

**The Role of Biotechnology Training Partnerships in Expanding Local Employment Opportunities for Community College Graduates in California's Biotechnology Industry**

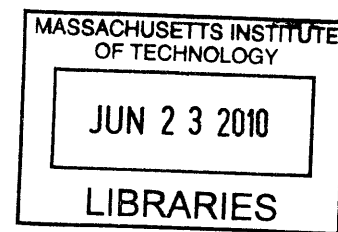
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Submitted to the Department of Urban Studies and Planning  
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Urban and Regional Studies

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2010

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Submitted to the Department of Urban Studies and Planning on May 20, 2010 in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Urban and Regional Studies

## **ABSTRACT**

This study addresses a gap in the policy and planning literature regarding the extent to which public workforce intermediaries in a knowledge-intensive industry expand employment opportunities for a nontraditional, i.e., less-educated or displaced workforce. Specifically, it investigated the recruitment and hiring practices for entry-level biomanufacturing and biological technicians among a sample of life sciences companies in the San Francisco Bay Area and the Greater San Diego Area in order to determine whether training partnerships composed of community colleges, employers and public agencies shape labor supply and demand in favor of community college graduates. The study also examined the mechanisms through which such intermediaries influence recruitment and hiring practices, focusing on strategies to encourage employers' active engagement in the partnership and to facilitate extensive collaboration among key partners.

To measure impact on industry practices, I gathered from a treatment and comparison group of firms the percentage of technicians in the current entry-level workforce that holds a community college degree or certificate. To determine the factors associated with successful (or unsuccessful) program intervention in the sample firms' recruitment and hiring practices, I conducted qualitative interviews of company staff regarding the education and training needs of the company with respect to its technician-level workforce, as well as the company's perceptions of its community college hires vis-à-vis their bachelor-degreed counterparts.

The evidence shows that, among companies employing a bio-manufacturing workforce, the programs have succeeded in training future technicians to meet the needs of area employers (a supply-side goal); and in negotiating skills-based, as opposed to credential-based hiring, while legitimating the community college population as a viable candidate pool (both demand-side goals). The evidence is mixed with respect to the programs' ability to increase graduates' access to entry-level employment in the research laboratory setting. Finally, the evidence shows that partnership efforts produce industry-relevant curriculum, training, and services; facilitate the learning necessary to generate program innovation; and establish relationships of trust with company staff. Together, such outcomes positively shape the opportunity structure facing community college job seekers.

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## **Acknowledgments**

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Countless people supported and guided me through the completion of this dissertation. First, I thank my dissertation committee members, Paul Osterman, Frank Levy, and Karl Seidman, for their very helpful counsel. My advisor, Paul, deserves special thanks for his enduring patience and support over a long and demanding process. I am especially grateful to him for persistently challenging me to make my dissertation more practical and concrete, in order to produce more socially useful scholarship.

Over 100 scientists, production managers, hiring managers, HR personnel, community college faculty, and workforce agency staff helped me to better understand the nature and practices of labor market intermediation in California's biotechnology industry. These individuals gave generously of their time and showed immense patience, particularly those who explained to this non (physical) scientist a range of science-related principles, such as the difference between downstream and upstream processing and whether a particular process employs a biologics, device, or hybrid technology. Helen Chadd, Helyn Dahle, Paul Didas, Mary Glanville, Fred Hempel, Vishwanath Lingappa, Pat McKay, Chuck Olson, Salvador Rivera, Hank Stern, Michael Yoshida, and John Zimmerman are among these individuals.

I am especially indebted to the following people. Nora Lem was tireless in her encouragement and ever willing to field my calls, even on weekends, to help clarify my ideas about technician training from both the community college and employer points of view. Without the early and ongoing assistance of Raya Zion, who entrusted me with her contacts in local companies, this research would never have gotten off the ground. Peter Matlock offered extensive and extremely thoughtful comments on my research questions, ensuring their relevance to the biotech world.

My sincere thanks also go to: Maggie Wong, for her help working on and distributing the HR survey; Mary Ann Ireland, for contacting numerous HR staff on my behalf; Kristie Grover, for posting my HR survey on the HR network's website; Celeste Carter, Jim DeKloe, Mike Fino, Mary Pat Huxley, Elaine Johnson, James Lewis, Lori Lindberg, Yvette Nichols, Josie Sette, and William Watson, for particularly illuminating conversations about the relationship between employers' workforce needs and community college instruction; and all the faculty members who participated in my Educational Pathways Student Survey project (and thank you Nora Lem and the CalABC-Bay Area for commissioning the original survey). Finally, I learned a tremendous amount about workforce and economic development from Mark Troppe, while consulting for him at the National Center on Education and the Economy.

Friends and family members provided immense emotional uplift and support during this long process. My heartfelt thanks go to Aureliano Maria DeSoto, for his decades-long, intellectual companionship, which sparked my return to graduate school; Sabrina Williams, for forging a brilliant path from lawyering to urban planning, which I have sought to follow; Saku Papino, for so generously sharing her abundant wisdom, and for profoundly believing in me; Fatima Chakrani, for her constant encouragement and for introducing me to the amazing contributions that a committed and compassionate biotech scientist can make; and Marie Chua, for partnering with me in the daily practice of mindful living.

Loving thanks go to my siblings, Jeff Agia and Monique Agia, whose support continued through the remaining days of this project, with Jeff giving up his spring break and Monique flying cross-country to care for my infant daughter during the final edits and defense.

To my marvelous partner, Matthew Lamberti, who entered my life at the beginning of this endeavor and continues by my side: I cherish every moment with you! I have learned so much from our invigorating policy discussions, your endless curiosity about the world, and your amazing equanimity. I treasure the surprises that our time together has brought, including a move to California, then on to Bulgaria—and best of all, the birth of our delightful daughter, Annika, during the final year of this thesis.

Finally, I dedicate the dissertation to my wonderful parents, Dr. Raymond Agia and Susan Gaydosh Agia. Words cannot capture how deeply grateful I am for your boundless love and unconditional support, which manifested in innumerable and immeasurable ways throughout this journey.



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## **Chapter 1: Introduction**

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Economic and political changes in the U.S. over the last several decades—technological innovation, competitive pressures due to globalization, deregulation, declining unionization—have contributed to the restructuring of firms, the reorganization of work, and the breakdown of the traditional employment relationship. Pressure on firms to focus on core competencies and adopt flexible work and employment practices has encouraged them to downsize, outsource or offshore, hire contingent labor, and dismantle internal labor markets. These “externalization of work” strategies have increased the complexity, volatility, and unpredictability of labor markets (Benner 2003). While such restructuring spurs innovation and creates opportunities for both employers and workers, it also generates labor market inefficiencies and inequities. For many workers, the new flexible arrangements have resulted in greater job instability, reduced on-the-job training, a lack of clarity regarding career advancement opportunities, and rising wage inequality (Bernhardt et al. 2000). A growing segment of the workforce, moreover, faces a lifetime of dead-end jobs and poverty wages. For employers, the changes have contributed to increased worker turnover, skills mismatches, reduced incentives for training, and difficulties in finding and keeping qualified workers.

Many of these same economic forces—expanded international trade, globalized markets, and technological changes—have increased labor demand for more educated workers. Indeed, the rise in economic return to workers with higher levels of education over the last three decades has been striking (Ellwood 2003; Levy and Murnane 2004). The supply of highly educated workers, however, has failed to keep pace with demand, as forecast by falling college attainment rates, virtually zero net growth in the number of young workers, the impending retirement of baby boomers, and the boomers’ replacement primarily by less-educated immigrants (Turner

2007; Holzer and Nightingale 2007). In fact, the supply of workers with a high school diploma or less is expected to exceed demand in the years ahead, thereby exacerbating labor market inequality (Reed 2008).

These trends have led many to predict serious workforce skills gaps, particularly in those advanced industries most likely to fuel innovation and economic competitiveness (Aspen Institute 2003; but see Freeman 2007). Accordingly, to help mitigate the labor market inefficiencies and inequities resulting from perceived skills mismatches, experts increasingly have called for policies that promote education and skills development (Holzer and Nightingale 2007). A growing debate, however, centers on the kinds of skill, education, and training that are most appropriate in light of recent economic and political changes. In particular, given declining rates of college completion, questions revolve around the extent to which public investments should flow to education and training for jobs that require less than a four-year degree, but more than a high school degree, i.e., “middle-skill” jobs (Holzer and Lerman 2007). Indeed, there is evidence that demand for skills at this level has grown significantly, especially in key industry sectors. Given that middle-skill jobs continue to comprise the majority of U.S. jobs, the argument for enhancing job prospects at this level—for instance, through a renewed focus on occupational training, not just general academic studies—is strong.

In response to the labor market malfunctioning described above, a new type of labor market institution has emerged, one that is designed to improve job prospects for less-advantaged workers, as well as business outcomes for their employers. Known as workforce intermediaries, these organizations convene key stakeholders in the regional labor market to devise workforce strategies built on collaboration around shared needs and challenges. Because they seek to influence the behavior of their dual customers—workers and employers—workforce

intermediaries are inherently labor supply and labor demand policies (Bartik 2001). The most ambitious intermediaries, however, place special emphasis on altering the structure of demand, e.g., working with employers to increase access to good jobs for less-educated workers, raise skill levels, increase compensation, and improve work practices (Kazis 2004; Osterman 1999). They also seek to create systemic change within the labor market in order to enhance the employment environment for all labor market actors, program participants and non-participants alike (Conway et al. 2004).

Targeting industry sectors and coordinating broad networks of stakeholders are two strategies that appear to be closely associated with workforce intermediary effectiveness in improving labor market functioning (Giloath 2004). The first, sector-based strategies, organize multiple employers within an industry for collective action around common workforce concerns, and enable WIs to capitalize on economies of scale and scope, while gaining deep knowledge of industry functioning and business needs (Dresser and Rogers 2003). These initiatives work to create industry- and occupation-specific, multi-firm training and career ladders strategies, typically for workers with less than a college degree. Best practice features of these new institutions are their close connection both to employers, which ensures the necessary degree of demand responsiveness and industry buy-in, and to workers, especially through provision of enhanced material and social supports (Osterman 2007).

The second strategy, based on collaboration and partnerships, embeds the workforce intermediary within networks of employers, community colleges, community-based organizations, training providers, public agencies, and unions (where relevant). Such partnership strategies help generate new and better information and services by providing a forum for ongoing group dialogue, resource sharing, and relationship building (Giloath 2004). Although



sectoral and other demand-driven strategies have existed for more than a decade, research examining the nature, range, diffusion, and impact of such efforts remains limited (Conway et al. 2003; Benner 2003; Osterman 2007). Moreover, there is much less known about the efforts of workforce intermediaries in knowledge-intensive industries—such as biotechnology, the subject of the present study—than in traditional industries (Lowe 2007).<sup>1</sup> Considered engines of innovation, promising significant economic and employment growth, high-technology industries are actively courted by states and localities. However, while it seems clear that knowledge-based industries create high-skill, high wage jobs and generate substantial employment opportunities for highly skilled and educated workers, the extent to which lower-skilled, less-educated workers share in the employment boom remains an open question. There is evidence that they benefit far less than their more privileged co-workers (Sable 2006).

Nevertheless, while limited, there exists compelling evidence that concerted intermediary efforts to help less-educated workers attain industry-relevant education and training, while simultaneously working with employers to open up the hiring process to this workforce, can expand job and advancement opportunities in ways that make the labor market more effective and equitable.

Accordingly, this dissertation aims to contribute to the workforce and economic development literature by probing the nature of demand-side and structural change in the labor market for entry-level workers in the biotechnology/life sciences industries in California, i.e., biological and biomanufacturing technicians. It also seeks to investigate the role of workforce

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<sup>1</sup> With regard to advanced industries, researchers thus far have tended to focus on the role of intermediaries, especially placement agencies, in reducing labor market volatility in the information technology industry; highly educated tech workers have been the primary recipients of such intermediation services (Lowe 2007).

intermediaries in the labor market restructuring process,<sup>2</sup> paying particular attention to the ways in which intermediaries interact with the many for-profit labor market intermediaries dotting the field, such as temporary placement agencies. Specifically, this study aims to understand the extent to which sector-based training partnerships among community colleges, employers, and public agencies in two regions of California influence labor market demand for a non-traditional, underserved or disadvantaged labor pool, primarily individuals lacking a bachelor's degree and/or displaced workers. These partnerships promise to increase such workers' access to career ladder jobs in the biotech industry, while helping employers find and retain qualified technicians.

As biotechnology companies shift from research and development to product manufacturing and commercialization, the need for a well-trained technician workforce has grown; indeed, shortages are forecast for a number of high-demand, entry-level occupations, such as manufacturing and clinical lab technicians.<sup>3</sup> Opportunities for workers with less than a four-year degree likewise have grown, as many technician positions that, until recently, required a bachelor's degree now require, at a minimum, an associate's degree or certificate in biotechnology.<sup>4</sup>

Moreover, according to industry estimates, there are currently over 200 treatments in the final stage of research and development in California. As these treatments complete clinical trials and enter the production stage, companies must decide the location of the treatment's manufacturing facility. Each facility represents hundreds of technician-level jobs, as well as

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<sup>2</sup> Although biotechnology is a relatively young industry, as will be discussed later in this chapter, it has been buffeted by the same labor market forces that have restructured more traditional industries. Moreover, as a knowledge-intensive industry, it arguably is characterized by greater volatility and more rapid change than "old economy" industries.

<sup>3</sup> For example, biological technicians in California are projected to grow from 9,000 to 11,100 workers between 2004 and 2014, an increase of 23 percent, with average annual openings numbering 360. Labor Market Information Division (LMID), California Employment Development Department (CA EDD), [www.labormarketinfo.edd.ca.gov](http://www.labormarketinfo.edd.ca.gov).

<sup>4</sup> Indeed, around 30% of the total number of life sciences positions that are projected to be created nationwide require an AA degree (CA EDD LMID).

hundreds millions of dollars in other economic benefits (BayBio 2009). Hence, there exists a prime opportunity for workforce intermediaries to coordinate training, recruitment and hiring activities in ways that help anchor these establishments in the state, while opening up many of the newly created jobs to less-educated, local residents (Lowe 2007).

However, the extent to which actual demand for such workers has increased—as evidenced, for example, in employers’ active recruitment and hiring from community college biotechnology programs—is not clear from the literature. Moreover, very few studies appear to have elaborated the role of biotechnology partnerships and programs in shaping the labor market for a technician workforce, e.g., by acting as a regional labor market developer. It seems clear that, to date, industry partnerships with community colleges and other public sector organizations have not yet become the norm, despite a growing recognition that such community college partnerships can help meet the need for trained technicians while diversifying that workforce (Fitzgerald 2006, 2004; Time Structures 2006). Given the particularly expensive and resource-intensive nature of biotechnology training programs, as well as their growing popularity nationwide as states spend huge sums trying to attract the life sciences industry, an in-depth investigation into the effectiveness of these sectoral partnership programs seems warranted.

### Structure of the Study

The study consists of eight chapters. The remainder of Chapter One sketches the growth of the biotechnology industry in the U.S. and California. It outlines changing workforce and skills needs as companies move through the product development cycle, as well as the growth of the technician-level workforce. It also introduces several national and state workforce development efforts to address employer’s workforce needs for a well-trained technician workforce. The chapter concludes by presenting my research questions and hypotheses.

Chapter Two presents the literature on labor market intermediaries and sectoral employment strategies. It elaborates the nature of demand-side and systemic change in the labor market, discusses the features commonly associated with intermediary effectiveness, and outlines the role of community college-industry partnerships in addressing regional workforce needs.

In Chapter Three, I introduce a range of community college-industry partnerships in California, describing the origins and evolution of biotechnology programs in northern and southern California, and program design components of both certificate and associate's degree offerings. The chapter discusses trends and best practices in biotechnology education, and presents case studies of model partnership programs.

Chapter Four presents a deeper analysis of biotechnology production and its effects on skill demands for biological technicians, detailing the types of technician jobs by industry sector, formal education and training requirements for entry-level jobs, job quality at the technician level, and career paths within the industry. It discusses the pressures for upskilling, given rapidly changing technologies, and sketches recruitment, hiring, and training patterns for entry-level technicians. Finally, it discusses recent trends in the outsourcing of production, both domestic and offshore.

Chapter Five outlines my research design, explaining my decision to take a "sectoral" approach, that is, to study a single industry sector: biotechnology/life sciences production and manufacturing. I describe the characteristics of my treatment and comparison group firms, and of the labor market intermediaries in my sample. I also describe the qualitative and quantitative methods that I used to test my hypotheses about the impacts of workforce intermediary efforts on the labor market's demand side.

In Chapters Six and Seven, I analyze my field data. Chapter Six first provides a profile of current community college biotechnology students/job seekers in northern and southern California programs, through a presentation of my survey results. It then examines job placement data for the programs under study and employment outcomes for my sample of biotechnology companies in the two regions under study. It also examines current recruitment and hiring practices of these firms, as well as (any) indicators of changing employer practice.

Chapter Seven analyzes the factors conditioning success of biotechnology training partnerships based on the data. It assesses the partnerships' efforts to cultivate close employer relationships and encourage network formation, and the impact of these demand- and supply-side relationships on employment outcomes. It examines any evidence of systemic change in the recruitment and hiring processes related to entry-level technician positions.

Finally, Chapter Eight concludes by discussing the nature and practices of labor market intermediation within the biotechnology industry in California. It reflects on the ability of sectoral training partnerships in the biotechnology industry to influence the key decision of who gets hired for technician-level jobs, as well as to build leverage among key stakeholders in the effort to promote job opportunities for non-traditional and underserved workers.

## **1.1 Growth of the Biotechnology Industry**

### Industry Definition

In its most basic sense, biotechnology refers to the use of living organisms to create products or techniques.<sup>5</sup> As such, elements of biotechnology have been in existence since at least 4,000 B.C.E., when humans first learned how to ferment grains and fruits to produce bread and wine.

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<sup>5</sup> The U.S. Department of Commerce define biotechnology as “the application of molecular and cellular processes to solve problems, conduct research, and create goods and services” (US DOC 2003)

The roots of modern biotechnology date to 1953 when *Nature* published a letter by James Watson and Francis Crick that described the researchers' discovery of double helix DNA. The biotech industry emerged in the 1970s with the development of a new recombinant DNA technique by geneticist Stanley Cohen of Stanford University and biochemist Herbert Boyer of the University of California, San Francisco.<sup>6</sup> In a parallel development, pharmaceutical companies began incorporating biotechnology processes into their development activities in the 1970s, leading to the manufacturing and commercialization of biopharmaceuticals in the 1980s (NCBS 2003).

Since then, the biotechnology industry has generated more than 200 new vaccines and therapies, with more than 500 drug products and vaccines currently in clinical trials, and has produced hundreds of diagnostic tests (BIO 2008). Based on key economic and employment indicators (discussed below), the biotechnology and life sciences industries are the fastest-growing in the U.S., creating high-quality employment and generating substantial economic activity for states and communities nationwide.

Modern biotechnology is defined by the techniques or technologies that it uses to create products, rather than the products themselves. These technologies include DNA technologies, protein engineering technologies, bioprocessing technologies, nanobiotechnologies, microarrays, monoclonal antibodies, and information technologies. Biotechnology firms use these technologies for applications in medicine, agriculture, environmental remediation, consumer products, and food safety and industrial processes. Products include marketable goods and services, such as drugs and pharmaceuticals, genetically-modified foods, medical diagnostics and services, petroleum products, and agricultural products.

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<sup>6</sup> Boyer would go on to co-found Genentech, the first and still the largest biotech company in the world by market capitalization.

Because of the inclusiveness of the term “biotechnology,” there is no universally-agreed upon set of sectors or industries included in the cluster that features biotechnology and biotechnology-related products, processes, and services. Indeed, the “biotechnology industry” actually encompasses a broad range of industries, market sectors, and activities (e.g., manufacturing, services, and research), while spanning at least 23 industrial classifications (see Appendix A).<sup>7</sup> While narrow definitions of the cluster may include only commercial activities associated with DNA and RNA manipulation, loose definitions may include all drugs and pharmaceutical companies (even those that manufacture and market traditional drugs, e.g., chemical compounds developed through “trial and error”<sup>8</sup>), medical devices, and hospitals and clinics (RTS 2003).

Terms commonly used to describe this cluster include “life sciences,” “biosciences,” and “biomedical.”<sup>9</sup> In general, life sciences or biosciences are considered broader concepts than biotechnology, and typically include the following sectors and subsectors:

- Healthcare
  - Drugs and pharmaceuticals, e.g. prescription, generic, over the counter drugs
  - biologics, e.g., bacterial and viral vaccines, human blood products, gene therapy
  - Devices, e.g., pacemakers, contact lenses, prostheses

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<sup>7</sup> In 2005, the US Department of Labor charged the San Diego Workforce Partnership with collecting labor market information on the US biotechnology industry. The Partnership convened a National Advisory Committee to develop a consensus on the occupations constituting the industry. The Committee agreed on 23 North American Industrial Classification System (NAICS) codes, categorized into six industry segments: Agricultural Biotechnology; Industry Biotechnology; Medical Devices; Medical Equipment and Supplies; Pharmaceuticals and Related Manufacturing; and Research Services. See Appendix A. The committee also determined that the industry comprises more than 197 unique Radford occupations (829 when occupation levels are counted). [www.biotechwork.org](http://www.biotechwork.org)

<sup>8</sup> See Zhang and Patel (2005).

<sup>9</sup> For instance, a BIO-sponsored Battelle annual report uses the term “bioscience” and defines the industry as including four subsectors: Agricultural Feedstock and Chemicals; Drugs and Pharmaceuticals; Medical Devices and Equipment; and Research, Testing, and Medical Laboratories. The California Healthcare Institute (CHI) uses the term “biomedical” to include academic research, biopharmaceuticals, diagnostics, laboratory services, medical devices, and wholesale trade.

- Diagnostics, e.g., testing equipment and techniques such as microarrays and test kits (pregnancy, drugs, HIV, genetics)
- Combinations, e.g., drug/device, drug/biologic, drug/biologic/device
- Research Tools (e.g., DNA and protein sequences and microarrays)
- Agricultural Biotech (feedstock and chemicals)
- Industrial and Environmental Biotech
  - Energy
  - Environmental technology
- Biotechnology Research & Development

In this study, the term “biotechnology” will be used broadly to encompass those sectors often included in the life sciences or biosciences rubric, but excluded in stricter definitions of biotechnology: namely, medical devices and diagnostics. This is because many of the community college training programs that form the subject of this research train students and incumbent workers with skills that can be applied to most or all of these fields. However, as the majority of programs train for the biopharmaceutical fields, the term will usually refer to two sectors within this field: Pharmaceutical and Medicine Manufacturing (NAICS code 3254); and Research and Development in the Physical, Engineering, and Life Sciences (NAICS code 541710) (See Appendix A).

## **1.2 Industry Overview: Growth, Employment, and Wages**

### U.S. Overview

The biotechnology industry has grown rapidly since the 1990s. Between 1994 and 2003, for instance, biotechnology revenues increased by 250 percent, and total employment rose by 93 percent (Zhang and Patel 2005). The number of biotechnology products on the market increased from 2 in 1982 to more than 400 today (BIO 2008). The industry continued its expansion during



the economic downturns earlier this decade, suggesting that long-term trends in this high-growth sector will remain positive, even despite the current economic crisis.

The latest Ernst & Young annual biotechnology industry report estimated that, at the start of 2007, there were approximately 1,452 biotechnology companies in the U.S., employing approximately 180,000 people (BIO 2008). 336 of these companies (in 2006) were publicly held, generating sales of \$45.9 billion and revenue of \$53.5 billion, and spending \$27 billion on research and development. By the end of April 2008, the industry's market capitalization was \$360 billion.

Regarding the larger biosciences/life sciences industry, there were nearly 43,000 companies in 2006, employing almost 1.3 million people, up from 1.2 million in 2004 (Batelle 2008). While this employment figure represents a mere 1.1 percent of total U.S. private sector employment, the industry's economic impact is estimated to be much larger, due to its employment multiplier effect. Batelle Technology Partnership Practice has estimated that the bioscience industry in 2006 produced an additional 6.2 million related jobs, through indirect and induced employment. When added to direct jobs, the total of 7.5 million jobs represents an overall employment multiplier effect of 5.8.

Not only is the industry's employment base growing,<sup>10</sup> but its employment growth also appears to be outpacing that of the nation as a whole. From 2001 to 2006, for instance, bioscience employment grew by 5.7 percent, compared with 3.1 percent for the national private sector overall (Batelle 2008). Table 1, below, shows the largest and fastest-growing of the four biosciences subsectors included by Batelle:

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<sup>10</sup> The U.S. Department of Labor projects that employment in life sciences will increase by 18 percent between 2002 and 2012. BLS, Quarterly Census of Employment and Wages.

**Table 1.1**  
**U.S. Bioscience Employment and Establishments, 2006, and Changes, 2001-2006**

Bioscience Subsector	2006 Establishments	Change in Establishments 2001-06	2006 Employment	Change in Employment 2001-06
Agricultural Feedstock & Chemicals	2,183	3.8%	105,846	-6.1%
Drugs & Pharmaceuticals	2,654	1.9%	317,149	4.0%
Medical Devices & Equipment	15,215	0.3%	422,993	-0.9%
Research, Testing, & Medical Laboratories	22,857	32.7%	449,991	17.8%
<b>Total U.S. Biosciences</b>	<b>42,910</b>	<b>15.7%</b>	<b>1,295,979</b>	<b>5.7%</b>

Source: Batelle (2008) analysis of Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW) data.

Finally, the biosciences industry provides high-wage jobs, outstripping the average annual wages of other private-sector workers. In 2006, U.S. bioscience workers earned \$70,959 on average, compared to \$42,272 for the total private sector—a premium of nearly \$29,000, or 68 percent more than private sector wages overall. As the following table shows, wages were highest in the drugs and pharmaceutical subsector and lowest in the medical devices and equipment subsector:

**Table 1.2**  
**Average Annual Wages in the Biosciences and Other Major Industries, 2006**

U.S. Average Annual Wages per Employee, 2006	
<b>Drugs &amp; Pharmaceuticals</b>	<b>\$ 86,892</b>
Information	\$ 76,257
Professional, Scientific, and Technical Services	\$ 71,544
<b>Research, Testing, &amp; Medical Laboratories</b>	<b>\$ 71,284</b>
<b>Total Biosciences</b>	<b>\$ 70,959</b>
<b>Agricultural Feedstock &amp; Chemicals</b>	<b>\$ 67,870</b>
Finance and Insurance	\$ 65,095
<b>Medical Devices &amp; Equipment</b>	<b>\$ 59,441</b>
Manufacturing	\$ 54,856
Construction	\$ 43,215
<b>U.S. Total Private Sector</b>	<b>\$ 42,272</b>
Transportation and Warehousing	\$ 42,013
Real Estate and Rental and Leasing	\$ 41,071
Health Care and Social Assistance	\$ 40,205
Retail Trade	\$ 25,849

Source: Batelle (2008) analysis of BLS QCEW data

As with employment growth, average wage growth in the biosciences industry has surpassed that of the private sector overall. Since 2001, real earnings in biosciences grew by 7.5 percent, compared to 3 percent for the private sector as a whole (Batelle 2008).

### California's Biotechnology Industry

California is widely recognized as the global leader in biotechnology-related industries, as well as the birthplace of biotechnology. In the 1970s, with Silicon Valley growing and the venture capital industry taking off, two San Francisco Bay Area researchers discovered a new recombinant DNA technique. Their meetings with a venture capitalist who sought to commercialize this new technology led to the founding of the world's first biotech company, Genentech ("genetic engineering technology"), in South San Francisco—the city that proudly claims to be *the* birthplace of the industry (Zhang and Patel 2005).

According to a newly-formed alliance of the state's three largest life sciences associations, California's life sciences firms and research organizations represent almost half of the global biotechnology industry. California has a disproportionate share of the U.S. biotechnology industry: A 2003 U.S. Department of Commerce study reported that 26 percent of biotech companies nationwide were located in California (US DOC 2003). Other studies indicate that the state accounts for 53 percent of U.S. biotech revenues, and 43 percent of U.S. biotech employment (Zhang and Patel 2005). The largest biotech company in the world, Amgen, Inc., headquartered in Thousand Oaks, California, produces more than a third of the world's output of certain kinds of protein therapeutics.

The Batelle report (2008) estimates that the state's bioscience industry in 2006 employed 197,354 people in 6,096 establishments. Between 2001 and 2006, the state's employment in the two of the four subsectors grew faster than the national rate: Drugs and pharmaceuticals

employment growth was 13.6 percent (versus four percent for the nation), while agricultural growth was nine percent (compared to -6.1 percent for the nation). On average, California’s bioscience employees earned approximately \$79,000, far greater than the state’s annual average wage of \$41,796.

Using a slightly different categorization of life science subsectors, the California Healthcare Institute estimates that, in 2006, the state’s biomedical industry (of which biotechnology is a key part) employed 267,600 people working in more than 2,700 companies (CHI 2008). This employment figure represents an estimated growth of 5.4 percent since 2001—versus 3.1 percent for the state as a whole. Moreover, only the computer programming and related services industry employed more workers (306,200) than the biomedical industry in 2006.

As Table 1.3 shows, the largest share of bioscience employees worked in the medical devices, instruments, and diagnostics subsector, while those working in the biopharmaceutical sector earned the most (\$86,100) on average. Overall, biomedical employees earned \$18.2 billion in wages and salaries in 2006, for an overall average biomedical wage of \$71,300—a figure that is 61.4 percent greater than the average annual wage of \$44,180 for all occupations in the state.

**Table 1.3**  
**Distribution of Employment and Wages in CA Biomedical Industry, 2006**

Biomedical Subsector	Employment	Distribution of Employment	Average Annual Wages
Medical Devices, Instruments & Diagnostics	113,800	43%	\$71,200
Biopharmaceuticals	79,000	30%	\$86,100
Academic Research	39,800	15%	\$48,200
Wholesale Trade	30,000	11%	\$67,800
Laboratory Services	5,100	2%	\$44,200
<b>Total Biosciences</b>	<b>267,600</b>	<b>100%</b>	<b>\$71,300</b>

Source: California Healthcare Institute (2008). Note: Numbers may not sum to total due to rounding.

### Outsourcing

The industry has cited a litany of challenges to doing business in California, from high tax and regulatory burdens to the high cost of living and real estate. Many state and local governments also offer tax incentives and other infrastructure and transportation commitments as part of their industry attraction packages. California companies have responded, expanding their research and manufacturing operations outside the state at a rapid pace. For instance, 86 percent of California biomedical companies responding to a 2007 survey indicated that they already manufacture products in other states and countries (CHI 2008); 69 percent expanded their manufacturing facilities outside the state during 2006, and 78 percent expected to do so in the next two year. Such trends threaten to erode California's position as an industry anchor.

On the other hand, a majority of the respondents to the same 2007 survey expressed a commitment to remaining in the State and producing jobs: 68 percent expanded their R&D capacity within the state in 2006, and the same percent expected to do the same within the next two years. Moreover, fifty-nine percent of respondents expanded their in-state manufacturing capacity in 2006, and 61 percent expected to do the same within the next two years (CHI 2008). These trends, and their implications for the employment prospects of community-college trained technicians, will be examined in greater length in Chapter Eight.

### California's Biotech Clusters

Like other advanced knowledge industries, the biotechnology industry tends to cluster in areas with competitive advantage. Most biotech research and production occurs in nine metropolitan "super clusters:" Boston; San Francisco Bay Area; San Diego; Research Triangle Park, NC; Los Angeles; Philadelphia; New York/New Jersey; Seattle; and Washington DC/Baltimore.

Within California, the biotechnology industry is clustered in three centers: the San Francisco Bay Area, the Los Angeles region, and the San Diego region.<sup>11</sup> The Bay Area is widely regarded as having the largest concentration of life sciences firms in the world. The region's leading life sciences association, BayBio, estimates that the nine counties and 101 cities comprising the Bay Area are home to 1,377 life sciences companies, employing 90,000 direct life sciences employees and 180,000 indirect employees, and paying \$6 billion in wages. The life sciences industry in the Bay Area has produced 449 marketed products, and has 492 products in Phase Two or Three clinical trials. Moreover, Northern California is home to 34 percent of active U.S. venture capital firms, a regional concentration that is among the highest in the world.

San Diego County is also one of the nation's major biotechnology centers. While the biotechnology industry employs only one percent of all workers in the U.S., it employs 2.6 percent of workers in San Diego (SDWP 2006). The region's life sciences association, BIOCOM, estimates that the life sciences industry in Southern California employs more than 105,000 employees at more than 1,800 companies in 9 countries. Moreover, Southern California healthcare venture capital was \$1.68 billion in 2007; the region also received more than \$1.79 billion in research funding from the National Institute of Health.

### **1.3 Life Cycle of Biotech Products and Corresponding Workforce Needs**

The biotechnology industry cycle involves four primary stages of development: conception, formation, growth and maturity. The industry's workforce needs vary along this cycle, as will be discussed in the next section.

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<sup>11</sup> The Sacramento/Stockton areas in northern California is a fourth important biotech center. [get updated table on concentration of biotech companies by region.]

To highlight the steps involved in the development process, this section describes the development cycle of a drug, although the process applies as well to the development of a medical device, food product, agricultural product, or other biotech products. Drug development is a long and costly endeavor, taking 12-15 years and from \$800 million to \$1.7 billion to bring a new drug to market (Kellogg 2006). In addition, only one in five developed drugs makes it through clinical trials.<sup>12</sup>

### Research/discovery<sup>13</sup>

The first stage of the drug discovery process, often called the conception phase, can last from two to ten years. During this research stage, scientists and laboratory staff conduct small-scale experiments on promising compounds, treatments, and approaches. The typical R&D team consists of scientists, research associates, laboratory assistants and technicians. Most lead scientists have Ph.D.s in biology and chemistry, while other staff tend to have master's or bachelor's degrees. Some companies find that they can successfully rely on technicians trained in two-year Associate's degree programs. Most firms at this stage are small, employing between one and 50 people. In addition to such start-ups, drug discovery also occurs in academic research institutions and research parks/biotech incubators.

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<sup>12</sup> The former president of Bay Bio, the San Francisco Bay Area's life science association, recently argued with regard to the current economic crisis and its impact on biotechnology development that it is far more important to assess a company's prospects by how it performs in clinical trials than by how it does on Wall Street. That is, if the company fails in the current economy because of poor clinical trials, it would have failed even when the economy was stronger. He noted that the product pipeline *is* actively moving, and this factor most determines the industry's progress and growth, not conditions on Wall Street, particularly since only ten percent of companies are publicly traded. Moreover, because the product pipeline is about 14 years in length and the economic cycle is about seven, the biotech industry is anti-cyclical, thus buffering it somewhat from severe economic jolts.

<sup>13</sup> This section is drawn in part from Peters and Slotterbeck, 2004, "Under the Microscope: Biotechnology Jobs in California." Sacramento: California Employment Development Division, Labor Market Information Division.

## Development/clinical

In this second stage, also called the formation stage, the R&D team produces small amounts of the product for testing and experiments to determine the drug's safety and efficacy in humans.

Limited-scale production of the drug usually takes place in a pilot plant or separate section of the laboratory. Alternatively, a company may contract out to a contract manufacturing organization (CMO) for pilot-scale manufacturing of the drug.

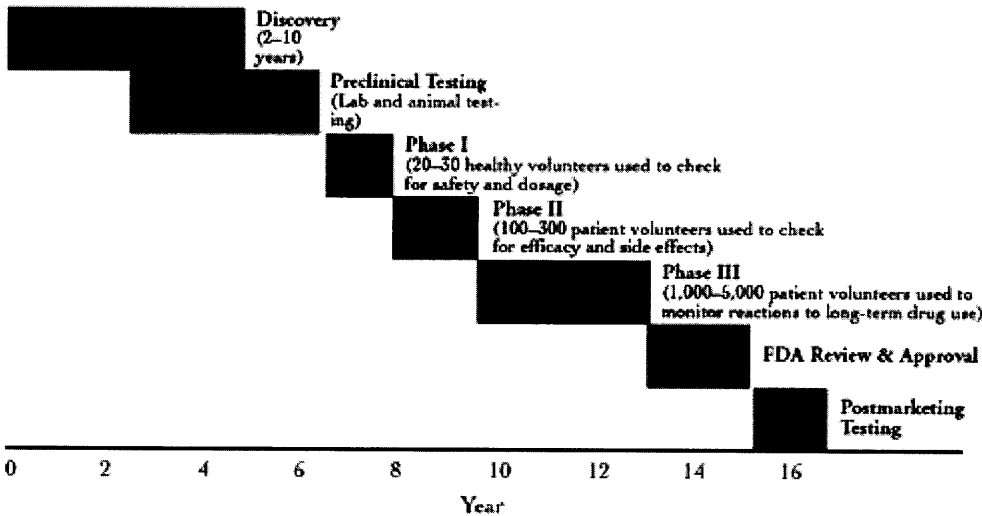
Once the company has produced sufficient quantity of the drug for use in clinical trials, the clinical trial stage begins. This stage, which is the most costly, lengthy, and regulated, occurs in three steps, as shown in Figure 1.1:

- Pre-clinical testing involves laboratory and animal testing.
- Clinical testing on patients, which occurs in three trial levels: Phase One, Phase Two, and Phase Three.
- FDA review of clinical trial test results to determine the drug's safety and effectiveness.

During the clinical trials stage, companies must secure sufficient venture capital and other investments to assist in the drug's development. Firms that are smaller and less established may decide to contract out their clinical trials production to clinical or contract research organizations (CROs). Primary occupations at this stage include clinical researchers and clinical lab technicians, who conduct the clinical research; statisticians; and sometimes MDs and nurses. Firms in clinical testing typically employ between 51 and 300 people.



**Figure 1.1: Biotech Drug Discovery Process**



Source: BIO website, [www.bio.org](http://www.bio.org); Ernst & Young LLP, *Biotechnology Industry Report: Convergence*, 2000

Even before receiving FDA approval for the manufacturing and marketing of their drugs or medical devices, the companies must demonstrate that they can manufacture their products consistently and in adherence with FDA and EPA regulations, namely Current Good Manufacturing Practices (cGMPs).<sup>14</sup> GMPs require that all manufacturing and testing equipment be qualified as suitable for use, and that all manufacturing methodologies and procedures be validated to show that they can perform their intended functions. Period FDA inspections ensure that the company is following these practices. For non-clinical trials, Good Laboratory Practices (GLP) apply.

### Manufacturing

In this growth stage, the company seeks to expand and develop industry networks, while engaging in business planning. Companies reaching this engineering and regulatory stage

<sup>14</sup> These practices apply to the testing and manufacturing of food products, pharmaceuticals and medical devices. See U.S. Food and Drug Administration, Center for Drug Evaluation and Research, 21 Code of Federal Regulations.

typically grow to employ upwards of 300 people. Once the company receives FDA approval, it can undertake large quantity production of the product. If it decides to produce the product in-house, it may need to create a manufacturing facility, and hire additional manufacturing process staff.

However, because the design, construction, validation, and licensing of a manufacturing facility takes four to five years to complete and is very expensive (costing from \$300 to \$500 million—five times more than a traditional chemical plant), companies must be able to commit to such projects well in advance of FDA approval—which does not always materialize (NCBC 2003; Kamarck 2006). Hence, many firms, particularly those that are small and less established, or that lack sufficient revenue streams, partner with other firms to share manufacturing capacity. A growing number is turning to contract manufacturing organizations for their product manufacturing. Some firms outsource manufacturing until they obtain FDA approval and can build their own manufacturing facilities, some do so while they increase their own manufacturing capacity, while others elect to outsource all manufacturing regardless of their capacity. The high cost of operating a plant when production is weak is another reason that many firms enter into capacity sharing or contract management arrangements.<sup>15</sup>

As discussed further below, this stage generates the broadest economic impact due to its significant job creation and expansion of occupations. In addition to engineers and regulatory staff, companies must hire manufacturing technicians, lab technicians, facilities maintenance staff, and quality control and assurance staff.

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<sup>15</sup> A (perceived) shortage of worldwide manufacturing capacity at the start of this decade led to a boom in facility construction by companies and CMOs alike, which apparently has abetted the problem (Thiel 2004).

## Commercial

This final stage, often called the maturity stage, involves the product's marketing and sales.

Company employment at this stage can reach into the thousands, and includes such occupations as sales, brand managers and medical affairs. Companies that employ a sales and marketing staff will often decide to market the drug themselves. Those without such a staff (usually smaller companies) may opt to sell or license the drug to another, often larger company; jointly market the drug with another company; or agree to be purchased outright by another company.

### **1.4 Biotech Occupations: Growth of the Technical Workforce**

As the biotechnology industry moves through the product life cycle—from research and development, to process and product development, and finally to manufacturing and commercialization—companies' human resource needs undergo substantial changes, all of which have important implications for job creation and employment. Three changes in particular merit attention.

#### 1. Employment growth

At the most basic level, the total number of employees increases throughout the product development cycle. As noted, firms starting out in the basic research phase employ under fifty employees, while those that reach the growth and maturity stages typically employ upwards of 300 people, and often in the thousands.

#### 2. Occupational growth

The industry's move to such downstream functions as clinical trials and product manufacturing alters the mix of jobs and skills, which increase in range and diversity. For instance, companies

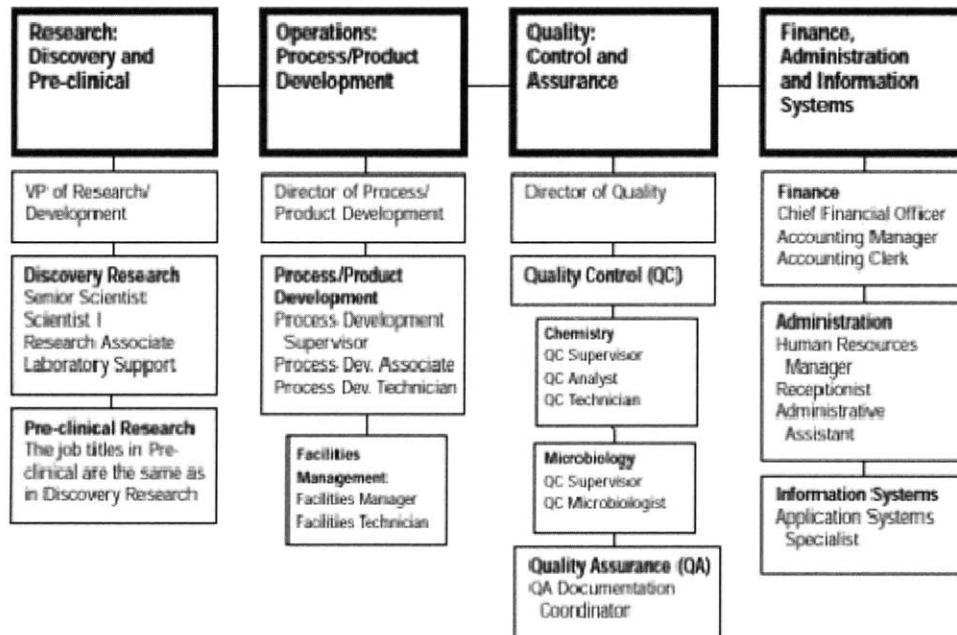
that reach the product development/clinical trials process must create independent laboratory facilities and develop their bioinformatics, manufacturing, quality control and assurance, and regulatory capacities (Time Structures 2006). These new functions increase demand for employees trained in the appropriate skill sets. Even firms that outsource their clinical trials production to CROs must hire in-house staff with knowledge of the clinical research process. Further, larger firms that reach the manufacturing and commercialization stages must hire staff trained in such areas as manufacturing production, facilities management, validation and instrumentation, business development, and marketing and sales. Many of these newly created positions offer entry-level employment opportunities that do not require an advanced degree. In addition, the increasing application of biotechnologies to other industry sectors (e.g., energy, the environment, regenerative medicine, nanotechnologies) requires that a growing number of biotech employees have cross-disciplinary training.

Figures 1.2 to 1.4 (in the pages below) offer an overview of biotechnology occupations and functions within companies at three different stages in the development life cycle. The organizational charts highlight the increase in technician and laboratory technician positions as the company adds such functions and activities as manufacturing, aseptic fill and validation.<sup>16</sup>

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<sup>16</sup> 313 different occupations have been identified within the biotech industry (NOVA 2004). The California Employment Development Department has grouped 36 major occupations constituting careers within the industry into seven occupational clusters: Research and Development; Clinical research, Manufacturing and production, regulatory affairs, Quality systems, Information systems. See <http://www.labormarketinfo.edd.ca.gov/?pageid=136>.

**Figure 1.2**  
**Small Biotechnology Companies (1-49 Employees)**



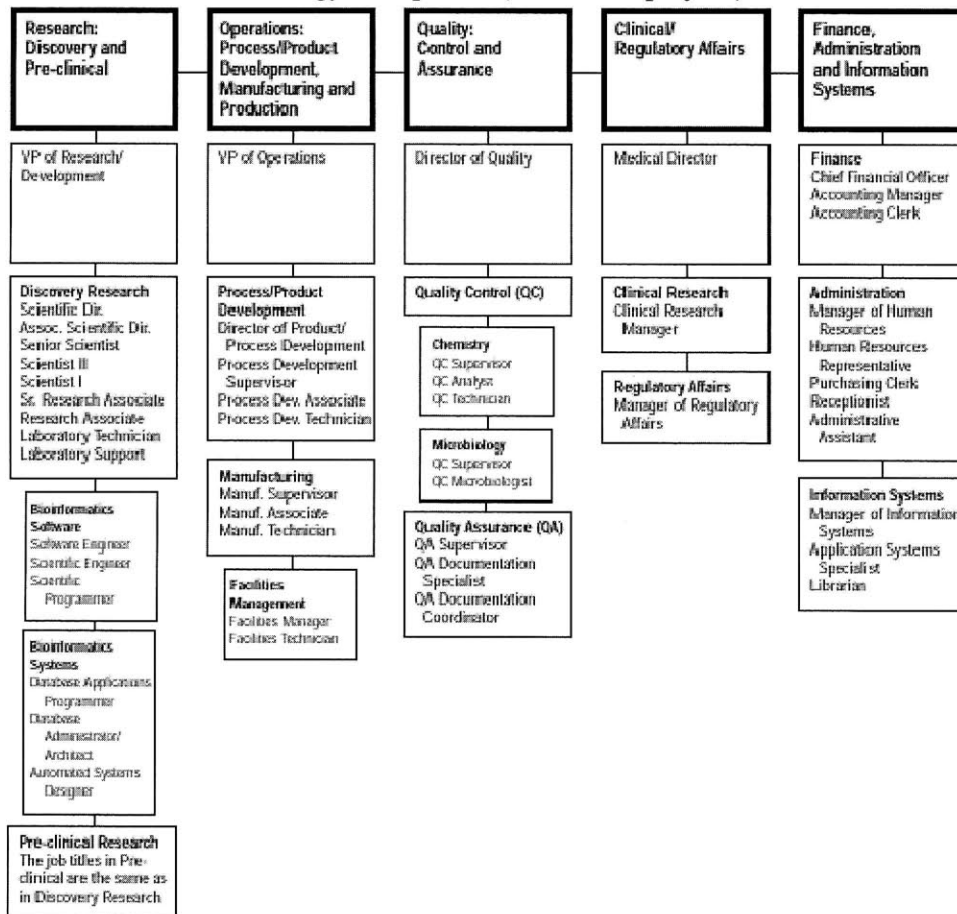
Source: Time Structures (2006), California State University, CSUPERB (2001).

For purposes of this study, the most significant aspect of the expansion and diversification of occupations is the growth of the technical or operational workforce. Technician-level occupations contain a sizable number of entry-level positions for workers without a four-year degree, and thus provide entry into the industry for many nontraditional workers. For instance, a 2003 U.S. Department of Commerce study found that the biotech-related R&D technical workforce<sup>17</sup> of 850 responding companies grew at an average rate of 12.3% from 2000 to 2002.<sup>18</sup> For science and clinical laboratory technician positions, which comprise approximately 30 percent of this workforce (and which contain entry-level positions), the annual growth rate was 13.8 percent over this period (Commerce 2003).

<sup>17</sup> Comprising this workforce are scientists, engineers, science and clinical lab technicians, and R&D-focused computer specialists; among these, 30 percent are technicians and 55 percent are scientists.

<sup>18</sup> In companies with 50 to 499 employees, this workforce grew at an average annual rate of 17.3 percent, while that of larger companies grew by 6.2 percent—lower than the average rate but still exceeding the rate for all U.S. nonfarm payroll employment.

**Figure 1.3**  
**Medium-Size Biotechnology Companies (50-149 Employees)**

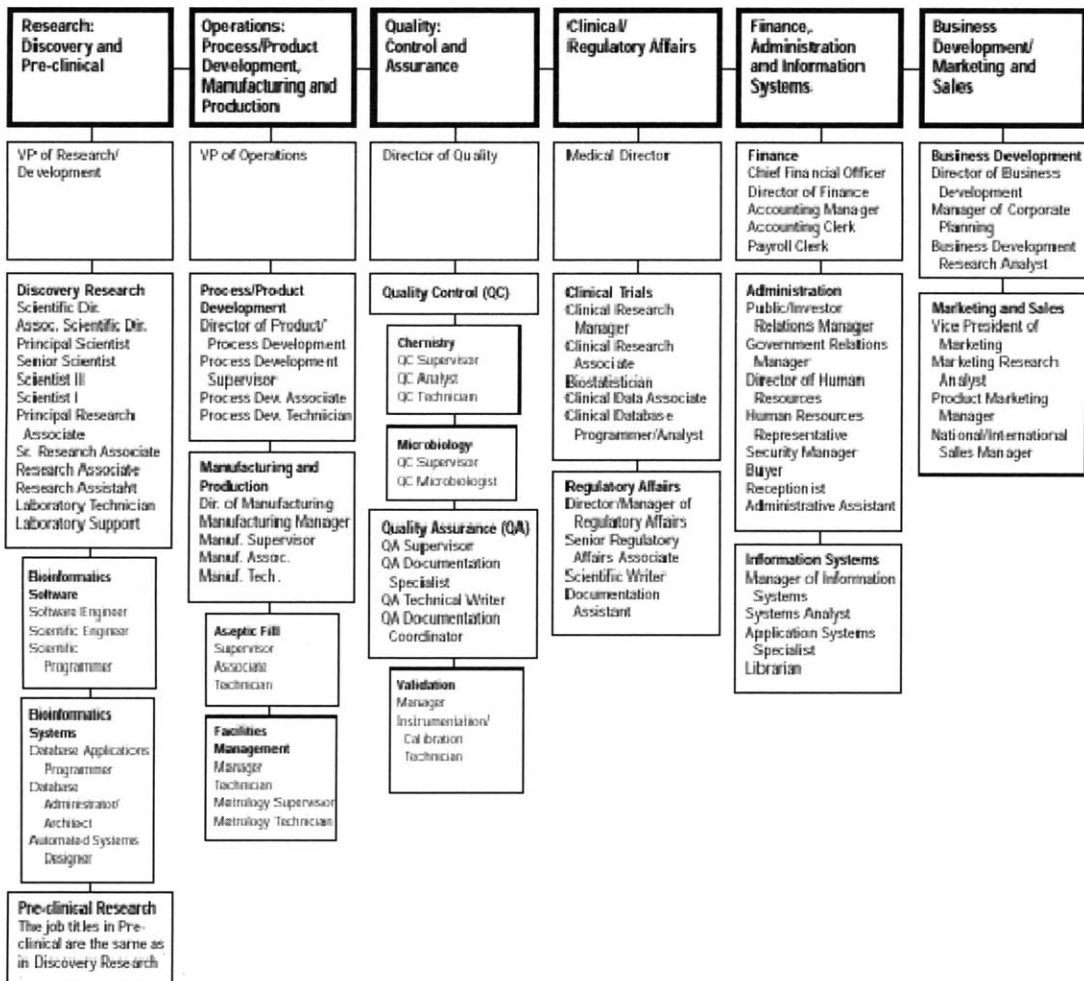


Source: Time Structures (2006), California State University, CSUPERB (2001).

With regard to one occupation of relevance to this study—that of biological technician—national and California data suggest that it is a high-growth, high-wage, in-demand occupation. As defined by the U.S. Department of Labor, biological technicians:

Assist biological and medical scientists in laboratories. Set up, operate, and maintain laboratory instruments and equipment, monitor experiments, make observations, and calculate and record results. May analyze organic substances, such as blood, food, and drugs (See <http://online.onetcenter.org/link/summary/19-4021.00>).

**Figure 1.4**  
**Large Biotechnology Companies (150+ Employees)**



Source: Time Structures (2006), California State University, CSUPERB (2001).

According to U.S. Bureau of Labor Statistics data, this occupation is projected to grow by 16 percent between 2006 and 2016, from 78,690 to 91,288, a faster than average growth rate for all industries. Within two key biotech subsectors, the pharmaceutical and medicine manufacturing industries and the Scientific R&D services industries, the corresponding growth rates for biological technicians are, respectively: 26.6 percent (from 20,440 to 25,754 over the ten year period)<sup>19</sup>; and 17.2 percent (from 20,000 to 23,440 employees). This occupation pays an

<sup>19</sup> A slightly different BLS calculation puts the growth rate for biological technicians at 28.2 percent between 2004 and 2014. See [http://www.doleta.gov/Brg/Indprof/Biotech\\_profile.cfm](http://www.doleta.gov/Brg/Indprof/Biotech_profile.cfm).

average hourly wage of \$18.18 and an average salary of \$37,810, and its projected need is for more than 41,000 employees.

California Employment Development Department data also paint a robust picture of this occupation, with the number of biological technicians increasing by 29.8 percent (from 10,400 to 13,500) between 2006 and 2016. The agency estimates that average annual openings will be 680, while additional openings due to net replacements will reach 3,700. Further, the occupation's hourly mean wage in the first quarter of 2009 was \$22.61, and the annual mean salary in 2008 was \$45,223 (the annual median salary in 2009 was \$43,642).<sup>20</sup>

Corresponding to the biological technician occupation are laboratory assistants and assay analysts, both of which have entry-level positions for workers with less than a four-year degree. Additional occupations within the larger categories of science and clinical laboratory technicians and manufacturing and bioprocess technicians include:

- Animal care technician
- Assay Analyst
- Aseptic fill technician
- Documentation associate/assistant
- Facilities/maintenance technician
- Instrumentation/calibration technician
- Laboratory technician
- Manufacturing/process technician
- Material handler/packager
- Process development associate
- Quality control (QC) technician
- Research technician/assistant

Based on a Mass Biotechnology Council outline of occupations in the biotechnology industry, Fitzgerald (2006) compiled the following table describing the four major types of

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<sup>20</sup> See the CA EDD's occupational profile for biological technicians:  
<http://www.labormarketinfo.edd.ca.gov/cgi/databrowsing/occExplorerQSDetails.asp?searchCriteria=technician&careerID=&menuChoice=&geogArea=0601000000&soccode=194021&search=Explore+Occupation>



production workers in a manufacturing facility and their corresponding educational requirements:

**Table 1.4  
Biotechnology Technician Job Descriptions**

<b>Position</b>	<b>Responsibilities</b>	<b>Entry-Level Education</b>
Facilities Technician	Monitors, repairs, and performs preventive maintenance on systems and equipment; documents repairs and may suggest changes to Standard Operating Procedures	AA/AS degree in mechanical/electrical field or high school diploma and 5 years of experience
Aseptic Fill Technician	Assists in Operating and Maintaining production systems; sets up and operates labeling and packaging equipment	AS (preferred) or Biomanufacturing Certificate; 1-2 years of experience; knowledge of regulations
Instrumentation/Calibration	Maintains, tests, troubleshoots, and repairs circuits, components, analytical equipment, and instrumentation; calibrates instrumentation and performs validation studies; requires continuous monitoring of equipment	AS in electronics technology or related field; 2-4 years of experience; GMP experience
Manufacturing Technician	Assists in specific production-related operations in cell culture/fermentation; operates and maintains production equipment (e.g., fermenters, bioreactors, cell harvest and separation operations); weighs, measures, and checks raw materials	High school diploma; Biomanufacturing Certificate

Source: Fitzgerald (2006), Mass Biotechnology Council

A 2006 study of the biotech industry’s entry-level hiring needs in two counties of the Bay Area with high concentrations of biotech companies (San Mateo and Alameda Counties) found that, among the 16 companies surveyed, the predominant hiring requirement was for manufacturing/production technicians, at an average starting salary of \$38,584 (PriceWaterhouseCooper 2006). While less than half of respondents indicated that they would hire such workers, those that expected to do so would be hiring in large quantities.

### 3. Shift in education and training requirements.

The third key human resources change that occurs as companies transition to commercialization is a shift in the education and training requirements for many of the newly-created technical positions. For an advanced industry, biotechnology is exceptionally knowledge-intensive, with a highly-educated workforce. More than 47 percent of biotech company founders, 40 percent of CEOs, and 80 percent of R&D officers hold doctoral degrees (Zhang and Patel 2005).<sup>21</sup> While the basic research process thus tends to require more scientists with Ph.D.s, the clinical trials and especially manufacturing processes can rely more heavily on technicians with less than a four-year degree in a biosciences-related field.

Comprehensive data on the percentage of a company's workforce that falls within the technician-level or entry-level category (i.e., those for which a community college certificate or associate's degree is the minimal educational requirement) are slim. One report estimates that a company's technician/operational workforce comprises from 40 percent to 80 percent of company employees, depending on the company's size and stage in the product lifecycle (CCC 2002). Another report for the California Community College Advanced Biological Initiative estimated that about 32 percent of new, entry-level jobs created between 2004 and 2006 within the life sciences industries required an Associate of Arts/Science degree. It further found that, among the 30,000 new life sciences-related positions that are projected to be created between 2002 and 2012, an estimated 25 percent will require an associate's degree (Time Structures 2006).

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<sup>21</sup> The biotech industry is commonly perceived to be similar in key respects to other high-tech industries, such as the computer, software, and semiconductor industries. However, the biotech industry differs from its high-tech counterparts in educational level, since most IT company founders and R&D employees are engineers (Zhang and Patel 2005).

The Labor Market Division of the California Employment Development Department projects that 43,600 technicians with AA degrees will be needed by 2010, an increase of 17 percent since 2000. 8,100 additional technician-level positions could become vacant due to separations and internal promotions (Time Structures 2007). Finally, a 2008 Batelle technology report notes that the largest bioscience subsector included in its study—medical and clinical laboratory technicians (with 305,470 employees nationwide in 2006)—is also the field in which a majority of bioscience graduates have received associate’s degrees.

Based on several reports from states with active life sciences clusters, educational requirements for new entry-level technician jobs appear to be variable. For instance, a recent report commissioned by the Massachusetts Biotechnology Council and the Massachusetts Life Sciences Center notes that the state’s life sciences industry is growing almost 45 percent faster than other industry sectors, and that, consequently, demand for highly qualified workers is increasing, both in R&D and in downstream business sectors, such as clinical trials and biomanufacturing. The report cautions that, of these newly-created jobs, more than 80 percent will require at least a four-year degree. However, it also notes that the industry continues to offer opportunities for manufacturing workers and skilled technicians without a four-year degree (MBC 2008: 11). Significantly, the report underscores the potential to expand employment opportunities for those with less than a four-year degree. Measures to achieve such a labor market transformation include more closely identifying the skills needed for entry-level positions in the state and better tailoring community college curricula and programs to meet these skill needs.

The apparent trend in Massachusetts toward hiring at higher educational levels for entry-level positions does not necessarily hold elsewhere, however, as the report notes. For instance,

in North Carolina, 75 percent of the positions in manufacturing/production require only a high school diploma, 13 percent require a two-year degree or certificate, and only 11 percent require a BS (with 1 percent requiring a MS/PhD (NCBC 2003)).<sup>22</sup> Moreover, about 50 percent of all employees work in production divisions, in which employees with high school diplomas or community college certificates and associate's degrees comprise 67 percent of the total workforce.

A more recent study of workforce development initiatives within North Carolina's life sciences industry found that approximately sixty percent of jobs at a typical life sciences company are accessible to high school diploma and GED holders (Lowe 2007). As the author explains, the composition of the life sciences industry in the state is likely one key factor in explaining the lower educational requirements. That is, traditional, chemical-based manufacturers have tended to dominate the industry, whose development processes are less advanced than biotechnology processes. However, as chemical companies begin using bio-manufacturing processes, or as more bio-manufacturing companies enter the state, the level of educational requirements could change to match that of other states, e.g., Massachusetts.

Within California, a leading biotechnology company conducted a similar analysis of job types by educational level within the San Diego life sciences cluster. Table 1.4 presents the results for the manufacturing and quality areas:

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<sup>22</sup> In surveying this data, Fitzgerald (2006) notes that North Carolina is one of the few states to compile such statistics. Indeed, California appears to lag behind both North Carolina and Massachusetts in this regard.

**Table 1.5**  
**Job Types by Education Levels (Estimates)**

Job Type	High school degree	2-year degree	4-year degree
<i>Quality</i>			
Quality Assurance	0	40%	60%
Quality Control	0	40%	60%
<i>Manufacturing</i>			
Operations	25%	50%	25%
Logistics	0	60%	40%
Materials Control	40%	40%	20%
Maintenance & Facilities	45%	50%	5%

Source: DOL (2004): IDEC Pharmaceuticals, San Diego, CA

Available data suggests that there is job growth among occupations for which a community college Certificate or Associate's degree is the minimal educational requirement. Table 1.7 presents the projected growth in selected life-science occupations from 2000 to 2010, as well as corresponding education levels for the occupations.

A 2006 study of the biotech and life sciences cluster in the San Francisco Bay Area surveyed 59 companies about their workforce needs, and concluded that there are significant opportunities for certificate and associate degree candidates. Table 1.6 shows that proportion of responding companies that require less than a bachelor's degree for the following occupations:

**Table 1.6**  
**Proportion of Companies Requiring Less than a Bachelor's Degree by Occupation**

Occupation	Proportion of Companies
Manufacturing Technician	78.3%
Calibration Technician	62.4%
Manufacturing Associate	55.0%
Bioassay Associate	52.9%
Animal Technician	40.0%
Clinical Lab Associate	22.3%
QA/QC Specialist	20.0%

Source: Godbe Research (2006).

The 2006 study analyzed high demand biotech occupations in the Bay Area, and found especially strong demand and potential workforce shortages for at least four occupations suitable for entry-level workers: bioassay analysts, calibration technicians, manufacturing technicians,

and clinical lab associates. It also found that, overall, the strongest percentage growth in total employment was forecast for manufacturing associates, bioassay analysts, clinical lab associates, process development associates, and biostatisticians.

**Table 1.7  
Biotechnology Careers at a Glance**

Occupation Clusters	Education	Growth 2000–2010 <sup>1</sup>	75th Percentile Hourly Wage <sup>2</sup>
<b>Research and Development Occupations</b>			
Greenhouse Assistants*	High School	23%	\$16.95 to \$22.56
Laboratory Support Workers*	High School	-2%	\$8.43 to \$16.48
Laboratory Assistants*	Certification or Associate	28%	\$21.96 to \$22.56
Plant Breeders*	Bachelor's	22%	\$16.95 to \$34.49
Research Associates (R&D)*	Bachelor's	34%	\$28.28 to \$42.59
Research Scientists*	Doctorate	34%	\$28.28 to \$42.59
<b>Clinical Research Occupations</b>			
Animal Handlers	High School	34%	\$11.97
Animal Technicians	Certification or Associate	44%	\$11.94
Biostatisticians	Master's	13%	\$42.48
Bioinformatics Specialists*	Master's	99%	\$42.28 to \$50.04
Clinical Research Associates*	Bachelor's	28%	\$35.92 to \$39.24
Medical (Technical) Writers	Bachelor's	30%	\$38.03
<b>Manufacturing Occupations</b>			
Assay Analysts*	Certification or Associate	35%	\$21.96 to \$22.37
Biochemical Development Engineers	Bachelor's	21%	\$49.96
Instrumentation/Calibration Technicians*	Certification or Associate	3%	\$18.06 to \$29.44
Manufacturing Engineers	Bachelor's	6%	\$43.18
Manufacturing Research Associates*	Bachelor's	21%	\$33.91 to \$43.18
Manufacturing Technicians*	Certification or Associate	9%	\$11.02 to \$18.66
Process Development Associates*	Bachelor's	15%	\$34.20 to \$43.18
Process Development Engineers*	Bachelor's	8%	\$43.18 to \$49.96
Production Planner Schedulers*	Bachelor's	14%	\$22.74 to \$43.18
<b>Regulatory Affairs Occupations</b>			
Documentation Coordinators	High School	19%	\$15.52
Documentation Specialists	Bachelor's	34%	\$47.73
<b>Quality Systems Occupations</b>			
Microbiologist	Bachelor's	41%	\$33.91
Quality Assurance Auditors	Bachelor's	12%	\$29.96
Quality Control Analysts	Bachelor's	12%	\$29.96
Quality Control Engineers	Bachelor's	6%	\$43.18
Quality Control Inspectors	High School	-1%	\$18.06
Safety Specialists	Bachelor's	24%	\$33.16
Validation Technicians	Certification or Associate	-1%	\$18.06
<b>Information Systems Occupations</b>			
Library Assistants	High School	27%	\$16.18
Scientific Programmer Analysts	Bachelor's	59%	\$41.18
<b>Marketing and Sales</b>			
Customer Service Representatives	Bachelor's	34%	\$18.44
Graphic Designers	Bachelor's	29%	\$27.70
Sales Representatives	Bachelor's	14%	\$45.67
Technical Services Representatives	Bachelor's	23%	\$22.56

\*Wages and employment reported for these occupations represent a sum of two or more Standard Occupational Classification (SOC) categories that together more fully describe the job within the biotechnology industry.

<sup>1</sup>See individual occupation descriptions for details about estimated number of job opportunities.

<sup>2</sup>The 75th percentile wage means that 75 percent of workers earn less than the 75th percentile wage and 25 percent of workers earn more. A range of wages in the 75th percentile wage column represents the spread among all the SOC categories that represent the biotechnology occupation.

Source: EDD/MI D's Employment Projections by Occupation 2000–2010 and Occupational Employment Statistics Survey 2004.

As will be discussed in greater detail later, the apparent shift in educational requirement is largely attributed to changes in the nature of the biological process as the company evolves. Generally, in the early stages of R&D development, the process is quite variable and changing, and thus highly-educated scientists are required to direct the process. Then, as the company enters the commercialized, mass-production mode, the associated biological process becomes much more stable. Technicians with perhaps a weaker understanding of science and math can operate successfully in these more stable environments. As such, having scientists perform this work is not cost-effective (albeit scientists may perform similar routinized lab functions during a company's start-up phase, particularly when they are one of a few employees in the company).

In addition, many functions within the manufacturing process are routine and repetitious; some functions require heavy lifting and other challenging physical activities, such as gowning up in hot environments; and, as the plants operate 24 hours a day, seven days a week, there is shift work. As I discuss in a later chapter, while these positions do require a high degree of technical skill, experience, and individual conscientiousness, they do not necessarily require high levels of formal education. Moreover, hiring workers with advanced degrees for such positions often results in a host of retention problems, as I will discuss in the next section.

