providers
- *Appendix A* provides occupational profiles for 12 key biotechnology occupations covered by the study.

# EXECUTIVE SUMMARY

## Introduction

In February 2006, work2future formerly known as Silicon Valley Workforce Investment Network, hired Godbe Research to conduct a workforce demand study of the biotechnology sector within the 11-County Bay Area. For the purposes of this study, the Bay Area region consists of the following 11 counties: Santa Clara, San Mateo, San Benito, San Francisco, Alameda, Contra Costa, Marin, Napa, Solano, Santa Cruz, and Sonoma.

The primary research objectives of the study were as follows:

- To identify the workforce needs of the biotechnology sector, with a focus on identifying where labor market gaps are the greatest;
- To evaluate existing and future biotechnology workforce challenges and opportunities; and
- To identify the biotechnology occupations within the region that are most likely to be undersupplied in the future.

## Project Methodology

There are two major research components to this study:

- Secondary research – synthesis and trend analysis of existing sources of information relevant to biotechnology employment in the 11-County Bay Area, including a review of current literature on the industry and research into the characteristics of the industry and the more prominent occupations.
- Primary research – interviews were conducted with 59 representatives from biotechnology employers in the 11-County Bay Area in order to gain insight into current and emerging workforce demands and issues in the sector. Executive interviews were conducted with education and training providers who have programs specific to the biotechnology sector.

## Key Findings

The future economic prosperity of the biotechnology industry in the Bay Area is highly dependent on the availability of a workforce that is both large enough and has the necessary education, training and skills to meet the rapidly growing industry demand, Addressing this and other workforce issues will be especially important in enabling the Bay Area to maintain and develop its leadership role in the biotechnology industry in the years ahead.

### High Demand Occupations

An analysis of employment projections and shortage indicators for 12 biotechnology occupations indicated particularly strong employer demand and potential future shortages in the Bay Area region for the following occupations:

- Bioassay associates
- Bioinformatics programmers and analysts
- Biostatisticians
- Calibration technicians
- Clinical lab associates
- Manufacturing associates
- Manufacturing technician
- Process development associates
- Regulatory affairs specialists
- Research Associate

Overall, the strongest percentage growth in total employment across all responding companies was expected for process development associates, manufacturing associates, bioassay analysts, clinical lab associates and biostatisticians.

*"Representing a marriage of IT and biotechnology, bioinformatics is poised to be one of the most prodigious growth areas in the next two decades (which) in turn will create a corresponding boom in job opportunities."*

**Bioinformatics Web**

### Strong Growth Forecast in the Bioinformatics Field

It is widely recognized that the field of bioinformatics[1] is one of the fastest-growing specialties in the life sciences. Industry experts have highlighted that the Human Genome Project[2] alone should foster a continuing explosion of data and a robust job market for computational biologists. Opportunities for applicants with the right interdisciplinary mix of skills in biology, biochemistry and computer science are expected to continue to grow rapidly over the next few years. In particular, there exists an opportunity for the retraining of IT workers, who already possess many of the skills required by bioinformatics employers, with the additional skills required to work in the biotechnology industry. Similar opportunities also exist for the retraining of biologists with the IT skills required for entry into the field of bioinformatics.

Most biotechnology employers in the region that indicated they had hired employees with bioinformatics skills in the past, expected to either keep hiring the same (53%) number of employees with a working knowledge of bioinformatics, or increase (34%) the number of employees they hire with a working knowledge in bioinformatics. The

[1] Appendix B on page 113 provides a detailed definition of bioinformatics.

[2] Completed in 2003, the Human Genome Project was a 13-year project coordinated by the U.S. Department of Energy and the National Institutes of Health. The project's goals included identifying all the genes in human DNA, determining the sequences of 3 billion chemical base pairs that make up human DNA, and the transfer of related technologies to the private sector.

*as of 2005, 10 percent of biotechnology occupations require some skill in the use of computational biology and bioinformatics; by 2010 that percentage will jump to 25 percent for all biotechnology occupations.*

**Robert Cormia, Regional Professor of Bioinformatics**

overall regional expectations for bioinformatics hiring is consistent with the expected demand of current employers in Santa Clara County as over 85% of employers in Santa Clara expect to keep hiring or increase hiring employees with skills in bioinformatics. A regional professor of bioinformatics, Robert Cormia, believes that as of 2005, 10 percent of biotechnology occupations require some skill in the use of computational biology and knowledge of bioinformatics; by 2010 he believes that percentage will jump to 25 percent for all biotechnology occupations. Combining the strong annual growth in employment for the entire biotechnology industry, and the growing proportional demand for employees with skills in computational biology and knowledge of bioinformatics, speaks to the need to expand and develop training programs in bioinformatics.

It should also be noted that all of the Santa Clara County biotechnology employers that participated in the survey and expect to increase hiring of bioinformatics skilled employees would be willing to hire individuals who do not meet the degree requirement that they have initially set for the position.

## Key Skills Needed for Bioinformatics

It is widely recognized that the field of bioinformatics[3] is one of the fastest-growing specialties in the life sciences. Industry experts have highlighted that the Human Genome Project[4] alone should foster a continuing explosion of data and a robust job market for computational biologists. Opportunities for applicants with the right interdisciplinary mix of skills in biology, biochemistry and computer science are expected to continue to grow rapidly over the next few years. In particular, there exists an opportunity for the retraining of IT workers, who already possess many of the skills required by bioinformatics employers, with the additional skills required to work in the biotechnology industry. Similar opportunities also exist for the retraining of biologists with the IT skills required for entry into the field of bioinformatics.

## General Shortage of Suitably Qualified Workers in the Bay Area

*"In the next five years, employers will have a need for workers with technical skills, written and oral presentation skills, team building, and project management skills."*

**Bay Area Biotechnology Employer**

The Bay Area's biotechnology industry is in need of qualified workers across all levels; however, the findings of the employer survey indicated there is currently a general shortage of suitable biotechnology applicants seeking employment in the region. At least 50 percent of employers reported at least "Some difficulty" finding suitable applicants for biostatistician, bioinformatics programmer/analyst, clinical lab associate, animal technician, calibration technician, regulatory affairs specialist, process development associate, and bioassay associate positions. In addition, at least one in five employers reported that they "Always" or "Frequently" recruited calibration technicians, regulatory affairs specialists, biostatisticians, and bioinformatics programmers/analysts from outside the region. Additional challenges are presented by the low awareness levels among local youth and adult populations about the opportunities which exist in the industry.

The current competitive environment between employers in the Bay Area region also indicates that shortages of suitable candidates exist in the region. Almost two-thirds of employers reported facing "Great" or "Some" difficulty retaining employees that could be hired by competitors, while over 40 percent faced difficulty retaining employees that could be promoted.

[3] Appendix B on page 113 provides a detailed definition of bioinformatics.

[4] Completed in 2003, the Human Genome Project was a 13-year project coordinated by the U.S. Department of Energy and the National Institutes of Health. The project's goals included identifying all the genes in human DNA, determining the sequences of 3 billion chemical base pairs that make up human DNA, and the transfer of related technologies to the private sector.

## Core Skill Requirements

A growing number of opportunities exist across a range of biotechnology occupations for candidates who possess the right mix of skills. As an example, biotechnology companies and research organizations are increasingly seeking workers across all levels with cross-functional skills, such as a combination of both computer science and life science skills. The tables below highlight some of the core basic, personal, and technical skills which biotechnology employers look for in potential candidates. The tables indicate that core biotechnology skills can be applied to many occupations with similar needs.

Table 1 Core Basic Skill Requirements for Biotechnology Occupations

| Basic Skill Requirements | Occupations Applicable To |
|---|---|
| Ability to understand and follow instructions<br><br>Math skills<br><br>Written and verbal communication | Animal Technician<br>Bioassay Associate<br>Bioinformatics Programmer/Analyst<br>Biostatistician<br>Calibration Technician<br>Clinical Lab Associate<br>Manufacturing Technician<br>Regulatory Affairs Specialist<br>Research Associate |

Table 2 Core Personal Skill Requirements for Biotechnology Occupations

| Personal Skill Requirements | Occupations Applicable To |
|---|---|
| Ability to work in a team<br><br>Ability to work independently<br><br>Attention to detail | Animal Technician<br>Bioinformatics Programmer/Analyst<br>Biostatistician<br>Calibration Technician<br>Clinical Lab Associate<br>Manufacturing Technician<br>QA/QC Specialist<br>Regulatory Affairs Specialist<br>Research Associate |
| Organizational skills | Animal Technician<br>Bioinformatics Programmer/Analyst<br>Biostatistician<br>Clinical Lab Associate<br>QA/QC Specialist<br>Regulatory Affairs Specialist<br>Research Associate |

Table 3 Core Technical Skill Requirements for Biotechnology Occupations

| Technical Skill Requirements | Occupations Applicable To |
|---|---|
| Ability to analyze/evaluate technical data | Bioinformatics Programmer/Analyst<br>Clinical Lab Associate<br>QA/QC Specialist<br>Research Associate |
| Biotechnology lab techniques/skills | Clinical Lab Associate<br>QA/QC Specialist<br>Research Associate |
| Computer skills | Animal Technician<br>Bioinformatics Programmer/Analyst<br>Calibration Technician<br>Clinical Lab Associate<br>Manufacturing Technician<br>QA/QC Specialist<br>Process Development Associate<br>Regulatory Affairs Specialist<br>Research Associate |
| Knowledge of life sciences | Animal Technician<br>Bioassay Associate<br>Bioinformatics Programmer/Analyst<br>Clinical Lab Associate<br>Manufacturing Technician<br>QA/QC Specialist<br>Research Associate |
| Manufacturing skills | Manufacturing Associate<br>Manufacturing Technician<br>Process Development Associate |
| Problem solving/critical thinking | Bioinformatics Programmer/Analyst<br>Bioassay Associate<br>Calibration Technician<br>Clinical Lab Associate<br>Manufacturing Technician<br>QA/QC Specialist<br>Research Associate |
| Technical writing skills | Bioinformatics Programmer/Analyst<br>Clinical Lab Associate<br>QA/QC Specialist<br>Regulatory Affairs Specialist<br>Research Associate |

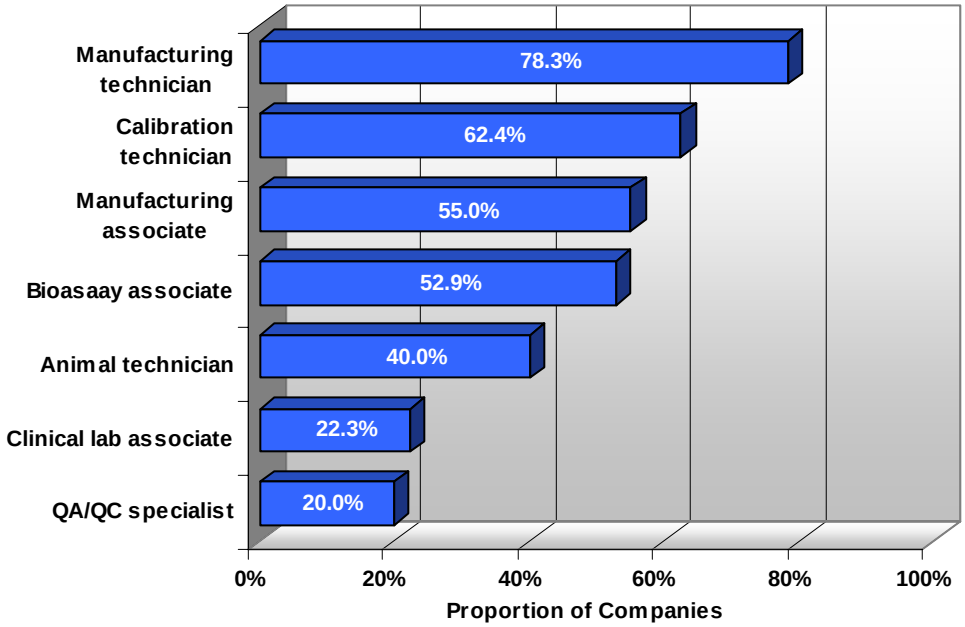
*"Those who attend community college biotechnology courses, including current workers and potential employees, gain the applied skills and the fundamental science knowledge that assist in filling the new technician/ operational workforce needs in California's life science companies."*

**California Community Colleges Economic & Workforce Development Program, 2004**

## Opportunities for Certificate and Associate Degree Candidates

There exists a misperception about the educational requirements for entry into the biotechnology industry; while many of the more advanced research positions typically require Masters' or PhD candidates, there are many job openings, particularly at the technician level, that require candidates to be educated to the certificate or associate's degree level. For example, although some companies require science technicians to hold a Bachelor's degree, most companies prefer to hire graduates of community colleges or technical institutes, or those who have completed college courses in chemistry, biology, mathematics, or engineering. As the biotechnology industry shifts from research and development to production and manufacturing, the demand for local, well-trained employees that do not need a bachelor's degree will create increased demand.

Figure 1 Proportion of Companies Requiring Less than a Bachelor's Degree by Occupation




In addition, almost three-quarters of responding employers indicated that they would consider hiring into occupations with set degree requirements, individuals with less than the degree requirement who had work-related experience or a specific certificate.

The findings from this study as well as those of similar studies reveal strong growth expectations for employment and economic output for the biotechnology cluster in the foreseeable future. However, these expectations of employment growth should be tempered with some of the trends that could negatively impact these employment projections. These caveats include:

- The high cost of doing business and living in the Bay Area;
- The possibility of outsourcing production and manufacturing positions overseas; *and*
- The competition both within the United States and outside of the country for attracting new or expanding current biotechnology employers.

This is not meant to be an exhaustive list of the issues and possible events that could hinder the growth of biotechnology in the region only a reminder of the type of issues

that should be considered when planning for the future biotechnology workforce in the Bay Area.

## Conclusions and Recommendations

Based on the findings of the secondary and primary research, Godbe Research offers the following conclusions and recommendations for work2future.

### Preparing Today's Workforce for the Biotechnology Industry

The sustained economic prosperity of the biotechnology industry in the Bay Area is highly dependent on the availability of a workforce that is both large enough and has the necessary education, training and skills to meet the challenges posed by global and national competition. work2future has two areas of opportunity to play an invaluable and immediate role in preparing today's Biotechnology workforce in the Bay Area. These opportunities include developing a comprehensive tool to assess applicants to the industry and expanding and developing education and training programs in biotechnology.

#### Create an Assessment Tool for Applicants to the Biotechnology Cluster

Over 85 percent of biotechnology employers indicated that they hire temporary workers as a recruitment strategy to eventually hire permanent employees. Given that only six percent of current biotechnology employees are hired on a temporary basis, this indicates that employers lack confidence in the skills and abilities of the employees they are hiring. This finding, coupled with the fact that training and education programs for biotechnology can be quite expensive, leads to the goal of more efficiently finding and training workers for the expanding needs of the biotechnology cluster.

> **Workf2future Opportunity**: Working with employers, industry leaders, and education and training providers, work2future could develop and administer an assessment of potential applicants to the biotechnology cluster. The assessment tool would allow work2future to develop an education and training plan for those individuals who require more skills and knowledge before being qualified for their occupations of interest and, for those individuals who are qualified for immediate employment in the industry, work2future would work with employers to find the best fit for employment in Biotechnology. This assessment opportunity could also provide an effective time to communicate with potential applicants the occupations that are in greatest demand within the region.

### Develop and Expand Associate's Degree and Certificate Programs at Local Community Colleges

*"There is a need to offer more training specific to our industry."*

**Bay Area Biotechnology Company**

Both a strong foundation in the life sciences as well as occupationally specific skills are needed in the biotechnology workforce. Biotechnology employers in the region expect qualified applicants to have both the necessary academic foundation in biology, chemistry, and/or information technology, as well as the specific training and understanding of the current tools needed to work in the biotechnology arena. Any education and training programs for biotechnology should provide a solid foundation in the life sciences while maintaining a flexible and responsive training curriculum that focuses on the current research tools that are in greatest demand within the industry.

> **Workf2future Opportunity**: Working with community colleges in the region, work2future could assist in expanding and developing a two-phase system for efficiently training young applicants interested in entry-level occupations in biotechnology. This program would provide individuals with a generalized foundation in science through an associate's degree tailored to the needs and requirements of biotechnology employers. After successfully completing an associate's degree, individuals would take courses to complete a specific certificate program tailored to the entry-level requirements for positions such as manufacturing technician, clinical lab associate or calibration technician. These certificate programs would be focused on the entry-level positions with the greatest demand and would be developed in a flexible manner so that certificate programs could adapt to changes in the specific occupational needs of the industry.

### Career Development Based on Expanding Skill Sets and Not Tied to Specific Occupations

The biotechnology industry is still emerging and undergoing rapid change while defining itself. Unlike a more mature industry such as healthcare, occupational titles and responsibilities are still evolving. Any employee development or industry-specific training programs should focus on expanding key skill sets rather than following an occupation-driven career ladder. One of the key challenges for this cluster is to develop workforce skills that can be applied to a range of occupations in the industry, rather than developing single occupation-specific training programs. Some of the core skill sets for biotechnology include:

- Clinical research and management,
- Bioinformatics and other computational information technology research tools,
- Quality assurance and quality control, and
- Regulatory affairs and requirements.

Given the rate of change found in biotechnology, it is important to annually reevaluate the core skill requirements for the industry. It also should be noted that some of these skill sets can be used in industries outside of biotechnology, such as healthcare.

Employee development and training programs are essential in a cluster such as biotechnology that is constantly changing. Like information security, many of the current biotechnology employees will need to be retrained on new techniques and research tools while they remain employed in biotechnology. Oftentimes, larger more established biotechnology employers have funded employee development and training programs, while most smaller, new biotechnology employers have little or no employee development programs.

> **Lifelong Learning Accounts** (LiLAs) provide a flexible alternative to smaller employers who are unable to completely pay for internal staff training and development programs. These portable individual accounts finance the education and training that current and future employees need for career advancement in the biotechnology sector. Similar to private and public retirement accounts (like a 401k for training and education) individuals, employers and public sources contribute to these accounts which provide individuals with the ability to develop new skills and progress through current or alternative career paths.

Employers and education and training providers have both indicated the need for greater collaboration between the two groups. Given the many niches and areas of specialization that exist within the cluster it would be invaluable to create a tool that would centralize all of the information related to needs, opportunities, and training that exist in the region for biotechnology.

> **Workf2future Opportunity**: There exists an opportunity for local Workforce Investment Boards to collaborate on the development of a 'Biotechnology Navigator.' This portal would provide a central repository of all the different biotechnology-related training programs which are available in the region, as well as financial aid programs and workforce opportunities which exist in the industry. The Navigator would provide information to one-stop employees in order to help them guide job seekers interested in the biotechnology field by making them more aware of the opportunities which exist in the industry, and by assisting them in a career transition. The creation of this application would help partnering organizations to better understand the pursuit of biotechnology careers as well as the barriers involved in entering the industry from the applicant's perspective.
>
> It is essential that any dissemination tool created for this industry include the collaboration of biotechnology employers, trade associations, universities, community colleges, university extension programs, appropriate high school programs, and Workforce Investment Boards in the region.

## Developing Tomorrow's Workforce for the Biotechnology Industry

### Communicate to High School Students the Opportunities in the Biotechnology Industry

A recent study by the Milken Institute[5] examined the top 12 biotechnology regions in the country. Overall, the Bay Area was well represented with San Jose, Oakland, and San Francisco. The results of the Biotech index ranked the 12 regions on their overall strength in biotechnology when considering research and development inputs, the availability of risk capital, the quality and quantity of human capital and the biotechnology workforce, as well as the current impact these regions are having in biotechnology. San Jose finished fourth in the overall biotech index with San Francisco eighth and Oakland following closely at ninth. However, the study did reveal some weaknesses in the San Jose and Bay Area regions relating to human capital in biotechnology. San Jose (11$^{th}$) and San Francisco (12$^{th}$) were at the bottom of the relative scale for regions with recent bachelors' degrees in fields directly related to biotechnology[6]. When looking at recent masters' degrees in fields related to biotechnology, both regions remained in the lower half of the twelve regions evaluated in this study; although the outlook improved slightly for San Jose (7$^{th}$), San Francisco again ranked in 12$^{th}$ place on this measure. Current human capital development is a reasonable barometer for the availability of qualified biotechnology workers in the future. Increasing the number of students who enter biotechnology related fields when they go to college is an important objective to meet the growing demand for local biotechnology employees, which continues to increase by about 10 percent annually.

The Biotech Academy at Andrew Hill High School (see case study below) provides a model that could be expanded and replicated within the region to increase the number of students considering and working towards a degree in a biotechnology related field.

**Case Study**: Andrew Hill High School – Biotech Academy: This academy is a three-year program dedicated to producing students with the science and laboratory skills necessary to enter the workforce and college. The academy is currently in its seventh year of operation with 125 students and a core group of eight teachers working with students in the program. The academy collaborates with both regional colleges and universities, such as Santa Clara University, San Jose State University and San Jose City College, as well as biotechnology employers in the region such as Genentech, Kaiser Foundation, and Agilent Technologies. These partnerships with colleges and universities provide seniors the opportunity for college credits as well as job mentoring and internships with regional employers.

The academy serves a mixed population of students – both male and female as well as those with special needs. At least 50 percent of the academy students are chosen for their "at-risk" status. Andrew Hill High School is demographically 58% Latino, 29% Asian, 4% Filipino, 4% European-American, 4% African-American, 0.5% Native American Indian, and is representative of the general local population.

[5] America's Biotech and Life Science Clusters, June 2004, DeVol, Wong, Ki, Bedroussian and Koepp. Milken Institute.
[6] This was derived in 2002, based on a per worker assessment of every 10,000 workers

# INDUSTRY ANALYSIS

## Biotechnology Industry Overview

*"Biotechnology refers to techniques that are used to genetically modify living organisms to produce marketable products."*

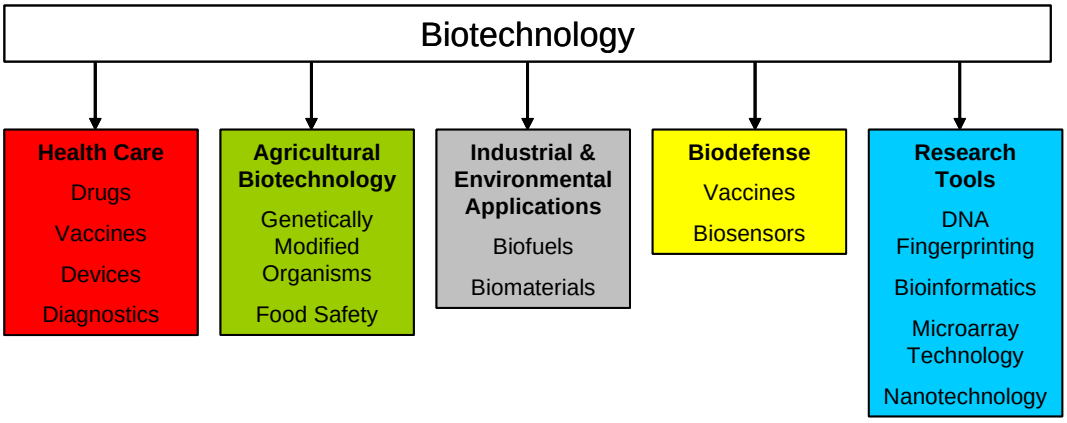
**Public Policy Institute of California, 2005**

The biotechnology industry *"uses knowledge of organisms and biological systems, and the ability to manipulate these systems at a molecular level, to create, develop, and market new techniques and products"* (BayBio, 2005). Although the biotechnology industry is based on biology, biotechnologists integrate and apply knowledge from other science and math disciplines, including chemistry, biochemistry, physiology, engineering, physics, and computer technology, to create and develop techniques and products.

The biotechnology industry is comprised of many sub-sectors, including:

- Health care – drugs, vaccines, devices, and diagnostics;
- Agricultural biotechnology – genetically modified organisms and food safety;
- Industrial and environmental applications – biofuels and biomaterials;
- Biodefense – vaccines and biosensors; *and*
- Research tools – DNA fingerprinting, bioinformatics, microarray technology, and nanotechnology.

Figure 2 Biotechnology Sectors




*"The biotechnology industry is a collection of firms that use cellular and molecular processes, particularly the recombinant DNA technology, to produce goods or provide services."*

**Public Policy Institute of California, 2005**

Biotechnology does not include medical technology (devices and instruments), high-tech medicine or medical informatics for medical records, as these disciplines are unconnected to genetic and cellular manipulation. An important exception to the group is the production of software and tools for gene sequencing and analysis (bioinformatics).[7]

[7] Center for Economic Growth, 2004.

## Biotechnology Industry Characteristics

In many ways, the biotechnology industry demonstrates similarities to other industries, including nanotechnology and information technology (IT). Some comparable features include the highly knowledge-intensive nature of the industry, as well the high proportion of venture capital investment which the industry has attracted.

Some of the other key characteristics which define the biotechnology industry are:

- The R&D intensive nature of the industry – employers spend an average of $121,000 per employee on R&D, compared to $30,600 in the pharmaceutical industry;
- High salaries – average wages in the industry are about 85% higher than the average for other sectors;
- The domination of small firms – the median biotech firm has 31 employees;
- A high level of dependence on innovation for continued financing;
- The central role played by government policy at almost every stage of biotechnology product development; *and*
- Intellectual property is a defining feature of the industry.

## Biotechnology Industry Classifications

The biotechnology industry cannot easily be defined using either the traditional Standard Industrial Classification (SIC) or the North American Industry Classification System (NAICS), as neither system separately classifies a specific proportion of the economy as the biotechnology industry. Instead, most biotechnology firms are assigned to the following two broader industry categories encompassing research and development (R&D) and drug manufacturing:

- Pharmaceutical and Medicine Manufacturing (NAICS code 3254); *and*
- Research and Development in the Physical, Engineering, and Life Sciences (NAICS code 541710).

Table 4 provides employment data for these industry groups. Overall employment in these industry groups represents 0.6 percent of employment across all industries in the US, 1.0 percent of employment across all industries in California, and 1.9 percent of employment across all industries in the 11-County Bay Area. By comparison, 17 percent of total US employment in these industry groups is based in California, while seven percent is based in the Bay Area.

Table 4 Biotechnology Industry Employment in the US, California, & Bay Area, 2004

| NAICS | Industry Title | Employment | | |
|---|---|---|---|---|
| | | US | CA | Bay Area |
| 325411 | Medicinal & Botanical Manufacturing | 22,909 | 2,673 | NA |
| 325412 | Pharmaceutical Preparation in Manufacturing | 225,471 | 29,992 | NA |
| 325413 | In-Vitro Diagnostic Substance Manufacturing | 14,541 | 4,459 | NA |
| 325414 | Other Biological Product Manufacturing | 24,278 | 3,379 | NA |
| 3254 | Pharmaceutical & Medicine Manufacturing | 287,199 | 40,503 | 15,110* |
| 541710 | Physical, Engineering, & Biological Research | 479,651 | 87,136 | 38,284* |
| | **All Industries** | **129,278,176** | **12,618,527** | **2,843,039** |

** Data derived from California EDD data file for the 11-County Bay Area.*

Sources: US Bureau of Labor Statistics; California EDD.