On the other hand, as I discuss in later sections, the advanced nature of the industry, with its rapidly changing technologies, means that there may pressures for upskilling even within the most entry-level positions. For instance, as companies seek to shorten product life cycles to under seven years, processes that used to be stable become more innovative and variable, requiring continual skills upgrading and resulting in rapidly changing skills requirements. One consequence may be the ratcheting up of formal educational requirements for these upgraded positions, as appears to be happening in North Carolina (Lowe 2007). As will be discussed

throughout this study, a key challenge for workforce development intermediaries is to ensure that less educated workers receive the education and training that they need to successfully compete for and thrive in these positions, while also working with employers to support such training efforts and actively recruit and hire such candidates.

On balance, it seems clear that the maturation of the biotech industry has coincided with the opening up of a range of employment opportunities for community college graduates.

### Workforce and Skills Shortages

For decades, industry and academic experts have warned that the demand for workers in the STEM fields (science, technology, engineering, mathematics) will exceed supply. Whether the evidence supports a looming shortage of technical workers appears to be an open question (Guess 2008). These concerns emerge with frequency, however, in the life sciences industries. A recent National Science Foundation found that the number of qualified applicants for biotech jobs has failed to keep pace with growing demand (CMI 2008). In executive forums convened by the U.S. DOL Employment Training Administration, biotech industry representations claimed that they struggle with recruitment of skilled workers (DOL 2004).

Moreover, a report of the proceedings of a recent conference, co-sponsored by the National Science Foundation and the American Association of Community Colleges, found that the biotech industry is “hungry for skilled workers,” and notes that a shortage of such workers could seriously hamper the industry’s growth in the U.S. During his keynote speech at this conference, titled “Educating Biotechnicians for Future Industry Need,” James Greenwood, president and CEO of the Biotechnology Industry Organization (BIO), asked:



Can you imagine a future with potential high-paying U.S. jobs [being] outsourced not because you can produce less expensively overseas, but because you can only produce overseas? That would be sad indeed.” (NSF/AACC 2008: 8)<sup>23</sup>

Leaders within biotechnology industry clusters now identify workforce development (i.e., the acquisition and retention of employees) as the second or third highest barrier to commercialization and economic success (Dahms 2003/1: 197; 207). According to a 2008 California Healthcare Institute study, sixty-nine percent of responding biomedical companies in California indicated that they expect to expand their workforce over the next two years. However, 32 percent of respondents rated the emerging workforce underprepared in math and science, while a slightly higher percentage (36) found them underprepared in reading and writing (CHI 2008).

Within the Bay Area, the world’s highest concentration of biotech and life sciences companies, a 2006 survey of employers suggests a general shortage of suitable biotech applicants (Godbe 2006). Fifty percent of responding employers reported at least “some difficulty” finding qualified applicants for clinical lab associate, animal technician, calibration technician, process development associate, regulatory affairs specialist, and bioassay associate positions, among several others. At least 20 percent said that they “always” or “frequently” recruited calibration technicians, regulatory affairs specialists, and a few other positions from outside the region. Finally, 42 percent of respondents said that they faced “some” or “great” difficulty recruiting adequately educated and trained entry-level employees, though they reported facing greater difficulty recruiting non entry-level employees.

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<sup>23</sup> Indeed, a Genentech representative declared recently that the company was “scrambling to grow,” due to a lack of qualified applicants (Timmerman 2007). With a workforce of over 10,000, the company must recruit more than 1,000 people annually to keep up the pace of its recent growth.

### Employer demand for hands-on laboratory skills and industry-relevant training

While start-up companies rely on the availability of highly-educated scientists, manufacturing companies also depend on a steady flow of skilled workers to operate sophisticated technical processes. Such processes require that these workers have specialty skills (e.g., knowledge of GMP or GLP, quality control, and FDA regulatory issues), as well as experience working in a highly regulated environment.

Among the most important technical skills that biotech employers seek (and also claim are in short supply) is hands-on laboratory experience. A survey of California life sciences companies and academic staff for the California Community College Applied Biotechnology Initiative asked respondents to name the top skills that technicians most need as the industry evolves. The ability to perform basic research, and specifically “practical lab experience with hands-on training, including lab equipment expertise, instrumentation and analysis” was second on the list for half of employer respondents (academic respondents agreed, adding aseptic techniques to this list) (Time Structures 2006: 55). The top choice, for 56 percent of respondents, was not actually a skill, but rather knowledge of biochemistry, molecular biology, cell culture and cloning.

The prevailing view among industry personnel and academic experts is that four-year college programs fail to adequately prepare students for applied research and production-oriented work through the use of hands-on laboratory techniques.<sup>24</sup> Surveys of employers consistently find that bachelor-degreed candidates tend to lack proficiency in basic lab skills and have insufficient hands-on experience with analytical instrumentation. Consequently, they tend to require additional training time before they can operate independently in labs (NCDC 2003;

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<sup>24</sup> For instance, according to several interviewees, even the extension school at the renowned University of California at San Francisco does not offer a laboratory curriculum.

Time Structures 2006). For instance, employers responding to a survey conducted by the Center for Bioeducation and Training in New York noted “overwhelmingly” that:

there is a need for graduates to have a better knowledge and understanding of topics not typically found in college curricula; namely good laboratory practices, good manufacturing practices, regulatory issues, instrument validation, and laboratory notebook and record keeping skills that conform to industry and government standard (Time Structures 2006: 57)

Survey respondents also listed general laboratory techniques as the most important technique when considering the hiring of a new employee, after DNA technology.

Additional evidence of the perceived failure of university science instruction can be found in California Assembly Bill 1885, 2003-04 Session, which was introduced to establish “training centers of excellence” throughout the state, and which proposed the creation of an East Bay Biotechnology Center located on the campus of California State University at Hayward.

Among the Legislature’s many findings justifying this center were the following:

...(4) Biotechnology employers need entry level and advanced professionals that have a background in, and familiarity with, industry-like conditions for basic, applied, and translational research, development and production....

...(6) Many firms have identified the difficulty in finding entry level biotechnology workers at both the graduate and undergraduate levels as being directly related to the students’ lack of applied industry training or exposure.

...(8) *Many of California’s firms have found that many students graduate from four-year university programs with adequate conceptual understanding of biotechnology, but with relatively little practical laboratory experience, especially in the skills and protocols that are specific to commercial ventures as opposed to academic research.*  
(Reproduced in BayBio, California Cures 2007, emphasis added.)

In contrast to typical research-based university science instruction, community college biotechnology programs specialize in a hands-on, laboratory-based curriculum, with instruction

focused on troubleshooting skills, in addition to traditional academic subjects.<sup>25</sup> Academic and industry experts uniformly consider this real-world focus to be a signature strength of such programs, enabling graduates to “hit the ground running,” a crucial benefit in a just-in-time business environment. In fact, the shortcomings in university lab-based instruction have led to the “B.A. retread” or “reverse articulation” phenomenon, in which workers already possessing a four-year degree enroll in community college programs to obtain the practical, hands-on training necessary for entry into the technician workforce—an issue that will be discussed in more detail in Chapter Three on community college-industry partnerships.<sup>26</sup>

Community college biotechnology program faculty routinely describe their programs as instructing students in the “skills, techniques, and information that is usually acquired only through on-the-job training” (Harrigan 2002, p:142). Courses tend to be designed so that students learn about all aspects of the industry, as well as basic laboratory skills and equipment use. Many programs offer short modules that allow the student to experience all of the operations within a biotechnology facility. To realistically experience the workplace within a classroom setting, students must learn on actual biotechnology equipment and in actual lab facilities. Given the extremely high cost of such equipment, college programs are dependent on industry donations of equipment and biotech supplies, pointing to a critical role for industry-college collaboration. Aligning curriculum with industry needs also requires close employer involvement, since employer skill needs are specific and often-changing, requiring periodic revisions to the techniques taught in class.

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<sup>25</sup> As Chapter Three on community college-industry partnerships discusses, the colleges’ joining of a workforce development focus with a traditional academic mission has played an important role in the practical, jobs-oriented focus of programs like biotechnology.

<sup>26</sup> As a result of this special focus, all community college faculty must balance the tension between employer’s needs for practical skills and customized training, and students’ needs for general training that is applicable across firms and that maintains academic rigor (Fitzgerald 2004).

In a recent book documenting best practices in biotech education, the author of a chapter on Florida Community College at Jacksonville's biotechnology laboratory program usefully highlights the pedagogical differences between community college and university science instruction:<sup>27</sup>

[O]ur [community college] program emphasizes universal and scalable laboratory skills. Solution formulation is one example. Students master preparing buffers, reagents, media, admixtures, colloids, and gels at scales from multiliter down to milliliter. Further, in our core curricula, students formulate all the solutions needed to isolate and analyze DNA, RNA, and proteins. For some Standard Operating Procedures (SOPs) they prepare a dozen solutions before performing the actual experiment. In one project, our students "clone themselves" by isolating a small amount of their individual DNA. They then insert their genes into bacteria making a simple genetic library. However, before constructing the library the class produces four kinds of bacteria growth media and nine different buffers and reagents for their molecular work.

*This training contrasts with typical laboratory college laboratory experiments where students use prepared media or kits, and perform only the last step of a single procedure. In the Biotechnology Laboratory Technician degree program trainees carry out all parts of a method, not just the endpoint of one recipe. Once in the workplace these skills and insights ensure success in any environment.*  
(Pegg 2008: 67-68, emphasis added)

As later chapters in this dissertation will show, my interviews with scores of California community college faculty and staff about the structure and content of their classroom instruction and training—all emphasizing practical, hands-on lab experience and critical problem-solving skills—suggest that these programs offer content and pedagogy that closely matches that of the Jacksonville program.

Related to this focus on hands-on training and industry-relevant curriculum is the provision of industry internships, which also distinguishes community college training. Internships provide students with real-world experience and frequently a leg up in hiring, while providing employers with useful, often subsidized labor, as well as the opportunity to assess the

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<sup>27</sup> The programs' students prepare for jobs in academic labs as molecular biology research assistants and in manufacturing operations as technicians using molecular techniques on an industrial scale.

skills of potential hires. Some community college programs require internships as part of their degree requirements, while others merely encourage students to undertake them. Internships will be discussed in greater length in Chapter Three.

The key feature characterizing both industry-relevant training and the provision of internships is strong employer-involvement, which likewise will be discussed at length in subsequent chapters. As the Chair of Austin Community College's highly-regarded biotechnology program recently noted, the program's "high job placement rate of biotech students from internships and apprenticeships [can be attributed] to the match between its curriculum and regional employer's equipment, protocols, and practices, including essential soft skills." Ensuring this match, she explained, required that faculty members maintain good contacts with industry personnel (American Association of Community Colleges 2008: 9)

In sum, beyond meeting individual employer's need for a well-trained technician workforce, and students' need for training that will help them find and succeed in career pathway jobs in the industry, the community colleges' ability to offer timely and relevant training is viewed as a key strategy for spurring region-wide industry growth. By creating a pool of well-trained technicians, college training programs can help reduce the advantages for firms to move to lower wage regions, thereby helping anchor biotechnology production in the region (Workforce Strategy Center 2005).

#### The labor pool for technician-level jobs

There is plenty of anecdotal evidence that technicians with four-year college degrees tend to be poorly suited to entry-level technician/operational jobs (CCC 2004). Inadequate training in hands-on, applied techniques and failure to learn problem-solving skills, as described above, is one explanation. Another involves the technicians' dissatisfaction with the job due to frequently

unrealistic expectations about pay or the work environment, e.g., the necessity of shift work in a manufacturing facility and/or the need to perform repetitive, routine tasks. A constant refrain among industry representatives is that many bachelor's degree holders view their entry-level technician job as solely a short-term stepping stone to higher-paid, more "prestigious" research-oriented positions in the industry, or else as a brief interlude before returning to graduate school for an advanced degree.<sup>28</sup>

As a consequence, turnover among this group is often high, with many leaving the job within a few months (Lowe 2007; NCBC 2003). A study of Bay Area workforce hiring needs noted that numerous employers experienced turnover rates among their production technician staff in the high teens, which places a burden on overall hiring and worsens the need for such technicians (PriceWaterhouseCooper 2006).<sup>29</sup> Such turnover is also quite costly to companies, which generally recoup costs associated with new hires' training and on-the-job learning only at two years (CCC 2006).<sup>30</sup>

By contrast, the widespread view is that many community college graduates experience longer tenure than their bachelor-degree counterparts, in part because many view technician jobs as a career. This in no way signals lack of ambition; indeed, many community college students

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<sup>28</sup> On the other hand, gaining production experience is deemed useful by many employers when promoting a bachelor-degreed technician to an research-oriented position (NCBC 2003).

<sup>29</sup> Noting that the trend in Massachusetts was toward hiring more bachelor-degree workers for life science jobs, leading to a relatively high turnover among entry-level workers, the Massachusetts Secretary of Labor, Suzanne Bump, recently stated: "A lot of the folks who are entering with a bachelor's degree are actually overeducated for the tasks that they're being asked to perform, so the turnover there is pretty swift....If instead of a bachelor's degree you can get an associate's [degree] or a credentialed person who would stay, because they see this as their career rather than aspiring to a higher level, then that's a benefit for the employer community" (Phillipidis, BioRegion News 9/22/08).

<sup>30</sup> The Director of the California Applied Biotech Center-San Diego, who formerly worked in industry, nicely summed up the prevailing sentiment: "If you hire somebody straight out of UCSD (UC San Diego), for instance, they often are headed to grad school....They are highly educated, and not used to doing grunt work. But you have to be a worker bee for a period of time. Finding good employees who will stay with you for three to five years is an issue" (Broderick, San Diego Business Journal, 5/7/07).

are the first in their families to attend college, or first generation English speakers (especially in places like California)—all sure-fire signs of ambition. Instead, technician-level work appeals to many workers who prefer to engage in applied and problem-solving work, and to work largely with their hands.

In addition, as community colleges typically aim to service the market within a 20 mile radius, community college graduates tend to be rooted locally. This factor is crucial in increasing their employment stability: already living in the area, often with mortgages to pay and families to support, they seek the good wages that such technician-level jobs command, and consequently are willing to stay longer in these positions. From a recruitment standpoint, this geographical rootedness makes them especially attractive to businesses, particularly in high cost of living areas, where relocating new employees may be a difficult undertaking. In the Bay area, for instance, companies report that they greatly prefer to draw talent that is already local because of the high cost of living (PriceWaterhouseCooper 2006). Moreover, companies report that some of the most productive and loyal biotech workers are retrained, older students who were downsized from other industries, a core demographic of many community college biotech programs, especially certificate programs (Biotech Resource Line 2007).

There appear to be no academic studies comparing tenure and productivity outcomes of two-year and four-year graduates. The only analysis that I have identified is a 2003 in-house study by Genentech, a key champion of community college-industry partnerships, which offers evidence that tenure and advancement rates vary by educational background of employee (Stern 2003). The study sought to understand the impact of the company's gradual move away from a practice of only actively recruiting manufacturing technicians with four-year college degrees (or higher) to recruiting students with a two-year degree or less. It concluded that community



college technician hires performed at least as proficiently as four-year college technicians, as measured by tenure, salary merit increases and promotion and developmental increases. For instance, among technicians employed as of September 30, 2000, community college graduates (of whom there were 63) had an average tenure of 4.2 years compared to 3.4 years for four-year college graduates (of whom there were 350). Those community college graduates also received salary merit increases and promotional salary increases at a greater rate than bachelor's graduates. These findings spurred the company to continue its practice of recruiting one-third of its technicians among two-year college graduates, one-third among four-year college graduates, and one-third from a non-traditional pool, i.e., workers having significant work experience, such as nurses or former military personnel.<sup>31</sup>

In sum, there appears to be a growing body of evidence (albeit mainly anecdotal) that life sciences employers find value in sourcing many of their entry-level technicians from a talent pool that is locally based and that has received community college training, due largely to the industry-relevance of this training and the apparent longer tenure of community college hires.

### **1.5. Workforce Development Efforts to Address Employer's Workforce Needs**

Recognizing that the demand for biological technicians—a well-paying, high-skilled occupation—is forecast to grow 26 percent by 2016, and that the availability of skilled technicians is an important factor in company decisions to relocate or create new jobs in a region, many economic and workforce development entities at the federal, state and local levels

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<sup>31</sup> While the study called for this analysis to be performed across multiple companies, and to investigate the number of technicians who remained in their current roles as compared to those who moved to positions of increased responsibility at the company, this significant research unfortunately has not been undertaken.

have formed multi-actor partnerships to educate, train, place, and advance a technician-level workforce. The following is a brief sketch of some of the most prominent partnerships.

### National Efforts

At the national level, the U.S. Department of Labor's High Growth Job Training Initiative had spent almost \$34 million in the biotechnology industry by 2007, including 16 High Growth Job Training Initiative grants totaling almost \$23 million and seven Community-based Job Training Grants totaling \$11 million, with leveraged resources from all grantees totaling almost \$24 million (USDOL website).

Three of these High Growth Job Training Initiatives (HGJTI) are under study here. One is the Bay Area Biotech Consortium Pathway Project, a regional partnership between the San Mateo County and Alameda County WIBs, Skyline College and Ohlone College, Opportunities Industrialization Center West, and a number of biotechnology firms, including Genentech, Bayer, Alza, Chiron (now Novartis) and Abgenix (now Amgen). As will be described in much greater detail in Chapter Four, the USDOL awarded this two-year, \$2 million grant to the Consortium in 2004 to retrain the thousands of workers who were laid off from the airline, aerospace, and IT industries following the September 11 attacks and the dot-com bust for new careers in biotechnology manufacturing, facilities management, quality control, and product engineering.<sup>32</sup>

The second HGJTI grant of \$2.5 million was to the San Diego Workforce partnership and BIOCOM, the regional life sciences association, to create a multi-purpose biotechnology training and resource center and to support workforce pipeline activities. Completed in 2006, the center

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<sup>32</sup> This grant expanded a pilot program developed in 2003 by the San Mateo WIB, Skyline College, the San Mateo Central Labor Council, and Genentech to train displaced airline workers for entry-level, career pathway positions in biotech manufacturing.

(see [www.biotechworkforce.org](http://www.biotechworkforce.org)) serves as a clearinghouse for local and national labor market research related to the biotech industry, as well as a national site for conducting focus groups, gathering and analyzing data, and generating reports and ideas. The second effort coordinates student internships (from high-school to post-doctoral levels) and teacher externships for the regional biotechnology community. The program is considered a model for linking students and teachers with the biotech industry (Slivka and Wildrick 2007).

A third HGJTI grant of \$5 million was awarded in 2004 to a partnership of five community colleges across the country to develop the National Center for the Biotechnology Workforce (NCBW). Designated Centers of Expertise, the five colleges are located in Winston-Salem, NC (the NCBW's headquarters); Portsmouth, NH; Ottumwa, Iowa; Bellevue, WA; and San Diego, CA. Among the National Center's goals are to coordinate the network of regional centers to enhance their capacity to increase biotech training in each region; and to create partnerships among educational institutions and industry enabling the regional centers to grow their expertise.<sup>33</sup> Within each regional center, goals include building regional biotech training capacity, developing and maintaining industry partnerships, defining technical skills standards, and developing and disseminating best practices. The San Diego college, MiraCosta Community College, is under study here and will be discussed in more detail in Chapter Four. In brief, the college is a BioProcessing Center of Expertise, offering one of the nation's only bioprocessing certificates. It also offers lab assistant and research and development technician certificates, built a state-of-the-art laboratory training facility in partnership with Genentech, and offers customized training and contract education for local employers.

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<sup>33</sup> The NCBW remained in this capacity until September 2008, after which it became a seventh center of BioNetwork, a North Carolina biotechnology training and educational initiative, which is discussed in Chapter Two.

Another national biotechnology partnership with links to a program under study here is Bio-Link, an Advanced Technological Educational (ATE) Center of Excellence for Biotechnology, founded in 1998 and funded by the National Science Foundation. Bio-Link's mission is to increase the number and diversity of well-trained technicians, meet industry needs for appropriately trained technicians, and institutionalize practices that are available to all students (Johnson 2003). Its goals include providing support for students and technicians, improving instruction and learning, sharing information and resources, and fostering collaboration and partnerships.

Bio-Link implements these goals through seven regional centers located at community colleges in Seattle, WA; Austin, TX; Madison, WI; Graham, NC; Portsmouth, NH, San Diego, CA; and San Francisco, CA. The regional centers develop relations with local industry and educational institutions including community colleges, baccalaureate institutions, and high schools. Bio-Link's national headquarters is at City College of San Francisco, whose Bridge to Biotech program is under study here, and will be described in Chapter Four.<sup>34</sup> Briefly, with Bio-Link's help and with industry input, CCSF developed a two-year certificate program to prepare laboratory technicians. This program has evolved to include an associate's degree, a certificate in biomanufacturing, a stem cell certificate program, a bridge to biotech learning community, an on-ramp program to the bridge, and upgrade training for industry and academic employees.

### California's Efforts

California's response to the growing need for skilled technicians was the creation, in 1996, of the Applied Biological Initiative (hereafter, Biotech Initiative), part of the California Community

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<sup>34</sup> The National Director of Bio-Link credits the organization's headquarters in one of the largest biotech clusters in the world with helping the organization to stay current with industry trends (Johnson 2003).

Colleges' (CCC) Economic and Workforce Development Program (EWD).<sup>35</sup> The Biotech Initiative is one of ten strategic economic industry areas of the EWD, whose primary mission is: "To advance California's economic growth and global competitiveness through high quality education and services focusing on continuous workforce improvement, technology deployment, and business development, consistent with the current needs of the state's regional economies." The Biotech Initiative consists of six regional centers organized geographically, one state director, and about 50 colleges offering biotech programs. The six regions are the San Francisco Bay Area, San Diego, Los Angeles/Orange Counties, North Valley (Sacramento), Central Coast (Ventura), and San Joaquin (Gilroy). The regional centers are community-college led partnerships with high schools, state and private universities, local biotech companies, economic development groups, biotech industry associations, and public agencies. They aim to improve community college effectiveness in supporting biotech-related economic development in the state, and provide workforce training.

The key activities of the regional centers are to facilitate communication among colleges and biotech companies, coordinate faculty interaction with industry, and stimulate industry-education collaboration. The centers also may operate job placement and students internship programs and develop core curriculum and academic support programs.

Among the California Community College (CCC) system's 109 colleges, 35 offer biotech-specific courses and programs. These programs educate and train a technician or operational workforce in three areas of the biotechnology industry: research and development (for such occupations as laboratory technicians or research assistants); maintenance and

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<sup>35</sup> The Economic and Workforce Development Program began in 1987 and the State Legislature codified economic development as part of the community college mission in 1991. The EWD operates out of the CCC Chancellor's Office. The other nine initiative areas include health care; emerging technologies; applied competitive technologies; environment, health, safety and homeland security; advanced transportation technologies and energy; international trade development; small business development; and multimedia and entertainment. See <http://www.cccewd.net>.

operations (for positions as instrumentation/calibration technicians, quality control/assurance technicians, and heating, ventilation and air conditioning (HVAC) technicians); and biomanufacturing (in areas such as manufacturing operations, fermentation operations, quality control/assurance, and regulatory affairs) (Huxley 2004).

The CCC system offers three main types of training programs that vary on the basis of program type and partnership structure, thus exhibiting a range of design elements and partners. *Certificate programs*, typically in biomanufacturing and bioprocessing, but also in other fields such as laboratory research, feature an intensive, specialized curriculum that is substantially shorter in length than the traditional two-year degree program, usually running one or two semesters in length. Such programs are often customized to employer needs. Programs that partner with local WIBs typically include the following program functions: the recruitment, screening, and selection of students (usually dislocated workers) to industry standards; classroom instruction based on cohort-style learning communities; and the provision of paid internships. They also rely on a range of organizational partners to offer such services as intensive case management, industry pre-screening and assessment, and job development. In theory, these nimble and highly demand-responsive programs are the ideal workforce intermediaries. There is some disagreement, however, as to whether the programs are long enough to adequately train technicians in the fundamentals needed for entry into and advancement in the field (Fitzgerald 2006).

The longer, *one-year certificate and two-year AS degree programs* offer more comprehensive training and are more research-oriented than the semester-long certificate, equipping students to transition to four-year programs or to higher-level jobs in the biotech industry. They may be less flexible and demand-responsive as a result, however. The programs

tend to have fewer direct partners than the shorter programs, and generally do not directly offer job placement services. However, each college program has an industry advisory board, recruits industry to serve on its faculty, and receives technical assistance and support from the Biotech Initiative's regional center, whose express purpose is to ensure that the programs meet industry requirements and employer needs, and to cultivate employer involvement region wide. Finally, unlike some of the short-term programs, the programs provide open access to all students, thus potentially increasing the diversity of enrollees, although they may not offer supportive services to assist underserved communities.

The third type of program, the *Gateway or Bridge program*, seeks to prepare underserved communities for college and careers by bridging gaps in college readiness and helping students transition into career ladder jobs. These programs are linked directly to the one-semester certificate programs and several of the one-year certificate programs (although they also lead continuing students to the AS program).

## **1.6 Research Questions and Hypotheses**

### Research questions

As noted in the introduction, this dissertation seeks to understand the ability of workforce intermediaries in California's biotechnology industry to create quality job opportunities for displaced and less-educated workers, while improving business outcomes for their employers. It also aims to understand the extent to which these intermediaries can serve as regional labor market developers, influencing employers' decisions to expand or locate their manufacturing production in the region by actively working with firms to meet their critical workforce and economic development needs.

Specifically, my primary research question asks whether biotechnology training partnerships among industry, community colleges, and public agencies increase access to entry-level technician jobs for graduates of community college biotech programs, thereby improving employment opportunities for a non-traditional labor pool while helping employers attract and retain a well-trained technician workforce.

“Access” has both a supply-side and a demand-side component, and refers generally in this study to:

- The number of technicians graduating from community college biotechnology programs and entering biotech employment (the supply side)
- The active recruitment and hiring of community college graduates by biotechnology and life sciences companies (the demand side); and
- Employers’ changing perceptions regarding the suitability and desirability of community college graduates for technician jobs (the demand/systemic side).

Accordingly, to gain a supply-side understanding of the extent to which community college-industry partnerships are improving job access in the biotechnology industry for students and trainees, I examine program completion rates, job placement rates, and graduates’ starting wage and benefit levels (where feasible).<sup>36</sup> To determine *who* is gaining access to employment opportunities in the biotechnology industry as a (potential) result of intermediary intervention, I seek to build a demographic profile of the labor pool that the community college-industry partnerships are producing. The profile includes information on age, prior educational background, and employment history of the students in the regions under study. Finally, given that entry into the biotechnology field requires a relatively high degree of scientific knowledge and mathematics skills, I assess the partnership programs’ ability to reach out to a less academically prepared and/or more disadvantaged population and prepare them for training at

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<sup>36</sup> I define my outcome measures and describe my methodology and research design in Chapter Five.



the community college level, e.g., through provision of bridge programs and other social supports.

To ascertain the meaning of access on the demand side, I investigate the recruitment and hiring processes for entry-level biological technicians among sample companies. The first step involves documenting current practices, and the second involves detecting and measuring any changes in these practices over time. With regard to the recruitment process, I catalog primary recruitment practices for entry-level technicians, including any recruitment methods targeted to community college graduates; and current education and training requirements for entry-level technician-level jobs.

Regarding the hiring process, I seek to determine the proportion of the company's current technician workforce that has a two-year college degree or certificate, a key indicator of access; the number of internships filled by community college students or graduates, if the company hires interns; and the particular path that it took (or will take) to hire its technician-level workforce, as the company transitioned (or will transition) to production, in an effort to gauge reliance on workforce intermediaries for sourcing this workforce.

To understand whether, and if so, the extent to which recruitment and hiring practices have changed over time, I seek to answer the following sets of questions. Regarding the recruitment process:

- Has the company expanded its recruitment strategy to attract community college graduates—for instance, by attending, or increasing its attendance, at community college-sponsored job fairs, or otherwise marketing its career opportunities to community college students?
- Has the company made a formal decision to recruit a greater percentage of its new hires from community colleges?

- Has there been a shift over time in the company’s formal job requirements, e.g., from “BS required” to “BS preferred” or “AS preferred”? Or, instead, is the company recruiting and hiring more bachelor-degree candidates?

With regard to the hiring process:

- Has there been a proportional increase in entry-level technician hires from the community college pool over time?
- Has the company increased its reliance on partnership programs to supply an adequate technician workforce, particularly when it transitioned to the manufacturing and commercialization stages?
- If the company offers internships, has it increased the numbers of community college interns that it sponsors?

Finally, I aim to understand whether the sectoral training partnerships under study are effecting systemic change (primarily on the demand side). In part, such change involves improving, not just the employability of the participants in their programs, but also the “perceptions, attitudes and practices” of employers toward a nontraditional workforce, e.g., less-educated, less-advantaged and/or displaced workers (Roder et al. 2008). The following questions help guide an examination of intermediaries’ efforts to legitimate the community college population as a viable candidate pool:

- To what extent do the partnership programs actively encourage employer use of hiring criteria based on competencies, rather than on traditional measures of educational attainment, such as a four-year degree? Given that community college programs seek to train students in in-demand skills and competencies, partnerships that manage to redefine educational requirements for certain positions can help shift industry perceptions in favor of community college graduates.
- To what extent are partnership programs undertaking activities that seek to educate a company’s Human Resources recruiting staff about industry-wide skills standards for technician-level jobs, and more broadly about community college program offerings in the biotechnology field?

Company reluctance to recruit and hire community college graduates sometimes stems from the HR department’s failure to understand the specialized skill requirements for technician jobs or from misperceptions about the requirements for such jobs. HR staff

may also be unaware of the different educational pathways that potential employees may take to acquire skills, or of community college programs in general.

- Inasmuch as the preference for bachelor-degreed workforce may persist due to simple bias towards more highly-educated or advantaged candidates, what are the partnerships doing to involve employers in their programs in an effort to develop these employers' trust and buy-in? For instance, are the programs taking adequate advantage of their industry advisory boards in order to reach out to employers and seek their input on training curricula and industry needs? Are the programs inviting employers to be guest speakers in informational sessions at colleges? To attend community college job fairs? To serve as adjunct faculty? To hire interns?
- Given that production managers directly supervise technicians, including community college graduates, to what extent are partnership programs specifically reaching out to these staff in the ways described above? Have the programs created any communication channels with these managers in order to understand their expectations regarding technicians' competence and productivity, and their experiences (if any) with community college hires?

### Hypotheses

My primary hypothesis is that sectoral training partnerships in the biotechnology industry promote access to high-skill, high-wage entry-level technician jobs in the industry for community college graduates, and that employers who are involved to a meaningful degree in such partnerships are more likely to recruit and hire from a community college pool than those who are not so involved. Biotech training partnerships increase employer demand for community college-trained technicians, I claim, by producing graduates with the appropriate, in-demand skill sets, who compare favorably with or out-perform other types of graduates on various measures of retention and productivity.<sup>37</sup> The partnerships generate such outcomes by including some or all of the following features in their training and placement efforts:

- Collaborating with industry to design and deliver specialized curricula featuring hands-on applied skills training and extensive laboratory experience, as well as internship opportunities

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<sup>37</sup> Indeed, some programs claim that their curriculum's rigor and comprehensive lab training equip graduates to compete for positions advertised at the bachelor's degree level.

- Offering certificate training that is concentrated and with a cohort design<sup>38</sup>
- Providing comprehensive, industry-specific pre-screening and assessment
- Recruiting from a candidate pool that is locally-rooted
- Providing support services (e.g., bridge/gateway programs, case management) to help disadvantaged adults succeed in school and enter and stay in good jobs
- Building relationships of trust with companies

My second research question concerns the mechanisms and processes through which sectoral training partnerships in the biotechnology industry build effective career pathways and influence employers' recruitment and hiring practices. The literature associates two key workforce intermediary strategies with program effectiveness: encouraging employers' active engagement in the partnership; and facilitating extensive collaboration among key partners.

Accordingly, I hypothesize that effective intermediary programs, i.e., those that succeed in increasing graduate's access to technician-level jobs, are associated with the following: close relationships with employers (i.e., those involving industry at all levels of curriculum development, delivery and support); extensive inter-organizational collaboration; and an entrepreneurial design, enabling them to be flexible enough to respond quickly to industry and student needs. Such features, I argue, are designed to produce industry-relevant curriculum, training, and services; to ensure a greater and diverse pool of resources; and to facilitate the learning necessary to generate program innovation by fostering continuous feedback from key partners.

Finally, I hypothesize that programs that provide outreach and integrated supportive services, such as case management and a bridge program format, are more likely to succeed in

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<sup>38</sup> In addition, the flexibility and adaptability characterizing a number of community college programs, particularly the certificate programs, heightens their demand-responsiveness in comparison to their four-year degree program counterparts.

promoting access for students typically underrepresented in science and technology and disadvantaged students than those that do not.

In the following chapter, I examine the academic and practitioner literature that informs these questions and hypotheses.

## **Chapter 2: Labor Market Intermediaries: A Theoretical Framework**

For labor markets to achieve their key function of connecting workers and employers, both parties must be able to contact the other, gather sufficient information about the other's needs and abilities, and develop a level of mutual trust sufficient to enable them to enter into a contractual arrangement (Benner 2003). Until the last several decades, the primary institutions responsible for these core tasks of labor market functioning were well-developed internal labor markets and longer-term ties between firms and workers. Less significant institutions, such as classified advertisements, the public employment system, and informal social ties, also assisted in the operation of labor markets.

The economic and political changes over the last several decades—global competition, technological innovation, unpredictable financial markets, deregulation, and firm restructuring—have increased the complexity and volatility of labor markets and rendered the traditional labor market institutions less effective and, in many cases, obsolete. In response to the new pressures, firms have pursued flexibility in the arenas of work and employment (Benner 2002; Osterman 1999). Changes wrought by the emergence of flexible employment<sup>39</sup> include: the rise in nonstandard employment, e.g., temporary and sub-contracted labor; the weakening of the “standard” employment contract, evidenced by reduced tenure, increased turnover, and growing job insecurity; and the increasing mediation of employment relations by institutions external to

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<sup>39</sup> The movement toward flexible work seeks to accommodate rapidly changing skills requirements, swift fluctuations in the quantity of work required, and reflexivity in work tasks through such practices as self-managed work teams, job rotation, and quality circles.

the firm, such as temporary agencies, subcontracting arrangements, and various informal management practices (Benner 2002).<sup>40</sup>

## **2.1 The rise of labor market intermediaries**

To broker the new employment relationship in this uncertain environment, firms increasingly are turning to third-party intermediaries, which have emerged as leading alternatives to internal labor markets and other institutions that once enabled efficient labor market functioning. Temporary help agencies offer the most dramatic example of this phenomenon. Not only have such agencies experienced explosive growth in the last two decades, they also have “become increasingly integrated into the human resource practices of many...firms, entering into long-term contracts, providing management and recruiting staff on the work-site of client firms, and providing a variety of other value-added management and administrative services for a growing sector of the workforce” (Benner 2003: 623).

In addition to temporary help agencies, headhunters, permanent job placement agencies, and web-based job search sites have grown in prominence (Benner et al. 2007). Internet job search sites may be general in nature (such as Monster.com) or industry- and occupation-specific. Beyond temporary agencies, a wide range of entities varying in institutional origins, organizational structure, and impact on the labor market adjustment process have emerged to meet the need for increased labor market intermediation. Such entities include private-sector intermediaries, such as consultant brokerage firms and professional employer organizations;

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<sup>40</sup> Many commentators decry the high social costs and minimal general benefits accompanying the shift to labor market flexibility, which they deem “negative flexibility” (Dresser and Rogers 2003: 266). Indeed, competitive pressures stemming from the spread of information technology and the perpetual need for innovation appear to explain the new employment dynamic only in part (although these forces may be largely responsible for the transformation of work). That is, while flexible employment practices might in certain cases foster innovation and enhance economic performance, their widespread adoption arguably is due to their effectiveness in “cutting costs, shifting economic risk, [and] improving control mechanisms” (Benner 2002: 36), thus spotlighting the centrality of power in processes of labor market change.

membership-based intermediaries, such as unions and professional associations; and public-sector intermediaries, such as state employment agencies, Workforce Investment Boards (WIBs), community-based organizations (CBOs), and education-based institutions, especially community and technical colleges (Benner 2003; Giloth 2004). As this last category—public-sector intermediaries—forms the subject of the present study, I elaborate on such organizations in Section 2.6, below.

To date, much less is known about intermediation in high-technology industries, as compared to traditional, “old economy” industries (Lowe 2007). This is particularly the case with regard to labor market intermediaries whose primary objectives are to serve a less-educated and disadvantaged labor pool, that is, public-sector intermediaries. Instead, researchers who have studied intermediation in advanced industries have tended to focus on the role of placement agencies and network associations in assisting high-tech workers and employers (See Benner 2002; but see Benner et al. 2007, discussed below).

Within the biotechnology and life sciences industries, there is evidence that use of temporary placement agencies is high.<sup>41</sup> For instance, in the San Francisco Bay Area, over 85 percent of the biotech companies responding to a 2006 survey indicated that they hired temporary workers as a recruitment strategy for hiring permanent employees. The study determined, moreover, that a very low percentage of current employees were actually hired from their status as temporary employee (PriceWaterhouseCoopers 2006). My interviews indicate that some of the major manufacturing companies in the Bay Area contract with recruitment agencies, which, in turn, recruit from community colleges. The present dissertation study does not focus

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<sup>41</sup> Prominent temporary help and recruitment agencies include AeroTek, Kelly Services, OnLab Support, and K-Force. Use of Job boards in the biotech/life sciences industries is also high. Prominent boards include Biospace, JobScience, Bio Career Center, Science Careers, and Medzilla.<sup>41</sup> Premier job board organizations like Biospace hold life sciences career fairs throughout the country that can draw hundreds and sometimes thousands of job candidates.



on the role of temporary help and recruiting agencies in supplying a life sciences workforce to California employers, which is an important area for further research. Instead, it seeks to make sense of the myriad direct relationships between public-sector intermediaries and companies, and their respective roles in providing opportunities for entry-level biological technicians.

## **2.2. The role of LMIs and their Impacts**

Noting the lack of well-established theory on intermediaries in regional development, Benner (2003) hypothesizes that LMIs are playing an increasingly important role in shaping labor market adjustment processes, and consequently, in facilitating regional development.

Specifically, LMIs shape the speed and nature of labor market adjustment by performing three core functions: reducing transaction costs, which allows workers and employers to adapt to changing labor market conditions; building social and business networks, which strengthen the region's innovative capacity; and helping workers and employers manage the risks accompanying economic change (Benner 2003: 627-28).

In performing these functions, which help the region adjust to change and embrace innovation, LMIs shape regional development directly. Three trends reinforce this dynamic. First, firms are becoming less willing to take up the direct costs of operating labor markets, such as costs related to worker recruitment, information gathering, distribution of labor, and communication. By providing these services, LMIs are becoming more important in “actually operating markets for labour” (Benner 2003: 629). Second, due to the increased porosity of firm borders, the spread of multi-firm production networks, and the rising prominence of industry cluster dynamics in driving labor demand, the influence of individual firms over labor market changes has weakened. By contrast, LMI influence over labor demand is growing, on account of

the institution's direct involvement in labor market processes and acute sensitivity to cluster dynamics. As Benner explains:

By sharing information about changes in regional labour demand with firms and workers, [LMIs] do more than simply respond to changing labour market demand. They in fact help shape that demand by accelerating processes of adjustment, both reinforcing growth in areas of expertise in high demand, and hastening decline in areas of waning demand (ibid.).

Finally, the swift pace of change in skill requirements is hampering the abilities of both formal education institutions to offer up-to-date curricula and of firms to provide work-based learning environments that reflect the latest skill sets. LMIs are gaining importance in shaping labor supply due to their understanding of changing skill requirements and their ability to “incorporate subtleties in skills demands into their training programs” (ibid.).

### The impacts of LMIs

As noted, the forces pushing for labor market flexibility have opened up opportunities for LMIs to play an increasingly important role in operating regional labor markets and shaping labor demand and supply. Whether this new form of intermediation is having a positive impact on the labor market adjustment process as a whole, as well as the distributional impacts of the changes on workers and employers, are questions that are less well understood.

As Benner (2003: 628) makes clear, although a key LMI function is to help stakeholders manage risk, many workers have become more vulnerable by the “tenuous and temporary employment relationships associated with the rise in intermediaries.” He elaborates:

By using intermediaries, [firms] can delay hiring permanent employees till later in cyclical upturns, and lay off temporary employees earlier in cyclical downturns. On the structural side, an increase in the volatility experienced by firms has led many businesses to attempt to reduce their own internal labor force and shift economic risk through a series of more short-term contracts with external agents. Firms also are able to shift risks to intermediaries by reducing their own human resource screening, hiring and

administrative functions, reducing their exposure to unexpected downturns while still benefiting from access to workers during upturns (ibid.).

Benner and colleagues' recent study of the impact of LMIs in two regional labor markets (Silicon Valley and Milwaukee) squarely addresses such issues (Benner et al. 2007). The comprehensive set of intermediaries under study included temporary agencies; professional associations; community and vocational colleges; and unions, nonprofits, and government agencies. From their quantitative data, the authors found only negative correlations between use of temporary agencies and both hourly wages and access to employer-provided benefits. In addition, they found that temporary agencies provide fewer services than other LMIs and lead to less satisfaction for workers. While they did find some positive effects associated with the use of permanent agencies and headhunters, these were mainly limited to workers with college education.

Given the widespread use of temporary agencies, these negative impacts are indeed striking. Unfortunately, the data was not more encouraging with regard to the other types of intermediaries in question, revealing few clear relationships between their use and labor market outcomes. That is, professional associations, community and vocational colleges, unions, nonprofits or government agencies had little consistent impact on labor market outcomes.

The authors offer several reasons that their data might understate the positive impacts of these other intermediaries. For instance, they note that their survey might have produced too few observations, and that the categories that they used to distinguish among intermediaries might have been too broad. In addition, the quantitative data could not account for a dynamic revealed by their qualitative data, namely that many intermediaries work together, rather than in isolation. For instance, some temporary agencies directly recruit workers from nonprofit or government agencies; some nonprofits place large numbers of their clients through temporary agencies; and

some community colleges partner with their internal placement programs or with private placement agencies.<sup>42</sup> Because the quantitative data could not untangle these relationships, it might disguise certain outcomes relating to specific kinds of intermediary use.

The authors' qualitative data, however, identified many important "best practices" and characteristics associated with LMI effectiveness, which their survey of workers could not measure directly. For example, they found that, among the community and technical colleges in the study, some of which were model programs:

[T]he most successful activities are consistently marked by partnerships with industry, the community, and other LMIs. In both regions, the colleges' education and training systems reached a broad range of workers and employers, including the most disadvantaged sectors of the labor market and also higher levels. These colleges have a strong tradition of industry input into curricula, often based on industry participation on advisory boards. For more customized and employer-directed training, colleges may gain an advantage in knowing what skills are in demand and where career ladders might exist by hiring instructors who come from industry (ibid. 94).

The authors suggest that future in-depth, qualitative research on particular aspects of intermediary activity, e.g., the community college partnership activity described above, will be needed for systematic understanding of the labor market impacts of these activities. Of relevance to this dissertation, the authors note that their qualitative data supported their hypothesis that LMIs that are most likely to result in positive outcomes for disadvantaged workers are those that "hold worker and community interests as central, maintain strong relations with both workers and employers, and seek to expand their scope of operations to improve the structure of work, thus altering the demand side" (Benner et al. 2008: 19). They suggest that additional research is needed to assess the impact of such features on labor market outcomes—precisely the subject that dissertation seeks to address.

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<sup>42</sup> Indeed, as noted, a number of temporary agencies in the biotech/life sciences industries in the Bay Area, for instance, work with community college biotech programs to recruit students.

## **2.3 Dimensions of labor market change**

### The nature of demand-side change

A key claim of this project is that the significance of workforce intermediaries lies in their ability to produce demand-side change. That is, even when supply-side interventions are “employer-driven,” they may not go far enough in meeting current labor market challenges, which may require employers to restructure jobs and employment opportunities. As Giloth asserts, an “employer-driven approach must include the commitment of employers to invest in skills, modernization, and changing the internal culture of work in their firms to support a diverse and frequently nontraditional workforce” (2000: 346, citing Fitzgerald 1998).

Core areas of employer practice that demand-side interventions may target for reform include the recruitment and hiring process, the employment structure, and workplace practices (Bartik 2001). The first area, recruitment and hiring practices—the subject of this dissertation—includes a workforce intermediary’s efforts to work with a firm or group of firms in order to:

- Expand their recruitment practices to include community college graduates;
- Modify their hiring practices in order to encourage a diverse or nontraditional labor force; and
- Offer industry internships.

Other demand-side interventions include working with firms to create or improve entry-level job standards, including wage and benefit levels; institute better human resource practices; modify promotion policies; create new family-supporting jobs; offer pre- and post-employment supports (e.g., job shadowing and mentorships), particularly for low-income workers; and increase investment in upgrading skills and creating career ladders.

Whether a given workforce program operates on the demand or supply side is largely an empirical question. As Fitzgerald (2004a: 4) observes, even efforts designed to influence job quality—arguably a key criteria for demand-side change—might operate on the supply side to

the extent that they are limited to “improving training, working with employers to reduce turnover, connecting participants to child care and other worker supports, and participating in local and state workforce policy debates.” By contrast, activities that are “achieving outcomes related to hiring and job advancement and...encouraging change in the internal culture of work” likely would qualify as demand-side (ibid.). An important difference between the two sets of activities is that the former, unlike the latter, might require no change in employer practice: improving training, for instance, may leverage no additional employer investment in skills upgrading or may fail to lead to wage progression and job advancement for workers.

As such, the workforce intermediary’s ability to leverage deep employer engagement in labor market reform appears to be a key condition for demand-side change. The example of career ladder programs is instructive. If companies need skilled workers immediately, yet it will take years for participants of a career ladder program to ascend the rungs to become job eligible, the program is, in practice, no more than a supply-side training effort (Chapple 2005). To qualify as a demand-side effort, the program may have to work closely with a network of employers to alter their training and hiring practices so as to create multiple avenues (along vertical, diagonal or horizontal routes) out of low-skill, low-wage jobs and into family-supporting ones (Mills and Prince 2003).<sup>43</sup>

### Systemic labor market change

In addition to working on both the supply and demand sides of the labor market, workforce intermediary strategies also strive to produce systems or structural change, that is, “fundamental

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<sup>43</sup> In addition, a workforce intermediary program that is deeply demand-oriented might work with employers to identify new production methods, upgrade equipment, apply new technology and adopt model human resource practices, as well as assist firms in linking to new markets and setting industry skills standards (Mills and Prince 2003). Because they have the potential to improve firm productivity, such business services may be viewed as incentives that the WI offers in exchange for employers’ active cooperation on workplace or industry reform efforts. Such activities also bring the WI closer to the firm’s internal culture and organization of work, thus strengthening its ability to influence demand.

chang[e] in the labor market of the target industry and region such that economic outcomes are improved for both sector program participants and workers in the industry who are not program participants” (Conway et al. 2004: 2).

The Aspen Institute and Public/Private Ventures are among the few research organizations systematically to have studied systems change efforts in the workforce development arena. According to Aspen Institute research, workforce intermediaries may undertake systems change work by engaging in one (or more) of three primary systems:

- *Industry practices*, primarily those that shape the way firms recruit, hire, train, promote, and compensate workers;
- *Education and training systems*, including Workforce Investment Boards, community-based training providers, community colleges, and apprenticeship programs; and
- *Public policy*, including rules, regulations, and funding streams related to the workforce and education systems, as well as those influencing business practices (Aspen Institute 2007a).

Regarding industry recruiting and hiring practices—the primary subject under investigation in this dissertation<sup>44</sup>--the Aspen Institute suggests that there are both carrot and stick strategies that workforce intermediaries, and specifically sector initiatives, can employ to effect systems change. These strategies can be especially effective once the sector initiative’s relationship with business has deepened, thereby better positioning the initiative to influence firm practices. The strategies include negotiating changes in hiring qualifications and/or negotiating a set of competencies or skills for hiring; developing internships “that expose businesses to non-traditional labor pools;” and helping employers institute new skills standards and credentialing (Aspen Institute 2007b).

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<sup>44</sup> Overall, however, the activities of the workforce intermediaries under study in this dissertation fall within each of the three spheres, including education and training systems and public policy.

Private/Private Venture's Sectoral Employment Initiative (P/PV 2008) has delineated systems change goals within each of these systems, some or all of which goals the six sector skills-training organizations in its study succeeded in achieving to varying degrees. First, within the arena of industry practices, workforce intermediaries can aspire to influence the policies and practices of sector employers by:

- Changing employer perceptions of low-income, minority workers, as well as less-educated workers;
- Changing employer requirements to benefit those with less education; and
- Positioning the organization to work with sector employers

The workforce intermediary also can seek to influence the policies and practices of competing businesses. Second, within education and training systems, the intermediary can seek to influence policy and practice in higher education. Finally, within the public policy area, the intermediary can seek to influence legislation and policy around public funding for skills training, as well as legislation or policies and regulations that affect working conditions.

The practitioner literature offers several specific examples of strategies that sector initiatives have used to influence industry recruiting and hiring practices. One of the very few examples from the biotechnology industry involves the work of the BioTechnical Institute (BTI) of Maryland, which trains low-income Baltimore residents to become entry-level biotechnology laboratory associates. To solve a common problem among area employers—high turnover in such laboratory positions among incumbents with bachelor's degrees—BTI worked with employers to change the educational requirement for such entry-level work, once the parties had jointly determining that competency in specific industry-based skills, rather than a degree credential, was necessary. In reviewing this model program, the Aspen Institute (2007a: 28) concluded that BTI succeeded in “convincing employers to hire individuals trained to work in a sterile environment and in other critical skills, even those these individuals do not have the



bachelor's degree in science usually required." While the program's work toward changing hiring practices sought to create "access to good jobs for individuals who previously were excluded," it also "responded to employers' problems retaining the more highly educated workers with whom they were familiar and more comfortable hiring, but who also left quickly for better opportunities" (ibid.)

While the practitioner literature thus provides descriptive examples of systemic change, the nature of the relationship between demand-side change and systemic change remains understudied. One of the few studies to offer support for such a link is Melendez and Harrison's (1998) analysis of the success of the Center for Employment Training (CET), a San Jose-based organization that has been replicated nationwide. The authors posit that a key structural explanation for the organization's effectiveness is its ability to incorporate itself into the "trusted recruiting networks of area companies," a function that operates on the demand side. Harrison and Weiss (1998: 68) observe: "CET's approach has been to gradually penetrate this cluster of companies by working closely with a few firms, developing trust, and gradually transforming weak ties into strong ones—literally becoming part of the procurement and human resources systems of the valley."

Conversely, as Fitzgerald (2004b: 402) suggests, a sectoral strategy may fail to achieve the scale and scope necessary for significant systems reform to the extent that it fails to induce employers to change their practices. She reviewed several programs that were successful in connecting low-income people to well-paying jobs and even successfully coordinated state training policy with the actions of community colleges and the local WIs. The programs ultimately failed to transform the local labor market in the targeted sectors, however, largely

because they did not affect labor demand: in particular, they had “had little success in convincing employers to create more career ladders” (ibid.).

#### **2.4. LMIs: What they do**

Benner and colleagues (2007:10) define labor market intermediaries as “organizations—public, private, nonprofit, or membership-based—that help broker the employment relationship through some combination of job matching, training, and career support services.” Their indispensable function, in the authors’ view, is job matching; organizations that provide training and/or career support, but not active job placement, would not qualify in their schema.

As the authors note, their definition of workforce intermediaries excludes those community college programs that provide education and training, but not job placement. For people entering community colleges for training to enter the labor market for the first time (commonly considered “traditional” students), community colleges are best understood as part of the basic educational system. For people returning to the community colleges for training in order to reenter the labor market (sometimes referred to as “nontraditional” students), the community colleges function as a labor market intermediary. Many of these colleges, in addition, have established economic development and contract training departments, and offer customized assistance to businesses, further reinforcing their intermediary role (ibid. 48).

This distinction has relevance for the programs under study here. As will be discussed in greater detail in Chapter Three, the key community college biotechnology programs at the center of this study include a job placement component, usually as part of a partnership with public agencies responsible for aiding displaced workers (i.e., WIBs). However, the individual community college biotechnology programs throughout the state may not provide active job

placement, instead relying on the college's workforce and economic development program to offer this function, along with such economic development activities as providing technician assistance to businesses. In addition, each college biotechnology program is tied into the statewide biotech initiative through a Regional Center, which offers such services. An important sub-question, then, is whether programs with weaker job placement programs might still partially perform as workforce intermediaries.

To address their central inquiry—how labor market intermediaries affect labor market outcomes for disadvantaged workers—the authors theorized the different ways in which LMIs might affect labor market processes. Specifically, they classified intermediary activities into three broad categories that delineate a continuum of ways in which such activities shape labor market dynamics (see also PEERS 2003). At one end of the continuum are “market meeting” activities, which comprise the job-matching activities of outreach, assessment, placement, and support services—efforts that seek to fill existing jobs. As such, these activities take the quality of those jobs, with their wage/benefit levels and opportunity structures, as given.

In the middle of the continuum are “market molding” activities, which generally go beyond short-term job matching to improve workers' career mobility or the economic paths of firms and regional industries. While these activities do not necessarily change the underlying characteristics of jobs, they do “have the potential for changing flows of labor through the labor market and providing improved employment opportunities for disadvantaged workers over the long term” (ibid. 72-73). Included among these market molding activities are pre-employment and vocational training programs, the production and dissemination of information on industry or occupational trends, and efforts to improve networking among workers and employers.

At the opposite end of the continuum are “market making” activities, the quintessential demand-side activities that seek to change the underlying quality and distribution of jobs in labor markets—in essence, the “structures of opportunity” facing workers. Activities include incumbent worker training; advocacy activities; efforts to improve work organization and job conditions through contractual bargaining; and the intermediary’s serving as the employer of record.<sup>45</sup> Also falling within this category are business improvement services, which many sector initiatives provide. These services include assistance with organizational restructuring, production modernization, new technology implementation, marketing, and human resource development.

#### Market making? The case of North Carolina’s industry-education partnership

A recent study of workforce intermediaries within the life sciences industry in North Carolina—one of the few academic studies on this subject to date—elaborated the mechanisms through which such entities might engage in market-making, demand-side change. Because of its relevance to the present dissertation, and the many insights it holds for my analysis of biotechnology training partnerships, I discuss this study at length.

To understand whether knowledge-intensive industries, such as biotechnology, can produce quality, stable employment for workers with limited education and training, Lowe (2007) examined the role of workforce development agencies in influencing industry location and hiring decisions in order to stimulate regional employment generation (see also Fitzgerald 2006). Noting that many of the jobs that intermediaries (even in advanced industries) traditionally train for, e.g., lower level manufacturing jobs and service jobs, are increasingly

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<sup>45</sup> As Pastor and colleagues (2003: 79) contend, however, “market making” is, in fact, a “neutral description.” They note, for instance, that temporary help agencies, the single largest category of LMIs, frequently help employers lower their wage and benefit levels and change work rules in ways unfavorable to workers.

being outsourced or off-shored, she posits that workforce intermediaries may need to move from a “peripheral role of increasing the supply of entry-level workers in a region to a more central role as regional labor market developer” (ibid. 340).

The state’s primary workforce development approach to identifying and addressing shared regional workforce development needs in the life sciences industry has been to rely on a network of specialized community college programs as “instruments for regional integration” (ibid. 342). Over the past ten years, life sciences companies have increasingly outsourced their training for production, manufacturing support and quality control positions to this community college network, specifically to those colleges participating in the state’s BioNetwork program (described below). These colleges offer pre-hire, entry-level courses, company-specific customized training, two-year associate’s degrees in applied biotechnology, and related transfer programs to four-year institutions.

For instance, BioWork is a 128-hour, semester-long certificate course providing entry-level process technician training in both biomanufacturing and chemical-based pharmaceutical manufacturing. Begun in 2001, the course is offered by 12 of the state’s 58 community colleges, and is now required for most entry-level biopharmaceutical jobs. More than 900 students enrolled in the course in 2005. With its limited enrollment requirements, the course reaches the less educated job seeker: A 2006 survey showed that only 25 percent had earned a two-year associate’s or four-year undergraduate degree. In addition, 64 percent of enrollees were female, 53% identified as African-American, and the median age was 38.

The BioWork program grew out of a formal partnership in 1998 between the North Carolina Biotechnology Center (a state economic development agency) and the community college system. From the beginning, the partnership encouraged active industry involvement,

particularly in curriculum development for the certificate program. For instance, an early industry “champion” of the partnership, Novozymes, pilot tested the initial curriculum on its incumbent workforce, reviewed job applications from trainees at the first college to offer the program, assisted with modifications to the curriculum, and donated \$250,000 to finance a training laboratory at this college.

Other companies also have worked closely with college instructors to revise and improve the training modules and test the curriculum. In one region where chemical-based production processes dominate the manufacturing process, life sciences manufacturers worked with the local college to modify the curriculum to train students in the relevant skills. In return, the companies agreed to reserve interviews with program graduates for relevant job openings. This commitment created a feedback loop between the college and companies by opening the door for college faculty and career counselors to solicit company and student feedback on the interview process.

In analyzing the role of North Carolina’s industry-community college partnerships in the labor market process, Lowe raises two theoretical challenges to the efficacy of this LMI model. First, industry’s increasing outsourcing of training to community colleges raises the question of whether this trend reflects merely the dynamic of overlapping skills requirements—as opposed to a proactive strategy intervention by the state—as well as a corresponding reduction in firm investments in training, as this human resources function gets shifted to the state’s educational system. Lowe acknowledges that the growth of bio-manufacturing firms has led to demand for similar skill sets, and hence greater opportunities for employee mobility, which in turn incentivizes firms to decrease their investment in up-skilling.

However, while community colleges have increased their training offerings over this period, firms have continued to invest heavily in training, with some of this investment directed to general-use training infrastructure (i.e., for use by local residents and future employers). For instance, three manufacturers agreed to contribute eight cents per \$100 in property value to a training fund to help finance construction of the county's Workforce Development Center. The Center provides local firms with off-site training space and serves as a satellite campus of a local community college, which offers courses in applied math, science and engineering to county residents. The ensuing access by firms to general and customized community college courses had helped firms reduce their start-up training times. In return, firms have donated training equipment to the Center and regularly conduct outreach to students and faculty regarding local employment opportunities in the industry.

Moreover, industry's increased reliance on community colleges for training cannot, Lowe argues, be attributed to a "simple change in specific skills," since "educators and workforce practitioners [have] actively encourage[d] manufacturing firms to outsource their training needs to technical colleges in an effort to further anchor these establishments in the region" (Lowe 2007: 344). Moreover, beyond worker training, local colleges have begun offering job placement and career development services in their effort to "negotiate for expanded employment opportunities for North Carolina's disadvantaged socioeconomic groups" (ibid.), and thus better balance the needs of multiple stakeholders (e.g., employers, displaced workers, high school graduates). By developing this "market making" function, these colleges have become workforce intermediaries. She concludes that the colleges' "ability to offer top-quality, state-of-the-art training and their long-standing role as community educators not only enable them to influence who gets access to well-paying jobs in North Carolina's life sciences industry

but how life sciences firms themselves come to value particular segments of the region's workforce" (ibid.)

The second, and related, challenge to the LMI model under study is that the inevitable "blurring of boundaries" between industry and the colleges raises the question of whether college educators can properly balance the needs of workers and students with those of employers. She claims, however, that the North Carolina experience shows that "the deepening of ties with life science manufacturers seems to have opened up opportunities for state officials and educators to push firms to modify hiring practices and preferences in ways that are more socially inclusive" (ibid. 346). As an example, she points to the college, noted above, that customized its training programs to reflect the needs of local chemical manufacturers, who in turn agreed to reserve interviews from program graduates. She remarks:

The college's willingness to customize programs to reflect the needs of local manufacturers essentially gave it greater bargaining power when making demands for more inclusionary employment review processes. In this case [the college] has essentially created its own version of a first-source hiring agreement, whereby public sector organizations act as de facto employment agencies. Whereas traditional incentives-for-jobs type arrangements influence only the number of new hires at a subsidized firm, [the college] and other first-source brokers are shaping who from the regions gains access to high-paying manufacturing jobs (ibid. 346-47).

Finally, perhaps the strongest case for the ability of this model to shape local hiring practices in ways that expand opportunities for the less-educated—arguably a demand-side outcome—is that, as Lowe argues, the model appears to have succeeded in maintaining employment opportunities in the life sciences for high school degree holders. That is, in contrast to other life sciences clusters that have experienced a "ratcheting up" of educational requirements for manufacturing positions, North Carolina has managed, for the time being, to maintain a relatively high percentage of jobs for less-educated workers. The primary reason, she



explains, is the partnerships’ “incremental approach to upskilling” (ibid. 347). That is, by interacting regularly with local firms, organizing industry focus groups, and conducting surveys with human resource managers, state training providers have been able to develop a detailed understanding of the skills requirements of each manufacturing job category, track changes in these requirements over time, and forecast future skill needs—all key “market molding” activities. The result is that: “Rather than addressing potential skills shortages by bumping up the formal degree requirements of potential job applicants, firms in North Carolina have built on their relationships with local community colleges to respond to skills gaps by co-developing and piecing together customized training modules. Under this system, firms are assured follow-up training support for workers who enter with lower levels of formal schooling” (ibid. 347). A related industry benefit, she notes, is the reduction in the turnover rate in the manufacturing workforce, as well-trained community college graduates tend to stay longer in this positions than their over-educated (i.e., bachelor-degreed) counterparts.

In sum, by offering industry-relevant training and the provision of just-in-time industry information—all of which helps meet industry needs for a well-trained, stable workforce—the partnerships have built strong, trusted relationships, which in turn have enabled the workforce intermediaries to build the necessary leverage to influence hiring practices in ways that benefit the state’s less-educated workers.

## **2.5 What makes LMIs effective?**

The literature associates two key WI strategies with program effectiveness: 1) encouraging employers’ active engagement in the partnership; and 2) facilitating extensive collaboration among key partners. Employer involvement ensures that training and other services are aligned

to employer/industry needs; helps WIs build strong and credible working relationships with employers; and increases employer commitment to career pathway development. Collaboration facilitates the inter-organizational learning necessary for the production of innovation by providing a forum for ongoing group dialogue, joint planning, and relationship building and by linking partners to the resources and capacities needed for systems change.

### Employer Involvement

A key claim throughout the literature is that the most effective workforce intermediaries are demand driven, defined as programs that work actively with employers to solve shared workforce challenges. Truly demand-driven intermediaries are positioned to develop deep knowledge of employer needs and create highly responsive programs. They also offer workforce intermediaries the opportunity to build trusted relationships with employers and thus a solid foundation for positively influencing employers' workforce development choices.

A primary strategy for developing genuinely demand-driven programs is to expand opportunities for employer participation in program activities, particularly those designed to ensure that employer practices support employment opportunity and worker mobility. Such participation usually takes the form of contributions of staff time, expertise, and resources (both in kind and monetary), including such activities as:

- Assisting in curriculum development and review;
- Serving on community college partnership program advisory boards;
- Working with intermediary staff to update skills specifications for occupations; and redefine standards and competencies;
- Donating specialized equipment for the community college training laboratories;
- Providing direct money and support for grants;

- Offering student internships, especially paid internships;
- Serving as adjunct faculty (industry co-faculty) or teaching parts of training sessions;
- Participating as guest lecturers at community college information fairs and conferences;
- Providing job shadowing and company tours;
- Funding intermediary staff;
- Providing tuition assistance or paid leave for trainees; and
- Hiring program graduates<sup>46</sup>

As the Aspen Institute concluded in its review of systems change efforts, which highlighted efforts to influence industry practices: “There are a wide variety of [] ways sector programs have influenced hiring practices, such as working with employers to create internship opportunities, so that candidates can get work experience; negotiating job shadowing roles for candidates, so employers have a chance to see a candidate in the work place; offering various post-placement support services to convince an employer to hire a candidate who is perceived as more risky, etc” (Conway et al. 2007a).

Two key factors shape the effort’s orientation to demand and supply. One is level of employer participation, which can range from low-intensity consultation on initial program design to high-intensity involvement in program implementation/management. In the latter case, involvement usually extends from executive level staff to department managers responsible for daily program operation. Also, the parties tend to enter into program agreements, rather than

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<sup>46</sup> For example, the Biotech Workforce Network under study here lists the following activities as signifying engagement in the partnership: “Ongoing curriculum creation and review, active participation from staff and scientists, internal champions including human resource staff and hiring managers, industry and company orientations and tours, and most importantly, access to high wage, high growth career opportunities.” Further, the Skyline College-Genentech partnership program, also under study, identifies three forms of employer involvement as key to its high program completion and placement rates: “Having a job developer who accesses established corporate networks; access to paid internships with local corporate partners; [and] establishing scheduled meetings with corporate partners designed to increase conversion from internships and employment rates” (from power point)

engage ad hoc, on such issues as the responsibilities of contact personnel, development of training curricula, compensation for program placements, and hiring/promotion systems. Such high-level involvement, I argue, increases employer ownership of the program and willingness to alter employment practices. The other factor shaping labor market orientation is activity type. Activities that bring the intermediary closer to the firm's internal culture/organization of work—e.g., redefining occupational standards and competencies, as well as job responsibilities, developing portable credentials, modifying HR practices to support skill acquisition, reduce turnover, and accommodate career ladders—potentially augment the intermediary's ability to shape employer demand. Not surprisingly, such activities also tend to require high levels of involvement.<sup>47</sup> Programs that have an economic development component—e.g., offer business development assistance—may also be more likely to undertake such demand-responsive activities. Accordingly, I will seek to measure extent of employer involvement by examining:

- Type of contribution (e.g., monetary, in-kind donation, advisory/time)
- Frequency of participation (e.g., ad hoc, periodic, or ongoing)
- Type of activity (e.g., curriculum review, guest lectures)

Finally, workforce intermediaries can use a variety of organizational arrangements to foster employer engagement, including *governance*, *staffing*, and *network structures*. For example, employers may serve on boards and advisory panels/committees to offer guidance on skills requirements, assessment criteria, and industry needs. While such governance structures are often considered “passive,” skillful intermediaries can induce members to devote considerable effort to program design, management, and oversight. Workforce intermediaries

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<sup>47</sup> Differing approaches to developing training curricula illustrate how level of employer involvement and type of activity interact to shape the effort's responsiveness to supply or demand. A WI that works closely with a training provider to develop new course content, yet solicits employer input only with respect to the curriculum's initial design, arguably operates on the supply side. By contrast, a WI that works with employers on a regular basis to develop industry-standard certifications and other portable credentials—requiring detailed, ongoing input from employers regarding needed skills—arguably serves the demand side. While employer consultation is a necessary step in aligning training with skill needs, I contend that activities requiring ongoing involvement are more likely to ensure relevant content *and* effect systemic labor market change.

also might appoint staff with backgrounds in the targeted industry to serve as liaisons to employer partners, often co-locating them so that staff can provide workers on-site skills assessment and other career services. Finally, networks (considered “active” structures) connect employers with providers of education/training, recruitment/ screening, and support services to provide a regular flow of relevant information into the career development process. An employer-trainer network, for instance, might encourage firms to provide ongoing feedback to trainers based on their experiences with program hires.

### Interorganizational Collaboration

Another key claim in the literature is that WIs generate labor market innovation by performing two essential roles: they assemble a broad network of partners, providing a venue for joint planning; and they resolve emerging conflicts among partners. Such collaborative networks increase partners’ access to the range of resources, services, and capacities needed for labor market change, while improving partners’ ability to learn from one another, build trusted relationships, monitor each other’s efforts, solicit feedback, and revise programs with agility and speed. Moreover, the WI’s ability to reduce competition among partners and balance conflicting needs allows for more effective pooling of resources/information and joint problem solving.