It should be noted that, although these industry categories overlap substantially with most biotechnology firms, they are not a perfect fit as they also include firms that are not involved with biotechnology. Also, some biotechnology firms will be classified within other industry categories; according to a recent study by the US Department of Commerce, for example, as many as 35 percent of responding biotechnology companies were classified in other NAICS industry groups. Some caution must therefore be taken when interpreting biotechnology industry employment data based on NAICS industry classifications.

## Biotechnology Industry Employment

Estimates of employment levels in the US biotechnology industry vary widely and are largely dependent upon how the industry is defined. The latest Ernst & Young annual biotechnology industry report estimated that the US biotechnology industry employed 187,500 people across 1,444 companies in 2004. The total number of biotechnology employees in the US is likely to be much greater, however, as this count excludes those working for universities, seed companies, traditional pharmaceutical companies, and other industries that are also conducting research and creating biotechnology products. Table 5 below provides an overview of biotechnology and related industry employment estimates drawn from a number of different sources.

Table 5 Estimates of Biotechnology Industry Employment

| Companies | Employees | Region | Industry Description | Year | Source |
|---|---|---|---|---|---|
| - | 406,700 | US | Biopharmaceuticals | 2003 | Milken Institute (2004) |
| 2,600 | 230,000+ | CA | Biomedical / Life Sciences* | 2004 | California Healthcare Institute (2004) |
| 1,400 | 220,000 | US | Biotechnology | 2000 | California Community Colleges (2002) |
| 1,473 | 198,300 | US | Biotechnology | 2003 | BIO Website |
| 1,466 | 194,600 | US | Life Sciences | 2004 | Center for Economic Growth (2004) |
| 1,444 | 187,500 | US | Biotechnology | 2004 | Ernst & Young (2005) |
| 400+ | 100,000 | CA | Biotechnology | 2004 | California EDD LMID (2004) |
| 400 | 85,000-100,000 | CA | Biotechnology | 2000 | California Community Colleges (2002) |
| 726 | 80,000 | Bay Area | Life Sciences | 2003 | Bay Area Life Sciences Strategic Action Plan (2003) |

** Includes both businesses and academic institutions*

Firms engaged in biotechnology activities vary greatly in size and scope. At one end of the spectrum are small dedicated biotechnology companies that focus on research, while at the other end of the spectrum are large, diversified firms with well-established production and distribution systems and greater in-house resources[8].

[8] US Department of Commerce, 2003.

## Biotechnology Employment in California and the Bay Area

*"By any measure, at least one-third of the US life science sector is based in Northern California."*

**BayBio, 2005**

Research indicates that around one-third of all biotechnology companies in the US are located in California, and that these firms collectively employ an estimated 100,000 workers. Of these, it is estimated that around 30,000 to 40,000 employees are based in the Bay Area. Although employment in the biotechnology industry makes up only a small fraction of total employment in California and the Bay Area, biotechnology employment in these regions accounts for a large proportion of the total US biotechnology economy. Table 6 below shows that 32 percent of biotechnology employees in firms responding to a recent US Department of Commerce survey were based in California, compared to 11.5 percent in Massachusetts, which had the second-highest proportion of employees.

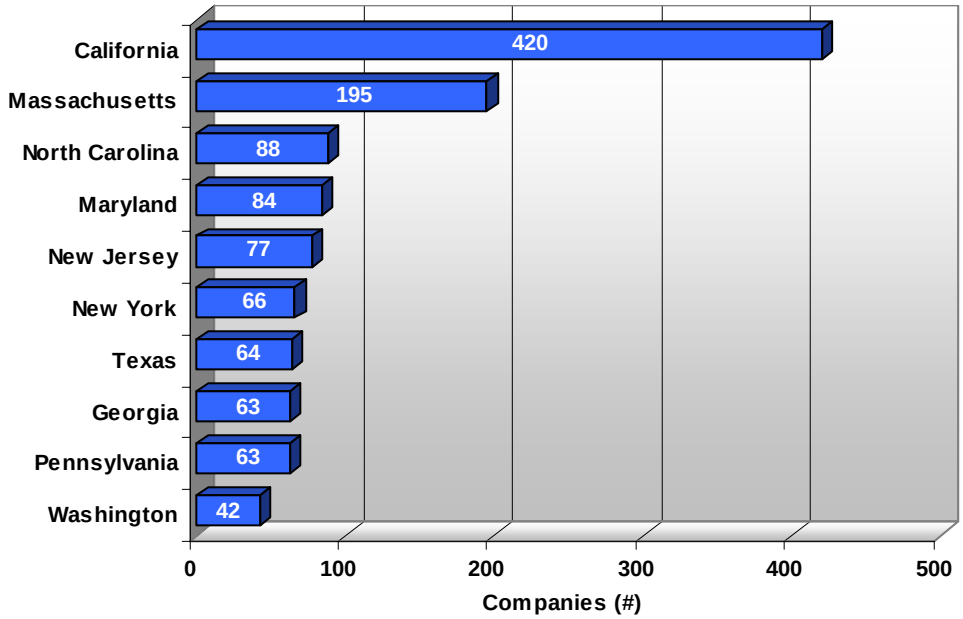
Table 6 US States with a High Proportion of Biotechnology Employees, 2002

| State | Employees in Responding Companies | % of Total |
|---|---|---|
| California | 4,418 | 32.0% |
| Massachusetts | 1,586 | 11.5% |
| Maryland | 1,195 | 8.7% |
| Sweden | 758 | 5.5% |
| Pennsylvania | 705 | 5.1% |
| New Jersey | 703 | 5.1% |
| **All States** | **13,789** | **100.0%** |

Source: US Department of Commerce, 2002.

Similarly, Figure 3 below shows that, in terms of company volume, California, with over 400 biotechnology firms, had more than double the number of firms as the second leading state – Massachusetts.

Figure 3 Top Ten Biotechnology States in the US by Number of Companies, 2004




*"California's dominance in biotech primarily results from its large share of the US biotech research."*

**Public Policy Institute of California, 2005**

Source: Ernst & Young, 2004.

*"California was the largest recipient of biotech venture capital investment from 2001-2003, with an annual average $1.0 billion, or 38 percent of total biotech venture capital."*

**Milken Institute, 2004**

Within the state of California, three major biotechnology regions have been identified: the Bay Area; Los Angeles region; and San Diego region. These biotechnology regions have the following features in common:

- Major research universities and leading research institutions;
- A highly skilled bioscience and biotechnology workforce;
- An abundant experience pool from other industries, including information technology, pharmaceuticals, medical devices, and electronics;
- Access to investment funding for high technology enterprises.

Table 7 provides a summary of the characteristics of California's primary biotechnology regions. The table indicates that, of the three regions, the Bay Area has the highest number of biotechnology companies and employees.

Table 7 Characteristics of California's Biotechnology Centers

| | Bay Area | Los Angeles Region | San Diego Region |
|---|---|---|---|
| Population (2004) | 7,103,450 | 17,516,110 | 2,931,714 |
| Total Employment (2004) | 3,469,800 | 7,932,400 | 1,418,500 |
| Life, Physical & Social Science Employment (2004) | 46,570 | 53,170 | 19,040 |
| Biotechnology Employment Estimate (2004) | 27,270 | 17,390 | 14,442 |
| Biotechnology % of total Employment | 0.8% | 0.2% | 1.0% |
| Biotechnology Companies | 257 | 98 | 205 |

Sources: U.S. Census Bureau; California EDD; Bioability.

*"Given bioscience's long development cycle across multiple disciplinary fields, tight government regulation and larger capital investment up front, the requirement for a suitable workforce is crucial."*

**Milken Institute, 2004**

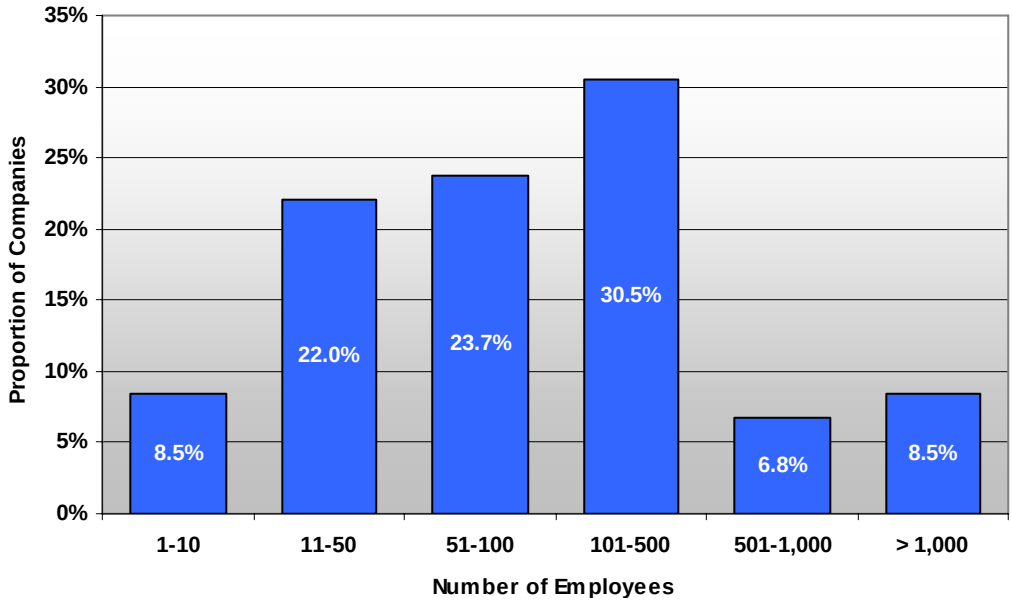
In particular, the Bay Area has a rich cluster of companies engaged in pharmaceutical and biotechnology research, including Genentech, Chiron Corporation, Abbott Laboratories, Bayer HealthCare Biological Products Division in Berkeley, and ALZA Corporation, headquartered in Mountain View, which is a leading developer and manufacturer of drug delivery-based products for the global healthcare industry.

## Current Employment

In order to supplement the findings from the secondary research, Godbe Research carried out survey interviews with a number of biotechnology employers in the 11-County Bay Area. The first substantive questions of the survey asked responding companies to record the number of permanent full-time and part-time employees currently working at their business location, as well as the number of temporary and/or seasonal employees.

Overall, a total of 27,993 employees were recorded across 59 responding companies, averaging 474 at each business location, while the median number of employees was lower at 73. Of these, the majority were employed on a permanent full-time basis (83% of all 27,993 employees), while the average proportion of full-time permanent employees was 88 percent. The total number of employees, including full-time permanents, part-time permanents, and temporary or seasonal workers, at each business location ranged from two, at one business location, up to 10,230 at one business location. Figure 4 below indicates that just under a third of responding companies (31%) employed between one and fifty employees, 24 percent had 51 to 100 employees, while a further 31% had 101 to 500 employees.

Figure 4 Size of Responding Companies by Number of Employees



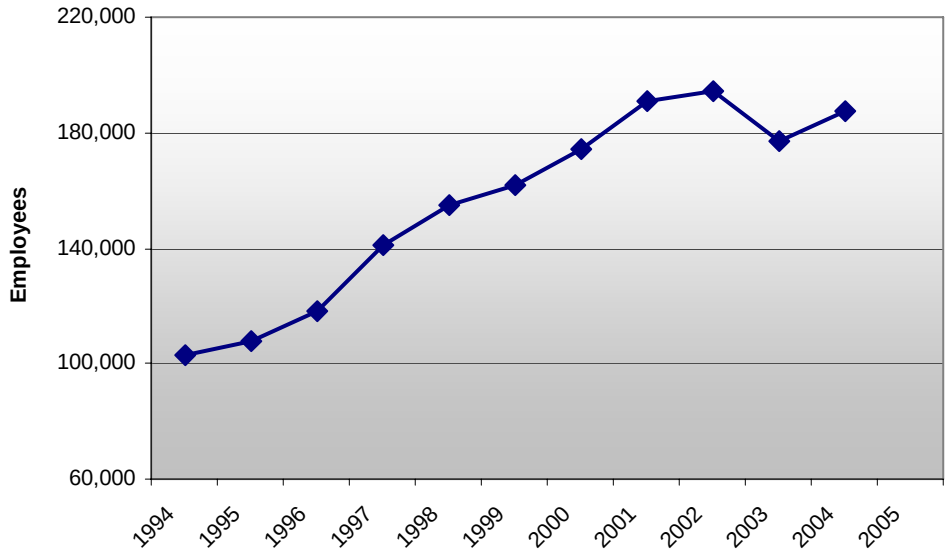

## High Level of Part-Time and Temporary Employment

Overall, 68 percent of responding organizations reported that they hired permanent part-time employees, while 63 percent reported that their company employed workers on a temporary and/or seasonal basis. Overall, 2,983 part-time permanent employees were recorded across 40 organizations, representing 11% of the total workforce in responding companies. By comparison, 1,813 temporary and/or seasonal employees were recorded across 37 organizations, representing seven percent of the total workforce in responding companies. On average, six percent of employees were part-time permanents, and six percent were temporary/and or seasonal workers. These findings suggest that part-time and non-permanent hires account for a comparatively large proportion of employment in the industry.

## Biotechnology Industry Employment Trends

Employment in the US biotechnology industry increased at an average annual rate of 10 percent between 1994 and 2002 when employment in the industry reached 194,600.

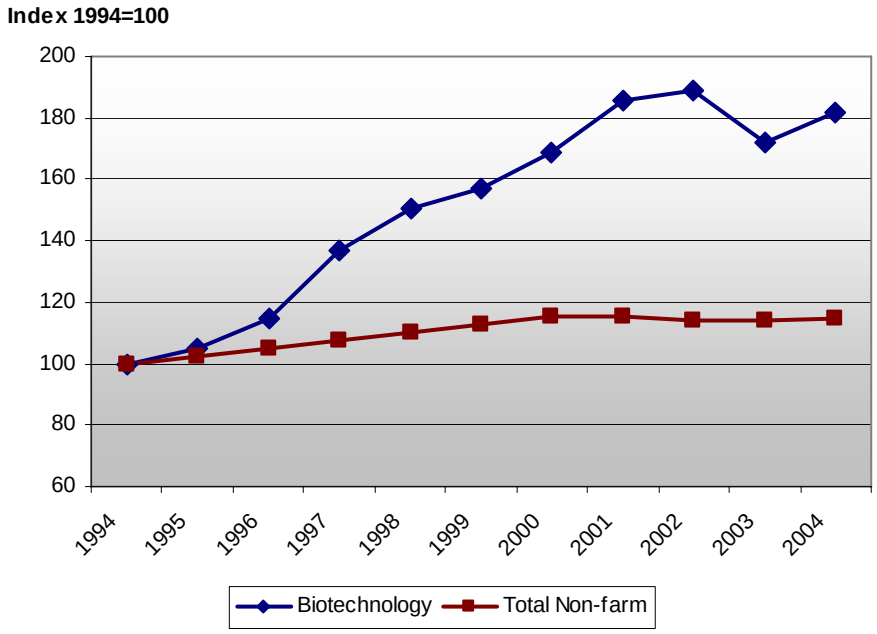
Figure 5 Biotechnology Industry Employment in the US, 1994-2005




Source: Ernst & Young: Annual Biotechnology Industry Reports.

Figure 6 indicates that, between 1994 and 2004, US biotechnology employment grew at a faster rate than total non-farm employment in the country.

Figure 6 Biotechnology Employment Growth vs. Total Non-Farm Employment Growth, 1994-2004




Source: Ernst & Young: Annual Biotechnology Industry Reports; US Bureau of Labor Statistics.

## Biotechnology Industry Employment Projections

*"The outlook for the biotechnology industry in California is very bright."*

**California Community Colleges, 2002**

Employment in the biotechnology industry has been growing by around 10 percent a year; this job growth is expected to continue, with estimates suggesting that up to a million people could be employed in the industry by 2015. Research conducted by the Milken Institute has projected that US employment in the biopharmaceutical industry will grow by almost 30 percent between 2004 and 2014. By comparison, employment growth in California is expected to exceed the national average, with projections forecasting an increase of almost 40 percent over the same period (see Table 8).

Table 8 Employment Growth in the Biopharmaceutical Industry by State, 2004-2014

| State | Employment 2004 | Employment 2009 | Employment 2014 | Employment Growth 2004-2014 |
|---|---|---|---|---|
| California | 71,273 | 84,115 | 99,607 | 39.8% |
| New Jersey | 46,044 | 47,511 | 49,802 | 8.2% |
| New York | 36,935 | 41,204 | 45,631 | 23.5% |
| Pennsylvania | 35,954 | 41,154 | 48,330 | 34.4% |
| North Carolina | 24,788 | 28,450 | 32,038 | 29.2% |
| Massachusetts | 22,682 | 29,160 | 37,257 | 64.3% |
| Illinois | 21,993 | 23,119 | 24,220 | 10.1% |
| Indiana | 19,591 | 21,435 | 23,587 | 20.4% |
| Texas | 12,791 | 14,315 | 15,800 | 23.5% |
| **US** | **413,774** | **469,826** | **536,295** | **29.6%** |

Sources: Milken Institute; Economy.com; BLS.

In Northern California, survey research also reflects an optimistic growth picture in the life science industry, of which biotechnology makes up a significant proportion. Employee levels in Northern Californian life science companies are projected to increase by 10 to 20 percent annually, with estimates predicting 8,000 new hires in 2006.

In addition, research has shown that job growth in the biotechnology industry has a positive impact on employment growth within the wider economy, due in part to the high salaries and employee contributions made by biotechnology employees within their communities. Research conducted by the Milken Institute, for example, suggested that the 'job multiplier' for the biopharmaceuticals industry in California may be as high as 4.5, which is substantially above the average for all industries. This means that for every job created in the biopharmaceutical industry, 3.5 jobs are created elsewhere in the economy. For the biotechnology industry in California, a report by the California EDD indicated that the employment multiplier was around 2.9, meaning that almost two additional jobs are created elsewhere in the economy for every job created directly in biotechnology.

Within the industry, particularly strong job growth is expected in the area of medicines and products used in diagnosing disease, since these are the areas in which most research and development is currently concentrated. In addition, biotechnology pharmaceuticals are expected to remain an important factor in California, and many new jobs are also expected to be created by the growing bioinformatics sector and in stem cell research, due to the annual allocation of $295 million in funding set out by Proposition 71.

## Projected Employment Growth in Bay Area Biotechnology Companies

In addition to the questions about current employment levels, the survey also asked companies to record the level of permanent and temporary/seasonal employees which they expected to have in 12 months' time. Of the firms which responded to this question, 69 percent expected to increase the total number of employees at their business location over the coming year, 25 percent thought that the number of employees would remain the same, while five percent anticipated a decline in employee numbers over the next 12 months.

Table 9 below indicates that total employment among all responding companies is expected to increase by around 2,700 employees over the next 12 months, representing a growth rate of around 10 percent, which indicates a highly positive outlook for the industry, at least in the short-term. The table provides a breakdown of expected employment growth for both permanent and temporary/seasonal employees. The table shows that overall employment growth expectations over the next 12 months are higher among permanent employees (10%) when compared to temporary and/or seasonal employees (2%).

Table 9 Projected Employment Growth Over the Next 12 Months

| | Permanent Employees | Temporary/ Seasonal Employees | All Employees |
|---|---|---|---|
| Current Total Employees | 26,180 | 1,813 | 27,993 |
| Expected Employees in 12 Months | 28,837 | 1,854 | 30,691 |
| Expected Total Growth Over Next 12 Months | 10.1% | 2.3% | 9.6% |
| % of Companies Expecting to Increase Employees | 67.8% | 19.5% | 69.5% |
| % of Companies Expecting to Have the Same Number of Employees | 28.8% | 63.4% | 25.4% |
| % of Companies Expecting to Decrease the Number of Employees | 3.4% | 17.1% | 5.1% |

## Biotechnology Industry Outlook

*"Job creation in the biotech industry hinges on firm creation – more than half of the job growth in biotech is attributable to new firms."*

**Public Policy Institute of California, 2005**

The continued strong growth of the biotechnology industry in the Bay Area region is dependent upon a number of factors. In particular, because the industry is currently relatively small, it has been suggested that growth in the industry will be more dependent on the formation of new businesses rather than existing firm expansion. The Bay Area is currently facing intense competition from other regions within the State of California, other states within the US, as well as other countries, to both attract new companies and retain existing companies and their operations within the region.

California's strengths compared to other regions in the US include:

- Strong research capacity;
- A long tradition of venture capital investment;
- High-quality labor pool;
- Pioneering research conducted by California's universities in biological, medical, and chemical sciences.

Some of the competitive advantages which the Bay Area region has in comparison to other biotechnology centers within California include:

- Containing a higher proportion of the industry's leading companies;
- Bay Area organizations spend more on R&D than in the other regions;
- The Bay Area continues to receive the highest level of venture capital investment;
- A higher proportion of venture capital firms are located in the Bay Area region;
- Bay Area companies hold more biotechnology patents.

*"Policymakers throughout the country, eager to capture some of the economic potential of biotechnology, are willing to offer incentives and investments to foster their own biotech economies."*

**Public Policy Institute of California, 2005**

Comparative to other states and countries, California's most prominent disadvantages are the high cost of living and high cost of conducting business in the state. The comparatively high cost of living may drive away talent, while high relative business costs potentially threaten the state's ability to attract new businesses and retain current biotechnology firms. In addition, most US states have initiated policies to promote their own biotech economy, such as strategic industry planning, offering tax incentives to companies to relocate, as well as funding and support for research in the industry. Some of the incentives to biotechnology companies currently being offered by other states include:

- A $140 million allotment by Arizona to attract new biomedical companies;
- A 30% investment tax credit in Maine;
- No corporate income tax in Nevada; *and*
- A North Carolina program which offers loans to early-stage companies, incubator space, grants, and a 25% tax credit for investing in machinery and R&D.

*"Some biotechnology companies build manufacturing plants outside of the state due to the high cost of doing business in California due to high taxes, wages and cost of living."*

**California Community Colleges, 2002**

In particular, it has been suggested that California's existing tax regime provides a disincentive for biotechnology companies wishing to establish manufacturing plants in the state, which can cost up to $600 million to construct. However, research has indicated that the benefits gained from being close to a highly concentrated biotech research and development hub, and the utilization of a shared labor pool and infrastructure, has led many firms to set up their manufacturing operations in California, despite the high comparative cost of doing business in the state. In addition, a recent study by the California Healthcare Institute found that in 2003:

- 66% of biomedical companies which manufacture products expanded manufacturing in California;
- 61% planned to increase the number of manufacturing employees in California; *and*
- 64% sought to recruit manufacturing staff for their California facility in 2003.

Despite increasing competition, the outlook for continued biotechnology industry growth in the California remains positive. For example, the findings of a recent study by the US Department of Commerce indicated that 38 percent of new firms established between 1997 and 2001 chose to locate in California, raising the number of biotechnology firms by 45 percent. Only one state, North Carolina, experienced higher growth over the same period. In addition, while research has shown that more biotechnology companies are moving out of the state than are moving in, more new jobs were created in California than were lost as a result of these movements. This is because the companies which relocated to California were typically larger, had greater growth potential, and had a higher rate of survival than those which relocated out of the state.

*"Other states have not only identified workforce development and retention as a priority; they have set their sights on competition with California for these critical assets."*

**California Life Sciences Action Plan**

Some of the factors which indicate growth in the industry in the coming years include:

- The growing number of biotech firms with clinical trials;
- Plans by the Food and Drug Administration (FDA) to shorten the time taken to get new drugs approved for the market.

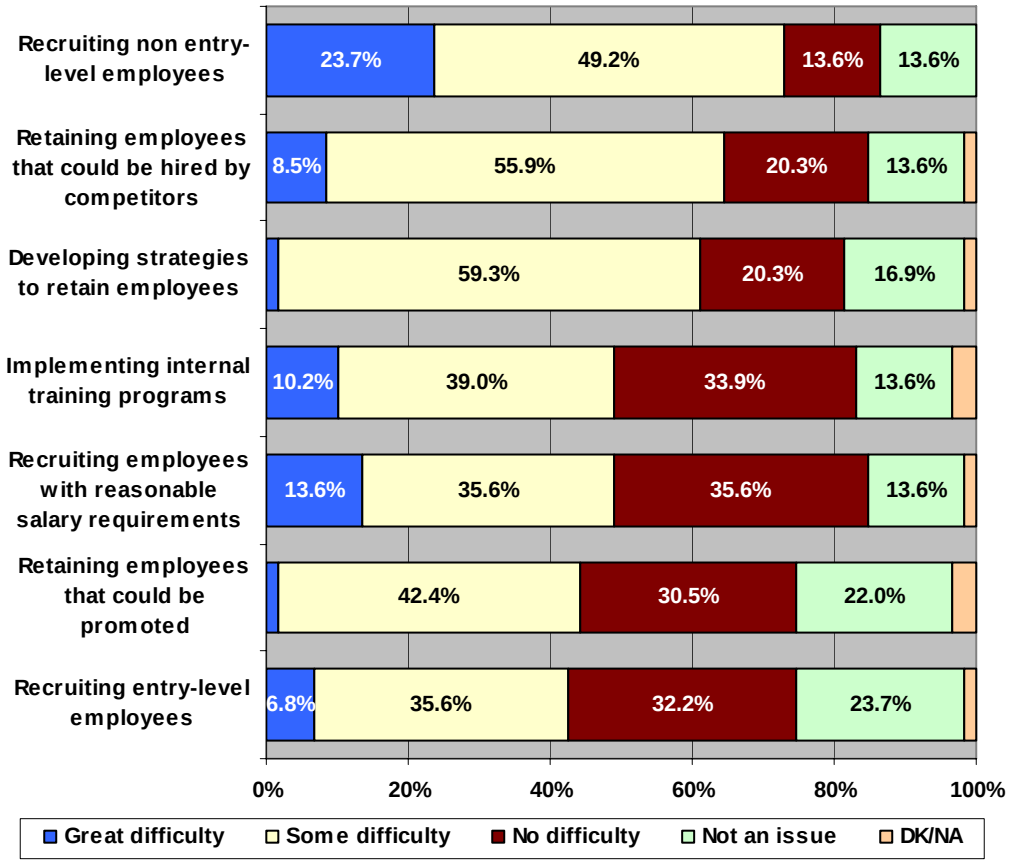
By 2005, biotechnology companies in Northern California had already delivered 240 life science products, while a further 200+ were in the development stage.

# BIOTECHNOLOGY WORKFORCE ISSUES AND CHALLENGES

The future economic prosperity of the biotechnology industry in the Bay Area is highly dependent on the availability of a workforce that is both large enough and has the necessary education, training and skills to meet the challenges posed by global and national competition. The need to develop a sufficient workforce to meet rapidly growing industry demand, as well as the education of future workers and up-skilling of existing workers with the required mix of skills, will create challenges for biotechnology workforce development in the years ahead. Addressing these issues will be especially important in enabling the Bay Area to maintain and develop its leadership role in the biotechnology industry.