Because such networks provide something of value to employers—e.g., access to new labor pools; assessment/screening of job seekers, which reduces the risks associated with hiring them; and customized training—intermediary partnership-building efforts arguably function as a key lever for change in the labor market. That is, the collaborative arrangement enables workforce intermediaries to build leverage vis-à-vis employers, thus generating countervailing power.

Variation in intermediation collaboration can be analyzed with respect to three features: the type of interaction among partners; the type of agreements structuring the interactions; and information flows among partners (Lawrence et al. 2002). The literature suggests that collaborations characterized by deep partner interaction, partnership arrangements, and bilateral information flows, as described below, are most likely to produce positive change in labor market outcomes:

- *Deep partner interaction*: A range of personnel from partner organizations interact, not just organizational counterparts. For instance, while commitment by executives is essential, the individuals responsible for program operation (e.g., department managers/supervisors, line staff, training instructors) must have the support necessary to work with their counterparts on an ongoing basis.
- *Partnership structure*: Partnership arrangements identify mutual agreements on partners' specific roles and responsibilities. For example, employers and intermediaries may enter into agreements regarding hiring and promotion systems, whereby employers commit to fill vacancies by upgrading incumbent workers and otherwise source workers through the intermediary. Firms also may enter into agreements with intermediaries and training providers to develop customized training curricula, or with service providers to provide supports to program participants.
- *Bilateral information flows*: Information flows among the partners, all of whom learn from one another. For example, communication channels/feedback loops that solicit regular and frequent evaluation from partners allow the WI to revise program structure in light of changes in staff/personnel, strategy, and scope.

## **2.6 Public-sector intermediaries**

Since the mid-1990s, the public workforce system has evolved in ways that align with, and often promote, the work of labor market or workforce intermediaries (Kazis 2004). Until passage of the Workforce Investment Act (WIA) in 1998, federal workforce programs had tended to prioritize job placement for unemployed and low-income people, primarily through the provision of pre-employment services. Overall, these programs have been a disappointment. Evaluations in the 1980s and 1990s showed minimal wage gains for most recipients; and the work-first

approach of welfare reform, which also emphasized immediate job placement over job training, retention, and advancement, resulted in a low-skilled population of new workers who tended to become trapped in low-wage work (Benner et al. 2007).

WIA's passage in 1998 was intended to rectify deficiencies in the way workforce services were designed and provided, as well as to respond to a host of changes—globalization, technological advances, and economic restructuring—that posed new workforce development challenges. Key objectives of WIA include:

- An increased focus on job training, career development and employment-related services, and a corresponding expansion of performance standards to include retention and advancement, not just job placement, outcomes.
- The move away from a targeted system serving primarily economically disadvantaged jobseekers, and toward a more universal system serving a greater range of customers; under this approach all jobseekers and workers, regardless of income, are offered “core” services, with intensive training and services offered to those most in need.
- The consolidation and coordination of programs, and the streamlining of services.
- The creation of a demand-driven workforce system, emphasizing a dual-customer approach responsive not just to jobseekers and workers, but also to employers.

(Kazis 2004; Clagett 2006). Regarding WIA's move toward a universal system, it is important to note that, in so loosening service eligibility requirements, Congress intended for the system to be more relevant for high-wage, high-skill employers, and better aligned with economic development efforts. Regarding the objective to build a demand-driven system, the new workforce system has built on earlier efforts to cultivate employer involvement, beginning with the Private Sector Initiative Program under the Comprehensive Employment Training Act (CETA), and intensifying under the Private Industry Councils (PICs) of the Job Training Partnership Act (JTPA) (Wallace 2007).

WIA's successor to the PICs are mandated Workforce Investment Boards (WIBs), boards appointed by locally-elected officials in each local workforce investment area, which aim to ensure community and private sector input into the design and provision of local workforce efforts. Chaired by a business leader, the WIB must be composed of a majority of business members, with the remaining members representing education (K-12 and postsecondary), labor, economic development and other community organizations. Among other responsibilities, WIBs designate service providers for and provide oversight to each local area's comprehensive One-Stop systems, which deliver the employment and training services.

Despite facing a multitude of challenges, such as "inadequate funding, conflicting statutory and governance requirements, narrowly-drawn geographic boundaries, turf battles, cultural blinders, and in some cases old line bureaucracies," the new workforce development regime has made, in numerous states and localities, significant progress in breaking away from "40 years of supply-side federal workforce policy" in order to embody a demand-side, dual-customer approach (Claggett 2006: 7).

As Claggett (2006: 8) claims, some of WIA's most notable strategies include:

- Sectoral initiatives that focus on the needs of many employers in a specific industry;
- Cluster-based initiatives that focus on the workforce needs of groups of companies and/or services in a region, and the public and private entities on which they depend (including suppliers, consultants, education and training providers, business and professional associations, and government entities)
- Career ladder approaches to training that provide upward mobility opportunities for low-skilled, low-wage workers;
- Utilization of specialized intermediaries (labor market organizers and partnerships that help workforce systems to plan, convene, broker, and organize the various critical components of labor market services in what that successfully connect the needs of jobseekers and employers);



- Implementation of incumbent worker training to avert layoffs, increase productivity, and increase regional competitiveness; and
- Other strategies that result in the leveraging of resources, and the building of regional economies that benefit a wide range of workers and employers, as well as strengthen regional tax bases.

Kazis (2004) suggests that it is indeed possible for a Workforce Investment Board to take on the role of workforce intermediary by consolidating and coordinating multiple funding sources and by organizing employers and other stakeholders to improve job placement, retention, and advancement services for employers and workers. However, for “reasons of history, culture, staffing, and their role as a public institution, most WIBs will decide not to expand their functions and become a workforce intermediary” (Kazis 2004: 77). Instead, most will continue to play a key role as the “regional labor market institution that sets goals, allocated resources based on needs, and monitors systems performance” (ibid. 89). Nonetheless, as the list, above, of new WIA practices and achievements suggests, WIBs can play a catalyzing role in the formation and implementation of workforce intermediary partnerships.

### Sector-based strategies

An important type of LMI—and the key workforce intermediary under study here—is the sectoral partnership. In the 1990s, workforce and economic development programs began focusing their efforts on specific industry concentrations with the aim of better targeting potential employers, collecting industry and occupation-specific information, customizing education and training efforts, and developing career advancement strategies (McGahey 2004). Since then, the sector approach has spread rapidly: From a few dozen sector-based organizations targeting a handful of industries in the late-1990s, the field has grown to over 200 organizations targeting at least 20 industries (Aspen Institute 2007c).

In what has become a standard definition in the field, sector strategies are understood as an approach to workforce development, usually undertaken on behalf of low-income individuals, that:

- *Targets a specific industry or cluster of occupations*, developing a deep understanding of the interrelationships between business competitiveness and the workforce needs of the targeted industry;
- *Intervenes through a credible organization, or set of organizations*, crafting workforce solutions tailored to that industry and its region;
- *Supports workers in improving their range of employment-related skills*, improving their ability to compete for work opportunities of higher quality;
- *Meets the needs of employers*, improving their ability to compete within the marketplace; and
- *Creates lasting change in the labor market system to the benefit of both workers and employers.*<sup>48</sup>

(Aspen Institute 2007a:11). As such, sector programs aim to go beyond helping individual workers find jobs to influencing the operations of the labor market, as well as public policy (as will be discussed in greater detail below). To do this, they intervene in two primary arenas: job access and job quality. Where job quality tends to be good with respect to wages, benefits, and working conditions, but where access to such jobs is limited, the sector strategy will seek to promote entry into the sector by eliminating barriers to recruitment, hiring, and/or advancing in the industry sector, as well as by offering new worker training and job placement and incumbent worker training. On the other hand, where job quality is poor, the sector strategy will seek to improve the quality of those jobs. To date, the majority of sector initiatives engage in job access

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<sup>48</sup> While complementary to sector strategies, cluster strategies are distinct in that they are mainly economic development strategies that target local industry sectors for the primary purpose of helping businesses in the sector succeed, by developing industry-relevant services, activities and investments (WSI 2007c: 2). Sector strategies also target multiple business and seek to develop an in-depth understanding of industry dynamics and trends in order to provide industry-relevant assistance, but the primary focus of such strategies is the worker.

strategies to remedy industry or workers skills gaps, while fewer programs engage in job quality strategies to address a wage and/or working conditions gap (Aspen Institute 2007a: 35).

As noted, given the relatively high wages and high skills characterizing the biotech/life sciences industries (even among entry-level positions), the strategies employed within this industry tend to focus on increasing access to those good jobs for nontraditional workers, i.e., workers without a four-year college degree and/or displaced workers, by eliminating barriers to entry and providing in-demand, industry-relevant training and job placement assistance.

### Community college sectoral partnerships

Increasingly, key partners in sector initiatives are community colleges. As the Workforce Strategy Center (2002:1) claims, these institutions constitute the “most logical foundation” for a broad-based workforce development system:

Colleges combine accessibility to the community, low tuition, an open-door admissions policy, a wide range of education and training offerings, and a continuing funding base. No other institution can match the ability of community colleges to educate and train large numbers of people.

Community colleges can provide a bridge to high-wage, high-demand employment for undereducated workers by serving as the focus point of regional partnerships that bring together all the key actors in the workforce development system—workforce agencies, community-based organizations, social service agencies and employers.

Similarly, in her study of several successful community college career ladder partnerships, Fitzgerald (2004: 358) maintains that community colleges have the “potential to influence the structure of employment” when they partner with other entities, since they provide education and training and often have economic development missions—thus positioning them to address both supply- and the demand-side issues. She notes, however, that there had been “little evidence to date [in 2004] that community colleges have the leverage needed to convince employers to change if the low road is profitable” (ibid. 363).

An additional potential weakness of relying on community colleges as the centerpiece of a sectoral strategy is that the institution as a whole suffers from poor student retention and program completion rates. As Osterman (2007) notes, most students fail to complete even a year of community college training, which wipes out nearly all of the potential economic return to a community college education. For instance, within the California Community College system, a recent California Postsecondary Education Commission study revealed that relatively few students are earning two-year degrees or certificates, or transferring to a California public university. Of the 52,622 community college students tracked by the Commission over a five year period (2001 to 2005):

- Only 29 percent earned a certificate or associate's degree and/or transferred to a state university;
- Fifty-two percent left during the five year period without transferring or earning a degree or certificate;
- Nineteen percent were still enrolled in the community college as of 2005;
- Twenty-two percent transferred to a state university; and
- Seventeen percent were degree or certificate earners, of which ten percent were also among the students who transferred to a state university.

(California Postsecondary Education Commission 2007).

As Osterman also notes, however, for students who do complete a community college degree or certificate, the returns are substantial (2007). Hence, the ability of community college occupational programs to adequately support their students so that they complete their training program or transfer is of central importance to the effectiveness of this intermediary model.<sup>49</sup>

## **2.7 Outcomes of sector initiatives**

With the help of the Charles Stewart Mott Foundation, the Ford Foundation, and the Annie E. Casey Foundation, two major research and demonstration projects have undertaken to study

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<sup>49</sup> As the data will show, many of the model certificate programs in this dissertation study have attained very high placement rates.

sectoral initiatives: the Aspen Institute's Sectoral Employment Development Project (SEDLP), which examined six well-established sectoral programs; and Public/Private Venture's Sectoral Employment (SEI), which studied nine newly forming initiatives, six of which eventually developed training programs (and thus became amenable to an investigation of program outcomes). As each project notes, sector strategies usually document direct outcomes for program participants, primarily rates of program completion and job placement for individual job seekers and workers, as well as wage and benefit levels. Indeed, most evaluations of sectoral work continue to measure program success largely in terms of these outcomes (Fitzgerald 2004a). Increasingly, however, programs also are measuring workers' rates of retention and advancement into positions with higher wages and greater benefit coverage.

Both the SEDLP and SEI conducted longitudinal surveys of program participants to evaluate such direct employment outcomes. Both projects found that, after two years of training, participants earned higher incomes, due to increases in hourly earnings and hours worked; participants worked more consistently, i.e., worked year round; participants' jobs were of higher quality, as measured by access to health insurance, paid vacation time, paid sick leave, and a pension plan other than Social Security; and participants were optimistic about their future job prospects due to their participation in the sectoral program (WSI 2007c).

The two research projects also identified and documented program outcomes on the business side, noting that a growing number of sector initiatives are beginning to recognize the need to make the business case for sector programs, and thus are assessing demand-side outcomes for employers. Efforts by the sector program to demonstrate such benefits helps establish its credibility with employers, and thus may serve as "an important leverage point in achieving sectoral change (Conway et al. 2003: 4). These business-related outcomes tend to

center on improvements in an employer's ability to find and retain qualified workers, such as the development of a larger pool of qualified applicants for entry level positions, lower recruitment costs, reduced turnover, and training systems that are accountable to employer demand (WINs 2002: 14; Conway et al. 2003). Business outcomes also involve improvements in the quality of existing workers, as measured by improvements in their productivity or the efficiency of the work process (Aspen Institute 2007c).

A third category of outcomes are systems change or process outcomes, also sometimes referred to as second-order outcomes, which encompass an array of results related to organizational capacity and systemic or institutional change (Chapple 2005). As noted above, systems change activities have the potential to benefit low-income and/or less-educated workers throughout the targeted sector, and to institute change within a system that lasts beyond the workforce intermediaries' efforts (P/PV 2008). Consequently, researchers have suggested that sectoral employment strategies are a principle means for workforce development programs to achieve systems change (Fitzgerald 2004a). For instance, Aspen Institute researchers claim that sectoral workforce development *is* systems change, given the emphasis in sector work to create lasting change in the labor market for the benefit of both workers and employers.

Evaluating a program's impact in terms of such outcomes is a far less common undertaking, and one that remains in the early stages of development. Noting that systems change outcomes are "often difficult to achieve, identify and rigorously measure" (Conway et al. 2004: 8), researchers at the Aspen Institute's Workforce Strategies Initiative suggest that:

It will be an important advancement for the sector field to identify the many types of "improvements" that provide evidence of systemic sectoral change, for whom, over what time period, and the strategies that have demonstrated success in achieving these improvements (ibid. 3).

The researchers (Aspen Institute 2007b) note that systems change outcomes “most often are qualitative and can be observed through such indicators as the creation of new relationships, the institutionalization of new processes aiming key actors such as educational institutions or employers, enhanced organizational reputation, or revised public policies.”

As such, a study of regional workforce development collaboratives in California that sought to include second-order outcomes in its analysis focused on the new projects, new relationships, and organizational capacity that emerged from the process of organizing and implementing the workforce development programs (Chapple 2005). For instance, the study documented the development of new relationships between business, WIBs, CBOs and community colleges; new funding sources, including the leveraging of government money; new courses at the community college; and new training programs and other initiatives, such as a regional skills alliance. Regarding organizational capacity, the study considered the programs’ “ability to mobilize resources, adapt to change, and influence system change (in this case, the state and local workforce development system)” (ibid. 43)

Both the Aspen Institute’s SEDLC and P/PV’s SEI projects have sought to evaluate the sector approach to systems change, albeit in more descriptive than experimental terms. One of the 13 sector projects that the SEDLC’s reviewed is the Skyline College partnership with public agencies, including the San Mateo County WIB, and with biotech companies, notably Genentech—also one of the model initiative’s under study here. The Aspen Institute researchers noted that the partnership’s bio-manufacturing certificate program was “designed to open opportunities to area residents who might otherwise not find a pathway into this growth industry,” and thus qualified as a systems approach to change as it sought to leverage new industry and economic growth for the benefit of existing unemployed and under-employed

residents (2007a: 14). The researchers also noted the certificate program's impressive outcomes, including a graduation rate of 98 percent, a job placement rate of 88 percent, and an average starting wage of \$18.89 per hour. Such data will be discussed in subsequent chapters.

## **2.8 The Biotech/Life Sciences Industry Target Population: Is It “Disadvantaged”?**

An important concern regarding the choice of biotechnology as a sector in which to examine the efforts of workforce intermediary programs is that such programs may not sufficiently benefit lower-income or disadvantaged individuals. This issue is significant given that a defining feature of sectoral programs is that they provide training and other services designed to benefit such individuals, including “the unemployed, non-traditional labor pools and low-wage incumbent workers” (National Network of Sector Partners website, <http://www.insightcced.org/nnspp.html>; Clarke and Dawson 1995).

As noted, workforce partnership programs in California's biotechnology industry typically provide training for manufacturing, process, or laboratory technicians (also called operational workers). Because the skills needed by these workers include fundamentals of biology, chemistry, math and physics, in addition to the soft skills of communication and teamwork, the perception (if not the reality) is that the biotechnology industry draws a more educated workforce than do industries targeted by conventional sectoral programs, such as traditional manufacturing or health care. Indeed, a 2004 White Paper on the California Community Colleges' Biotech Initiative notes, with some surprise, that many biotech program enrollees already have earned a bachelor's degree, and some hold master's degrees or above. Also, as the enrollees' average age is 32, they likely have been in the workforce already, and thus



are not the “stereotypical” students who are “fresh out of high school and either looking to go on to a four-year institution or find a job soon” (Huxley 2004: 12).<sup>50</sup>

The same report observes, however, that the students enrolled in the biotechnology programs match the racial and ethnic diversity of California’s population groups, and that the Biotech Initiative partners with a range of advocacy groups to ensure that the programs serve underrepresented groups.<sup>51</sup> The report notes that many biotechnology firms rely on the community colleges to help diversify their workforce. As such, this Initiative appears to be playing a critical role in diversifying the labor pool and workforce for the biotechnology industry, surely an important objective of sectoral programs.

The potential for sectoral programs in the biotechnology industry to reach low-income and/or underrepresented workers becomes more apparent when examining the sector partnerships under study. As will be discussed in more detail in Chapter Three, the Community College of San Francisco, for instance, explicitly targets a lower-skilled, “economically and educationally disenfranchised” population. Its On-Ramp to Biotech Program (previously operated by the non-profit organization, San Francisco Works) serves as a “refresher course” for adults who do not have recent or significant math or science school experience or training, and offers significant pre- and post-placement support to participants. Similarly, the Bay Area Biotech Consortium Career Pathway Project, led by two Bay Area WIBs, recruits low-skilled

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<sup>50</sup> This concern parallels a debate within the community college community as to whether such institutions serve the neediest students (Huxley 2004; Grubb et al. 2003). Some researchers argue that community colleges serve a more elite population but have the potential to reach out to the less advantaged, for instance, by using noncredit education as a “bridging mechanism” (Grubb et al. 2003). This argument lends support to the claim that community colleges can play a critical role in workforce development by providing a “bridge to high-wage, high demand employment for undereducated workers by serving as the focal point of regional partnerships that bring together all the key actors in the workforce development system” (Alssid et al. 2002: 1).

<sup>51</sup> For example, the CCC Applied Biological Initiative partners with the Math, Engineering and Science Achievement program (MESA); the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS); and the National Institutes of Health Bridges Program (CCC ABI 2004).

individuals and trains them for entry-level positions as biotech manufacturing technicians. It also partners with CBOs to offer participants remediation skills in English, math, communication, and employment readiness, as well as career orientation and social support.

Moreover, the Biotech Career Pathway Project emerged essentially to respond to a pressing regional need: to assist the thousands of workers who were laid off from the airline, aerospace, and IT industries following the September 11 attacks and the dot-com bust. The innovative program was specifically designed to attract and retrain dislocated and unemployed airline workers and others in the expanding biotech sector for such positions as quality control and product engineering. As such, the effort promises to shed light on the perennial social policy debate about whether to invest in universal or targeted strategies, which is acute within the workforce development context. Noting that the issues raised by the debate are in need of further research and analysis, Kazis (2004: 90) presents a rationale for expanding the reach of workforce intermediary programs:

...[L]ow-income workers are not the only people in need of greater assistance in this volatile labor market. Perhaps a less targeted, more universal system would be more politically attractive. Employers may also be more interested in getting help from organizations that address not only entry-level workforce needs but also workforce needs at higher levels.

Hence, while the biotech programs may not serve the most disadvantaged population, especially in comparison to more traditional sectoral programs, they do appear to be highly sensitive to the need to expand the reach and accessibility of their efforts, as well as to prepare a more diverse biotechnology workforce.

## **Chapter 3: Community College Biotechnology Programs in the Bay Area and San Diego County: History and Features**

### **3.1 The Community College Role in Workforce Development**

In contrast to a number of other developed countries, the U.S. accords formal schooling a dominant role in workforce preparation. Community colleges in particular are the primary source of workforce development in the U.S., especially for middle-level jobs (Jacobs and Norton 2006). While Japan or the German-speaking countries, for instance, rely on a work-based system for preparing job seekers (e.g., through apprenticeship forms of learning), the U.S. system largely involves education providers, rather than employers, in determining the criteria for credentials that purport to meet occupational skill demands (ibid.). This is particularly the case among community colleges, which are multi-mission institutions “oriented toward four-year transfer and preparing students in specific occupational areas” (ATE report 200?)

Over the last several decades, efforts to reform the workforce preparation system to boost the relatively low skills levels among the U.S technical workforce have ranged from creating new credentials and increasing work-based learning to creating firm-specific certificates—the latter approach emerging most strongly among information technology firms in the 1990s (e.g., Microsoft and Cisco). Indeed, some commentators warned that this private-sector response to the perceived skills crisis would eventually displace community colleges as a source of IT training (ibid.). While this threat has not materialized, many community colleges responded to the challenge by seeking better alignment between their job preparation strategies and the workplace, spotlighting issues related to the linkages between colleges and employers, and the balance of specific versus general approaches to workforce preparation.<sup>52</sup>

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<sup>52</sup> The issue of specific versus general training programs refers to whether the curriculum and pedagogy focuses on encouraging specific skills-oriented instruction or on giving students a broader, conceptual understanding of the

Firm-specific certification has not taken hold in the biotechnology industry as it has in IT, thereby posing little threat to the key role of community colleges in preparing a bio-technician workforce. Nonetheless, many community colleges have been quick to respond to the growing need in the industry for employer-driven and workplace-relevant training; these “entrepreneurial” colleges have spearheaded efforts to customize training programs to industry specifications; to revamp the credentialing system, e.g., to focus on demonstrating specific competencies at the completion of the training; and to create institutional linkages between employers and educators, e.g., through the creation of industry advisory boards. The following review of a sample of California Community College biotech partnership programs seeks to demonstrate the variety of strategies undertaken by these programs to better align industry demand for technical and workplace-related skills with the college provider’s supply.

### **3.2 Origins and History of California Community College Biotech Programs**

California’s community college system, comprised of 109 colleges in 72 independently governed districts throughout the state, and enrolling more than 2.6 million students, is the largest system of higher education in the nation, and possibly the world (CCCCO website; Hamilton 2006).

The colleges offer more than 175 degree and certificate programs, from accounting to computer programming to zoology, and are California’s largest workforce provider.

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underlying technologies and their application. Best practice, of course, is to incorporate both approaches into workforce preparation. Indeed, all of the community college instructors interviewed for this study insisted that they sought to teach students not just specific industry techniques, through a hands-on, skills-oriented curriculum, but also how to “think like scientists—to look at a problem, and figure out what the controls are and how to phrase the questions” (Foothill College interview #2).

Of the state's three public postsecondary systems<sup>53</sup>--the California Community Colleges, The University of California, and California State University—the CCC system has the clearest workforce development mission and the strongest infrastructure to support it (CPEC 2007).<sup>54</sup> In 1960, California's Master Plan for Higher Education designated academic and vocational education as the CCC system's primary mission.<sup>55</sup> It also included such other objectives as offering instruction and courses for workforce training, remedial education, English as a Second Language, and adult noncredit instruction.

State law codified vocational education as a primary mission of the CCC system in 1989, alongside transfer to four-year institutions. Two years later, the state added a third legally mandated primary mission—economic and workforce development—and created the system's Economic and Workforce Development Program (EWDP).<sup>56</sup> The EWDP aims to strengthen the ties between colleges and the economy and “advance the state's economic growth and global competitiveness through education, training and services that contribute to continuous workforce improvement” (EC Sec. 66010.4(a)(3)) For instance, in 2005, the CCCs invested more than \$350 million in direct workforce training and development in a range of occupational programs and emerging areas such as biotechnology (CPEC 2005).

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<sup>53</sup> Within this tripartite system, the UC system admits the top 12.5 percent of high school graduates, the CSU system admits the top 33.3 percent, and the CCC admit the “top 100 percent” (Galleago).

<sup>54</sup> The state's first “junior” college was founded in 1910 in Fresno.

<sup>55</sup> Pursuant to its transfer mission, more than 60 percent of California State University graduates, and 30 percent of University of California graduates, originated in the community college system (cite).

<sup>56</sup> Until 2003, the EDWP program was called the Economic and Workforce Development Coordination Network (ED>Net program).

As an open enrollment institution, the CCCs generally have succeeded in providing broad access to college.<sup>57</sup> With 109 community colleges located throughout the state, most Californians are within commuting distance to a nearby college or satellite campus. The colleges are also among the most ethnically and racially diverse institutions of higher education in the country. In 2008, for example, approximately 36 percent of entering CCC students were White, 29 percent were Latino, 17 percent were Asian/Pacific Islander, and 7 percent were Black. In addition, approximately 56 percent of students were female and 44 percent were male. In terms of age, approximately 25 percent of students in 2006 were age 19 or younger (i.e., of traditional college age), 27 percent were ages 20-24 and 12 percent were ages 25-29, while 10 percent were ages 40-49 and 12 percent were over 50 (CCLC Fast Facts 2008).

While diverse, the question remains whether the CCC, like community colleges generally, reach lower-income or disadvantaged students. As Grubb et al. (2003: 219) note:

In practice...community colleges have never reached the neediest individuals in any great numbers. The younger students coming right out of high school have tended to come from the middle of the distribution—with middling grades, middling income levels, middling (and sometimes inchoate) aspirations for their futures. Many older students are experienced workers seeking to upgrade their skills; some have been sent by their employers, who tend to support only the most promising workers; and those seeking retraining, to find new occupations because of dislocation in the economy, tend to be experienced.<sup>58</sup>

To address this problem, the CCC system has instituted a number of programs to reach into the ranks of disadvantaged students, including a Gateway Initiative, described below, that provides a bridge to underserved students and seeks to build career ladders in several industries, including biotechnology. As noted in a previous chapter, the issue of access by the neediest

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<sup>57</sup> Under its open door policy, the CCCs admit all students regardless of academic preparation. Free until 1984, the CCC currently charge \$20 a unit (approximately \$? a year for a full-time student).

<sup>58</sup> Grubb (2001) identifies five main categories of low-skilled individuals at the community colleges: recent high school graduates, experimenters, experienced workers seeking advancement, dislocated workers and others switching occupations, and populations with special needs.

students is particularly acute in an advanced field like biotechnology, with its higher-level math and science requirements, as well as industry preference for experience. However, a number of biotech programs have sought explicitly to include lower-income students who are traditionally underrepresented in the sciences. These are described below.

Perhaps the most severe challenge facing students at the CCC concerns the low rates of retention and degree completion. A 2007 report found that California is nearly last among states in the number of degrees and certificates awarded in relation to the number of student enrollees. For instance, approximately 40 percent of first-time CCC students are not seeking a degree or certificate, but instead are enrolled to obtain basic skills or job skills, or for personal fulfillment. Of the remaining 60 percent, only about one quarter succeed in earning a degree or certificate or transferring to a university within six years (Shulock and Moore 2007). Moreover, Black and Latino students have lower rates of completion than their White and Asian counterparts. Completion rates were 15 percent for Black students and 18 percent for Latino students, compared with 27 percent for White students and 33 percent for Asian students. As the authors note, “These disparities are of critical importance because Latino students make up the fastest-growing population within community colleges as well as the workforce. The community college is viewed as the principal route to upward mobility for many of California’s Latinos, but the disparities in completion rates belie this hope” (ibid. 8).

As a senior researcher on California higher education has argued with respect to science and technical education at the CCCs, the system enrolls two major populations of students: the “college ready,” who enter with a high GPA, know how to study, and can navigate college as a social organization; and the “college challenged,” who are often the first in their family to attend college, did relatively poorly in school, have to work full time to support themselves and

frequently a family, may suffer discrimination if they are of color, and may suffer from low self esteem or feel they do not belong (MacLaughlan presentation 2008). The researcher argues that, while the former group attracts the most media attention, and is hailed as the new generation of scientists whom the CCCs will provide, the reality is that about 80 percent of incoming students fall into the latter category, requiring intensive remediation.

The CCC system has undertaken a number of steps to address the retention and completion problem. As will be discussed in individual program profiles, below, a number of biotechnology programs have instituted various curricular and support measures to ensure high program completion rates among their students.

#### CCC Applied Biological Initiative

In 1996, the CCC Chancellor's Office created ten strategic initiatives, each focused on a different industry within the state, to further the community college system's economic and workforce development mission (see footnote 35, above, for a list of the initiatives). The Applied Biological Technologies Initiative ("Biotech Initiative"), one of the ten strategic industry clusters mandated by California Education Code 88500, seeks to provide a well-trained workforce for California's biotechnology industry (Huxley 2002). Specifically, the Biotech Initiative helps provide job-relevant life science knowledge and skills to Californians at the technician or operational level.

The Biotech Initiative consists of one statewide director; six regional centers, each led by a center director; and 35 individual colleges offering biotech programs. The regional centers are grouped into two hubs, one based in Northern California and the other in Southern California.



The six regions, the regional center, and the community college hosting the center are as follows<sup>59</sup>:

**Table 3.1  
CCC Biotech Initiative Regional Centers**

<u>Region</u>	<u>Regional Center</u>	<u>College</u>
San Francisco Bay Area	Northern California Biotechnology Center (now the California Applied Biotech Center-Bay Area)	City College of San Francisco
San Diego County	Southern California Biotechnology Center	Since 2003, Miramar College (initially MiraCosta College, then San Diego City College)
Los Angeles and Orange Counties	Los Angeles/Orange County Biotechnology Center	Pasadena City College
Central Coast (Ventura and Santa Barbara areas)	Central Coast Biotechnology Center	Ventura College
North Valley (Sacramento area)	North Valley and Mountain Biotechnology Center	American River College in Sacramento
San Joaquin Valley (inland agricultural region)	San Joaquin Biotechnology Center (now CalABC for the Silicon and San Joaquin Valleys)	Since 2008, Ohlone College in Fremont (initially Gavilan College in Gilroy)

Source: Author compilation

In 1996, the Northern and Southern California Biotechnology Centers were the first two regional centers to begin operations, followed by the Central Coast Biotech Center in 1997 and the remaining three centers in 1998. Each Regional Center has an advisory committee composed of industry, education, and community representatives. These advisory committees join a Statewide Biotechnology Committee, which meets three or four times a year, to form an extended statewide committee, which meets annually. Each individual college biotech program likewise has an industry advisory committee.

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<sup>59</sup> For a list of individual college biotech programs within each center, see Appendix C?

The primary objectives of the Regional Centers are to improve community college effectiveness in supporting biotech-related economic development in the state and serve the educational and hands-on learning needs of the biotech workforce in California. Specifically, they aim to facilitate community communication among colleges and industry, coordinate faculty interaction with biotech companies, and encourage industry-education collaboration. While the primary focus of the Biotech Initiative in its early years was capacity development (e.g., developing curriculum, training faculty, and building industry connections), it has gradually shifted to include service delivery. Today, the Regional Centers' key activities include the following (Huxley 2002):

- Determining biotech employee skill needs through surveys and communication with industry personnel
- Fostering community college-led partnerships with local biotechnology companies, high schools, state and private universities, economic development groups, industry associations, and public agencies
- Creating and supporting connections between biotech faculty and local industry personnel, who may serve on college advisory committees, volunteer as guest lecturers, teach lab classes and seminars, conduct company tours, provide internships for students, and provide equipment and supplies
- Helping colleges develop core curricula and faculty/student internships, and assisting students with job placement
- Arranging one-day, hands-on workshops on state-of-the-art lab techniques
- Supporting the community of biotech instructors through advisory committees, mini-grants, list serves, annual curriculum sharing days, marketing, and creating and maintaining mobile labs<sup>60</sup>
- Organizing equipment donation and redistribution efforts

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<sup>60</sup> Costing a minimum of \$12,000 to purchase and \$3,000 to \$5,000 annually to maintain (in 2002 dollars), the mobile labs ensure wide student access to hands-on fundamental biotech lab protocols (for instance, nearly 12,000 students used the labs in 2002) (Huxley 2002).

- Developing community forums to educate neighborhood groups about biotechnology research and production

The following examples highlight the diverse roles that industry and education partners play in Center activities:

CalABC–Bay Area: The Bio-Link CCSF Depot. Supported by CalABC-Bay Area and Bio-Link (a national biotech education center funded by the National Science Foundation), and coordinated by City College of San Francisco, the Equipment Depot secures new and used biotech equipment and lab supplies from companies that restructure, move, or upgrade. During several open houses each year, teachers from over 250 Bay Area schools and colleges—representing about 12,000 students—select items, free of charge, for use in their classrooms. For instance, between March 2006 and July 2007, the Depot distributed approximately \$1.2 million in equipment and supplies to 49 high schools, 14 community colleges, 9 four-year institutions, and 4 community-based groups. The Depot was established in 2002 with a \$50,000 grant from Genentech to Bio-Link.

Southern California Biotechnology Center: DACUM. To ensure that area community college students receive industry-relevant and up-to-date instruction, the center conducted a DACUM—a formal process of **Designing a Curriculum**—to establish research assistant skill sets (for in-vitro biology). The “thorough, but gut wrenching, two-day analysis of a job” is performed *by workers of their own jobs*, who are guided by a facilitator (Huxley 2007). The participants produced a research chart for the position detailing requirements of the position in the following areas: general knowledge and skills; worker behaviors; duties and tasks; tools, equipment, supplies and materials; and future trends and concerns. The DACUM process is especially relevant to the design of certificate programs, which teach industry-defined theory and hands-on techniques.

Los Angeles/Orange County Biotech Center: Biotech Business Incubator. In 2005, the regional center partnered with the Pasadena Bioscience Collaborative to create an incubator for start-up companies. The center director provides wetlab oversight and serves as an advisory board member of the incubator, and the Collaborative, in partnership with the Oak Crest Institute, houses the incubator. By 2007, the incubator had grown from 500 to 3,000 square feet and housed eight early-stage companies, of which two had received patents, three had received Small Business Innovative Research grants, three had received investor funding, and two which had recently “graduated” out of the incubator, becoming program alumni.

Central Coast Biotechnology Center: Rapid Detection Seminars/Workshops. After industry experts used a particular instrument to detect the bacterial contamination of spinach in California in late 2006, the Central Coast regional center began using this instrument in seminars designed to demonstrate the latest technology to industry representatives from a variety of companies. Inspired by this effort, a state-funded project to map water contamination now uses the instrument for training high school and community college instructors in bacterial detection and identification. Moreover, a local industry executive in charge of his company’s manufacturing team, who had heard about the CCBC seminars, contacted the center director to discuss the possibility of using a suite of technologies alongside the particular instrument to achieve faster detection and identification of contamination. Consequently, the executive brought his entire manufacturing team to a bacterial identification and validation workshop organized by the director. During the three-hour workshop, in which the director asked his student team to serve as co-leaders, the participants explored the possibility of using this suite of instruments to bring

the time of detection and identification to 15 minutes or less, as opposed to the two days or more using traditional methods.

North Valley Biotechnology Center: Short Courses for Incumbent Workers. The center offers three popular computer short-courses for incumbent workers: Excel in the Lab, Advanced Excel in the Lab and Access in the Lab. The courses seek to assist workers in processing the data from biotech research, a skill set in great demand within life science laboratories. The Excel in the Lab course, for instance, teaches participants how companies mine data through Microsoft Excel. Held on Saturdays in a computer lab at an easily accessible off-site campus of American River College, the course costs \$40 dollars. The regional center has also offered two sections of the Access to the Lab course, one designed for a general audience and the other customized for a local company. At the course's debut, 25 employees—or half of the company's workforce—attended the customized section. That company's IT staff followed up after the training by providing supplementary assistance to the employees who had taken the course.

San Joaquin Biotechnology Center: Industry Skills Training with Mobile Labs. To support hands-on classroom instruction in community college and high school biotech-related programs in the region, the SJBC purchased from several companies 44 mobile laboratory kits, including a DNA Fingerprinting kit, a Simulation of HIV Detection kit, and a PCR (polymerase chain reaction) kit. Each kit contains sufficient supplies for a single lab experiment for 25-40 students.

According to the EWDP's latest Annual Report to the Legislature (2009), the regional centers in the Biotech Initiative leveraged funds, in 2007-2008, worth nearly \$1.6 million, with average funds per center in the amount of \$205,000. Collectively, the six centers served 2,147

students; offered instruction totaling 17,089 credit/non credit hours and 90 contract education hours; placed 119 students in jobs; and served 481 businesses and 962 employees.

From 2003 to 2006, the CCC biotechnology and biomedical technology programs awarded a total of 377 associate’s degrees and certificates, as follows:

**Table 3.2  
CCC Biotechnology Degree and Certificate Awards, 2003-2006**

<i>Years</i>	<i>A.S. Degree</i>	<i>Certificate (credit)</i>
2003-2004	17	61
2004-2005	38	94
2005-2006	36	131

Source: Accountability Reporting for the CCC: System wide Indicators (2007)

In 2001, the CCC instituted a Career Ladders Project, focused on the development of bridge programs, regional partnerships, and comprehensive, industry-driven career pathways in several high-growth industries, including biotechnology.

### **3.3 Local Community College Origins of Biotech Initiative**

Several years before the official founding of the Biotech Initiative in 1997, a number of local community colleges had begun to develop and implement biotech training and education programs, giving shape and direction to the statewide effort. The two college programs described below highlight several innovative features of the biotech education and training models that were to follow. Each college programs displays a different origin—the first involving direct collaboration between the college and industry and the second involving a partnership between the college and publicly-funded workforce development organizations.

### Solano Community College (SCC).

A close collaboration in the mid-1990s between an SCC instructor and Genentech sparked the development of one of the nation's first biomanufacturing programs. Solano County, where the college is located, lies midway between the San Francisco Bay Area and Sacramento—a stretch known as the I-80 Corridor. Solano County has become the main “connector” in this corridor on account of its thriving biotech cluster, whose growth between 2000 and 2006 outpaced that of the Bay Area (Mills-Faraudo 2008). The cluster emerged in the late 1980s when Alza Corporation (now part of Johnson and Johnson) located its headquarters, research and manufacturing in the city of Vacaville, followed by the Emeryville, CA-based Chiron Corporation (now Novartis), which opened its first large-scale, commercial manufacturing facility there in 1992. The South San Francisco-based Genentech began site-hunting in Solano County in 1994 for its new manufacturing facility, and by 1998 had built the world's largest multiuse cell facility for \$150 million in Vacaville. Among the reasons these industry giants decided to locate their production in Solano County were its wide availability of land for growth; its proximity to the Bay Area, with the world's largest concentration of biotech firms and talent; a skilled labor pool from nearby University of California at Davis; a business-friendly environment, ensuring quick approval of company location and expansion decisions; and the absence of an earthquake fault, which decreases the risk of losing products.

In 1996, after Genentech chose Vacaville for its new manufacturing site, a director of manufacturing at the company and a Solano College professor collaborated to design training for production technician positions that the company would need to fill shortly. According to the instructor, some in the company were initially skeptical about partnering with a community college science program, as the company's practice had been to take bachelor-degreed graduates

(“because it could”), and UC Davis potentially offered a large supply of candidates. However, it was willing to “give community college students a try,” in part, the instructor suggested, because its decision to locate in Vacaville—a far more conservative place than the Bay Area where the company is headquartered—entailed some risk (e.g., in light of the company’s liberal policies, such as offering domestic partnership benefits to its employees). Hence, as a form of community outreach, Genentech donated generously to the Vacaville school district, which has since developed a life science curriculum, and Solano Community College. Moreover, despite the company’s bias in favor of BA graduates, a few community college science graduates had “snuck in,” according to the company’s manufacturing director. Suitably impressed by these workers’ performance, the director was willing to work with the community college to develop training.<sup>61</sup>

Consequently, in 1996, the SCC instructor embarked on a novel six-month internship at Genentech to study its manufacturing practices and, in collaboration with 60 Genentech employees, to ascertain the company’s production technician workforce needs.<sup>62</sup> The result was the creation of a curriculum featuring intensive lecture and laboratory courses that stress the basic concepts underlying cell culture, recovery and product analysis—essential knowledge for use in a manufacturing environment. In addition, an important component of the program “examines how modern business principles and sound manufacturing procedures assure the

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<sup>61</sup> Author interviews with Solano Community College faculty member (6/07) and Genentech production manager (5/07).

<sup>62</sup> In 2004-2005, the same instructor was awarded a year-long sabbatical to reestablish and strengthen industry ties and to validate protocols, SOPs and cGMPs (2004-2005 Top Code Determination Process). Among other activities, he assisted with curriculum development for Quality Assurance and Quality Control employees of Amgen, built ties with new partners, including local high schools and community colleges nationwide, reviewed and contributed to a key biotech textbook, and developed a new short course (Solano Community College District Governing Board, Unadopted Minutes, April 5, 2006) .



quality and safety of a product as the manufacturing team moves a product through the biotechnology production pipeline ” (Solano County Economic Development Corporation 2007).

The Solano College biotech curriculum leads to a *Certificate in Applied Biotechnology*, which can be earned in as little as one semester, if all prerequisites are filled; a year-long *Certificate in Industrial Biotechnology*, or a two-year *Associate in Science Degree in Industrial Biotechnology*. These programs prepare graduates for the position of production technician. The college reports that several other countries have looked to the biotechnology curriculum as a model for teaching biotechnology. It also inspired the development of a similar effort at Southern California’s MiraCosta College, which partnered with Biogen-IDEA (now Genentech) (see below for description of program).

Finally, in addition to the creation of this early biotech curriculum, the instructor’s internship experience inspired the development of a larger faculty internship program in Southern California (described below, in section x), as well as heightened interest among several colleges to replicate this faculty internship program.

### Foothill College

The biotechnology program at Foothill College, located in Los Altos Hills, CA (in the heart of Silicon Valley), is another of the region’s programs that developed prior to, and served as a model for, the statewide Biotech Initiative. The program originated in a partnership between Foothill College; a publicly-funded workforce organization, the Occupational Training Institute (OTI); and the local Private Industry Council (now WIB), called NOVA, which is located in neighboring Sunnyvale, CA. The OTI, which originated as a CETA program, provides workforce training and employment services for students within the Foothill-De Anza Community College District. Its mission is to prepare socioeconomically disadvantaged students

for employment through a variety of state- and federally-funded welfare-to-work and technical training programs.

Known for its highly competitive health care programs (e.g., physician's assistant, dental hygiene, pharmacy technician, and radiology technician programs), and its commitment to developing innovative, high-skill education and training programs, Foothill College developed a biotechnology pilot program in 1994. It enrolled 15 students, including twelve JTPA participants, in the pilot's first class, and established an industry advisory committee to develop initial curriculum and provide direction.

During this period, OTI and NOVA began working together to help dislocated defense industry workers retrain for new jobs, particularly in the area's high-tech industries. As the defense industry downsized, NOVA established an onsite center at Lockheed Martin for outplacement services, including recruitment and enrollment at Foothill and De Anza. NOVA also helped students obtain books and offered job placement services upon program completion.

In support of Foothill College's pilot biotechnology program, OTI provided \$15,000 in start-up funds to the program. To expand this effort, OTI obtained a \$107,000 grant from the CCC Chancellor's Office to enable Foothill to develop and provide a six-to-nine month Pharmacy/Biotechnology Technician certificate program that would incorporate the latest instructional techniques and methods. In this two-pronged program, students would take a set of core general courses, leading them into two possible career tracks—an approach viewed as cost effective and offering greater opportunities for professional advancement than a stand-alone program in each discipline. To ensure provision of support services, especially internships, resume preparation, job placement, and a 90-day follow up, NOVA offered a matching grant in

the amount of \$122,000 (primarily using JTPA funds). The program also enlisted the support of placement agencies, such as Biospace and Kelly Services, to assist with job placement.

Program objectives included strengthening the industry-advisory board; recruiting 15 percent women and 50 percent people of color into the program; enrolling at least 20 JTPA eligible participants; offering apprenticeships/internships to all students; providing job placement services and follow-up for each student; and achieving at least an 80 percent positive placement rate.

As the prerequisites for the pharmacy and biotechnology disciplines grew further apart as the fields advanced, the joint technician program eventually evolved into two separate programs, each of which continues to exist independently. Early in its history, the biotechnology program won an innovation award for its effectiveness in meeting industry needs and training qualified technicians who exhibited skills levels comparable to their bachelor-degreed counterparts. Though initially targeted at entry-level manufacturing technician positions, the program prepared students to work in research as well, which was particularly relevant given that most manufacturing jobs had moved away from the peninsula and to the East Bay by the late 1990s.

Currently, Foothill's biotech laboratory technician program offers a two-year A.S. degree and a nine-month career certificate in biotechnology, which prepare students for work in laboratories involved in research, product development, manufacturing, quality control, and clinical studies. For incumbent workers, the program also offers a number of short, technique-focused courses, designed to provide a comprehensive understanding of the technique, how it works, and how it is used in industry and research; and to provide hands-on, laboratory bench proficiency.

### **3.4 Profiles of CCC partnership programs**

The following partnership programs are grouped into four main models of biotech education and training. Although each model is distinct, key design elements of the partnership program frequently overlap. Moreover, most of these partnership programs are ongoing, although a few were pilot projects that did not receive additional funding after the project ended. Because these efforts inspired and/or were incorporated into subsequent efforts, I present those pilots here to portray a more complete universe of responses by community colleges, industry, and public and nonprofit organizations to industry's need for a well-trained technician workforce.<sup>63</sup>

The first model is a community college-industry-public agency partnership in which the WIB plays a key role in funding dislocated worker training through Workforce Investment Act funds, as well as other state and federal grants. This model provides a full array of support services for participants, and tracks student and graduate outcomes for a specified period of time. The Bay Area and San Diego County each have award-winning WIB partnerships in place. The second model is a school-to-career partnership, often called a 2+2 model or high school bridge program, which articulates high school biotech courses with a community college certificate program in order to increase the pipeline of students, particularly disadvantaged students and students of color, prepared to enter the biotechnology field. Internships and support services are key features of this model. The Bay Area's nationally-recognized 2+2 program, with a unique corporate history, is based in a non-profit organization, while San Diego's model is an NSF-sponsored program based in a community college. The third model is a community college bridge program that seeks to recruit a more disadvantaged adult population into the community college system and prepare them for industry jobs or further education. Finally, the fourth model

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<sup>63</sup> The partnership programs profiled in this section do not, of course, comprise the full universe of programs, but instead highlight the more innovative and apparently successful efforts to train a biotechnician workforce.

involves a close partnership between a community college biotech program and an employer, often a single, strong industry supporter.

### **3.4.1. Model 1: WIB partnerships and Dislocated Worker Training**

#### The Bay Area Biotech Workforce Network

The September 11 attacks hit the economy of the Bay Area's San Mateo County particularly hard. Home to San Francisco International Airport (SFO) and its dominant carrier, United Airlines—which serves as the county's single largest employer—San Mateo County lost more than 5,000 workers employed in the air transportation and related industries. These layoffs followed the earlier “dot com” bust, which had displaced thousands of technology workers. To respond to the urgent need to retrain these dislocated workers for new careers in high growth industries, the San Mateo County Workforce Investment Board (San Mateo WIB) formed an innovative partnership in 2002 with Skyline College, one of three community colleges located in the county; the San Mateo Central Labor Council; and Gruber and Pereira Associates, a workforce development consultant (White 2003).

Initially called the Airport Industry Dislocated Worker Project, the partnership chose to focus on training for the biotechnology industry, given the sharp increase in the demand for skilled biomanufacturing workers among a number of local companies, and the recognition that most of the displaced workers were trained under Federal Aviation Administration (FAA) regulations, and so could more easily be retrained under Food and Drug Administration (FDA) regulations. To implement the training program, Skyline College created an internal workforce and development arm, called the internal Center for Workforce Development, which immediately began working with Genentech, the Bay Area's largest biotech employer, to design

the curriculum for an entry-level biomanufacturing certificate. While Skyline had offered biotech education and training for some time, its four-semester course was too lengthy for employers who urgently needed workers and for the dislocated workers seeking immediate employment.

In 2003, assisted by a \$940,000 grant from the California Employment Development Department to the San Mateo WIB, the partnership launched the Bio-Manufacturing Certificate Program at Skyline College. A diagram of the San Mateo Career Ladder Pathway System is presented on the following page. Key features of this 12-week, intensive training program include:<sup>64</sup>

- Targeted outreach, recruitment and assessment to industry (initially Genentech) standards, provided by the San Mateo WIB and local One Stop
- Short-term, customized training based on industry standards and linked to job-related skills, developed jointly by Skyline College and Genentech. (Genentech even sent employees to teach parts of the curriculum.) The three-month, college-credited course delivered by Skyline includes topics in applied chemistry and biology, lab skills, applied math, mechanical systems, microbes, and Good Manufacturing Practices and regulations.

The training prepares students for entry-level employment in biotech and pharmaceutical manufacturing companies in such positions as bio-process technicians, labeling and packaging operators, instrument and media prep technicians, manufacturing associates, and laboratory technicians.<sup>65</sup> Moreover, the classes follow a learning cohort approach in which students enter as a group and stay together throughout the program, which helps build teamwork and support.

- The opportunity for paid work experience in the form of subsidized (\$12-15 per hour) three-month, on-the job, “try-out” employment, supported by Genentech and the San

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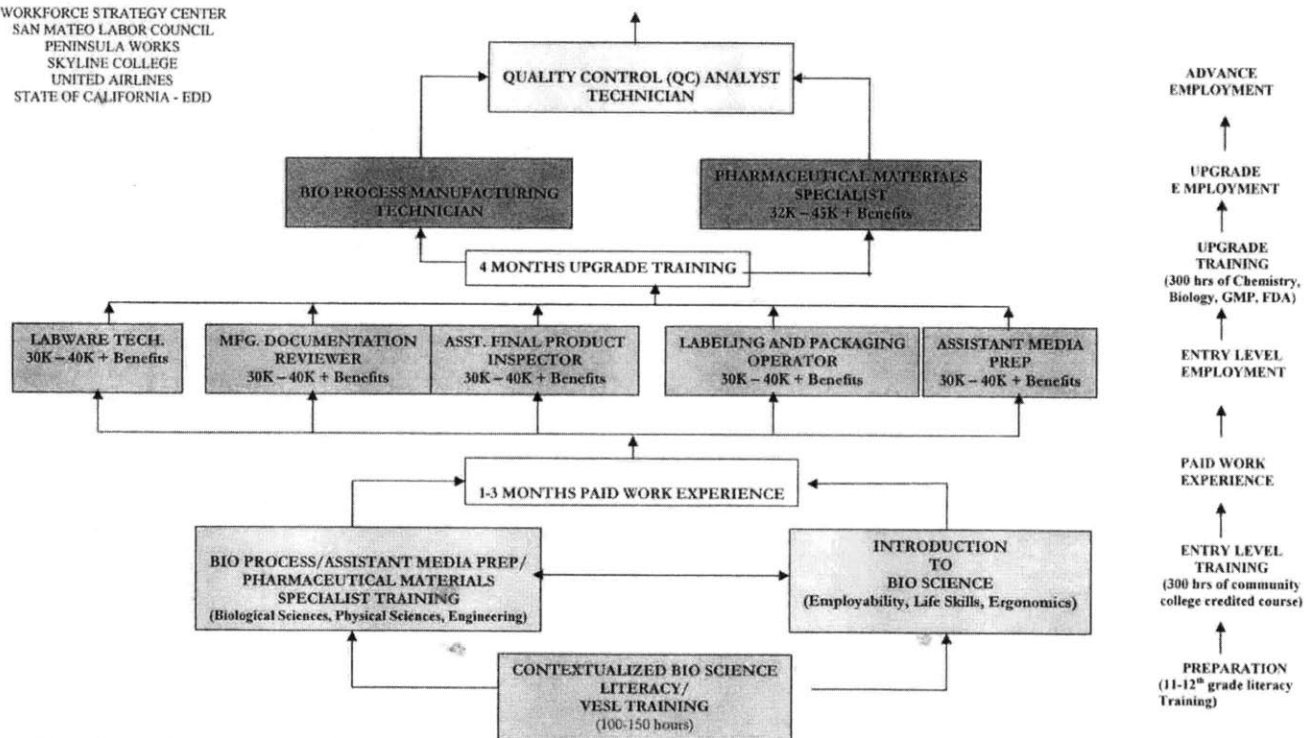
<sup>64</sup> This summary is based on the following material: Biotech Workforce Network presentation (2006), Leiva et. al (2007); and Poindexter PowerPoint presentation (2006).

<sup>65</sup> Skyline College also offers a two-year Associate Degree in Biotechnology. Moreover, since 2009, Skyline College has converted this certificate program into an “open enrollment” course, meaning that all students may enroll, not just displaced workers qualifying under WIA regulations.

## THE SAN MATEO REGIONAL BIOTECH CAREER PATHWAYS SYSTEM

### GENENTECH INC. MODEL

**PARTNERS**  
 WORKFORCE STRATEGY CENTER  
 SAN MATEO LABOR COUNCIL  
 PENINSULA WORKS  
 SKYLINE COLLEGE  
 UNITED AIRLINES  
 STATE OF CALIFORNIA - EDD



Source/Contact: Workforce Strategy Center, [www.workforcestrategy.org](http://www.workforcestrategy.org).  
 Career Pathway Primer

Mateo WIB. Genentech agreed to offer the paid internships in anticipation of full-time employment by graduates.<sup>66</sup> The program also features job placement in employment at local biotech companies, with starting salaries ranging from \$30,000 to \$40,000. The San Mateo WIB/local One Stop and a job developer employed by the Central Labor Council provide placement services.

- A Faculty Rotation Program provides faculty the chance to gain an industry understanding of Genentech's core Product Operations functions involved in the manufacturing of Genentech products. The program occurs over a six to eight month period and involves five rotation assignments in the Products Operations division, namely fermentation, recovery, lab services, media prep, and filling (Poindexter testimony 2007).

The early success of the pathway program—for instance, 100 percent of the 35 students completing the program in its first two years found employment in the biotech field—led to two additional grant awards in 2004. First, the California Community College Chancellor's Office awarded Skyline College over \$700,000 to enhance the bio-manufacturing certificate program through 2006 through such activities as expanding partnerships with local employers; collaborating with the Northern California Biotech Center (now CalABC-Bay Area) and the CCC Career Ladders Project to build a regional career ladders approach to biomanufacturing based on industry standards; and working with the NSF-funded Bio-Link to help community college faculty train dislocated and underemployed workers (Skyline College 2005).

Second, the Alameda County WIB received a \$2 million award in 2004 from the U.S. Department of Labor, through the President's High Growth Job Training Initiative.<sup>67</sup> The main project goal was to expand the San Mateo County program to Alameda County, in San Francisco's East Bay, which also suffered massive layoffs of airline and high-tech workers. New program partners included Ohlone College, located in Fremont, California, which delivered the biomanufacturing training in the East Bay; more than 25 biotech employers, with Bayer

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<sup>66</sup> Genentech also had created a customized co-op program to place community college graduates in full-time positions in the following areas: Lab Services, Media Prep, Manufacturing (Fermentation and Recovery), Filling, and Packaging (Poindexter PowerPoint 2006).

<sup>67</sup> The U.S. Department of Labor's Employment and Training Administration (DOLETA) administers this grant.



Healthcare joining Genentech as a lead employer partner;<sup>68</sup> and Opportunities Industrial Centers (OIC) West, a community-based organization that provides remediation training. In addition to training more displaced workers for entry-level biomanufacturing employment, the project also aimed to work with community-based organizations, like OIC West, to develop a bridge program to prepare lower-skilled individuals for certificate-level training by offering instruction in English, math and communication skills, as well as career orientation and social support. The program also sponsored an industry study by PriceWaterhouseCooper to assess industry for biological technicians in the Bay Area.

The expanded partnership program—renamed the Bay Area Biotechnology Career Pathways Project, and presently called the Bay Area Biotech Workforce Network—targeted laid-off aerospace, airline and IT workers for retraining. Specifically, it sought to prepare up to 150 workers for employment as entry-level bio-pharmaceutical manufacturing technicians, at wages of \$35,000 to \$40,000 per year; and 40 dislocated engineers for positions in facilities management, quality control, and product engineering at wages of \$50,000 to \$80,000 per year.

As a result of the new regional initiative, Ohlone College expanded its curriculum to include a Bio-Pharmaceutical Manufacturing Certificate Program, which offers accelerated 13-week classroom/lab training to prepare displaced workers for entry-level employment in biotechnology, pharmaceutical manufacturing, and quality control. The program features all the recruitment and case management support services offered by the San Mateo WIB program, as presented in the following program flowchart:<sup>69</sup>

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<sup>68</sup> Key company partners included Genentech, Bayer, Baxter, Chiron (now Novartis), Abgenix (now Amgen), and Alza.

<sup>69</sup> In addition to the short-term certificate program, Ohlone College also developed a career-to-work program (see discussion of LAB program, below) to recruit disadvantaged high school students to the college's year-long biotech certificate program. The college offers a number of one- to three-day biotechnology workshops for incumbent



**Bio-Manufacturing Certificate Program Flowchart**  
 Skyline College, San Mateo County Workforce Development & Genentech

Stage	Delivered by ...	Step	Details
Recruitment	Skyline College/ SMCWDU / Labor Council	Entry Point	Walk-Ins Direct Calls
		▼	
	Peninsula Works One Stop	Orientation to One Stop Services	½ hour orientation
		▼	
	Peninsula Works One Stop	Referral for WIA Enrollment	Must complete and submit 1. Cover letter 2. Resume 3. Supplemental Questions 4. WIA Documents
		▼	
Assessment	Peninsula Works One Stop	Referral for Comprehensive Assessment	
		▼	
	Peninsula Works One Stop	Comprehensive Assessment Report Provided to Intake Worker	JVIS and Wonderlic Tests
		▼	
Qualification	Peninsula Works One Stop	Refer Completed Packet to Biotech Case Manager for Consideration	If student is not selected, they will be referred to other services available thru the One-Stop-Centers
		▼	
	SMCWDU	Referred for Skyline Overview	Student may need to complete a SMCCD placement test
		▼	
	Skyline College / SMCWDU / Peninsula Works One Stop	Panel Interviews	3 to 4 person panel interviews of candidates
		▼	
	Skyline College / Biotech Companies	Mandatory Skyline Biotech Orientation	Orientation includes information from biotech companies & Skyline College
		▼	
Workshops	Skyline College / SMCWDU	Biotech Case Manager Conducts Job Search / Interview Strategies Workshops	Interview Taking and Resume Writing Workshops
		▼	
Bio-Manufacturing Certificate Program	Skyline College	Start of Bio-Manufacturing Class	Various Tours / Workshops / Mixers
		▼	
	Skyline College	Completion of Bio-Manufacturing Class	
		▼	
Internship / Job Placement	Skyline College / SMCWDU	Application for Paid Internships	
		▼	
	Skyline College / SMCWDU / Job Developer	Student Status Follow-up	Job Developer Assists with Job Placement

workers on such topics as writing SOPs, GMPs, intro to stats for QA/QC, and quality system regulation (medical devices).

Based on outcomes of the regional partnership programs, which will be discussed in Chapter Six, the Biotech Workforce Network received a number of national and state awards, including: the 2005 Recognition of Excellence Award by the U.S. Department of Labor; the 2005 Excellence in Partnership Award by the California Community College Association of Occupational Education for the successful Skyline-Genentech-WIB model; the 2005 Innovations in Human Services Award by the National Association of County Human Services Administrators, for the San Mateo biotech training program; the 2005 San Mateo County Community Partnership award by the San Mateo County Human Services Agency for Skyline College's biotech training programs; and the 2006 Second Place Winner of the Theodore E. Small Workforce Partnership Award by the National Association of Workforce Boards.

The third iteration of this regional partnership program—called Life Sci X—began in 2006, when the Alameda County WIB received \$1 million in WIA-Dislocated Worker 25 Percent funds to expand the program to Contra Costa County, located northeast of San Francisco, and Santa Clara County in South Bay. Specifically, the program joined five workforce investment agencies—San Mateo, Alameda, the City of Richmond, Contra Costa County, and the San Jose/Silicon Valley Workforce Investment Network (renamed work2future)—to expand the biotech training curriculum to Contra Costa College and train more than 125 laid-off workers for entry-level biotech employment by June 2008. As with the other programs, the new regional initiative provides assistance with recruitment, outreach, assessment, case management, job-related training, job placement, follow-up activities, and tracking. The program was extended to June 2009. Chapter Six presents its outcomes.

### San Diego Workforce Partnership programs

Founded in 1974 through a joint powers agreement between the City and County of San Diego, the San Diego Workforce Partnership (“Workforce Partnership”) is a nonprofit organization that coordinates job training and employment programs for the region’s employers and job seekers, largely through its regional network of six One-Stop Career Centers and its targeted adult and youth employment and training programs. The Workforce Partnership began working formally with the life sciences industry in 2002, with creation of the Life Sciences Pilot Project (see below), to develop partnerships and programs to address the industry's regional workforce needs.

In 2004, the San Diego Workforce Partnership and its partner, BIOCOM, San Diego life sciences industry and trade association, received a two-year, \$2.5 million grant through the President’s High Growth Job Training Initiative to address two critical needs: 1) building a pipeline of qualified workers interested in biotech employment while improving teachers’ understanding of industry workforce needs; and 2) developing the capacity to collect biotech-related labor market and occupational information. The following two programs—the Life Sciences Summer Institute and the Biotech Workforce Portal—are the primary outcomes of this grant.

### San Diego’s Life Sciences Summer Institute

Launched in 2005, the Life Sciences Summer Institute (“LSSI”) connects upper-level high school students, community college and university students, and high school and community college teachers with local life sciences companies in order to expose students and teachers to occupational skills needs of and career options within the industry through student internships and teacher externships; and to expose companies to prospective employees. Specifically, the program aims to “provide industry with well-prepared interns; provide students with hands-on

experience with the life sciences industry; and better equip teachers to prepare our future workforce” (Slivka and Wildrick 2008: 54).

Efforts to develop the program commenced in 2004, when the Workforce Partnerships and BIOCOM created a taskforce committee and working sub-groups composed of industry representatives and educators, which were charged with conducting a needs assessment of the region and designing the internship and externship programs. To ensure that industry needs are being served, BIOCOM also formed several committees, composed of members from the life sciences industry, academic institutions, research institutes, staffing agencies, and local and state workforce agencies. These committees, such as a board-level Workforce Capabilities committee, a human resources subcommittee, and an education subcommittee, have met regularly to allow members to discuss workforce, education and training needs, and to provide feedback and make recommendations regarding the program’s continued development. As Slivka and Wildrick (2008: 59) comment, “This structure allows for maximum input from interested parties, and fosters participation from industry at multiple levels.”

The program’s main partners include the Workforce Partnership and BIOCOM, which implement the program; the Southern California Biotechnology Center (SCBC) at Miramar College, which designed and hosts the one-week “Boot Camp” training required for all students; and two major industry supporters: Biogen Idec, which hosted the teacher externship program for the first three years in its state-of-the-art Community Facility Lab, and also hosts student interns; and Invitrogen, which has donated products to support the student and teacher programs. In addition, the LSSI received a three-year grant from the Amgen-Bruce Wallace Biotechnology Laboratory Program to expand the program into San Diego County, for the purchase of equipment and supplies used to make “laboratory kits,” which are rotated throughout county

classrooms; and for the hiring of an outreach coordinator who oversees distribution of the kits and provides teachers with ongoing support in curriculum implementation. Finally, over twenty biotechnology companies have hosted both interns and externs.

Key components of the LSSI program are as follows:

#### Student Internship Program:

- Eligibility: Students who have completed their junior or senior year in high school, are attending a San Diego community college or four-year college, and have completed at least one lab science course are eligible to participate in the program. The program places special emphasis on identifying and recruiting students from groups that are historically underrepresented in the sciences.
- Selection process: The process for selecting students follows a temp agency placement model in which the program pools student applications and host institutions (local life sciences companies) interview and “hire” the candidates.
- One-week “Boot Camp”: All students are required to attend this intensive 40-hour course introducing students to the biotech industry. Designed by the Southern California Biotechnology Center (SCBC) at Miramar College as an accredited course (offering one full unit of college credit), the hands-on curriculum provides training in laboratory skills, an introduction to regulatory issues (GLP, GMP, FDA), an introduction to the drug and device development process, and a workplace-relevant soft skills component. The training takes place at Miramar College over five days, with the sixth day reserved for training on-site in internship.
- Industry internship: The employer establishes the wage rate for the position for the eight-week supervised internship and chooses intern projects prior to the start of the summer. Students must keep an internship notebook throughout the summer.
- Poster development session: Students develop and exhibit scientific posters to the life science community at a “Celebration of Science” awards banquet.

#### Teacher Externship Program:

- Eligibility: High school and community college instructors who teach biology, chemistry or physics are eligible to participate. The teachers receive training stipends and may obtain academic semester units from a California State accredited university.
- Curriculum training: The program trains teachers using the Amgen-Bruce Wallace Biotechnology Laboratory Program at the Biogen Idec Community Lab. This curriculum consists of eight lab exercises that teachers can conduct in typical high school class periods.

- Externships: Over a two-week period, teachers visit a variety of industry sites for half-day externships to view both hard and soft skills in practice, and to gain exposure to drug development processes and general company structures and functions. Host institutions include at least one large manufacturing site, a large R&D site, a small start-up company, and a research institution.
- Curriculum Sharing and Peer Networking: Teachers reconvene at the Biogen Idec Community Lab over a week-long period to share best practices, engage in curriculum troubleshooting.
- Curriculum Implementation: Teachers who lack equipment for implementing the labs in their classrooms receive free supplies, loaner equipment, and staff support in partnership with the Southern California Biotechnology Center (SCBC) and through grant funding from the Amgen Foundation. Also, the SCBC employs an outreach coordinator (funded by the Amgen Foundation) to offer teachers ongoing support in implementing the curriculum.

As will be discussed in Chapter Six, from 2005 to 2008, 184 students attended the Boot Camp course; 168 students participated in internships; and 69 instructors, who teach nearly 13,000 students, participated in the teacher externship program. Moreover, the program claims that 20 percent of the interns continued to work either part-time or full-time for the companies in which they interned.

### LMI Biotech Portal

The Workforce Partnership and BIOCOM developed the national Biotech Work Portal, located at [www.biotechwork.org](http://www.biotechwork.org), to respond to the need for relevant, up-to-date local and national labor market information related to the biotech industry for both curriculum development and regional economic planning, particularly in light of constantly changing biotech hiring and training trends, as well as the lack of knowledge by the business community and broader workforce about biotech education and training opportunities in San Diego and beyond.

Unveiled in 2007, the Portal is a central clearinghouse that provides comprehensive, up-to-date labor market information about the U.S. biotech industry, as well as access to

international biotech information. It also offers “innovative technology solutions that enable online networking, interactive data dissemination, and real-time user contributions and participation” (SDWP press release 2007). The Portal, which updates its labor market information on a regular basis and relies heavily on data collected by partner organizations, contains information on biotech careers, labor market statistics, labor market reports, education and training programs, special events, and biotech websites. For guidance in determining the structure and contents of the Portal and planning dissemination strategies, the Workforce Partnership and BIOCUM convened a National Biotechnology Advisory Committee, composed of industry, education, research, and workforce development representatives. It also partnered with Biospace.com to provide relevant content and assist with distribution and marketing of the site.