In order to gain further insight into the current workforce issues of importance to the biotechnology industry, survey respondents were presented a series of items and were asked to rate the level of difficulty which their firm faced in addressing each issue. Figure 7 below indicates that, of the seven workforce issues considered, employers faced the most difficulty "Recruiting non entry-level employees with adequate skills and work experience" (73% "Some" or "Great" difficulty) and "Retaining employees that could be hired by competitors" (64% "Some" or "Great" difficulty). By comparison, 42 percent of respondents faced "Some" or "Great" difficulty "Recruiting entry-level employees with adequate training and education."

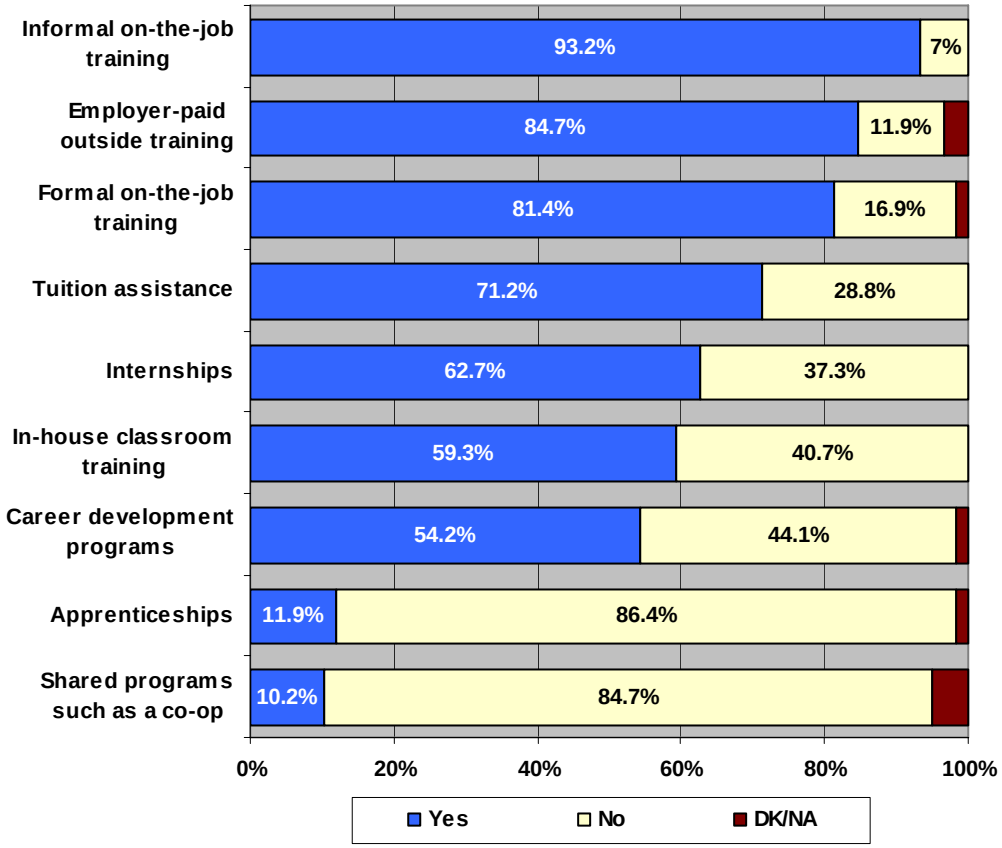
Figure 7 Workforce Issues of Importance



## Employee Development Practices

The survey findings indicated that the most frequently used employee development practice among biotechnology organizations in the Bay Area was informal on-the-job training (93%), followed by employer-paid outside training (85%), and formal on-the-job training (82%). By comparison, the least frequently used practices were shared programs, such as co-ops (10%) and apprenticeships (12%).

Figure 8 Use of Employee Development Practices



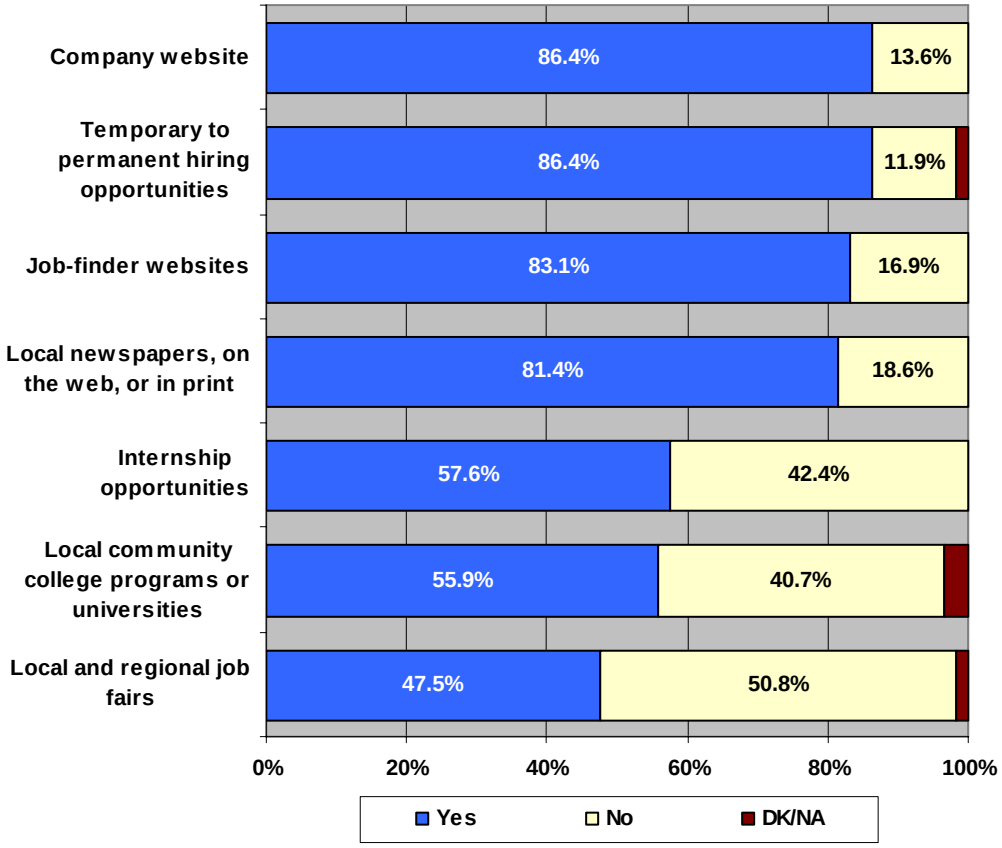

The education benefits in biotechnology are typically good, with many companies offering full tuition reimbursement for employees who go back to college to compete a degree that is useful to the company. This employee development allows employees to move up in the company with the support of their employer. Many companies also offer internship programs for students to help them gain experience in the field and make them more likely to be hired when they graduate[9].

[9] *Careers in Biotechnology* – California Community Colleges, 2002

## Employee Recruitment Practices

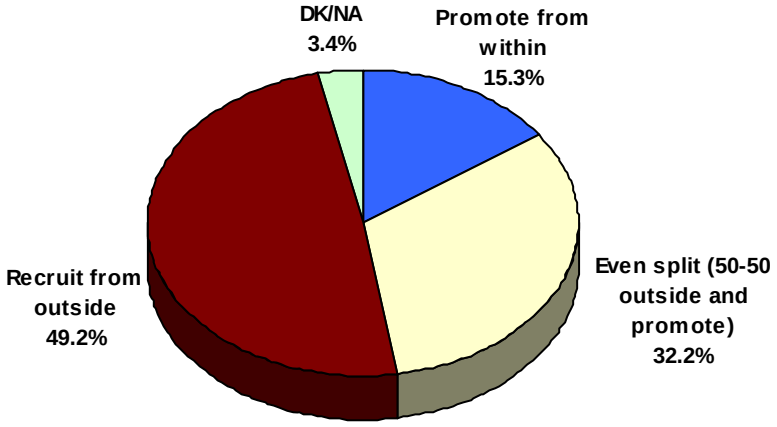
The most popular employee recruitment practices of those asked which were used by responding biotechnology companies were “Job announcements on your company’s website” (86%) and “Temporary to permanent hiring opportunities” (86%), followed by “Advertising on job-finder websites like Monster.com or Biospace.com” (83%) and “Advertising in local newspapers, on the web, or in print” (81%). By comparison, responding companies were less likely to use “Participation at local and regional job fairs” (48%), “Working with local community college programs or university departments for recruiting” (56%), and “Internship opportunities” (58%) when recruiting applicants for hiring.

Figure 9 Use of Employee Recruitment Practices



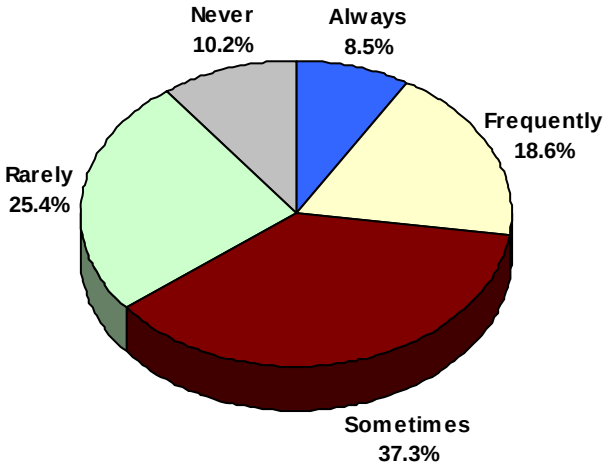
Despite the high use of informal and formal on-the-job training by the biotechnology companies which participated in the survey, respondents did not place a high level of importance on using internal promotions to fill non entry-level job openings, as illustrated by Figure 10 below. Among the organizations interviewed, only 15 percent said they typically filled available positions by promoting current employees, compared to 49 percent which recruited from outside the organization to fill non entry-level positions. A further 32 percent of respondents indicated that they used both methods when hiring non entry-level employees.

Figure 10 Hiring Practices for Non Entry-Level Positions




In addition to the question about hiring practices for non entry-level positions, the survey also asked biotechnology companies to record the frequency which their business recruits individuals from outside Northern California area. Figure 11 below shows that over a quarter of the companies surveyed (27%) indicated that they “Always” or “Frequently” recruited from outside the 11-County Bay Area, indicating a shortage of suitable candidates for job openings in biotechnology companies in the region. A further 37 percent of respondents said that they “Sometimes” recruited individuals from outside the region.

Figure 11 Frequency Firms Recruit from Outside Northern California



Research indicates that US biotechnology firms rely heavily on recruiting research and manufacturing employees from local labor markets to meet their biotechnology workforce requirements. Table 10 below indicates that, in 64 percent of companies, over 75 percent of biotechnology employees were recruited from the local labor market, while 37 percent of companies recruited more than 95 percent of employees from the local labor market.

Table 10 Biotechnology Workforce Recruitment Sources

| Source/Share of Workforce | More than 75% | More than 95% |
|---|---|---|
| Recruited from the local labor market | 63.9% | 37.3% |
| Recruited from US four-year degree / postgraduate degree | 18.4% | 8.3% |
| Recruited from US two-year degree / junior college / technical school | 0.2% | 0.2% |

*Source: Critical Technology Assessment of Technology in US Industry* – US Department of Commerce, 2002.

Table 11 below shows the proportion of biotechnology companies which use a number of different recruitment techniques to meet their workforce needs. The table indicates that in-house training and increased salaries were used by a high proportion of companies with difficulties filling fewer than five percent of positions, as well as those with difficulties filling more than 20 percent of positions.

Table 11 Proportion of Companies Using Recruitment Techniques to Meet Workforce Demands

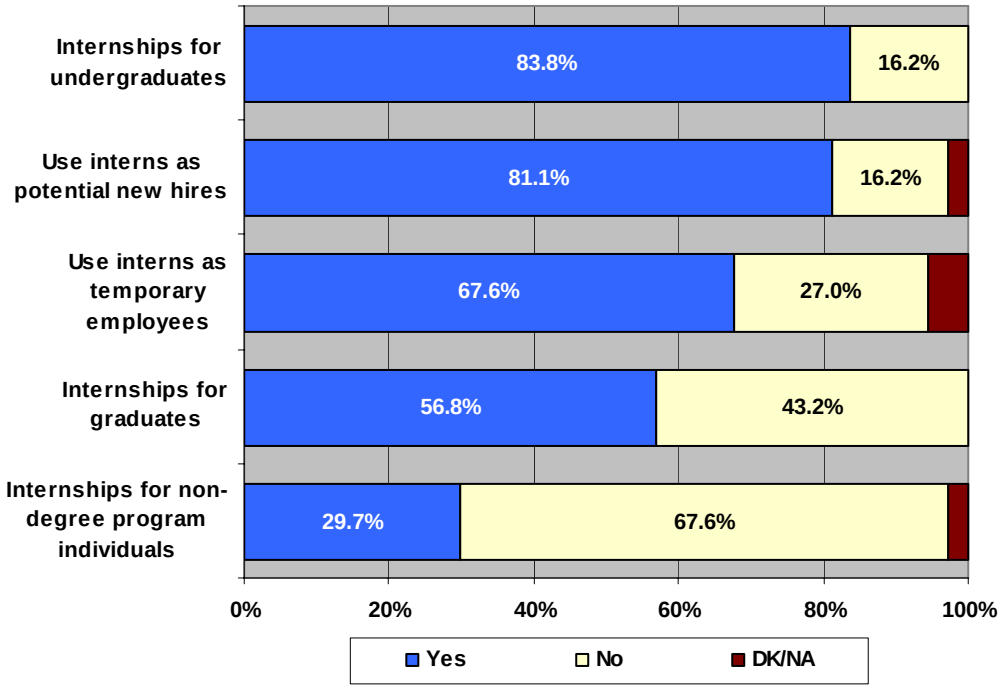
| Recruitment Technique | Companies Reporting Difficulty Filling… | |
|---|---|---|
| | Less than 5% of positions | More than 20% of positions |
| In-house training | 89.5% | 76.9% |
| College recruiting | 68.4% | 38.5% |
| Increased salaries | 67.7% | 65.4% |
| Enhanced benefit plans | 57.9% | 34.6% |
| Recruiting bonuses | 57.9% | 11.5% |
| Outsourcing | 37.6% | 19.2% |
| Subcontracting to another company or academia | 27.1% | 34.6% |
| Establishing foreign facilities | 11.3% | 15.4% |
| Overtime incentives | 10.5% | 0.0% |
| Foreign recruiting | 9.8% | 19.2% |

*Source: Critical Technology Assessment of Technology in US Industry* – US Department of Commerce, 2002.

## Internship Opportunities

Among the companies which indicated that they offered internship opportunities at their organization, 84 percent said they had internship programs for individuals who are in an undergraduate degree program, such as an AA/AS or BA/BS. By comparison, 57 percent of companies offered internship programs to individuals in a graduate degree program, such as an MA/MS or PhD, while 30 percent had internships for individuals who are not in a degree program (see Figure 12). The survey findings also indicated that a majority of biotechnology firms (81%) used interns as a source for potential entry-level new hires, while 68% said they used interns as temporary, short-term employees.

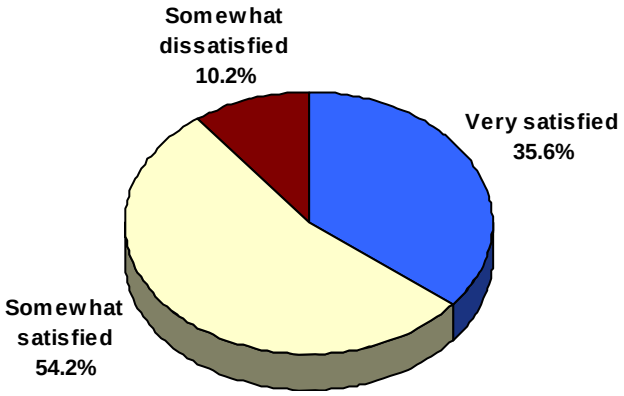
Figure 12 Use of Internship Opportunities




## Satisfaction with Recruitment Strategies

Overall, companies reported that they were typically satisfied with their current workforce recruitment strategies (90% “Very” or “Somewhat” satisfied).

Figure 13 Satisfaction with Workforce Recruitment Strategies



## Challenges for Biotechnology Workforce Development

The findings of the research study indicate that the main workforce challenges for biotechnology workforce development in the Bay Area are:

1. The rapidly evolving nature of the biotechnology industry, which makes it difficult to predict its future direction from a workforce perspective. Occupational definitions and skill requirements are not set in stone, and will change as the industry develops and expands. One of the key challenges for the industry will be to implement training programs that focus on the development of a local workforce with a core set of transferable skills that can be applied to a range of shortage occupations in the industry.

2. The strong growth in employment demand forecast over the next few years, coupled with the shortage of a local workforce with the adequate skills and training requirements for a number of occupations, presents challenges for meeting the workforce needs of local industry, particularly in emerging technical areas such as bioinformatics.

3. Overcoming the misperception that exists about education and training requirements to enter the industry – applicants don't always need a Bachelor's degree or a PhD.

4. Overcoming the low awareness that exists among local youth and adult populations about the broad range of opportunities that exist in the industry.

5. Identifying specific opportunities which exist for retraining the local workforce with the skills needed to enter shortage occupations. For example, the increasing demand for biotechnology workers with IT skills creates an opportunity for the retraining of local IT workers with the biotechnology skills required for entry-level positions in shortage occupations, such as bioinformatics.

6. The high proportion of companies which reported difficulties retaining valuable employees presents an opportunity for the implementation of more long-term employee development practices, such as LiFAs, which are aimed at improving retention levels among local companies. Retention is a key issue for the biotechnology industry due to the high level of investment made by companies in training their workforce.

7. The lack of awareness among companies of local Workforce Investment Boards (WIBs). Current relationships between biotechnology businesses and education in the region typically focus on partnerships with large universities. There is an opportunity for increasing the industry's awareness of the quality and availability of biotechnology programs offered by local community colleges.

# OCCUPATIONAL ASSESSMENT

Employment opportunities in the biotechnology industry arise at different stages throughout the product development process. The table below summarizes the associated job functions and identifies the occupations which are the focus of this workforce study.

Table 12 Focus Occupations by Biotechnology Job Function

| Biotechnology Product Job Function | Focus Occupations |
|---|---|
| ***Research and Development***<br>This is a lengthy process that often lasts many years for each product. Research scientists concentrate on new discoveries, while other scientists and technical staff engage in process development and the scaling up of production resources to conduct full-scale manufacturing.<br>At this point, the number of staff is usually quite small. A typical R&D team consists of scientists, research associates, laboratory assistants, and technicians. Most lead scientists possess PhDs while other research associates and technical support staff have bachelor's and master's degrees. Some entry-level positions that require a high school diploma or associate degree include laboratory support worker, laboratory assistant and laboratory technician. | Research Associate |
| ***Clinical Research***<br>Companies must prove to the FDA that their product is safe and effective. Clinical trials begin once approval has been received from the FDA. During this phase product production takes place in a pilot plant or an expanded section of the laboratory.<br>A small number of workers may be employed to operate the small manufacturing facility and to conduct clinical research. | Animal Technician<br>Biostatistician<br>Bioinformatics Programmer/ Analyst<br>Clinical Lab Tech |
| ***Regulatory Affairs***<br>Employees help companies remain up-to-date on all requirements and regulations that affect a current or potential product. Entry-level jobs include regulatory affairs specialist, documentation specialist, or documentation coordinator. | Regulatory Affairs Specialist |
| ***Quality Systems***<br>Quality assurance and control is a vital part of the manufacturing process. The role of the QA/QC department is to ensure that regulations are followed, manufacturing processes are carried out consistently, final products meet all specifications and the entire process is documented. | QA/QC Specialist |
| ***Manufacturing and Production***<br>Upon receiving permission from the FDA, the manufacturing process is expanded to produce large quantities of the product. Additional staff is hired for the manufacturing process, including technicians, operators of production and packaging equipment, quality systems personnel, and workers involved with product distribution.<br>At this stage of operation, companies hire more technical personnel with bachelor's or master's degrees, and fewer with PhDs. Employment opportunities increase for technicians with associate's degrees from community colleges, and for support staff with high school diplomas or above. | Bioassay Associate<br>Calibration technician<br>Manufacturing Associate<br>Manufacturing Technician<br>Process Development Associate |

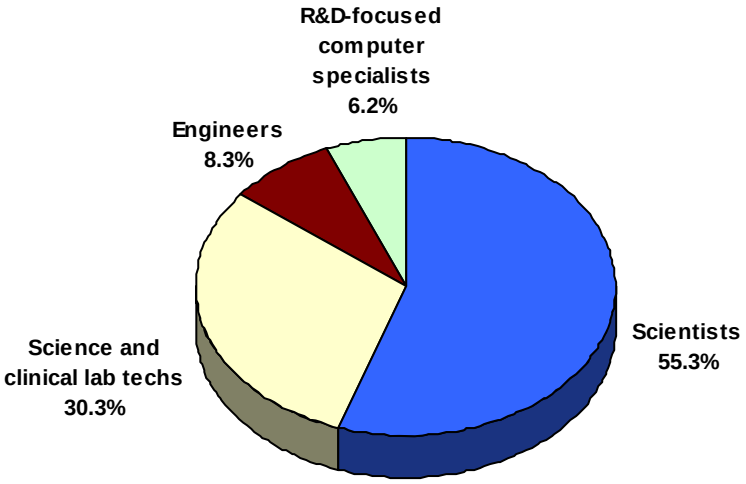
*Source: Under the Microscope: Biotechnology Jobs in California*, California EDD, 2004; *Careers in Biotechnology*, California Community Colleges, 2002.

## Biotechnology Occupations

As a knowledge-based industry, biotechnology is highly dependent on the availability of specially trained professionals, particularly research scientists and technicians. Biotechnology employees are highly educated; many have doctoral degrees.

Biotechnology-related occupations are typically knowledge-based and employees in the industry tend to be highly educated. The figure below provides an overview of biotechnology employment by occupation among 1,031 companies surveyed by the US Department of Commerce[10]. The figure indicates that a majority (55%) of biotechnology employees were broadly defined as "Scientists," while a further 30 percent were described as "Science and clinical laboratory technicians."

Figure 14 Biotechnology-Related Occupations, 2002




## Key Skill Requirements

Employers in the biotechnology industry typically seek workers with excellent science knowledge and laboratory skills and the ability to work as a team member.

Some of the primary skills required by biotechnology employers include:

- Ability to work in a team;
- Knowledge of Good Laboratory Practices;
- Attention to detail;
- Problem recognition and ability to report problems;
- IT skills, including word processing, spreadsheet, and data manipulation skills;
- Ability to understand and follow instructions and directions;
- Written and spoken communication skills;
- Record-keeping skills;
- Math skills.

[10] *Critical Technology Assessment of Technology in US Industry* – US Department of Commerce, 2002.

## Potential Occupational Shortages

There is no single equation that can determine the probability that an occupation will be undersupplied in the future. However, a comprehensive evaluation of both the quantitative and qualitative indicators of supply and demand for each of the occupations in question, combined with a thorough evaluation of the industry as a whole, allow at least an estimate of those occupations that potentially are most likely to be undersupplied in the future.

The table below categorizes each of the occupations into one of two levels of potential shortage:

- **Red**: Occupations that provide the strongest indication that they will be undersupplied in the future.
- **Yellow**: Occupations that provide some indication that they may be undersupplied in the future.

Table 13 Potential Biotechnology Occupation Shortages

| Occupation | Shortage Indicator |
|---|---|
| Bioassay Associate | RED |
| Bioinformatics Programmer/Analyst | RED |
| Biostatistician | RED |
| Calibration Technician | RED |
| Clinical Lab Associate | RED |
| Manufacturing Associate | RED |
| Process Development Associate | RED |
| Regulatory Affairs Specialist | RED |
| Research Associate | RED |
| Animal Technician | YELLOW |
| Manufacturing Technician | YELLOW |
| QA/QC Specialist | YELLOW |

Typical Education, Training and Salary Range by Occupation

| Occupation | Education | Work Experience | Median Salary Estimate |
|---|---|---|---|
| Animal Technician | Certificate or Associate Degree | Certification as an Assistant Laboratory Animal Technician by the American Association for Laboratory Animal Science is preferred | $35,984 |
| Bioassay Associate | Associate or Bachelor's Degree in Science | Up to two years of experience in a sterile manufacturing environment | $41,012 to $50,691 |
| Bioinformatics Programmer / Analyst | Master's or Doctorate Degree in Bioinformatics, Computer Engineering, or Computational Biology | Up to two years of related experience | $83,809 to $101,855 |
| Biostatistician | Master's or Doctorate Degree in Mathematics or Statistics | One to four years' related experience | $104,705 |
| Calibration Technician | Certificate or Associate Degree in Biotechnology, Electronics, or Instrumentation | One to two years of experience in quality control systems | $28,613 to $57,558 |
| Clinical Lab Associate | Bachelor's Degree in Science | Up to two years' of related experience | $70,397 to $89,706 |
| Manufacturing Associate | Bachelor or Master of Science Degree in Engineering or a life science | Up to two years' experience in a manufacturing environment | $61,446 to $85,319 |
| Manufacturing Technician | Certificate or Associate Degree in Biotechnology | Several years' experience in a sterile manufacturing environment | $22,907 to $31,066 |
| Process Development Associate | Bachelor or Master of Science Degree in Biosciences or other scientific discipline | Up to two years experience in manufacturing | $61,446 to $85,319 |
| QA/QC Specialist | Bachelor or Master of Science Degree in Biosciences or other scientific discipline | Up to two to five years of QA/QC experience | $45,188 to $58,069 |
| Regulatory Affairs Specialist | Bachelor of Science Degree in a scientific field | Three to five years' experience in documentation or QA/QC | $68,333 to $133,022 |
| Research Associate | Bachelor or Master of Science Degree in the sciences | Up to two years' laboratory experience with a Master of Science or two to five years' experience with a Bachelor of Science Degree | $61,446 to $84,276 |

Source: California EDD, Godbe Research.

# BIOTECHNOLOGY EDUCATION AND TRAINING PROVIDERS

*"As long as California's universities continue to conduct pioneering research in biological, medical, and chemical sciences, the Golden State's lead in the biotech industry is likely to continue."*

**Public Policy Institute of California, 2005**

According to research carried out by Bio-Link (Advanced Technological Education Center of Excellence for Biotechnology, City College of San Francisco), California is the nation's clear leader for availability of formal biotechnology education programs, with more than a third of all programs being based in the state.

## University of California

- Biotechnology Research and Education Program established in 1985 – this is an advanced training program that awards grants to fund outstanding research and graduate training in biotechnology-related disciplines.

## University of California Santa Cruz – Extension

- Certificate programs in Biotechnology, Bioinformatics, Bioscience Business and Marketing, Clinical Trials Design and Management and Regulatory Affairs. These programs are designed for those individuals with a solid scientific foundation or familiarity in the biotechnology arena.