Finally, another innovative Workforce Partnership program, funded through WIA rather than the President’s High Growth Job Training Initiative, is the Life Sciences Pilot Project. Though it ended in 2006 despite attempts to obtain additional funding to expand it to other local community colleges, the program had an important impact on the design of the certificate curriculum of the host college, Mira Costa College (under study here), as well as on later efforts by other WIB partnerships to develop dislocated worker training partnership programs (such as the Bay Area Biotech Network, described above).

#### San Diego’s Life Sciences Pilot Project

In early 2002, IDEC Pharmaceuticals (now Biogen-IDEc) received FDA approval to market a new cancer treatment drug, and planned to build a production plant in Oceanside, CA (north of San Diego in North County), which would need to hire at least 200 entry-level workers in production level 1 jobs. The San Diego Workforce Partnership seized this opportunity to develop



a Life Sciences Pilot Project with its industry, education, and workforce agency partners, namely BIOCOM (the regional life sciences industry association), MiraCosta College, The North County Coastal Career Center, the Milken Institute, and Gruber and Pereira, a consulting firm.

In November 2003, the California Employment Development Department awarded the Workforce Partnership, as lead fiscal agent for the Pilot Project, a grant in the amount of \$678,546. The Workforce Partnership enjoined MiraCosta College and local industry employers like Biogen-IDEC and Beckman Coulter to develop a bioscience training program that would combine classroom training and an on-the-job (OJT) training experience. The program targeted adult and dislocated workers who sought to obtain entry-level production technician positions with an annual salary of \$25,000 to \$27,000 and career advancement opportunities. To meet the immediate needs of bioscience employers, the program trained two cohorts of 22 participants each over a two-year period. The newly created curriculum<sup>70</sup> consisted of three months of customized classroom training, which included coursework on biotech regulations, lab instruments, and quality control in biosciences production; as well as three months of work readiness training that prepared participants in the soft skills necessary for employment in the biosciences industry. In addition, following the classroom training, participants undertook six weeks of OJT opportunities with local bioscience employers, which would facilitate employment in the industry.

Other key components of the program included support and job placement services. North County Coastal Career Center, for instance, provided recruitment, screening, intake, eligibility certification, case management, and supportive services to participants. BIOCOM collaborated with the Career Center to coordinate job placement at Biogen-IDEC, Beckman Coulter, and other employers to ensure that all participants who successfully completed the

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<sup>70</sup> This curriculum has since been wrapped into the curriculum for the bioprocessing certificate.

training obtained employment in the industry. BIOCOM also used its employer network to identify hiring opportunities for participants not offered jobs through their OJT component. Finally, the Milken Institute conducted labor market research to ensure that the region would be prepared to meet the industry's future needs.

Outcomes of the Life Sciences Pilot project, which ended on June 30, 2006, will be discussed in Chapter Six.

### **3.4.2 Model 2: High School to Community College Programs**

#### Biotech Partners

A nationally recognized model for school-to-career partnerships, Biotech Partners (formerly known as Berkeley Biotechnology Education, Inc. or BBEI) was founded in 1993 as part of a 30-year Development Agreement between the City of Berkeley, CA and Bayer Healthcare. The German-based company had operated a facility in Berkeley for more than 90 years, originally producing plasma-based products, and wanted to transform the facility into its “worldwide headquarters for biotechnology,” given the site’s close proximity to major research institutions and biotech companies (Fern Tiger Associates 2002: 2). To obtain maximum flexibility in developing the site, as well as to build goodwill with the Berkeley community (which tended towards skepticism of “establishment” institutions like Bayer and was especially concerned about biotechnology’s potential dangers to health and community) the company entered into a lengthy negotiation process with the city, marked by hundreds of public hearings and community meetings.

The community’s vocal concerns about jobs and workforce training, particularly for the less advantaged members of the community, aligned well with the company’s interests in such

issues, given its cultural tradition of apprenticeships and vocational training, as well as unionized employment structure that involved organized labor in determining job and training requirements.<sup>71</sup> In addition, having reached the production stage for a number of its products, the company needed highly skilled technicians to manufacture its products, but had experienced difficulty recruiting such workers. College graduates, the company found, were not interested in remaining in manufacturing positions for long, and most non-college graduates lacked the requisite skills. Hence, the idea for an education-to-employment program that would combine academic preparation and hands-on laboratory work experience took root.

In February 1992, after more than a year of planning, Bayer and the city of Berkeley signed the Development Agreement funding the “creation of a new, not-for-profit organization dedicated to providing comprehensive biotechnology training and career opportunities to non-college-bound youth who represented the demographics of south and west Berkeley where Bayer was located” (ibid. 6).<sup>72</sup> BBEI officially started in 1993. As it has evolved, the main components of the program include the following:

- High school program. At high schools in the Berkeley and (now) Oakland Unified School Districts, the two-year high school component begins in the 11<sup>th</sup> grade with a skills-based curriculum, hands-on lab experience, and small classes. Students continuing the program into their senior year receive paid summer internships in the industry, earning approximately \$1,400. Students also learn job readiness skills at evening seminars, and participate in industry site visits and a career awareness conference at a bioscience industry partner.
- Community college program. Within the Peralta Community College District (Laney College, Berkeley City College, and Merritt College), high school students can continue their studies at the community college level in a one-year biotechnology certificate program. During the school year, community college students are offered a year-long co-

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<sup>71</sup> Bayer is one of the few life sciences companies in the United States with a union structure.

<sup>72</sup> This was the first time in the city’s history that the city, a private corporation, and community leaders had come together to approve a development agreement, and the first time such an agreement called for creating an independent organization that would provide education and training for traditionally under-served youth (Fern Tiger Associates: 10).

op job in a partner company to prepare them for entry-level employment in bioscience laboratories, production facilities, and healthcare settings. Each student is paired with a Biotech Partners-trained mentor during the year for support and supervision. Students also receive periodic performance reviews.

- Job Placement. Services to assist graduates in finding employment include job development, preparation, and counseling for interviews.
- Support services. Services for both students and families include tutoring, mentoring, scholarships, motivational speakers, career guidance, and efforts to help families understand work experiences.
- Paid teacher internships in industry. The internships expose public school teachers to industry needs and skills by offering teacher training in specific biotech curriculum issues, as well as biotech-related social, political and ethical issues.
- Industry outreach. Ongoing efforts seek to obtain commitments for internships and co-op jobs, curriculum guidance, teacher training, and equipment donations.

Since its founding in 1993, the collaboration has grown to include three local unified school districts and over forty biotechnology, health care and science-based partners. It claims to have achieved, since its founding, a 98 percent high school graduation rate (100 percent in 2005-2007); a 97 percent enrollment rate in post-secondary education; and a 60 percent graduation rate from Laney College's certificate program.<sup>73</sup> It also claims to have placed students in 900 internships and co-op jobs, and to have achieved a 100 percent job placement rate for those seeking employment after obtaining the biotech certificate.

#### Southwestern College/BETSI Project

Located in Chula Vista, CA, San Diego County's southernmost town, Southwestern College serves a largely Latino student body, granting more associate's degrees to Latino students than all but two colleges in the country (National Science Foundation 2008). The college's

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<sup>73</sup> This compares to a 25 percent rate for the community college system as a whole.

biotechnology program was founded in 1999, with 14 students in the first class.<sup>74</sup> Today, the program serves an average of 11 students a year, approximately eight of whom enter employment after program completion and the rest of whom transfer to a four-year program. Based on the Bridges to the Future initiative,<sup>75</sup> the program trains students in the skills necessary to enter the industry as entry-level lab technicians, e.g., to conduct basic experiments, collect data, and keep laboratory records, and/or as biotechnology research assistants.<sup>76</sup> It offers a Certificate of Achievement, which can be completed in three semesters, and an Associate in Science degree, which usually takes an additional year. In addition to these two tracks, students also have the choice of two additional tracks: a transfer track (transfer to a four-year institution) or a parallel track (simultaneous enrollment in the SWC Biotechnology Program and a four-year university<sup>77</sup>). All four tracks lead to possible employment within the biotechnology industry or post-graduate study.

Since its inception, the program has provided all students who complete the requirements for the certificate a paid internship opportunity. The internship is usually completed over a ten-week period in the summer at a range of biotechnology companies, research institutes, and universities. Since 2004, the NSF grant that the program receives for the BETSI Project funds the internships; prior to that, the biotech program negotiated with each company or institute hosting the intern to fund the internship. The program claims that 100 percent of all students

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<sup>74</sup> After one year, the program had retained 70% of the enrollees and four qualified for the certificate.

<sup>75</sup> Bridges to the Future is a federally funded program that aims to increase the number of underrepresented minority students in the sciences at community colleges who are considering bio-medical research as a major and a career, and who intend to transfer to a four-year university.

<sup>76</sup> The program found that 47 percent of the firms that it surveyed required a Bachelor Degree, while 27 percent required an Associate Degree or a high school diploma for this position.

<sup>77</sup> Students currently enrolled at a four-year institution and majoring in molecular biology and genetics need complete only two SWC courses (Intro to Biological Research I, II) to qualify for the biotechnology certificate.

who have completed the internship have either transferred to a four-year institution or become employed in the biotech industry

### BETSI Project

Founded in the fall of 2004 and funded by the National Science Foundation as an Advanced Technological Education (ATE) program, the BETSI Project (Biotechnology Education and Training Sequence Investment) is designed to educate students in biotechnology from three local high schools, recruit them into Southwestern College's biotech program, and help them advance into college or a career in biotechnology.

The pilot phase of the program was devoted primarily to conducting outreach to the feeder high schools, increasing the number of internships for Southwestern College students, and cultivating industry relationships. The project's Leadership Institute offers training and professional development to high school teachers and selected students, introducing them to advanced biotechnology techniques, activities, and theory. Each high school has ongoing access to biotech equipment, which is kept at Southwestern College, as well as supplies for integrating biotechnology into the curriculum and access to technical support. Through its Mobile Lab, the project also prepares and delivers state-of-the-art equipment and supplies to high schools throughout the area so that they can implement the biotechnology experiments and teach an updated curriculum. The project also aims to update the SWC biotech curriculum to address such current topics as the ethical, legal and social implications of the Human Genome Project.

A key feature of the BETSI Project involves using community college students trained through the Southwestern College biotechnology program, as well as the project coordinator, to serve as mentors to high school students in the program and provide technical support as lab assistants to high school faculty.

The focus of the current second phase of the project (which is due to expire in 2010), is on improving parental awareness of the biotech education and training available at Southwestern College. Through Parent Workshops, the project seeks to expose parents of high school students to the scope of educational and career opportunities in biotechnology, and to the enhanced biotech lab curriculum at the college. The workshops also “serve the need for adult education for a population with a rudimentary understanding of this important industry in San Diego County” (NSF Summary II).

#### Ohlone College LAB Program

The LAB (Learning Alliance for Bioscience) Project at Ohlone College in Fremont, CA is also an NSF-funded ATE program, which seeks to increase the number of students participating in biotech programs, particularly those from underrepresented groups. Begun in 2005 with eight students, the program now involves nine high schools, two middle schools and two community colleges (Ohlone and nearby Chabot College), enrolling more than 400 students. This Career and Technical Education allows high school students, beginning in their sophomore year, to complete the introductory classes in Ohlone College’s biotech certificate program. Once students graduate from high school, they can attend a four-year university or continue the program at Ohlone, where they can earn the biotech certificate in one year and/or an Associate’s degree in an additional year.

The program features small learning communities and the use of trained and paid community college students who serve as peer tutors; outreach activities involving parents and community residents; summer bridge programs; and staff development for high school and community college faculty, which promotes industry collaborations and leads to curriculum development. The program also emphasizes outreach to and recruitment of 18-24 year old

underrepresented students, primarily Latino. During the program’s first two years, about half of the students were from underrepresented groups (NSF 2008). A chart of Ohlone’s pathway training programs follows on the next page.

### **3.4.3 Model 3: Community College Bridge and Career Pathway Programs**

#### CCSF Biotechnology Career Pathway Programs

One of the largest community colleges in the country, with over 100,000 students (including credit and non-credit students), the Community College of San Francisco (CCSF) established its biotechnology program in 1991, when it became the headquarters of the Northern California Biotechnology Center (now CalABC-Bay Area). However, while the one- and two-year certificate programs were developed with industry input, they suffered from low enrollments. In addition, as those students who did enroll tended to have four-year degrees in biology and chemistry, the programs were not serving students who were already enrolled at CCSF. Indeed, communities in two economically disadvantaged areas of San Francisco in which CCSF has campuses (Bayview-Hunter’s Point and Mission District, predominantly African-American and Latino communities, respectively) demanded greater access to CCSF program offerings.

Once faculty and staff determined the primary reason for diminished access by such groups—namely, that the program screened applicants, many of whom lacked the requisite science and mathematics background—they created a “Bridge to Biotech” program in 2002. This program is designed to provide underserved students with the skills needed to enter the CCSF biotechnology certificate program or entry-level jobs in the industry. Soon after

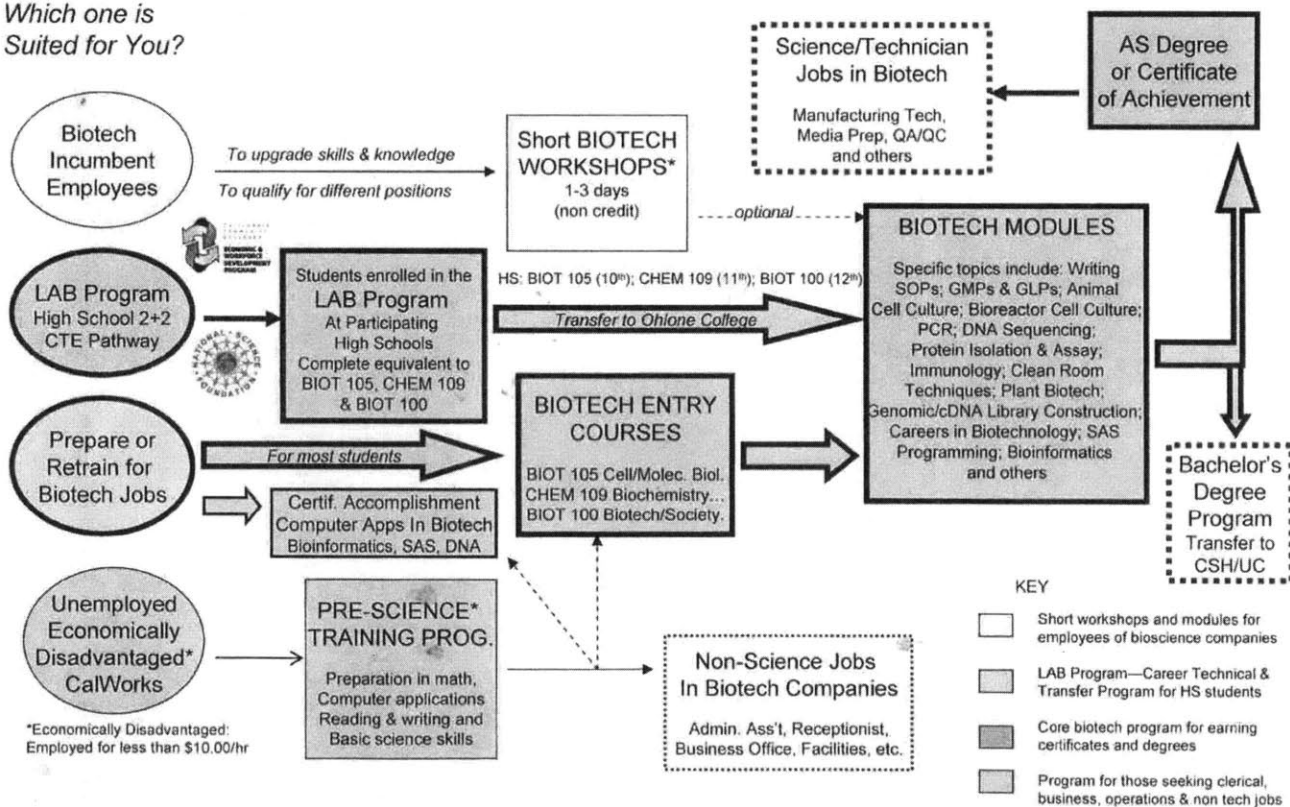


# Ohlone College Biotechnology Training Programs



## Program Options Offered

Which one is Suited for You?



instituting this program, CCSF found that qualified applicants to the certificate programs increased from about 20 per year to more than 200 per year.

A unique feature of the Bridge program are its highly contextualized biotech mathematics and language courses, which teach both the skills set and the language of those skills, e.g., the biotech math course makes sense of the raw data collected in the lab and the biotech language course provides the skills needed to document the data in the lab. A key motivation for designing the courses in such a manner was that students entered the program with very different math and language skills, e.g., some students are immigrants with a math degree in their home country, while others may be native speakers with poor science skills. Teaching students how to make sense of the data in a lab engages everyone in the curriculum, even those with strong math skills. Similarly, all students benefit from learning how to accurately and concisely present their skills in the cover letter and resume, and to talk about their skills in the interview. That is, students learn how to “tag” skills, such as “aseptic technique for maintaining a contaminant-free environment,” which function as keywords on a resume.

In the course of screening applicants for Bridge to Biotech, the CCSF program soon realized, however, that many students were not ready even for this program, which requires a ninth-grade math level; instead, these students needed a “pre” bridge program. Consequently, in partnership with San Francisco Works (SFWorks), an affiliate of the San Francisco Chamber of Commerce and a nonprofit workforce development organization, as well as the Private Industry Council of San Francisco, CCSF designed a lead-in curriculum to prepare students for entry to the bridge program, called the “On Ramp to Biotechnology.”<sup>78</sup>

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<sup>78</sup> To reach as broad a potential candidate pool as possible, SFWorks has marketed the On Ramp to Biotech program through fliers that proclaim: “You don’t need to know what biotech is to begin developing a career in it; we have training options at all skill levels. If you have a high school diploma or GED, can pass a drug test, and have no drug felonies, you may also be eligible for paid internships and job placement assistance. This is your chance to

Accordingly, the CCSF's biotech program contain six levels of career ladder training, each of which is detailed below: two bridge programs, the On Ramp and Bridge to Biotech; three certificate programs, in Biomanufacturing, Biotechnology, and Stem Cell Technology; and an AS in Biotechnology.

In 2004, the National Science Foundation awarded the partnership between CCSF and SFWorks two grants totaling \$1.1 million to expand the two bridge programs. SFWorks received \$600,000 to strengthen the On Ramp program, and CCSF received \$500,000 to expand the Bridge to Biotech program to additional campuses, including the Mission Campus, and to offer the program to limited-English speakers from under-served Asian, Filipino, Pacific Islander, Latin and Eastern European communities. Also in 2004, the Association of Community College Trustees recognized the CCSF-SFWorks partnership as one of the five best practices nationally for community economic development (Office of the Mayor Press Release 2004).

On Ramp to Biotechnology. Targeting low-income, under-skilled, and underrepresented adults with no prior science and math background and a 7-9<sup>th</sup> grade education level, the On-Ramp prepares students for CCSF's biotech and biomanufacturing certificate programs, as well as entry-level employment. The ten-week preparatory program offers an introduction to the life and laboratory sciences, simulated lab procedures, contextualized mathematics, and professional development (e.g., communication, resume writing, mock interviews, and professional work skills). When students reach the Bridge to Biotech program, SFWorks continues to offer professional development coaching, and places students in subsidized, part-time lab internships. Sixty-three percent of the population served is African American; 37 percent is Latino, Asian or other; 30 percent is unemployed; and 50 percent receives public assistance.

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take that first step." The flier also notes that "Biotech offers excellent salaries starting at \$26,000 - \$32,000 + benefits and rapid career growth opportunities."

Bridge to Biotech. This one-semester program provides students with the college-level math, biology and communication skills necessary to succeed in the biotech certificate programs. Designed to accommodate working adults, the program holds classes during the day and evenings. Each entering class is a cohort or learning community that completes all required courses together, which take place over three days for four hours per day. For students participating in the Bridge Internship and Job Preparation (BIJP) program, students attend an additional day of laboratory experience. Once they have completed both the Bridge and BIJP programs, they are placed in a paid (\$9 per hour) internship at a Bay Area lab for 10-15 hours per week. SFWorks assists students not continuing on to the certificate program in finding jobs in the bioscience industry. Students qualify, depending on internship experience, for positions as bio-processors, glassware technicians, lab assistants, animal care technicians, environmental health and safety technicians, and media prep technicians.

Students who have at least one semester of college-level general biology and two semesters of college-level general chemistry can enroll in three different biotech certificate programs in the areas of biomanufacturing, biotechnician, and stem cell technology. In addition to students who have completed the Bridge to Biotech program, these certificate programs serve displaced workers and returning students, who already have an AA degree or higher and who seek retraining in biotechnology. The certificate offerings are as follows:

Biomanufacturing Certificate. This one-year program provides students with the fundamentals of biology and chemistry required to pursue studies in biotechnology, as well as the essential lab skills needed to get a job in biomanufacturing. The certificate prepares students for entry-level positions as bio-process technicians, media prep technicians, pharmaceutical materials specialists, and pharmaceutical manufacturing technicians.

Biotechnology/Biotechnician Certificate. Students who complete the one-year biomanufacturing certificate program or who have a string grasp of algebra, biology, and chemistry from previous academic or work experience, may take an additional year of classes to fulfill the requirements for this two-year program. Focusing primarily on applied research techniques, it prepares students for transfer to a four-year university or for work as a technician in quality control, research and development, or biomanufacturing.

Stem Cell Certificate. This program is designed for students who have earned the biomanufacturing or biotechnician certificate or have sufficient academic grounding in math and science. The additional semester of courses prepares students to work at a biotech company or academic research lab as a technician in mammalian cell culture or adult and embryonic stem cell culture.

Associate Degree in Biotechnology. This two-year program prepares students for transfer to a four-year program while providing them with specialized training for employment as a biotechnician engaged in research, design, manufacturing, operations, marketing, testing, or sales.

#### East Bay Career Advancement Academy/California Gateway Project

In 2005, the Career Ladders Project of the California Community Colleges Board of Governors launched the California Gateway Project (also called the College and Career Pathway Program), a pilot program linking WIBs, community colleges, social services agencies, community organizations, and employers to connect disadvantaged youth and adults to post-secondary education and career pathways in high-demand fields, such as biotechnology, health services, construction and automotive trades, energy and petrochemicals, and financial services.

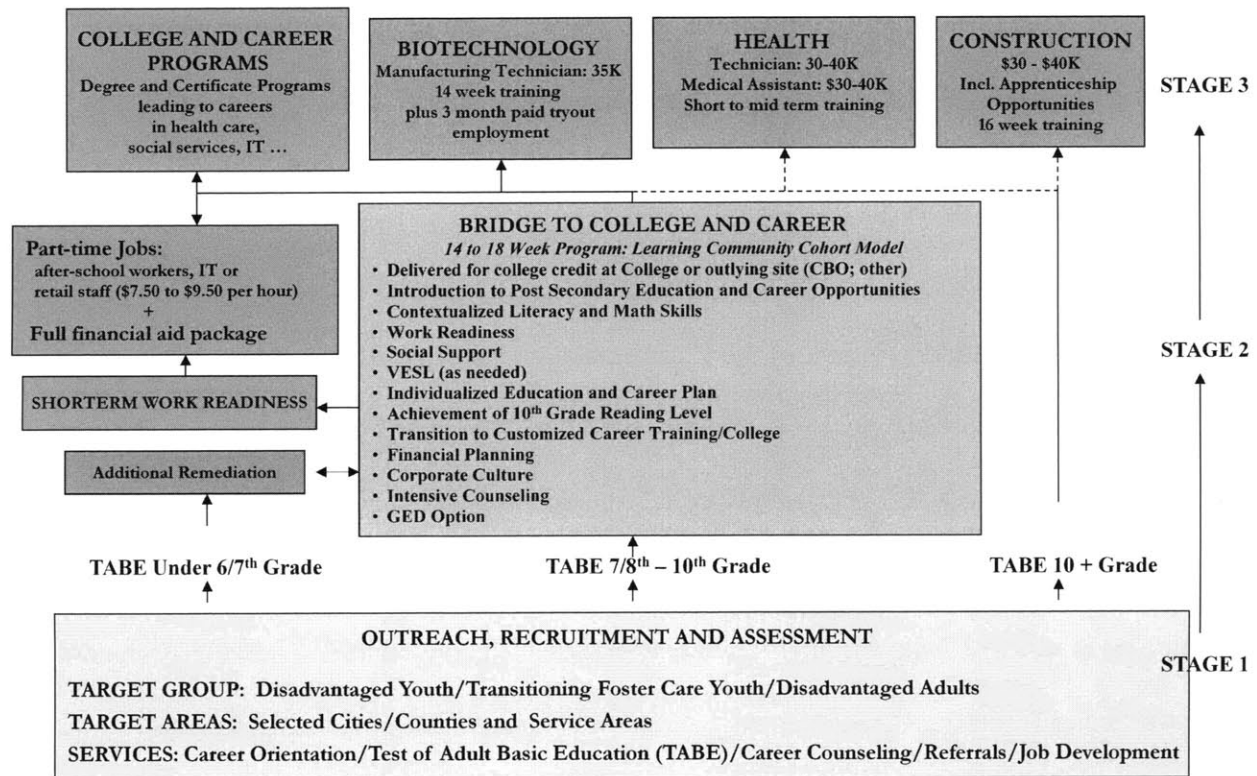
Originally offered in six counties, including Alameda, Contra Costa, San Mateo, and Santa Clara

counties, the project consisted of an intensive, 14-18 week “bridge” curriculum delivered for college credit in a learning community design. Program features included contextualized basic skills preparation in English and math, part-time jobs and full financial aid, an in-class counselor, “wrap around” support services and case management, an introduction to educational and career opportunities, and program coordination as students transition to community college certificate or degree programs.

In light of the success of Skyline’s biomanufacturing certificate program, Skyline College and Canada College, both in San Mateo County, created their gateway program in 2005 to prepare students for entry into this certificate program. A diagram of this model “gateway to biotech” program follows:

**Figure 3.1**

**THE COLLEGE AND CAREER PATHWAY PROGRAM**



Developed by: THE CAREER LADDERS PROJECT and GRUBER & PEREIRA ASSOCIATES

In 2007, the larger Gateway Project pilot ended and, with grants from the Chancellor's Office of the CCC, transformed into the regional Career Advancement Academies (CAA) pilot project. Funded with renewals for up to three years, each of the three statewide academies—in the East Bay, the Central Valley and Los Angeles—was designed to establish pipelines for underprepared, underemployed young adults to careers and additional higher education opportunities.

Operating with the San Francisco Bay Area (one of the two regions under study here), the East Bay CAA is a partnership among two community college districts, seven community colleges, and a range of CBOs, adult education providers, and industry and workforce development partners in Alameda and Contra Costa Counties. Open to adults between the ages of 18 and 30 years of age, the East Bay CAA is a focused, one semester (18-week), basic skills program that prepares students to enter industry-related occupational training programs at participating community college programs or jobs in four targeted industries: biotechnology, allied health and human services, automotive technology, and construction and building trades.

The program features four components:

- Industry-driven program design, led by a Regional Advisory Council and an Industry Alignment Subcommittee, both consisting of representatives from the targeted industries, educational institutions, community organizations, and workforce development agencies.
- Collaborative curriculum development and instruction. The accelerated, two-phase curriculum emphasizes “contextualized basic skills,” using specific industry content, in phase one; and training in the skills sets of students’ chosen industry, in phase two. In addition, the CAA uses a cohort-based learning community model to improve retention and educational success. It also uses a set of pedagogic strategies that aim to equip academically underprepared students with the skills and ability to enter college-level technical education programs or entry-level jobs.
- Professional development for faculty, to help faculty coordinate and improve instructional delivery.

- Comprehensive student support services. More than a dozen community and workforce partners are collaborating to provide students with intensive and ongoing support services, including a network of social services, career assessment services, life skills courses, and financial support resources. The program also makes tutors available to students and matches students with a community mentor to ensure their access to community social networks.

Students who choose the biotechnology career path attend Laney College, which offers a one-semester “fast track” Certificate of Proficiency in Biomanufacturing and a two-semester, intensive Certificate of Achievement in Biomanufacturing. Laney College is also the community college which students in the Biotech Partners program attend upon completion of high school (see description of Biotech Partners in Section 3.2.4., above).

#### **3.4.4 Model 4: Community College - Industry Partnerships**

##### MiraCosta Community College--IDEC/Biogen-IDEC/Genentech Partnership

MiraCosta College in Oceanside, CA first offered biotechnology classes in research and development in 1990. From 1996 to 2001, it served as the Southern California Biotechnology Center, where it “developed new curriculum, accepted donations from industry on behalf of the region, performed outreach to local high schools, and coordinated with local and state-wide initiatives with respect to biotechnology workforce development” (MCC Biotechnology Backgrounder). As companies transitioned to later stage development and production, the college recognized the need to develop a new biotechnology manufacturing curriculum, and so initiated partnerships with several employers and the local chapter of the International Society of Pharmaceutical Engineers to expand the college’s biotech program.

During this period, IDEC Pharmaceuticals was searching for a site in which to locate a large manufacturing facility, and was considering either San Diego or Texas. As part of the inducement package, San Diego’s mayor offered MiraCosta as the college that would train the



company's new employees. Hence, IDEC was especially interested in working with the college to develop training that would address the needs of large-scale, FDA-regulated biopharmaceutical production. Consequently, the partners created a new bioprocess technology curriculum—to date, the only recognized bioprocessing training program in Southern California.

As noted above, once IDEC received FDA approval to market its new cancer treatment drug in 2002, it began construction on a production plant in Oceanside. Interested in having the training for the new bioprocessing curriculum occur in a “dedicated and immersive environment,” the company entered into a partnership with MiraCosta College to support the development of a state-of-the-art, professional-quality teaching facility at the college. The company directed its own construction company and engineering and architectural firm to design the facility, pro bono (at an estimated cost to the company of \$200,000). The college also assisted with the costs of building this multimillion-dollar facility. The 3,500 square foot building, which includes a biomanufacturing laboratory, a simulated “clean” room, and a classroom for lectures, as well as over \$1 million in cutting-edge equipment, opened to classes in November 2005. A DOL High Growth Jobs Training Initiative Grant provided for the purchase of equipment, while local companies and service providers have donated hundreds of thousands of dollars worth of equipment. Finally, IDEC also supported the creation of a dedicated, tenure-track faculty position whose member would lead the program, donating an additional \$200,000 to this effort.

When an East Coast company, Biogen, bought IDEC, the Miracosta College biotech program was concerned that it would lose support of its key industry partner. Biogen-IDEC, however, supported the program, and continued the partnership with the college. Subsequently,

Genentech bought the entire facility, but decided to keep working with the college—a testament to the power and resilience of this industry partnership.

The US DOL has named MiraCosta College a Bioprocessing Center of Expertise in recognition of its successful partnership initiatives and unique curriculum. Introduced in the 2004-2005 academic year, the curriculum prepares students for careers in research, development, quality control/assurance, manufacturing, and analytical testing, as well as for work as a lab technician. Specifically, the college offers two certificates of proficiency, which are designed to be the first step in a career ladder; a certificate of achievement, the next step up the ladder; and finally, an Associate's degree, as follows:

- Certificate of Proficiency in Laboratory Skills. This two-semester certificate program prepares students in the technical skills necessary to perform tests and routine tasks in a wide range of laboratory settings.
- Certificate of Proficiency in Bioprocess Technology. This three-semester certificate program provides a foundation in, and practical application of, the technologies used by biotech companies that produce cell-derived products, so that they can perform technical work in a regulated environment, e.g., production, process development, validation, quality control, calibration, and maintenance.
- Certificate of Achievement in Research and Development. This three-semester certificate program gives students the theoretical background and practical experience necessary to be effective lab technicians, while also preparing them for upper division course work. Graduates can start careers in quality control/assurance, production, applied research, product development, analytical testing, and academic (basic) research.
- Associate's of Arts in Research and Development. Finally, students who have completed the Certificate of Achievement in Research and Development and the requisite general education courses may earn the two-year associate's degree.

#### Bio-Link/SCBC – Faculty Externship pilot

In 2002, Bio-Link's Southwest Regional Center at San Diego City College conducted a summer internship program in biotechnology manufacturing for five faculty members from San Diego County community colleges at IDEC Pharmaceuticals. Having broken ground on its 450,000

square foot manufacturing facility in Oceanside, IDEC Pharmaceuticals (now Biogen-IDEc) anticipated demand for 500-700 highly-trained manufacturing operations staff by 2006, when the facility would be fully commissioned. The Southern California Biotechnology Center, also hosted by SDCC, convened industry and education leaders to develop a program to address the shortage of bioproduction education programs within North San Diego County, where IDEc was located.

Given that few faculty had a “clear understanding of the technical skill requirements of large-scale bio-pharmaceutical manufacturing operations, or knew how these competencies differed from the skill sets currently being taught to students preparing for employment in biotechnology research and development operations,” the parties developed a five-week faculty internship program, inspired by an earlier, successful initiative in which a Solano College faculty member interned at Genentech’s Vacaville manufacturing facility for six weeks and developed an industry-responsive bio-manufacturing program at the college (see above for project description) (Kane and Buecheler 2003: 5). IDEc also intended to benefit from the externship program by gaining access to a “new, larger pool of local workforce candidates trained according to the industry’s own specifications” (ibid.) The company anticipated as well an decrease in costs associated with the ability to hire well-trained technicians locally.

Intending to serve as a model/blueprint for industry-education internships nationwide, the faculty program included the following goals: to help instructors understand the skills required in biotechnology manufacturing and the ways in which such skills differed from research and development skills; to forge relationships between instructors and IDEc staff; to encourage IDEc input on curriculum development; to encourage IDEc staff to serve as guest speakers and visiting instructors in community college classes; and to “give instructors an appreciation of how

each of their disciplines interrelated with other academic disciplines in the biotech manufacturing setting” (ibid. 5) This last goal emerged from the recognition that biotech education in the CCCs traditionally has been biology-based, even though other disciplines are integral to the manufacturing process, e.g., chemistry, manufacturing technology, clean room technologies/facilities control, and instrumentation calibration. Having faculty members from diverse disciplines intern together helped them understand the interdependence of their respective disciplines within the manufacturing process, so that they could better revamp the conventional curriculum.

In its evaluation of program outcomes, Bio-link concluded that the program succeeded in increasing faculty member’s appreciation for how biotech product manufacturing differs from R&D, for the “scale, complexity and intricacy of the production process,” and for the “challenges of the physical environment and working under cGMP guidelines in clean room conditions” (ibid. 13). For instance, a biology instructor commented: “When you’re doing R&D on the bench top, as hard as it is, with the 80% failure rate, you can’t even imagine how much more difficult this would be on a large scale under scrutiny of the FDA, and knowing you are going to be injecting this into people...it just magnifies on a logarithmic scale and that was impressive to see” (ibid.). Also, noting that the fermenters at IDEC’s facilities made her feel like “an ant standing in front of Mount Everest,” she observed: “Until you see the manufacturing operations, you can’t understand what it takes to make these large-scale media and buffers under clinical conditions and FDA guidelines” (ibid.)

The report also found that this new respect for the “scale, complexity and intricacy of the production process...would impact the development of appropriate courses and programs” (ibid.). For instance, one instructor, surprised by the SOPs complexity and depth, noted that he

would now include variability and percentage of uncertainty in his course. “The accuracy level at IDEC is much higher than other industries, and this is information that I need if I am to be successful with this next class in terms of biotech” (ibid. 14).

Moreover, the report found the “face-to-face contact with IDEC managers invaluable for developing an understanding of the precise skills needed in bio-manufacturing, which can increase their credibility among their peers in the community college curriculum review process” (ibid.). Because IDEC staff could delineate precisely how and where current college programs fell short of their requirements, the faculty gained adequate input into on the curricular content needed to equip students for biotechnology manufacturing jobs.

The report concluded that the internship project has a “substantial positive impact on biotechnology course and program development, on regional coordination and specialization among the region’s community colleges, and on coordination between the colleges and the biotechnology industry” (ibid. 21). Regarding the deepening of the community college-industry partnership, the report observed:

While the interns learned about the training needs of employees in biotechnology product manufacturing, IDEC staff developed a vested interest in working with community college professionals to help design effective college courses and programs to meet industry needs. IDEC employees now routinely contact their training manager before discarding unused or obsolete equipment and materials to see if these might be of interest to regional community colleges; IDEC employees attend career days hosted by the colleges, participate as guest lecturers in college courses, and provide ongoing advice on curriculum development and state-of-the-art technology” (ibid. 24).

Moreover, as noted above, the company contributed design services and equipment to MiraCosta College’s new training facility, in part as a result of the close relationship that one of the interns, who happened to be dean of MiraCosta College’s science programs, developed with the company.

### **3.5 Best Practices in Biotech Education**

In arguing that community colleges can play critical roles in advancing low-skilled workers, Grubb (2001: 287) presents a set of five precepts for effective programs that may be used to judge their potential effectiveness:

1. Understanding the local labor market and targeting high-wage, high growth jobs.
2. Combining an appropriate mix of academic (or remedial/basic) education, occupational skills, and work-based learning.
3. Providing a variety of support services to participants.
4. Delineating pathways or ladders of further education opportunities so that students understand how to continue their education and training.
5. Collecting appropriate information about program results and conducting outcome evaluations.

Research by the Workforce Strategy Center (Alssid et al. 2002), the Aspen Institute (WSI 2007), and the Life Science Career Alliance (2006) specifies additional best practices in biotech education and training programs, including:

- Shortening the time that it takes for students to complete the program, e.g., from four semesters to one.
- Offering students on-the-job experience through internships and paid work experience while they study.
- Creating bridge programs to reach and support disadvantaged and underserved students.
- Ensuring that teachers are experienced in the industry through industry externships.
- Developing links to the workforce, education, and social services systems.
- Partnering with employers, and in particular, involving employers in curriculum development.
- Instituting regional partnerships.

Finally, along these lines, a recent national conference convened by the National Science Foundation and the American Association of Community Colleges to explore ways to strengthen technician education proposed a number of recommendations for community colleges, as well as universities, secondary school, and government and industry partners (Patton 2008). Across several categories, recommendations most relevant to the issues under study here include:

Curriculum:

- Provide instruction in written and verbal communication, and “soft skills” such as teamwork and time management
- Core curriculum courses should transfer and articulate from high school to two-year and four-year programs.
- Courses should provide a strong theoretical understanding of the entire manufacturing process, from upstream to downstream processes.

Training programs:

- Support industry externships for faculty, secondary school teachers, and guidance counselors.
- Develop multi-disciplinary programs for cross-training of college faculty and students (e.g., microelectronics as it relates to emerging diagnostic technologies)
- Institute a “parallel analysis” of skills from different subfields to inform retraining programs so that biotechnicians are better prepared to shift fields within the rapidly changing industry.

Relationships and partnerships:

- In addition to encouraging such partnerships among education, industry, and government, develop regional biotech partnerships that prepare students with crossover skills used by particular industries in multiple states.

Marketing and communications

- Raise industry awareness of existing biotech programs, including graduate employee successes.

As the previous profiles of the San Francisco Bay Area and San Diego County biotechnology programs sought to demonstrate, and as I will argue in Chapter Seven, the programs under study here share many of the best practices highlighted above or are seeking ways to incorporate them into their program offerings.



## **Chapter 4: Biotechnology Industry Dynamics and the Technician Workforce**

This chapter describes the major types of technician-level occupations which the community college biotech programs, profiled in this study, prepare students to enter. It outlines entry requirements for these occupations, categorized by biotechnology sector, as well as associated career paths and general working conditions. The chapter also discusses recruitment and hiring practices.

### **4.1 Job Functions and Occupations by Stages of Production and Industry Sector**

The majority of biotechnology activity involves the development of pharmaceuticals or human therapeutics, i.e., of new and unique drugs for the treatment of human diseases and disorder. Applications in human therapeutics include vaccines, gene therapy, human growth and other hormones, and therapeutic drugs. As discussed in the first chapter, other life sciences activities that frequently are included within the biotech industry sector involve the production of biomedical devices, instruments/reagents, and human diagnostics.<sup>79</sup> While the focus of most of the community college biotechnology programs under study here is on biopharmaceutical development and manufacturing, many do prepare students to enter these other sectors as entry-level technicians. The following discussion of technician-level occupations and job requirements, however, will center on biopharmaceutical production.

Each area of biotechnology, e.g., pharmaceuticals, instrumentation and bio-industry suppliers, agricultural and food science, environmental, energy, genetic testing, is composed of

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<sup>79</sup> *Bio-medical device* companies use naturally-derived materials to make medical appliances, e.g., heart valve replacements and skin grafts. Applications include wound-healing devices, tissue regeneration and engineering, drug-coated stents, and micro devices (embedded drug delivery devices). *Instrumentation and biological reagent* companies seek to improve the efficiency and efficacy of drug development research and testing performed by private companies, universities and hospitals. Applications include micro-assay technology, DNA diagnostics, and medical diagnostic testing. *Human diagnostic* companies seek to identify the presence or absence of specific chemicals, genes, or proteins, which may indicate disease. Applications include biological imaging, biosensors, DNA probes, and monoclonal antibodies (MassBioEd Foundation 2007).

several different job functions or job families, which correspond to the primary stages of production, i.e., from R&D through clinical trials to commercial production and marketing. The job families include research and development, clinical development, regulatory, quality, product/process development, manufacturing, and sales, marketing, and technical support. Most of the entry-level occupations that community college biotech program graduates enter are clustered in the R&D, clinical development, quality, process development and manufacturing job families. Hence, the following sketch of technician-level positions available to program graduates is limited to those job families.

### Research and Development

Research and development to discover new or improve existing therapeutic products is a lengthy process that begins in the laboratory as scientists test biologically active molecules and compounds with the potential to prevent or treat disease. Once they identify such a compound, researchers subject it to extensive testing on laboratory animals to determine the compound's mechanisms and assess its safety for human testing. Typically, only one in every 5,000 to 10,000 compounds tested and screened ultimately becomes an approved drug (BLS Career Guide). Researchers at the early R&D phase also develop a dosage form of the compound.

The development cycle for human diagnostics is different than that for human therapeutics (i.e., drug development for treatment of human diseases). Diagnostics involves the identification of the presence or absence of specific chemicals, genes, or proteins in the body that may indicate disease. Applications in the field include biological imaging; DNA cloning for sequencing or analysis of genes; the diagnosis of hereditary or infectious diseases; and the identification of genetic fingerprints. Diagnostic products have a shorter development cycle than therapeutic products—taking up to two years to bring the product to market, as opposed to 8 to

10 years—as well as lower development risks and costs, primarily because diagnostic products are not required to go through the human clinical trials process (see below).

Large biotech companies usually have in-house R&D departments, while the start-ups tend to be devoted solely to this function. Because most of the activity at this early stage involves research, the majority of employees have Ph.D. or Master's degrees. However, associated with the discovery research process are several entry-level positions, which usually require an associate's degree or certificate, but sometimes require no more than a high school diploma. As described below, these positions include Laboratory Support Worker, Laboratory Assistant, and Laboratory Technician. From these entry-level positions, technicians may progress in their careers to higher-level research assistant and associate positions, especially if they obtain a bachelor's or master's degree, and also may transition to a supervisory pathway with additional education (Life Science Career Alliance 2006).

Note: Most of the entry-level positions described in this section typically include four levels of job title to which workers may advance upon obtaining increased education, training and/or work experience. For instance, Lab Assistant I requires a minimum of a high school diploma and 0-2 years of related experience, while Lab Assistant 4 requires a high school diploma and a minimum of 6+ years experience (Biotech Work Portal, Career Ladder Chart, [www.biotechwork.org](http://www.biotechwork.org)).<sup>80</sup> Additional education, e.g., a certificate or A.S. degree, normally corresponds with fewer years of requisite work experience. The tables below, however, reflect average education and training requirements, as identified by the Bureau of Labor Statistics and Life Science Career Alliance (2006).

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<sup>80</sup> The 2006 Radford Biotechnology Survey also identifies four levels within each position (Godbe 2006).

Laboratory Support Worker. Also known as laboratory glass washers or cleaners, laboratory support workers wash, dry, sterilize, and restock glass and plastic ware used in the labs, such as pipettes, petri dishes, and test tubes. To ensure that no unwanted organisms are introduced into the experiment, they must keep the glass washing facility clean, according to standard guidelines; sterilize items using an autoclaver; test cleaned glassware for sterility; and keep inventory. They must keep computerized records of the equipment that is used and cleaned, and may also assay samples, prepare them for study, maintain and repair equipment, and perform instrument calibration, and maintain quality control. Typical job and skill requirements, as well as average wages/salary for the position are as follows:<sup>81</sup>

*Laboratory Support Worker*

Requirements	Skills	2007 Wage Range
HS diploma or A.S. degree or certificate; up to 2 years of work experience preferred.	<u>Technical</u> : Record keeping; equipment maintenance; information ordering. <u>Personal</u> : Detail oriented; organization skills; manual dexterity; lift 10-50 lbs.; perform routine, repetitive work	\$7.61 to \$8.97 for Dishwashers; \$11.68 to \$19.05 for Medical Equipment Preparers <sup>82</sup>

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<sup>81</sup> The information contained in this and subsequent job position tables comes from the following sources: Peters and Slotterbeck (2004), with wage figures updated by the CA Employment Development Department in 2007; Frierman-Hunt and Solberg (2002); Godbe Associates (2006); Life Science Career Alliance (2006); and the Biotech Work Portal, [www.biotechwork.org](http://www.biotechwork.org).

<sup>82</sup> As the Bureau of Labor Statistics does not collect data on laboratory support workers, the California Employment Development Department uses data for occupations found in the biotech industry that have similar duties to the one in question. Hereinafter, the table will list only the wage amount, not the equivalent position used.

Laboratory Assistant/Technician. Laboratory Assistants or Technicians perform research lab tasks and conduct experiments under the supervision of scientists or team leaders. They can work in such biotechnology areas as research, production or process monitoring. Though job classifications vary by company, lab assistants are usually considered more entry-level, requiring an A.S. or certificate, usually in biotechnology; some employers, however, may prefer to hire candidates with a Bachelor's degree. Lab technicians are usually considered higher-level positions, requiring more extensive background in science. Many employers prefer B.S. candidates for these positions, although some will hire candidates with a specialized A.S. degree in biotechnology and experience as a lab assistant.

*Laboratory assistants* help conduct routine tests, experiments, and well-defined procedures under close supervision, and maintain laboratory equipment and inventory levels for laboratory supplies. They also may be responsible for equipment calibration and monitoring, troubleshooting, maintaining samples, growth media and specimens, and ensuring quality control, and may write experimental reports, summaries and protocols. They must compile and record test results daily in computer databases and/or in chart/graph format. They also may be expected to engage in glasswashing activities.

*Laboratory technicians* perform similar functions as lab assistants, but as their experience increases, they handle more specialized procedures. They weigh, measure and check materials to assure batches contain proper ingredients and quantities, and may assist with in-process testing to assure batches meet specifications. They also may interpret data, calculate and record results, develop conclusion, troubleshoot, and even help develop new procedures.

### *Laboratory Assistant*

Requirements	Skills	Wage/Salary Range
HS diploma or AS degree or equivalent. 1 to 2 years related lab experience.	<u>Technical</u> : Biotech lab procedures; knowledge of SOPs and GLPs; read and interpret technical materials; record keeping; computer skills <u>Personal</u> : Organizational and observation skills; team work skills; Detail oriented; manual dexterity.	\$15.68 to \$26.46 per hour (2007); or \$24,000 to \$33,000 annually (2006)

### *Laboratory Technician*

Requirements	Skills	2007 Wage Range
B.S. or A.S. degree in biotechnology.	<u>Technical</u> : Analyze, evaluate technical data; biotech lab procedures; knowledge of SOPs and GLPs; read and interpret technical materials; record keeping; computer skills. <u>Personal</u> : Organizational and observation skills; team work skills; Detail oriented; manual dexterity.	\$15.68 to \$26.46 per hour

### Pilot-Scale Manufacturing

Once researchers identify and test a promising compound, the company manufactures the compound at pilot scale for use in initial studies and clinical trials. For biopharmaceutical products, cells are grown in a volume of about 10-200 liters, while for traditional pharmaceutical products, the product is produced in a chemical synthesis process that is small scale (North Carolina Biotechnology Center 2003). Researchers are also drawing up initial plans for the subsequent manufacturing process, should the product receive FDA approval upon completion of clinical trials.

If the company lacks internal manufacturing capabilities, it contracts with a contract manufacturing company (CMO) to produce sufficient supplies of the product—small volumes in the case of pre-clinical trials and development, and larger amounts in the case of clinical trials

and commercialization. Firms must decide upon FDA approval whether to build its own manufacturing facility or contract fully with a CMO.

Because the entry-level positions associated with this phase of the drug discovery process are similar to those involved in the post-clinical trial manufacturing stage, the manufacturing technician positions will be described later in this section.

### Clinical Trials

Researchers in the company's clinical development area may begin clinical testing of the product once they have received FDA approval to do so. A clinical trial is the process for testing a new drug candidate in human subjects (as noted, diagnostic products need not undergo this clinical trials process). The three distinct phases of testing involve, in the first phase, administering the drug to a small group of healthy volunteers to determine appropriate dosage and safety; and in the subsequent phases, testing the drug in successively larger groups of patient volunteers with varying degrees of the disease to check for efficacy, side effects, and reactions to long-term drug use. The Phase III group may include up to 10,000 patients. Only one out of 200 drugs that enter pre-clinical tests will gain FDA approval, while approximately 75 percent of drugs that complete Phase III trials and apply for a New Drug Application will gain approval.

During these trials, workers document toxicity and side effects, modify drug dosage, monitor blood levels, determine compatibility with other medications, and gather data relating to the drug's efficacy. As in the discovery research phase, most clinical lab positions require a bachelor's degree. However, two entry-level positions, clinical document assistant or clinical lab assistant/associate, typically require a high school diploma, with preference for a biotech certificate or A.S. degree. The majority of companies may still prefer to hire B.S. graduates for clinical lab associate positions, however. With additional education (typically at the graduate

level), clinical lab workers may progress to the following positions: clinical data associate, biostatistics associate, clinical research associate/senior associate, medical writer/senior writer, and a range of scientist and supervisory positions.

Clinical Document Assistant. This employee works with the document management system to support clinical development and the new drug approval application process, including activities related to document creation, publication, review, approval and distribution. The document assistant also serves as a liaison between the clinical development and regulatory affairs departments in the document planning and publishing functions.

*Clinical Document Assistant*

Requirements	Skills	2006 Salary Range
HS diploma; preferably a biotech certificate or A.S. degree and 1 to 2 years related lab experience.	<p><u>Technical</u>: Biotech lab procedures; read and interpret technical materials; record keeping; computer skills</p> <p><u>Personal</u>: Organizational and observation skills; team work skills; detail oriented.</p>	\$24,000 to \$33,000 <sup>83</sup>

Clinical Laboratory Assistant/Associate. Also called a clinical lab technician, this employee supports data collection and operation of the clinical lab, while coordinating documentation related to conducting clinical studies. Additional responsibilities may include administering test drugs and/or drawing blood; helping create standardized clinical trial tools, processes and SOPs; and distributing the results of test results and studies.

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<sup>83</sup> All 2006 salary ranges are from the Life Science Career Alliance (2006) and/or Godbe Associates (2006).



*Clinical Laboratory Assistant/Associate*

Requirements	Skills	2006 Salary Range
HS diploma with 2 to 4 years related experience; or a biotech certificate or A.S. degree and 0 to 2 years related lab experience.	<u>Technical</u> : Analyze/evaluate technical data; biotech lab techniques; knowledge of health/safety regulations; problem solving/critical thinking; technical writing; computer skills <u>Personal</u> : Organizational and observation skills; team work skills; detail oriented.	\$25,000 to \$35,000 for entry-level workers; \$30,000 to \$45,000 for experienced workers.

Quality Assurance/Control (QA/QC) and Validation

Companies that manufacture products must develop and institute a system for ensuring that the manufacturing process complies with regulatory requirements. QA/QC employees are involved at every stage of the production process to ensure that the process is progressing according to these standards. They conduct audits and test product composition, equipment, and environmental conditions. Since biotech manufacturing is normally conducted around the clock, QA/QC staff in this area may need to be available at all times, and thus shift work is common.

Validation involves performing tests during the production process to ensure that every step process complies with regulations and company specifications; it proves that, by carrying out the process on specified equipment, the company will consistently produce the product to described specifications. Every part of the operation process must be validated, e.g., manufacturing equipment, utilities, and the computer data-processing system for documenting all aspects of production. Validation technicians may perform work in “clean rooms,” which strictly control the room’s temperature, humidity and dust content, and which require all workers to wear masks, gloves, and smocks to prevent contamination.

There are several entry-level positions in the QA/QC and Validation fields, including Quality Assurance Documentation Administrator, Quality Control Inspector or Technician, and Validation Technician. Although a high school diploma is the minimum educational

requirement for QA/QC positions, most employers prefer to hire associate's degree applicants in a related field and at least one year of experience. Validation positions normally require an A.S. or B.S. in a biotechnical or related health sciences or engineering field, although some employers may hire a high school graduate with related work experience. Workers in QA/QC positions may progress, with additional education and experience, to such positions as Quality Control Analyst, Quality Assurance Auditor, Quality Assurance or Control Engineer, GMP Trainer, and QA or QC Managers. Validation technicians may progress to Validation Engineer, Computer Validation Specialist or Validation Management.

Quality Control Inspector or Technician. These workers examine both raw materials and finished manufactured products, undertaking a variety of inspections, safety and quality checks, tests, and sampling procedures to that the manufacturing process complies with GLP and GMP standards. They monitor equipment and instruments, and must document inspection results and product deviations from the standards. They may draft and update inspection procedures, and review blue prints and drawing specifications during the inspection process. More experienced technicians may analyze manufacturing failures and troubleshoot solutions.

*Quality Control Inspector/Technician*

Requirements	Skills	Wage/Salary Range
HS diploma and 1 to 2 years related experience; preferably a biotech certificate or A.S. degree and 1 to 2 years experience in quality control systems.	<u>Technical:</u> Analyze/evaluate technical data; knowledge of GMPs and SOPs, and of life sciences; manufacturing skills; record keeping; computer skills <u>Personal:</u> Detail oriented; observation skills; works independently; works well under pressure	\$10.40 to \$19.76 per hour (2007); or \$30,000 to \$48,000 (2006)

Validation Technician. The technician prepares installation and tests validation procedures/protocols to ensure that the product is manufactured in accordance with appropriate regulations and company specifications. Responsibilities include compiling and analyzing

validation data, preparing reports, and maintaining validation files. The technician may also troubleshoot problems and recommend technical solutions.

*Validation Technician*

Requirements	Skills	2007 Wage Range
A.S. or B.S. degree in biotechnical or health sciences or engineering field. Experience in sterile environment preferred.	<u>Technical</u> : Knowledge of life sciences and chemistry, as well as GMPs, GLPs, SOPs, and sterilization principles; technical writing; record keeping; computer skills <u>Personal</u> : Detail oriented; organizational skills; works independently;	\$10.40 to \$19.76 per hour

Scale-Up to Commercial Production

Once researchers discover a potential new drug, they must design a process for manufacturing the quantities needed for use in clinical trials (assuming they do not contract to a CMO for such manufacturing). During clinical trials, researchers must develop a process for the manufacture of the desired production volume in the event the drug receives FDA approval. This stage involves scaling-up potential products and improving the efficiency of the production process.

Entry-level positions in the Product/Process Development area include Process Development Operator and Process Development Technician or Associate. The latter positions usually require a B.S. degree

Process Development Operator or Technician. These technicians implement production procedures to ensure stable, efficient manufacturing processes and meet regulatory requirements. They also develop scalable processes to improve product yield and reduce manufacturing system costs. They maintain, and often package and distribute, production equipment. They may be responsible for developing and implementing new methods and technologies to improve the production process, while resolving problems associated with full-scale production. Technicians

who obtain a bachelor or master's degree may progress to process development associate, while higher level positions require a Ph.D.

*Process Development Operator/Technician*

Requirements	Skills	2006 Salary Range
A.S. in biosciences or related scientific discipline and 2 to 5 years of industry experience or B.S. and 0-2 years experience.	<u>Technical</u> : Speaking and writing skills; computer and electronics skills; chemistry; knowledge of production and processing; active learning; problem sensitivity	\$24,000 to \$33,000 annually for Process Development Operator; \$30,000 to \$48,000 for Process Development Technician

Manufacturing and Production

Once a product receives FDA approval to go to market, it must be manufactured in large quantity. Before manufacturing begins, however, the company must obtain all necessary federal approvals relating to operation of the manufacturing facility and the production process. Large corporations may have multiple facilities in different locations, each manufacturing a different product or involved in different parts of the production process. This stage of production employs the vast majority of pharmaceutical and biomanufacturing workers, and comprises several divisions: research and development (as these functions pertain to the manufacturing process and product); process development; production; manufacturing support, e.g., materials management, facilities management, including utility systems maintenance and waste management, and environmental health and safety; and quality control, quality assurance, and validation.

The production division is the heart of manufacturing, and employs most of the company's production employees, who work directly with the manufacturing process at each of its different steps: *synthesis*, which involves mixing and measuring chemicals and reagents to create the product; *purification*, which involved separating the synthesized product from the

chemicals left over from a living cells and byproducts to create the bulk product, which may be sold as is or processed further; *formulation*, which involves transforming the bulk product into the final dosage form in which it will be retailed; and *final dosage form manufacturing*, which involves putting the formulated product into its final form, e.g., sterile solutions or tablets, and dispensing it into containers, which are labeled and packaged (North Carolina Biotechnology Center 2003).

Production employees, usually called manufacturing technicians or process operators, operate and monitor the equipment, prepare media for each production stage, and transfer materials from one operational unit to the next. Because the vast majority of these positions are considered entry-level, they employ many of the graduates from the biotechnology certificate and degree programs profiled in this study. These positions, all of which require a minimum of either a high school diploma or community college certificate or degree, include: Material Handler, Packaging Technician, Aseptic Fill Technician, Manufacturing Technician, Assay Analyst, and Manufacturing Instrumentation/ Calibration.

There are plenty of career advancement opportunities for manufacturing technicians, who may advance into positions as manufacturing associates, lead technicians, and supervisors; quality control or assurance technicians (with additional experience); lab technicians or research associate positions (with additional education); and technical services or sales representative positions.

The following are occupational descriptions of the three main positions for which the community college biomanufacturing programs prepare graduates:

Manufacturing Technician. Manufacturing technicians are involved in the manufacturing and assembly of clinical and commercial products. They operate and maintain production

equipment; weigh, measure and check raw materials to ensure that the manufactured batches contain the proper ingredients and quantities; order enough raw materials to ensure an adequate supply; assist chemists in pooling bulk products; and maintain records and a “clean room” environment to comply with regulatory requirements, GMPs and SOPs. They may help validate processes and equipment directly related to filtration, cleaning and sterilization; assist with product sampling; and write SOPs.

*Manufacturing Technician*

Requirements	Skills	Wage/Salary Range
Certificate or A.S. in biotechnology; up to 2 years in sterile manufacturing environment preferred.	<u>Technical</u> : Biotech lab procedures; manufacturing skills; knowledge of GMPs and SOPs; computer skills; problem solving/critical thinking; read/interpret technical materials <u>Personal</u> : Detail oriented; lift 10-50 lbs.; organizational skills; work as a team; works well under pressure	\$8.19 to \$24.23 per hour (2007)  \$30,000 to \$48,000 annually (2006)

Assay Analyst. Assay analysts conduct routine analyses of tissue and cell culture to ensure compliance with company specifications. They prepare, maintain, and check reagents, cell and tissue cultures, and equipment prior to running tests, and follow written protocols during tests. They must understand QC systems, as well as scale up, bioreactors, filtration and other basic cell culture unit operations, and must document experimental results and write technical reports. They may be responsible for modifying assay procedures to improve speed and accuracy, and for making changes to manufacturing processes.

*Assay Analyst*

Requirements	Skills	Wage/Salary Range
A.S. or B.S. in biotechnology or related field; up to 2 years in sterile manufacturing environment.	<u>Technical</u> : Chemistry, Math, Biology; information ordering; problem solving/critical thinking	\$15.41 to \$26.463 per hour (2007)  \$35,000 to \$60,000 annually (2006)

Instrumentation/Calibration Technician. These technicians work on the specialized equipment necessary for the manufacturing and research processes. They perform maintenance, testing, troubleshooting, calibration and repair on a variety of analytical equipment and instrumentation. They request purchase of components; maintain spare parts inventory, logs and required documentation; and analyze test results. They may develop test specifications and electrical schematics, and prepare technical reports recommending solutions to technical problems.

*Instrumentation/Calibration Technician*

Requirements	Skills	Wage/Salary Range
A.S. in biotech, electronics, instrumentation, or health-related fields; up to two years experience in quality control systems.	<p><u>Technical</u>: Computer skills; knowledge of electronics; operate diagnostic equipment; read/interpret technical materials; record keeping skills; troubleshooting</p> <p><u>Personal</u>: Detail oriented; good vision and color perception; manual dexterity; perform physically demanding work; works well under pressure</p>	<p>\$10.40 to \$33.64 per hour (2007)</p> <p>\$35,000 to \$60,000 annually (2006)</p>

**4.2 The Quality of Biotechnology Jobs**

The working conditions in bio-pharmaceutical manufacturing plants—where the vast majority of technicians are employed—are considered to be good, indeed far better than those of traditional manufacturing plants. Regarding hours, production workers in the pharmaceutical and medicine manufacturing industries worked an average of 41.8 hours per week in 2006, compared with 33.9 for workers in all industries (Bureau of Labor Statistics 2007). Most biomanufacturing plants operate 24 hours a day, seven days a week, and thus work is organized around three shifts. Workers assigned to the second or third shift normally receive extra pay. As many applicants find shift work to be undesirable, however, this organizational feature poses an important recruitment challenge to biomanufacturing companies (North Carolina Biotechnology Center

2003). Finally, work is usually steady, as drug production tends not to be affected by seasonal variation or fluctuation in economic activity.

Regarding the work environment in this advanced and well-regulated industry, production plants are usually air-conditioned, well-lighted and quiet, and equipment and works areas are kept clean due to the danger of contamination. Ventilation systems are designed to protect workers from fumes and dust. Companies must take special precautions to protect employees working with poisonous chemicals and infectious cultures. Most work requires minimal physical effort, except for that performed by maintenance workers, material handlers, and some laboratory assistants. The incidence of work-related injury and illness in 2006 for pharmaceutical/medicine manufacturing workers was 2.4 cases per 100 full-time workers, compared with 6 per 100 for all manufacturing workers, and 4.4 per 100 for the entire private sector (BLS 2007).

Regarding opportunities for career advancement in the biotechnology industry, the occupational profiles presented above demonstrate that the several key job families are organized in such a way that they contain intermediate jobs for workers to advance through as they gain skills and experience, without necessarily obtaining a bachelor's degree (Fitzgerald 2006). A number of state and national organizations and platforms (e.g., the online Biotech Work Portal, the Life Science Career Alliance, and MassBioEd) have identified, developed and publicized these career pathways so that job seekers and incumbent workers are aware of the skills and experience needed to progress into higher-level and better-paid jobs.

Moreover, the biotech industry provides educational benefits that are deemed to be quite good, even excellent (Godbe 2006; Freirman-Hunt and Solberg 2002; Fitzgerald 2006). For instance, many companies offer full tuition reimbursement for employees who return to college



to complete a degree that is useful to the company, as well as continuing education programs. Companies also provide ongoing job training to ensure that workers stay current in their jobs, which are continually advancing and changing.

### **4.3 Recruitment and Hiring Practices**

Previous chapters have highlighted the important role that community colleges play in meeting employer demand for a well-trained, technician-level workforce by providing hands-on laboratory skills and industry-relevant education and training. Numerous surveys show that employers typically view Bachelor of Science graduates as lacking sufficient hands-on experience with analytical instrumentation, as well as proficiency in basic lab skills. By contrast, a hallmark feature of community college biotech programs is their emphasis on developing hands-on, practical lab experience and facility in using lab equipment, through classroom lab instruction and internships experiences; as well as on cultivating workplace-related soft skills, e.g., through team-work based exercises and instruction in applied science and language skills. In addition, curricula are usually designed to educate students in all aspects of the industry, including downstream and upstream processes. As the president of the Biotechnology Industry Organization (BIO) recently commented, “Specific procedures for advanced skills can be taught by companies’ in-house education programs, but only if workers have the basic foundations in practical laboratory procedures. We need workers with excellent team work, record-keeping, and communication skills” (Patton 2008: 8).

As noted earlier, an important factor informing employer preferences for education and training backgrounds of entry-level technicians is the company’s stage of production and attendant changes in the biological process. As the company moves from research to

commercialized production, the production process becomes more stable, defined, and validated, and job functions become more routine. Workers must possess relatively high levels of technical skill and work experience (see section below), but they need not have high levels of formal education. Those with such education often become bored by the repetitive nature of lower-level production tasks or have excessive pay expectations for a technician-level job. Technicians recruited from non-local, four-year programs often begin their employment with high debt burdens while facing very high costs of living in the industry cluster locale (which is particularly the case in the Bay Area and San Diego regions), and so seek to advance rapidly to higher paying, often non-production jobs, thus increasing turnover rates. Hence, well-trained, locally-based community college graduates that have been exposed to the production environment in classroom labs or internships and who expect to spend some time (three to five years) in this setting before progressing up the career ladder are the ideal candidates for many entry-level manufacturing positions.

However, as industry interviews make clear, the division between stable and variable manufacturing functions is not uniformly clear. For instance, within the fermentation process, half of the functions involve “touching cells,” which requires an understanding of aseptic techniques. Mistakes made on this side of the line are extremely costly. The other half involves media makeup, which entails working with large sacs of powder, such that the technician frequently becomes dirty and hot. Similarly, on the recovery side of the production process, half of the functions involve “touching proteins,” a more advanced technique, while the other half involves making up buffers through such activities as weighing, adding water, heavy lifting, and documenting results.

While employers may prefer to hire community college graduates to perform the media makeup and buffer functions in order to avoid a potential increase in production mistakes (a subject of some controversy, which Chapter Six will discuss), many community college biotech programs provide training in the more advanced techniques within each production area. For instance, most programs teach aseptic techniques, which are reinforced in community college lab classes and internship experiences. Some colleges teach cell fermentation on very expensive, and thus, donated lab equipment. Because technicians tend to work in a team environment, there are usually other workers with a more advanced scientific background who can guide their more entry-level co-workers when it becomes necessary for them to make on-the-spot decisions.

#### The key role of industry work experience

Besides hands-on, workplace-based technical and soft skills, another key quality that employers seek in technicians is prior industry experience. Indeed, for many bio-pharmaceutical companies, “experience in the industry supersedes educational achievement as a qualification for most positions” (North Carolina Biotechnology Center 2003). In large part, this is because the industry is highly regulated by the FDA, with current Good Manufacturing and Laboratory Practices affecting almost every area of manufacturing and clinical laboratory research. As a training needs assessment for the biomanufacturing workforce has found: “Implementing these practices requires behaviors learned only after living them day by day in a GMP environment. Training times for new hires are half as long, on average, if they have prior pharmaceutical industry experience. Most of this difference is due to GMP experience, not specific technical experience” (ibid. 23).