## California State University

- Program for Education and Research in Biotechnology established in 1987 – this is a multi-campus, interdisciplinary training program that fosters workforce development. The program also encourages joint research with the industry and facilitates technology transfer. The program's main activities include:
  - Developing biotechnology-related curriculum and special training programs;
  - Providing funds to hire instructors;
  - Supporting faculty and student research and travel to biotechnology-related conferences;
  - Acquiring, maintaining, and upgrading educational and research facilities;
  - Running biotechnology symposiums, short courses, and workshops.

## California Community Colleges

*"A highly educated labor force is needed for the biotech industry, and the state of California meets this need with various special programs in its higher education system."*

**Public Policy Institute of California, 2005**

In 1996, the California legislature amended the mission of community colleges to explicitly require that they contribute to economic growth through continuous workforce improvement. Biotechnology was specified as one of the key areas that community colleges should help with labor training. To fulfill this requirement, the California Community College Biological Technologies Initiative was launched in 1997. Biotechnology centers have now been established at a number of community colleges throughout the state:

The activities at these centers include:

- Developing biotechnology curriculum;
- Facilitating university-industry communication and collaboration;
- Running job placement and internship programs in biotechnology.

Bay Area biotechnology programs include:

**City College San Francisco**

- Biotechnology and Biomanufacturing Certificate Programs that provide students with hands-on laboratory skills and the theoretical background suitable for technician jobs in bio-manufacturing as well as research and development in the industry. It also runs two basic introductory programs: the On-Ramp to Biotechnology in partnership with San Francisco Works, and the Bridge to Biotechnology, to prepare trainees for the Biotech Program itself. City College of San Francisco also hosts "Bio-Link," the only National Science Foundation Advanced Technology Education Grant for biotechnology for community colleges throughout the United States. Bio-Link is committed to program improvement, instructor enhancement, communication, program assistance, and supporting school-to-career activities in biotechnology.

**College of Marin**

- Offers a two-year program in Biology with an emphasis in Biotechnology. Students who complete the program will meet entry level requirements for employment in research or commercial laboratories and production facilities, or will be ready to transfer to a four-year institution to continue their studies.

**College of San Mateo**

- Offers short courses in PCR and ELISA, as well as a Careers in Biotechnology course.

**Contra Costa College**

- The two-year biotechnology program at Contra Costa College offers students extensive hands-on experience with many experimental approaches and a variety of sophisticated instruments currently being used in different biotechnology companies. In addition, students have the opportunity to meet and learn from professional scientists working in the biotechnology industry. Students also learn good manufacturing practices (GMP) documentation and produce a resume. Students who complete the Biotechnology Major as a part of their Associate in Science degree program at Contra Costa College receive a Certificate of Achievement.

**Foothill College**

- The biotechnology curriculum an intensive nine month sequence of instruction, with entry in the Fall Quarter only. The program is designed to prepare students for jobs as entry-level laboratory technicians in a variety of research areas, including pharmaceutical, biotechnology, and medical laboratories. A certificate in bioinformatics is also offered, as well as short courses to enhance job skills. Students have two options:
  - Those who complete the program in a satisfactory manner will be awarded a Certificate of Proficiency in Biotechnology. Completion of the program allows graduates to compete for jobs in laboratories involved in research, produce development, manufacturing, quality control, and clinical studies; or
  - Students can complete a two-year expanded program in Biotechnology, leading to an A.S. degree in Biotechnology, which offers the student the ability to transfer to a four year program or to enter the job market with additional technical and theoretical training and background.

**Laney College Biotech Career Institute**

- The Bioscience Career Institute offers a Certificate of Achievement in Biotechnology that satisfies the minimum requirement for skilled technical positions in biotechnology and related bioscience industries.

**Las Positas College**

- Added a class in Introductory Biotechnology Methods to the Science Technology curriculum in Spring 2001 to complete the requirements for an Associate in Science degree with a Biological Sciences in response to the increasing presence of the biotechnology industry in the area.

**Ohlone College**

- Offers a Biotechnology Certificate Program. Participants in the Biotechnology Certificate Program are also required to complete general education courses in English and Mathematics. All students must also demonstrate appropriate computer skills, and take "Research Techniques." While the completion of an internship or work experience with a biotech company is not required for the Biotechnology Certificate, it is strongly recommended. The college also runs a high school outreach program.

**Skyline College**

- Offers an Associate in Science degree in Biotechnology to teach the knowledge and skills necessary to become a biotechnology technician. Short courses to enhance job skills are also available. Skyline College recently began a partnership with Genentech and the San Mateo County Workforce Investment Board to train displaced workers for the biotechnology industry.

**Solano Community College**

- Offers a biotechnology technician program that prepares members of the community to enter a career in biotechnology production. Program specifics include how modern business principles and sound manufacturing procedures assure the quality and safety of a product as the manufacturing team moves a product down the biotechnology production pipeline; and the role of governmental oversight and regulation during the discovery, development, and manufacture of new products produced by genetically engineered cells. The biotechnology program supports the cluster of companies that have located along Interstate 80 in Solano County's Life Science Corridor.

**Vista College**

- Offers courses applicable to a Biotechnology Technician degree and certificate. Vista College's program integrates academic and occupational instruction as well as prepares graduates for entry-level employment as bioscience technicians. Students who finish the two-year program in biotechnology earn either an Associate in Science Degree or a Certificate of Completion. The college also runs a high school outreach program.

**Gavilan College**

- The College presently incorporates biotechnology training within existing biology and chemistry courses, and is establishing the Gavilan College Bioscience Institute (tentative opening 2007). Training in the Institute will be hands-on and geared toward a two-year for-credit certificate program, with internships, job shadowing and entry-level employment opportunities. Addressing the need for entry-level trained technicians within the biotechnology industry has spawned agreements with three local high schools and one middle school that have agreed to develop and begin increasing the existing science courses to include bioscience training. Approved high school curriculum will be coordinated with approved community college curriculum and industry input.

**Andrew P. Hill High School – Biotechnology Academy**

- The Biotechnology Academy is part of the Andrew P. Hill High School Medical/Health Professions Magnet. The academy is a three-year program dedicated to producing students with science and laboratory skills necessary to enter the workforce and college. The program is currently in its seventh year of operation with 125 students. The academy works with Santa Clara University, San Jose City College, Gavilan College, San Jose State University, and San Jose City College. In addition to the relationships with colleges and universities, the academy also has partnerships with biotechnology companies, including Kaiser Foundation, Alza Corporation, Genentech, Agilent Technologies, and Guidant, as well as a local partnership with Santa Clara County Biotechnology Education Consortium.

# APPENDIX A: OCCUPATIONAL PROFILES

## Manufacturing Technician

### Occupation Description

Manufacturing technicians perform the manufacturing and assembly of clinical and commercial products, operate production equipment, and weigh, measure and check raw materials to assure batches manufactured contain proper ingredients and quantities. They may also help in validating processes and equipment that are directly related to filtration, cleaning and sterilization, maintain records and clean room environment to comply with regulatory requirements, Good Manufacturing Practices and Standard Operating Procedures, or assist chemists in pooling bulk and other tasks. They may assist with in-process testing to assure batches meet specifications.

### Secondary Titles

Other job titles include process technician, manufacturing engineer technician, product technician, aseptic fill technician, assay analyst, bioprocess technician, cell culture and fermentation technician, manufacturing operator, manufacturing service technician, plant technician, process operator, and product development technician.

### Assessment of Need

Yellow – some potential shortage indicators.

- Strong projected job growth over the next 12 months – 7%
- 39% of companies reported difficulties finding suitable applicants who met their hiring standards
- 16% of companies reported difficulties retaining current employees
- 12% of companies “Always” or “Frequently” recruited from outside Northern California
- 68% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 63 percent reported that they currently employed manufacturing technicians at their business location. Overall, a total of 642 manufacturing technicians were recorded across 23 companies, averaging 28 per business location. The total number of employees across responding business locations was expected to increase by seven percent over the next 12 months.

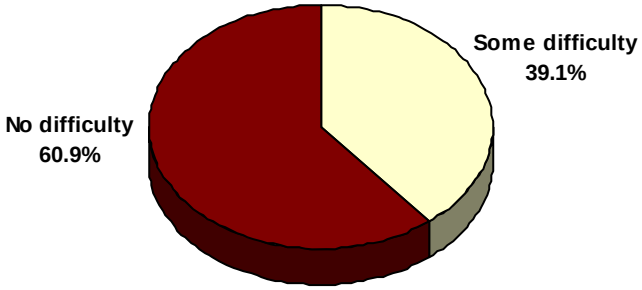
Table 14 Manufacturing Technicians – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 642 | 687 | 45 | 7.0% | 23 |

## Difficulty Finding Suitable Applicants

Figure 15 below shows that 39 percent of responding companies reported difficulties finding suitable manufacturing technicians who met their hiring standards.

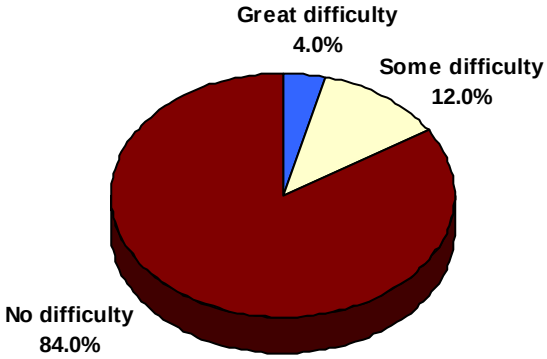
Figure 15 Difficulty Finding Suitable Manufacturing Technicians




## Difficulty Retaining Current Employees

Figure 16 below shows that 16 percent of responding companies reported difficulties retaining current manufacturing technicians.

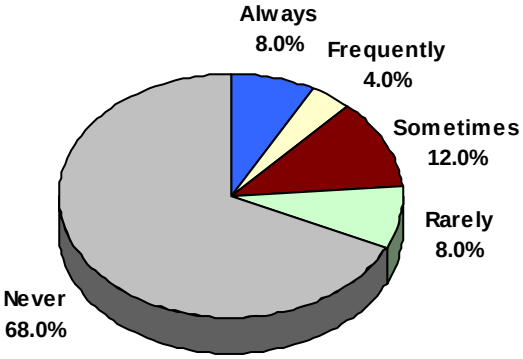
Figure 16 Difficulty Retaining Manufacturing Technician Employees




## Frequency Recruit from Outside Northern California

Figure 17 below shows that 12 percent of responding companies “Always” or “Frequently” recruited manufacturing technicians from outside of Northern California.

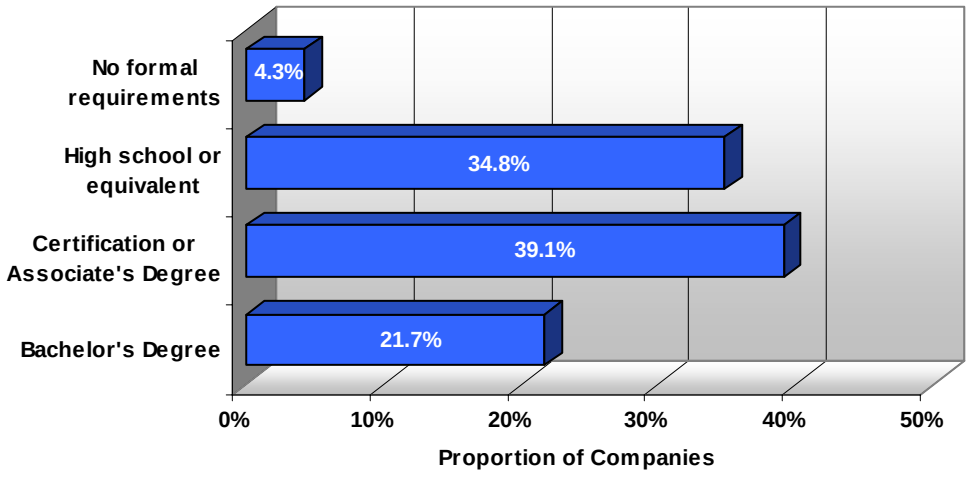
Figure 17 Frequency Recruit Manufacturing Technicians from Outside Northern California



## Typical Education Requirements

Figure 18 indicates that 39 percent of responding companies required manufacturing technicians to have a certification or associate's degree, 35 percent required them to have a high school or equivalent education, 22 percent required a bachelor's degree, and four percent did not have any formal educational requirements for this position.

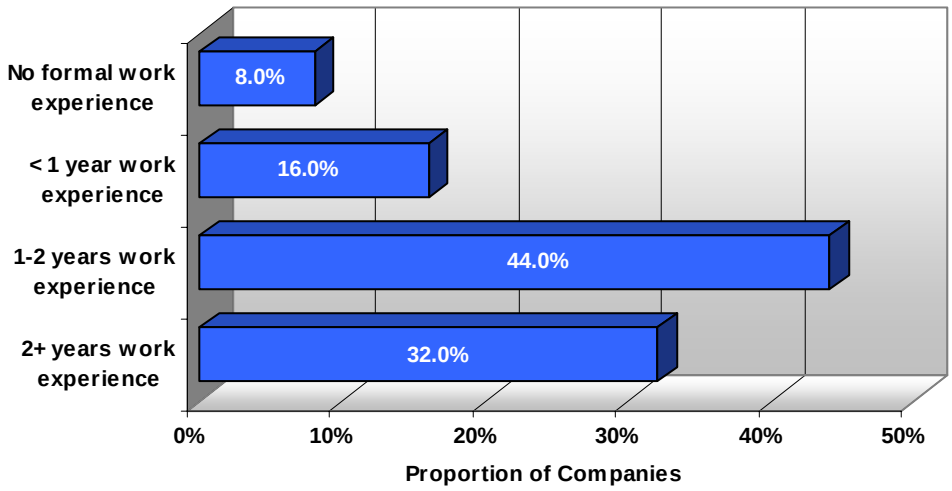
Figure 18 Typical Education Requirements for Manufacturing Technicians




## Typical Work Experience Requirements

Figure 19 indicates that 44 percent of responding companies required manufacturing technicians to have between one and two years of work experience, 32 percent required them to have two or more years' experience, 16 percent required up to one year of experience, and eight percent did not require any formal work experience for this position.

Figure 19 Typical Work Experience Requirements for Manufacturing Technicians



## Education and Work Experience Requirements by Job Level

Table 15 provides an overview of the typical education and training requirements for manufacturing technicians by level of seniority.

Table 15 Manufacturing Technician Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on assignments that are semi-routine in nature in which ability to recognize deviation from accepted practice is required. Normally receives general instructions on routine work, detailed instructions on new assignments. | High school diploma or equivalent experience with a scientific background with a minimum of 0 to 2 years' laboratory experience. |
| 2 | Works on assignments that are moderately complex in nature in which judgment is required in resolving problems and making routine recommendations. Normally receives no instruction on routine work, general instructions on new assignments. | High school diploma with a minimum of 2 to 4 years' laboratory experience, or AA degree with 0 to 2 years' experience. May have a Bachelor's degree, although not required. |
| 3 | Works on assignments that are complex in nature in which considerable judgment and initiative are required in resolving problems and making recommendations. May determine methods and procedures on new assignments and may provide guidance to other individual contributor personnel. | High school diploma with a minimum of 4 to 6 years' laboratory experience, or AA degree with 2 to 4 years' experience. May have a Bachelor's degree, although not required. |
| 4 | Works on assignments that are extremely complex in nature in which independent action and a high degree of initiative are required in resolving problems and developing recommendations. Acts independently to determine methods and procedures on new assignments and may oversee the activities of other individual contributor personnel. | High school diploma with a minimum of 6+ years' laboratory experience, or AA degree with 4 to 6 years' experience. Bachelor's degree preferred. |

Source: 2006 Radford Biotechnology Survey

## Career Advancement Opportunities

Manufacturing technicians may advance into positions as manufacturing associates, lead technicians and supervisory positions in manufacturing. With experience, there may be opportunities for manufacturing technicians to move to quality control or quality assurance technician positions. There may also be opportunities to become technical services or sales representatives, or research and development positions such as laboratory technician. Manufacturing technicians with a bachelor's degree may advance into research associate positions (see *Careers in Biotechnology* – California Community Colleges, 2002, for more information).

## Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for manufacturing technician positions was “Technical competence specific to the position” (76%), followed by the “Ability to work independently” (16%).

For manufacturing technicians, other important skills, knowledge, and abilities include:

**Mechanical** – Knowledge of machines and tools, including their designs, uses, repairs, and maintenance.

**Operation Monitoring** – Watching gauges, dials, or other indicators to make sure a machine is working properly.

**Operation and Control** – Controlling operations of equipment or systems.

**Control Precision** – The ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions.

**Production and Processing** – Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.

**Problem Sensitivity** – The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.

Table 16 Manufacturing Technician Skill Requirements

| Basic | Personal | Technical |
|---|---|---|
| Advanced math skills<br>Read and follow instructions<br>Written and oral communication | Detail oriented<br>Lifting 10-50lbs<br>Manual dexterity<br>Mechanical aptitude<br>Perform physically demanding work<br>Troubleshooting<br>Work as a team<br>Work independently | Biotechnology procedures knowledge<br>Computer skills<br>Knowledge of life sciences and chemistry<br>Knowledge of SOPs, GMPs, and GLPs<br>Manufacturing skills<br>Problem solving/critical thinking<br>Read and follow safety procedures<br>Read and interpret technical materials<br>Record keeping skills |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Skill Deficiencies

According to responding companies, manufacturing technicians were most deficient in “Written communication skills” (41%), “Creative problem-solving skills” (23%), and “Technical competence specific to the position” (18%).

## Wages

Wage levels for this occupation can vary substantially, and are often dependent upon the level of education required by companies.

Table 17 Manufacturing Technician Salary Ranges

| Level | Salary Range |
|---|---|
| Entry-Level | $27,000 to $40,000 |
| Experienced | $35,000 to $60,000 |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Research Associate

### Occupation Description

Research associates perform research and/or development in collaboration with others for projects. They make detailed observations, analyze data, and interpret results. They also exercise technical discretion in the design, execution and interpretation of experiments that contribute to project strategies. Other duties include preparing technical reports, summaries, protocols, and quantitative analyses; investigating, creating and developing new methods and technologies for project advancement. Research associates maintain a high level of professional expertise through familiarity with scientific literature, and may participate in scientific conferences and contribute to scientific journals. They may also be responsible for identifying patentable inventions, and act as principal investigator in conducting their own experiments.

### Secondary Titles

Other job titles include biotechnology research associate, research associate I, II, and III, research assistant, clinical research associate and associate research scientist.

### Assessment of Need

Red – strong potential shortage indicators.

- Strong projected job growth over the next 12 months – 13%
- 61% of companies reported difficulties finding suitable applicants who met their hiring standards
- 32% of companies reported difficulties retaining current employees
- 13% of companies “Always” or “Frequently” recruited from outside Northern California
- 43% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 83 percent reported that they currently employed research associates at their business location. Overall, a total of 604 research associates were recorded across 37 companies, averaging 16 per business location. The total number of employees across responding business locations was expected to increase by 13 percent over the next 12 months.

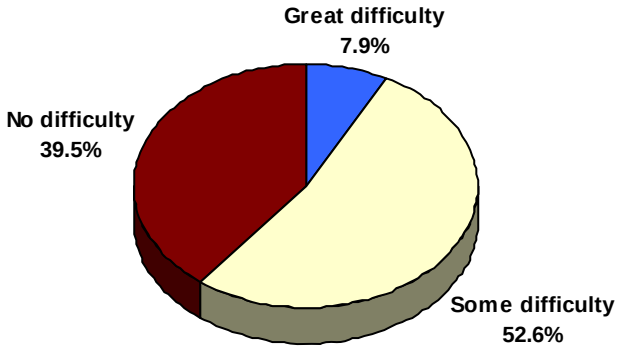
Table 18 Research Associates – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 604 | 680 | 76 | 12.6% | 37 |

## Difficulty Finding Suitable Applicants

Figure 20 below shows that 61 percent of responding companies reported at least "Some difficulty" finding suitable research associates who met their hiring standards.

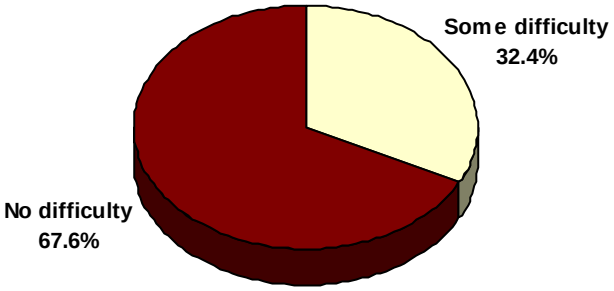
Figure 20 Difficulty Finding Suitable Research Associates




## Difficulty Retaining Current Employees

Figure 21 below shows that 32 percent of responding companies reported "Some difficulty" retaining current research associates.

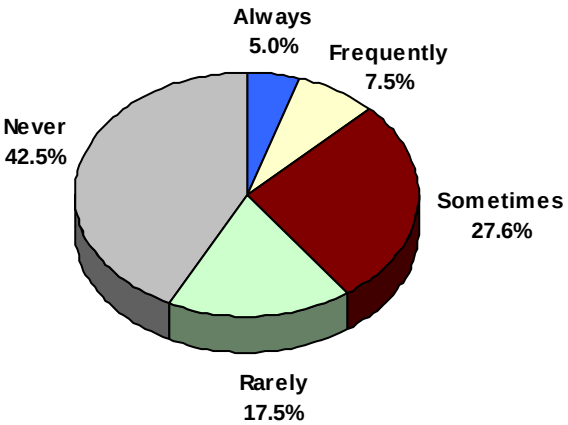
Figure 21 Difficulty Retaining Research Associate Employees




## Frequency Recruit from Outside Northern California

Figure 22 below shows that 13 percent of responding companies "Always" or "Frequently" recruited research associates from outside of Northern California.

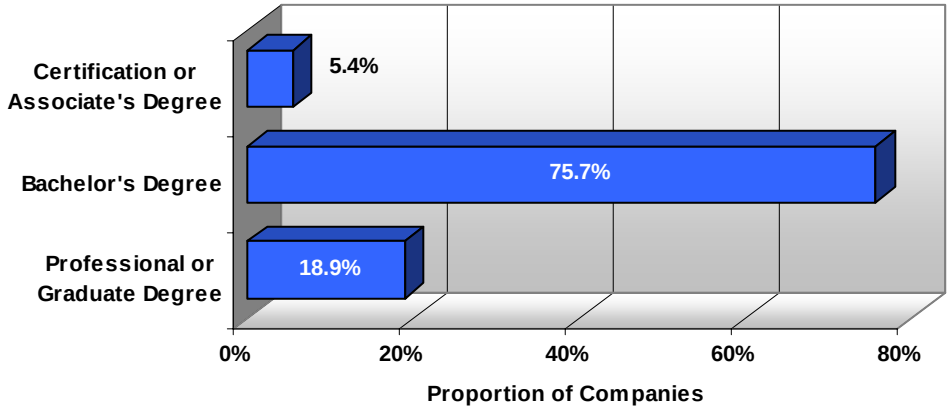
Figure 22 Frequency Recruit Research Associates from Outside Northern California



## Typical Education Requirements

Figure 23 indicates that 76 percent of responding companies required research associates to have a bachelor's degree, 19 percent required them to have a professional or graduate degree, and five percent required a certification or associate's degree for this position.

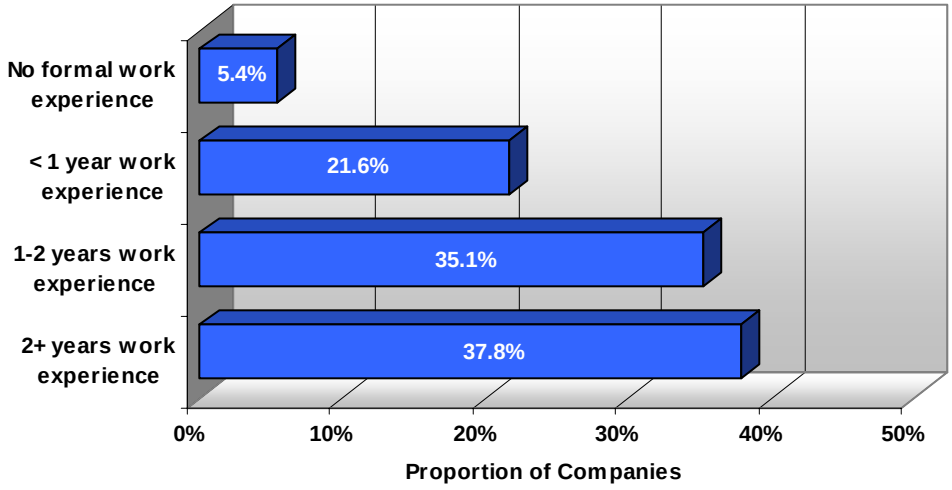
Figure 23 Typical Education Requirements for Research Associates




## Typical Work Experience Requirements

Figure 24 indicates that 38 percent of responding companies required research associates to have two or more years' experience, 35 percent required them to have between one and two years of work experience, 22 percent required up to one year of experience, and five percent did not require any formal work experience for this position.

Figure 24 Typical Work Experience Requirements for Research Associates



## Education and Work Experience Requirements by Job Level

Table 19 provides an overview of the typical education and training requirements for research associates by level of seniority.

Table 19 Research Associate Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on problems of moderate scope in which analysis of situation or data requires a review of identifiable factors. Exercises judgment within defined procedures and practices to determine appropriate action. Normally receives general instructions on routine work, detailed instructions on new assignments. This is an entry-level position. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 0 to 2 years' experience. |
| 2 | Works on problems of diverse scope in which analysis of data requires evaluation of identifiable factors. Exercises judgment within generally defined practices and policies in selecting methods and techniques for obtaining solutions. Normally receives no instructions on routine work, general instructions on new assignments. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 2 to 5 years' experience, or 0 to 2 years' with a Masters, and demonstrated working knowledge of scientific principles. |
| 3 | Works on complex problems in which analysis of situations or data requires an in-depth evaluation of various factors. Exercises judgment within broadly defined practices and policies in selecting methods, techniques and evaluation criteria for obtaining results. May determine methods and procedures on new assignments and may provide guidance to other lower-level personnel. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 5 to 8 years' experience, or 2 to 5 years' experience with a Masters, and demonstrated working knowledge of scientific principles. |
| 4 | Works on extremely complex problems in which analysis of situations or data requires an evaluation of intangible variables. Exercises independent judgment in developing methods, techniques and evaluation criteria for obtaining results. Acts independently to determine methods and procedures on new assignments. May supervise the activities of other lower-level personnel. This is the most senior-level position on the Associate ladder. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 8+ years experience, or 5 to 8 years' experience with a Masters, and demonstrated working knowledge of scientific principles. |

Source: 2006 Radford Biotechnology Survey

## Career Advancement Opportunities

Career advancement typically requires further education, such as a master's degree or a PhD. Research assistants may be promoted into research associate I, II, and III positions, or to senior research associate. With the attainment of a PhD, research associates may advance into staff scientist positions. They may also move into management, quality assurance or marketing at biotechnology companies. Those employed at academic institutions may become professors once they have a PhD qualification (see *Careers in Biotechnology* – California Community Colleges, 2002, for more information).

## Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for research associate positions was “Technical competence specific to the position” (69%), followed by the “Ability to work as part of a science team” (18%).

For research associates, other important skills, knowledge, and abilities include:

**Chemistry** – Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.

**Biology** – Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment.

**Physics** – Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, atomic and subatomic structures and processes.

**Mathematics** – Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

**Science** – Using scientific rules and methods to solve problems.

**Critical Thinking** – Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems.

**Complex Problem Solving** – Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.

**Inductive Reasoning** – The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).

Table 20 Research Associate Skill Requirements

| Basic | Personal | Technical |
|---|---|---|
| Advanced math skills<br>Read and follow instructions<br>Written and oral communication | Detail oriented<br>Manual dexterity<br>Observation skills<br>Organizational skills<br>Work as a team<br>Work independently<br>Works well under pressure | Analyze/evaluate technical data<br>Biotechnology lab techniques<br>Computer skills<br>Knowledge of life sciences and chemistry<br>Knowledge of SOPs, GMPs, and GLPs<br>Plan and carry out research<br>Problem solving/critical thinking<br>Read and interpret technical materials<br>Record keeping skills<br>Technical writing skills |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Skill Deficiencies

According to responding companies, research associates were most deficient in "Creative problem-solving skills" (28%), "Technical competence specific to the position" (19%), "Ability to work as part of a science team" (17%), and "Written communication skills" (14%).

## Wages

Wage levels for this occupation can vary considerably depending on experience, type of employer and educational background. Private companies usually pay higher salaries than universities.

Table 21 Research Associate Salary Ranges

| Level | Salary Range |
|---|---|
| With a bachelor's degree | $30,000 to $45,000 |
| With a master's degree | $40,000 to $70,000 |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Clinical Laboratory Associate

### Occupation Description

Clinical laboratory associates support all aspects of data collection and operation of the clinical lab, and assist in the coordination of documentation associated with conducting clinical studies. They may administer a test drug, and/or draw blood, or support the creation of standardized clinical trial tools, processes and SOPs. They may also be responsible for exporting the results of studies, test results, and data entry.

### Secondary Titles

Other job titles include clinical research associate, laboratory operations associate, laboratory project manager, clinical laboratory scientist, clinical lab sciences associate, clinical associate, medical laboratory technician, laboratory technician, and research laboratory technician.

### Assessment of Need

Red – strong potential shortage indicators.

- Very strong projected job growth over the next 12 months – 18%
- 80% of companies reported difficulties finding suitable applicants who met their hiring standards
- 40% of companies reported difficulties retaining current employees
- 13% of companies “Always” or “Frequently” recruited from outside Northern California
- 50% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 32 percent reported that they currently employed clinical laboratory associates at their business location. Overall, a total of 129 clinical laboratory associates were recorded across 13 companies, averaging 10 per business location. The total number of employees across responding business locations was expected to increase by 18 percent over the next 12 months.

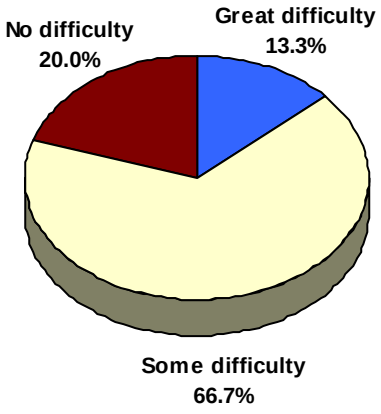
Table 22 Clinical Laboratory Associates – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 129 | 152 | 23 | 17.8% | 13 |

## Difficulty Finding Suitable Applicants

Figure 25 below shows that 61 percent of responding companies reported at least "Some difficulty" finding suitable clinical laboratory associates who met their hiring standards.

Figure 25 Difficulty Finding Suitable Clinical Laboratory Associates




## Difficulty Retaining Current Employees

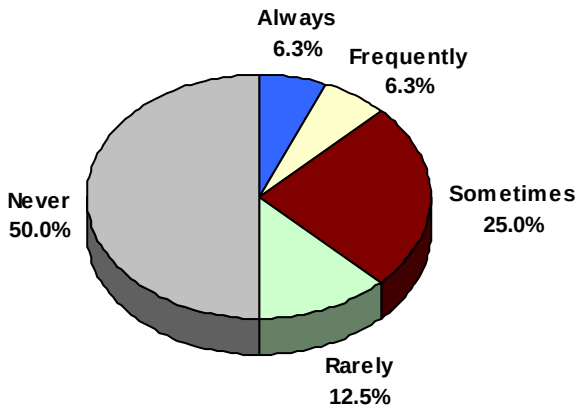
Figure 26 below shows that 32 percent of responding companies reported "Some difficulty" retaining current clinical laboratory associates.

Figure 26 Difficulty Retaining Clinical Laboratory Associate Employees

## Frequency Recruit from Outside Northern California

Figure 27 below shows that 13 percent of responding companies “Always” or “Frequently” recruited clinical laboratory associates from outside of Northern California.

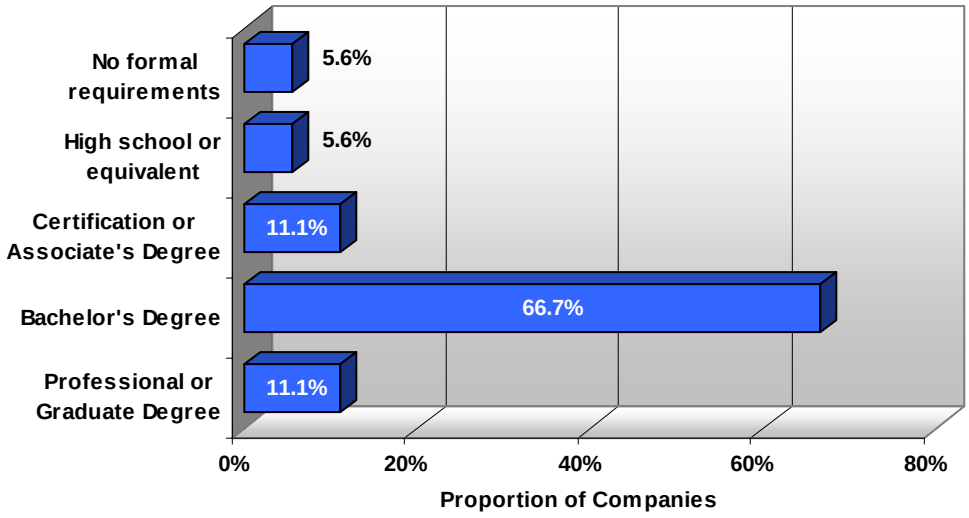
Figure 27 Frequency Recruit Clinical Laboratory Associates from Outside Northern California




## Typical Education Requirements

Figure 28 indicates that two-thirds of responding companies required clinical laboratory associates to have a bachelor’s degree, 11 percent required them to have a professional or graduate degree, and 11 percent required a certification or associate’s degree for this position.

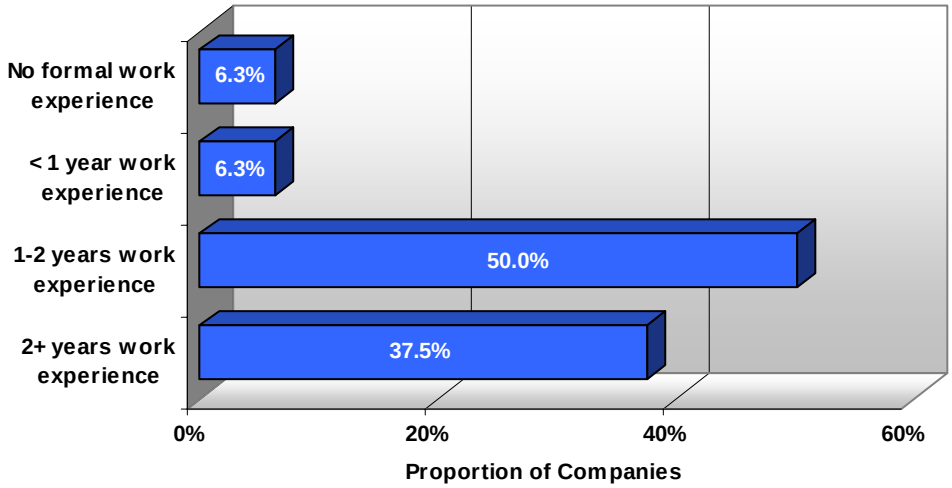
Figure 28 Typical Education Requirements for Clinical Laboratory Associates



## Typical Work Experience Requirements

Figure 29 indicates that 50 percent of responding companies required clinical laboratory associates to have between one and two years of work experience, 38 percent required them to have two or more years' experience, six percent required up to one year of experience, and six percent did not require any formal work experience for this position.

Figure 29 Typical Work Experience Requirements for Clinical Laboratory Associates



## Education and Work Experience Requirements by Job Level

Table 23 provides an overview of the typical education and training requirements for clinical laboratory associates by level of seniority.

Table 23 Clinical Laboratory Associate Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on assignments that are semi-routine in nature in which ability to recognize deviation from accepted practice is required. Normally receives general instructions on routine work, detailed instructions on new assignments. | High school diploma or equivalent with a minimum of 0-2 years' related experience. |
| 2 | Works on assignments that are moderately complex in nature in which judgment is required in resolving problems and making routine recommendations. Normally receives no instruction on routine work, general instructions on new assignments. | High school diploma with a minimum of 2-4 years' experience, or an AA degree with 0-2 years' experience. May have a Bachelor's degree, but not required. |
| 3 | Works on assignments that are complex in nature in which considerable judgment and initiative are required in resolving problems and making recommendations. May determine methods and procedures on new assignments and may provide guidance to other individual contributor personnel. | High school diploma with a minimum of 4-6 years' experience, or an AA degree with 2-4 years' experience. May have a Bachelor's degree but not required. |
| 4 | Works on assignments that are extremely complex in nature in which independent action and a high degree of initiative are required in resolving problems and developing recommendations. Acts independently to determine methods and procedures on new assignments and may supervise the activities of other individual contributor personnel. | High school diploma with a minimum of 6+ years' experience, or an AA degree with 4-6 years' experience. Bachelor's degree preferred. |

Source: 2006 Radford Biotechnology Survey

## Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for clinical laboratory associate positions was "Technical competence specific to the position" (67%), followed by the "Ability to work as part of a science team" (17%).

For clinical laboratory associates, other important skills, knowledge, and abilities include:

**Mathematics** – Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

**Active Learning** – Understanding the implications of new information for both current and future problem-solving and decision-making.

**Science** – Using scientific rules and methods to solve problems.

**Instructing** – Teaching others how to do something.

**Reading Comprehension** – Understanding written sentences and paragraphs in work related documents.

**Speaking** – Talking to others to convey information effectively.

Table 24 Clinical Laboratory Associate Skills

| Basic | Personal | Technical |
|---|---|---|
| Advanced math skills<br>Read and follow instructions<br>Written and oral communication | Detail oriented<br>Lifting 10-50lbs<br>Manual dexterity<br>Observation skills<br>Organizational skills<br>Work as a team<br>Work independently | Analyze/evaluate technical data<br>Biotechnology lab techniques<br>Certification may be required<br>Computer skills<br>Knowledge of health and safety regulations<br>Knowledge of life sciences and chemistry<br>Knowledge of SOPs, GMPs, and GLPs<br>Problem solving/critical thinking<br>Read and interpret technical materials<br>Record keeping skills<br>Technical writing skills |

*Source: Careers in Biotechnology* – California Community Colleges, 2002*.

## Skill Deficiencies

According to responding companies, clinical laboratory associates were most deficient in “Creative problem-solving skills” (25%), “Technical competence specific to the position” (25%), and “Interpersonal communication skills” (19%).

## Wages

Wage levels for this occupation can vary considerably depending on experience, type of employer and educational background. Private companies usually pay higher salaries than universities.

Table 25 Clinical Laboratory Associate Salary Ranges

| Level | Salary Range |
|---|---|
| Entry-Level | $25,000 to $35,000 |
| Experienced | $30,000 to $45,000 |

*Source: Careers in Biotechnology* – California Community Colleges, 2002*.

*Information not available for clinical laboratory associates – data relates to laboratory technician positions.

## Animal Technician

### Occupation Description

Animal technicians perform the daily care of research animals for experimental purposes, which may include cleaning cages and racks, and coordinate with vendors and supervisors on operational, administrative and technical responsibilities. They may perform some surgery and post-operative care as directed and are responsible for overseeing procurement of animals and supplies, preventive maintenance of facility equipment, daily rounds and observation to check animal health status. They may also develop standard operating procedures and maintain records to comply with regulatory requirements.

### Secondary Titles

Other job titles include animal care technician, animal study technician, animal health technician, assistant animal technician, laboratory animal technologist, and veterinary technician.

### Assessment of Need

Yellow – some potential shortage indicators.

- Low projected job growth over the next 12 months – 1%
- 67% of companies reported difficulties finding suitable applicants who met their hiring standards
- 44% of companies reported difficulties retaining current employees
- No companies “Always” or “Frequently” recruited from outside Northern California
- 60% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 20 percent reported that they currently employed animal technicians at their business location. Overall, a total of 166 animal technicians were recorded across nine companies, averaging 18 per business location. The total number of employees across responding business locations was expected to increase by one percent over the next 12 months.

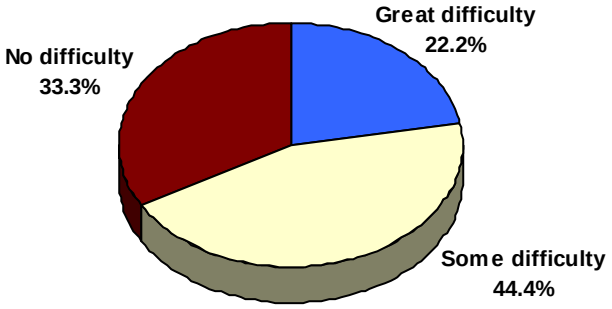
Table 26 Animal Technicians – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 166 | 168 | 2 | 1.2% | 9 |

## Difficulty Finding Suitable Applicants

Figure 30 below shows that 67 percent of responding companies reported at least "Some difficulty" finding suitable animal technicians who met their hiring standards.

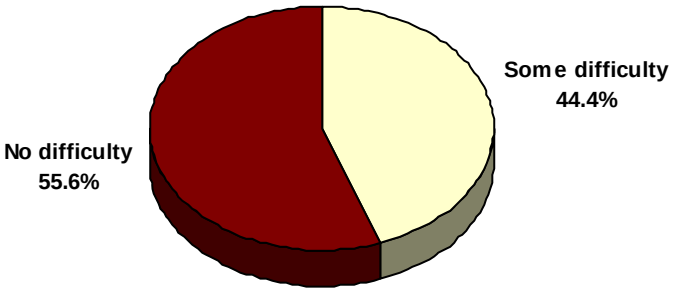
Figure 30 Difficulty Finding Suitable Animal Technicians




## Difficulty Retaining Current Employees

Figure 31 below shows that 44 percent of responding companies reported "Some difficulty" retaining current animal technicians.

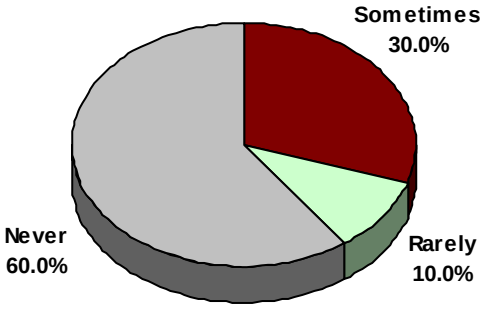
Figure 31 Difficulty Retaining Animal Technician Employees




## Frequency Recruit from Outside Northern California

Figure 32 below shows that 30 percent of responding companies "Sometimes" recruited animal technicians from outside of Northern California.

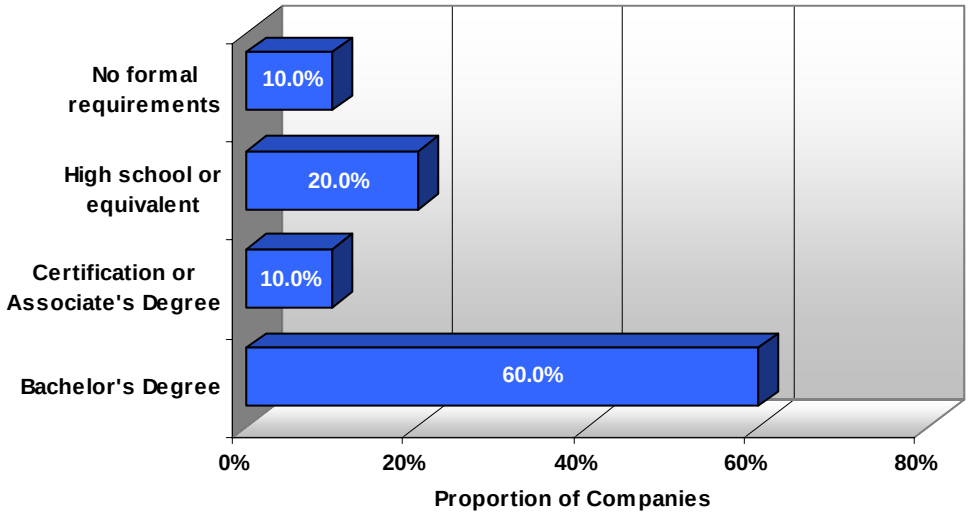
Figure 32 Frequency Recruit Animal Technicians from Outside Northern California



## Typical Education Requirements

Figure 33 indicates that 60 percent of responding companies required animal technicians to have a bachelor's degree, 20 percent required them to have a high school or equivalent education, 10 percent required a certification or associate's degree, and 10 percent required no formal education requirements for this position.

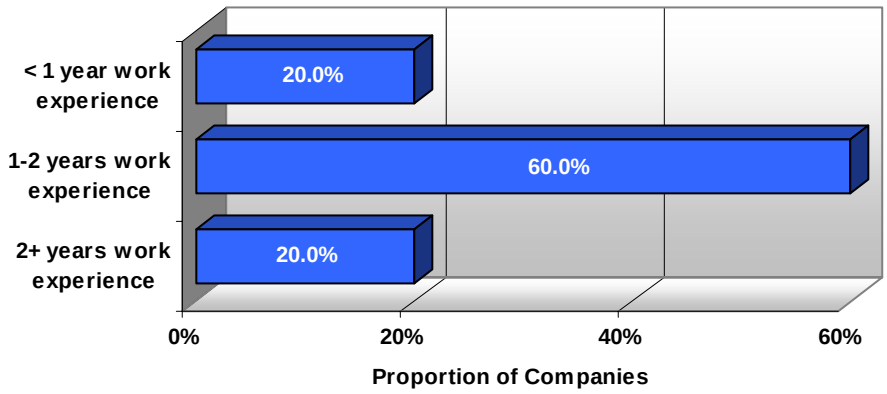
Figure 33 Typical Education Requirements for Animal Technicians




## Typical Work Experience Requirements

Figure 34 indicates that 60 percent of responding companies required animal technicians to have between one and two years of work experience, 20 percent required them to have two or more years' experience, and 20 percent required up to one year of experience for this position.

Figure 34 Typical Work Experience Requirements for Animal Technicians



## Education and Work Experience Requirements by Job Level

Table 27 provides an overview of the typical education and training requirements for animal technicians by level of seniority.

Table 27 Animal Technician Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on assignments that are semi-routine in nature in which ability to recognize deviation from accepted practice is required. Normally receives general instructions on routine work, detailed instructions on new assignments. | High school diploma or equivalent with a minimum of 0 to 2 years' related laboratory experience. |
| 2 | Works on assignments that are moderately complex in nature in which judgment is required in resolving problems and making routine recommendations. Normally receives no instruction on routine work, general instructions on new assignments. | High school diploma or equivalent. Prefer certification through the technician level. A minimum of 2 to 4 years' related laboratory experience. May have a Bachelor's degree but not required. |
| 3 | Works on assignments that are complex in nature in which considerable judgment and initiative are required in resolving problems and making recommendations. May determine methods and procedures on new assignments and may provide guidance to other individual contributor personnel. | High school diploma or equivalent. Prefer ALAS certification through the technician level. A minimum of 4 to 6 years' related laboratory experience. May have a Bachelor's degree but not required. |
| 4 | Works on assignments that are extremely complex in nature in which independent action and a high degree of initiative are required in resolving problems and developing recommendations. Acts independently to determine methods and procedures on new assignments and may supervise the activities of other individual contributor personnel. | High school diploma or equivalent. Require ALAS certification through the technician level. A minimum of 6+ years' related laboratory experience. Bachelor's degree preferred. |

Source: 2006 Radford Biotechnology Survey

## Career Advancement Opportunities

Animal technicians may be promoted into supervisory positions. Some animal technicians may choose to get a bachelor's degree and go into research positions, such as laboratory technician or research associate. Another option is to become a registered veterinary technician, which requires completion of a two-year program at a community college or private school (see *Careers in Biotechnology* – California Community Colleges, 2002, for more information).

## Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for animal technician positions was “Technical competence specific to the position” (64%), followed by the “Ability to work as part of a science team” (27%).

For animal technicians, other important skills, knowledge, and abilities include:

**Biology** – Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment.

**Science** – Using scientific rules and methods to solve problems.

**Active Listening** – Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times.

**Equipment Selection** – Determining the kinds of tools and equipment needed to do a job.

**Oral Comprehension** – The ability to listen and understand information and ideas presented through spoken words and sentences.

**Wrist-Finger Speed** – The ability to make fast, simple, repeated movements of the fingers, hands, and wrists.

Table 28 Animal Technician Skills

| Basic | Personal | Technical |
|---|---|---|
| Advanced math skills<br>Read and follow instructions<br>Written and oral communication | Detail oriented<br>Observation skills<br>Organizational skills<br>Perform physically demanding work<br>Perform routine, repetitive work<br>Work as a team<br>Work independently<br>Works well under pressure | Animal care skills<br>Biotechnology laboratory procedures<br>Certification may be required<br>Computer skills<br>Knowledge of health and safety regulations<br>Knowledge of life sciences<br>Knowledge of SOPs, GMPs, and GLPs<br>Read and follow technical instructions<br>Record keeping skills |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Skill Deficiencies

According to responding companies, animal technicians were most deficient in “Creative problem-solving skills” (30%), “Technical competence specific to the position” (20%), “Interpersonal communication skills” (20%), and the “Ability to work as part of a science team” (20%).

## Wages

Part-time work is often available in this position.

Table 29 Animal Technician Salary Ranges

| Level | Salary Range |
|---|---|
| Entry-Level | $19,000 to $25,000 |
| Experienced | $25,000 to $41,000 |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Calibration Technicians

### Occupation Description

Calibration technicians perform maintenance, testing, troubleshooting, calibration and repair on a variety of circuits, components, analytical equipment and instrumentation for laboratory and manufacturing equipment. They specify and request purchase of components, maintains all logs and required documentation, analyze results, and may develop test specifications and electrical schematics. They may also maintain spare parts inventory, and prepare technical reports with recommendations for solutions to technical problems.

### Secondary Titles

Other job titles include instrumentation technician, calibration specialist, calibration technician specialist, instrumentation and controls technician, calibration lab technician, electronics engineering technician, engineering technician, validation technician, field calibration technician, electronic calibration technician, test and calibration technician, and calibration instrumentation technician.

### Assessment of Need

Red – strong potential shortage indicators.

- Strong projected job growth over the next 12 months – 8%
- 60% of companies reported difficulties finding suitable applicants who met their hiring standards
- 40% of companies reported difficulties retaining current employees
- 20% of companies “Always” or “Frequently” recruited from outside Northern California
- 47% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 36 percent reported that they currently employed calibration technicians at their business location. Overall, a total of 65 Calibration technicians were recorded across 14 companies, averaging five per business location. The total number of employees across responding business locations was expected to increase by eight percent over the next 12 months.

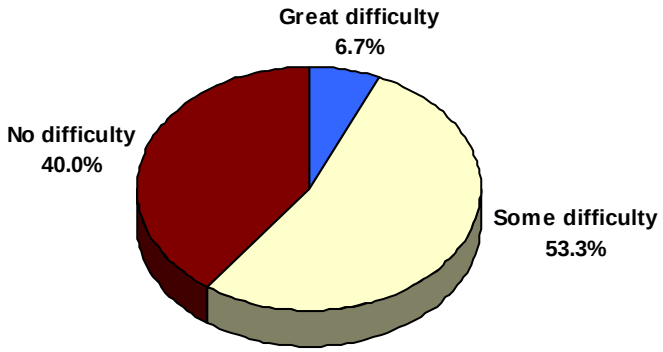
Table 30 Calibration Technicians – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 65 | 70 | 5 | 7.7% | 14 |

## Difficulty Finding Suitable Applicants

Figure 35 below shows that 60 percent of responding companies reported at least "Some difficulty" finding suitable calibration technicians who met their hiring standards.

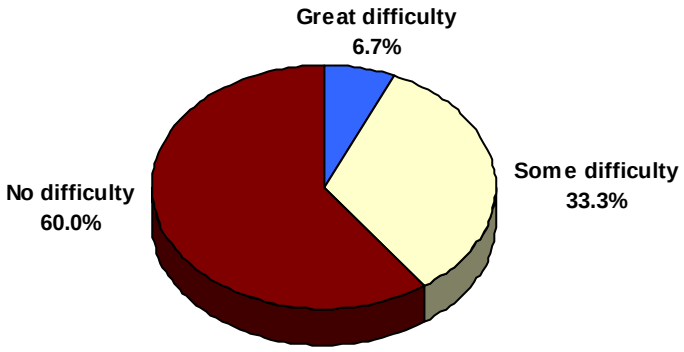
Figure 35 Difficulty Finding Suitable Calibration Technicians




## Difficulty Retaining Current Employees

Figure 36 below shows that 40 percent of responding companies reported at least "Some difficulty" retaining current calibration technicians.

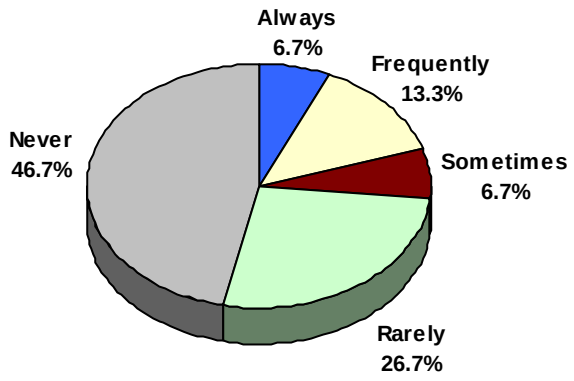
Figure 36 Difficulty Retaining Calibration Technician Employees



## Frequency Recruit from Outside Northern California

Figure 37 below shows that 30 percent of responding companies “Sometimes” recruited calibration technicians from outside of Northern California.