Title 21 of the Code of Federal Regulations (CFR) governs food and drugs within the U.S. for the FDA and other agencies. Various parts within sections 200, 300 and 600, which set

forth regulations pertaining to pharmaceuticals and biological products, including GMPs and GLPs, specify that personnel in the manufacturing of drug products must have certain, total levels of education, training and experience. However, employers have discretion to determine the specific combination of these three factors, in order to achieve a mix appropriate for their production process. Indeed, a recent survey of biomanufacturing employers in Northern California found wide variation in the typical educational requirements for manufacturing technician positions. For instance, approximately 4 percent of respondents had no formal requirements for the position; 35 percent required a high school diploma or equivalent; 39 percent required certification or an associate's degree; and 22 percent required a bachelor's degree (Godbe 2006: 47).

One explanation for this disparity is that many employers choose to emphasize work experience in the recruitment process to reflect the specialized nature of bio-manufacturing work, for which the regulatory standards are among the most stringent of any industry. For example, with regard to maintaining cleanliness in the plant, some foreign products are allowed to enter food products, e.g., insect parts, which are forbidden to enter drug-related products. Because it may be necessary to scrap an entire batch of product if skin or even an eyelash enters the batch, the job requires a high degree of maturity, conscientiousness, and experience working within these standards among its production staff.<sup>84</sup>

A related factor that shapes employer preference for higher levels of work experience in job applicants is the nature of the company's product, and specifically, whether the company must maintain a sterile production environment. Some companies produce products that must be made under aseptic conditions, e.g. the product is injectable. The company cannot sterilize such

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<sup>84</sup> This discussion is based in part on an author interview with a bio-manufacturing supervisor at Solstice Neurosciences in the San Francisco Bay Area.

products after they are produced—i.e., there is no “rework.” By contrast a non-sterile product, such as an inhalant, need not be produced under sterile conditions. Hence, an employer might prefer to hire more mature and experienced candidates to fill positions in the former (sterile) environment, while remain willing to employ less experienced candidates in the latter.

Companies that manufacture toxins, e.g., botulism, are held to even higher regulatory standards, and thus desire the most experienced technicians possible. That is, employers may prefer an applicant with only a high school diploma but many years of experience working in a GMP environment, as compared to a bachelor-degree candidate with the appropriate scientific background but with far less relevant working experience.

An important issue for community college programs is whether hands-on experience in a classroom lab, which may simulate a clean room environment and thus require students to follow GMPs, even to “gown up,” can substitute for requisite work experience and on-the job training. The biomanufacturing training facility at MiraCosta College, described in the previous chapter, was developed with this very aim. Obviously, internships and co-op experiences provide students with direct industry experience, and hence are considered by many companies to be important recruitment tools (Godbe 2006). The overall question remains, however, as to the sufficiency of the internship experience vis-à-vis actual, full-time work experience. As Grubb (2006: 134) warns: “If...employers hire on the basis of experience or other qualities and ignore credentials in hiring, credentials may seem superfluous.” Qualitative data that addresses this issue will be presented in a subsequent chapter.

A survey of life sciences employers in North Carolina’s biotechnology industry found that employers considered graduates *at all levels* to be:

- “Unaware of how the pharmaceutical industry works, so they do not understand how what they do on the job can affect other aspects of the manufacturing process;

- Unaware of the constraints required in working in a regulated environment;
- Often lacking in problem-solving skills;
- Often unrealistic in their expectations concerning pay or job demands;
- Lacking in interpersonal/team skills and project-management skills.”

(North Carolina Biotechnology Center 2003: 24)

As noted, many of the program features of community college biotech programs are designed expressly to address these concerns. Indeed, a key “marketing and communication” recommendation that emerged at a recent NSF-sponsored national conference on educating the biotechnical workforce was for community college programs to raise industry awareness of these program features and highlight biotech graduate employee successes (Patton 2008).

The community colleges’ ability to establish their market niche and convince employers that graduates can meet their needs for a well-trained technician workforce is all the more imperative given recent employment projections showing that the majority of new life sciences jobs—over 80 percent—will require at least a four-year degree, as Table 4.1 shows:

**Table 4.1**  
**Education and Training Requirements for Critical Life Sciences Occupations**

<i>Education Requirement*</i>	<i>Projected Occupational Growth, 2006-2014</i>	<i>Percent of Total Projected Occupational Growth</i>
Work experience in a related occupation	69	0.7%
On-the-job training	317	3.4%
Associates degree	1,355	14.4%
Bachelors degree	4,218	44.9%
Bachelors or higher degree, plus work experience	1,283	13.7%
Doctoral degree	1,540	16.4%
First professional degree	599	6.4%
<b>Bachelors Degree or higher</b>	<b>7,640</b>	<b>81.4%</b>
Total (for occupations with detailed data)	9,385	100%

\*An occupation is placed in one of 11 categories that best describes the postsecondary education or training needed by most workers to become fully qualified in the occupation.

Source: UMass Donahue Institute (2008); U.S. Bureau of Labor Statistics

While technician-level jobs are also expected to increase during this time period—and hence, employment opportunities for community college-trained graduates—the advanced nature of the industry, with its continually changing technologies—suggests that the need for frequent skills upgrading among workers may serve as a countervailing pressure on some employers to choose a more highly-educated workforce. The community college’s role in staying abreast of advancing technologies and forging closer relationships with companies to increase internship opportunities, industry input in curriculum, and lab equipment donations, will become more crucial as these pressures increase.

## **Chapter 5: Research Design and Methodology**

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### **5.1 Research Design**

To understand whether and, if so, how workforce intermediaries in the biotech industry shape labor market demand for an entry-level technician workforce, I conducted a descriptive case study of six biotechnology training partnerships in two regions of California—the San Francisco Bay Area and San Diego County (and vicinity). As Chapter Three elaborated, I examined three partnership programs in the San Francisco Bay Area: the Biotech Workforce Network; Biotech Partners; and the City College of San Francisco’s Bridge to Biotech program. In San Diego County, I examined the San Diego Workforce Partnership’s Life Sciences Summer Institute; the MiraCosta Community College Bioprocessing Center of Expertise; and Southwestern College’s BETSI Project.

In addition, I examined the two regional California Community College programs that offer support to all of the community college biotech programs within these two regions: the California Applied Biotechnology Center-Bay Area and the Southern California Biotechnology Center. Each regional center operates under the auspices of the California Community College’s Applied Biological Initiative. As such, all the partnership programs under study are embedded, to varying degrees, in broad networks of relationships and partnerships.

This dissertation undertakes two main lines of inquiry. The first examines various employment outcomes for graduates of the partnership programs under study in order to understand the extent to which firm behavior changes as a result of working with community college biotech programs. The second examines the mechanisms through which partnership



programs affect such employment outcomes and, as a result, may (or may not) be considered effective in expanding employment opportunities for community college graduates.<sup>85</sup>

As the next section on outcomes data specifies, I have obtained (where available) various, direct program outcomes for community college graduates, in particular, program completion rates and job placement outcomes. My primary aim, however, is to document demand-side change. Hence, the majority of my outcomes measures probe the extent of partnership influence on employer recruitment and hiring practices, where “influence” refers generally to a shift in corporate hiring practices away from a strict reliance on a bachelor's degree credential and towards employer recognition that an associate's degree or certificate offers the necessary showing of competency in industry-based skills.

Accordingly, my primary unit of analysis involves workforce intermediary interventions that target recruitment and hiring practices for entry-level technicians in an effort to shape the community college graduate's access to entry-level biological and/or bio-manufacturing technician jobs. I discuss such employment practices and related outcomes data in Section 5.2, below. To test my core hypothesis—namely, that biotech companies' behavior changes as a result of working with community college biotech programs—I compare the practices and outcomes data across a sample of biotechnology companies located in the two regions of California (Northern and Southern) under study. Hence, my research design attempts to control for several variables, while varying along several additional dimensions, as detailed in the following sections.

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<sup>85</sup> As such, the first part of the analysis asks the “what or how much” type of research question, while the second asks the explanatory “how or why” (Yin 2003).

### 5.1.1 Case controls

The three variables that the study seeks to control are the following:

1. Labor market dynamics

By selecting companies and partnership training programs operating within the biotechnology/life sciences industry, the design attempts to limit the influence of labor market dynamics on employment outcomes. This sectoral focus allows me to control for such industry features as occupational position, employment levels, and skills, as well as sources of pressure that potentially shape employers' workforce development decisions, including the strength or weakness of relevant labor markets, labor and skills shortages, industry dynamics, and the regulatory regime.

2. Geographical location

The San Francisco Bay Area and the San Diego County area contain the highest concentrations of biotechnology activity in California, and are among the top biotech clusters in the U.S, thus offering a broad selection of biotech companies for prospective inclusion in the research sample. Corresponding to this concentration, the majority of state community college biotech programs are likewise located within these two regions. By choosing a sample of biotechnology companies and education training programs within these regions, the study seeks to control for statewide differences in population, skills/labor shortages, and political economy. Moreover, while the two California regions may differ by population size and regional economy, both are coastal, predominantly metropolitan areas (albeit with rural areas within their borders), and have similar demographics, thus facilitating cross-regional comparison.

I note that some companies in my sample have facilities or subsidiaries located in each of the regions under study. In such cases, I include each facility as a separate company for

purposes of data collection and analysis. In addition, the headquarters of several of the larger U.S.-based companies in the sample are located in different states, while a number of the European-based multinationals have their headquarters overseas. I gathered data solely from the California-based companies or subsidiaries located in the two regions under study, although I provide select background information about the entire company, as outlined in Section 5.4, below.

### 3. Partnership program objectives

As sector-based intermediaries, the partnerships by definition aim to shape, not just labor supply, but also demand, in order to generate systemic labor market change. While the actual extent of partnership intervention on both sides of the labor market varies, the partnership's intent to be highly responsive to its dual customers—in effect, to be demand-driven—is a key feature of every initiative.

### 4. Organizational form

Each biotech training program operates as a hub in a broad network of relationships and partnerships, rather than as a stand-alone organization.

## **5.1.2 Case variation**

This study varies along the following key dimension:

1. Workforce intermediary intervention in the labor market for entry-level biological and/or manufacturing technicians.

To test for the impact of biotech partnership program intervention, I have constructed a sample of companies that comprise two groups: treatment-group companies and comparison-group companies. Treatment-group companies are those that currently are involved, in some meaningful way, with biotech training partnerships involving community college biotech

programs and/or workforce and community organizations. The comparison-group companies are those that have had no (or minimal) involvement in such partnerships.

The level of employer participation can range from low-intensity consultation on initial program design to high-intensity involvement in program implementation and management. To gauge the meaningfulness or extensiveness of an employer's involvement with a partnership program, I use the following four main measures as a guide:

- Content and type of employer involvement (monetary, in-kind, or advisory), including:
  - Assisting in curriculum development and review
  - Providing direct money and support for grants
  - Donating equipment
  - Serving on advisory boards
  - Defining industry standards and competencies for relevant positions
  - Providing job shadowing and company tours
  - Sponsoring adjunct faculty (industry co-faculty) and guest speakers
  - Participating in community college-sponsored conferences
- Duration and frequency of involvement:
  - Ad hoc
  - Periodic
  - Continuous and ongoing
- Positions of employer personnel involved
  - Executive-level staff (including HR)
  - Department managers, line supervisors, training instructors
- Formalization of collaboration (if any), including:
  - Partnering agreements
  - Advisory board membership
  - Other organizational arrangements designed to foster active employer participation

At the highest levels of employer involvement, company and workforce intermediary staff enter into program agreements—rather than engage ad hoc—on such issues as the responsibilities of contact personnel, development of training curricula, compensation for

program placements, and hiring/promotion systems. Involvement usually extends from executive level staff, including HR personnel, to department managers responsible for program operation. For instance, an employer's executive staff may direct a manager to coordinate an ongoing internship or job shadowing program with particular community college programs. Company executives may sit on advisory boards and/or designate company training instructors or line supervisors to work with community college faculty to review program curricula. Moreover, the employer may donate equipment on a regular basis or contribute to a program's lab modernization efforts through cash or grant donations.

At lower levels of involvement, a line supervisor or scientist supportive of community college biotech programs might attend an annual community college-sponsored job fair to recruit students, or serve as a one-time guest speaker or adjunct faculty in a biotech course. In such cases, however, executive level, especially HR, staff would not be connected to the biotech program in any formal way. At the most minimal/ informal level of involvement, a community college biotech program instructor and a production supervisor might regularly discuss the program and its graduates during after-hours socializing.

My interviews with company personnel and biotech program staff and faculty (as discussed in the section on methods, below) enabled me to gather qualitative data on the employer's level and manner of involvement in partnership training programs for purposes of assigning a company to the treatment or comparison group. I describe participation levels for each sample company in the next chapter on outcomes data and analysis.

#### Criteria for matching companies

For a proper comparison of employment outcomes across the two groups of companies in my sample, the groups must be matched as closely as possible on a set of relevant features. For this

study, I focused on the following key features: bioscience industry sector, and company workforce size and/or stage of production/production process. I discuss each feature in turn.

### 1. Industry sector

As noted in Chapter One, the biosciences industry cluster contains numerous sectors and subsectors, and different organizations include different sectors in their industry definitions. The four major sectors (or segments) are typically understood as the following: Agricultural Feedstock and Chemicals; Drugs and Pharmaceuticals; Medical Devices and Equipment/Supplies; and Research, Testing, and Medical Laboratories. As the company profiles (below) show, the vast majority of companies included in this study's sample are engaged in the drugs/pharmaceutical sector, although several operate primarily in the medical instruments/supplies or diagnostics sectors.

In general, it is appropriate to compare companies within, as opposed to across, industry sectors. However, many companies, particularly the larger ones, operate in multiple sectors simultaneously, e.g., producing drugs as well as microarrays (diagnostics). Companies also may produce "combination" products containing two or more regulated components, such as a drug/device or a drug/biologic/device product; examples include a surgical mesh with antibiotic coating and a spinal fusion device with a genetically engineered human protein (BayBio 2009).<sup>86</sup> Medical device and instruments technologies, moreover, have advanced such that the therapeutic product is often part of the device, rather than a separate process, thereby changing the way that the product is delivered (e.g., time release technology). Hence, a company categorized as a medical device company might produce products for the device that are primarily biologics-

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<sup>86</sup> Biologics are products derived from living sources rather than from a chemical process (BayBio 2009).

based, in which case the company would more appropriately be considered (or compared to) a biologics company, as opposed to a (physical) device company.

NAICS codes<sup>87</sup> that are used to classify companies do not always reflect these sector overlaps or hybrid technologies. The upshot is that the matching process is not a mechanical one. For the most accurate comparisons, it often is necessary to rely largely on descriptions of the relevant product and/or technology given by the companies themselves. I indicate below when a comparison group company is categorized under a different subsector or NAICS code than its treatment group counterpart.

Further, as noted previously, the community college biotechnology programs aim to prepare students for entry into more than one biotech sector field. For instance, biomanufacturing certificate programs typically claim that their graduates are equally qualified to work in both pharmaceutical and diagnostic production. Skills sets and procedures taught in such programs include DNA sequencing and cell culturing abilities (used mainly in drug production), as well as the making and mixing of reagents, the detection of solutions, and pipetting (used mainly in diagnostics). Students also learn how to wash, sort, stack, and box compounds and glassware (undertaken in nearly all production and laboratory work). Accordingly, comparing companies that fall within different subsectors may be entirely appropriate, provided that the type of work involved in the job positions in question encompasses skills taught in the community college biotechnology training program.

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<sup>87</sup> NAICS stands for North American Industrial Classification System, which is the standard government system for reporting industry information. A chart setting out the main biotech segments and corresponding NAICS codes was attached as an appendix to Chapter One.

## 2. Company workforce size, stage of production, production process

As noted in Chapter One, the company's workforce size generally corresponds to the company's stage of production. Smaller companies and start ups, engaged mainly in the research/discovery stage, typically employ between one and 50 people. At the development/clinical stage, the company needs small quantities of the product for use in clinical trials, and thus engages in (or contracts out) limited-scale production of the drug. Workforce size generally grows to 51-300 people during this stage. Upon receiving FDA approval, the company then enters the manufacturing stage, and usually employs upwards of 300 people.

However, it is important to keep in mind that these variables are not perfectly aligned. As some companies engage in clinical and/or commercial manufacturing in-house, while others contract out such work to a contract research and/or manufacturing organization, workforce sizes at each development stage may vary. Moreover, some companies may conduct their manufacturing in-house, yet that manufacturing may occur in company sites or affiliates/subsidiaries located in different parts of the U.S. or the world. Hence, a company site that is located in the Northern or Southern California region under study may be a smaller R&D unit of a larger company designated primarily as a pharmaceuticals manufacturer. Alternatively, the manufacturing workforce of a smaller company may be similar in size to that of a much larger company that maintains a smaller manufacturing workforce in the facility under study. In addition, a large company may completely outsource its manufacturing work and undertake only research and/or clinical trials work in-house at the site under study.

In presenting my hiring outcomes data in Chapter Six, I categorize the companies by the type of entry-level technician workforce that the company employs, i.e., manufacturing, research, or clinical trials. In the next section, which describes the companies in the sample, I



categorize the companies by workforce size (i.e., large, medium, and small) and geographical location (San Francisco Bay Area or San Diego County area). I do not indicate the company's stage of production, provided that the company employs a workforce whose size generally matches its production stage. However, I do note if the company unit under study engages in a different production process than its larger parent company. As mentioned above, the primary focus of the company site under study might be research or clinical trials, while the site's parent company is designated as a pharmaceutical manufacturer.

Moreover, as there is no standard definition of company size by number of employees—e.g., some sources define a large company as composed of 300 or more employees, while others use a figure of 500 or more—I do not always strictly match companies according to workforce size, particularly when the employment numbers are close and the companies' production processes are similar. In addition, on account of ongoing restructurings during the current (2008-2009) economic crisis, many companies have shrunk their workforces or been acquired by larger companies. Hence, the companies under study currently may fall within a different category than their 2008 year-end employment figure would suggest. (I note when the size of a company's current workforce differs substantially from its 2008 figure.)

#### Selection of sample companies

To identify treatment group companies, I interviewed partnership program staff and community college instructors about the employers with whom they worked as part of the training program's operation (e.g., for curricular input, guest lectures, equipment donation), as well as job placement efforts. I also reviewed various program documents for lists of company partners. To identify comparison group companies, I asked the same staff and faculty for their suggestions regarding companies that were similar in size and product focus to their employer partners, but were not

partnering (for whatever reason) with the training programs. I also asked each biotech company staff interviewee for his/her suggestions regarding their employer's peer companies or competitors.

## **5.2 Outcomes Data**

As noted, my primary hypothesis is that biotechnology training partnerships increase community college graduates' access to entry-level technician positions by influencing employers' human resource practices in ways that lead to increased recruitment and hiring from this labor pool.

Below are the supply-side and demand-side outcome indicators that I used as measures of community college graduates' access to entry-level technician jobs. The indicators are largely quantitative in nature, although they include several qualitative measures.

### Supply-side indicators (direct program outcomes):

- Student demographic data.
- Program completion rates.
- Job placement rates in the biotechnology/life sciences industry.

### Demand-side indicators (process improvement outcomes):

#### Recruitment

- Primary recruitment methods for the company's entry-level technician workforce, including any methods targeted to community college biotechnology program graduates.
- Education and training requirements for entry-level technician jobs.

#### Hiring/Internships

- Number of community college-trained, entry-level technicians in the company's current technician workforce.

- Proportion of entry-level technician workforce with a community college associate's degree or certificate.
- In transitioning to production/manufacturing, the particular paths the company took (or will take) to hire its entry-level technician workforce.
- If the company offers internships, the number of internships filled by community college biotechnology program students or graduates.

I describe each of these measures in greater detail in the following chapter on data outcomes and analysis. Regarding the supply-side indicators, I asked partnership programs to provide the relevant data beginning from the program's inception, when such records were available.

Regarding the demand-side indicators, I asked each company to provide hiring data for the company's current technician workforce, as well as for the previous three years (i.e., from 2006 to 2008), to the extent such records were available. See Appendix B for the questions setting forth my specific data request to biotechnology employers.

### **5.3 Methods**

To gather the qualitative and quantitative data related to the outcomes of workforce intermediary interventions, as well as to the mechanisms through which the biotech training partnerships achieved such outcomes, I relied on the following sources of case study evidence:

#### Documentation

I gathered a variety of documents from both the partnership training programs and the biotechnology companies under study. To understand the origins and history of the partnership programs, as well as the roles of the program partners, I collected various administrative documents, such as proposals, progress reports, and any other internal records. I also examined any formal studies or evaluations of the programs; program and community college websites;

and newspaper articles on the programs. This information helped me to develop chronological and descriptive summaries of all program collaborations.

To understand the product focus, workforce size, and structure of the biotech companies under study, I reviewed company websites; online business-related sources, such as Hoover's, Lexis Nexus, and the SEC's Edgar database (for 10K and other filings); and newspaper articles on company developments, such as acquisitions and restructurings. I also requested from each company in my sample a copy of the job description/advertisement for each technician-level position at issue.

### Archival records

From partnership programs, I gathered archival records such as student graduation, internship, job placement data, and names of company placements. I also collected the minutes to steering committee meetings, where available.

### Interviews

I have conducted in-depth, semi-structured interviews with over 120 key personnel from community college biotechnology programs, biotechnology companies, workforce agencies, and community-based organizations. All interviews lasted at least half an hour, with most lasting an hour, and some lasting two hours or more. I also conducted follow-up interviews as needed.

Specifically, I interviewed the following categories of individuals:

1. Community college faculty, administrators, and staff - 35 people

I met with a range of individuals from the California Community College (CCC) system, including biotechnology program faculty; college deans; the director of the statewide CCC Career Ladders project; directors of five of the CCC regional centers; a CCC hub director; and

the CCC statewide director. These interviews helped me learn about the certificate and degree programs under study, including program requirements, student demographics, and the role of company partners in curricular development and course instruction. I include my interview protocol for community college faculty and staff in Appendix A.

At each community college that I visited as part of my interview, I toured the biotech program's laboratory facilities.

## 2. HR staff at biotechnology companies – 31 people

I contacted HR staff at both treatment and comparison group firms to obtain the relevant recruitment and hiring data, including job qualifications for technician-level positions and employer assessments of technician performance, where available. To each company staff member, I forwarded a seven-question survey document presenting the primary data that I sought to collect. See Appendix B. After the HR staff person filled out the questionnaire, I followed up with a phone call to elaborate on the data, as well as to discuss such qualitative issues as the level of company involvement (if any) with biotech training partnership programs.

When HR staff declined, on behalf of their companies, to participate in the dissertation study, I inquired into the reasons for this decision, paying special attention to any explanations that were related to purported lack of fit between the technician training needs of the company and the community college training program offerings.

## 3. Production managers, scientists, corporate communications, and other management staff at biotechnology companies – 39 people

A key claim of this study is that workforce intermediary interventions increase access to biotechnology jobs for community college graduates by producing well-trained technicians who meet employers' workforce needs. These interviews helped me test this claim by learning about

the company's technician training needs; managers' expectations about and evaluations of community college graduates' work performance; and company efforts to help build a pipeline of qualified technicians. Whenever possible, I toured the laboratory and production facilities at the companies included in my sample. I include my interview protocol for production managers/scientists and other management staff in Appendix C.

4. Industry association and human resource network staff – 6 people

To learn about industry workforce training needs and regional efforts to build a pipeline of qualified technicians, I spoke with the directors of the state's three leading regional industry associations (BayBio in the Bay Area, SoCalBio in Los Angeles/Orange County, and BIOCOM in San Diego). I also worked with the directors of two Bay Area human resource network associations—the Biotech Human Resource Network (BHRN) and Biotech Organization and Learning Development (BOLD)—as well as the director of a San Diego human resource association (affiliated with BIOCOM), in order to disseminate my recruitment and hiring questionnaire to the HR networks' members.

5. Workforce agency staff – 10 people

I met with workforce agency staff from the San Mateo County, Alameda County, San Jose, and San Diego Workforce Investment Boards, from whom I obtained various archival data related to the WIA dislocated worker programs under study, particularly program completion and job placement data. I also spoke with staff from the statewide Employment Training Panel about incumbent worker training efforts.

6. Community-based organization staff – 7 people

I met with staff at several community-based partner organizations, including Biotech Partners and the San Mateo County Central Labor Council, to learn about the roles of the various community partners in providing case management and other support services to community college program trainees.

7. Workforce development/research consultants – 3 people

I spoke with several research consultants who helped develop and/or evaluate some of the award-winning training programs under study.

Conferences; advisory board and other meetings; legislative hearings

I attended seven day-long, workforce development and/or biotechnology-related events, as well as several Biotech Task Force meetings, over the course of my fieldwork. Specifically, I attended: Two Industry Advisory Board meetings convened by the California Applied Biotechnology Center-Bay Area; one Community College meeting for Northern California faculty and staff convened by the Northern California hub of the CCC Applied Biotech Initiative; a national Community College Biotech conference as part of the Biotechnology Industry Organization (BIO) annual gathering; an annual conference convened by BayBio, the Bay Area's leading biotechnology industry association; a California state select subcommittee hearing on the biotechnology industry and related workforce development issues; and an annual California workforce and economic development conference. I also attended three meetings of the San Mateo County Blue Ribbon Task Force on Biotechnology, chaired by a San Mateo County council person and attended by community college, industry, and community group representatives.

## Surveys

To build a basic profile of current community college biotech program students and job seekers, I conducted a short, anonymous survey of current students in the community college training programs under study. See Appendix D for my survey questions. The faculty who agreed to participate in the survey project administered the survey online, using the SurveyMonkey.com platform, by sending my link to their students (with responses automatically returned to my SurveyMonkey account).

In addition, to identify and reach out to as many companies as possible for participation in the study, I worked with directors of the leading biotech Human Resource associations in the Bay Area and San Diego (the BHRN, BOLD and BIOCOM, as noted above). One director sent my seven-question recruitment and hiring questionnaire to her association's member via the group's list serve and newsletter, and the other posted the questions in survey format, using the online SurveyMonkey.com platform (with responses returned automatically to my SurveyMonkey account).

### **5.4 Sample Biotechnology Companies – Treatment and Comparison Groups**

As noted, the treatment group is composed of firms that have (or have had) a meaningful degree of involvement with community college biotechnology programs and/or workforce boards. The comparison-group firms are those that have had no (or minimal) involvement with such partnership programs. The two sets of firms are matched as closely as possible on the basis of their location, size, stage of production, and sector focus. Table 5.1 presents the matched sets of companies (see note below regarding my use of pseudonyms to shield company identity).



Sections 5.4.1 and 5.4.2 present profiles of each company in my sample, listed alphabetically. Each profile includes, where available, standard information concerning the company's location/headquarters; primary biotech sector and NAICS code; 2008 revenues; workforce size (per location, where available); and peer companies or competitors, as suggested by interviewees and business data sources, such as Hoover's online, Lexis, and BNET. The profile also briefly sketches the relevant piece of each company's history, such as acquisitions of the study sites and the locations of the company's primary manufacturing facilities (if any). Most of the companies in the sample are public, and thus such information tends to be readily available. Where the company is private and such information is not available, I leave the relevant sections blank.

Although I match each treatment-group company with a comparison-group company (see Table 5.1), the comparison-group companies may constitute a suitable match to more than one treatment-group company, due to similarities in product focus and production process among many of the firms in the sample. Indeed, most companies in the treatment group could be matched appropriately with any of the companies in the comparison group.

I list companies alphabetically within each size category.

#### Company confidentiality

Although the recruitment and hiring data that I gathered does not constitute proprietary material, many human resources staff expressed concerns regarding confidentiality of the data. Hence, I assured all company interviewees that I would shield company identity by using a pseudonym in place of each company's name when reporting the outcomes data, including whether the company falls into the treatment or comparison group. As such, the profile section groups together all treatment and comparison groups within each of the three employee size categories.

I likewise disguise company identity in the discussion of my qualitative findings in Chapters Six and Seven where failure to do so would reveal the confidential hiring data.

Each pseudonym is composed of the following elements: the letters T for treatment-group company or C for comparison-group company; an identifying number; and the abbreviations BA for Bay Area or SDA for San Diego area

**Table 5.1  
Treatment Group and Comparison Group Companies in Northern and Southern  
California**

**San Francisco Bay Area**

<b>Treatment Group</b>	<b>Comparison Group</b>
Large Companies	
T1-BA	C1-BA
T2-BA	C2-BA
T3-BA	C3-BA
T4-BA	C4-BA
T5-BA	C5-BA
T6-BA	C6-BA
	C7-BA
	C8-BA
Medium-Sized Companies	
T7-BA	
T8-BA	C9-BA
T9-BA	C10-BA
T10-BA	C11-BA
T11-BA	
Small Companies	
T12-BA	C12-BA
T13-BA	C13-BA
T14-BA	C14-BA
T15-BA	
T16-BA	

**San Diego County Area**

<b>Treatment Group</b>	<b>Comparison Group</b>
Large Companies	
T1-SDA	
T2-SDA	C1-SDA
T3-SDA	C2-SDA
Medium- and Small-Sized Companies	
T4-SDA	C4-SDA
T5-SDA	C5-SDA
	C6-SDA
	C7-SDA

### 5.4.1 Company Profiles – San Francisco Bay Area

#### Large companies (301 or more employees at principal California location(s))

##### 1. Abbot Laboratories

<u>Year Founded:</u>	1888 (Abbott Park, IL)
<u>Principal CA location(s):</u>	Alameda, Santa Clara
<u>Sector:</u>	Drugs and pharmaceuticals
<u>Primary NAICS code:</u>	325412 (Pharmaceutical preparation manufacturing)/ 325413 (in-vitro diagnostic substance manufacturing)
<u>Employees (2008):</u>	69,000 worldwide; 512 in Alameda; X in Santa Clara
<u>Revenues (2008):</u>	\$29.5 billion
<u>Peer companies/competitors:</u>	Johnson & Johnson, Pfizer, Novartis, Life Scan

Abbott Labs develops, manufactures, and markets pharmaceuticals; medical products, including devices and laboratory diagnostics; and nutritional products. The company has plants in six cities in California: Santa Clara, Alameda, Redwood City, and Fairfield in the Bay Area, and South Pasadena and Temecula in Southern California. Abbot Diagnostics, located in Santa Clara, offers instrument systems and tests for hospitals, reference labs, blood banks, physicians' offices, and clinics.

Abbott Diabetes Care, located in Alameda, was created in 2004 when Abbott Labs merged its diabetes-care unit (founded through the acquisition of MediSense in 1996) with a newly-acquired company, TheraSense. Abbott Diabetes develops and manufactures glucose monitoring equipment and supplies for use in both home and hospital settings.

##### 2. Affymetrix

<u>Year founded:</u>	1992
<u>Principal CA location(s):</u>	Santa Clara, Fremont
<u>Sector:</u>	Drugs and pharmaceuticals/Research services
<u>Primary NAICS code:</u>	334516 (Analytical laboratory instrument manufacturing)
<u>Employees (2008):</u>	1,102
<u>Revenues (2008):</u>	\$410 million

Peer companies/competitors: Life Technologies, Beckman Coulter, Abbott Labs, BD Biosciences

Affymetrix develops treatments for infectious diseases, cancer, and other diseases by using its GeneChip system and other technologies to identify, analyze, and manage genetic data.

The company maintains manufacturing facilities in California, Cleveland, and Singapore. In 2009, the company closed its West Sacramento facility and consolidated all of its array manufacturing to its Singapore facility. It manufactures reagents in its Cleveland, Ohio and Fremont, California facilities, but will be closing the Fremont facility in 2010 and incorporating those functions into its Santa Clara facilities. The company maintains a pilot manufacturing and process engineering/development facility in Santa Clara.

### 3. Amgen

<u>Year founded:</u>	1980
<u>Principal CA location(s):</u>	Thousand Oaks (HQ), Fremont, South San Francisco
<u>Sector:</u>	Drugs and pharmaceuticals
<u>Primary NAICS code:</u>	325414 (Biological product manufacturing)
<u>Employees (2008):</u>	17,000 worldwide; X in Fremont
<u>Revenues (2008):</u>	\$15 billion
<u>Peer companies/competitors:</u>	Johnson and Johnson, Novartis, Abbott, Baxter Bioscience, Merck, Pfizer, Roche

Known as the world's first big biotechnology company, Amgen discovers, develops, manufactures and markets human therapeutic products to treat cancer, kidney disease, rheumatoid arthritis, anemia, and other illnesses. It has multiple approved and Phase III products.

Amgen's first manufacturing site, located in Thousand Oaks, is increasingly dedicated to clinical operations. In 2006, the company expanded its capacity to develop and produce monoclonal (therapeutic) antibodies by acquiring Abgenix, Inc. in Fremont, whose treatment for

colorectal cancer was approved by the FDA that year. Amgen produces Vectibix, a monoclonal antibody cancer therapeutic, in this site's 100,000-square-foot manufacturing facility.<sup>88</sup>

#### 4. Baxter Bioscience

<u>Year founded:</u>	1931 (Chicago, IL)
<u>Principal CA location(s):</u>	Hayward, Thousand Oaks, Los Angeles
<u>Sector:</u>	Drugs and pharmaceuticals
<u>Primary NAICS code:</u>	325414 (Biological product manufacturing)
<u>Employees (2008):</u>	48,500 worldwide; X in Hayward
<u>Revenues (2008):</u>	\$12.3 billion
<u>Peer companies/competitors:</u>	Bayer, BD Biosciences, Johnson & Johnson, Pfizer, Novartis, Roche

Now headquartered in Deerfield, IL, Baxter has three business segments—bioscience, medication delivery, and renal—through which it develops and manufactures medical devices, pharmaceuticals and biotechnology products to treat hemophilia, immune disorders, infectious diseases, kidney disease, trauma and other chronic and acute medical conditions.

The company's bioscience segment, Baxter Bioscience, operates manufacturing facilities in three California cities: Hayward, Thousand Oaks, and Los Angeles (site of the company's new plasma fractionation facility). Baxter Bioscience manufactures protein and plasma therapies to treat hemophilia and immune disorders; vaccines for meningitis C and smallpox, with vaccine products in development for SARS, Lyme disease, and influenza; and biological sealants used to close surgical wounds. It had 2008 sales of \$5.3 billion.

#### 5. Bayer HealthCare Pharmaceuticals

<u>Year Founded:</u>	1863 (Germany)
<u>Principal CA location(s):</u>	Berkeley, Emeryville, Richmond
<u>Sector:</u>	Drugs and pharmaceuticals
<u>Primary NAICS code:</u>	325414 (Biological product manufacturing)
<u>Employees (2008):</u>	108,000 worldwide; 1,500 in Berkeley, 600 in Emeryville
<u>Revenues (2008):</u>	32 billion Euros

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<sup>88</sup> Amgen also maintains manufacturing locations in Colorado, Puerto Rico, Rhode Island and Washington.

Peer companies/competitors: J&J, Abbott, Novartis, Pfizer, Merck

Bayer HealthCare Pharmaceuticals is the U.S.-based pharmaceuticals unit of Bayer HealthCare, a division of Bayer AG. Bayer Healthcare's presence in the Bay Area began in 1974, when the company acquired a Berkeley-based plasma production company. The Bay Area has since become the global center for Bayer's biotechnology initiatives, with the Berkeley site serving as Bayer's headquarters for its global biotech product supply organization. The company focuses on therapeutic areas with high medical need, especially hemophilia and multiple sclerosis, producing millions of units of protein therapeutics daily.

The Berkeley campus, the company's major biomanufacturing site, employs more than 1,500 people to produce a leading recombinant therapy for the treatment of hemophilia A. In 2007, the company acquired a biologics manufacturing facility in Emeryville from Novartis, a peer biotech company under study here. The facility is dedicated to producing proteins used in the treatment of multiple sclerosis (the drug Betaseron). Bayer retained the employees associated with the manufacture of this product, and currently employs 600 at the site. With the Emeryville acquisition, Bayer became the second largest employer in the Bay Area.<sup>89</sup>

## 6. BioMarin Pharmaceuticals

Year founded: 1998  
Principal CA location(s): Novato (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325412 (Pharmaceutical preparation manufacturing)  
Employees (2008): 649  
Revenues (2008): Nearly \$300 million  
Peer companies/competitors: Johnson & Johnson, Pfizer, Novartis

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<sup>89</sup> In addition, the company's US research team is based in Richmond, CA, just north of San Francisco. It also operates four manufacturing facilities in the Greater Seattle area.

BioMarin develops and commercializes biopharmaceuticals for serious diseases and medical conditions, especially rare ones. It has three FDA-approved products and multiple clinical and preclinical product candidates.

The company manufactures two of its approved products, both recombinant enzymes, in its approved GMP production facility located in Novato. Contract manufacturers perform vialing and packaging for these drugs. A contract manufacturer also produces BioMarin's other approved drug.

## 7. Elan Pharmaceuticals

Year founded: 1969 (Dublin, Ireland)  
Principal CA location(s): South San Francisco (HQ)  
Sector: Drugs and pharmaceuticals/Research services  
Primary NAICS code: 325412 (Pharmaceutical preparation manufacturing)/ 541711 (Research and development in biotechnology)  
Employees (2008): 1,687 worldwide; 357 in South San Francisco  
Revenues (2008): \$1 billion  
Peer companies/competitors: Genentech, Biogen Idec, Pfizer, Merck, Novartis

Elan Pharmaceuticals is the biopharmaceuticals segment of Dublin-based parent company Elan Corporation. Elan Corporation, a neuroscience-based biotechnology company, formed Elan Pharmaceuticals in 1998 to oversee the company's drug-development and marketing operations. Elan Pharmaceuticals develops, manufactures and markets therapies in the areas of neurology, severe chronic pain, and autoimmune diseases, such as Alzheimer's, Parkinson's, and Crohn's diseases, and multiple sclerosis.

## 8. Exelixis (Company C8-BA)

Year founded: 1994 (Cambridge, MA)  
Principal CA location(s): South San Francisco (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414 (Biologic product manufacturing)  
Employees (2008): 676



Revenues (2008): \$118 million  
Peer companies/competitors: Genentech, Amgen, Bayer, Pfizer, Novartis, Roche

Exelixis moved its headquarters from Cambridge to South San Francisco in 1997. The company engages in genomics-based drug discovery and development of novel, small molecule therapeutics for the treatment of cancer, as well as metabolic and cardiovascular disease. It has a pipeline of 14 compounds, all in the clinical development stage. To finance its drug development, Exelixis has partnered with GlaxoSmithKline, Genentech, Wyeth, and Bristol-Myers Squibb, among others.

## 9. Genentech

Year founded: 1976  
Principal CA location(s): South San Francisco (HQ), Vacaville, Oceanside  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414 (Biological product manufacturing)  
Employees (2008): 11,000+ total; 2,000 in SSF; X in Vacaville; X in Oceanside  
Revenues (2008): \$13.5 billion  
Peer companies/competitors: Amgen, Bayer, Abbot Labs, Biogen Idec, J&J, Novartis, Elan, Pfizer, Merck

Genentech is considered the world's first biotechnology company, and remains one of its most successful. The company uses human genetic information to develop, manufacture, and commercialize new drugs to treat serious or life-threatening medical conditions. It has over 100 projects in the pipeline in the therapeutic focus areas of oncology, immunology, disorders of tissue growth and repair, and neuroscience.

Swiss pharmaceutical company Roche, which owned a majority stake in Genentech, took full ownership of the company in 2009. Roche is keeping both Genentech's name and its South San Francisco headquarters, and contends that it will maintain the company's innovative culture.

Genentech operates manufacturing facilities in three sites in California<sup>90</sup>: South San Francisco; Vacaville, located in Solano County, about 50 miles northeast of San Francisco; and Oceanside, located about 35 miles north of San Diego. The South San Francisco site, which houses a research facility and business functions in addition to its manufacturing operations, employs about 2,000 people. The company acquired its Vacaville site in 1994, beginning a major expansion of the facility ten years later. When completed, the Vacaville site will be the largest biotech manufacturing plant of its kind in the world. Finally, the company purchased its Oceanside site, a state-of-the-art commercial and clinical biologics manufacturing facility, from Biogen Idec in 2005. Upon receiving FDA licensure in 2007, the facility added 90,000 liters of capacity, dedicated largely to producing bulk substance of its blockbuster drug Avastin.

#### 10. Gilead Sciences

<u>Year founded:</u>	1987
<u>Principal CA location(s):</u>	Foster City (HQ), San Dimas
<u>Sector:</u>	Drugs and pharmaceuticals
<u>Primary NAICS code:</u>	325414 (Biological product manufacturing)
<u>Employees (2008):</u>	4,000 total; 289 in Foster City; X in San Dimas
<u>Revenues (2008):</u>	\$5.3 billion
<u>Peer companies/competitors:</u>	Roche, Abbott Labs, Genentech, Merck, Novartis, Pfizer

Gilead Sciences discovers, develops, and commercializes therapeutics for the treatment of life-threatening infectious diseases, especially HIV and Hepatitis B, as well as cardiovascular conditions and respiratory diseases. The company has 12 marketed products and a growing product portfolio in clinical trials.

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<sup>90</sup> In addition, the company began construction of a new state-of-the-art fill/finish facility in Hillsboro, Oregon, about 20 miles west of Portland. It expects to employ about 300 people there by 2015. In 2006, Genentech and Lonza entered into an agreement to manufacture Genentech's product Avastin at Lonza's Singapore facility, which remains under construction. Genentech also began construction in 2007 of an E.coli manufacturing facility in Singapore for production of bulk drug substance for its drug Lucentis.

Gilead's antiviral research facilities are located in Foster City. The company's site in San Dimas, north of San Diego, manufactures, packages, and labels various antiviral and other products.

#### 11. Johnson & Johnson – *Life Scan and Alza*

Year founded: 1887 (New Brunswick, NJ)  
Principal CA location(s): Milpitas (Life Scan); Vacaville (Alza)  
Sector: Drugs and pharmaceuticals/Medical equipment/supplies  
Primary NAICS code: 325412 (Pharmaceutical preparation manufacturing)/  
339112 (Surgical and medical instrument manufacturing)  
Employees (2008): 118,700 worldwide; X in Milpitas; 760 in Vacaville  
Revenues (2008): \$63.7 billion  
Peer companies/competitors: Pfizer, Novartis, Abbot Labs, Amgen, Baxter, Allergan

The health care giant develops and commercializes multiple products within three segments—pharmaceuticals, medical devices and diagnostics, and consumer care—through more than 250 operating companies located in approximately 60 countries.

In 1986, J&J's device and diagnostics segment acquired Life Scan, headquartered in Milpitas, which makes blood glucose monitoring systems for home and hospital use by diabetics. Life Scan has manufacturing facilities in Milpitas, Puerto Rico, and Scotland, and employs more than 2,500 employees worldwide.

In 2001, J&J's pharmaceuticals segment acquired Alza, founded in 1986 in Mountain View, CA. Alza manufactures a variety of pharmaceutical and drug delivery systems, in particular time-release medication capsules used to treat attention deficit disorder, ovarian cancer, and other illnesses. Alza purchased its manufacturing facility in Vacaville in 1994.

#### 12. Life Technologies/Applied Biosystems

Year founded: 2008  
Principal CA location(s): Carlsbad (HQ), Foster City, Pleasanton  
Sector: Drugs and pharmaceuticals

Primary NAICS code: 325413 (In-vitro diagnostic substance manufacturing)  
Employees (2008): 9,500 worldwide; X in Foster City; X in Carlsbad  
Revenues (2008): \$3 billion  
Peer companies/competitors: BD Biosciences, Affymetrix, Life Scan, Thermo Fisher

In November 2008, Invitrogen, based in Carlsbad, CA, and Applied Biosystems, based in Foster City, CA, merged to form Life Technologies. The new company's headquarters remain in Carlsbad, north of San Diego, where Invitrogen was founded in 1987.

Focused on advancing personalized medicine, regenerative science, molecular diagnostics, forensics, and agricultural and environmental research, Life Technologies develops instrument systems, chemical reagents, software, and other laboratory consumables and products (e.g., cloning kits and cell culture products) that facilitate and simplify genetic cloning, expression, and analysis.

Life Technologies' primary California production facilities are located in Carlsbad and Camarillo in southern California; and Pleasanton and Foster City in the Bay Area. The former Applied Biosystems continues to produce mass spectrometry systems, biochromatography media products, and laboratory software at its primary site in Foster City, as well as in Pleasanton.<sup>91</sup>

### 13. Novartis

Year Founded: 1996 (Basel, Switzerland)  
Principal CA location(s): Emeryville, Vacaville  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414 (Biological product manufacturing)  
Employees (2008): 96,000 worldwide; X in Emeryville; X in Vacaville  
Revenues (2008): \$42 billion  
Peer companies/competitors: Pfizer, Johnson & Johnson, Merck

Novartis was created in 1996 by the merger of Sandoz and Ciba-Geigy, both Swiss-based chemical/life sciences companies. Of Novartis' four divisions, two have locations in California:

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<sup>91</sup> In addition to other U.S.-based sites, the company maintains manufacturing facilities in Japan, Israel, and Singapore.

the Vaccines and Diagnostics division, located in Emeryville, and the Pharmaceuticals division, located in Vacaville. The Pharmaceuticals division develops, manufactures, and sells pharmaceuticals in such therapeutic areas as cardiovascular, oncology, neuroscience, ophthalmics, respiratory, and immunology and infectious diseases. The Vaccines and Diagnostics division consists of two separate businesses: Novartis Vaccines, which produces flu, meningococcal, pediatric, and travel vaccines; and Chiron, which offers blood testing and molecular diagnostics to protect the global blood supply.

Novartis formed the Vaccines and Diagnostics division when it acquired Chiron Corporation in 2006. The East Bay's largest (and home-grown) biotech company, Chiron (which continues to operate under this name) manufactures equipment to test blood donations for infectious diseases.

Medium-sized companies (51-300 employees at principal California location(s))

14. Alexza Pharmaceuticals

Year founded: 2000  
Principal CA location(s): Mountain View (HQ)  
Sector: Drugs and pharmaceuticals (drug delivery systems)  
Primary NAICS code: 325412 (Pharmaceutical preparation manufacturing)  
Employees (2008): 111  
Revenues (2008): \$500,000  
Peer companies/competitors: Abbott Labs, Nektar, Pfizer, Novartis

Alexza Pharmaceuticals is an emerging biotechnology company that develops and commercializes products for the acute treatment of central nervous system conditions. Its products are all based on an inhaler technology that contains a heating element coated with a thin layer of medicine. When heated, the inhaler vaporizes the medicine, allowing the medicine to be rapidly absorbed through the lungs at a rate comparable to or faster than oral and intravenous mediations.

The company has six product candidates in clinical trials, with a lead product candidate in late-stage clinical development for the acute treatment of agitation in patients with schizophrenia or bipolar disorder. The company opened a new manufacturing facility at its headquarters in 2007. Part of its main product device is also manufactured in Singapore.

#### 15. Amyris Biotechnologies

Year founded: 2003  
Principal CA location(s): Emeryville (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325411 (Medicinal and botanical manufacturing)  
Employees (2008): 150  
Revenues (2008): \$21.2 million  
Peer companies/competitors:

Formerly part of a nonprofit venture to develop a low-cost malaria drug, Amyris Biotechnologies transforms plant-based feedstocks, such as sugarcane, into 50,000 different molecules used in a variety of energy, pharmaceutical, and chemical applications. It produces renewable fuels, malaria treatments, and environmentally friendly chemicals for use in consumer products and industrial applications currently dependent on petrochemical components.

#### 16. Facet Biotech

Year founded: 1986/2008  
Principal CA location(s): Redwood City (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414 (Biological product manufacturing)  
Employees (2008): 327 (200 currently)  
Revenues (2008): \$18.3 million  
Peer companies/competitors: Genentech, Pfizer, Novartis, Elan

Facet Biotech was formed in late 2008 when PDL BioPharma spun off its biotechnology operations to separate its development operations from its existing drug royalty patents, which remained with PDL (now based in Nevada). Facet Biotech develops antibody (protein) therapies

for immune system diseases and cancers. It is focused on developing four clinical-stage candidates, as well as several late-stage research programs.

#### 17. Genencor

Year founded: 1982  
Principal CA location(s): Palo Alto (HQ)  
Sector: Industrial biotechnology/Research services  
Primary NAICS code: 325199 (Basic organic chemical manufacturing)/ 541711 (Research and development in biotechnology)  
Employees (2008): 7,000 worldwide; 200 in Palo Alto  
Revenues (2008):  
Peer companies/competitors: Novozymes

In 2005, Danisco, the Danish food ingredient company, acquired Genencor. Operating as Danisco's biotechnology division, Genencor develops and manufactures genetically modified, protein enzyme products for industrial, agricultural, and consumer product markets. Upon acquiring Genencor, Danisco became the second largest supplier of industrial enzymes in the world. Genencor maintains a manufacturing facility at its Palo Alto headquarters.

#### 18. Mendel Biotechnology

Year founded: 1997  
Principal CA location(s): Hayward (HQ)  
Sector: Research Services (biotech/plant sciences)  
Primary NAICS code: 541711 (Research and development in biotechnology)  
Employees (2008): 75  
Revenues (2008): \$9 million  
Peer companies/competitors:

Mendel applies functional genomics to the study of plant genes, developing products that control plant genes to improve the yield and quality of row crops and cellulosic biofeedstocks. It also is developing new seed products for the emerging bioenergy market, especially cellulosic ethanol.

## 19. Merck

<u>Year founded:</u>	1891
<u>Principal CA location(s):</u>	San Francisco (Sirna Therapeutics), La Jolla (Sibia Neurosciences)
<u>Sector:</u>	Drugs and pharmaceuticals
<u>Primary NAICS code:</u>	325412 (Pharmaceutical preparation manufacturing)
<u>Number of employees:</u>	55,200 worldwide; 68 in San Francisco; X in La Jolla
<u>Revenues (2008):</u>	\$23.9 billion
<u>Peer companies/competitors:</u>	Pfizer, Baxter, Abbot Labs, Bayer, Roche, Amgen, Allergan

Headquartered in Whitehouse Station, NJ, Merck & Co. develops, manufactures, and markets vaccines and medicines in such therapeutic areas as Alzheimer's, cardiovascular disease, diabetes and oncology.

To strengthen its genomics capabilities, Merck acquired several biotech firms in 2006, including Sirna Therapeutics, located in San Francisco. A wholly-owned subsidiary of Merck, Sirna conducts research in the cutting-edge area of RNA interference (RNAi), a tool for studying and manipulating gene expression. The company develops RNAi therapies in the areas of infectious disease, dermatology, metabolic disease, and the central nervous system.

In 1999, Merck acquired Sibia Neurosciences, located in La Jolla. Founded in 1981, Sibia (also a wholly-owned subsidiary) develops novel small molecule therapeutics for the treatment of neurodegenerative, neuropsychiatric, and neurological disorders, such as Alzheimer's and Parkinson's diseases.

## 20. Metabolex

<u>Year founded:</u>	1991
<u>Principal CA location(s):</u>	Hayward
<u>Sector:</u>	Drugs and pharmaceuticals/Research services
<u>Primary NAICS code:</u>	325412 (Pharmaceutical preparation manufacturing)
<u>Employees (2009):</u>	73
<u>Revenues (2009):</u>	\$7.3 million
<u>Peer companies/competitors:</u>	Pfizer, Novartis



Metabolex discovers and develops therapeutics to treat type 2 diabetes and related metabolic diseases. It has four compounds in phase 2 clinical trials, three in preclinical trials, and one in the research stage.

## 21. Nektar Therapeutics

Year founded: 1990  
Principal CA location(s): San Carlos (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325412 (Pharmaceutical preparation manufacturing)  
Employees (2009): 335 total; 280 in San Carlos  
Revenues (2009): \$72 million  
Peer companies/competitors: Amgen, Abbott Labs, Genentech, Merck, Pfizer, Roche, Novartis, Alexza Pharmaceuticals

Nektar creates pharmaceuticals using a technology that enhances the performance of existing drugs by reducing immune response, allowing for longer-term treatment. It has nine approved products, developed in partnership with other biotech companies, in such therapeutic areas as immunology and oncology, along with five cancer compounds in clinical trials, as well as nine other compounds in pre-clinical or clinical trials in the areas of immunology, anti-infectives, and hemophilia. The San Carlos headquarters houses the company's corporate offices and R&D laboratories. Manufacturing is located in a facility in Huntsville, Alabama.

### Small companies (1-50 employees at principal California location)

## 22. Anaspec

Year founded: 1993  
Principal CA location(s): Fremont  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 541712 (Research and Development in the Physical, Engineering, and Life Sciences)  
Employees (2008): 100  
Revenues (2008): Technical and scientific research services  
Peer companies/competitors: Diagnostic Biosystems

Anaspec provides drug discovery reagents to life sciences companies and academic research institutions worldwide. Its custom services include peptide synthesis, antibody production, assay development and oligonucleotide synthesis.

### 23. Bay Bioanalytical Laboratory

Year founded: 1993  
Principal CA location(s): Hercules  
Sector: Technical and scientific research services  
Primary NAICS code: 541712 (Research and Development in the Physical, Engineering, and Life Sciences)  
Employees (2008): 11  
Revenues (2008): \$1.2 million  
Peer companies/competitors:

Bay Bioanalytical Laboratory is a contract laboratory that offers analytical services to companies requiring analytical characterization of proteins, small molecules and other polymers. The firm supports all aspects of drug discovery and development, ranging from analysis of research reagents to drug products

### 24. BiosPacific

Year founded: 1989  
Principal CA location(s): Emeryville  
Sector: Pharmaceuticals manufacturer; diagnostic substances  
Primary NAICS code: 325413 (In-Vitro Diagnostic Substance Manufacturing)  
Employees (2008): 10  
Revenues (2008):  
Peer companies/competitors:

BiosPacific manufactures and supplies antibodies and antigens for the development of diagnostic assays.

## 25. Cel Analytical

Year founded: 1993  
Principal CA location(s): San Francisco  
Sector: Medical laboratories and research  
Primary NAICS code: 621511 (Medical Laboratories)  
Employees (2008): 4  
Revenues (2008): \$190,000  
Peer companies/competitors:

Cel Analytical is a woman-owned environmental laboratory that analyzes water generated from such sources as wastewater/sludge, construction, the wine industry, residential or source drinking water, bathing water/swimming pools, and storm water. The company also provides molecular methods such as PCR analysis of DNA for rapid detection and screening of pathogens.

## 26. ChiroSolv

Year founded: 1995  
Principal CA location(s): Santa Clara  
Sector:  
Primary NAICS code:  
Employees (2008):  
Revenues (2008):  
Peer companies/competitors:

ChiroSolv offers productivity tools and services to help scientists develop chirally pure drugs.

## 27. Diagnostic BioSystems

Year founded: 1994  
Principal CA location(s): Pleasanton  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414  
Employees (2008): 25  
Revenues (2008):  
Peer companies/competitors: Anaspec, BioSpecific

Diagnostic BioSystems is an immunohistochemistry company that develops and manufactures reagent products, including monoclonal and polyclonal antibodies, histology kits, and buffers, which diagnose and monitor cancer and other diseases.

The company manufactures its products at its Pleasanton site, which contains a licensed Medical Device Manufacturing facility.

#### 28. Prosetta Bioconformatics

Year founded: 1992  
Principal CA location(s): San Francisco  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 541712 (Research and Development in the Physical, Engineering, and Life Sciences)  
Employees (2008): 40  
Revenues (2008): \$1.9 million  
Peer companies/competitors:

Prosetta Bioconformatics develops small-molecule antiviral therapeutics for such diseases as influenza, HIV, and HCV.

#### 29. Spring Bioscience

Year founded: 2001  
Principal CA location(s): Pleasanton  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414  
Employees (2008): 12  
Revenues (2008):  
Peer companies/competitors:

Spring Biosystems is an immunohistochemistry company that develops and supplies next generation rabbit monoclonal antibodies and other reagents. It operates as a wholly-owned subsidiary of Ventana Medical Systems, which acquired the company in 2008 promote Ventana's work in the area of companion diagnostics and personalized medicine.

## 5.4.2 Company Profiles – Greater San Diego Area

### Large Companies (301 or more employees at principal California location(s))

#### 1. Beckman Coulter

<u>Year founded:</u>	1935
<u>Principal CA location(s):</u>	Fullerton (HQ), Brea
<u>Sector:</u>	Drugs and pharmaceuticals/Medical devices
<u>Primary NAICS code:</u>	325413 (In-vitro-diagnostic substance manufacturing)/ 334516 (Analytical laboratory instrument manufacturing)
<u>Employees (2008):</u>	11,000 worldwide; 1,200 in Fullerton
<u>Revenues (2008):</u>	\$3 billion
<u>Peer companies/competitors:</u>	BD Bioscience, Abbott Labs, Roche Diagnostics

Formed in 1997 when Beckman acquired Coulter Corporation, Beckman Coulter manufactures and sells biomedical testing instrument systems, tests and supplies that enhance laboratory processes in the clinical diagnostics, cellular analysis, and biomedical research areas. It provides a variety of cellular, chemistry, immunoassay, drug discovery, and lab automation products.

#### 2. Becton, Dickinson

<u>Year founded:</u>	1897
<u>Principal CA location(s):</u>	San Jose, San Diego, Oceanside?
<u>Sector:</u>	Medical equipment and supplies
<u>Primary NAICS code:</u>	339112 (Surgical and medical instrument manufacturing)
<u>Employees (2008):</u>	28,300 worldwide; 749 in San Jose; X in San Diego
<u>Revenues (2008):</u>	\$7.1 billion
<u>Peer companies/competitors:</u>	Beckman Coulter, Abbot Labs, Baxter, Gen-Probe

Headquartered in Franklin Lakes, NJ, Becton, Dickinson and Company (BD) develops, manufactures, and markets medical supplies/devices, instrument systems, diagnostic products, and reagents. It has three business segments: BD Medical, BD Diagnostics and BD Biosciences. The company's biosciences segment, with sites in San Jose and San Diego, provides products and services for genomics, proteomics, drug discovery & development, oncology, and immune

function. Products include reagents, antibodies, cell imaging systems, and labware, such pipettes and tubes, used in basic and clinical research.

### 3. Biosite

Year founded: 1988; acquired 2007  
Principal CA location(s): San Diego (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325413 (In-Vitro Diagnostic Substance Manufacturing)  
Employees (2006): 1,036  
Revenues (2008):  
Peer companies/competitors:

Biosite discovers and develops protein-based diagnostics and antibody development technologies used in drug screens, pathogen detection, and medical diagnostics. It also develops diagnostic tests to detect intestinal parasites, diagnose congestive heart failure, and measure the biomarkers associated with stroke. The global medical diagnostics firm Inverness Medical acquired Biosite in 2007.

### 4. Genentech

Year founded: 1976  
Principal CA location(s): South San Francisco (HQ), Vacaville, Oceanside  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414 (Biological products manufacturing)  
Employees (2008): 11,000+ total; 2,000 in SSF; X in Vacaville; X in Oceanside  
Revenues (2008): \$13.5 billion  
Peer companies/competitors: Amgen, Abbot Labs, Biogen Idec, J&J, Novartis, Merck

For company description, see Bay Area companies, above.

### 5. Life Technologies

Year founded: 2008  
Principal CA location(s): Carlsbad (HQ), Foster City, Pleasanton  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325413 (In-vitro diagnostic substance manufacturing)  
Employees (2008): 9,500 worldwide; X in Foster City; X in Carlsbad

Revenues (2008): \$3 billion  
Peer companies/competitors: BD Biosciences, Affymetrix, Life Scan, Thermo Fisher

For a company description, see Bay Area companies, above.

## 6. Pfizer

Year founded: 1849 (New York City, HQ)  
Principal CA location(s): South San Francisco (Rinat), La Jolla (CovX)  
Sector: Drugs and pharmaceuticals/Research services  
Primary NAICS code: 325412 (Pharmaceutical preparation manufacturing)/  
541711 (Research and development in biotechnology)  
Number of employees: 81,800 worldwide; 80 in South San Francisco; 1,000 in La Jolla  
(45 in CovX)  
Revenues (2008): \$48.2 billion  
Peer companies/competitors: Bayer, Merck, Novartis, Amgen, Abbott, Genentech

The world's largest research-based pharmaceuticals firm, Pfizer develops and manufactures medicines in eleven therapeutic areas, including cardiovascular and metabolic diseases, central nervous system disorders, arthritis, infectious and respiratory diseases, oncology, and ophthalmology.

In 2006, Pfizer expanded its neuroscience research by acquiring South San Francisco-based biotech firm Rinat Neuroscience, which was developing protein-based therapeutics for pain, Alzheimer's disease, and other neurological disorders. Rinat is part of the company's biotherapeutic discovery efforts, headquartered in its San Francisco-based Biotherapeutics and Bioinnovation Center (BBC).

Pfizer's La Jolla Laboratories, located on a 33.5-acre campus comprising eight buildings, focus on developing treatments in the areas of oncology and ophthalmology. In addition, to enhance its biologics portfolio, Pfizer acquired San Diego-based CovX Pharmaceuticals in 2007, a biotherapeutics company specializing in preclinical oncology and metabolic research. Like Rinat, CovX operates as a unit of the company's BBC.

Medium companies (51-300 employees at principal California location(s))

7. Arena Pharmaceuticals

<u>Year founded:</u>	1997
<u>Principal CA location(s):</u>	San Diego (HQ)
<u>Sector:</u>	Drugs and pharmaceuticals
<u>Primary NAICS code:</u>	325414 (Biological product manufacturing)
<u>Employees (2008):</u>	499 (currently down to approx. 300)
<u>Revenues (2008):</u>	\$9.8 million
<u>Peer companies/competitors:</u>	Abbot Labs, Pfizer, Neurocrine, Eli Lilly

Arena Pharmaceuticals is a clinical-stage biopharmaceutical company focused on discovering and commercializing oral drugs in four therapeutic areas: cardiovascular, central nervous system, inflammatory and metabolic diseases. Its lead drug candidate, intended for the treatment of obesity, is in Phase 3 clinical trials. All of Arena Pharmaceutical's revenue comes from partnership agreements with larger pharmaceutical companies.

8. Gen-Probe

<u>Year founded:</u>	1983
<u>Principal CA location(s):</u>	San Diego (HQ)
<u>Sector:</u>	Drugs and pharmaceuticals
<u>Primary NAICS code:</u>	325413 (In-vitro diagnostic substance manufacturing)
<u>Employees (2008):</u>	1,037 total; 220 in San Diego
<u>Revenues (2008):</u>	\$472 million
<u>Peer companies/competitors:</u>	Abbot Labs, Becton Dickinson, Roche

Gen-Probe develops, manufactures, and markets nucleic acid tests to diagnose human diseases, especially STDs, tuberculosis, strep throat, pneumonia, and fungal infections, as well as to screen donated blood for HIV, Hepatitis C, and the West Nile virus. It is developing a screening test for prostate cancer, drug-resistant hospital infections, human papillomavirus, and other diseases. In



1989, Chugai Pharmaceutical acquired Gen-Probe, but then spun it off as a separate company as a result of Chugai's merger with Nippon Roche in 2002.

One of Gen-Probe's two manufacturing facilities in the U.S. is located at the San Diego headquarters, and is dedicated to producing the company's clinical diagnostic products. The other facility is located in Rancho Bernardo, northeast of San Diego.

#### 9. Isis Pharmaceuticals

Year founded: 1989  
Principal CA location(s): Carlsbad (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325412 (Pharmaceuticals preparation manufacturing)  
Employees (2008): 300  
Revenues (2008): \$107 million  
Peer companies/competitors: Gilead Sciences, Merck, Pfizer

Isis Pharmaceuticals develops products from its RNA-based technologies, focused on treating cardiovascular, metabolic and severe neurodegenerative diseases and cancer. The company is a leader in antisense drugs, which are the first class of drugs to control the expression of genes by interacting with RNA. It has 19 antisense compounds in development, most of them partnered with such drug firms as Eli Lilly and Merck.

Isis operates a drug substance manufacturing facility at its Carlsbad location. Due to increased demand for its antisense drugs, it currently is upgrading this facility, a process that it expects to complete in 2009.

#### Small companies (1-50 employees at principal California location)

#### 10. Anadys Pharmaceuticals

Year founded: 1992  
Principal CA location(s): San Diego (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414 (Biological product manufacturing)

Employees (2008): 47  
Revenues (2008): \$24.1 million  
Peer companies/competitors: Pfizer, Gilead Sciences, Novartis, Amgen

Anadys Pharmaceuticals is a clinical-stage biopharmaceutical company focused on developing new therapeutic treatments in the areas of Hepatitis C and oncology. Anadys does not have manufacturing facilities, and instead contracts out production of its trial drugs.

#### 11. MO BIO Laboratories

Year founded: 1993  
Principal CA location(s): Carlsbad (HQ)  
Sector: Medical testing  
Primary NAICS code: 541380 (Testing Laboratories)  
Employees (2008): 25  
Revenues (2008): <\$500,000  
Peer companies/competitors:

MO BIO specializes in technologies for nucleic acid purification and isolation, and provides DNA and RNA research-related products to biotechnology laboratories around the world.

#### 12. Neurocrine Biosciences

Year founded: 1992  
Principal CA location(s): San Diego (HQ)  
Sector: Drugs and pharmaceuticals  
Primary NAICS code: 325414 (Biological product manufacturing)  
Employees (2008): 125  
Revenues (2008): \$3.9 million  
Peer companies/competitors: Pfizer, Novartis, Eli Lilly, Merck, Arena Pharmaceuticals

Neurocrine Biosciences is a clinical-stage biopharmaceutical company that develops and commercializes drugs to treat neurological and endocrine-related diseases and disorders, such as endometriosis, congestive heart failure, depression, pain, diabetes, irritable bowel syndrome, and insomnia. Its drug compounds are in all phases of clinical development.

## **Chapter 6: Outcomes Data**

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This chapter presents the dissertation study's main outcomes data. Specifically, I collected three types of outcomes data that are largely quantitative in nature, but that also contain several qualitative measures:

- Demographic and profile data of students enrolled in the core classes of several California community college biotechnology programs;
- Program completion and job placement rates for the three public workforce system-funded, and three industry/nonprofit-funded, biotechnology training partnership programs under study; and
- Recruitment and hiring data from the treatment and comparison group biotechnology/life sciences companies in my research sample.

The first two types of data constitute the study's key supply-side indicators of community college graduates' access to technician training and entry-level technician positions in the biotech industry, while the third constitutes the study's primary demand-side indicator of expanded employment opportunities for such graduates.

### **6.1 California Community College Biotechnology Program - Student Profile Data**

In order to build a basic profile of California Community College biotechnology program students and job seekers, I conducted an online, anonymous survey of such individuals in the spring of 2009. The students were enrolled in the core classes of eight biotechnology programs located in both Northern and Southern California.<sup>92</sup> Typically called "Introduction to Biotechnology" or "Fundamentals of Biotechnology," these classes constituted the core courses

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<sup>92</sup>As noted in the previous chapter's methodology section, participating faculty members administered the survey online, using the SurveyMonkey.com platform, by sending a computer-generated link to their students, whose survey responses were automatically returned to my SurveyMonkey account

for the colleges' Associate degree and certificate programs. The participating colleges were as follows:

San Francisco Bay Area:

City College of San Francisco  
Contra Costa College  
Foothill College  
Ohlone College  
Skyline College  
Solano College<sup>93</sup>

Greater San Diego Area:

MiraCosta College  
Miramar College  
Southwestern College

To ascertain the students' basic demographics, educational background, job history, and reasons for enrolling in the biotechnology program, the eight-question survey asked for the following information:

- Name and location of current community college biotech program
- Age, gender, and race/ethnicity
- Educational background, i.e., whether students had a previous community college education, bachelor's degree, and/or graduate or professional degree, specifying the type of degree, field of study, and date of graduation
- For students with a prior bachelor's degree, their reason(s) for attending their current community college program
- Previous two jobs that students held, including occupation/position and approximate dates of employment;
- Students' intended trajectory after completing their current community college program, namely, entering the workforce and/or continuing their education by pursuing an associate's and/or bachelor's degree.