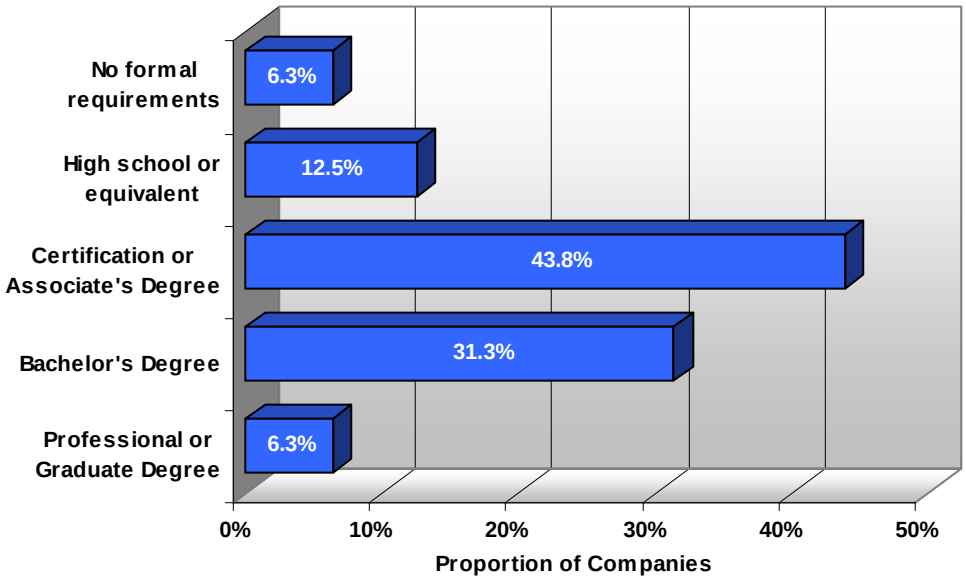
Figure 37 Frequency Recruit Calibration Technicians from Outside Northern California




## Typical Education Requirements

Figure 38 indicates that 44 percent of responding companies required calibration technicians to have a certification or associate’s degree, 31 percent required them to have a bachelor’s degree, and 13 percent required a high school or equivalent education for this position.

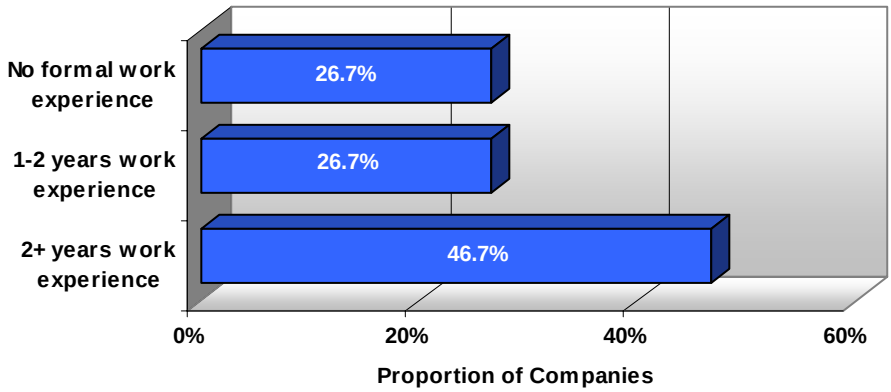
Figure 38 Typical Education Requirements for Calibration Technicians



## Typical Work Experience Requirements

Figure 39 indicates that 47 percent of responding companies required calibration technicians to have two or more years' experience, 27 percent required them to have between one and two years of work experience, and 27 percent required no formal work experience for this position.

Figure 39 Typical Work Experience Requirements for Calibration Technicians




## Education and Work Experience Requirements by Job Level

Table 31 provides an overview of the typical education and training requirements for Calibration technicians by level of seniority.

Table 31 Calibration Technician Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on assignments that are semi-routine in nature in which ability to recognize deviation from accepted practice is required. Normally receives general instructions on routine work, detailed instructions on new assignments. | High school diploma or equivalent with a minimum of 0 to 2 years' related experience. |
| 2 | Works on assignments that are moderately complex in nature in which judgment is required in resolving problems and making routine recommendations. Normally receives no instruction on routine work, general instructions on new assignments. | High school diploma, AA degree or equivalent with a minimum of 2 to 4 years' related experience. |
| 3 | Works on assignments that are complex in nature in which considerable judgment and initiative are required in resolving problems and making recommendations. May determine methods and procedures on new assignments and may provide guidance to other individual contributor personnel. | High school diploma, AA degree or equivalent with a minimum of 4 to 6 years' related experience. |
| 4 | Works on assignments that are extremely complex in nature in which independent action and a high degree of initiative are required in resolving problems and developing recommendations. Acts independently to determine methods and procedures on new assignments and may oversee the activities of other individual contributor personnel. | High school diploma, AA degree or equivalent with a minimum of 6+ years' related experience. |

Source: 2006 Radford Biotechnology Survey

### Career Advancement Opportunities

Calibration technicians with leadership skills may advance into supervisory positions. Advancement into a wide range of professional engineering positions is possible with the attainment of a bachelor's degree or higher in an engineering discipline. There may also be opportunities to advance into technical service representative roles (see *Careers in Biotechnology* – California Community Colleges, 2002, for more information).

### Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for calibration technician positions was "Technical competence specific to the position" (69%), followed by the "Ability to work as part of a science team" (13%).

For calibration technicians, other important skills, knowledge, and abilities include:

**Design** – Knowledge of design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models.

**Mathematics** – Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

**Equipment Selection** – Determining the kinds of tools and equipment needed to do a job.

**Equipment Maintenance** – Performing routine maintenance on equipment and determining when and what kind of maintenance is needed.

**Problem Sensitivity** – The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.

**Deductive Reasoning** – The ability to apply general rules to specific problems to produce answers that make sense.

Table 32 Calibration Technician Skills

| Basic | Personal | Technical |
|---|---|---|
| Advanced math skills<br>Read and follow instructions<br>Written and oral communication | Detail oriented<br>Good vision and color perception<br>Manual dexterity<br>Mechanical aptitude<br>Perform physically demanding work<br>Work as a team<br>Work independently | Computer skills<br>Knowledge of electronics<br>Knowledge of SOPs, GMPs, and GLPs<br>Operate diagnostic equipment<br>Problem solving/critical thinking<br>Read and follow safety procedures<br>Read and interpret technical materials<br>Record keeping skills<br>Troubleshooting |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Skill Deficiencies

According to responding companies, calibration technicians were most deficient in "Technical competence specific to the position" (27%), "Interpersonal communication skills" (27%), and "Written communication skills" (27%).

## Wages

Table 33 Calibration Technician Salary Ranges

| Level | Salary Range |
|---|---|
| Entry-Level | $25,000 to $32,000 |
| Experienced | $30,000 to $55,000 |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## QA/QC Specialists

### Occupation Description

QA/QC specialists perform a wide variety of activities to ensure compliance with applicable regulatory requirements by conducting audits, training programs, data and documentation reviews and analysis. They write and revise standard operation procedures and related manufacturing documents and may conduct investigations related to manufactured products and also generate reports.

### Secondary Titles

Other job titles include quality control analyst, quality assurance associate, quality assurance technician, quality systems validation technician, validation specialist, validation technician, quality control associate, quality control technician, and quality control technical specialist.

### Assessment of Need

Yellow – some potential shortage indicators.

- Strong projected job growth over the next 12 months – 10%
- 42% of companies reported difficulties finding suitable applicants who met their hiring standards
- 28% of companies reported difficulties retaining current employees
- 8% of companies “Always” recruited from outside Northern California
- 60% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 71 percent reported that they currently employed QA/QC specialists at their business location. Overall, a total of 264 QA/QC specialists were recorded across 34 companies, averaging eight per business location. The total number of employees across responding business locations was expected to increase by 10 percent over the next 12 months.

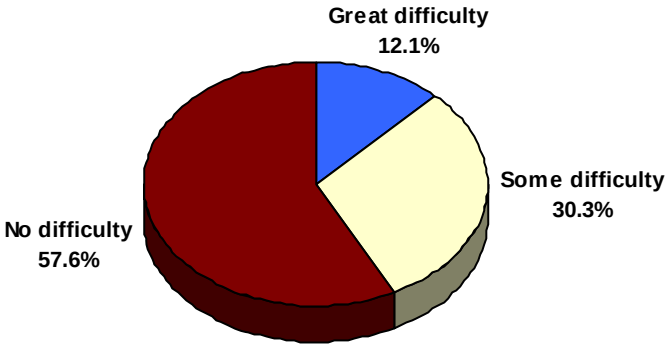
Table 34 QA/QC Specialists – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 264 | 290 | 26 | 9.8% | 34 |

## Difficulty Finding Suitable Applicants

Figure 40 below shows that 42 percent of responding companies reported at least "Some difficulty" finding suitable QA/QC specialists who met their hiring standards.

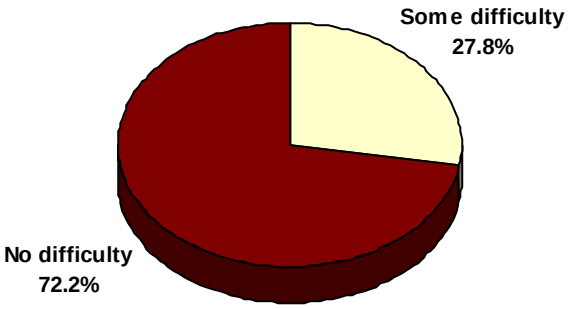
Figure 40 Difficulty Finding Suitable QA/QC Specialists




## Difficulty Retaining Current Employees

Figure 41 below shows that 28 percent of responding companies reported "Some difficulty" retaining current QA/QC specialists.

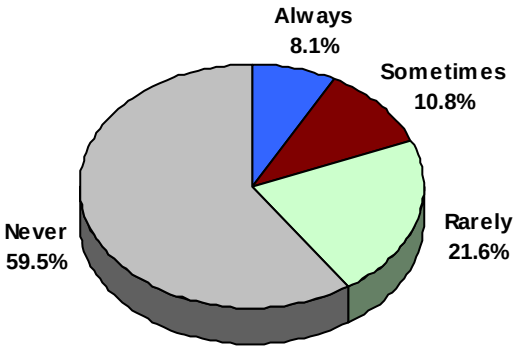
Figure 41 Difficulty Retaining QA/QC Specialist Employees




## Frequency Recruit from Outside Northern California

Figure 42 below shows that 19 percent of responding companies "Always" or "Sometimes" recruited QA/QC specialists from outside of Northern California.

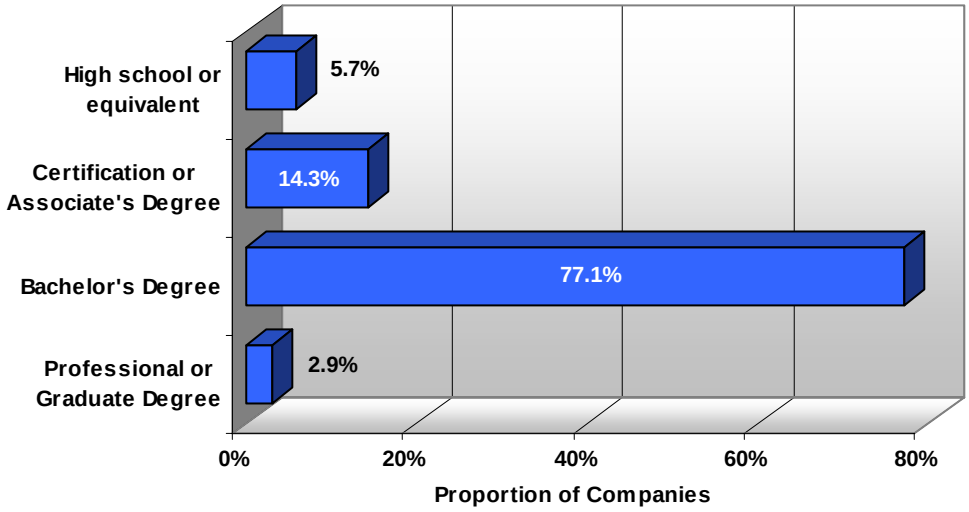
Figure 42 Frequency Recruit QA/QC Specialists from Outside Northern California



## Typical Education Requirements

Figure 43 indicates that 77 percent of responding companies required QA/QC specialists to have a bachelor's degree, 14 percent required them to have a certification or associate's degree, six percent required a high school or equivalent education, and three percent required a professional or graduate degree for this position.

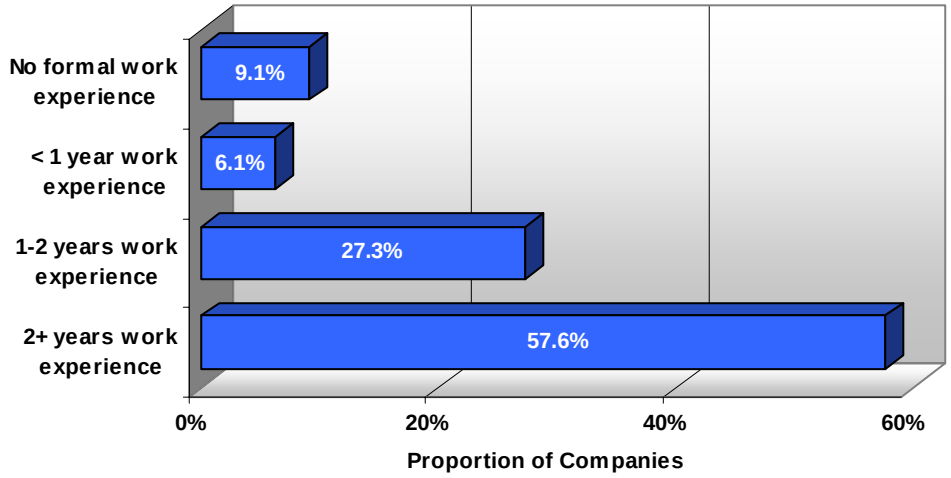
Figure 43 Typical Education Requirements for QA/QC Specialists




## Typical Work Experience Requirements

Figure 44 indicates that 58 percent of responding companies required QA/QC specialists to have two or more years' experience, 27 percent required them to have between one and two years of work experience, six percent required up to a year's experience, and nine percent required no formal work experience for this position.

Figure 44 Typical Work Experience Requirements for QA/QC Specialists



## Education and Work Experience Requirements by Job Level

Table 35 provides an overview of the typical education and training requirements for QA/QC specialists by level of seniority.

Table 35 QA/QC Specialist Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on problems of moderate scope in which analysis of situation or data requires a review of identifiable factors. Exercises judgment within defined procedures and practices to determine appropriate action. Normally receives general instructions on routine work, detailed instructions on new assignments. This is an entry-level position. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 0 to 2 years' related experience. |
| 2 | Works on problems of diverse scope in which analysis of data requires evaluation of identifiable factors. Exercises judgment within generally defined practices and policies in selecting methods and techniques for obtaining solutions. Normally receives no instructions on routine work, general instructions on new assignments. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 2 to 5 years' related experience, or 0 to 2 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |
| 3 | Works on complex problems in which analysis of situations or data requires an in-depth evaluation of various factors. Exercises judgment within broadly defined practices and policies in selecting methods, techniques and evaluation criteria for obtaining results. May determine methods and procedures on new assignments and may provide guidance to other lower-level personnel. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 5 to 8 years' related experience, or 2 to 5 years' with a Master's degree and demonstrated working knowledge of scientific principles. |
| 4 | Works on extremely complex problems in which analysis of situations or data requires an evaluation of intangible variables. Exercises independent judgment in developing methods, techniques and evaluation criteria for obtaining results. Acts independently to determine methods and procedures on new assignments. May supervise the activities of other lower-level personnel. This is the most senior-level position. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 8+ years' related experience, or 5 to 8 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |

Source: 2006 Radford Biotechnology Survey

## Career Advancement Opportunities

QA/QC specialists may advance into supervisory positions, such as inspector, or into analyst positions, such as quality control analyst. The possibility of advancing without further education is much greater in the manufacturing side of biotechnology than the research side, where advancement typically requires a bachelor's or master's degree (see *Careers in Biotechnology* – California Community Colleges, 2002, for more information).

## Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for QA/QC specialist positions was “Technical competence specific to the position” (76%), followed by the “Ability to work as part of a science team” (11%).

For QA/QC specialists, other important skills, knowledge, and abilities include:

**Production and Processing** – Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.

**Engineering and Technology** – Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.

**Mathematics** – Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

**Quality Control Analysis** – Conducting tests and inspections of products, services, or processes to elevate quality or performance.

**Science** – Using scientific rules and methods to solve problems.

**Information Ordering** – The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (e.g., patterns of numbers, letters, words, pictures, mathematical operations).

Table 36 QA/QC Specialist Skills

| Basic | Personal | Technical |
|---|---|---|
| Advanced math skills<br>Written and oral communication | Detail oriented<br>Manual dexterity<br>Observation skills<br>Organizational skills<br>Work as a team<br>Work independently<br>Works well under pressure | Analyze/evaluate technical data<br>Biotechnology laboratory skills<br>Computer skills<br>Knowledge of life sciences and chemistry<br>Knowledge of SOPs, GMPs, and GLPs<br>Problem solving/critical thinking<br>Read and follow technical instructions<br>Record keeping skills<br>Technical writing<br>Troubleshooting |

*Source: Careers in Biotechnology* – California Community Colleges, 2002*.

* Information not available for QA/QC specialists – data relates to QA/QC technicians.

## Skill Deficiencies

According to responding companies, QA/QC Specialists were most deficient in "Technical competence specific to the position" (42%), "Written communication skills" (24%), and "Creative problem-solving skills" (18%).

## Wages

Higher salaries can be earned by those with more experience, and for supervisory and inspector positions.

Table 37 QA/QC Specialist Salary Ranges

| Level | Salary Range |
|---|---|
| QA/QC Technician | $30,000 to $50,000 |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Regulatory Affairs Specialist

### Occupation Description

Regulatory affairs specialists perform the coordination and preparation of document packages for regulatory submissions from all areas of company, internal audits and inspections, and compile all materials required in submissions, license renewal and annual registrations. They also recommend changes for labeling, manufacturing, marketing, and clinical protocol for regulatory compliance, and may monitor and improve racking/control systems. They need to keep abreast of regulatory procedures and changes, and may direct interaction with regulatory agencies on defined matters, or recommend strategies for earliest possible approvals of clinical trials applications.

### Secondary Titles

Secondary titles include documentation associate, documentation coordinator, documentation specialist, regulatory policy specialist, regulatory specialist, and regulatory documentation coordinator.

### Assessment of Need

Red – strong potential shortage indicators.

- Strong projected job growth over the next 12 months – 15%
- 67% of companies reported difficulties finding suitable applicants who met their hiring standards
- 33% of companies reported difficulties retaining current employees
- 23% of companies “Always” or “Frequently” recruited from outside Northern California
- 36% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 66 percent reported that they currently employed regulatory affairs specialists at their business location. Overall, a total of 89 regulatory affairs specialists were recorded across 28 companies, averaging three per business location. The total number of employees across responding business locations was expected to increase by 15 percent over the next 12 months.

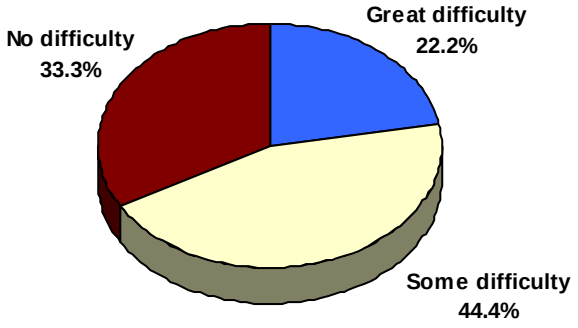
Table 38 Regulatory Affairs Specialists – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 89 | 102 | 13 | 14.6% | 28 |

## Difficulty Finding Suitable Applicants

Figure 45 below shows that 67 percent of responding companies reported at least "Some difficulty" finding suitable regulatory affairs specialists who met their hiring standards.

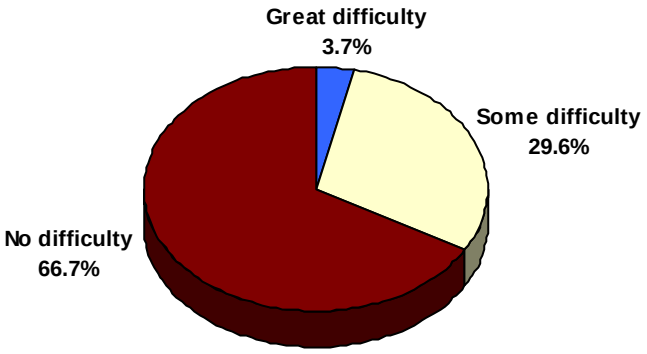
Figure 45 Difficulty Finding Suitable Regulatory Affairs Specialists




## Difficulty Retaining Current Employees

Figure 46 below shows that 33 percent of responding companies reported "Some" or "Great" difficulty retaining current regulatory affairs specialists.

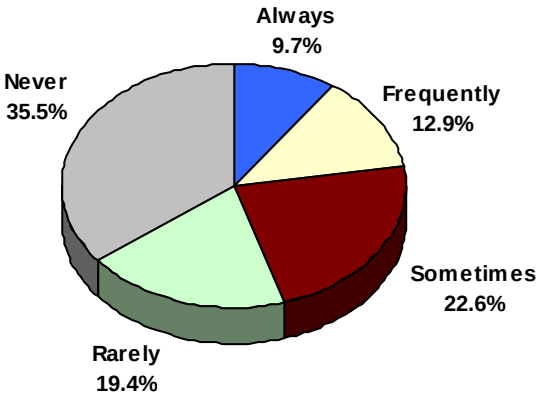
Figure 46 Difficulty Retaining Regulatory Affairs Specialist Employees




## Frequency Recruit from Outside Northern California

Figure 47 below shows that 23 percent of responding companies "Always" or "Frequently" recruited regulatory affairs specialists from outside of Northern California.

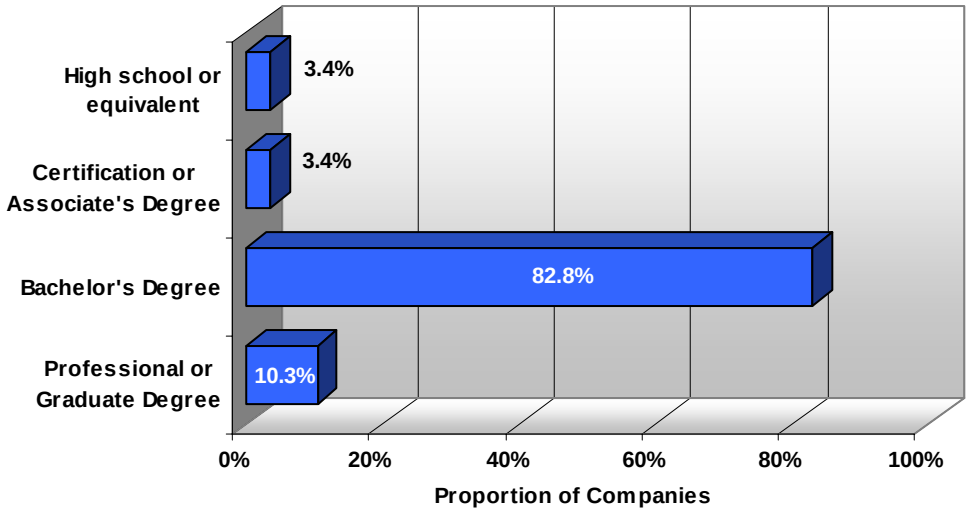
Figure 47 Frequency Recruit Regulatory Affairs Specialists from Outside Northern California



## Typical Education Requirements

Figure 48 indicates that 83 percent of responding companies required regulatory affairs specialists to have a bachelor's degree, while a further 10 percent required a professional or graduate degree for this position.

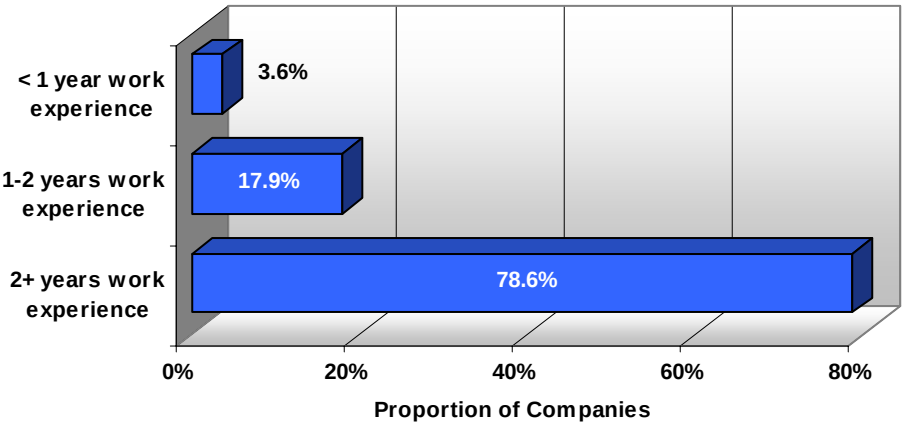
Figure 48 Typical Education Requirements for Regulatory Affairs Specialists




## Typical Work Experience Requirements

Figure 49 indicates that 79 percent of responding companies required regulatory affairs specialists to have two or more years' experience, 18 percent required them to have between one and two years of work experience, and four percent required up to a year's experience for this position.

Figure 49 Typical Work Experience Requirements for Regulatory Affairs Specialists



## Education and Work Experience Requirements by Job Level

Table 39 provides an overview of the typical education and training requirements for regulatory affairs specialists by level of seniority.

Table 39 Regulatory Affairs Specialist Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on problems of moderate scope in which analysis of situation or data requires a review of identifiable factors. Exercises judgment within defined procedures and practices to determine appropriate action. Normally receives general instructions on routine work, detailed instructions on new assignments. This is an entry-level position. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 0 to 2 years' related experience. |
| 2 | Works on problems of diverse scope in which analysis of data requires evaluation of identifiable factors. Exercises judgment within generally defined practices and policies in selecting methods and techniques for obtaining solutions. Normally receives no instructions on routine work, general instructions on new assignments. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 2 to 5 years' related experience, or 0 to 2 years with a Master's degree and demonstrated working knowledge of scientific principles. |
| 3 | Works on complex problems in which analysis of situations or data requires an in-depth evaluation of various factors. Exercises judgment within broadly defined practices and policies in selecting methods, techniques and evaluation criteria for obtaining results. May determine methods and procedures on new assignments and may provide guidance to other lower-level personnel. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 5 to 8 years' related experience, or 2 to 5 years' with a Master's degree and demonstrated working knowledge of scientific principles. |
| 4 | Works on extremely complex problems in which analysis of situations or data requires an evaluation of intangible variables. Exercises independent judgment in developing methods, techniques and evaluation criteria for obtaining results. Acts independently to determine methods and procedures on new assignments. May supervise the activities of other lower-level personnel. This is the most senior-level position. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 8+ years' related experience, or 5 to 8 years' with a Master's degree and demonstrated working knowledge of scientific principles. |

Source: 2006 Radford Biotechnology Survey

## Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for regulatory affairs specialist positions was “Technical competence specific to the position” (64%), followed by the “Ability to work as part of a science team” (11%), and “Creative problem-solving skills” (11%).

For regulatory affairs specialists, other important skills, knowledge, and abilities include:

**Law and Government** – Knowledge of laws, legal codes, court procedures, precedents, government regulations, executive orders, agency rules, and the democratic political process.

**Engineering and Technology** – Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.

**Reading Comprehension** – Understanding written sentences and paragraphs in work related documents.

**Speaking** – Talking to others to convey information effectively.

**Writing** – Communicating effectively in writing as appropriate for the needs of the audience.

**Critical Thinking** – Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems.

**Evaluating Information to Determine Compliance with Standards** – Using relevant information and individual judgment to determine whether events or processes comply with laws, regulations, or standards.

**Updating and Using Relevant Knowledge** – Keeping up-to-date technically and applying new knowledge to your job.

Table 40 Regulatory Affairs Specialist Skills

| Basic | Personal | Technical |
|---|---|---|
| Basic math<br>Read and follow instructions<br>Written and oral communication | Detail oriented<br>Organizational skills<br>Work as a team<br>Work independently | Computer skills<br>Knowledge of SOPs, GMPs, and GLPs<br>Record keeping skills<br>Technical writing<br>Troubleshooting |

Source: *Careers in Biotechnology* – California Community Colleges, 2002*.

## Skill Deficiencies

According to responding companies, regulatory affairs specialists were most deficient in “Technical competence specific to the position” (29%), “Creative problem-solving skills” (29%), “Written communication skills” (13%), and the “Ability to work as part of a science team” (13%).

* Information not available for regulatory affairs specialists – data relates to documentation coordinators.

## Wages

Table 41 Regulatory Affairs Specialist Salary Ranges

| Level | Salary Range |
|---|---|
| Documentation Coordinator | $24,000 to $40,000 |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Biostatistician

### Occupation Description

Biostatisticians perform the design, development, modification and evaluation of a technical infrastructure to expedite conducting and evaluation of clinical trials and basic research. They also perform statistical analysis, develop tracking systems to determine the efficiency of clinical trials, interact with clinical investigators to determine protocol design. They may also evaluate databases and statistical analyses programs and interact with computer groups to determine hardware/software compatibility. The job requires maintaining expertise in state-of-the-art data manipulation and statistical analyses.

### Secondary Titles

Secondary titles include clinical biostatistician.

### Assessment of Need

Red – strong potential shortage indicators.

- Strong projected job growth over the next 12 months – 17%
- 90% of companies reported difficulties finding suitable applicants who met their hiring standards
- 50% of companies reported difficulties retaining current employees
- 39% of companies “Always” or “Frequently” recruited from outside Northern California
- 39% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 29 percent reported that they currently employed biostatisticians at their business location. Overall, a total of 29 biostatisticians were recorded across 14 companies, averaging two per business location. The total number of employees across responding business locations was expected to increase by 17 percent over the next 12 months.

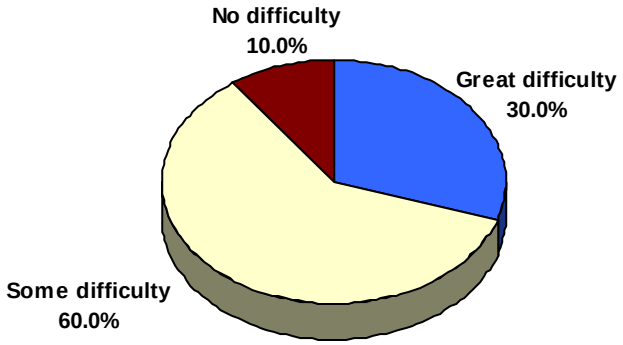
Table 42 Biostatisticians – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 29 | 34 | 5 | 17.2% | 14 |

## Difficulty Finding Suitable Applicants

Figure 50 below shows that 90 percent of responding companies reported at least "Some difficulty" finding suitable biostatisticians who met their hiring standards.

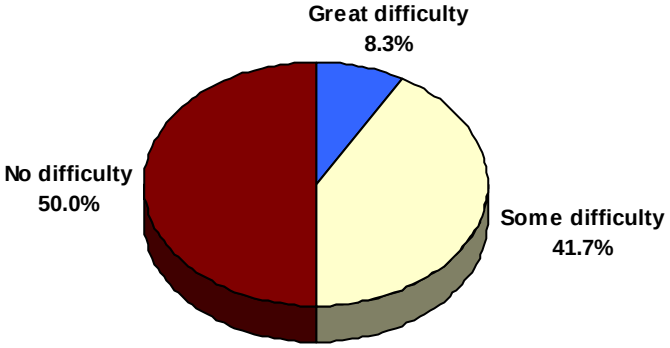
Figure 50 Difficulty Finding Suitable Biostatisticians




## Difficulty Retaining Current Employees

Figure 51 below shows that 50 percent of responding companies reported "Some" or "Great" difficulty retaining current biostatisticians.

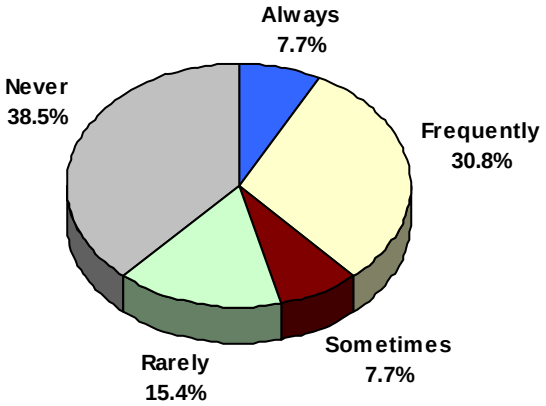
Figure 51 Difficulty Retaining Biostatistician Employees




## Frequency Recruit from Outside Northern California

Figure 52 below shows that 39 percent of responding companies "Always" or "Frequently" recruited biostatisticians from outside of Northern California.

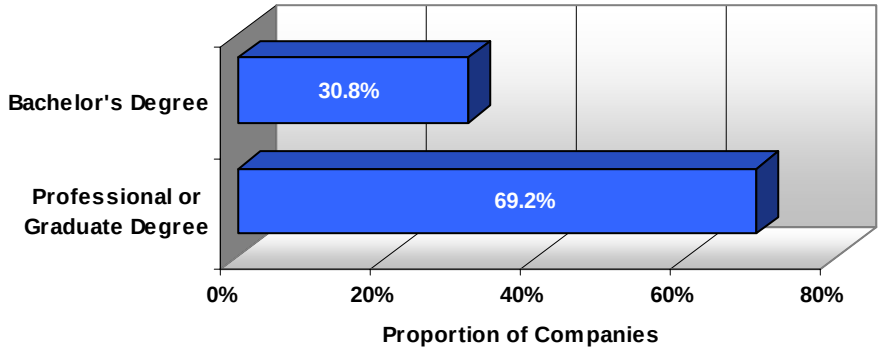
Figure 52 Frequency Recruit Biostatisticians from Outside Northern California



## Typical Education Requirements

Figure 53 indicates that 69 percent of responding companies required biostatisticians to have a professional or graduate degree, while the remaining 31 percent required at least a bachelor's degree for this position.

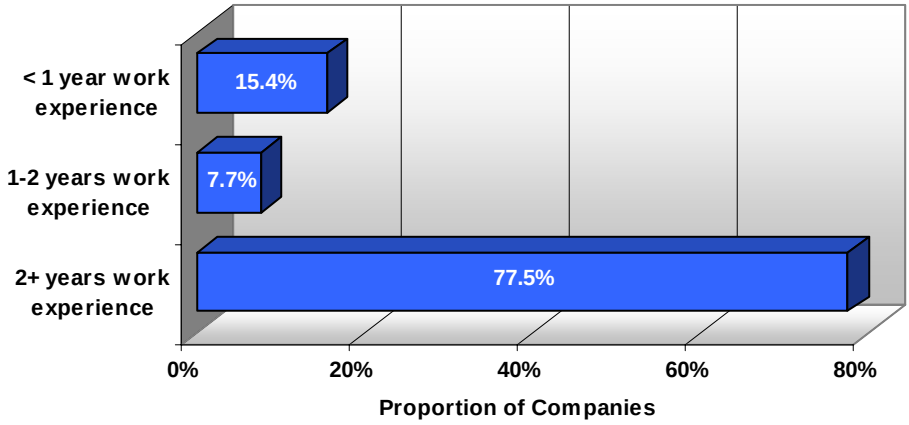
Figure 53 Typical Education Requirements for Biostatisticians




## Typical Work Experience Requirements

Figure 54 indicates that 78 percent of responding companies required biostatisticians to have two or more years' experience, eight percent required them to have between one and two years of work experience, and 15 percent required up to a year's experience for this position.

Figure 54 Typical Work Experience Requirements for Biostatisticians



## Education and Work Experience Requirements by Job Level

Table 43 provides an overview of the typical education and training requirements for biostatisticians by level of seniority.

Table 43 Biostatistician Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on problems of moderate scope in which analysis of situation or data requires a review of identifiable factors. Exercises judgment within defined procedures and practices to determine appropriate action. Normally receives general instructions on routine work, detailed instructions on new assignments. | Master's/PhD or equivalent with a minimum of 0 to 2 years' related experience. |
| 2 | Works on problems of diverse scope in which analysis of data requires evaluation of identifiable factors. Exercises judgment within generally defined practices and policies in selecting methods and techniques for obtaining solutions. Normally receives no instructions on routine work, general instructions on new assignments. | Master's/PhD or equivalent with a minimum of 2 to 5 years' related experience. |
| 3 | Works on complex problems in which analysis of situations or data requires an in-depth evaluation of various factors. Exercises judgment within broadly defined practices and policies in selecting methods, techniques and evaluation criteria for obtaining results. May determine methods and procedures on new assignments and may provide guidance to other lower-level personnel. | Master's/PhD or equivalent with a minimum of 5 to 8 years' related experience. Must have expertise in statistical methodology, software languages and computer systems. |
| 4 | Works on extremely complex problems in which analysis of situations or data requires an evaluation of intangible variables. Exercises independent judgment in developing methods, techniques and evaluation criteria for obtaining results. Acts independently to determine methods and procedures on new assignments. May oversee and manage the activities of other lower-level personnel, but primary role to the company is as an individual contributor. | PhD with 8 to 12 years' related experience. Must have expertise in statistical methodology, software languages and computer systems. |
| 5 | Works on significant and unique issues where analysis of situations or data requires an evaluation of intangibles, and may impact future concepts, products, or technologies. Creates formal networks with key decision makers and serves as external spokesperson for the organization. Exercises latitude in determining objectives and approaches to critical assignments. Leveling Tip: This position is more likely to be found in large organizations, but may be considered a strategic leader in smaller organizations. Barriers to entry such as committee review exist at this level. | PhD with 12+ years' related experience. Must have expertise in statistical methodology, software languages and computer systems. |

Source: 2006 Radford Biotechnology Survey

### Important Skills, Knowledge, and Abilities

According to responding companies, the most important skills when considering applicants for biostatistician positions were “Technical competence specific to the position” (92%), and “Creative problem-solving skills” (8%).

For biostatisticians, other important skills, knowledge, and abilities include:

**Mathematics** – Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

**Active Learning** – Understanding the implications of new information for both current and future problem-solving and decision-making.

**Complex Problem Solving** – Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.

**Critical Thinking** – Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems.

### Skill Deficiencies

According to responding companies, biostatisticians were most deficient in “Technical competence specific to the position” (27%), “Creative problem-solving skills” (27%), and “Interpersonal communication skills” (27%).

## Bioinformatics Programmer/Analyst

### Occupation Description

Bioinformatics programmers/analysts direct and guide the computational sequence analysis methods for database searches and the analysis of resulting data, implement users' needs in database searching and integration which includes interpretation of similarity of sequence searches, multiple sequence alignments and gene expression patterns, and the quality control of sequence data. They also maintain the computational infrastructure and control the flow of samples and information for large-scale studies. They may also provide Web-based bioinformatics and access to public and proprietary relational databases, develop and apply computational tools, and work in collaboration with drug discovery project teams.

### Secondary Titles

Secondary titles include bioinformatics software engineer, bioinformatics scientist, bioinformaticist, bioinformatics specialist, and informatics developer.

### Assessment of Need

Red– strong potential shortage indicators.

- Strong projected job growth over the next 12 months – 9%
- 50% of companies reported difficulties finding suitable applicants who met their hiring standards
- 41% of companies reported difficulties retaining current employees
- 28% of companies "Always" or "Frequently" recruited from outside Northern California
- 28% of companies "Never" recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 36 percent reported that they currently employed bioinformatics programmers/analysts at their business location. Overall, a total of 46 bioinformatics programmers/analysts were recorded across 16 companies, averaging three per business location. The total number of employees across responding business locations was expected to increase by nine percent over the next 12 months.

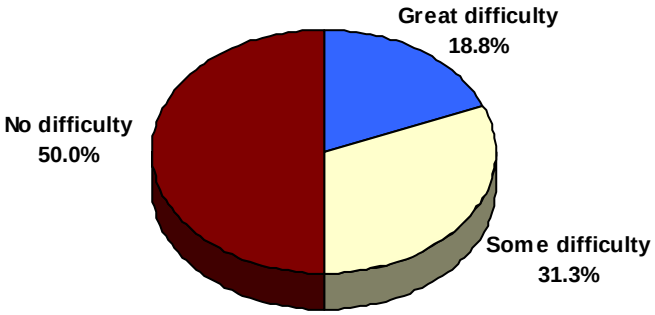
Table 44 Bioinformatics Programmers/Analysts – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 46 | 50 | 4 | 8.7% | 16 |

## Difficulty Finding Suitable Applicants

Figure 55 below shows that 50 percent of responding companies reported at least "Some difficulty" finding suitable bioinformatics programmers/analysts who met their hiring standards.

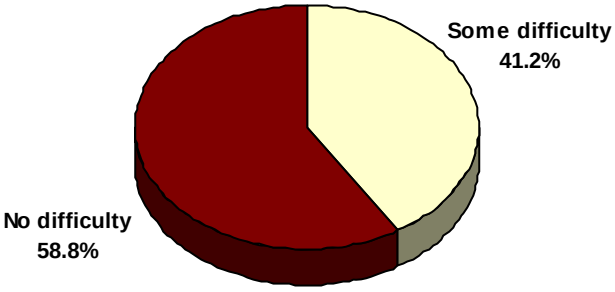
Figure 55 Difficulty Finding Suitable Bioinformatics Programmers/Analysts




## Difficulty Retaining Current Employees

Figure 56 below shows that 41 percent of responding companies reported "Some" difficulty retaining current bioinformatics programmers/analysts.

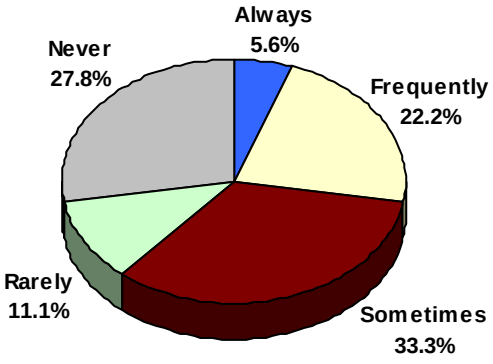
Figure 56 Difficulty Retaining Bioinformatics Programmer/Analyst Employees




## Frequency Recruit from Outside Northern California

Figure 57 below shows that 28 percent of responding companies "Always" or "Frequently" recruited bioinformatics programmers/analysts from outside of Northern California.

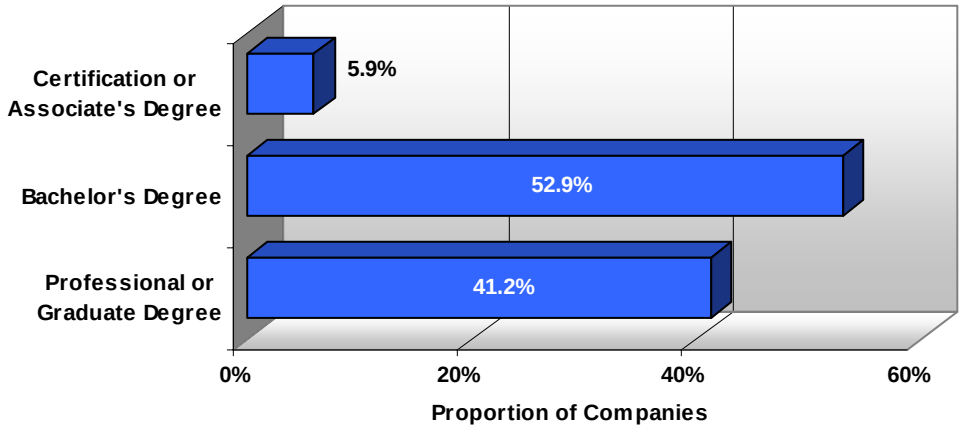
Figure 57 Frequency Recruit Bioinformatics Programmers/Analysts from Outside Northern California



## Typical Education Requirements

Figure 58 indicates that 53 percent of responding companies required bioinformatics programmers/analysts to have a bachelor's degree, 41 percent required a professional or graduate degree, and six percent required a certification or associate's degree for this position.

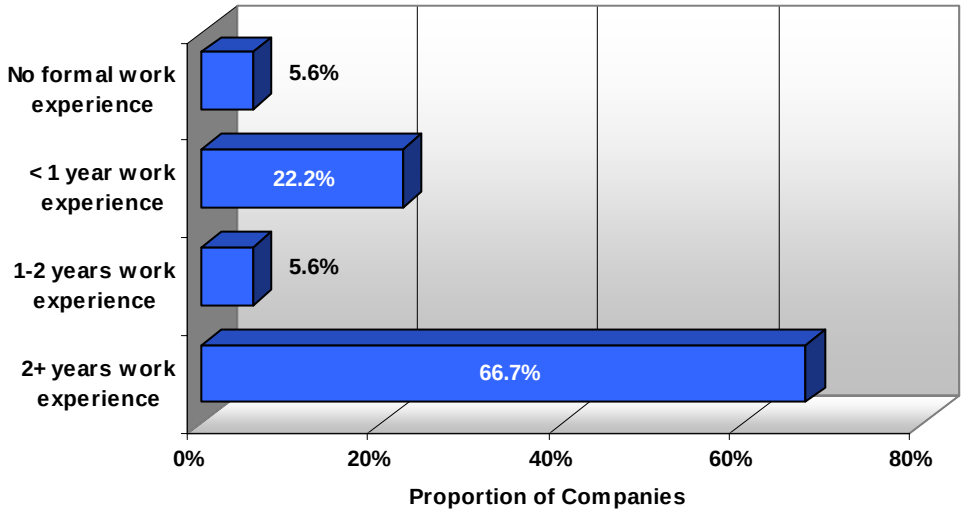
Figure 58 Typical Education Requirements for Bioinformatics Programmers/Analysts




## Typical Work Experience Requirements

Figure 59 indicates that 67 percent of responding companies required bioinformatics programmers/analysts to have two or more years' experience, 22 percent required them to have up to a year's experience, six percent required between one and two years of work experience, and the remaining six percent required no formal work experience for this position.

Figure 59 Typical Work Experience Requirements for Bioinformatics Programmers/Analysts



## Education and Work Experience Requirements by Job Level

Table 45 provides an overview of the typical education and training requirements for bioinformatics programmers/analysts by level of seniority.

Table 45 Bioinformatics Programmer/Analyst Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on problems of moderate scope in which analysis of situation or data requires a review of identifiable factors. Exercises judgment within defined procedures and practices to determine appropriate action. Demonstrates technical proficiency, scientific creativity, collaboration with others and independent thought. Normally receives general instructions on routine work, detailed instructions on new assignments. | MS degree required in addition to in-depth knowledge of computational analysis and interpretation of DNA sequences and protein analysis. Strong background in database and utility programming in a UNIX/MAC environment coupled with excellent verbal and communication skills. |
| 2 | Works on problems of diverse scope in which analysis of data requires evaluation of identifiable factors. Exercises judgment within generally defined practices and policies in selecting methods and techniques for obtaining solutions. Demonstrated success in technical proficiency, scientific creativity, collaboration with others and independent thought. Expert knowledge of scientific principles and concepts. | Bachelor's/Master's degree or equivalent with 2 to 5 years' experience, in addition to an in-depth knowledge of computational analysis and interpretation of DNA sequences and protein analysis. Strong background in database management, client server technology and utility programming in a UNIX/MAC environment and algorithm design and implementation. |
| 3 | Works on complex problems in which analysis of situations or data requires an in-depth evaluation of various factors. Exercises judgment within broadly defined practices and policies in selecting methods, techniques and evaluation criteria for obtaining results. Demonstrated success in technical proficiency, scientific creativity, collaboration with others and independent thought. Expert knowledge of scientific principles and concepts. May determine methods and procedures on new assignments and may provide guidance to other lower-level personnel. | Bachelor's/Master's degree or equivalent with 5 to 8 years' experience, in addition to an in-depth knowledge of computational analysis and interpretation of DNA sequences and protein analysis. Strong background in database management, client server technology and utility programming in a UNIX/MAC environment and algorithm design and implementation. |
| 4 | Works on extremely complex problems in which analysis of situations or data requires an evaluation of intangible variables. Exercises independent judgment in developing methods, techniques and evaluation criteria for obtaining results. Acts independently to determine methods and procedures on new assignments. May oversee and manage the activities of other lower-level personnel, but primary role to the company is as an individual contributor. | Bachelor's/Master's degree or equivalent with 8 to 12 years' experience, in addition to an in-depth knowledge of computational analysis and interpretation of DNA sequences and protein analysis. Expert knowledge in technical proficiency, scientific creativity, collaboration with others, independent thought, and of scientific principals and concepts. Strong background in database management, client server technology and utility programming in a UNIX/MAC environment and algorithm design and implementation. |
| 5 | Works on significant and unique issues where analysis of situations or data requires an evaluation of intangibles, and may impact future concepts, products, or technologies. Creates formal networks with key decision makers and serves as external spokesperson for the organization. Exercises latitude in determining objectives and approaches to critical assignments. This position is more likely to be found in large organizations, but may be considered a strategic leader in smaller organizations | Bachelor's/Master's degree or equivalent with 12+ years' related experience and expert knowledge of computational analysis and interpretation of DNA sequences, protein analysis, and in technical proficiency, scientific creativity, collaboration with others and independent thought. Expert knowledge in software languages and computer systems. |

Source: 2006 Radford Biotechnology Survey

### Career Advancement Opportunities

Bioinformatics programmers/analysts may advance into higher level scientist positions that supervise other science staff or manage entire projects. They can also move into company management positions, such as administering programs for research activities (see *Careers in Biotechnology* – California Community Colleges, 2002, for more information).

### Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for bioinformatics programmer/analyst positions was “Technical competence specific to the position” (63%), followed by “Creative problem-solving skills” (21%).

For bioinformatics programmers/analysts, other important skills, knowledge, and abilities include:

**Computers and Electronics** – Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.

**Operations Analysis** – Analyzing needs and product requirements to create a design.

**Science** – Using scientific rules and methods to solve problems.

**Programming** – Writing computer programs for various purposes.

**Written Comprehension** – The ability to read and understand information and ideas presented in writing.

**Oral Expression** - The ability to communicate information and ideas in speaking so others will understand.

Table 46 Bioinformatics Programmer/Analyst Skills

| Basic | Personal | Technical |
|---|---|---|
| Advanced math skills<br>Read and follow instructions<br>Written and oral communication | Detail oriented<br>Organizational skills<br>Work as a team<br>Work independently | Analyze/evaluate technical data<br>Computer skills<br>Knowledge of life sciences and chemistry<br>Problem solving/critical thinking<br>Read and interpret technical materials<br>Record keeping skills<br>Technical writing skills |

*Source: Careers in Biotechnology* – California Community Colleges, 2002.

## Skill Deficiencies

According to responding companies, bioinformatics programmers/analysts were most deficient in the “Ability to work as part of a science team” (29%), “Technical competence specific to the position” (24%), “Interpersonal communication skills” (24%), and “Written communication skills” (18%).

## Wages

Table 47 Bioinformatics Programmer/Analyst Salary Ranges

| Level | Salary Range |
|---|---|
| Entry-Level | $45,000 to $55,000 |
| 3 Years’ Experience | $50,000 to $80,000+ |

Source: *Careers in Biotechnology* – California Community Colleges, 2002.

## Process Development Associates

### Occupation Description

Process development associates conduct the implementation of production procedures to optimize manufacturing processes and regulatory requirements, and assist process development in developing scalable processes with improved product yield and reduced costs for manufacturing systems. Additionally, they assist with maintenance of production equipment, and may research and implement new methods and technologies to enhance operations.

### Secondary Titles

Secondary titles for process development associates include associate process development engineer, research associate – process development, process associate, manufacturing process associate, development associate, and associate – product development.

### Assessment of Need

Red – strong potential shortage indicators.

- Very strong projected job growth over the next 12 months – 34%
- 91% of companies reported difficulties finding suitable applicants who met their hiring standards
- 41% of companies reported difficulties retaining current employees
- 9% of companies “Always” or “Frequently” recruited from outside Northern California
- 35% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 48 percent reported that they currently employed process development associates at their business location. Overall, a total of 93 process development associates were recorded across 20 companies, averaging five per business location. The total number of employees across responding business locations was expected to increase by 34 percent over the next 12 months.

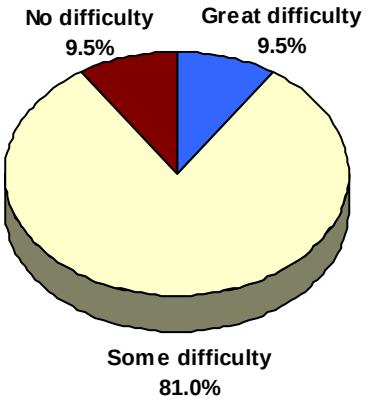
Table 48 Process Development Associates – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 93 | 125 | 32 | 34.4% | 20 |

## Difficulty Finding Suitable Applicants

Figure 60 below shows that 91 percent of responding companies reported at least "Some difficulty" finding suitable process development associates who met their hiring standards.