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<sup>93</sup> The two San Francisco Bay Area colleges from which I did not receive student responses were Berkeley City College and Laney College. Unfortunately, state budget cuts forced Berkeley City College to end its biotechnology program in late 2009.

In total, 132 individuals completed the survey.<sup>94</sup> With 177 students enrolled in the classes to which the participating faculty members sent the survey link, the response rate was 75 percent. I note that several features of the survey design acted to minimize any potential bias. First, because of the survey's online format, participating faculty could distribute the survey simultaneously to all students in their core classes, thus avoiding a situation in which only students present at the survey's distribution might receive the survey. Second, the online format reinforced the voluntary and anonymous nature of the survey, as students completed the survey at their leisure, the survey was returned automatically to my SurveyMonkey account (rather than to the faculty member), and I asked for no personal identifiers. Third, the introduction to the survey made clear that participation was voluntary and completely anonymous.<sup>95</sup>

The survey responses reveal that the community college biotech programs under study enroll a highly diverse and fairly well educated student body. While 40 percent of respondents entered the biotech programs with only a high school degree, a near majority (45 percent) held a bachelor's degree or higher. This confirms the existence of the so-called "reverse articulation" or "BA retread" phenomenon, in which workers already possessing a four-year degree enroll in the community college biotech programs to obtain the practical, hands-on laboratory training necessary for entry into the technician-level workforce. The responses by numerous bachelor-degreed students in the sample to the question of why they enrolled in a community college program despite having an advanced degree bear this rationale out.

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<sup>94</sup> Appendix E presents the student survey.

<sup>95</sup> The introduction to the survey stated the following, in part: "The data from this survey, which will be kept confidential, will provide important information about the educational pathways of community college-trained biological technicians. The data will be aggregated across biotech programs for use in the researcher's dissertation....Please note that your participation in the survey is voluntary; you may decline to answer any question without adverse consequences; and your responses will be kept anonymous." The full student survey is contained in Appendix E.

However, while the advanced educational backgrounds of many respondents suggest that the programs do not reach the neediest students exclusively, other indicators—in particular, gender, race/ethnicity and age—suggest that the programs do expand educational opportunities to an underserved or nontraditional labor pool. As the results show, a majority of the respondents enrolled in this scientific discipline are women, people of color, and older than the traditional college-age student. Indeed, at the least, the programs appear to be playing a critical role in diversifying the labor pool and workforce for the biotechnology industry.

To place the survey responses in context, I also provide publically-available demographic data on students enrolled in the higher education system in California. Specifically, I retrieved data from the California Postsecondary Education Commission (CPEC),<sup>96</sup> the California Community Colleges Chancellor's Office (CCCCO), and the Community College League of California (CCLC). The CPEC's and CCCCCO's custom data reports provided the following information:

1. Spring term 2009 enrollment data for all California Community College (CCC) students within the biotechnology and biomedical technology sub-discipline, aggregated by:
  - Gender
  - Age
  - Race/ethnicity
2. Enrollment data for students attending the state's three public higher education systems—the University Of California (UC), California State University (CSU), and California Community College (CCC) systems—for 2008 (the most recent year available), aggregated by:

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<sup>96</sup> “The Commission integrates policy, fiscal, planning, data, and programmatic analyses about issues concerning education beyond high school to the legislative and the executive branches of California government and to the general public.” <http://www.cpec.ca.gov>.

- Age distribution, including student level
  - Ethnicity
  - Gender
3. Bachelor's or Associate's Degrees awarded, in 2007 or 2008 (see below), aggregated by:
- Higher education system, i.e., the three public systems, as well as private institutions<sup>97</sup>
  - Discipline/institutional program, specifically the biological and biomedical science program within the STEM life sciences category
  - Ethnicity
  - Gender

A number of caveats are in order with respect to the CPEC and CCCCO data. First, regarding the “degrees awarded” data (number two, above), the latest data available for the public systems is 2008, while for the private institutions it is 2007. Second, regarding the category of discipline/institutional program, only the CCCCO database includes the biotechnology/biomedical technology program; the CPEC database includes a biological and biomedical sciences program, not a biotechnology program (even though it also contains data on the community colleges). Hence, the “degrees awarded” data is not a direct match to the biotechnology programs under study here. Second, the CPEC database aggregates the enrollment data by discipline, i.e., biological/biomedical sciences, only for the UC and SCU systems, not for the CCC or private universities. With regard to the latter two systems, the database aggregates by discipline only with respect to the category of degrees awarded. The present study's survey, however, examined students currently enrolled in the biotech programs under study, not the degrees awarded. Hence, the closer match is with the UC and CSU datasets, although the degree awarded dataset is still useful for purposes of reviewing the relevant demographics within private institutions and the CCC generally. Finally, with regard to its

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<sup>97</sup> These are non-public, four-year institutions accredited by the Western Association of Schools and Colleges (WASC).

community college data, the CPEC database aggregates only by associate's degree, not certificates, within the category of degrees awarded. Hence, this data understates the number of community college students graduating with this life sciences degree.

Despite the imperfect matches among the multiple data sets, the demographic data on the larger public and private student body in California offers an important perspective on the biotech program student survey data compiled for this dissertation study. The most striking difference between the survey respondents and their peers in the other educational systems involves their ages: Survey respondents were significantly older than the UC and CSU students, as well as the CCC student body as a whole. This suggests that the community college biotechnology programs enroll a higher percentage of students seeking retraining. In addition, the survey respondents were generally more diverse than students who received life sciences degrees in the private universities, while generally as diverse as the other students. Finally, a significantly higher percentage of survey respondents (45 percent) held a bachelor's degree or higher than their peers in the CCC system as a whole (8 percent), which underscores that the biotech program is a magnet for individuals seeking retraining.

Below are the main results of this dissertation study's student profile survey, along with the additional higher education data.

Note: I have italicized the student profile data in order to highlight it.

### 1. Gender

Of the 131 respondents who answered this survey question, 55 percent of respondents were female, and 45 percent were male. This breakdown is similar to the other categories of students, except for that of biological/biomedical science degree recipients in the CSU system, 76 percent of whom were female.



**Table 6.1**  
**Sample Biotech Program, CCC Biotech, and Total CCC Students by Gender**

Year	System	Male		Female		Total***
		N	%	N	%	
2009	<i>Sample Biotech Programs</i>	59	45	72	55	131
2009	CCC Biotech*	768	41	1,040	56	1,855
2008	CCC Total**	1,293,306	45	1,562,086	54	2,897,531

Sources: Author Survey; CCCCCO; CCLC

\*This category comprises CCC students statewide enrolled in the Biotechnology and Biomedical technology subdiscipline

\*\*This category comprises the total student body enrolled in the CCC.

\*\*\*Totals include additional categories, i.e., American Indian, unknown responses, that are not included here.

**Table 6.2**  
**Enrollment by Biological and Biomedical Sciences (Life Sciences) Program and Gender, UC and CSU Students (Undergraduate Level), 2008**

System	Male		Female		Total*
	N	%	N	%	
UC	9,689	41	13,818	59	23,530
CSU	7,048	38	11,315	62	18,363

Sources: CPEC

\*The total includes a category of unknown responses not included here.

**Table 6.3**  
**Biological and Biomedical Sciences (Life Sciences) Degrees by Education System and Gender**

Year	System	Male		Female		Total**
		N	%	N	%	
2008	CCC*	189	24	599	76	790
2008	UC	2,737	44	3,517	56	6271
2008	CSU	926	38	1,533	62	2459
2007	Private	482	37	823	63	1,305

Source: CPEC

\* The CCC awards Associate's degrees, while the other three systems award bachelor's degrees.

\*\* Totals include unknown responses that are not included here.

## 2. Age

The average age of the 124 students responding to the survey was 33, with the youngest aged 18 and the oldest aged 62. In comparison to the other categories of students, there were

significantly fewer survey respondents under the age of 20 than all other students, and a greater percentage of older students than in the UC and CSU systems. Specifically, the percentage of students falling in the traditional college-age subgroups (under age 20, and ages 20-24) is significantly lower for the survey respondents than for all other students. For instance, only 4 percent of survey respondents were under age 20, compared to 26 percent of CCC students overall, 37 percent of UC students, and 25 percent of CSU students. Further, only 20 percent of survey respondents were ages 20-24, compared to 26 percent of all CCC students, 57 percent of UC students, and 52 percent of CSU students. Similarly, far higher percentages of survey respondents fell within the age categories considered nontraditional for undergraduate students, i.e., age 25 and older. For instance, the percentage of survey respondents in the ages 25-29 category (26 percent) was double that of the CCC and CSU students, and more than six times that of the UC students. The differences among students in the ages 30-39 and above were as marked. For instance, 28 percent of survey respondents were ages 30-39, compared to only one percent of UC students. As the qualitative data confirms (see below), the community college biotech programs clearly draw large percentages of students interested in upgrading or learning new skills, in likely preparation for a career change.

**Table 6.4**  
**Sample Biotech Program, CCC Biotech and Total CCC Students by Age**

Age Range	Sample Biotech Program (2009)		CCC Biotech (2009)		Total CCC (2008)	
	N	%	N	%	N	%
Under 20	5	4	228	12	749,556	26
20-24	25	20	361	19	760,683	26
25-29	33	26	347	19	370,353	13
30-39	36	28	363	20	401,216	14
40-49	14	11	287	15	274,037	9
50-59	12	9	269	15	325,103	11
60+*	2	2				
Total	127	100	1,855	100	2,897,531	99

Source: Author survey; CCCC; CCLC

\*The CCCC and CCLC data sets do not include this category.

**Table 6.5**  
**Enrollment by Age, UC and CSU Students (Undergraduate Level), 2008**

Age Range	UC		CSU	
	N	%	N	%
18-19	64,784	37	90,389	25
20-24	98,304	57	189,338	52
25-29	6,245	4	45,534	13
30-39	2,013	1	19,735	5
40-49	493	.3	7,574	2
50-64	206	.1	3,502	.1
65+	13	.007	254	.07
Under 18	716	.004	5,897	.02
Total	172,774		362,225	

Source: CPEC

### 3. Race/Ethnicity

Students of color comprise the majority of respondents to the student survey, and come from a variety of ethnic backgrounds. Asian Americans make up 45 percent of respondents, followed by Whites (30 percent), Latinos (13 percent) and African Americans (6 percent). As such, survey respondents were generally as diverse as students in the CCC system as a whole, as well

as UC and CSU students enrolled in the life sciences program (except that the CSU life sciences program had a higher percentage of Latino enrollees—22 percent versus 13 percent of survey respondents). Moreover, there were significantly higher percentages of Asians, Blacks and Filipinos among survey respondents than among students who received life sciences degrees in the private institutions.

**Table 6.6**  
**Sample Biotech Program Students by Race/Ethnicity**

<b>Race/Ethnicity</b>	<b>Number</b>	<b>Percentage</b>
<i>Asian American</i>	26	21
<i>Chinese American</i>	6	6
<i>Filipino American</i>	10	8
<i>South Asian/Indian</i>	6	6
<i>Japanese</i>	2	2
<i>Korean, Laotian</i>	2	2
<i>White</i>	39	30
<i>Latino</i>	16	13
<i>African American</i>	8	6
<i>Mixed*</i>	8	6
<i>Total</i>	123	100

Source: Author survey

\*This category includes students who self-identified as, e.g., Black/Filipino, White/Native American, and Arab.

**Table 6.7**  
**CCC Biotechnology and Total CCC Students by Race/Ethnicity**

<b>System</b>	<b>Asian/PI</b>		<b>Black</b>		<b>Filipino</b>		<b>Latino</b>		<b>White</b>		<b>Total***</b>
	N	%	N	%	N	%	N	%	N	%	
CCC* Biotech	607	33	128	7	98	5	215	12	513	28	1855
Total** CCC	359,314	12	217,719	8	95,452	3	857,853	30	975,022	34	2,897,531

Sources: Author Survey; CCCCCO; CCLC

\*This category comprises CCC students statewide enrolled in the Biotechnology and Biomedical technology subdiscipline.

\*\*This category comprises the total student body enrolled in the CCC.

\*\*\*Totals include additional categories, i.e., American Indian, unknown responses, not specified here.

**Table 6.8****Enrollment by Biological and Biomedical Sciences (Life Sciences) Program and Race/Ethnicity, UC and CSU Systems Only, 2008**

System	Asian/PI		Black		Filipino		Latino		White		Total*
	N	%	N	%	N	%	N	%	N	%	
UC	10,459	44	730	3	1,572	7	3,243	14	5,644	24	23,530
CSU	3,736	20	1,108	6	1,251	7	3,995	22	5,410	29	18363

Source: CPEC

\*The total includes a category of unknown responses not specified here.

**Table 6.9****Biological and Biomedical Sciences (Life Sciences) Degrees by Education System and Race/Ethnicity**

Year	System	Asian/PI		Black		Filipino		Latino		White		Totals**
		N	%	N	%	N	%	N	%	N	%	
2008	CCC*	176	22	30	4	75	10	134	17	292	37	790
2008	UC	2,821	45	128	2	367	6	488	8	1,726	28	6,271
2008	CSU	539	22	105	4	135	5	328	13	904	37	2,459
2007	Private	396	30.3	43	3.3	0	0	144	11	583	44.7	1,305

Source: CPEC

\* The CCC awards Associate's degrees, while the three other systems award bachelor's degrees.

\*\* Totals include additional categories, i.e., other, alien, American Indian, and unknown responses, which are not specified here.

**4. Educational Background**

Of the 131 respondents who answered this question, 55 percent had less than a bachelor's degree and 45 percent held a bachelor's degree or higher. Forty percent of those students who did not have a bachelor's degree had only a high school degree, while 15 percent had a previous associate's degree or certificate (whether from a public or private institution). Among bachelor-degreed candidates, eight percent also held an associate's degree or certificate, while 11 percent also held an advanced degree. Specifically, 12 students had master's degrees, one student had an MBA, and one student had a Ph.D.

Among those survey respondents with an advanced degree, the vast majority majored in scientific fields, such as biology, chemistry, engineering, zoology, and botany. Liberal arts

degrees were in such diverse fields as anthropology, museum studies, communications, psychology, creative writing, French language and literature, and modern Russian literature.

A far higher percentage of respondents held a bachelor's degree (or higher) already (45 percent) compared to the CCC system as a whole, in which only eight percent held such a degree (see Table 6.11). This characteristic of biotech program respondents clearly suggests the strong motivation among such students to retrain in order to enter the biotechnology field.

**Table 6.10**  
**Biotechnology Students' Education Background**

<b>Level of Education</b>	<b>Number</b>	<b>Percentage</b>
<i>High school diploma/GED (highest level)</i>	53	40
<i>Associate's degree or certificate (highest level)</i>	19	15
<i>Bachelor's degree or above</i>	48	37
<i>Bachelor's degree or above and Associate's degree or certificate</i>	11	8
<i>Total</i>	131	100

Source: Author survey

**Table 6.11**  
**Educational Backgrounds by Student Level, CCC, 2008**

<b>Student Level</b>	<b>Number</b>	<b>Percentage</b>
Concurrent High School	64,915	4
Freshman	902,766	52
Sophomore	207,745	12
Unclassified Undergraduate	140,943	8
AA/AS Recipient Returning to College	72,004	4
BA/BS Recipient Returning to College	140,436	8
Unknown Student Level	198,990	12
Totals	1,727,799	100

Source: CPEC

## 5. Bachelor's Degree Holders' Reasons for Attending Community College Program

The top three reasons respondents gave for enrolling in the community college biotechnology program when they already held a bachelor's degree or above were:

- Improve skills and job opportunities (23 respondents)
- Career change or change in scientific field (20 respondents)
- Obtain hands-on laboratory experience and/or work experience via internship (9 respondents)

Other reasons that respondents gave included: to prepare for graduate school; because they could not find a job with their present degree; and to take advantage of the support system that the biotech program offered.

The following sample of responses captures many of respondents' key motivations for attending the biotechnology program:

### Career change:

- "Retraining for new career - had been a self-employed cabinetmaker, developed asthma, was interested in biotechnology and thought I could leverage my previous science education to get a job in biotechnology without having to move somewhere else. San Francisco has more job opportunities in biotechnology than most of the rest of the country, so biotechnology seemed like a good career choice. Also, I have always been a science geek and biotechnology is the new bleeding edge."
- "I am working in the Informatics side of a biotech/pharma company. I would like to be more involved in the biological research side as well. So it's kind of a career change."

### Find employment:

- "Because of being out of work for so long I learned my Bachelor's degree was not enough to find a job. I made a decision to go back to school because S.F. City College is affordable and convenient, I wanted to be active, and the Bridge to Biotech program could help me with basic concepts, my resume, possibly interviewing, and finding work."

### Obtain work experience:

- “I was not getting replies from biotech companies for which I was applying. Many companies preferred experienced candidates. The program will give me an internship that will give me the lab experience needed.”
- “Took a break to raise family. With limited experience enrolled to brush up on latest techniques and obtain a certificate.”

### Obtain laboratory experience:

- “I am a stage III malignant melanoma survivor who became interested in molecular genetics & immunology when researching clinical trials available for my form of cancer. I'm hoping to work in the area of cancer drug discovery & development and have neither the time nor funds to pursue a second undergraduate degree in molecular biology. The CA community colleges & UC Berkeley extension are providing me with a good basic science background & hands-on experience in appropriate laboratory techniques.”
- “1. To update skills (biotech cGMP, various lab techniques, strengthen knowledge of Biology and Chemistry). 2. Obtain Career Counseling Services (counseling, testing, transfer information to other CSU's and UC's and researching new career paths. 3. To challenge self in writing skills and simulated laboratory working environments. 4. To update resume, attend Biotech Career Fairs and network.”

## 6. Work experience – Previous Two Jobs

Of the 87 students who answered this question, six indicated that they did not have prior work experience. The vast majority (66 respondents or 76 percent) listed, as their previous two job positions, employment that did not appear to be related to the science or engineering fields, while 21 respondents (or 24 percent) listed employment that clearly was science- or engineering-related.

Science-related jobs included laboratory technician, manufacturing technician, veterinary technician, bioinformatics analyst, chemical laboratory assistant, and nuclear medicine technologist. The responses indicated that a number of students were also incumbent workers at area biotechnology companies. The wide array of non-scientific or non-technical jobs included:



security guard, retail sales associate, real estate lease analyst, telemarketer, administrative assistant, kitchen help, parking lot attendant, massage therapist, grocery store cashier, restaurant server/bartender, valet, accountant, kiosk sales associate, wireless messaging agent, and telephone sales representative.

#### 7. Intended Post-Program Trajectory

Of the 95 students who answered this question, 34 (or 35 percent) indicated that they wanted to enter the workforce exclusively; eight (8 percent) indicated that they wanted to pursue an Associate's degree exclusively; ten (11 percent) indicated that they wanted to pursue both an associate's degree and a bachelor's degree; and ten (11 percent) indicated that that they wanted to pursue a bachelor's degree (or higher) exclusively. Of those who wanted to enter the workforce exclusively, only eight did not have a prior Bachelor's degree.

### **6.2 Biotechnology Partnership Program Completion and Job Placement Data**

As described in Chapter 3, both the San Francisco Bay Area and San Diego area are home to a number of highly-regarded and nationally-recognized biotech training partnership efforts, approximately half of which have been funded primarily through state and federal grants. This section presents relevant performance outcomes for six of these programs. Specifically, it provides data compiled by three programs in the Bay Area: the Biotech Workforce Network, in its three incarnations (the Skyline Bio-Manufacturing Certificate program, the Bay Area Biotechnology Career Pathways Project, and Life Sci X); Biotech Partners; and City College of San Francisco's Bridge to Biotech program. It likewise presents outcomes data for three

programs in the San Diego area: the Life Sciences Pilot Project, the Life Sciences Summer Institute, and the Biotechnology Education and Training Sequence Investment (BETSI) project.<sup>98</sup>

As the available performance data shows, these partnerships appear to have succeeded in developing employer-responsive and results-oriented programs.

### **6.2.1 San Francisco Bay Area: Biotech Workforce Network**

Funded primarily through a state grant, the San Mateo County WIB, Skyline College, Genentech, and several community partners launched the Bio-Manufacturing Certificate Program at Skyline College, an intensive 12-week intensive, cohort-based training program to assist workers displaced from the airline and travel industries after 9-11. As detailed in Table 6.12, through December 2008, the program trained 206 students and placed 83 percent of these graduates in full-time employment, primarily in the biotechnology industry:

With additional funding through the President's High Growth Job Training Initiative, the original Skyline-Genentech-San Mateo WIB partnership subsequently expanded to include the Alameda County WIB, Ohlone College, and additional biotech employers; the partnership has since become known as the Biotech Workforce Network (BWN). Tables 6.12 and 6.13 compile student and employer outcomes for the Bio-Manufacturing Certificate programs at both Skyline College and Ohlone College.<sup>99</sup> Table 6.13 also presents student outcomes for the California Gateway Program at Skyline College (now the East Bay Career Advancement Academy), a pilot "bridge" program linking WIBs, community colleges, community organizations, and employers

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<sup>98</sup> Due to the reporting requirements that WIA imposes on the projects that its funds, the WIB-funded partnership programs have compiled the most detailed and complete outcomes data.

<sup>99</sup> As such, there is some overlap with the outcomes data for the Skyline College Bio-Manufacturing Certificate program, which is presented in the previous table. I am awaiting separate data for the Ohlone College Bio-Manufacturing Certificate program from the Alameda County WIB.

**Table 6.12**  
**Bio-Manufacturing Certificate Program, Student Placement, 2003-2008**

<b>Skyline College Cohorts</b>	<b>Enrolled in Program</b>	<b>Completed Program</b>	<b>Placed Outside of Biotech Industry</b>	<b>Placed in Biotech Industry</b>	<b>Total Placements</b>	<b>% Students Completing Program Who are Placed in Field</b>
Cohort 1 (2003)	18	17	0	17	17	100%
Cohort 2 (2003)	20	18	1	17	18	100%
Cohort 3 (2004)	20	19	1	14	15	79%
Cohort 4 (2004)	20	19	0	15	15	79%
Cohort 5 (2005)	22	21	6	14	20	95%
Cohort 6 (2005)	30	29	3	18	21	72%
Cohort 7 (2006)	30	27	2	24	26	96%
Cohort 8 (2006)	21	19	*	*	14	74%
Cohort 9 (2007)	20	17	*	*	13	76%
Cohort 10 (2008)	21	19	*	*	11 <sup>100</sup>	58%
<b>Total 1 - 7</b>	<b>206</b>	<b>181</b>	<b>13</b>	<b>119</b>	<b>171</b>	<b>83%</b>

Source: "Bio-Manufacturing-Workforce Partnerships: Recruitment, Program Completion, and Placement: A Presentation for the Genentech Oregon Workforce Partnership" (2006).

\* The summary of placement outcomes for Cohorts 8 through 10 does not break down the data by type of industry employment. I have requested such information and am awaiting a response by the appropriate WIB staff.

<sup>100</sup> At the time this summary of placement outcomes was compiled, Cohort 10 was interviewing, and thus the placement rate was expected to increase.

**Table 6.13**  
**Biotech Workforce Network Outcomes, 2004-2007<sup>101</sup>**

<b>Demand</b>	<b>Target</b>	<b>Actual</b>	<b>Percent of Target</b>
New Employee Hires	154	187	121%
New Biotech Partners	4-6	25	625%
Repeat Business Customers	50%	44%	88%
Regional Partners	10	11	110%
Create Quality Control Training <sup>102</sup>	1	1	100%
<b>Supply</b>			
Enrollments in training (Customers Served)	230	242	105%
Training Completions (Graduates)	230	208	90%
Entered Employment Rate (Placement Rate)	95%	90%	94%
Average Wage at Placement	\$16.83	\$19.54	116%
Quality Control Training Graduates	40	78	195%
<b>Gateway Training</b>			
Enrollments		112	
Graduation Rate		90%	
Entered Employment Rate		79%	
Average Wage at Placement		\$16.89	

Source: “Ahead of the Curve: Responding to the Dynamic Biotech Sector” (2007).

to connect disadvantaged youth and adults to post-secondary education and career pathways in high-demand fields such as biotechnology.

As the data show, the BWN partnership trained 208 individuals and placed 187 of them in jobs paying an average wage of almost \$20 per hour. The partnership also succeeded in building a large base of employer partners—25 in total—an accomplishment that far surpassed its initial aim to target positions at only four to six biotechnology and medical manufacturers throughout the Bay Area.<sup>103</sup>

<sup>101</sup> I note that the information compiled in Table 6.13 is incomplete: It includes the job placement rate, but not the number of job placements; and it does not specify the number of job placements in the industry and outside of the industry. I have contacted the agency that compiled this data about this issue and am awaiting a response.

<sup>102</sup> The partnership developed this training program to retrain dislocated engineers from the airline, aerospace, and information technology sectors for high-level manufacturing and engineering positions.

<sup>103</sup> This group of 25 employers formed my initial list of prospective companies—for both my treatment and comparison groups—that I contacted for my research sample.

A San Mateo WIB program document lists the companies that hired 158 of the Biotech Workforce Network graduates as interns and/or full-time hires between September 2003 and June 2006. According to the document, the BWN's lead company partner hired half of the graduates (76) in a wide array of entry-level positions.<sup>104</sup> All of these graduates had been employed as interns at the company prior to the positions' conversion to full-time employment.

The following table lists those companies under study here that hired program graduates over this time period, indicating whether the graduates filled internship positions before being hired full time; the internship positions (if any); the number of full-time hires; and the positions in which the companies hired the program graduates. To protect confidentiality, I disguise the names of those companies that are in my research sample by using the pseudonyms that I devised for those particular companies (see Chapter Five). For companies not in my sample, I use a generic company name (e.g., Company A).

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<sup>104</sup> These positions include: Pharmaceutical Materials Specialist, Media Prep Technician, Labware Technician, Manufacturing Technician – Pharmaceuticals, Pilot Plan Technician, Pharmaceutical Filling, Biochemistry Operations, Lab Services Technician, Assistant Inspector/Packaging, Manufacturing/Data Entry, Senior Facilities Coordinator, Instrumentation Technician, and Bioprocess Technician

**Table 6.14**  
**Selected Biotech Workforce Network Graduate Hires, 2003-2006**

Company	Internship	Hires	Position
T1-BA	All positions had corresponding internships	76	See footnote 105 for a list of positions.
Company A (now part of C2-BA)	Finishing Inspector (only)	3	Finishing Inspector, Manufacturing Associate, Engineering Technician
T2-BA	Pharmaceutical Filling and Facilities Maintenance (only)	9	Purification Technician, Product Technician, Biological Analyst, Pharmaceutical Filling, Product Specialist, Manufacturing Technician, Aseptic Process Technician, Data Collection Specialist , Facilities Maintenance
Company B	No	4	Manufacturing Associate, QC Specialist II, Facilities Maintenance,
T8-BA	Packaging Technician only	3	Bioprocess Technician, Packaging Technician
C11-BA	Lab Technician	3	Lab Technician
Company C	No	1	Lab Technician

Source: San Mateo WIB spreadsheet, on file with author

Leveraging the success of this partnership effort, the Biotech Workforce Network subsequently obtained additional WIA (Governor’s 25 Percent Discretionary) funds to expand the program to train additional dislocated workers within Alameda County and to extend it to neighboring Contra Costa County. Over the period January 1, 2007 to March 31, 2009, the program trained an additional 72 such workers and placed 93 percent of them in employment, as the following table shows.<sup>105</sup>

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<sup>105</sup> I am awaiting the final results of the Life Sci X program, which ended in June 2009, from the Alameda County Workforce Investment Board.

**Table 6.15****Life Sci X Performance Indicators Report, January 1, 2007 – March 31, 2009**

<b>Biotech Workforce Network</b>	<b>Enrollments</b>	<b>Training Completions</b>	<b>Graduation Rate</b>	<b>Job Placement</b>	<b>Average Wage</b>
Life Sci X – Alameda County	73	61	84%	92%	\$19.46
Life Sci X – Contra Costa Cty	37	11	30%	100%	\$19.63
<b>Totals</b>	<b>110</b>	<b>72</b>	<b>65%</b>	<b>93%</b>	

Source: Life Sci X Performance Indicators Report (April 30, 2009), Alameda County WIB

### 6.2.2 San Francisco Bay Area: Biotech Partners

Biotech Partners is a nonprofit organization connecting youth who are under-represented in the sciences to the biotechnology industry. Founded in 1993 as part of a 30-year Development Agreement between the City of Berkeley, CA and Bayer Healthcare, the school-to-career partnership has grown to include three local unified school districts and over forty biotechnology, health care and science-based partners. The organization asserts that it has achieved a 98 percent high school graduation rate (100 percent in 2005-2007); a 97 percent rate of enrollment in post-secondary education; and a 60 percent graduation rate from Laney College's certificate program.<sup>106</sup> It also claims to have placed students in 900 internships and co-op jobs and to have achieved a 100 percent job placement rate for those seeking employment after obtaining the biotech certificate. See <http://www.biotechpartners.org>.

Specifically, with respect to hires, a document filed as part of the Development Agreement between Bayer and the City of Berkeley shows that, between 1995 and 2007, Bayer hired 48 Biotech Partners graduates in full-time positions, while other biotechnology companies hired an additional 87, for a total of 135 graduates placed in biotechnology-related jobs.

<sup>106</sup> This final figure compares to a 25 percent graduation rate for the community college system as a whole.

### **6.2.3 San Francisco Bay Area: City College of San Francisco's Bridge to Biotech program**

The Bridge to Biotech program at City College of San Francisco (CCSF) prepares low-income, underrepresented adults with no prior math and science background to enter the college's biotechnology (certificate and/or AS degree) program and eventually to enter biotech employment. Results show that the bridge program has improved recruitment and retention for the biotechnology program (90 percent), as well as increased enrollment in the program from 50 in 2001 to a current enrollment of over 600 students per semester (Institute for a Competitive Workforce 2009). Further, over 90 percent of program graduates find employment in bioscience and/or enroll in further bioscience education (Klein-Collins 2006).

### **6.2.4 San Diego Area: Life Sciences Pilot Project**

This state-funded pilot program, operated through the San Diego Workforce Partnership, brought together MiraCosta College; BIOCUM, the regional industry association; and local industry employers like Biogen-IDEC and Beckman Coulter, to develop a bioscience training program for dislocated workers seeking entry-level production technician positions. To meet the immediate needs of employers, the program combined classroom training and on-the-job experience training experience to train two cohorts of 22 participants each over a two-year period.

In addition to supporting the creation of a new biosciences training design and curriculum at MiraCosta College,<sup>107</sup> which since has been named a Bioprocessing Center of Expertise by the USDOL, the Life Sciences Pilot Project achieved an overall job placement rate of 91 percent (38 enrolled participants obtained unsubsidized employment), and an employment rate in the

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<sup>107</sup> The curriculum prepares students for careers in research, development, quality control/assurance, manufacturing, and analytical testing, as well as for work as a laboratory technician.



biosciences industry of 63 percent. The retention rate of 91.7 percent and earnings replacement rate of 115.8 percent both exceeded the planned targets, as the following table shows:

**Table 6.16**  
**Performance Summary, Life Sciences Project, 2004 to 2006**

<b>Performance Measure</b>	<b>Planned Performance Targets</b>	<b>Actual Performance</b>
Enrollment in Entry-Level Training	44	44
Completion of Initial Entry-Level Training	40	41
Enrollment in On-the-Job Training	40	35
Completion of On-the-Job Training	36	29
Employment as Production Technicians	36	26
Employment Retention Rate	81%	91.7%
Earning Retention Rate	85%	115.8%
Employment and Credential Rate at Exit	82%	88.1%

Source: WIA Closeout, Life Sciences Pilot Project, End of Project Report, San Diego Workforce Partnership, September 2006.

### **6.2.5 San Diego Area: Life Sciences Summer Institute**

Launched in 2005 through a President’s High Growth Job Training Initiative grant, the Life Sciences Summer Institute (“LSSI”) seeks to build a pipeline of qualified workers interested in biotech employment, while improving teachers’ understanding of industry workforce needs. The LSSI is a partnership between the San Diego Workforce Partnership; BIOCUM, the regional industry association; the Southern California Biotechnology Center (SCBC) at Miramar College; and two major industry partners, Invitrogen (now Life Technologies) and Biogen Idec.

Through 2008, the program targeted upper-level high school students, community college and university students, as well as high school and community college teachers, for student internships and teacher externships in local life sciences companies, in order to raise awareness about the occupational skills needs of the life sciences industry.<sup>108</sup> Since the program’s

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<sup>108</sup> Beginning in the summer of 2009, the program targeted only high school students for the internships, but continued to obtain externships for community college and high school faculty.

founding, between 22 and 30 local biotechnology companies have hosted interns and externs each summer.

The program estimates that, by the summer of 2007, it had placed 118 students in internships and 51 teachers in externships; eight schools had implemented the curriculum learned during the program, reaching 1,228 students; and approximately 6,804 students had benefited from the program. Further, the program estimated that 20 percent of the interns placed in internships continued to work either part-time or full-time for the companies in which they interned.

#### **6.2.6 San Diego Area: Biotechnology Education and Training Sequence Investment (BETSI) at Southwestern College**

Founded in 2004 and funded by the National Science Foundation as an Advanced Technological Education (ATE) program, the BETSI Project is designed to educate students in biotechnology from three local high schools, recruit them into Southwestern College's biotech program, and help them advance into college or a career in biotechnology. Industry internships for Southwestern College students constitute the heart of the program, and through spring 2007, every BETSI intern had obtained industry employment.

### **6.3 Biotech Company Outcomes**

The following section presents the main hiring data that I gathered from Human Resources staff (as Chapter Five's methodology section outlines). Although HR was the main repository of this information, I also conducted multiple discussions with other company personnel—in particular, production or hiring managers—in order to ensure that the entry-level technician positions at issue were comparable across firms. Such conversations were critical, moreover, to an

understanding of the ways in which the hiring data arguably reflects (or does not reflect) changes in company recruitment and hiring practices.<sup>109</sup>

Before presenting the study's primary quantitative data, namely, the proportion of the sample company's entry-level workforce that holds a community college A.S. degree or certificate, it is necessary to indicate the criteria by which I placed companies in the treatment and comparison groups. As previously noted, treatment group companies are those that are currently involved with biotechnology training partnerships involving community colleges and/or workforce and community organizations, while comparison group firms are those that have had no or minimal involvement in such partnerships. I assess the level of employer involvement based on four primary measures that are set forth in the literature (see e.g., Pindus et. al 2004; Aspen Institute 2004):

1. The content and type (monetary, in-kind, or advisory) of employer involvement, specifically:

- Assisting in curriculum development and review
- Offering internships
- Serving on advisory committees/boards
- Providing direct money and support for grants
- Sponsoring adjunct faculty (industry instructors) and/or guest lecturers in biotech classes
- Donating equipment
- Providing job shadowing and company tours
- Participating in community college-sponsored conferences

2. The duration and frequency of involvement (ad hoc, periodic, or continuous and ongoing)

3. The positions of personnel involved (executive-level staff, including HR and chief scientific officers, or department managers, line supervisors, and training instructors); and

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<sup>109</sup> The next chapter analyzes the mechanisms by which partnership programs influence hiring decisions.

4. The formalization of the collaboration (if any), such as partnering agreements and advisory board membership.

In this study, I define employer involvement in a partnership as constituting three or more partnership activities undertaken by the company. This definition of partnership involvement seeks to ensure a relatively high level of employer commitment in order to increase the likelihood that the activities undertaken by the company will have an influence on its recruitment and hiring practices and policies. Hence, I include more than one activity (or two) in the definition because some activities require a greater depth of commitment than others, in terms of time, resources, or the level of personnel involved. However, depending on the circumstances, those activities in isolation may fail to register a deep commitment on the company's part. For instance, advisory board membership is an important commitment that often involves personnel at the higher levels of a company, yet the program's advisory board may fail to meet regularly (some meet only once a year). Sponsoring co-instructors involves a serious time commitment on the adjunct faculty's part, but that instructor may not have much influence with HR regarding recruitment and hiring decisions. Offering company tours may involve far less time on the company's part, yet because HR or hiring managers typically attend, the impact on company policy may be greater. Hence, by including at least three activities, the chances are greater that the company involvement reflects a serious commitment by the company.

As the criteria suggest, companies' involvement can vary in intensity. At one end of the spectrum, a company may invest many thousands of dollars and countless hours in support of a program. For instance, in the Biogen Idec partnership with MiraCosta College, the company designed a state-of-the-art teaching facility for the college at a cost of \$200,000 (see discussion in Chapter Three). Faculty and company staff met weekly during the design/construction

process, and also as part of the development of the curriculum for the new bio-processing program at the college. This level of financial and time commitment required corporate buy-in, and hence participation in the partnership at all levels of the company, as well as formal contracts between the parties.

At the more modest end of the partnership spectrum, a company may allow a production manager to teach a course in a college program; offer company tours to program students, upon program request; and send HR, production, or research staff to speak at community college conferences or attend community college job fairs. In between these extremes, a company may send one or more staff to sit on a program's advisory committee; participate regularly in an equipment/surplus donation program; and offer regular company tours and job shadowing opportunities to program participants.

By contrast, comparison companies have no formal ties with a community college program or partnership, or else may participate in one or two partnership activities solely on an ad hoc basis. For instance, HR staff may attend an industry association meeting co-sponsored by a partnership program or a college-sponsored job fair. Company scientists and community college biotech faculty may belong to the same professional association (e.g., the International Society of Pharmaceutical Engineers), and they may socialize regularly in a professional or social capacity. Such informal ties and/or ad hoc attendance at partnership events thereby ensure that one or more company staff, potentially at higher levels of the corporate hierarchy, is aware of the existence of community college biotech the programs and may even be convinced of the programs' merits. While such personal relationships can be very important to fostering awareness and/or positive perceptions of the programs—indeed, I argue that these relationships

are central to program effectiveness—such interactions do not rise to the level of partnership status due to their tentative and noncommittal nature.

Tables 6.9 and 6.10, below, present my findings regarding the types and levels of employer involvement among partner companies in the San Francisco Bay and San Diego areas. The next chapter will elaborate these findings. *Note: To ensure company confidentiality, I replace the names of treatment and comparison group companies with pseudonyms, as explained in the previous chapter on research design.*

Regarding the fourth measure of employer involvement—the formalization of collaboration—I note that only two companies have entered into partnering agreements: Genentech and Bayer (see Chapter 3 for a discussion of such agreements). A number of companies have formalized their commitment to the partnerships by sending one or more members to sit on advisory boards, however, as indicated in both tables.

Finally, tables 6.11 through 6.14 present this study’s hiring outcomes data regarding the educational backgrounds of the entry-level technician workforce in the treatment and comparison group companies. The tables list the names of the entry-level technician positions at issue within each sample company.

**Table 6.17**

**Type and Level of Partnership Involvement in Biotechnology Programs among Treatment Group Companies, San Francisco Bay Area**

<b>Company</b>	<b>Curriculum Review</b>	<b>Internships</b>	<b>Advisory Board</b>	<b>Equipment Donation</b>	<b>Grants</b>	<b>Job Shadowing, Company Tours</b>	<b>Adjunct Faculty</b>	<b>Conference/CC Class Presentations</b>	<b>Positions of staff involved</b>
T1-BA	Ongoing	Yes	Ongoing	Ongoing	Ad hoc	Ongoing	Ongoing	Ongoing	All levels
T2-BA	Ongoing	Yes	Ongoing	Ongoing	Ad hoc	Ongoing	Ongoing	Ongoing	All levels
T3-BA	Ongoing	Yes	Ongoing	Ongoing	Ad hoc	Ongoing	Ongoing	Ongoing	All levels
T4-BA		Yes		Ongoing		Ad hoc		Ad hoc	HR
T5-BA	Ongoing			Ongoing			Ongoing	Ongoing	Prod. Mgr.
T6-BA						Ad hoc	Periodic	Ad hoc	Prod. Mgr.
T7-BA		Yes	Ongoing			Ongoing		Ongoing	HR/Prod.
T8-BA		Yes	Ongoing				Periodic	Ad hoc	Instructor, HR
T9-BA						Ad hoc	Ad hoc	Ad hoc	Manager
T10-BA	Ad hoc		Ongoing			Ongoing			Executive
T11-BA	Ad hoc					Ongoing		Ad hoc	HR
T12-BA		Yes	Ongoing			Ad hoc		Ad hoc	HR
T13-BA			Ongoing			Ad hoc		Ad hoc	CEO, all levels
T14-BA		Yes				Ad hoc		Ad hoc	CEO
T15-BA	Ad hoc	Yes					Ad hoc	Ad hoc	CEO
T16-BA	Ad hoc					Ad hoc		Ad hoc	CEO

**Table 6.18**

**Type and Level of Partnership Involvement in Biotechnology Programs among Treatment Group Companies, Greater San Diego Area**

<b>Company</b>	<b>Curriculum Review</b>	<b>Internships</b>	<b>Advisory Board</b>	<b>Equipment Donation</b>	<b>Grants</b>	<b>Job Shadowing, Company Tours</b>	<b>Adjunct Faculty</b>	<b>Conference/ CC Class Presentations</b>	<b>Positions of staff involved</b>
T1-SDA	Ongoing	Yes	Ongoing	Ongoing	Ad hoc	Ongoing	Ongoing	Ongoing	All levels
T2-SDA	At program founding		At program founding			At program founding	Periodic	At program founding	All Levels
T3-SDA	Ongoing	Yes	Ongoing	Ad hoc	Ad hoc	Ongoing	Ongoing	Ad hoc	All levels
T4-SDA	At program founding					Ad hoc		Ad hoc	HR
T5-SDA	Ad hoc			Ongoing		Ad hoc		Ad hoc	CEO



**Table 6.19**  
**Entry-level Technician Positions and Percentages of Entry-Level Technicians with a Community College Degree or Certificate in Large and/or BioManufacturing Companies, San Francisco Bay Area**

Treatment Group			Comparison Group		
Company	Entry-Level Technician Positions	% Entry-level Technician Workforce w/ CC degree	Company	Entry-Level Technician Positions	% Entry-Level Technician Workforce w/ CC degree
T1-BA (Vacaville site)	Manufacturing Bioprocess Technician; QC Analyst	20%	C1-BA	Production Technician	<5%
T2-BA	Product Technician; Media Prep Operator	>15% <sup>110</sup>	C2-BA (Vacaville site)	Associate Manufacturing Operator	18%
T3-BA	Manufacturing Technician	25%	C3-BA	Manufacturing Technician	<5%
T4-BA	Process Technician, Quality Analyst	>15%	C4-BA	Manufacturing Technician	<5%
T5-BA	Technical Applications	>15%	C5-BA	BioProcess Assistant	<5%
T6-BA	Manufacturing Technician	16%	C6-BA	Lab Assistant (Media Prep)	0
T7-BA	Process Technician	4%	C8-BA	Process Technician	<5%
T12-BA	Manufacturing Technician	16%	C12-BA	Laboratory Technician	0

<sup>110</sup>I indicate a range, rather than a specific percentage, when the HR staffer would or could not provide me with the information necessary to calculate a specific percentage, i.e., the number of employees in the entry-level technician workforce and the number of such employees with a community college degree or certificate.

**Table 6.20****Entry-level Technician Positions and Percentages of Entry-Level Technicians with a Community College Degree or Certificate in Medium- or Small-Sized, Clinical Trials and/or R&D Companies, San Francisco Bay Area**

<b>Treatment Group</b>			<b>Comparison Group</b>		
<b>Company</b>	<b>Entry-Level Technician Positions</b>	<b>% Entry-Level Technician Workforce w/ CC degree</b>	<b>Company</b>	<b>Entry-Level Technician Positions</b>	<b>% Entry-Level Technician Workforce w/ CC degree</b>
T8-BA	Laboratory Technician	10%	C9-BA	Research Associate	0
T9-BA	Laboratory Technician	0	C10-BA	Laboratory Assistant	0
T10-BA	Laboratory Associate	0	C7-BA	Clinical Development Assistant	0
T11-BA	Manufacturing Technician	0	C11-BA	Research Associate	0
T13-BA	Laboratory Assistant	10%	C14-BA	Laboratory Assistant	0
T14-BA	Glass washer, Lab Assistant	20%			
T15-BA	Laboratory Assistant	30%			
T16-BA	Laboratory Assistant	25%	C13-BA	Research Associate	0

**Table 6.21**

**Entry-level Technician Positions and Percentages of Entry-Level Technicians with a Community College Degree or Certificate in Large and/or BioManufacturing Companies, Greater San Diego Area**

Treatment Group			Comparison Group		
Company	Entry-Level Technician Positions	% EL Technician workforce w/ CC degree	Company	Entry-Level Technician Positions	% EL Technician workforce w/ CC degree
T1-SDA	Manufacturing Bioprocess Technician	30%	C6-SDA	Manufacturing Technician	<10%
T2-SDA	Advanced Production Technicians	50%	C1-SDA	Manufacturing Technician	< 5%
T3-SDA	Technical Applications	> 15%	C2-SDA	Laboratory Technician	< 5%

**Table 6.22**

**Entry-level Technician Positions and Percentages of Entry-Level Technicians with a Community College Degree or Certificate in Medium- or Small-Sized, Clinical Trials and/or R&D Companies, Greater San Diego Area**

Treatment Group			Comparison Group		
Company	Entry-Level Technician Positions	% EL Technician workforce w/ CC degree	Company	Entry-Level Technician Positions	% EL Technician workforce w/ CC degree
T4-SDA	Assistant Scientist <sup>111</sup>	0%	C3-SDA	Laboratory Assistant	0%
T5-SDA	Services Lab Technician	15%	C4-SDA	Scientist <sup>112</sup>	0%
			C5-SDA	Laboratory Assistant	0%

<sup>111</sup> Although labeled as “scientist,” this entry-level research position does not require a Ph.D., or even a Master’s degree, contrary to the common understanding of this title.

<sup>112</sup> See note 22, above.

Before discussing these results, it is necessary to raise a few caveats regarding the outcomes data. First, the hiring figures were based on the HR staff person's determination of what constituted an entry-level position, for which a community college associate's degree or certificate either was required or deemed to be adequate. Although I asked for job descriptions from each company, the staff person may have excluded relevant positions. Moreover, while I periodically checked the company's website and other online jobs databases for open positions at each company in my sample, internet research does not always pull up descriptions of positions that have closed. To provide a check on the accuracy of the HR staffer's determination of the relevant job positions, I interviewed production or hiring managers in each company to determine the positions which, in their view, were considered suitable for a community college graduate.

Second, some companies' database management systems track educational level by highest degree obtained, i.e., if a new hire had a previous bachelor's degree yet came to the company directly from a community college program, the tracking tool would pull up only the bachelor's degree. While smaller companies could use alternative means to determine the exact number of technicians with a community college background, e.g., reviewing resumes or using first-hand knowledge when the workforce was very small, larger companies would often have to rely on ranges or estimates of the number of such technicians. Again, my discussions with other company personnel, particularly production or hiring managers, served to provide additional information that might confirm and/or refine the numbers provided by HR staff.

## 6.4 Findings

The outcomes data presented above support two major findings:

1. Bio-manufacturing companies that partner with the programs have a higher percentage of community college-trained technicians in their entry-level technician workforces than companies that do not so partner.
2. Regardless of their partnership status, only a few small to medium-sized firms that engage primarily in research and development or that have not yet reached the manufacturing/commercialization stage hire significant percentages of community college trained technicians.

Based on the interview and other data described in the next chapter, these findings in turn support a third finding:

3. Even if partnership programs do succeed in changing the hiring practices of smaller, research-oriented companies in favor of community college graduates, this development arguably would not be as responsive to industry needs as efforts to develop other kinds of biotechnology training programs, such as training for clinical laboratory technicians.

Each of these findings is discussed in turn.

1. Among companies employing a bio-manufacturing workforce, treatment-group companies have a higher percentage of community college-trained technicians in their entry-level technician workforces than comparison-group companies<sup>113</sup>

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<sup>113</sup> This category includes large firms that manufacture many or all of their products and/or other companies' products (e.g., through partnering arrangements). However, because the company division in the region under study may not employ a large technician workforce, the size of its entry-level technician workforce may be relatively small, and in fact, may be comparable in size to that of a much smaller firm. Conversely, several types of small- to medium-sized firms may undertake manufacturing, including companies that choose to manufacture, in-house, the products needed for their clinical trials (rather than outsourcing such work), even though they may not have reached the commercialization stage, i.e., are still at the clinical or pilot manufacturing stage. Companies that produce certain types of products, such as antibodies, also engage in manufacturing, albeit on a much smaller scale.

Both the program job placement data and the company hiring data presented in previous sections suggest that the training partnerships under study in both Northern and Southern California have been successful in creating job opportunities for program graduates at large, bio-manufacturing companies that partner with the programs. Compared to the companies that the partnerships did not actively work with, the partner firms employ a technician-level workforce with a higher proportion (15 percent or above) of entry-level technicians who have a community college degree or certificate.

My interviews with HR staff and production managers at treatment group firms likewise support the finding that biotech partnership programs meet employers' workforce needs by producing a pool of well-trained technicians whom employers recruit and hire. The qualitative evidence indicates that such programs have found a niche in training students and job seekers for manufacturing/production technician jobs, on account of two main factors: 1) There is a close fit between the level and type of training that the colleges provide and the type of work that is available in manufacturing companies at the technician level; and 2) The partnerships have developed and honed key design elements that ensure industry-responsive programs and help students become successful job candidates, particularly with regard to manufacturing employment. In the next chapter I discuss the design elements responsible for program effectiveness, including widespread use of adjunct faculty that promotes industry-relevant offerings and curricula, and rigorous candidate screening and recruitment. Here, I elaborate the finding that community college biotech training aligns well with the needs of bio-manufacturing employers.

Quoted on an Ohlone College biotechnology brochure, a Genentech production manager asserts that community college graduates "are as fully prepared to work at entry-level positions

in the biotechnology industry as students with a bachelor's degree." As a result, this manager notes, Genentech "now hires one-third of its workforce from community college programs...."<sup>114</sup>

While no other company appears to match Genentech in its rate of hires from the community college labor pool, numerous hiring managers and production supervisors have affirmed that: 1) the community college biotech programs adequately prepare students for entry-level production work; and 2) the community college graduates tend to be a good fit for the manufacturing environment, possessing more realistic expectations of and a greater commitment to the work than typical bachelor-degree graduates.

Most of my interviewees affirmed the prevailing view that the last decade or so has witnessed a shift in industry perception regarding the educational requirements for technician-level jobs. Ten to fifteen years ago, they noted, biotech companies routinely required a bachelor's degree for technician-level positions. Having only recently entered the manufacturing stage, with its demand for a dedicated, technician-level workforce, these companies were just beginning to determine their education and training needs with respect to this workforce. Although commercialized production's more stable biological process allowed manufacturing jobs to become more routine, and thus to be organized in such a way that the technicians did not need as deep an understanding of science as R&D staff, companies still looked to the four-year colleges to fill entry-level technician positions. In part, this was because the companies, rooted in academia and Ph.D.-driven, retained a bias for advanced degrees, while in part it was simply "because they could" fill these desirable, often cutting-edge jobs with highly-credentialed candidates.

Meanwhile, community college biotech programs were just beginning to develop a pool of alternative job candidates. While several community colleges began offering biotechnology

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<sup>114</sup> See Ohlone College biotechnology program brochure: [www.ohlone.edu](http://www.ohlone.edu).

classes as early as 1990-1991 (e.g., MiraCosta College in Oceanside and CCSF in San Francisco), the first bio-manufacturing program did not emerge until 1996 (at Solano Community College), the same year that the statewide community college biotech initiative was founded.

Some interviewees claim that the recruitment and hiring environment for entry-level technicians has not changed in a profound way. For instance, a clinical trials scientist at Exelixis argued:

The mentality, the perception of people in the industry regarding education hasn't changed much over time. If there are two unknowns, the trump card is the BA, because there's two extra years of education. And the UC candidate will beat out the Cal State candidate. There haven't been enough 2-year degree people hired to start changing perceptions, to prove it's OK to hire them, that they're technically sound. Also, biotech is so new, so the knee jerk reaction [in favor of BA and against AS graduates] is strong.

Indeed, as the hiring data show, commercialized companies today continue to recruit and hire most heavily from four-year schools for manufacturing positions. However, most of my interviewees argue that these jobs no longer typically *require* a bachelor's degree. As a Bayer production manager claimed: "If it's a [FDA] licensed process, it has fixed procedures, and for 90 percent of those jobs, community college folks are OK." A former director of BayBio, the Bay Area's industry association, remarked that companies risk generating "quality inflation" when they recruit the candidates they want—i.e., a bachelor degree candidate with extensive experience—rather than those they need: well-trained, GMP-certified community college graduates. He observed: "There is such a thing as over qualification in manufacturing, and BS+ is an over qualification."

Instead, bio-manufacturing jobs require a showing of specialized skills, particularly hands-on laboratory skills. As a production supervisor at Solstice Neurosciences stated: "The applicant does not have to have a B.A. to do the work, she needs skills: how to operate a



machine, add some pharmaceutical ingredients. Quality labs—it’s like CSI!” He further noted: “Operation of fermentation, sterilization of equipment, operation of processing equipment—these are the critical tasks in the job. Also, automatic equipment (PLC) is the backbone now. Having experience with these tasks really stands out in a candidate.” Moreover, as a production manager at Vaxgen explained, hands-on experience is “critical, a tremendous benefit, since workers must operate the equipment under pressure, and there are always safety risks. When I started out as a technician, I was apprehensive for months that the equipment would explode.”

My interviewees were unanimous in declaring that the community college programs with which they are familiar emphasize the appropriate hands-on and practical skills, as well as regulatory issues, in contrast to the four-year college programs that they have encountered.<sup>115</sup> For instance, a Bayer production manager noted that, while the four-year degree graduates he supervised were well versed in the science behind the techniques, they had never pipetted,<sup>116</sup> which necessitated costly on-the-job training in basic laboratory tasks. A Genitope production manager similarly noted that, to his surprise, the University of California graduates he supervised did not know how to make buffers.<sup>117</sup> By contrast, community college graduates are trained in these and other fundamental techniques, including those that the Solstice Neuroscience manager mentioned, above. Importantly, these techniques tend to be up-to-date and relevant, as does the lab equipment on which the students train. As the next chapter will detail, industry input in curriculum design, as well as receipt of donated lab equipment, account in large measure for the programs’ ability to deliver relevant course offerings.

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<sup>115</sup> In fact, several interviewees stated that, because entry-level manufacturing work “is not rocket science,” it was possible to train high school students to do much of this work, although companies usually prefer community college graduates on account of their specialized training and greater level of maturity and work experience.

<sup>116</sup> A pipette is a laboratory instrument used to measure and transport a fixed volume of liquid.

<sup>117</sup> A buffer is a solution that can resist changes in pH when small quantities of acid or base are added to it.

In addition to their often superior hands-on, laboratory skills, many community college graduates also possess key traits necessary for successful performance in the heavily regulated manufacturing environment: specifically, maturity and conscientiousness. Employees must comply with a host of cGMP (Current Good Manufacturing Practices)<sup>118</sup> regulations to ensure the quality and purity of the product and the repeatability of the production process. As a production manager at Nektar explained, companies “need the highest degree of conscientiousness in the candidate because they may have to scrap a whole batch of product if skin or even an eyelash gets in the batch.” In addition, the Solstice Neurosciences manager noted: “The technician has to document well, so handwriting skills are important. There’s even a CFR [Code of Federal Regulations] around that! The technician also must enter data to an excel spreadsheet. It doesn’t require lots of calculations, but it does require attention to detail.”

A former industry executive who now serves as an administrator in the California Community College biotechnology initiative noted that, not only are community college biotech students trained in regulatory procedures, they also tend to be older and more experienced than the typical bachelor degree candidate—an observation that my student survey findings confirm—and thus more likely to thrive in a regulatory environment.<sup>119</sup> He remarked:

Do B.A.s [bachelor degree students] do well under SOPs? If you violate a single SOP the FDA sends a warning and the site need to be re-inspected. So, this doesn’t happen! If it does, people lose their jobs. What kind of student fits into that?

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<sup>118</sup> These regulations, enforced by the FDA, require that manufacturers and packagers of drugs, medical devices, food and blood ensure that their products are safe and effective. The regulations cover such issues as recordkeeping, personnel qualifications, sanitation, cleanliness, equipment verification, process validation, and complaint handling. See: <http://www.gmp1st.com/gmp.htm>.

<sup>119</sup> A community college administrator and former biotech employer has observed, however, that the students’ grounding in practical issues can be limiting. As he noted: “They [community college students] can be surprisingly unaware of what’s going on in the industry. Some don’t stretch their horizons too much. They haven’t had enough time and experience. And they have a different level of interest [from the four-year college student]: they want to get a job. They don’t immerse themselves in, for instance, *Nature*, biology magazine.”

A Genitope production manager provided one answer, pointing to his experience supervising graduates of Skyline and Ohlone Colleges' short-term bio-manufacturing certificate programs, which recruited dislocated workers: "A person who has worked around pipes, such as in a refinery, will be conscientious because they don't want to blow the place up. Also, the airline industry is highly regulated, so those workers are used to documentation. These are the right kind of people for manufacturing."

The next chapter discusses the rigorous recruitment and screening process that all the very effective bio-manufacturing certificate programs have undertaken. It is worth noting, however, that several interviewees suggested that recruiting dislocated workers rather than traditional age students entailed certain unfavorable tradeoffs. Specifically, a scientist at a clinical trials company under study here said that he found HR staffers at his company to be wary of hiring such graduates, since more experienced workers are often less interested in taking lower-level positions than they had been accustomed to in their previous careers. Moreover, a faculty member who has worked with many employer partners claimed that these employers appreciated the maturity and hard working nature of the dislocated worker program graduates, but found that they "often did not fit in to the company culture and environment. Often, the older adults have certain expectations about working, so they're harder to retrain."

Nonetheless, most interviewees were very pleased with the attitudes and expectations of the community college hires, and in fact, many found that such individuals possess, in greater doses than their bachelor-degreed counterparts, the drive to succeed in and loyalty to the manufacturing job. As a Genitope production manager argued:

The certificate holder needs the job, the 9-5, to feed the family. She doesn't mind doing the same thing over and over. She's willing to work the graveyard swing shift, and willing to start as entry-level and train. This makes all the difference.....

Among BA applicants, I get a lot of “I might go back to school” for a medical degree or a master’s. This is not the best thing for manufacturing hiring. The phrase “looking for a research position” in the cover letter is a job killer for manufacturing. Research is a wine and cheese experience, it’s cerebral. But, if you say you want manufacturing, this means you don’t mind moving 50 pounds worth of solution back and forth, and working in the clean room environment.

So, the CC grads have a better attrition rate. And they’ve got loyalty. So the company doesn’t have to train every three months.

Numerous other managers echoed this characterization of community college graduates’ motivation to stay in the job, and hence of their reliability and stability. A Cell Genesys manager commented:

City college grads see manufacturing jobs as a career. It’s high paying, with benefits, and so they have longer retention – in the order of only one to two percent turnover per year. These grads are more reliable, more motivated to stay in their jobs. When they’re cross trained, they can add more value to the organization than a BA grad can, because, in reality, you don’t need a BA in manufacturing.

Similarly, a Bayer manager stated: “The downside with the more highly educated group is that they won’t stay. As technicians they get exposure to different opportunities in the industry.

Turnover was higher than the company liked, and it was constantly recruiting. So, it started a relationship with the Berkeley biotech education group [Biotech Partners].” Another high level manager of manufacturing at Bayer, who has been very involved in the Biotech Partners program,<sup>120</sup> summed up the differences in attitudes between the two sets of candidates as follows:

The Biotech Partners [graduates] are the first in their family to go to college. They’re a struggling demographic; they never dreamed they’d be in a technologically sophisticated job. They’re very ambitious, motivated, engaged. This compares to a college degree student, who feels entitlement, who’s arrogant; they went to Cal [UC Berkeley] so they shouldn’t have to mop floors, make buffers. College grads are difficult because their work ethic is dismal. Kids of recent immigrants do not have this problem.

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<sup>120</sup> As discussed in Section 6.2, above, and in Chapter Three, the Biotech Partners program provides an entry-level biotechnology education and training program for students typically underrepresented in the sciences. Beginning in 11th grade and continuing through community college, the program offers paid summer internships for high school students, year round co-op jobs for community college students, as well as support services for all participants.

So, community college students have an advantage, they work hard, have a good work ethic, and they work better in teams. They're willing to learn, to put in their time. Sometimes, they don't have the same "candlepower" to solve complex technical problems [compared to the four-year students] – but maybe this group is only 20 percent overall, and they are the ones who should be in this job [manufacturing technician] forever. But as for the rest, do they have the same opportunities as the four-year kids? No, and that's the only difference them. For them, the community college is the fastest way to economic sustainability.

While the majority of interviewees praised the community college students' soft skills, a few did point to an important challenge facing many students: their frequently poor communication skills, particularly writing skills. For instance, an employer who has taken a number of community college interns claimed: "The only difference between a four-year and a two-year degree student is the level of writing, English capabilities. People with an AA degree have good technical skills but their writing skills suffer." A faculty member considers this skills deficit to be the students "biggest obstacle," arguing that:

The students are hard workers but their writing skills tend to be less well developed. So the companies target the BA degree holders because of all the reports that need to be generated. So, someone with a B.A., who has upper division work, has an advantage.

As the next chapter will show, many of the highly effective community college biotech programs incorporate communication skills training, as well as other soft skills training, in their curricula.

While the consensus seems to be that entry-level manufacturing jobs do not require a four-year degree, there is a split of opinion as to whether community-college trained technicians are prepared to perform higher-level manufacturing work, such as cell-scale up work, also known as "touching cells" (or seeding cells, "seed-train" work), which requires an understanding of aseptic techniques. A standard response is that such work requires a four-year degree. A Bayer production manager argued thus:

If what's involved is cell scale up work – involving multimillion dollar decisions – only a BA grad has the level of sophistication to do this....If a cell culture process goes south,

you want a BA there, who understands more complex physics, math, and can make the proper judgment. Experience, having a “gut feel,” is crucial, but the worker still needs to have a BA. Community college graduates don’t have the three years of microbiology—they get through only one year—and they don’t have the physical sciences.

A Genentech production manager similarly claimed that manufacturing work that involves touching cells, within the fermentation process, or touching protein, within the recovery process, requires a bachelor degree, not least because mistakes in either process are “extremely expensive,” thus favoring technicians with a greater understanding of science. Community college graduates, he said, are better prepared for the other “half” of both fermentation and recovery work: respectively, media makeup, which involves working with large sacs of powder and which can be grungy and hot; and buffer makeup, which involves such tasks as heavy lifting, weighing, documentation, and adding water, a process that must occur throughout a 24-hour period, thus necessitating the night shift.

Others disagreed with this conventional wisdom, contending that community college graduates are capable of undertaking more advanced fermentation and recovery work. For instance, production managers at Cell Genesys and Bayer attributed the Genentech manager’s delineation to the view that “there’s a distribution of intelligence that’s real.” As one manager observed: “There’s a preconception—a misconception—that you need to have a degree to do certain tasks. Is it people’s ego? It’s a mystery to me: supervisors get frustrated by the high turnover, but they’re unwilling to do something different.” A community college instructor who trains his students to touch cells using expensive (and donated) fermentation equipment, and who places them successfully at Genentech and other area bio-manufacturers, also strongly disagreed with the Genentech manager’s assessment of the students’ capabilities. This instructor was, in fact, quite surprised by the assessment, since he knows that manager to be a “most stalwart supporter” of the community college biotech programs. He claimed that this was a “perfect

example of how [program] supporters can still have a bias about students' capabilities." He elaborated:

The choice is between someone with a B.A. who has sat in a 500 student-strong amphitheater lecture, without lab experience, who has checked off the box that they have a degree, and someone in a community college program who has performed cell culture, who has worked on the hoods, who has exactly the skills involved in touching cells. Who would you hire? Prejudice trumps all common sense! But, biotech comes out of an academic tradition.

This instructor also disputed a key justification for hiring bachelor-degree graduates for higher-level positions, namely that the rapid technological and scientific change endemic to the field require that candidates have a deeper understanding of science, as well as the creativity, independence and sound judgment typically found in four-year program graduates. Besides the fact that many two-year college graduates also possess these traits, he argued: "Innovation is not as fast as you might think, especially in manufacturing, which is hampered by the comfort level of the regulatory agencies. That is, you don't change a process until the FDA has a certain level of familiarity with the new techniques, and this can take a long time."

Finally, another factor shaping company expectations regarding the educational backgrounds of manufacturing technicians is the company's corporate practice. On the one hand, as companies grow in size, they establish Human Resources departments and begin formalizing job descriptions. By the time the company has entered the commercialization stage, its HR practices tend to be fairly mature. Several interviewees have found that HR staff in such companies are more inclined at this stage to recruit from community college programs.<sup>121</sup> On the other hand, commercialization and growth often create a corporate culture that generates

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<sup>121</sup> However, the prevailing sentiment among my interviewees from the manufacturing departments and community college programs is that HR staff tend to be unaware of community college programs and unwilling to recruit from such alternative sources. As one interviewee put it: "When [companies] do hire HR, they get people trained as HR types. Sometimes they have learned elsewhere that community college grads exist. But, in my experience, they never even think of the community colleges."

pressure to hire more credentialed candidates for all jobs, including manufacturing jobs.

Company T3-BA, a treatment group company, provides a good example of corporate pressure to hire bachelor-degree candidates for such jobs. However, as the next chapter will describe in greater detail, this company also illustrates the positive role that deep employer involvement in training partnerships can play in sustaining support for community college biotechnology programs.

Headquartered in Southern California, Company T3-BA acquired, in 2006, a smaller biotechnology company, Company D, based in an East Bay town (part of the San Francisco Bay Area). Company D had been a particularly strong supporter of the Ohlone College bio-manufacturing certificate program since that program's inception; for instance, several production managers helped devise the certificate's curriculum. Company T3-BA has continued many of Company D's community college recruitment practices at the East Bay manufacturing facility. For instance, the company provides regular company tours to Ohlone College students, donates laboratory equipment to the program through its national foundation program, and has supported a number of employees to serve as adjunct faculty in the program. Several senior-level management and production staff also sit on the college's industry advisory board.