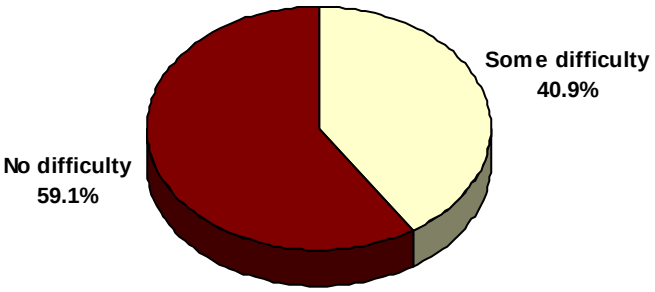
Figure 60 Difficulty Finding Suitable Process Development Associates




## Difficulty Retaining Current Employees

Figure 61 below shows that 41 percent of responding companies reported "Some" difficulty retaining current process development associates.

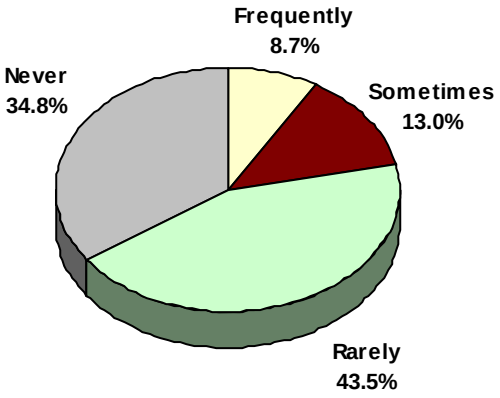
Figure 61 Difficulty Retaining Process Development Associates




## Frequency Recruit from Outside Northern California

Figure 62 below shows that nine percent of responding companies "Frequently" recruited process development associates from outside of Northern California.

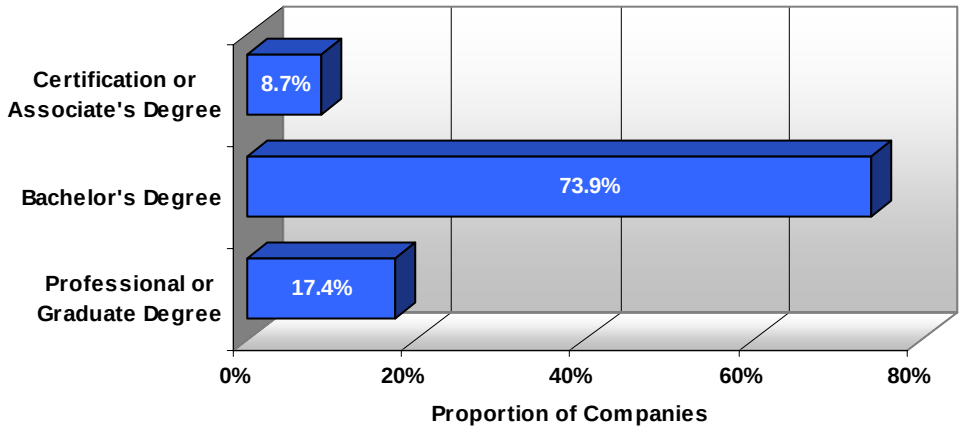
Figure 62 Frequency Recruit Process Development Associates from Outside Northern California



## Typical Education Requirements

Figure 63 indicates that 74 percent of responding companies required process development associates to have a bachelor's degree, 17 percent required a professional or graduate degree, and nine percent required a certification or associate's degree for this position.

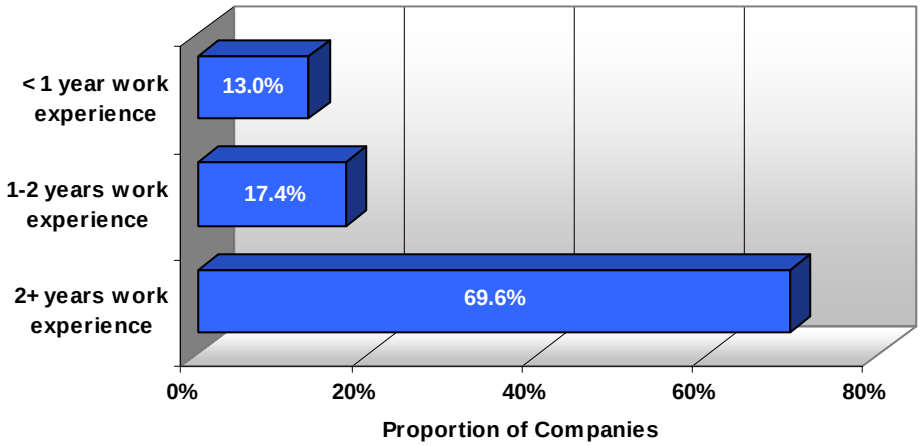
Figure 63 Typical Education Requirements for Process Development Associates




## Typical Work Experience Requirements

Figure 64 indicates that 70 percent of responding companies required process development associates to have two or more years' experience, 17 percent required them to have between one and two years of work experience, and 13 percent required up to a year's work experience for this position.

Figure 64 Typical Work Experience Requirements for Process Development Associates



## Education and Work Experience Requirements by Job Level

Table 49 provides an overview of the typical education and training requirements for process development associates by level of seniority.

Table 49 Process Development Associate Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on problems of moderate scope in which analysis of situation or data requires a review of identifiable factors. Exercises judgment within defined procedures and practices to determine appropriate action. Normally receives general instructions on routine work, detailed instructions on new assignments. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 0 to 2 years of experience. |
| 2 | Works on problems of diverse scope in which analysis of data requires evaluation of identifiable factors. Exercises judgment within generally defined practices and policies in selecting methods and techniques for obtaining solutions. Normally receives no instructions on routine work, general instructions on new assignments. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 2 to 5 years' experience, or 0 to 2 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |
| 3 | Works on complex problems in which analysis of situations or data requires an in-depth evaluation of various factors. Exercises judgment within broadly defined practices and policies in selecting methods, techniques and evaluation criteria for obtaining results. May determine methods and procedures on new assignments and may provide guidance to other lower-level personnel. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 5 to 8 years' experience, or 2 to 5 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |
| 4 | Works on extremely complex problems in which analysis of situations or data requires an evaluation of intangible variables. Exercises independent judgment in developing methods, techniques and evaluation criteria for obtaining results. Acts independently to determine methods and procedures on new assignments and may supervise the activities of other lower-level personnel. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 8+ years' experience, or 5 to 8 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |

Source: 2006 Radford Biotechnology Survey

### Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for process development associate positions was “Technical competence specific to the position” (65%), followed by the “Ability to work as part of a science team” (22%), and “Creative problem-solving skills” (13%).

For process development associates, other important skills, knowledge, and abilities include:

**Speaking** – Talking to others to convey information effectively.

**Writing** – Communicating effectively in writing as appropriate for the needs of the audience.

**Computers and Electronics** – Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.

**Chemistry** – Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.

**Production and Processing** – Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.

**Systems Evaluation** – Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.

**Active Learning** – Understanding the implications of new information for both current and future problem-solving and decision-making.

**Problem Sensitivity** – The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.

### Skill Deficiencies

According to responding companies, process development associates were most deficient in “Technical competence specific to the position” (29%), “Written communication skills” (24%), and the “Ability to work as part of a science team” (19%).

## Bioassay Associate

### Occupation Description

Bioassay associates run clinical and/or non-clinical assays for screening of protein targets and compound testing, and utilize biochemical assays for lead validation and optimization for disease-related targets. Emphasis may be utilization of biochemical assays for High Throughput Screening (HTS). They may also analyze and report screening results as appropriate and contribute to project process within scientific discipline(s).Bioassay associates should maintains familiarity with current scientific literature.

### Secondary Titles

Secondary titles for bioassay associates include assay associate, assay analyst, and bioassay development associate.

### Assessment of Need

Red – strong potential shortage indicators.

- Very strong projected job growth over the next 12 months – 20%
- 77% of companies reported difficulties finding suitable applicants who met their hiring standards
- 62% of companies reported difficulties retaining current employees
- 7% of companies “Always” or “Frequently” recruited from outside Northern California
- 21% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 29 percent reported that they currently employed bioassay associates at their business location. Overall, a total of 35 bioassay associates were recorded across 12 companies, averaging three per business location. The total number of employees across responding business locations was expected to increase by 20 percent over the next 12 months.

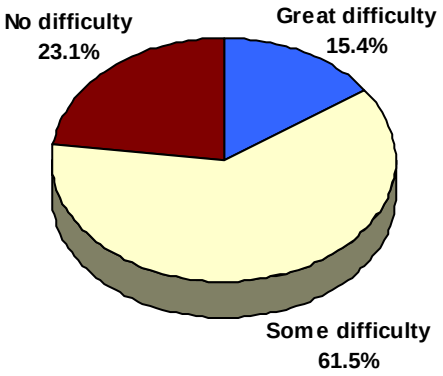
Table 50 Bioassay Associates – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 35 | 42 | 7 | 20.0% | 12 |

## Difficulty Finding Suitable Applicants

Figure 65 below shows that 77 percent of responding companies reported at least "Some difficulty" finding suitable bioassay associates who met their hiring standards.

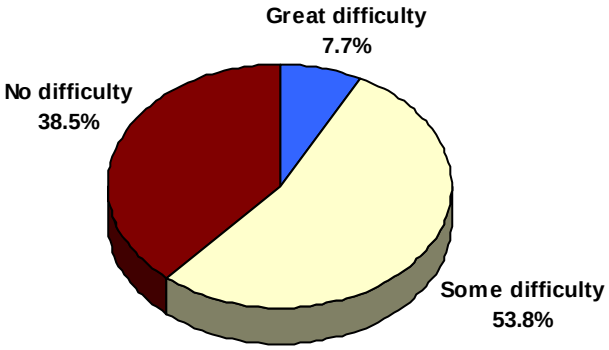
Figure 65 Difficulty Finding Suitable Bioassay Associates




## Difficulty Retaining Current Employees

Figure 66 below shows that 62 percent of companies which responded to this question reported at least "Some" difficulty retaining current bioassay associates.

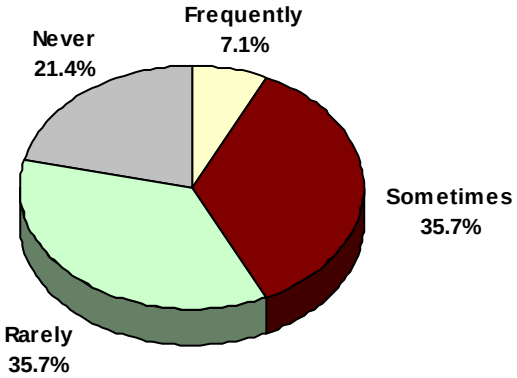
Figure 66 Difficulty Retaining Bioassay Associates




## Frequency Recruit from Outside Northern California

Figure 67 below shows that seven percent of responding companies "Frequently" recruited bioassay associates from outside of Northern California.

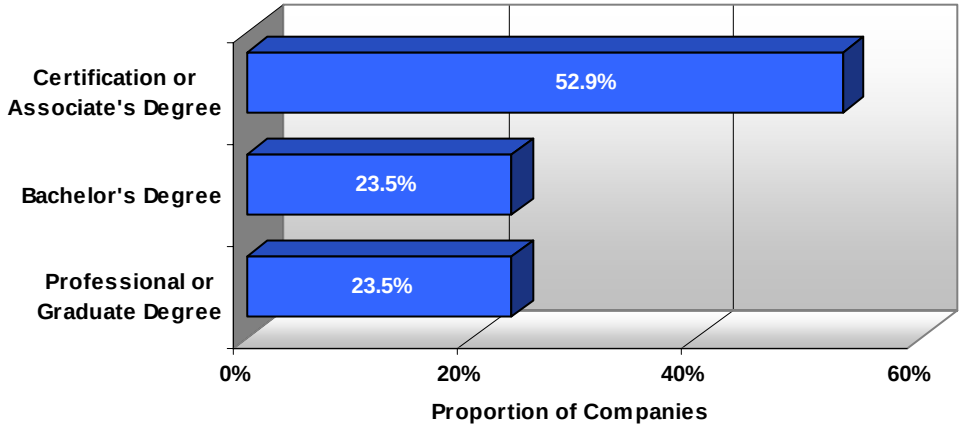
Figure 67 Frequency Recruit Bioassay Associates from Outside Northern California



## Typical Education Requirements

Figure 68 indicates that 53 percent of responding companies required bioassay associates to have a certification or associate's degree, 24 percent required a bachelor's degree, and 24 percent required a professional or graduate degree for this position.

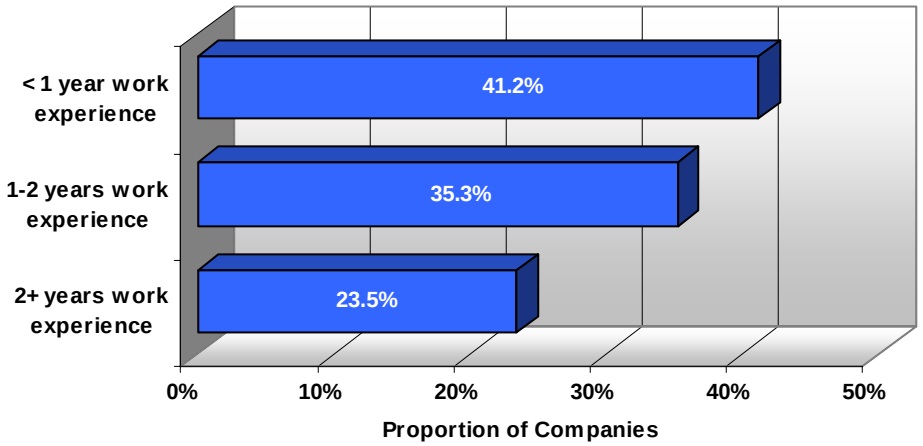
Figure 68 Typical Education Requirements for Bioassay Associates




## Typical Work Experience Requirements

Figure 69 indicates that 41 percent of responding companies required bioassay associates to have up to a year's work experience, 35 percent required between one and two years of work experience, and 24 percent required them to have two or more years' experience for this position.

Figure 69 Typical Work Experience Requirements for Bioassay Associates



## Education and Work Experience Requirements by Job Level

Table 51 provides an overview of the typical education and training requirements for bioassay associates by level of seniority.

Table 51 Bioassay Associate Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on problems of moderate scope in which analysis of situation or data requires a review of identifiable factors. Exercises judgment within defined procedures and practices to determine appropriate action. Normally receives general instructions on routine work, detailed instructions on new assignments. This is an entry-level position. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 0 to 2 years' experience. |
| 2 | Works on problems of diverse scope in which analysis of data requires evaluation of identifiable factors. Exercises judgment within generally defined practices and policies in selecting methods and techniques for obtaining solutions. Normally receives no instructions on routine work, general instructions on new assignments. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 2 to 5 years' experience, or 0 to 2 years' experience with a Master's degree, and demonstrated working knowledge of scientific principles. |
| 3 | Works on complex problems in which analysis of situations or data requires an in-depth evaluation of various factors. Exercises judgment within broadly defined practices and policies in selecting methods, techniques and evaluation criteria for obtaining results. May determine methods and procedures on new assignments and may provide guidance to other lower-level personnel. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 5 to 8 years' experience, or 2 to 5 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |
| 4 | Works on extremely complex problems in which analysis of situations or data requires an evaluation of intangible variables. Exercises independent judgment in developing methods, techniques and evaluation criteria for obtaining results. Acts independently to determine methods and procedures on new assignments. May supervise the activities of other lower-level personnel. This is the most senior-level position on the associate ladder. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 8+ years' experience, or 5 to 8 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |

Source: 2006 Radford Biotechnology Survey

### Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for bioassay associate positions was “Technical competence specific to the position” (60%), followed by the “Ability to work as part of a science team” (20%).

For bioassay associates, other important skills, knowledge, and abilities include:

**Biology** – Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment.

**Chemistry** – Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.

**Mathematics** – Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

**Science** – Using scientific rules and methods to solve problems.

**Information Ordering** – The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (e.g., patterns of numbers, letters, words, pictures, mathematical operations.

**Critical Thinking** – Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems.

### Skill Deficiencies

According to responding companies, bioassay associates were most deficient in “Technical competence specific to the position” (31%), “Interpersonal communication skills” (31%), “Written communication skills” (15%), and the “Ability to work independently” (15%).

## Manufacturing Associate

### Occupation Description

Manufacturing associates implement production and large-scale manufacturing procedures to optimize processes and regulatory requirements. Responsibilities include scale-up and troubleshooting for equipment and systems. They may also establish operating equipment specifications and improve manufacturing techniques, assist with resolving technical issues, as well as maintenance of production equipment, review existing operational and process discrepancies in manufacturing, and provide technical expertise to improve procedures.

### Secondary Titles

Secondary titles for manufacturing associates include associate manufacturing engineer, cell culture manufacturing associate, production associate, developmental associate, manufacturing process associate, and pharmaceutical manufacturing associate.

### Assessment of Need

Red – strong potential shortage indicators.

- Very strong projected job growth over the next 12 months – 25%
- 38% of companies reported difficulties finding suitable applicants who met their hiring standards
- 13% of companies reported difficulties retaining current employees
- 6% of companies “Always” or “Frequently” recruited from outside Northern California
- 21% of companies “Never” recruited from outside Northern California

### Current Employment and Projected Growth

Of the companies which responded to the survey, 59 percent reported that they currently employed manufacturing associates at their business location. Overall, a total of 598 manufacturing associates were recorded across 16 companies, averaging 37 per business location. The total number of employees across responding business locations was expected to increase by 25 percent over the next 12 months.

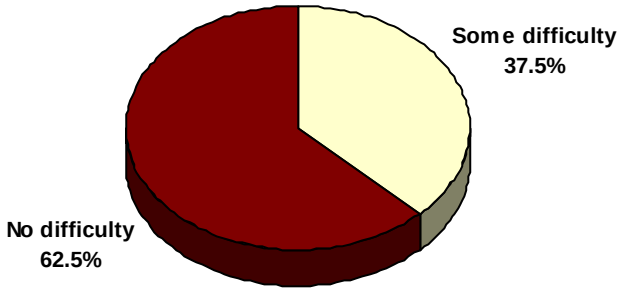
Table 52 Manufacturing Associates – Current and Expected Employment

| Current Employment | Expected Employment in 12 months | Growth (#) | Growth (%) | Number of Companies |
|---|---|---|---|---|
| 598 | 750 | 152 | 25.4% | 16 |

## Difficulty Finding Suitable Applicants

Figure 70 below shows that 38 percent of responding companies reported “Some difficulty” finding suitable manufacturing associates who met their hiring standards.

Figure 70 Difficulty Finding Suitable Manufacturing Associates




## Difficulty Retaining Current Employees

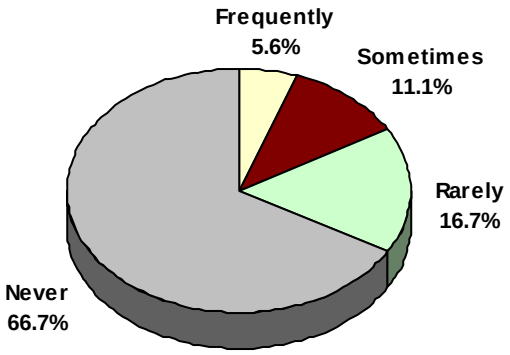
Figure 71 below shows that 13 percent of companies which responded to this question reported “Some difficulty” retaining current manufacturing associates.

Figure 71 Difficulty Retaining Manufacturing Associates

## Frequency Recruit from Outside Northern California

Figure 72 below shows that seven percent of responding companies “Frequently” recruited manufacturing associates from outside of Northern California.

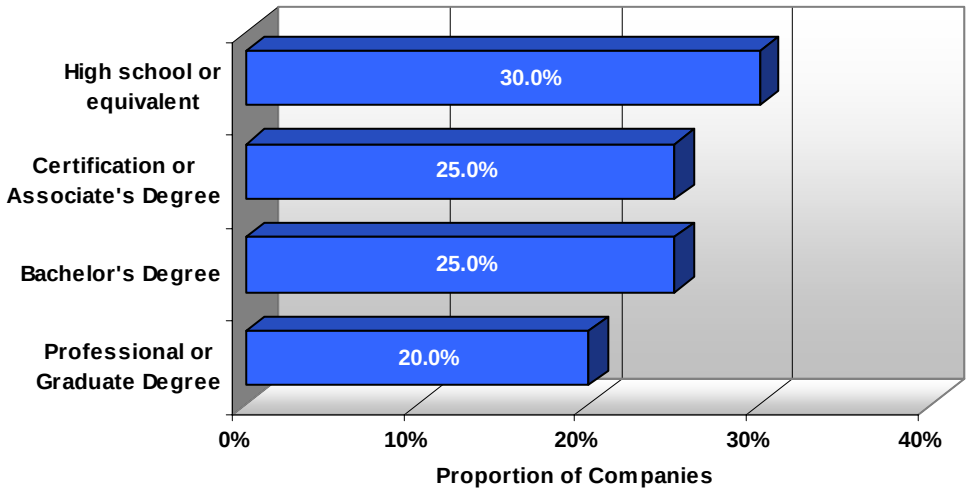
Figure 72 Frequency Recruit Manufacturing Associates from Outside Northern California



## Typical Education Requirements

Figure 73 indicates that 30 percent of responding companies required manufacturing associates to have a high school or equivalent education, 25 percent required a certification or associate's degree, 25 percent required a bachelor's degree, and 20 percent required a professional or graduate degree for this position.

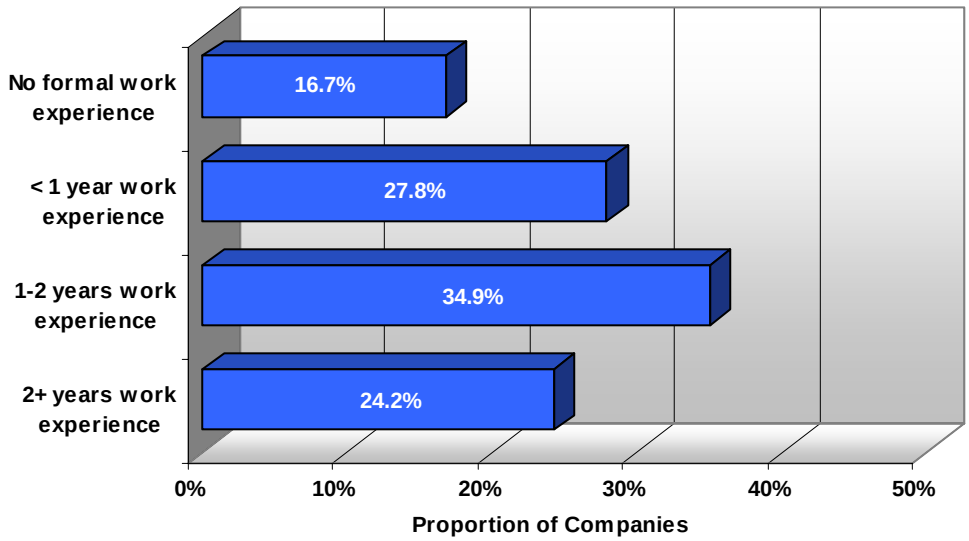
Figure 73 Typical Education Requirements for Manufacturing Associates




## Typical Work Experience Requirements

Figure 74 indicates that 35 percent of responding companies required manufacturing associates to have between one and two years of work experience, 28 percent required up to a year's work experience, 24 percent required them to have two or more years' experience, and 17 percent did not require any formal work experience for this position.

Figure 74 Typical Work Experience Requirements for Manufacturing Associates



## Education and Work Experience Requirements by Job Level

Table 53 provides an overview of the typical education and training requirements for manufacturing associates by level of seniority.

Table 53 Manufacturing Associate Education and Training Requirements by Job Level

| Level | Job Description | Education and Training |
|---|---|---|
| 1 | Works on problems of moderate scope in which analysis of situation or data requires a review of identifiable factors. Exercises judgment within defined procedures and practices to determine appropriate action. Normally receives general instructions on routine work, detailed instructions on new assignments. This is an entry-level position. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 0 to 2 years' related experience. |
| 2 | Works on problems of diverse scope in which analysis of data requires evaluation of identifiable factors. Exercises judgment within generally defined practices and policies in selecting methods and techniques for obtaining solutions. Normally receives no instructions on routine work, general instructions on new assignments. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 2 to 5 years' related experience, or 0 to 2 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |
| 3 | Works on complex problems in which analysis of situations or data requires an in-depth evaluation of various factors. Exercises judgment within broadly defined practices and policies in selecting methods, techniques and evaluation criteria for obtaining results. May determine methods and procedures on new assignments and may provide guidance to other lower-level personnel. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 5 to 8 years' related experience, or 2 to 5 years' experience with a Master's degree and demonstrated working knowledge of scientific principles. |
| 4 | Works on extremely complex problems in which analysis of situations or data requires an evaluation of intangible variables. Exercises independent judgment in developing methods, techniques and evaluation criteria for obtaining results. Acts independently to determine methods and procedures on new assignments. May supervise the activities of other lower-level personnel. | Bachelor's degree in a scientific discipline or equivalent with a minimum of 8+ years' related experience, or 5 to 8 years' with a Master's degree and demonstrated working knowledge of scientific principles. |

Source: 2006 Radford Biotechnology Survey

### Important Skills, Knowledge, and Abilities

According to responding companies, the most important skill when considering applicants for manufacturing associate positions was “Technical competence specific to the position” (67%), followed by the “Ability to work as part of a science team” (22%).

For manufacturing associates, other important skills, knowledge, and abilities include:

**Mechanical** – Knowledge of machines and tools, including their designs, uses, repairs, and maintenance.

**Engineering and Technology** – Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.

**Operation Monitoring** – Watching gauges, dials, or other indicators to make sure a machine is working properly.

**Operation and Control** – Controlling operations of equipment or systems.

**Control Precision** – The ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions.

**Production and Processing** – Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.

**Problem Sensitivity** – The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.

### Skill Deficiencies

According to responding companies, manufacturing associates were most deficient in “Technical competence specific to the position” (21%), “Written communication skills” (21%), and “Creative problem-solving skills” (21%).

# APPENDIX B: BIOINFORMATICS DEFINITION

Roughly defined, bioinformatics is the use of computer technology to manage biological information. The field of bioinformatics combines the disciplines of computer science, information technology and genetics to determine and analyze genetic information, integrating mathematical, statistical and computer methods in the analysis of biological, biochemical and biophysical data. Bioinformatics uses IT in biotechnology for the data storage, data warehousing and analyzing the DNA sequences.

To enter the field of bioinformatics, cross-disciplinary knowledge is typically required, including biology, mathematics, computer science, physics and chemistry, as well as IT knowledge to analyze biotechnology data. Bioinformatics is not limited to the computing data, but in reality it can be used to solve many biological problems and find out how living things work.

Bioinformatics specialists can be involved with all aspects of collecting, assembling and analyzing the ‘staggering quantities’ of information that are being generated by the Human Genome Project, as well as genome projects for other animals, plants and disease-causing micro-organisms. Bioinformatics specialists work in close collaboration with bench scientists, helping them to plan and organize experiments and data collection so as to maximize the production of reliable and useful information. They are found in academic, governmental and industrial research labs.

The field of bioinformatics has broadened widely over the last few years and is now becoming embedded in all stages of the drug discovery process.

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