As the hiring data reveal, 25 percent of the East Bay facility's current technician-level workforce has a community college degree or certificate, a sizable number. Nonetheless, several of the facility's HR staff members indicated that Company T3-BA's hiring practices remain rooted in a "corporate mentality," one that views all science-based positions as requiring, at minimum, a bachelor's degree. Indeed, one staff member claimed that corporate headquarters considers its ideal candidate—even for operations-level positions, such as those at the East Bay facility—to be someone with both a four-year science degree and an MBA, credentials that the



interviewee claimed were manifestly unnecessary for such positions. Because of its national reputation, however, the company is able to rely on a steady stream of recent, four-year college graduates from top schools across the country to fill the ranks of its operations-level (technician) staff. Apparently feeling constrained by headquarters to abide by company-wide job requirements, HR staff at the East Bay facility admit to occasionally screening out well-qualified, local, community college-degreed candidates for these positions. The staff members whom I interviewed are aware of the disjuncture between corporate and local needs; as one interviewee stated, several of the company's neighboring competitors (e.g., Company T1-BA) are "way ahead" on the issue. These staffers claim that they continue to negotiate with headquarters for greater leeway in hiring. In the meantime, due in large part to the positive experiences that many current managerial staff have had, and continue to have, with the Ohlone College program, as well as with the program graduates who serve within the company's ranks, the East Bay facility remains a strong supporter of the program.

#### Outcomes Data Outliers

The company hiring data cited above reveal several exceptions to the finding that treatment group companies employ a greater percentage of community college hires than do comparison group companies. Specifically, among treatment group firms, Company T7-BA's entry-level technician workforces contains a much lower proportion of community college degree graduates (four percent) than would be expected based on the companies' involvement in the partnership programs. Conversely, among comparison group companies, Company C2-BA's technician-level workforce has nearly the same proportion of community college graduates (18 percent) as several of its treatment group counterparts. The following section suggests explanations for these particular outcomes.

Company T7-BA. This company's relatively low percentage of current entry-level technicians with a community college degree (4 percent) is surprising, given the company's strong support of community college programs. This support includes such activities as the company's participation on the Skyline College advisory board; provision of on-site tours to students of its R&D facilities, including the opportunity for students to meet fellow entry-level technicians (Process Technicians) who may have gone through the community college program; and its practice of offering staff presentations to classes at Skyline College when needed, as well as at various community college conferences.

Indeed, the company changed its hiring practices partly as a result of its collaboration with Skyline College's Bio-Manufacturing Certificate program (beginning in 2004). Prior to this collaboration, the company's Process Technician position required a bachelor's degree. High turnover among bachelor-degreed staffers who left to enter research positions, however, convinced the company that it needed to build an alternative pipeline of qualified candidates. According to the lead production supervisor of its technician-level workforce, the company's involvement with the Skyline College program led the company to change its hiring criteria from bachelor's degree to associate's degree, with relevant experience.

The company has since revised the educational criteria for the Process Technician position to require a high school diploma with relevant experience, although the associate's degree is considered a "plus."<sup>122</sup> In part, the company's work with the San Mateo High School Regional Occupation Program, which prepares high school students for biotech careers, motivated this change. Currently, the majority of Process Technicians have a high school degree (14), while eight have a bachelor's degree and one has an associate's degree. The low proportion

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<sup>122</sup> Arguably, this more recent hiring criteria revision has further opened up opportunities for a nontraditional and/or less advantaged labor pool.

of community college-degreed graduates within the company's entry-level technician workforce thus might be explained by the fact that high school graduates now increasingly fill this position.

Staff members make clear, however, that Company T7-BA remains committed to hiring from a community college pool. The educational backgrounds of the company's recent hires support this suggestion. For instance, in both 2006 and 2008, 50 percent of the new Process Technician hires held an associate's degree or certificate: two out of four hires in 2008 and one out of two hires in 2006 had such a credential. (The current community college-trained workforce is down to just one person, however, as both the 2006 hire and one of the 2008 hires have since left the company.)

Company C2-BA. According to the HR Director of the company's Vacaville facility, the company currently does not have a relationship with the local community college biotechnology program (Solano Community College) or the Regional Center (CalABC-Bay Area), although staff members are aware of the program and have favorable views toward it. These views in part may explain the relatively high percentage (18 percent) of community college-trained technicians in the Vacaville facility's current workforce, despite the company's lack of a relationship with the community college program.

HR staff's awareness of the Solano Community College biotech program stems largely from outreach on the part of the program director, as well as its knowledge of the earlier involvement in such partnerships by its sister facility in the East Bay. In 2006, that facility acquired Company B, which had been an active partner in the Genentech-Skyline College partnership. According to staff at the East Bay facility, Company C2-BA continued this relationship until 2007, when it sold the manufacturing unit that had hired most of the

partnership's certificate graduates to Company T2-BA. (Currently, Company C2-BA in the East Bay does not partner with the Biotech Workforce Network.)

The HR Director at the company's Vacaville facility attributes its current lack of involvement with the community college biotech program or Regional Center to the very low turnover that the company has experienced in the last several years; for instance, no entry-level technicians were hired in 2008. She stated that the company does intend to "build a relationship" with Solano Community College, i.e., to turn to the college as a recruitment strategy, once hiring picks up, given staff members' positive views of the program.

2. Among small to medium-sized, research-oriented or clinical trials companies, partnership programs have had less success in opening up employment opportunities for community college graduates.

As the hiring data show, relatively few of the sample's smaller companies, all of which are engaged primarily in research and development or clinical trials development, have a significant percentage of community college-trained technicians within their entry-level workforces. The exceptions—Companies T8-BA, T12-BA, T14-BA, T15-BA, and T16-BA, all in the San Francisco Bay Area—have developed strong and innovative internship programs in partnership with Ohlone College, City College of San Francisco, and Contra Costa College, as the next chapter will elaborate. The following section outlines the main factors influencing the hiring decisions of the remaining companies (both treatment and comparison group) with respect to their entry-level workforces.

As noted, it appears fairly well established that entry-level, bio-manufacturing positions do not require a four-year degree, even though companies continue to hire a large percentage of bachelor-degree graduates for such positions. However, for research and development positions, such as laboratory assistance/technician or research assistant/technician, there seems to be no

industry-wide consensus on whether community college programs provide the necessary level of training that might justify hiring from this labor pool. Indeed, as my interviews show, the prevailing view is that laboratory work in the research setting generally requires the applicant to have higher levels of training than these programs—particularly the shorter, certificate programs—provide, as well as more work experience than the typical community college graduate possesses. This finding has potential significance for the ability of community college biotech programs to expand employment opportunities for its graduates, in two ways. First, a number of community college certificate programs train students specifically for research lab positions, although most programs claim generally that they prepare students for entry-level positions in the lab. Second, long-term employment growth in the two regions under study may be stronger within research companies than manufacturing companies. As a former director of BayBio, the San Francisco Bay Area’s leading biotechnology industry association, commented: “While manufacturing technician positions may be at risk in the Bay Area, research assistants/associates are not. There are opportunities for people with an AA degree to work, at least in the larger labs.”<sup>123</sup> Moreover, as is typical in other industries, smaller companies, i.e., those with 50 employees or less, hire approximately 80 percent of all biotechnology workers (Huxley power point presentation 2007).

The primary concern among early-stage or research-oriented employers is that the community college programs best prepare students to undertake routine or repetitive work, yet such companies typically are too small—i.e., the volume of production is not large enough—to

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<sup>123</sup> However, the former director noted that, even if the volume of manufacturing work in the Bay Area declined significantly over time, process development skills—which all community college biotech programs teach—are “used across the board in most companies, so there is room for students who learn these skills.”

support this kind of work.<sup>124</sup> Instead, these employers argue, work in the smaller company is more changeable and varied: “Staff are wearing lots of different hats, they need to do lots of different things, so they need a level of independence, of creativity, that four-year degree students tend to have.”

As for the laboratory work that is, in actuality, more routine in nature—e.g., glass washing and media preparation—smaller companies, particularly start ups, typically claim that they cannot afford the \$30,000 to \$40,000 annually that is required to hire an entry-level laboratory assistant or technician to perform such work. Instead, all staff persons, including the Ph.D. scientists, must perform their own routine tests and prepare the materials used in their experiments. As an HR staffer at Amyris Biotechnologies in Berkeley observed: “In an early stage company, the scientists need to do all the mundane tasks themselves to get ready for the experiment, like make sure all the reagents are available or order them if necessary. They’re functioning as lab technicians.” According to this logic, then, there is no place in the ranks of economically-strapped smaller firms for community college hires.

A sampling of comments from HR staff and several production managers in the smaller companies regarding technician-level positions capture this rationale:

- “If we got bigger, maybe we would need someone doing solutions that the chemists or biologists might need, because you can’t farm that work out...if we had 30 chemists, we might need someone making large quantities [of solution].”
- “We have no [laboratory or research] assistants in the lab—all are required to do multiple jobs.”
- “If we were bigger, we’d have more routine work for them to do, but we don’t do high volume. Research is unique.”

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<sup>124</sup> The companies may be small in size because they are start ups or have yet to emerge from the clinical trials stage; because they have suffered a reduction in force, a common occurrence in these recessionary times; or because a larger commercial firm has spun them off as a smaller R&D company. The companies in my sample fit all of these categories.

- “If we had a commercial process, we’d consider hiring two-year graduates. Actually, if we had a highly repetitive position, we’d hire from the community colleges in an instant.”
- “Our entry-level position requires a bachelor’s plus one or two years experience working in the lab. So we don’t hire at the community college level.”
- “When we were bigger, we did have Associate’s degree people, who were able to do quality work, but [that work] was very repetitive.”
- “If we were a large company like Pfizer or Merck, we could hire technicians, but it’s really hands-on in the lab. You’re expected to present data to the management team, and the design is multifunctional. We want people who can make judgment calls”
- “Because we’re smaller, we tend to err on the side of hiring bachelor’s students.”

My interviews suggest that these concerns are rooted in legitimate factors related to the company’s stage of production, the company’s economic model and organization of work, and the larger economic climate, as well as in industry and employer misperceptions regarding the qualifications and preparedness of community college graduates. Moreover, the ability of industry-education partnerships to shape employer hiring decisions with respect to the technician-level workforce depends largely on the nature of the concerns that predominate.

As noted, the assumption that laboratory work in a research setting is too advanced for community college students ignores the existence of lab-related tasks that are routine in nature, such as media preparation. The HR staffer at Amyris Biotechnologies noted: “The infrastructure needs people to order supplies, prepare reagents, clean glassware, and maintain the infrastructure.” One biotech faculty member objected to the commonly-held notion that research/laboratory technicians are constantly performing all sorts of creative tasks: “That super dynamo myth is just that, a myth. Companies are fooling themselves, as lab techs are all cultivating the same kinds of cells. There’s a great deal of repetition in the lab.” Moreover, a Contra Costa College biotech program faculty member noted that the basic work of even the smallest of companies—start ups—involves major repetition of tasks:

In any start up, whether the product is cloned genes, or ELIZA assays or a prototype of a new medical device, the whole process of assay development<sup>125</sup> relies on the ability of the start up to prove robustness and replicability of approach. The data must be rock solid, which may entail doing 1,000 replications of the same experiment and doing statistical tests.

Nevertheless, compared to manufacturing production, with its relatively stable biological processes that generate a great deal of routine or repetitive work, laboratory work does support a more varied and complex array of tasks. A scientist at Mo Bio Laboratories in San Diego remarked: “Any company has SOPs; you have to follow directions. That’s rote, mundane. And there is some assembly, which a B.A. won’t do. But for the science part, doing R&D, you have to be creative.”

In fact, as an HR manager at one treatment group company, “Even repetitive tasks require critical thinking.” For example, he explained that, while cleaning glassware is routine, “it’s not like washing glassware at a restaurant. It requires more science, based on an understanding of contaminants, safety procedures, protocols.” Moreover, he distinguished an entry-level, R&D position (called a “research technician” in his company) from the position one level up (the “research associate”) as follows:

The research technician thinks like an engineer, who tends to work with preexisting processes, equipment, devices or agents, while the research association thinks like a scientist. But the research technician needs to critically manage these tasks. For example, like with a recipe, you need to adjust it to smaller or larger portions, to recalculate. This is a critical task. If the garlic looks funny, you must troubleshoot, be critical.

Similarly, with respect to the more basic research tasks, the Mo Bio Laboratories scientist stated:

“There are no jobs where people don’t have to use their brains.....They’re all doing science [including entry-level lab technicians]. To make a reagent at a specific molarity, you need to know what that means. You must be interested in science to do the job well.”

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<sup>125</sup> An assay is a procedure for testing or measuring the activity of a drug or biochemical in an organism.



According to some community college faculty, the biotech certificate programs, especially the manufacturing programs, are not oriented to training students to undertake certain higher-level tasks, such as developing SOPs, engaging in problem-solving of technical issues, or developing and implementing process improvements, all of which tasks are common in scientific research. Indeed, as a community college faculty member remarked, even the “B.S.-level person is going to struggle with [such] tasks at the outset until they build some experience and likely get mentored by more senior staff.” Other faculty members argue, however, that their students are trained in many of the more advanced skills and processes that are used in the laboratory. A MiraCosta College faculty member noted:

The students train on every instrument in the lab and they learn a huge amount of skills. They learn pipetting, centrifuges, ELIZA, DNA isolation, transformation. Also, they do different types of analyses with protein, separation, microbiology, Western Blotting, analyzing new bacteria. They also read protocols.

In contrast, the justification by a production manager at Company C4-SDA as to why his company does not recruit community college graduates for its entry-level technician position (called a “scientist”) centers on the need to perform a range of tasks that, he believes, such graduates are not trained to perform:

Our pilot plant is highly automated, very state of the art. Complex reactions happen very quickly. For example, 80 chemical reactions occur over 7 hours, so the scientist must sit in front of the PLC screen and make decisions on how the reaction is proceeding. This is fairly repetitive work that a trained community college student could do. But this work only occupies 20-25 percent of the scientist’s time. The scientist also does R&D work, deals with quality systems and GMP—so their documentation practices have to be immaculate. The scientists also have to modify equipment and understand all sorts of different items.

So, the key is to multitask and transition from project to project. One day the scientist is an engineer, the next day a programmer; they must be experts in various fields. I’ve pulled people for these jobs from the Stanford program, from top schools.

I asked several faculty members to review this company's job description for its entry-level scientist position, and all claimed that the programs do prepare the students to undertake the majority of these tasks, although many of the higher-order responsibilities, like developing SOPs and process improvements, would prove challenging for most new hires from the community college *and* from four-year degree programs alike, as noted above. In fact, in light of the emphasis that many community college programs place on training students in computer and automation skills, the program graduates are especially prepared to work in DNA sequencing or synthesizing companies like Isis, which have a higher rate of mechanization than drug companies, as well as companies doing "small volume work," in which there is a great deal of automation. Regarding the responsibility listed first in the company's job description for the scientist position—"Synthesize and purify oligonucleotides using automated equipment in a GMP clean room environment"—a community college administrator (and former company executive) noted that the scientist does not have to understand the chemistry behind the procedure because it is performed by machine. Instead, the scientist "just needs good techniques," which the community college programs adequately train students to perform.

As in the case of bio-manufacturing, community college and university biotech programs appear to differ in the extent to which each emphasizes the hands-on laboratory skills used in research settings. A number of interviewees affirmed that community college programs have an edge over four-year college programs in this regard. For example, a scientist at Cel Analytics, which participates in the City College of San Francisco's Bridge to Biotech internship program and has taken on a number of interns, praised the Bridge program classes for their emphasis on practical skills:

If [the class] is teaching PCR, it only teaches that. It's not going into lots of background detail through lectures, because the bottom line is, if you're in the lab and holding a

pipette in your hand, you need to be able to do that. So [the course instruction] is solid, and it's hands-on. The same with Western blotting—[the class] is really teaching that: how to put the gel together, run the protein samples. In a bachelor's program, there's more emphasis on theory, less on lab. But an entry-level technician needs to know what a DNA structure is; they don't need to understand the complexity of that structure.

Similarly, a scientist at Company T5-SDA explained, “The university students don't know pipetting; they usually have just one lab class. So, the programs aren't preparing people for lab jobs. If you have lab experience, you have a deeper understanding of molecular biology.”

Finding the training at Mira Costa College to be “relevant to molecular biology and really good,” he noted that his 30-person company has hired two MiraCosta College graduates. He explained the company's hiring process as such:

We look at the resume, training, any relevant lab skills and give a test, which we use to rate people, on retention of basic information: pipetting, how to do a basic concentration, PCR, if they know about molecular biology, etc. If the applicant does well, we bring her to an interview, where they're asked to make kits of DNA, RNA. If they do OK, there's a second interview: DNA isolation in the lab [a routine procedure to collect DNA for molecular analysis]. The people in the MiraCosta program did OK.

He noted that both MiraCosta College students, one with a prior bachelor's degree and one without, were hired as entry-level technicians and both advanced in the company to become lab managers. The one without a four-year degree at the time of hire eventually transferred to UCSD and continued working at the company during school. She has since left to work at the National Marine Fisheries Service's research lab located in La Jolla, CA. The student with the bachelor's degree already advanced from laboratory manager to quality control manager.

Firmly believing that the MiraCosta College biotech program “helps people get a foot in the door,” this CEO indicated that he informs the program director when the company is looking for technicians, asking him “to send people doing really well.” Below and in the next chapter I present additional examples of companies that, as a result of their positive experience with

community college hires, rely on the community college programs to recruit their technician-level staff—a key indicator of program effectiveness on the demand side.

Beyond training students in the techniques through hands-on instruction, a number of community college faculty members claim that the programs also train students to “think like scientists.” For instance, the chair of one of the most respected biotech programs in the Bay Area, Foothill College, asserted that she trained her students first and foremost to “THINK! They have to look at a problem, figure out what the controls are and how to phrase the questions.” Her students often tell her that the troubleshooting that they learned in her classes was the most important skill they had. She claimed: “Bachelor’s grads don’t know how science works. They have theoretical knowledge, but that’s it.” She offered as an example a student who was working with a post-doc when an assay went wrong:

The Ph.D. threw up her hands and went home. My student did some research, called the lab where [the assay] was from, did troubleshooting with them to fix the protocol for the assay. The next morning when the Ph.D. came in, the problem was fixed. Of course, the Ph.D. got credit for the whole experiment.

Moreover, a number of community college biotechnology programs explicitly train students in the methods and techniques used in research settings. MiraCosta College in the San Diego Area, for instance, offers two research-oriented certificate programs that are intended to form steps in an academic career ladder. The first step is the Certificate of Proficiency in Laboratory Skills, which trains students in the technical skills necessary to perform tests and routine work “inherent to a wide range of laboratory settings.” The second step is a Certificate of Achievement in Research and Development, which is:

designed to give students the theoretical background and the practical experience necessary to be effective laboratory technicians. It also prepares students for upper division course work in the biosciences. Graduates can expect to start careers in quality control, quality assurance, production, applied research, product development, analytical testing, and academic (basic) research. (See [www.miracosta.edu/biotech](http://www.miracosta.edu/biotech).)

The students completing this certificate program are qualified for positions that contain advanced tasks, as well as more routine work.

Similarly, Ohlone College in the San Francisco Bay Area offers a Certificate of Achievement in Quality Control/Research Associate, which prepares students for entry-level positions as research assistants, quality control and/or quality assurance assistants/technicians, and laboratory assistants/technicians.<sup>126</sup> In fact, all of the college's certificate program students, including those enrolled in the bio-manufacturing certificate program, are trained in research skills. Two courses in particular, BIOT-111A and 111B, which all of the department's certificate programs require, teach such fundamental research skills as reverse transcription polymerase chain reaction (RT-PCR), library construction/building, and library design.<sup>127</sup> A program faculty member noted that there have been heated faculty discussions about whether the content and level of instruction in these courses are appropriate, particularly for students who have come through Ohlone College's Learning Alliance for Bioscience (LAB) program, the college's bridge program for high school students. She commented, "Some [faculty] ask: Is the course too challenging? They suggest that maybe biomanufacturing students should be able to

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<sup>126</sup> The certificate program trains students in "DNA and protein laboratory techniques and assays, laboratory record keeping, sterile techniques, advanced PCR procedures, and genomic/cDNA library construction and analytical skills."

<sup>127</sup> The course descriptions for the two courses are as follows:

**BIOT-111A Genomic and cDNA Library Construction and Analysis**

9.00 hrs lecture, 27.00 hrs lab Units: 1.00; Prerequisite: BIOT-110A1 Accepted For Credit: CSU

This course teaches students the theory and practice lab techniques used to construct, search, and analyze simple genomic and cDNA libraries. Students will learn replica plating, southern and northern blotting, ELISA, and the use of non-radioactive oligonucleotide probes for searching libraries. (GR)

**BIOT-111B PCR Primer Design & Optimization and Reverse Transcription**

9.00 hrs lecture, 27.00 hrs lab, Units: 1.00, Prerequisite: BIOT-110A2 Accepted For Credit: CSU

Students will learn advanced topics in PCR, including BLAST searches and DNA alignment protocols for locating minimal variable sequences to use in constructing PCR primers, principles of primer design, and optimization techniques for PCR reactions. Students will design primers, optimize salt and temperature parameters for PCR, and perform RT-PCR. (GR)

waive this class. But the course professor insists that all the students do just fine. And by the time they take this class [BIOT 111A], they've been immersed in the program for long enough that they can handle it.”

Hence, the assumption among many of the company staff in my research sample—that laboratory work in a research setting is not the type of work for which community college graduates are prepared—appears to be incorrect, at least in regard to many of the students who complete an R&D certificate program like the ones described above. As a faculty member of one such program observed, “The relevancy of the coursework they get in a specialized program like ours, coupled with the right person with the right aptitude, is at least comparable to the [bachelor’s] degree.” He argued that the top quarter of students in his program would “fare just as well” as bachelor-degree students at any of the smaller companies under study here. Moreover, as the results from this dissertation study’s student survey showed, almost half of the community college respondents already hold bachelor degrees in science-related fields, presumably giving them the science background needed to perform the more rigorous research tasks found in the laboratory.

A separate issue, however, is the extent to which research companies are able and willing to organize their work so as to support the laboratory positions for which the community college programs, especially the specialized R&D certificate programs, train students. As noted, in smaller companies, financial considerations often necessitate that all staff members perform the routine laboratory tasks, such as media preparation. In start-up companies that employ just a handful of scientists, for instance, it is common for all employees to wash their own petri dishes and prepare their own solutions. Other companies that have experienced an involuntary reduction in force due to financial circumstances also may be forced to do without an entry-level

technician workforce. Indeed, several of the companies in the research sample, e.g., C5-SDA and T4-SDA, have suffered through several Reduction in Force (RIF) actions over the last several years. Because they had worked closely with community college programs and had hired program graduates when their workforces were larger, HR staff members at these companies indicate that the companies intend to resume recruiting from the community college programs once their financial situation improves.

As the first chapter discussed, the biotech industry's workforce needs tend to vary along the company's developmental cycle. The first stage of development, research/discovery, which involves small-scale experiments on promising compounds, typically employs between one and 50 people. Start ups, as well as academic research institutions and biotechnology incubators, fit this category. The next stage, developmental/clinical, involves limited-scale production of the compound for testing in a pilot plant, a separate section of the laboratory, or, if the company chooses to contract out this work, a contract research organization (CRO). Such firms usually employ between 51 and 300 people. A number of interviewees indicated that, once a firm reaches this stage, it can capture efficiencies by establishing what is usually called a core facility, a centralized unit within the firm that specializes in certain key functions. The work that is performed in the core facility is often highly suitable for community college-trained technicians, as a scientist at Exelixis, a sample company at the clinical trials stage, explained:

When the company gets to a certain size, say 100 people, it establishes a certain way of doing something, e.g., how it screens drugs. It wants no time delays in doing the functions and wants the tasks to be more consistent. Cell culture work, splitting cells, oligonucleotides, enzymatic assays, sequencing, etc., must be done again and again as quickly as possible. So [this work] is perfect for entry-level technicians; it lends itself to someone who is technically sound. For instance, to run the sequencing lab, you get lots of samples and look at the genetic mutations, so you have to sequence their DNA to see if there are mutations. A small core facility runs this work.

Hence, firms that choose to undertake such work in-house, as opposed to contracting it out to a CRO, arguably have positions at the technician-level.<sup>128</sup> Indeed, a hiring manager at C7-BA noted: “If we didn’t outsource to a CRO, the entry-level technician workforce would probably be triple the size.”

One treatment group company that has chosen to perform its core facility work in-house is T9-BA, a 150-person company headquartered in Emeryville, California. The HR manager offered the following description of how a core facility emerges:

The scientific researchers must think creatively around the design of experiments, as there’s no pre-established road map. Now, as that capability gets strong within the company, the researchers lay down the methods and processes, which become more settled. So, someone can pick up that road map and follow.

It’s the same with analytical chemistry. In design mode, the work involves how to do analysis of samples, of strains of chemicals and compounds developed in the lab. The researchers need to think outside of the box until they settle on a standardized way. At that point, every time they get blood samples or compounds, they can say: this is the best way to analyze them. Here are the five, predefined steps, which can be done repetitively. So, the company needs a different profile for this position.

Also, as the work becomes more operational, boundaries shift and there’s a need for more QC, etc., and this work is suitable for AA degree holders.

Having thus reached this stage in its development, and recognizing the opportunity to recruit a well-qualified technician staff, the company is creating a new career ladder for research technicians, which will target community-college trained workers. Table 6.15 presents the company’s draft version of this career ladder, which remains in the planning stages. The two employment tracks at issue in this ladder are the Research Technician (RT), which will require, at minimum, an associate’s degree, and the Research Associate (RA), which will require, at minimum, a bachelor’s degree. These positions involve two different sets of competencies. As noted above, the manager compared the research technician to an engineer, who works with

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<sup>128</sup> He noted that this work constitutes a “sub-industry, which supplies the same proteins, antibodies, and does its own QC [quality control]. It’s very specialized work. It’s like a manufacturing lab because it’s very well QC’d.”



preexisting processes and equipment, while he described the research associate as “more akin to the definition of scientific researcher, who has to think creatively around the design of experiments and go to the literature to tease out methods and processes needed to do the experiments.” Though the research technician does not have to exercise as much independent thinking and judgment in her position as the research associate, she still must think critically and troubleshoot to perform her tasks effectively. Because the company values the competencies that the research technician brings to the job, it has carved out four rungs on the technician ladder—RT1, RT2, RT3, and Senior RT—which the technician can climb in order to advance to a research associate position without returning to school for an advanced degree. However, the technician need not reach the senior technician rung before advancing to the research associate ladder. For instance, “If an RT2 is working in a cell culture facility and becomes an expert at this, and an RA1 job opens up in the assay development group, the RT2 can move up through a demonstrated capacity. She doesn’t need the degree.”

The HR manager indicated that the company is now trying to go “one step further” and figure out how to “improve processes,” which will allow the company to open up more work to technicians without an advanced degree. As he explained: “This is where automation comes in, which is very prevalent in the labs these days, and allows for process improvement. Robots and devices run preexisting assays. But this equipment needs someone to operate it and follow through.” He anticipates that research technicians will be the most qualified to operate this equipment. In describing the company’s (and his) motivation to create the career ladder and push for process improvements that expand the role for research technicians, he stated:

From an HR perspective, this process allows the company to create positions and dig deeper into the community, and foster science. It roots science in the community and creates diversity in science. The employees have a tremendous loyalty, as does the larger community. The question is: how do we keep people, whose passion is science, from

getting discouraged by the lack of stability in the industry, or the sense that a science career is not sustainable over the long term, and so give them a place to work in the industry and therefore a reason not to go back to school to get an MBA.

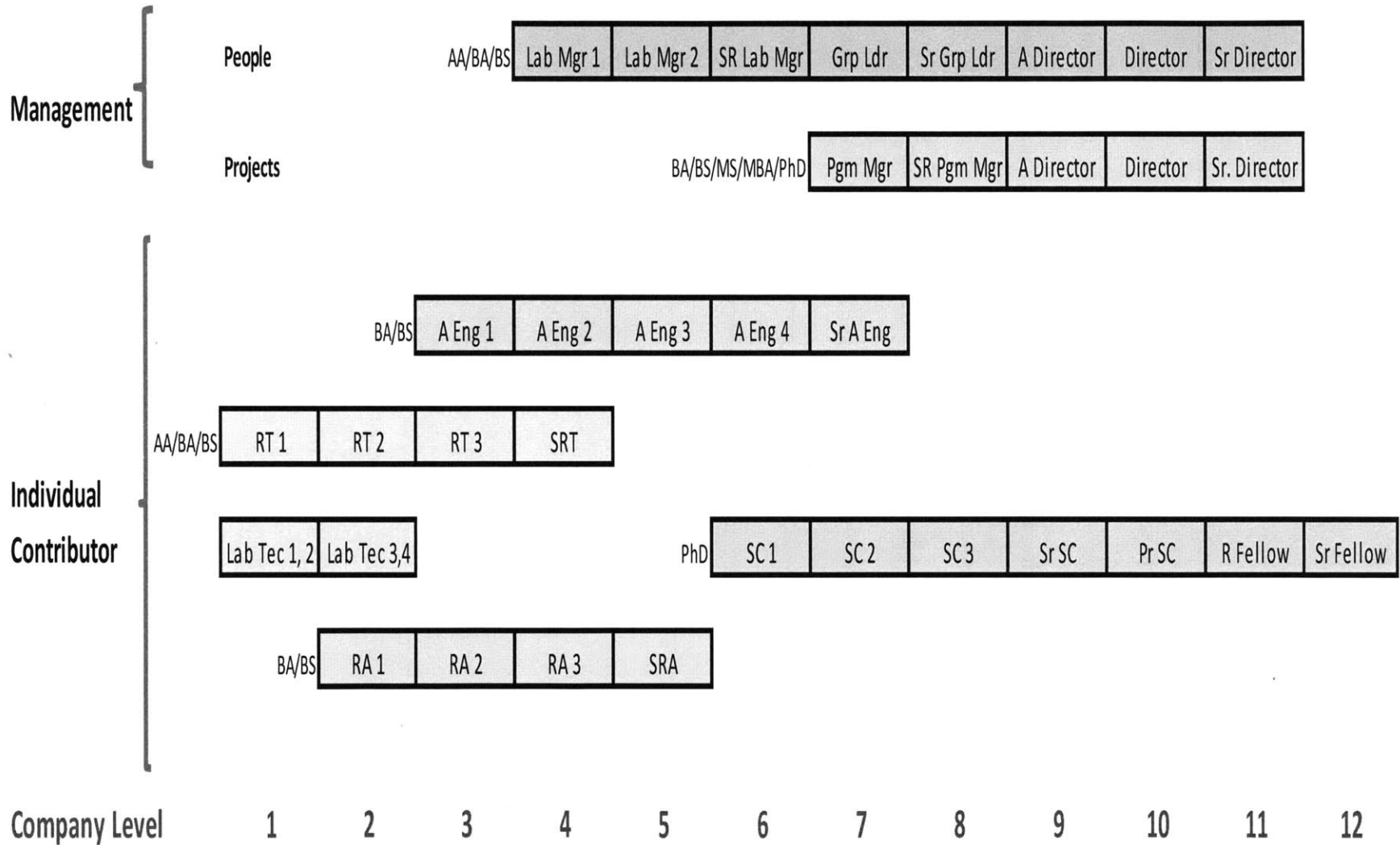
The company started out as a nonprofit created to cure malaria. As such, it attracted zero pharma people. The people who are here are true believers, who therefore support the career ladder concept. That was strongest when the company had only 25-30 employees, but now that we're almost 200, there is more of a push to hire based on professional capabilities. But the spirit is still present.

Companies, like this one, that have grown in size to accommodate a core facility and have chosen to undertake such work in-house would seem to be the most suitable for developing a technician-level workforce. However, as my interviews show, even the smallest and most financially strapped of companies have found ways to organize their work so as to open up both internship and full-time employment opportunities for entry-level technicians. For instance, a number of start-ups have hired community college students as interns and have found them to have the hands-on laboratory skills needed to thrive in a research environment.<sup>129</sup> The Foothill College biotech program's director recounted the case of one company with a total of six or seven Ph.D.s on staff, which recruited unpaid interns from three schools in the area: Santa Clara University, San Jose State University, and Foothill College (whose biotech program is under study here). Initially, all the interns were asked to undertake lower-level tasks, such as media preparation. Within six months, the supervisors realized that the Foothill College students had better hands-on skills than the university students, and invited the former to perform more advanced work. Once the company was acquired and thus better able financially to increase its paid workforce, it offered all of the interns full-time positions (however, because the acquired company had moved to Boston by this time, the Foothill College interns did not accept the offer because they did not want to relocate).

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<sup>129</sup> While internships are often unpaid, some of the partnership programs under study, especially the WIB-funded programs, offer stipends to students.

**Figure 6.1**  
**Research Career Ladders**



Several small companies in my research sample have repeatedly accepted and hired interns from the Community College of San Francisco's Bridge to Biotech program.<sup>130</sup> For instance, San Francisco-based company T14-BA, a medical therapeutics company with a total of 35 employees, has hired seven former interns of the program—a hiring rate of 20 percent. The program's founder and owner said that the program “exceeded his expectations” and that he found the interns to be “stellar.” He noted that one of the interns that the company had hired was recently tapped to be a team leader, proving that it is possible to enter a small company as an entry-level technician and “rapidly move up.” Moreover, this new team leader does not have a four-year degree, but instead has “demonstrated ability.”

This company's owner took issue with the commonly-held view that small companies lack the time and resources to supervise interns, arguing that the right attitude and proper approach to supervision can enable the scientist to “double the creative experiments that you do.” He explained this approach as such:

I tell them [the interns]: Here's what I'm doing; now watch me. Then, after a while, you do it and I'll watch. How much time does this really take? Also, by watching someone else do it, you get more insight into what you are doing.

The beauty of biology is that you don't have to be a genius to do it; you must be meticulous and attentive to detail, and curious and well-trained. You need only have them [the interns or new hires] watch you one or two times, then you have them do it and you watch them. That's how you teach interns in medicine: “This is how you do it; now watch me and then do it.” The most sophisticated things are done this way.

He also offered a compelling justification for how, and why, he recently turned a Bridge program internship into a part-time company hire:

One intern was very sincere, earnest, though he didn't know that much (yet). And he's not the most sophisticated fellow; he got arrested in Chico, hanging out with the wrong crowd. So, he's a kid off the street, but he has a passion, a thirst to learn, he really wants

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<sup>130</sup> As described in Chapter Three and in Section 6.2.3., above, the Bridge to Biotech program prepares low-income, underrepresented adults with no prior math and science background to enter CCSF's biotechnology program and eventually to enter biotech employment.

to be a scientist. So, I got permission to add a 20-hour a week glass washer position, and offered it to this intern. But I knew it wouldn't necessarily take 20 hours a week to do that job—maybe 4 hours a week if you're doing it efficiently. So, I offered him the chance to continue doing what he did in the internship, for example, Western blot, running gels.

These activities [e.g., Western blotting] require very sophisticated biochemistry analysis. Obviously, this new hire did not have the experience or education level to interpret the data on his own, but as long as he follows the protocols, to the letter, I can interpret the data. So, I've doubled my personal capacity—I can do two experiments at once! The test is straightforward, though not unsophisticated, so it can be handed off to the entry-level technician.

Finally, a very small, San Francisco-based firm that has taken on interns from the Bridge to Biotech program is Company T15-BA, an environmental laboratory that analyzes water from multiple sources for purposes of identifying bacteria. With just three staff, the company has taken four interns to date, one of whom was hired for full-time employment and has worked at the company for the last two and one-half years. As noted above, the company CEO finds that CCSF's Bridge program offers solid instruction that is relevant to the work of a small testing company like hers. Because the company is so small, she explained, the interns must wear many hats:

I hire them and get them right to work—whatever needs to be done. There's no room for doing just the basics. So, they wash dishes, order stuff, receive stuff, answer the phone, run experiments, and prepare reports. I put them under pressure. Some survive, some don't. I can't afford to babysit them. I show them how the experiments are done and expect them to learn.

Based on experiences such as these, the chair of Contra Costa College's biotech program argued that the “next big opportunity for partnerships development and the next real wave of opportunity” for biotech program job placement involves the cultivation of ties with start ups in an effort to develop large-scale internship programs. As she claimed, “the people who form start ups, the two or three Ph.D.s, they don't have the time to do these critical but repetitive assays. They really don't have lab equipment or the space or the man/woman power to help refine the

research idea. There's no way for them to turn their ideas into actuality." The community college biotech program can supply all of these inputs, thereby benefitting companies as well as students, who would have "the opportunity to really understand how many layers of challenges must be met to get a product to where the company can seek licensing." Moreover, the start ups would be in a position to assess the talent from the college programs, and thus would be a great source of future employment once the firms ramp up for production, as well as a mechanism for "spreading the word about the programs to area scientists and managers."

Finally, my interviews reveal several other factors that shape the smaller and/or early-stage companies' perceived ability to create a technician-level workforce and hire community college graduates for these positions. One key question revolves around the industry-related, work experience requirement, namely, whether classroom laboratory experience can count as the requisite one to three years of relevant lab experience for entry-level technicians. Many companies are unaware that the programs provide extensive, hands-on lab experience. For instance, when asked about this issue at an industry advisory board meeting of the California Applied Biotech Center-Bay Area, a leading company supporter of the biotechnology training programs under study replied that colleges would have to offer training in such areas as operations labs, vessels, and piping systems in order for the laboratory experience to count as work experience, and that, in her view, the programs did not do so. Several faculty members responded by noting that many classroom labs do, in fact, train students in these precise areas.

Hence, partnership programs can play a critical role in informing companies about the level of training that community college students receive, the positions for which they are qualified, and the diversity in the student body, especially regarding the fact that many students already possess an advanced degree or have an extensive work history. The partnerships also

can work with companies to help them better understand their hiring needs with respect to a technician-level workforce. For instance, community college faculty members have observed that companies frequently hire bachelor's degree graduates for media preparation and solution preparation positions. Although these positions involve mostly routine work and are at the same level as bio-manufacturing positions, many employers consider them to be more advanced because they occur on the research side. Hence, the company may not realize that it can hire community college graduates for these jobs, who are likely to have more hands-on laboratory experience and to stay longer in the job than their bachelor-degreed counterparts, for the reasons set forth earlier.

Moreover, a number of interviewees have attributed company reluctance to hire community college graduates to their HR department's failure to understand the specialized skill requirements for technician jobs and the different educational pathways that potential employees may take to acquire skills. As a Solstice Neurosciences production manager commented: "There's a disconnect between HR and the requirements. HR in [company headquarters in Pennsylvania] said: We'll send you job description [for an entry-level validation technician position]. When I took a look at it, I said: Where did you come from? The description was so off the mark." Consequently, production supervisors often describe the need to become internal champions for community college programs, rewriting technician job descriptions that typically default to the de-facto standard of a four-year degree. An HR manager at Company C10-BA, who indicated that the company only hires at the bachelor-degree level for its entry-level positions, acknowledged: "There may be the perception that the community college programs are not rigorous enough. Employers and hiring managers do not know enough about them. Maybe they are getting the same sets of skills?"

Perhaps more so than in the manufacturing environment, a bias in favor of candidates with an advanced degree appears to permeate many early-stage and/or smaller companies. The HR manager at Company T9-BA described this preference as such:

The industry norm is for the head of science, the CTO (Chief Technical Officer) or CRO (Chief Research Officer), to say: ‘I want the best and the brightest,’ ‘the scientific athletes,’ so recruit from the top schools... If they’re not from the top schools with some experience in the research lab, for example, working with the PI [principal investigator], the candidate doesn’t rank high.

Also, as noted above, this traditional view is compounded by the fact that scientists in most early-stage companies tend to perform all the mundane tasks in preparation for the experiments themselves. The manager at Company T9-BA elaborated:

When there’s money available, I tell the scientist, “Good news, we can hire someone to help you.” And the response is, “Great, go find someone from UC Berkeley.” But then I ask the scientist whether there will be more interesting work down the line to engage the BA grad, since much of this work is boring. And the scientist says, we’ll find something at that time. But from a recruiting perspective, that’s not the way to go. The BA grad wants to take a few years off before grad school [to work in the company], but he’ll leave much sooner if the work is not sufficiently challenging.

Unfortunately, the bias towards higher-degreed candidates often constitutes a bias against candidates with a community college background, as the following comments illustrate:

- The smaller R&Ds have a bias against someone with just an AS degree. They think, if everyone else has a Master’s, why don’t they?
- “Our motto is ‘hire the brain and farm out the brawn.’ We keep the organization small. For repetitive tasks, we contract out.”
- “The work we do, it’s not the manufacturing setting, it’s on the discovery side. So you have to be insightful, not Mr. Potato Head. You have to say ‘I did all this, but I have questions, so I need to talk to the senior scientist about this.’ So we prefer bachelor’s students, whose plan is to complete a master’s or Ph.D., someone whose intellect is at that level, someone inquisitive when doing their work. Community college students don’t want to go further, they’re not so inquisitive....”

A faculty member at San Jose State University’s biotech program, who is very involved in Bay Area industry-education partnerships, particularly at the high school level, offered another



explanation for employer reluctance to hire community college graduates in R&D positions: namely, that scientific research requires a degree of maturity that community college students—and California State University (CSU) students as well—do not possess:

It's not all bias. CSU students have just as hard a time as the California Community College students. In general, students in each of those systems have not reached a certain level in high school of maturity, responsibility. They haven't reached their full potential, or they need extra time. They have a lot more catching up to do to reach the level of someone doing independent research. It does take a certain personality to do that. I see such types at CSU, but it's rare. Even students in the master's program at CSU are not up to the UC level in their ability to do research, lab work. Occasionally, one or two students really stand out.

The next chapter offers several examples of companies whose perceptions regarding community college students have changed as a result of working with the partnership programs. Indeed, as hypothesized, a key role of the partnership programs involves shifting employers' perceptions about their entry-level workforce needs in favor of community college graduates by encouraging use of hiring criteria based on competencies rather than traditional measures of educational attainment, such as a four-year degree. In addition to training future technicians, then, the programs aim to legitimate the community college population as a viable candidate pool. Partnership programs do this in a variety of ways, including employing a job developer to reach out to companies to raise awareness about the types of skills students gain in the program; inviting company staff to sit on the college's industry advisory boards and to participate in curriculum review; developing internship opportunities allowing companies to "try out" community college candidates; and ultimately building trust with staff by soliciting and incorporating company feedback regarding the training and preparedness of program interns and graduates.

3. Even if partnership programs do succeed in changing the hiring practices of smaller, research-oriented companies in favor of community college graduates, this development arguably would not be as responsive to industry needs as efforts to develop other kinds of training, such as training for clinical laboratory technicians.

As argued in previous chapters, sector partnerships are heralded for their ability to stay responsive to employer needs. In the regions studied here, biotech training partnerships have succeeded in meeting manufacturing employers' demands for a well-trained, technician workforce. While the availability of a well-trained workforce is an important factor shaping company decisions to remain in an area, or to locate or expand there, other factors, particularly the state's regulatory climate, tax burden, and cost of living, appear to be more important. The consensus view is that, within California, such factors point to a decline in extensive, large-scale manufacturing.<sup>131</sup> It is perhaps indicative that Genentech has opened manufacturing facilities in Hillsboro, Oregon and Singapore, although it also has expanded its Vacaville, California facility.

The next two chapters will discuss this issue in greater depth. The question posed here is whether community college biotech programs can remain relevant if the state's bio-manufacturing base shrinks considerably. As a number of researchers have argued with respect to the information technology/high-tech industry in Silicon Valley, while outsourcing may occur with respect to lower level jobs, high-level, research-oriented work likely will remain and thrive in the region, given its extremely high levels of intellectual and venture capital, and supportive regional environment (Piore 2004; Saxanian 1994). If the same proposition holds true for the biotechnology industry, community colleges would do well to shift additional resources to better meeting the needs of smaller R&D firms. However, as the evidence regarding the composition

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<sup>131</sup> As noted earlier, it is likely that a certain level of manufacturing always will remain in the Bay Area. To get FDA approval of a drug product, the company's manufacturing facility must be licensed as well. Hence, until licensure, it is common for companies to keep their manufacturing facilities close by its R&D labs to ensure oversight. The high concentration of companies headquartered in the area, together with the large number of drugs currently in the pipeline waiting for approval, suggests that manufacturing will remain local for some time.

of the entry-level workforce in the companies under study here suggests, there may be limits to the ability of biotechnology partnership programs to open up significant opportunities for program graduates at these firms. Financial constraints facing smaller companies are of perennial concern, limiting the ability of those companies to hire entry-level staff. Moreover, many companies' biases in favor of bachelor-degreed candidates for research jobs may be too ingrained to change so as to address students' needs for employment in a timely manner, particularly in these punishing economic times.

An HR manager at Amgen argued:

Technician positions are no longer feeder positions. The community colleges are behind. They geared up to supply large companies with such a workforce in 2000-2001, when those companies were entering manufacturing. Now, these companies have gone past this, they're moving to the next phase.

In his view, the next phase involves "quality-type work," e.g., quality assurance and quality control, as well as regulatory compliance. He noted that it can take from six months to one year of quality training for an employee to qualify for a quality assurance validation position, and that offering such training at the community college level would allow the entry-level employee to more easily move from a technician position to other parts of biotech. In fact, the Biotech Workforce Network developed a Quality Control and Facilities Maintenance program at five Bay Area colleges in 2007.

Program faculty members, particularly those with close ties to industry, have also proposed new directions in training. For instance, a Solano College faculty member indicated that his program is considering instituting certificate programs in such areas as building management systems and maintenance; clinical trials; forensics ("this is tempting!" he said); imaging ("electron microscopy, nanotechnology will be big"). Currently, his program is

partnering with neighboring UC Davis to take advantage of the opportunities along the “mouse research corridor.” He explained:

Every human gene from the genome project is being put into a mouse, put into reverse and then shut off. There are 200,000 mice involved. It’s hush-hush because they don’t want to draw attention to animal rights activists. So, we’re working with a pathologist at UC Davis, because there are major skills gaps and a need for a para-pathologist, who can do routine things like dissect the mice. We’re making sure our students have enough pathology training. If they can’t identify something, they bring the issue up to a real pathologist. A number of companies engage in this work, such as Jackson Labs, even Genentech, and of course, UC Davis. So there’s a real industry need for these positions, which our program is trying to meet.

This faculty member noted, however, that administrative realities can pose challenges to efforts to be demand-responsive. “Given the economic climate, it’s better to hunker down and focus on the core programs. You need to have a full class, and if you offer specialties, you may get a class of nine, but when the maximum is 20—and nine is under 50 percent—the class will be cancelled.”

A relatively new direction in community college education, which a number of partnership program staff, employers, and state actors are urging community colleges to pursue, involves clinical trials training and clinical laboratory training, two separate yet related occupational areas.

Recent reports suggest that the health care industry faces a severe shortage of clinical laboratory scientists (CLSs) and medical laboratory technicians (MLTs).<sup>132</sup> A white paper by the Healthcare Laboratory Workforce Initiative declares that the “shortage of laboratory science

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<sup>132</sup> “Clinical laboratory practitioners help in detecting and diagnosing disease or pre-disease states, as well as in monitoring the progress and results of treatment. General job responsibilities include the collection, examination, and analysis of body fluids, tissues, and cells for signs of infections, chemicals, abnormalities, and other indications of disease or precursors to disease.” Chapman, Susan et al. 2005. “The Clinical Laboratory Workforce: The Changing Picture of Supply, Demand, Education, and Practice,” U.S. Department of Health and Human Services, Bureau of Health Professions: 8.

workers is one of the most pressing workforce issues facing hospitals today.”<sup>133</sup> While the great majority of CLS and MLTs work in hospitals and clinics, an increasing number of clinical laboratory positions are found in the life sciences industry. In particular, these positions are essential to enabling companies to support the growing, industry-wide focus on personalized medicine, the development and production of which, commentators predict, will remain in the U.S and California for at least the next decade. Personalized medicine involves using information about each individual’s DNA and the ways in which mutations influence his or her response to therapy and drugs in order to provide more successful treatment.<sup>134</sup> To identify patients whose genetic information indicates that they likely will not respond to certain treatments, drug manufacturers are developing companion diagnostic tests, along with new drug products, early in the R&D stages.<sup>135</sup> CLS and MLT staff are especially in demand to run and analyze these tests, as well as perform quality control.

All life sciences companies—not just those focused on genomic medicine—rely on clinical laboratory scientists and technicians to shepherd the company through its clinical trials phase. As noted in Chapter One, the clinical trials stage of the drug discovery process involves pre-clinical testing in the laboratory and on animals, followed by clinical testing on patients.

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<sup>133</sup> The occupational demand for clinical or medical laboratory technicians within California is strong. The California Employment Development Department projects that, from 2006 to 2016, employment in the field will increase 17.1 percent, from 10,500 to 12,300, with average annual openings of 340. <http://www.edd.ca.gov/>

<sup>134</sup> A current U.S. Senate bill (S.976), which aims to expand genomics research, defines personalized medicine as: “The application of genomic and molecular data to better target the delivery of health care, facilitate the discovery and clinical testing of new products, and help determine a person's predisposition to a particular disease or condition.” BayBio describes the personalized medicine field as such: “Decades of advances in molecular biology are now delivering important new diagnostics for Personalized Medicine (PMDx) to determine the patient's response, resistance or toxicity risk before or during treatment, in order to optimize the selection of medical treatments from amongst the alternative options. Patients benefit enormously by not wasting valuable months of treatment time and not undergoing the side effects and physical insult of ineffective or toxic treatments like chemotherapy in cancer.” [www.baybio.org](http://www.baybio.org).

<sup>135</sup> Recent evidence suggests that the use of such tests to exclude patients from clinical trials can improve clinical trials data and increase the chances of FDA approval of the new drug for use in targeted patient populations.” See Bogosloaw, David. March 2010. “Personalized medicine Could Shake Up Pharma.” *Business Week*.

Given the increasing pipeline of drugs expected to come to market in the next decade, the industry's ability to find and retain a well-trained, clinical laboratory technician workforce is critical to these efforts. However, as a former executive director of BayBio, the Bay Area's industry association, noted: "A quadrupling of the San Jose State University's Clinical Lab Scientist's training program, which runs the tests, would only meet the acute needs of hospitals, not the biotech industry." Similarly, the organization's director of workforce and education remarked: "Even with all the CLS/MLT programs in the state, they only meet one-quarter of the needs of hospitals, and so they don't even get to the personalized medicine needs of diagnostic companies."

Currently, there are only eight community college-based MLT programs in the state, primarily because industry internships are necessary for licensure and the programs have not yet been able to negotiate a sufficient quantity of internships. The state approved MLT licensure in 2002, finalized regulations in 2005 and issues the first MLT exam in 2008. The biotech programs face an extra hurdle with regard to internships, since the regulations require that the facility provide a certain number and type of experiences, which the biotech companies are not always able to meet. Community college administrators are working with industry representatives to modify such regulations so as to open up the field to more host biotechnology companies.

In addition to collecting samples of blood or other substances from clinical trials participants, performing diagnostic testing, and providing test results—which only licensed MLTs can now perform—technician-level clinical staff also support data collection and operation of the clinical laboratory, while coordinating documentation related to conducting clinical studies.

A clinical operations manager at Exelixis indicated the qualities that she looks for in candidates for clinical laboratory technician positions:

Someone with the knowledge and experience with GCP: Good Clinical Practices. The [clinical operations] group lives and dies by these. The team is aware that it's hard to get even that year of experience when you're right out of school. The skills are gained on the job, but there are very good classes on GCP out there, such as UC Berkeley Extension. So, that would really stand out if I saw those classes on a resume. Also, the FDA has a self-training course that you can take on line—a refresher course on GCP guidelines. You can put that on the resume as well. I'm surprised that community colleges don't train for this.

In fact, at least one director of the CCC Applied Biotech regional centers (at the Bay Area CalABC) has worked with other partnership staff and various employers to begin development of a clinical trials training program that would provide students with information about how clinical trials are conducted and train them in the data collection and analysis skills necessary to help administer the trials. She suggested that the colleges are very well-suited to providing this kind of training. However, in light of the severe budget cuts to state higher education programs during the current economic crisis, it remains to be seen whether development of such programs will proceed.

## **Chapter 7: Mechanisms of Effective Partnerships**

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As the last chapter argued, the biotechnology partnerships programs under study have been successful in opening up employment opportunities for community college biotech program graduates, primarily in larger, bio-manufacturing employers. This chapter examines the key features associated with these programs' effectiveness, namely, strong employer involvement in the partnerships; and inter-organizational networking and collaboration among the partners, in particular, the formation of inter-organizational networks on the demand side (with employer partners) and the supply side (with public workforce agency and community-based partners). The examples of partnership activities presented below show that, by fostering close ties on both the demand and supply sides of the labor market for entry-level biological technicians, the workforce intermediaries help shape employers' recruitment and hiring practices in favor of program graduates.

### **7.1 Employer Involvement**

As the literature suggests, employer involvement in workforce intermediaries helps to ensure that training and other services are aligned with industry needs, while increasing employer commitment to practices and policies that support employment opportunity and worker mobility. Intermediaries that are demand-driven, i.e., that work actively with their employer partners, are well-positioned to develop deep knowledge of industry needs and thus to create highly responsive programs. By building trusted relationships with employers, such demand-driven partnerships create the foundations necessary for positively influencing employers' workforce development decisions.



A key strategy for developing truly demand-driven programs is to create opportunities for employer involvement in partnership activities. As noted in the previous chapter, there is a wide range of activities that allows employers to contribute staff time, expertise, and/or resources to the partnerships. Those observed in this study include: assisting in curriculum development and review; serving on industry advisory boards; donating specialized equipment and supplies for the community college training laboratories; serving as adjunct faculty or teaching parts of training sessions; participating as guest lecturers at community college conferences; participating in community college job fairs; offering company tours and job shadowing opportunities; offering student internships; and providing direct money and support for grants.

All the partnerships examined here make use of industry employees as adjunct faculty or co-faculty. This form of employer involvement functions as an especially powerful means of strengthening program curricula, as well as of developing network ties between faculty and company staff by establishing a chain of a formal (or informal) contacts. Another highly effective device for forging ties between programs and employers is the provision of student internships, which, among other things, helps build feedback loops between partners, thereby ensuring program responsiveness to industry needs while also promoting industry buy-in. Each of these demand-side mechanisms is discussed in turn.

### **7.1.1 Adjunct Faculty/Instructors/Guest Lecturers**

Every community college biotech program under study has employed industry representatives as adjunct faculty or lecturers. Some partnership initiatives, such as San Diego County's Life Sciences Pilot Project, recruited all of the instructors for the program's classroom training

component directly from industry.<sup>136</sup> Moreover, many full-time, community college faculty members have worked in industry, either as full-time employees prior to joining the faculty or through externships and sabbaticals while teaching. Every one of the instructors in the City College of San Francisco's Bridge to Biotech program, for instance, previously worked in industry. At Skyline College's biotech program, which likewise has recruited heavily from industry, the lead faculty member spent his entire sabbatical at Genentech, where he worked full-time to understand how the company operates and what its needs are with respect to its entry-level technician workforce. Upon returning to Skyline College, he spent additional time reflecting on how to create a program that would meet the needs, not only of Genentech, but also of the biotech industry more generally. As he observed, this "open door" between industry and the community colleges promotes a cross-fertilization of applied and theoretical concepts that enriches program curricula and instruction.

Many industry co-faculty teach in the program for extended periods of time, thereby cementing the formal ties between the company and the community college program. An example of a long-term teaching commitment involves a scientific manager at Genentech, in charge of the company's antibody group, whose relationship with the City College of San Francisco (CCSF) stretches back to 1995. This instructor began teaching at CCSF as a consultant in the science department's "Introduction to Immunology" class, a one-week course that took place over two evenings. Working with the course professor, she helped to develop the class into a two-week segment, then a four-week segment, and eventually into a full-semester offering. She also became involved in developing a pilot course for the college's Bridge to Biotech program. Over the past 14 years, she has taught a full-semester "Molecular and Cell

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<sup>136</sup> Several of the industry instructors who taught the semester-long classroom part of the certificate program had taught at MiraCosta College before.

Biotechnology” course, which takes place two nights a week (four and a half hours each night, for nine hours total), and which involves a lab component. She also has taught two short courses: “Introduction to Immunoassay,” a 24 hour (one unit) course that takes place over three consecutive Saturdays; and a 24-hour Western Blotting technique course. In addition to her time at CCSF, she has spent several years teaching immunology at Skyline Community College. She stated that, on account of the large number of instructors coming from industry to teach, the community college programs are “hugely valuable” to the students.

Another ongoing relationship between a scientist, now at Bio-Rad, and two San Francisco Bay Area colleges showcases the diverse range of activities that industry-education partnerships can undertake for the benefit of both students and companies. The formal relationship began when the scientist, who had recently founded a small startup, approached the director of Community College A’s biotech program, whom he knew personally, with a proposal to collaborate on a project. Specifically, the startup had received a Department of Agriculture grant to work on small molecule production with a bacterium involved in citrus fruit, and needed certain lab equipment, such as a shaking incubator, to undertake the work. The program director turned to the director of Community College B’s biotech program, which had the requisite equipment.<sup>137</sup>

The collaboration promised to be a win-win for the college and the company, as the program director explained:

We had the right equipment for him, and this equipment was being dramatically underutilized. It was being used for only certain courses and in certain labs during certain times of the year. So his use would make no negative impact on our classroom use. He was willing to have students participate in the project. Students, as a part of their academic experience, could work on a REAL project for a real start-up company.

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<sup>137</sup> The Community College B faculty member noted that, in addition to this personal introduction, a newly hired chemistry faculty at the college had worked with the scientist previously, “so there were terrific references through the grapevine.”

After securing the support of the math/science dean and the college president, the program director approached the college's Board of Trustees, which expressed interest in the proposal. Anticipating that one member might want a "cut of the profits if the product succeeded," the director offered 0.5 percent of future revenue. Eventually, the parties settled on a figure of around two percent, and the Board formally approved the project. The director drew up a quick contract using an online template, and work was scheduled to begin.

Unfortunately, the project never materialized. As the director explained:

The lawyers got involved and it all went to hell! The lawyers said that our quick contract wasn't good enough, that they would have to draft something. I had anticipated that they would bring up liability, but [the startup] had its own insurance. And we waited, and waited, and waited. When they came back they argued that if we allowed [the startup] to use our facility, then we would have to open the facility up to absolutely any member of the public who asked. What? Aren't we entering into a contract with this particular company? Can't you make an exclusive contract? Anyways, they just weren't good at addressing these things. Our college doesn't have a staff lawyer and keeps one on retainer as a consultant. I don't think that they really wanted to pay them for this analysis. The proposal died with a whimper.<sup>138</sup>

The Community College A program characterized this episode as a "tremendous opportunity wasted," since it would have allowed the program to develop a course around the research in which students would have undertaken research for the company, gaining valuable training. Nonetheless, the relationship between the scientist and the program has continued. In addition to joining the biotech program at Community College A as an adjunct faculty member, the scientist, now working for Bio-Rad, has entered into a partnership with both Community College A and Community College B to beta-test several of Bio-Rad's new educational products,

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<sup>138</sup> The director stated: "If I had to do it over again, I would have done this "under the radar" by having [the scientist] sign up as an independent study student of mine. Or hired my own lawyer...."

in particular the company's Biotechnology Explorer kits.<sup>139</sup> As the program director at Community College B noted, "We beta tested their newly marketed experiment where students clone the gene for GADPH from a mystery plant and then get it sequenced to end up in a publication. The college beta tested a new "Biofuels" education kit that Bio-Rad is working on, as well as a protein staining technique. [The college] is featured in the company's catalog—our lab technician is on the cover."

The following sections discuss two key benefits of recruiting instructors from industry to teach in the programs: 1) Ensuring that the concepts and techniques taught in program courses remain relevant and reflective of industry needs, thus enabling the programs to deliver appropriate skills in an up-to-date curriculum; and 2) Assisting the program's job placement efforts by enabling the instructors to screen future hires in the course of assessing their abilities.

#### Industry-relevant course offerings

As Benner (2003) argues, fast-changing skills requirements hinder the abilities of educational institutions to offer in-demand curricula and even of firms to provide learning environments that reflect the latest skills sets. To the extent that labor market intermediaries "incorporate subtleties in skills demands into their training programs," then, they can play a key role in shaping labor supply (ibid. 629).

There is substantial evidence that all of the biotech training programs in this study have been effective in gaining a deep understanding of changing skill requirements and in incorporating those requirements into their training curricula. Repeatedly, throughout my industry interviews, company staff noted the relevance of the various programs' course curricula,

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<sup>139</sup> Designed for use in life science courses at the high school, community college and university levels, these kits provide laboratory-based activities that enable students to conduct experiments around the basic techniques of DNA technology. See "Life Science Education" page on <http://www.bio-rad.com>.

particularly its laboratory components. For instance, a production manager at Genitope remarked that: “While some B.A.s may have lab experience, the key difference is relevance. It’s the same lab [class], but the community colleges are using relevant equipment. The equipment may be outdated, but it’s relevant, and they [the community colleges programs] emphasize it.” Similarly, a production manager at Cell Genesys observed: “The four-year courses [in the sciences] are more theoretical because the schools don’t know where the students will end up, which could be in very different areas. So, the students get a wider variety of knowledge at the four-year colleges, but it’s not as relevant. The community colleges tailor the labs and the coursework to the work the companies are doing now.”

The effort involved in creating relevant course offerings can be intensive, as illustrated by a current Amgen employee’s development of a Clean Room class for Ohlone College’s bio-manufacturing certificate program. The employee learned about the industry-instructor job opening through an advertisement that Ohlone had placed on the company’s local (Fremont) website. Having taught cGMP procedures for years at his previous company, he decided to give college-level instruction a try. He interviewed before a panel of four program faculty, who probed his ability to teach in areas in which the program sought to develop courses, such as writing SOPs, knowledge of GMPs, and clean room technologies. He chose to develop a clean room course because:

If you really want to be prepped for an (entry-level) job in industry, for example in manufacturing or environmental monitoring, you need to understand clean room operations and aseptic practices. You need to have real skills to offer, and also to know what you’re getting into, if manufacturing is for you. It’s a claustrophobic environment. One woman said [after taking his class], “I won’t do this!”

He noted, moreover, that certain processes, like gowning, are qualifications-driven in the pharmaceutical industry, i.e., before even stepping into the manufacturing operations, the

employee must qualify to perform the task, usually by repeating it a certain number of times pursuant to industry criteria.

It soon became clear to him that he had free rein to develop every aspect of the course, in part because few of the faculty he worked with had in-depth knowledge of clean room procedures and he had nearly 12 years of industry experience in this setting. To ensure that students would have an understanding of clean room protocols and clean room gowning, he not only designed the course content, lectures, and quizzes, but he converted the only available room—a small, barely adequate space—into a mock-up gowning room. He ordered equipment and supplies, such as a bench and gowns. He arranged for different functional groups within his company to donate gloves and masks, and for a supplier in the company's Fremont facility to donate gowns and booties. He brought in guest speakers from other departments of the company, so the students would learn about the entire operations.

Integrated into the college's certificate program curriculum, the course began as half a unit, offered one night a week for six weeks. When he took a leave from teaching the course after three semesters, the community college department was in the process of making the course a mandatory program offering.

### Job Preparation and Recruitment

As industry employees, instructors bring to their classes their experiences hiring and managing employees, or their knowledge of what other managers look for in job candidates. This information can help prepare community college students for industry employment, while potentially opening up job opportunities in the instructors' companies. For instance, based on her experience as hiring manager for her group, an adjunct faculty member at Skyline College and CCSF realized that what often went missing from the skills sets of her bachelor- and master-

degreed hires was coaching or mentoring in preparing for a job interview. Recognizing that poor interviewing skills can stymie even the top students, she thus incorporates resume writing and interviewing techniques into her community college courses. Because she keeps in contact with many of her former students, who often seek her advice when they are updating their resumes, she is able to refine her counsel regarding the job application process.

This adjunct faculty member also has recruited job applicants directly from her community college classes. One example demonstrated the persistence required vis-à-vis HR staff, even when the job candidate was highly credentialed. The student was a corporate attorney with 10 years experience, an impressive academic background (a JD from Harvard), and bar licensure in three states. Deciding that her career was too stressful, and financially able to withdraw from the labor force, she moved to the West Coast and enrolled in CCSF's semester-long biotech certificate program with the aim of branching out into a new field. Impressed by this student's abilities, the course instructor recommended her to Genentech's HR department. However, even though the student was at the top of her class, HR and the group's hiring manager resisted her application because she had no science background (save a few college chemistry courses) and had been enrolled at CCSF for just one semester. But, convinced that she would do a stellar job in the company, the instructor actively supported her application. The student eventually was hired and successfully worked in the instructor's group for several years before moving to a Quality Assurance position within the company.

As the above examples demonstrate, hiring adjunct faculty can bestow myriad benefits on the programs, the students, and the instructors (who gain teaching experience), but there also may be costs. For instance, a faculty member from one community college program, which has aggressively recruited adjunct faculty, remarked:



It's a hardship for the program because even if the person has an interest in higher education and is maybe thinking of it as a second career, they're often terrible teachers, so the college needs to undertake lots of development [of the instructor] to prepare them to be effective instructors.

But once that transition is made, they [the adjuncts] are incredibly generous allies. Also, the students love having opportunities to speak with someone working at, say, Genentech or to have [that instructor's] email address to take past HR.

Because of the benefits, however, a number of colleges have fashioned various institutional arrangements to maximize the use of industry co-faculty. For instance, Ohlone College took its semester-long (16-18 weeks) bio-manufacturing certificate program and broke it into several three-week modules, with most or all of the modules taught by different faculty. This allowed the program to hire industry faculty who were unavailable to teach an 18-week course but could commit to a shortened class schedule. Contra Costa College addressed the perennial uncertainties surrounding the funding of industry co-faculty by institutionalizing the instructor positions:

We put these working professionals through the complete hiring process. It was a bureaucratic ordeal, but we succeeded in hiring them, and they continue to teach. Now, when the state budget allocation allows us to hire adjunct faculty, we do. These faculty are evaluated like full-time faculty, they have rehire rights, and their compensation is higher than the stipends they would normally get. It has allowed us to keep these wonderful people. But these arrangements can take years to develop.

The adjunct faculty, who hail from such companies as Genentech, Bio-Rad, and Bayer, teach several of the program's specialized courses, including ELISA, PCR, GMP/GLP and protein purification. The college program lists the names of these faculty and their company employers on its website, a powerful marketing tool for the program.

### **7.1.2 Internships**

Virtually all of the partnership programs under study here include industry internships as an integral program component. The WIB-funded programs (the Life Sciences Summer Institute

and the Biotech Workforce Network/Life Sci X programs) guarantee paid internships at participating employers, supported jointly by the employers and the workforce investment boards.<sup>140</sup> Biotech Partners offers paid summer internships for high school students and year round, co-op jobs for community college participants; the CCSF's Bridge to Biotech program offers internships to students completing its "Internship and Job Preparation Program;" and Southwestern College's biotech program offers students ten-week, paid internships as part of the NSF-funded BETSI program. A number of stand-alone community college biotech programs (e.g., Foothill College and Berkeley City College) require or encourage their students to find internships as part of the certificate program.

In addition to providing students with critical hands-on, industry experience, internships serve to promote industry recruitment and hiring of students; assist with program outreach to industry; and generate key feedback loops between the programs and employers, which heighten the programs' demand-responsiveness. Each of these mechanisms is discussed in turn. It is worth noting that, while the conventional wisdom asserts that smaller companies lack the time and necessary financial resources to support student interns, all of the company examples used to illustrate internship-based partnership mechanisms in this study involve smaller, researcher-oriented firms.

#### Job Recruitment/Screening

One of the smallest partner companies in the sample, T12-BA, with 25 employees, created its internship program explicitly as a hiring and screening tool. As the company's HR director explained,

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<sup>140</sup> The Biotech Workforce Network program called the internships "subsidized 12-week on-the-job, try-out employment positions." As noted earlier, funding for the latest incarnation of this program (LifeSciX) ended in June 2009.

As a small company, it's crucial that we identify the right people and make sure that they fit in. The best way [to do this] is through an internship program, which allows us to evaluate the intern's abilities. For a small company, this is very important."

The company has taken a number of interns from the Ohlone College biotech program; the interns work in the company's manufacturing, R&D, and inside sales (marketing) departments. In fact, as the HR director stressed, the company only takes interns from the Ohlone program (apart from the few interns from area high schools who perform data entry). As discussed below, all of these candidates have a bachelor's degree in science or higher.

Finding it very difficult to properly evaluate candidates in six or eight weeks, the length of traditional internships, the company initially structured its internship program to last four months. However, the company realized that it was taking about two months for the students to learn the necessary company-specific techniques, so it increased the program to six months. The first three months of the internship are unpaid and the latter three are paid, after which the company makes hiring offers. The company has hired most of its new employees from this intern pool. As the outcomes data presented in Chapter 6 indicated, 16 percent of the company's entry-level technicians have a biotech certificate (from Ohlone). Its present hiring rate is 50 percent from the community college program: two of the four candidates to whom it has made or plans to make offers are from the program.

The HR director is quick to point out that the Ohlone interns may not be "typical," since many already have a Master's degree in science (typically from India, their birth country), and several have worked for numerous years in science-related fields; as such they are "extremely well qualified" for the job. Having worked with the Ohlone College internship coordinator for some time, she said that she feels confident that the program will always send her top candidates.

Another small partner company in the sample, T8-BA, with approximately 45 employees, also takes a significant number of interns from Ohlone College. The origins of the company's internship program challenge the conventional wisdom that smaller or early stage companies are less capable of supporting internships. As a (former) senior scientist at the company explained: "The internship program was born out of necessity. After 9/11, the budget was very tight, the company wasn't hiring. The only way to get the work done was to have interns do it." Previously the head of the company's internship program (until he resigned recently to start his own company), as well as a long-term, adjunct faculty at Ohlone College's biotech program, this scientist noted that the internship program has since evolved as a key recruitment tool for the company. He outlined at length the motivating philosophy and pedagogy that have enabled the program to thrive. As this discussion sheds light on relevant aspects of employment within smaller biotech companies, I reproduce much of it here, paraphrasing when necessary:

People view internships, especially at a larger company, as a charity, which they have to spend money on rather than getting something out of it. As a start up, we could not afford to spend one minute being charitable, doing a favor for someone. So we devised a situation: if you come to our company you will learn about the work of the company, about its place in the industry. We're not going to assess you on how well you make solutions or do a hard molecular biology project and succeed. Instead, we're going to ask you to do manual tasks, working alongside scientists.

So, if the scientist needed help transplanting plants, the interns would do it. They were really participating, doing something that really needed to be done, partnering in the work of the company. They had the chance to talk to the scientists every day. If a scientist happened to need someone to assist them with their work in molecular biology, maybe the interns would get to do that, but it wasn't a promise. Instead, the promise was that you can see what goes on in the company while doing manual tasks, and we can help you think about your career.

We found that it was more important to give them an opportunity to watch scientists work than to require them to have lots of references and give a research talk. So, we weren't assessing how well they do chemistry. Instead, we could see how well they

made solutions by watching them transplant. It was a simple means to see how well they performed.<sup>141</sup>

The work was menial, but most of what PhDs do has lots of repetitive stuff. The job is really about the culture of the company, how people get along, and interns become a part of this. They would ask: “Do we really have to transplant before lunch? Does it really matter?” That discussion would not take place without the interns being on the spot.

It’s hard to put together a program for students where they learn about the company. At Mendel, it’s very fluid because it’s small. The interns can go to company meetings to see what’s happening. At a larger production company, if there are multiple layers of management above the intern and they are isolated from decision making in the company, the internship may well be charity.

Interns are not just something you did when you had extra money. When a company is not doing well, get more interns in! You have to create a win-win, a net benefit to the company.

### Outreach to Companies and Feedback Loops

An innovative feature of the CCSF Bridge to Biotech program is its Internship and Job Preparation Program (IJPP), which prepares program participants for work as interns in local research laboratories. As noted in Chapter Three, the Bridge program was founded in partnership with San Francisco Works (SFWorks), an affiliate of the San Francisco Chamber of Commerce and a nonprofit workforce development organization. Until its grant funding ended a few years ago, forcing it to move on to other projects, SFWorks offered the Bridge program such services as internship development and job placement. Once SFWorks withdrew from the program, the Bridge has had to provide many services on its own. However, as the program director stated, “We’re getting exhausted trying to find internships.” Consequently, the program

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<sup>141</sup> With respect to his experience teaching high school students in an outreach program, a production manager at a medical device company articulated a similar philosophy: “So often, people try to bring in disadvantaged students and show them what to dream about, or get them artificially involved. But it’s better to treat them with respect and include them in what you’re doing. That’s much more important than giving them a dog and pony show, heavy on field trips, wowing them with new machines, but light on getting them involved, having them learn some skills, interact with others, participate in something that’s real. Have them learn about the different levels people are working on, that is mentoring!”

designed the elements of the IJPP curriculum to promote company outreach and necessary feedback loops between intern sites and the program.

The first step to securing an internship involves students completing an “interest and availability” survey that specifies the kind of laboratory environment that they would prefer to work in, as well as the particular project they would like to undertake. Next, the students conduct research to identify two or three local research laboratories that fit these criteria. This research helps the Bridge program develop outreach to additional companies for student internships and job placement. CCSF sends letters to these companies, indicating that the program has students who are interested in interning in its laboratory.

Once the students have identified the labs in which they would like to intern and the company agrees to host qualified interns, the students write an internship posting similar to those that companies direct to prospective interns. Describing the project and stating the hours needed for the lab intern, the basic skills required, and the marketable skills that the student will acquire on the job, the posting outlines the student’s learning objectives and skills that they are expected to acquire. The program evaluates those skills in the students during the lab practicals that take place at the end of the IJPP class.

Finally, the students send this internship posting and their resume and cover letter, developed in the bridge, to the prospective internship site to set up the interview and schedule a site visit. The company selects interns from the program based on this application package, which helps to promote greater employer buy-in.

Midway through the internship, the program sends a survey to the student’s lab supervisor asking for feedback on the intern’s performance. This effort is especially useful in catching any “red flags, like: ‘Oh, the intern hasn’t been here in 3 weeks’.” This employer

contact also serves as an important means for establishing a relationship with a new supervisor, whose expectations eventually become “calibrated to the program.” Moreover, in this way, the interns become “ambassadors for the program.”

At the end of the internship, the program asks the supervisor to conduct a final interview with the student in order to assess whether the student achieved all of her objectives and asking the student to evaluate her experience. The program also asks the supervisor to help the student update her resume based on her work, and to serve as a reference for the student. The program director commented on this process:

The end result is: either the student is more trainable than the employer expected, or the skills required in the internship are too much for the student. Either way, the program is getting great feedback and the supervisors are putting out information [about the program] to their colleagues.

## **7.2 Inter-Organizational Networks**

The sociological literature on network theory and job search suggests that workforce intermediaries that develop rich networks of social contacts improve the career outcomes of job seekers, particularly low-income individuals, by helping them gain access to education and training opportunities and to obtain and advance in employment (Granovetter 1995). In its evaluation of social network theory, the literature on labor market intermediation counters that improving career outcomes requires more than the ability to generate social capital and network ties on the supply side so as to enhance worker employability and mobility; it also requires network actors—the LMIs themselves—to build strong ties on the demand side (Harrison and Weiss 1998; Benner 2003; Bernhardt et al. 2001).

The biotechnology training partnerships examined here engage, to varying degrees, in network formation on both the supply and the demand sides. Supply-side networking primarily

involves developing relationships with public workforce agencies, i.e., One Stops, and/or community-based organizations, e.g., SF Works, while demand-side networking involves relationship-building with employers. As the following examples show, the WIB-funded programs appear to have achieved the strongest network formation on both sides of the labor market, while the Regional Centers and individual community college biotech programs are generally more active in their demand-side collaborations.

### **7.2.1 Demand-Side Ties**

As Harrison and Weiss (1998:68) posit, a key structural explanation for the effectiveness of workforce intermediaries is their ability to incorporate themselves into the “trusted recruiting networks of area companies.” For instance, the highly successful Center for Employment Training (CET) in San Jose undertook an approach that “gradually penetrate[d] this cluster of companies by working closely with a few firms, developing trust, and gradually transforming weak ties into strong ones—literally becoming part of the procurement and human resources systems of the valley” (ibid.).<sup>142</sup> Likewise, the biotech partnerships under study here all seek to assemble a strong network of local employers who increasingly rely on them to source their entry-level technician workforce. Indeed, an apt description of how employer ties are meant to work is captured in the experience of a Bay Area program, whose director has developed a very strong partnership with the CEO of T16-BA, a small (under 20-person) contract HPLC lab in a Contra Costa County town:

The CEO has been very involved with the program for the last 15 years. When he has an opening, before he posts it on Craigslist, he calls us to see if we have somebody who might be a fit.

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<sup>142</sup> Harrison and White (1998) contend as well that CET’s links to supply side institutions, such as unions and religious organizations, were also very important to its ability to improve clients’ labor market outcomes.



### Job Development/Employer Outreach

As the Northern Hub director of the California Community College's Applied Biotech Initiative observed, the rule of thumb in the San Francisco Bay Area is that personal networking is the primary means for employers to find workers. Indeed, nearly all of the companies in my sample indicated that "recommendations by current staff" was their primary recruitment method for entry-level technicians. After networking, the director stated, the next major recruitment source is online postings on Biospace and Craigslist, followed by job fairs (the newspapers, he said, are used only to "justify the green card"). My data collection also confirms this hierarchy of staffing sources: online job boards and company websites were the next most important recruitment methods, along with recruitment agencies (where applicable), and followed by job fairs.

Three brief examples illustrate the role of personal recommendations and industry ties in recruitment and hiring of community college biotech program graduates. First, a Bay Area community college biotech program director observed:

The program has also been able to successfully place certain students, with or without a 4-year degree, in BioRad Labs. Before, [that] company would not even consider non-BA applicants, but because of the strong relationship we have with the manager there, we have been able to place students in [this] high growth-potential lab. But, there's no formal pathway. In each instance, the ability to place former students in jobs is through luck and by networks.

In another example, the Alameda County Workforce Investment Board, which had co-developed the Life Sci X program for displaced workers from the mortgage and real estate industries, enlisted the help of the director of the local biotech program to place in employment an "exceptionally adept student" enrolled in the director's program. Aware of an opening at a local company, the director spoke to the company's R&D manager, who offered the job candidate a management position in data analysis, the candidate's original field of work.

Although the candidate was not placed in the laboratory, the program has since succeeded in placing a number of other students in the lab, on account of its connection to this candidate. As the director noted, “This is ‘contact building,’ and the critical step is getting the first person through the door.”

Third, several company directors indicated that they initially decided to work with a local community college program to hire interns, and later to partner with the program, because of personal connections they had with program staff. For instance, the Chief Scientific Officer and co-founder of a small R&D company (T13-BA) explained that she knows the faculty member who coordinates the internship component of the college biotech program because their children grew up together, and they socialize on a regular basis. Further, the co-founder and owner of Company T14-BA learned of the City College of San Francisco’s Bridge to Biotech program because a program faculty member had been a post-doc working with a collaborator of his when both were at UCSF. “The [faculty member] knew I left UCSF to start a company and later contacted me and said ‘Remember me? We have this great program at [CCSF].’” The founder of Company T15-BA likewise learned about the Bridge program through a colleague who was on the CCSF faculty at the time.

Like the HR director of another small company (T12-BA) that has partnered with the Ohlone College biotech program, all three company directors indicated that they trusted the recommendation that their personal contacts made as to both the program and potential interns and/or full-time employee hires. As the Chief Scientific Officer of Company T13-BA commented: “If she [the biotech program’s intern coordinator] highly recommends someone, I know [that candidate] will be a good find. She only recommends good ones.”

Conversely, the CCC regional hub director argued, employers who are not aware of the community college programs through a personal connection are much more likely to pass on a community college student's resume that is posted on a job board like Craigslist, or even on the company's website. Based on his experience working at a start up, which has since become a multinational biopharmaceutical company, he found that relying on job postings is problematic for both employer and employee because, within minutes of placing the advertisement, biotech employers typically receive hundreds of resumes; even when the position listed is for glass washer (a low-level position), numerous Ph.D.s respond (a dynamic that the severe economic downturn has no doubt intensified). Moreover, he claimed that the quality of the applicant pool was always extremely high, a trend that many of my respondents have confirmed. His chief concern was that the company would have a hard time attracting such star applicants as it grew in size.

Based on such experiences and the importance of social networks, the regional hub director has concluded that the main challenge currently facing community college programs is their low visibility. The programs must "get on the radar screen" of employers, he proclaimed, by raising awareness among industry personnel that the programs do graduate quality candidates, whom the companies should consider as potential hires, especially when they expand operations. In fact, it is when companies are beginning to consider ramping up for production that a community college program can have the most impact, by shaping the companies' understanding of their future workforce needs and potential sourcing venues. Such an effort is particularly important in a relatively young industry like biotechnology industry, with its origins in the 1970s. As an HR staffer at Exelixis observed, unlike employers in more mature industries, like the pharmaceutical industry, biotech employers have not tended to "go through the process of

determining what's really required and defensible" with respect to their workforce needs. Moreover, as noted in the preceding chapter, virtually every one of my company respondents (HR and scientist/production manager alike) pointed to the industry's academic origins, with Ph.D. scientists founding the startups, as the prime explanation for the industry's bias in favor of candidates with advanced degrees. Finally, smaller, research-oriented companies—of which there is a proliferation in the Bay Area and San Diego Area (the two regions under study)—typically lack an HR department, which usually emerges as the company evolves through the biotechnology growth cycle to reach the clinical trials stage, when the workforce might reach upwards of 50 people.

Accordingly, the role of this regional hub director largely involves increasing awareness among employers of the community college programs, which he undertakes primarily through networking and relationship-building with company staff.<sup>143</sup> The CCC Applied Biotech Initiative likewise charges each of the six Regional Centers with this outreach role. The directors of two of the centers located in the San Francisco Bay Area (CalABC-Bay Area and CalABC-Silicon/San Joaquin/Central Valleys) affirmed that personal networking is the key strategy that they use to build connections with employers and ensure that HR and scientific staff are aware of the different educational pathways that students may take to obtain the relevant industry skills. Among the primary outreach methods that these directors employ are:

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<sup>143</sup> The hub director indicated that he is working on a number of strategies for community college programs to increase their visibility with industry, while boosting industry engagement in the programs. He sketched two "dream" strategies, as follows:

1. Honors program. In this two-year long honors program, students would not receive grades. Instead, an outside examiner—not the course professor--would write the exam based on a review of the curriculum. The director explained that this arrangement would "keep the professor up to date. It would be as much a test of the professor as the students."

2. "Iron Chef in the Lab": This activity would involve community college students volunteering to "show off what they've learned" in front of an invited audience of industry staff. There would be a sealed envelope with a problem in it, and the students would have several hours to solve it.

- Attending industry association meetings, including scientific and HR associations.
- Attending legislator’s meetings, e.g., a California state select subcommittee hearing on the biotechnology industry.
- Participating in area task forces, e.g., the San Mateo County Blue Ribbon Task Force on Biotechnology.
- Cold calling HR staff and sending them program literature in the mail.
- Sending email update to incumbent workers, who have taken upgrade training courses at the colleges, about new and upcoming workshops, and asking them to tell their industry colleagues about the courses.
- Asking adjunct faculty from industry about their contacts in previous companies in which they worked.

The full-time job developer for the WIB-funded Biotech Workforce Network added that outreach to companies involves “hitting the pavement, knocking on employers’ doors—otherwise they would not know about [the community college programs].” She considers herself a “go-to person” whom industry can call regarding its workforce needs. Because her background is in the staffing industry, she is immersed in the industry and knows who all the players are.

The Biotech Workforce Networks’ very high job placement rates (see Chapter Six) are attributable in large measure to her success in establishing contacts at companies and developing a network of employers that could be counted on, not only to hire graduates, but also to contribute in other ways, such as supporting industry faculty, offering company tours, or donating lab supplies.

The center and regional directors are continually trying to devise creative ways to reach out to companies. For example, one of the CalABC center directors (who herself is a scientist who worked in the biotech industry before joining the community college system) has developed a close relationship with the program director of the Bay Area Biotech Human Resources

Network (BHRN).<sup>144</sup> The BHRN director invited the center director to attend and sponsor a table at a BHRN networking event/mixer, which would be attended by association members and industry vendors. As the center director noted, doing so was “buying face time” with HR and other company staff. To maximize this opportunity, she created a short, one-page questionnaire directed to the attendees’ understanding of the community colleges and their programs, and sending the message that community college graduates are “worth looking at as new hires.” To thank participants for filling out the questionnaire, the center director handed out free T-shirts.

Participating in HR events is especially important, this center director explained, because HR staff are generalists, who tend to have a standard set of requirements for hiring managing supervisors, research managers, etc. They do not understand and are not well versed in different and more specialized skill sets, as well as the different pathways that potential employees may take to acquire these skills. She generally has found them to be somewhat rigid in terms of whom to hire or not hire. (However, she noted, once the employee is hired, “HR is great in terms of bringing the employee into the company’s culture.”)

Many of my respondents echoed these sentiments, even company production managers. For instance, a production manager at Cell Genesys, a champion of the community college biotech programs, states that he felt compelled to rewrite many job descriptions at the company, especially the prerequisites for entry-level jobs, so that the descriptions would include the community college biotechnology certificate as a potential option. Convincing HR and other staff members to agree to these changes often entailed tense discussions. Ultimately what convinced these staff was that the community college graduates whom he brought into his group demonstrated capability.

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<sup>144</sup> My relationship with the CalABC-Bay Area director led to a subsequent relationship with the BHRN director, with whom I co-developed an HR survey of employee and technician-level training, as noted in Chapter Five.

According to the Biotech Workforce Network’s job developer, even when the job description indicates that a high school degree or community college certificate is sufficient, “when it comes down to it, [HR staff] prefer B.A.s.” For example, she called HR staff members in one company to inquire about a recently posted job description for a non-bachelor degreed position. However, the HR representative said that, in fact, the company would prefer a bachelor’s degree for that particular position. The job developer then contacted one of the Skyline College graduates whom she knew worked at the company’s manufacturing plant; this graduate in turn spoke with his supervisor about recruiting community college-trained technicians for the position. The supervisor agreed and pressed HR to reconsider its stance regarding the preferred credential, who “had to do an about-face...but they did call [the job developer] back to discuss the position.”

As the director of the San Jose WIB’s biotech initiative explained:

Business likes to take shortcuts; it needs someone who is motivated, etc., so it says that it needs someone with a college degree. But it doesn’t really need that. It just needs a skill set. So, the WIB partner says: let’s start with your specifications for the position and go from there. Then the company says: OK, show me one such student and we’ll go from there. So, it’s an educational process. The issue of transferable skills is critical.

### Successful employer outreach: challenges and opportunities

Based on dozens of interviews with partnership staff, it appears that effective outreach to biotech employers is associated with two primary features: the intermediary’s persistence in establishing employer ties and the ability to engage employees at all levels of the company, particularly at the highest levels. Each feature is discussed in turn.

Persistence. The job developers hired by the WIB-funded partnerships, the California Community College Applied Biotech Initiative center directors, and several biotech program

faculty members all stressed the time-intensive nature of genuine partnership development. One program director, who has gained national recognition for his success in developing strong ties with industry, noted that his program's partnerships "took a long time to build, in many cases since the program's founding in 1996." Indeed, an HR representative at an 800-person, specialty generics pharmaceutical company in the East Bay affirmed this principle from the employer's perspective:

Working with or reaching out to programs is too labor intensive. It's a full-time job to find out what the programs offer in terms of skills levels, etc., and what their expectations are regarding the students. [The company] gets sufficient resumes for recruitment purposes, so we don't need to work with the programs directly to get candidates.

A major obstacle to developing strong and stable ties with employers involves the fluidity of companies and staff. Regarding companies, a center director noted the role of industry dynamics in her effort to engage employers on the advisory committee of a biotech program within her center's jurisdiction:

The advisory committee has grown continually. However, two or three years ago, it seemed to be falling apart; it was losing members because the industry was changing. Lots of new companies were coming into town, the multinationals were gobbling up the smaller companies. The committee had been relying on the smaller companies, so it had to start pursuing the big ones, but this is hard.

The key is to continue inviting companies to the advisory committee, to keep in touch. The problem is that many get acquired—this is the rule not the exception in this industry. So you have to keep on reaching out to small and medium-sized companies.

Company employees also come and go, suggesting a weakness in relying too heavily on personal relationships with such staff as a basis for employer involvement in the partnership. In the words of one faculty member: "You develop close relationships with individuals at companies, but then they move on and you have to go back and do it again." However, short of the "gold standard" in partnership development, i.e., establishing contractual arrangements with employers who formally commit to contributing to the partnership in specified ways (such as



Bayer's development agreement with the City of Berkeley and Biotech Partners), building and rebuilding personal relationships appears unavoidable.

The following two examples illustrate the overriding need for persistence on the intermediaries' part in conducting employer outreach. In one case, a center director found that a company that previously had supported the program stopped being responsive to the program's efforts to engage it in partnership activities after a scientist at the company, who also was a long-term adjunct faculty member at the college, left to start a company of his own. As the center director described her experience after the ally's departure:

I sent the company director invites to the advisory committee meetings and contacted him several times a year for two years. But there was never a response. Then finally, he [the CEO] said, "I'll pass this on to the new VP of HR," which he did, and [the VP] gradually but surely came through. He sent speakers for conferences and sponsored internships. He has hired from the program and has intentions to hire more. So, the company is again very supportive. But this took lots of perseverance.

As this example suggests, the fluidity of personal connections also can be an opportunity, particularly where the company gatekeepers (typically HR staff) are dismissive of or otherwise reluctant to partner with community college programs. The second example of persistent employer outreach highlights this potential upside to partnership networking. One of the center directors had met an HR staffer at the specialty generics pharmaceutical company, mentioned above, at the company's job fair, and subsequently invited her to the community college program's annual job fair. The staffer attended but declined to hire anyone from the fair. She also declined the center director's next invitation to the job fair on the grounds that the program failed to produce the kinds of graduates that the company needed. This company had also declined repeated invitations to attend the college program's advisory committee meetings. In learning of the difficulties establishing ties with this company, the program's dean noted that he had recently visited the company's manufacturing plant, where several graduates of the college's

biotech program were employed. The center director conveyed this information to the HR staffer, who insisted that the company was “more like a pharma company, they don’t hire community college grads, they hire people from out of state. I thought, come on, you don’t need to do that for these positions!” When that staffer eventually left, the center director contacted her replacement, who told her that the company now hires employees through its staffing agency, and encouraged her to contact the agency. The center director invited all of the staffing agency’s representatives to the next community college job fair, who ended up hiring six program graduates at the event. The agency subsequently contacted the representative of the One Stop located at the college in order to hire directly from the displaced worker program that the biotech program was operating.

As the foregoing discussion suggests, successful employer outreach requires dedicated job development on the part of workforce intermediaries. Yet, according to one regional center director:

The community colleges do not have the infrastructure to market themselves. They have a college relations office, which advertises on the radio, in buses, etc. But there’s no one constantly going after industry. There’s no [full time] job developer. So, the task falls on the laps of instructors, who don’t have the time to do this; it’s not in their job descriptions.

A faculty member concurred: “It’s a conundrum. In reality, the faculty do not have time to work with most firms directly, but without doing that, we can’t get our foot in the door.” Similarly, another faculty member lamented: “HR recognizes that they should be assuring a long-range pipeline of workers, but there are always 15 different fires [for them] to put out first....So, they never return the cold calls we make [to them] about our program.” By contrast, a full-time job developer would be able to follow through on such calls, as well as to regularly reach out to HR representatives on their turf, e.g., at company job fairs or industry association meetings.

Faculty members do, however, engage in informal job development, as one faculty member explains:

First, we use our own private, professional networks. Second, we share information [about the program] with biotech professionals who are interested in education. And third, we respond with alacrity and with as much information and support as possible when we are called to be a reference for an applicant. Because the biotech programs are very intense, the faculty really get to know the students and can speak pointedly about their qualifications and skills sets when answering the employer's questions.

Nonetheless, such informal job development, while extremely important, arguably does not substitute for full-time professional job development on the intermediary's part. As noted, each of the highly effective WIB-funded, displaced worker training programs employed such staff. Moreover, the current director of the regional center of the San Francisco Bay Area, the area with the state's highest concentration of both biotech companies and community college programs, is the center's first full-time, permanent director, as previous directors wore several different hats, such as a CCSF faculty member and administrator. However, based on descriptions of the job developer's work, presented here, these full-time professionals appear best equipped to tackle the many challenges associated with demand-side networking.

Deep partner interaction. The second feature associated with successful outreach is the intermediary's ability to reach the "right people" in the company. As noted in Chapter Two, the literature describes this dynamic as "deep partner interaction," whereby a range of personnel from partner organizations interact. That is, executives must commit to the partnership, while the individuals responsible for program operation (e.g., department managers, hiring supervisors, line staff, training instructors) also must have the support necessary to work with their counterparts on an ongoing basis.

Often, the top personnel at both the company—e.g., the VP of Operations, the VP of Manufacturing, or the President/CEO—and the educational partner must interface to establish a true partnership connection. For example, it took the involvement of two such personnel to renew a local manufacturing facility’s engagement with one program, as a center director explains:

Company D was tied at the hip with Ohlone College. It gave the college internships every summer, anything the college asked for. Company T3-BA [which acquired Company D] is a different culture. They’re philanthropic, but the college had to reestablish contact with the company located right across the freeway. This took forever. For instance, at the corporate level, the company has a summer fellows program. But Ohlone wanted someone to sit on the advisory committee from the [company’s local] Hayward site and to give company tours at that site.

Finally, the contact ended up happening through the President of Ohlone College, when the college was opening up its new, multimillion dollar science center in Newark to house the biotech program. The program needed funding for equipment, labs, with state of the art instrumentation. So, the president went to local companies, including T3-BA, for assistance. He got top management on board to support the college program. So, it took communication at that level. Then, gradually, it got through to the lower levels. Someone gave the go-ahead to someone in HR and to the site manager to work with Ohlone. So, finally, after months of trying to gain entry with other staff, who disappeared, we got in.

The lack of such high-level buy-in appears to have hampered the partnership prospects of another company under study here. An administrative assistant at Abgenix had taken a biotech course for non-scientists at Ohlone College, and was very impressed. Once this employee moved to Company T11-BA, she called the regional center director because the company had expressed interest in building a pipeline of well-qualified people. On numerous occasions, the center director has invited the company to participate in training and join the advisory committee, and has copied the company on emails about program activities, but the company has not yet “taken the bite,” i.e., agreed to become involved in the biotech program.

On the other hand, high-level buy-in may not translate into support at the level of HR or hiring managers. A number of faculty members have noted that, even when a company's top management supports the program, e.g., in the form of advisory committee membership or equipment donation, HR staffers often cling to the assumption that technician-level staff must hold bachelor degrees, seemingly unaware that community college graduates are employed at their companies. As one faculty member noted:

The receptivity to hiring someone with an A.S. degree, even in manufacturing, is variable throughout the company; it's not top to bottom. For instance, HR at Genentech says that, to move up to management, the candidate needs a B.A. But then, they realize that three of the eight top people in management were trained by the community college program [and do not have a B.A.].

### A Tale of Two Sites

The center director of the Silicon Valley CalABC says that she has tried for over one year to involve Company C3-BA's East Bay manufacturing facility in the Ohlone biotech program. She has repeatedly invited various company personnel to sit on the program's executive committee, and is in the process of contacting an Ohlone College graduate who is currently employed at the company with the aim of enlisting that employee's support, e.g., by giving a presentation to their supervisor and/or HR staff.

By contrast, the Company C3-BA site in Southern California has actively partnered with Moorpark College, located in Ventura, California. Interestingly, that college—one of the first bio-manufacturing programs in the state—experienced difficulty engaging Company T3-BA at its California headquarters; the company told the dean of the biotech program there that it was not interested in community college biotech programs. After the college established its partnership with Company C3-BA, Company T3-BA “figured it should jump on the bandwagon in a ‘me too’ mentality,” according to a faculty member.

So, why has Company C3-BA's East Bay site been non-cooperative? One explanation, suggested by the above discussion, is that the center director and, presumably, the WIB-funded job developer who worked out of Ohlone until the grant expired, were not able to connect with the right people at the company, who could induce HR or other personnel into joining the partnership. Another explanation is that companies are more susceptible to partnership involvement when they perceive that they have a workforce-related problem. As one faculty member noted, the community colleges were able to "break into Genentech when there was a terrible history of turnover at the company's South San Francisco site. The company was in crisis mode. Hank Stern's study (discussed in Chapter One) put a cash number on each percent of turnover." At that point, the company was ready to engage with the programs.

This study is not designed to test the reasons for comparison companies' non-engagement with the partnerships. However, as the foregoing examination suggests, whatever the range of factors serving to inhibit or promote a company's engagement in any particular case, the intermediaries under study have engaged in outreach to all of the treatment group companies in the sample. This association establishes the role of intermediary intervention in labor market intermediation. Moreover, as many of the examples demonstrate, partnership development can take years to reach fruition. The study provides evidence that companies that once resisted program intervention and partnership involvement have since joined the collaborative workforce development effort. It is reasonable to assume, then, that partnership actors engaged in job development, e.g., the regional center directors, college faculty, or other professionals, may succeed in bringing at least some of the current comparison group companies into the partnerships; and further, that the personal relationships that might develop at that point would serve as the necessary catalyst for increased hiring of program graduates.

## 7.2.2 Supply-Side Ties

Each of the Workforce Investment Board-funded biotech certificate programs for displaced workers, as well as the two Bay Area community-based organization (CBO) collaborations (Biotech Partners and Bridge to Biotech), have engaged a range of partners on the supply side, as well as the demand side, as noted in Chapter Three. For instance, the Biotech Workforce Network assembled six categories of partners in its public-private partnerships workforce development model. As the network's program materials indicate, these partners and their assigned roles are as follows:

- *Employers* - define standards and competencies, assist in developing curriculum, conduct internships, and hire qualified graduates
- *Community colleges* - develop and deliver industry-driven curriculum in traditional and short-term intensive formats
- *Workforce Investment Boards* - make key policy decisions on how to leverage and utilize funding to meet market demands, manage project performance and outcomes, and facilitate partner communications
- *One-Stop Career Center Stakeholders* - conduct regional outreach and assessment that meets industry standards, and prepares trainees for formal hiring
- *Labor Unions* – convey to the workforce system essential supportive services and training alternatives, connect qualified training graduates to employers, and work cooperatively with employers in designing programs that protect an individual's economic stability
- *Government* – plays a key role in supporting a regional vision and expansion through funding, policy decisions, and technical assistance<sup>145</sup>

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<sup>145</sup> Biotech Workforce Network, "Ahead of the Curve: Responding to the Dynamic Biotech Sector." I note that creation of the network's full-time job developer was the result of a labor initiative to promote job placement; the job developer was employed by the county's central labor council.

### Recruitment/Screening/Case Management

A key feature of all the Workforce Investment Act-funded programs and the two Bay Area CBO collaborations (Biotech Partners and Bridge to Biotech) is intensive recruitment and screening of applicants into the program. By contrast, the biotech programs' standard certificate and A.S. degree programs are open enrollment/access programs, i.e., students who meet minimal qualifications, such as having a high school diploma or GED, are eligible to enroll.<sup>146</sup>

All the companies that have partnered with these programs indicated that the rigorous recruitment and screening of program participants were crucial features, which served to ensure that the students selected to participate were capable of completing the program and suited to biotech employment. That is, these tools signaled that the program would send only “quality people” to the companies, an essential element in the development of trust between industry and education. Despite the intense administrative pressures to forgo rigorous screening in order to fill classes quickly, the programs acknowledged that sending “unqualified people” to the companies would damage the program’s reputation and thus diminish the chances of other participants.

For example, the Biotech Workforce Network partnership developed and implemented a rigorous, 90-day recruitment and screening period, which takes place in the semester prior to the start of classes. Table 7.1, below, which presents the program’s recruitment timeline and corresponding activities, indicates that prospective students must attend an information panel; undergo testing, a basic skills test typically administered by the One Stop workers; participate in a phone screen and panel interview, and attend an eligibility session—all prior to the start of classes.

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<sup>146</sup> As discussed below, several of the biotech programs that offered classroom instruction for the displaced worker programs (e.g., Miramar and Skyline Colleges) have institutionalized the course offerings once the WIB funding ended, i.e., they moved to an open enrollment certificate program.



Figure 7.1, below, contains the program’s “successful candidate profile,” which the program uses to screen applicants and which indicates the program’s high expectations for its enrollees. As the program administrator noted, she looks for applicants who “have stuck it out, are not quitters; have taken advantage of previous training opportunities; and are willing to take an entry-level manufacturing job for at least two years.”

The program also provides job development, including soft skills training, which includes interviewing practice, resume development, company tours and presentations. The program’s job developer coordinates with employer partners to put the various company events together. (See Table 7.4, which indicates the variety of partners involved in the certificate program and their assigned roles and activities.) Numerous employers have remarked that the jobs development component is an essential feature of the certificate programs. For instance, one of the initial WIB-funded programs, the Life Sciences Pilot Program in San Diego County, learned

**Table 7.1  
Recruitment Timeline for Ohlone College Bio-Pharmaceutical Manufacturing Certificate Program**

Week	Activity
1, 2 and ongoing	Marketing Activities – Flyer, email distribution to staff and grads, Ohlone website updates, Craigslist posting (if needed), Staff meeting, Rapid Response sessions, other
3	Information/Testing Session 1
4	Information/Testing 2 (overflow)
5	Phone Screen (1 and 2)
6	Panel Interview (1 and 2)
7	Holiday; Information/Testing Session 3; Eligibility Session A (1 and 2)
8	Information/Testing Session 4
9	Phone Screen (3 and 4)
10	Panel Interview (3 and 4); Information/Testing Session 5
11	Eligibility Session B(3 and 4); Information/Testing Session 6
12	Holiday; Phone screen (5 and 6)
13	Panel Interview (5 and 6); Eligibility Session C (5 and 6)
14	FINAL NOTIFICATION
15	Kick Off session; Resume Development Workshop
16	Class Start

Source: Adapted from Ohlone College Biotech Program handout, on file with author.

from employers who had hired the first cohort of program graduates that the new hires needed work readiness training that would prepare them in the soft skills necessary for employment in the biosciences industry. So, the program worked with its One-Stop partner to develop and implement such training for the second cohort of students. In addition, although the program sought to familiarize students with the pharmaceutical industry, it became clear that the first cohort was not sufficiently familiar with clean room activities. To expose students to this unique environment, the program instituted tours of different companies with clean room facilities. One student, who did not wear pants for religious reasons, had to reconsider her commitment to working in a manufacturing environment, since gowning up required employees to wear pants.

Table 7.2 presents the program’s job development activities during the 13-week certificate program, with its accelerated schedule:

**Table 7.2**  
**Ohlone College Bio-Pharmaceutical Manufacturing Program Event Schedule**

Date	Event
W 9/19	Biotech Program Kick-Off Session
Th 9/20	Bio-Manufacturing Resume Development Workshop
M 9/24	Class Starts MWF, T am
Th 9/27	Resume Working Sessions
W 10/10	Biotech Bay Life Science Career Fair – Biospace.com
Th 10/11	Draft Resumes emailed to program administrator
M 10/15, T 10/16, W 10/17	Resume Feedback Sessions, 30 minute appointments
Th 10/25	Bio-Manufacturing Interview Skills Workshop
T 10/30	Kelly Scientific (recruitment agency) Workshop
Th 11/1	Videotaped Group Interview/Feedback – 3 hour sessions
F 11/2	Final Resumes due
Th 11/8	Berkeley Heart Labs (local company) site presentation/tour
Th 11/15	Genencor site presentation/tour
Th 11/29	Bayer site presentation
T 12/11	Employment Workshop – Topics include job applications, company/career specific industry interviews, job search strategies
Th 12/13	Completion Ceremony

Source: Adapted from Ohlone College Biotech Program handout, on file with author.

As the program administrator notes, the program's commitment level is "intense," since students are expected to obtain employment after completing the thirteen weeks of the program's technical training component:

The students have no life for 13 weeks. There are no days off. If a student wants to work during the 13 week certificate program, I say no; if they have child care problems, I say no excuses, since we provide financial assistance, child care assistance, etc.

The program is a model one for dislocated workers. But, it's also cost prohibitive and labor intensive. It requires intensive hand-holding so people don't quit. Babies are born, the parents of students die, there's a murder, etc. Stuff happens, so there's a need for intensive casework.

Finally, an important feature of the WIB-funded programs and the Bridge and High School programs is the cohort model of instruction, in which students enter the program and graduate together. As one faculty member observed: "The cohort is a big variable. It's a learning community that leads to a higher rate of success because it has a built-in support system." As such, the programs promote supply-side networking among students. Similarly, a program administrator remarked:

The students help each other, so the cohort builds teamwork. The students feel comfortable and have self-confidence, which pays off in interviews. So, for instance, even though aircraft people may be scared to be around line cells, they come in as a group together, which helps minimize their fear very quickly.

### Open Enrollment Versus WIA-Funded Programs

As noted, the short-term (13- or 15-week) biomanufacturing certificate programs at four of the community colleges under study (Skyline, Ohlone, Contra Costa, and MiraCosta Colleges) were funded under the Adult and Dislocated Worker Program, Title I of the Workforce Investment Act of 1998. As such, only dislocated workers as defined by WIA regulations are eligible for the program. By contrast, the associate's degree and standard (i.e., one-year) certificate programs

of all the community colleges under study are open enrollment programs. That is, all individuals who meet minimal qualifications, such as having a high school diploma or GED, are eligible to enroll in the program.

With the termination of the Life Sci X program in the San Francisco Bay Area's Alameda and Contra Costa Counties, which graduated its last cohort of students in the spring of 2009,<sup>147</sup> all of the WIA-funded programs under study have now ended. However, with support from their respective departments, each of the four biotech programs that had partnered with the WIB have since institutionalized their biomanufacturing certificate programs.<sup>148</sup> Program administrators and faculty describe a number of tradeoffs inherent in the shift to an open enrollment system. As noted, a hallmark feature of the dislocated worker programs was the intensive recruitment, screening, assessment, and testing of applicants to the program by the One Stop Centers (OSC), based on targeted employer needs. In addition, the OSC provided crucial supportive services, such as case management and assistance with transportation, childcare, and books, as well as job placement. These services helped ensure a high retention and graduation rate: the screening services ensured that students who entered the program knew about the biotechnology industry prior to enrolling and thereby had relatively realistic expectations about this particular career path; and the case management services helped students negotiate personal difficulties arising during the program so that they could remain enrolled. As an instructor noted, a student who cannot pay for gas will drop out of the program, so the WIB works with that student to ensure that they have transportation, e.g., by providing them with a bus pass.

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<sup>147</sup> Skyline College's certificate program in biomanufacturing for dislocated workers ended in the Fall 2009 semester.

<sup>148</sup> The biotech programs continue to have a relationship with the local OSC, which offers program participants seminars on interviewing skills and resume writing and sponsors hiring fairs.

However, the disadvantage of WIA-funding is that, because the WIBs desire good placement rates, the OSCs have an incentive to cream the best applicants through highly selective screening (e.g., for motivation). At least one lead instructor claimed that the students in the dislocated worker program “came in with fairly similar backgrounds.” She argued that open enrollment enables the program to “open the doors to higher ed and career advancement in biotech....There are lots of smart people driving taxis, etc. who, because of family obligations, did not take the usual route to college.....these individuals need access and training.” Another instructor has witnessed an increase in younger students in his class since open enrollment, and in particular, “career tech people who are not sure of what they want to do. They liked biology, but they don’t want to go into medicine.” He also noticed an increase in students interested in following an “academic path,” i.e., transferring to a four-year program.

Of course, as a program administrator noted, open enrollment does not in itself guarantee that the programs will reach the neediest or least served students. As he explained, while enrolling literally requires only that the individual contact the college, take the placement test, and sign up by the deadline, the individual who is not familiar with this process, e.g., who has no historical experience of college attendance in his or her family, who has a fear of tests, or who has other barriers, including poor basic academic and soft skills, will not be able to “openly enroll.” To reach such students, then, the partnerships have created bridge and school-to-career programs, including the East Bay Career Advancement Academy, the City College of San Francisco’s Bridge to Biotech program, Biotech Partners, the Ohlone College LAB program, and Southwestern College’s BETSI program—all of which are profiled in Chapter Three. These programs are explicitly designed to reach youth and adults from underserved communities and prepare them for college-level certificate programs and/or entry-level employment in

biotechnology, thus helping to create a more local and diverse biotechnology workforce. Like the dislocated worker programs, the bridge and school-to-career programs partner with local workforce agencies, which enables them to offer intensive support services and case management assistance to participants. Unlike those programs, however, they seek to reach less advantaged students, i.e., those with only basic skills and weak work histories.

**Table 7.3**

**Bio-Pharmaceutical Manufacturing Certificate Program - Successful Candidate Profile**

**Job Requirements:**

- Meet the minimum requirements for the entry-level Bio Manufacturing positions?
- Have the flexibility to work in the environment outlined in the job descriptions?

**Communication Skills:**

- Able to express himself verbally, speak clearly, and understand interviewer without difficulty?
- Demonstrate active listening skills?

**Professionalism:**

- Conduct him/herself in a manner that would project a positive image as a representative of this program with employers & others?
- Candidate's appearance neat & professional to create a positive impression?

**Teaming & Interpersonal Skills:**

- Demonstrate the ability to work in a collaborative environment?
- Interact effectively with peers and supervisors to get the job done?
- Demonstrate the ability to effectively handle conflicts with peers?

**Initiative:**

- Demonstrate the ability to take the initiative? Go the extra step to prepare for the interview?
- Research the Biotech industry/Manufacturing positions and determine transferable skills?
- Demonstrate a desire to transition to a new career field and start in an entry-level position?

**Commitment:**

- Thoroughly understand & demonstrate his/her commitment to both the training and employment areas of this program?

**Adaptability:**

- Demonstrate openness to new ideas & suggestions, and a willingness to learn and be coached?

**Transferable Skills Preferred:**

- Hands-on technician, QC, or manufacturing/production background helpful
- Computer skills including basic Word & Excel & e- mail
- Attention to detail - accurate documentation
- Communication and interpersonal skills
- Dependable, reliable and punctual; able to work shifts, weekends, holidays
- Effective team member; enthusiasm for working in a group
- Follow standard written procedures & guidelines
- Diagnose, troubleshoot, & problem solve; maintain a solution oriented approach
- Critical thinking - review facts & weigh options to reach conclusion

**Ohlone College/ACWIB Bio- Pharmaceutical Manufacturing Certificate Program Step Chart**

<b>STEP</b>	<b>CONTACT</b>	<b>ACTION</b>
<b>Recruitment</b>	<b>EASTBAYWorks/ACWIB/Ohlone Coordinator</b>	<b>Publicize Program Refer candidates to Information Line to reserve seat in Information Session</b>
	<b>Ohlone Coordinator/ACWIB</b>	<b>Conduct Information Sessions</b>
<b>Testing</b>	<b>ACWIB CM</b>	<b>Wonderlic Basic Skills Test</b>
	<b>Ohlone Coordinator/ACWIB</b>	<b>If candidate meets requirements, scheduled for phone interview. If not, refer to Ohlone College &amp;/or job search services @ 1-Stops</b>
<b>Qualification</b>	<b>Ohlone Coordinator</b>	<b>20 Minute Phone Interview If candidate meets requirements, schedule for panel interview. If not, refer to Ohlone College &amp;/or job search services @ 1-Stops.</b>
<b>Final Selection</b>	<b>Ohlone/ACWIB/Partners</b>	<b>Panel interview for finalists Resumes, Wonderlic Results &amp; Interview Scores considered for final selection.</b>
	<b>Ohlone Coordinator/ACWIB</b>	<b>Selected candidates participate in Eligibility Session &amp; Kick Off</b>
<b>Workshops</b>	<b>Ohlone Coordinator</b>	<b>Resume Development/Interviewing Skills Workshops/Videotaped Interview Sessions customized to Biotech Manufacturing</b>
<b>Training</b>	<b>Ohlone Instructor</b>	<b>Classroom and Laboratory</b>
<b>Events</b>	<b>Ohlone Coordinator ACWIB Business Services Rep</b>	<b>Biotech Company Speakers &amp; Site Tours/ Workshops / Mixers / Mock Interviews are included during this phase</b>
<b>Post-Grad Activities/ Job Search</b>	<b>ACWIB/Coordinator/EASTBAYWorks</b>	<b>Resumes are forwarded to employer contacts Self-directed job search Workshops &amp; events held regularly with guest speakers</b>

**Table 7.4**



## **Chapter 8: Conclusions**

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### **8.1 Labor Market Intermediation in an Advanced Economy Industry: the Role of Biotechnology Training Partnership Programs**

This dissertation study sought to determine the extent to which biotechnology training partnerships expand local employment opportunities for graduates of community college biotech programs through efforts to influence the recruitment and hiring practices of a sample of biotechnology companies in the San Francisco Bay Area and the San Diego region. As such, the study adds to the evaluation evidence for a certain type of labor market intervention that, in a number of important respects, has been less well-studied to date (Lowe 2007).

First, most research on sectorally-focused intermediaries has examined programs that target traditional manufacturing industries, such as garments, metal working, and transportation equipment (see Conway and Loker 1999; Bernhardt, Dresser and Rogers 2001; Lautsch and Osterman 1998); or that involve lower-skilled occupations in the acute and long-term health care industries (Conway et. al 2007). By contrast, the present research involves workforce intermediation in a knowledge-intensive industry, in which even the entry-level positions require relatively high levels of academic and work-related skills. Moreover, because the targeted technician-level positions generally offer good wages, benefits, working conditions, and advancement opportunities, these partnership programs largely are able to sidestep the important question of whether such efforts are capable of altering the structure of jobs, as opposed to merely shaping access to them (Mitnik and Zeidenberg 2007; Dresser 2007). In essence, these jobs are “good” jobs, and hence, the sector strategies are properly focused on improving access to the jobs, as opposed to improving job quality.

Second, those studies of intermediation efforts in knowledge-intensive industries, such as information technology, have tended to focus on the supports that private intermediaries, such as

temporary staffing agencies or member-based employee groups, offer to more educated workers, particularly those with advanced degrees in scientific or engineering fields (Benner 2002). By contrast, the intermediaries under study here are largely publicly-funded partnerships, led by community colleges and/or workforce boards, which have been designed explicitly to benefit less educated and arguably less privileged job seekers (as well as their industry employers, given this new labor market institution's "dual customer" focus).

Third, most evaluations of workforce intermediaries to date have limited themselves to examining supply-side interventions, i.e., strategies to prepare workers for employment opportunities, and to measuring benefits to individuals, e.g., impacts on participants' wage and benefit levels (See, e.g., Conway et al. 2007; Maguire et al. 2009). Like those studies, the present study also examined supply-side mechanisms for assisting students (e.g., the provision of WIB-funded support services and the use of a cohort model of instruction), as well as compiled available data on participant impacts, e.g., program completion and job placement rates.<sup>149</sup> In addition, it collected original survey data on the educational backgrounds and other characteristics of enrollees in the core biotech classes of a sample of training programs.

The primary aim of this research, however, was to document the impact on industry recruitment and hiring practices of demand-side interventions, that is, those that are designed to ensure that employment opportunities are available and accessible to their clients (Conway et al. 2007). Specifically, it focused on strategies to promote access to good jobs by removing barriers to entering them, in particular, by: negotiating competency-based rather than credential-based hiring; demonstrating the quality of trainees from diverse or underserved backgrounds; and creating pre-employment work experience opportunities, particularly internships (Conway et al.

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<sup>149</sup> Because the entry-level jobs for which the programs are preparing students are "good jobs," i.e., are relatively high-skill and high wage, I do not examine earnings or benefits outcomes for program participants. Under WIA regulations, the WIB programs do track hourly wage at placement, which data is presented in Chapter Six, above.

2007).<sup>150</sup> Moreover, by demonstrating to employers that they can hire successfully from a labor pool—here, community college graduates—with which they may be unfamiliar, and consequently changing industry practices, demand-side interventions also potentially produce systems change, which this research likewise sought to probe.

Accordingly, to measure impact on industry practices, the study collected original data from a sample of biotech companies, namely, the percentage of technicians in the companies' current entry-level workforce that holds a community college degree or certificate. Moreover, to determine the factors associated with successful (or unsuccessful) partnership program intervention in the recruitment and hiring practices of sample firms, the study conducted qualitative interviews of company staff regarding the education and training needs of the company with respect to its entry-level technician workforce, as well as the company's perceptions of any community college hires vis-à-vis their bachelor-degreed counterparts. The study also interviewed partnership program staff and faculty to gain insights into the features of effective partnership programs, as well as of the opportunities and challenges facing program intervention in the labor market for entry level technicians. As such, the study sought to address a current gap in the literature, i.e., the need for in-depth, qualitative research on particular aspects of intermediary activity that aims to better illuminate the labor market impacts of these activities (Benner et al. 2008).

Finally, there has been little rigorous evaluation to date of sectoral intermediaries and their outcomes (King 2008). Of those evaluations that have used an experimental or quasi-experimental design, it appears that most, if not all, have focused on supply side, i.e., participant, outcomes. For instance, Public/Private Ventures' Sectoral Employment Impact Study used an

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<sup>150</sup> This is as compared to access strategies that seek to help workers move up into better jobs (Conway et al. 2007). As discussed below, I did not focus on advancement strategies, which form an important subject for further research.

experimental research design to assess the employment and earnings impacts of study participants (Maguire et al. 2009).<sup>151</sup> Another recent evaluation of an Austin, TX workforce intermediary used a quasi-experimental design to measure the organization's labor market impacts on participants' earnings (Smith et. al 2007).

By contrast, this dissertation study sought to conduct a rigorous evaluation of the impact of intermediary intervention on recruitment and hiring outcomes by collecting the data, noted above, from a sample of treatment group and comparison group companies in the two regions under study. While the sample size was relatively small (comprising 22 treatment group and 21 comparison group firms), the companies were matched as closely as possible on the basis of region, industry sector, product focus, stage of development, and employee size, as detailed in Chapter Five. The companies also represented the major sectors and development stages of the biotechnology industry.

Based on the foregoing quantitative and qualitative data, I conclude that the biotechnology training partnership programs under study have succeeded in producing positive impacts on both the supply side and the demand side of the labor market for entry-level biomanufacturing and biological technicians. In a nutshell, the programs not only have succeeded in training future technicians to meet the needs of area employers, they also have helped to legitimate the community college population as a viable candidate pool.

Regarding supply-side impacts, the evidence shows that the partnership programs have succeeded in offering in-demand, hands-on/applied training to a nontraditional, and arguably underserved, group of students. As the demographic data indicates, the students are quite diverse

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<sup>151</sup> Specifically, the study focused on five outcomes: total earnings, likelihood of employment, hours worked, hourly wages, and the availability of benefits (including health insurance, paid vacation, paid sick leave, or tuition reimbursement). Initial findings indicate that the sector programs resulted in significant earnings gains for participants (Maguire et al. 2009).

in terms of their gender and race/ethnicity, and tend to be older, reflecting the programs' mission to offer retraining opportunities to dislocated workers, as well as to other students interested in a career change and in need of new skills. Moreover, the evidence indicates that the programs are supplying the local biotechnology industry with a well-trained, technician-level workforce. First, among the programs that compile such data, retention, completion, and job placement rates for students are very high. Second, employer interviews suggest that the skills students learn in the programs are practical and relevant, particularly in comparison to those that bachelor-degreed candidates possess. Finally, regarding the community college programs' ability to connect youth and adults who are under-represented in the sciences to the biotechnology field, the evidence suggests that the bridge and school-to-career programs succeed in reaching a less advantaged population<sup>152</sup>; retaining these individuals in and graduating them from the programs; and enrolling them in biotech-related, higher education programs.

Regarding partnership program impacts on the demand side, the evidence suggests that the programs have convinced a set of biotechnology employers—primarily the larger firms that have reached the manufacturing and commercialization phases, that employ a manufacturing workforce, and that engage in a certain level of partnership activity with the programs—to change their hiring practices in a way that allows individuals who traditionally have not been considered for manufacturing technician jobs—i.e., community college certificate or Associate's degree graduates, with or without a prior bachelor's degree in science—to compete for these positions (see Conway et al. 2007). As such, it is possible to conclude that the programs have improved the employment prospects for community college biotechnology program graduates seeking work in such firms, while meeting all (or at least some) of the workforce needs of these employers for well-trained bioscience technicians.

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<sup>152</sup> However, see the section on the reaching the underserved, below, for gaps in this data.

Regarding graduates' access to employment in another set of firms that was under study here—mainly smaller, research-oriented firms—the evidence is mixed, and will be discussed in the next section, below. Here, I briefly review the primary outcomes data supporting my conclusion with respect to biomanufacturing employment. As described in Chapter Six, this data involves the percentage of the current entry-level workforce with an Associate's degree or certificate from a community college biotech program. Specifically, as Tables 6.11 and 6.13 show, all but one of the treatment group firms that employ a manufacturing workforce (n=11) employed at least 15 percent of their current, entry-level technician staff from the community college pool, compared to only one of the comparison group firms in this category (n=11). In addition, in approximately one-third of partner companies in this category (four out of eleven), the percentage of entry-level technicians with a community college background exceeds 20 percent.

Moreover, my qualitative interviews with company staff, including human resources personnel, scientific/production supervisors, and hiring managers, suggest that the partnership training programs have met the needs of this group of employers for a stable, well-trained, technician-level workforce. Interview data further indicates that program activities have helped change the perceptions of many staff within the companies under study about the suitability of community college graduates for bio-manufacturing employment. Specifically, the activities have helped shape employers' understanding of the primary qualification for these jobs, namely skills and competencies, rather than a formal (advanced) degree. Indeed, convincing employers that there is an important distinction between a degree and skills, and thereby influencing them to recruit from the community college pool, is, I argue, key demand-side work. The fact that a sizable number of program graduates already have a bachelor's degree, yet returned to the

community college program to gain the necessary skills, only serves to underscore this important distinction.

The previous chapter elaborated the mechanisms and processes through which the biotech training partnerships under study seek to influence employers' recruitment and hiring practices. As the qualitative evidence shows, the partnerships used a number of strategies to: 1) cultivate employers' active engagement in program activities, and 2) facilitate extensive collaboration among key partners—both key workforce intermediary interventions that the literature associates with program effectiveness. Regarding strategies to increase industry involvement, all the programs promote the use of adjunct faculty recruited from industry, while almost all have developed and maintain formal internship opportunities for students. As the interview material detailed, industry co-faculty have strengthened program curricula by ensuring that it is industry-relevant. They also have helped students prepare for work in the biotech industry by sharing their own experiences hiring and managing employees, as well as their knowledge of what other hiring managers look for in job candidates. In addition, numerous instructors have recruited students to their companies directly from their classes.

Industry internships also have promoted industry recruitment and hiring of students. As many employers indicated, the opportunity to “try out” community college candidates during the internships was well worth the time and effort required to supervise them. Internships also generate key feedback loops between the programs and employers through program efforts to solicit and incorporate company feedback regarding the training and preparedness of program interns (as well as graduates). Interviews suggested that such efforts ultimately help build trust between program and company staff, an essential component of program effectiveness.

Finally, to ensure that training is aligned with industry needs and to increase employer commitment to practices and policies that support employment opportunity for program graduates, programs have undertaken other key strategies, such as inviting company staff to sit on the college's industry advisory boards, to donate needed laboratory equipment, and to participate in curriculum review.

Regarding partner collaboration, all the programs have engaged in varying degrees of network formation on both the demand and supply sides of the labor market for entry-level technicians. On the demand side, programs engage in a number of strategies to assemble a strong network of local employers who increasingly rely on them to source their entry-level workforce. For instance, the WIB-funded programs funded a professional job developer to reach out to companies to raise awareness about the types of skills students gain in the program, as well as to serve as a point person for companies to contact when they have job openings or questions about the programs. The directors of the California Community Colleges Applied Biotech Initiative regional centers, as well as many biotech program faculty members, also undertake this outreach role to employers, while other faculty members do so informally. The interviews showed that building strong demand-side ties requires persistence in establishing relationships of trust with employer representatives, as well as the ability to engage staff at all levels of the company, particularly at the highest levels.

On the supply side, the partnership programs have developed relationships with a variety of partners, including public workforce agencies, i.e., One Stop Career Centers, community-based and labor organizations, and community colleges. These ties enable the programs to undertake intensive recruitment and screening of applicants, while providing a range of case management and services. The Workforce Investment Board-funded partnerships developed



especially close ties with such partners, although other programs, such as CCSF's Bridge to Biotech program and the Biotech Partners program, work closely with workforce development partners to offer program participants various support services. Indeed, even the college programs work with the One Stops to offer students workshops on interviewing and resume writing, as well as to sponsor industry-related career fairs.

To highlight the foregoing mechanisms of program effectiveness, I offer a further elaboration of the model partnership, described in Chapter Six, between Company T3-BA; Ohlone College's biotechnology program; the Alameda County WIB; and the California Applied Biotech Center (CalABC) for the Silicon, San Joaquin and Silicon Valleys (a regional center of the California Community College's biotechnology initiative, currently located on the Ohlone College campus).

Prior to its acquisition by T3-BA in 2006, Company D began plans to ramp up its manufacturing. Several scientists and engineers responsible for the transition recognized the need to find a technician-level workforce that was interested in working in a manufacturing role, as the company could not afford the high turnover rate among overqualified candidates, which afflicted numerous manufacturers. During this time, the job developer working with the Skyline-Genentech biomanufacturing training partnership approached the company to ask whether it would offer company tours to the program's current student cohort. One of the engineers responsible for internal company training agreed, as he previously had worked at Genentech and was familiar with the Skyline partnership. This engineer (hereinafter, "employer representative") felt that offering a company tour would be a good way for the company to learn about the biomanufacturing program and potentially recruit job candidates. Consequently, he put together several talks for the students on the biotechnology industry and the company's specific

technologies, and ultimately led tours for eight or nine different cohorts of Skyline College, and later Ohlone College, students.

At this time, the Skyline partnership was expanding to Ohlone College under a new WIA-administered grant. A lead instructor in Ohlone College's biotech program, who also had worked at Genentech, was designing the curriculum for the college's new bio manufacturing certificate program, and approached the company to gauge its interest in partnering with the program. The employer representative who led the company tours for the Skyline partnership agreed to provide feedback on the new curriculum, and made several suggestions as to additional topics that the classes should cover. For instance, he proposed a class on PH meters that would ensure that students were familiar with the instrument and could operate it. He also stressed that students needed to understand the importance of timely, accurate documentation ("If it's not documented, it doesn't exist...you didn't do it!"). The instructor asked if he would develop an example of the type of documentation essential to operations, so he developed a dummy batch record for the students to execute.

Ohlone College invited the employer representative, among others from the company, to attend the opening ceremony for its new science center and biotechnology laboratory, as well as to set up a table to recruit current students. As the company had open positions at the time, he and several colleagues agreed. Moreover, he and an HR staffer who became involved in the program also met periodically with the Workforce Investment Board specialist, who was co-located on the Ohlone campus and responsible for screening candidates for the program and offering case management, in order to give feedback on the interns that the company took from the program.

Meanwhile, Company T3-BA acquired Company D, and, as noted in previous chapters, the former company has continued many of the latter's community college recruitment practices. For instance, Company T3-BA provides regular company tours to Ohlone College students, donates laboratory equipment to the program through its national foundation program, and has supported a number of employees who serve as adjunct faculty in the biotech program. Several senior-level management and production staff also sit on the college's industry advisory board.

As an earlier discussion made clear, Company T3-BA's support is due largely to the fact that many former Company D staff who had partnered with Ohlone remain at the company and continue to promote the program. Several high-level members of Ohlone College and the regional CalABC have had to work hard to establish ties with the company's new corporate managers. Moreover, HR staff who support the program have had to battle what they describe as new hiring practices rooted in Company T3-BA's "corporate mentality" (see Chapter Six for a description of such practices). Nevertheless, as the hiring data show, 25 percent of the Fremont facility's current technician-level workforce has a community college degree or certificate, a sizable number. A hiring manager recently indicated that the company expects to begin a new round of hiring after a freeze over the last several years, and will turn once again to its contacts at Ohlone College for job candidates.

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This study's second major finding is that the partnership programs have been less successful to date in enabling program graduates to gain access to entry-level positions in the R&D laboratory setting, particularly in smaller firms that have not yet reached the manufacturing stage, but also in the research labs of some larger commercial manufacturing firms. As Tables 6.12 and 6.14 show (in Chapter Six, above), only four out of the ten treatment group companies

that engage primarily in research and development in this study's research sample have hired at least 15 percent of their current, entry-level technician workforce from the community college pool. None of the comparison group firms have hired fifteen percent or more from this pool (in fact, none of these firms has hired *any* community college program graduates).

The evidence suggests that an important factor influencing company recruitment and hiring for its entry-level technician workforce is the nature of the work that this workforce primarily undertakes, i.e., research and development, clinical stage development, or manufacturing/production. That is, to a far greater extent than companies hiring manufacturing technicians, companies hiring a research, development, or clinical trials level staff tend to believe that laboratory work requires a higher level of technical and soft skills than the typical community college graduate possesses. The section, below, on organization of work elaborates this issue.

As described in Chapter One, the nature of work in a biotechnology firm tends to be highly correlated with the company's size and stage of development: early stage and small companies engage primarily in R&D work, while larger companies typically have reached the manufacturing stage and thus undertake production work, as well as R&D and clinical trials work. While these variables are not mutually exclusive—for instance, large companies can outsource their manufacturing work and undertake research and/or clinical trials work in-house—the alignment of these variables can generate additional impacts on company recruitment and hiring practices. Specifically, a small company that remains in the early R&D stage of development is often financially constrained in its ability to hire an entry-level workforce. By contrast, a larger company that undertakes a greater volume of research work and has more resources at its disposal is usually better able to hire entry-level research or lab assistants.

Nonetheless, as discussed below, a number of smaller, research-oriented firms in the sample have hired community college graduates as interns or full-time employees and have been very satisfied with their performance. While many of these students or graduates have had prior bachelor's degrees, others have not, particularly students enrolled in the two Bridge programs under study. Additional qualitative evidence suggests that the partnership's efforts to conduct active outreach to smaller companies, establish relationships of trust with company staff, and secure company involvement in partnership activities plays a very important role in positively shaping employers' perceptions of the capabilities of community college graduates. As in the manufacturing realm, the cultivation of demand-side ties to R&D firms appears to make an important difference in the opportunity structure facing applicants to research-related positions.

As discussed in the following section, industry dynamics suggest that the presence of bio-manufacturing in the two regions under study will decline, given the high costs of living, among other factors. To the extent that training partnerships can succeed in opening up job opportunities for program graduates in R&D firms—whose innovative work likely will remain and flourish in the two regions—the question remains whether the programs can better meet the needs of its dual customers, i.e., job seekers and employers, by shifting the training focus to different areas and/or stages of the industry's development cycle, e.g., clinical trials training.

Finally, the evidence suggests that, regardless of the training focus, the key partners would best serve the needs of students and employers by institutionalizing the most successful features of the intermediaries, namely, intensive networking and relationship building on the labor market's demand-side.

## 8.2 Bio-Manufacturing in California—Will It Stay?

Since 2000, California has lost more manufacturing jobs—in both traditional and high-tech industries—than any other state. According to a 2009 Milken Institute report on California manufacturing, the state lost 390,000 total manufacturing jobs (or 30 percent of the industrial base) and 143,500 high-tech manufacturing jobs (or 23 percent of the high-tech base) between 2000 and 2007 (DeVol 2009).<sup>153</sup> The report found that, compared to seven peer states, California has lost a larger share of its manufacturing employment overall, especially in the high-tech industries, and at a faster rate. Like many commentators, it attributes such job losses to the state’s regulatory climate, tax burden, high cost of living, and reputation as a “difficult” place to do business.

However, certain high-tech industries have fared better than others. The report found that pharmaceutical and medicine manufacturing were among a handful of “gaining industries,” noting that the industry had added 16,000 jobs between 2000 and 2007, a seventeen percent increase.<sup>154</sup> Similarly, the California Healthcare Institute (CHI) determined that the larger biomedical industry, which employs 274,000 in 2,000 companies, added approximately 24,000 jobs between 2004 and 2008, with employment in the biopharmaceuticals segment increasing by 3.14 percent in that period, the highest rate of increase among biomedical industry segments (CHI 2010).<sup>155</sup> The most recent figures show that, between March 2008 and March 2009, the biopharmaceuticals segment added 252 jobs, while the medical devices, instruments, and

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<sup>153</sup> The resulting 1.5 million total manufacturing jobs and 485,900 high-tech manufacturing jobs represented 10.5 percent and 19.7 percent, respectively, of the nation’s total such jobs in 2007 (DeVol 2009).

<sup>154</sup> Since 1990, the pharmaceutical and medicine manufacturing industry has added more than 90,000 jobs (DeVol 2009).

<sup>155</sup> According to the latest state-of-the-industry report by BayBio, Northern California’s leading industry association, state employment in the life sciences industry increased by 3.2 percent in Northern California and by 2.3 percent in Southern California between 2003 and 2008 (BayBio 2010).

diagnostics segment registered the highest number of job losses at 2,216. Moreover, while all of the state's high-tech industries lost jobs between the first quarter of 2008 and the first quarter of 2009, the biomedical industry lost the fewest: just one percent, compared to eight percent for the motion picture industry, five percent for the telecommunications industry, and 4.5 percent for the information technology industry. For this and other reasons, the CHI considers the biomedical industry to be one of the state's most "recession-resilient" sectors (CHI 2010).

Indeed, according to the latest CHI - PricewaterhouseCoopers California Biomedical Industry Survey, 64 percent of California biomedical companies reported that they had expanded or sustained their workforce over the previous year. However, the data showed that companies that also maintain operations in other states or countries grew more robustly out-of-state: 63 percent of respondents added out-of-state manufacturing jobs, while 46 percent increased R&D jobs elsewhere. Looking forward, a sizable percentage of companies expected to expand their activities in the state over the next two years: 30 percent expected to expand their manufacturing operations inside California, 55 percent expected to hold manufacturing operations steady within the state, and 15 percent expected to reduce such operations. For research and development, the corresponding figures were 48 percent, 45 percent, and 7 percent, respectively. However, in a troubling sign, 66 percent of California-based employers reported that they expected to increase their manufacturing workforces out-of-state in the next two years, 30 percent expected to hold their out-of-state manufacturing activities steady, and 4 percent expected to reduce them. Somewhat surprisingly, 58 percent of respondents expected to add out-of-state R&D jobs in the next two years.

Finally, according to the California Employment Development Department's latest occupational projections of employment, the outlook for biological technician remains strong.<sup>156</sup> Between 2006 and 2016, the agency projects that employment in this occupation will increase nearly 30 percent, to 13,500 positions from 10,400, with average annual openings estimated at 680. The agency also projects that additional job openings due to net replacements will amount to 630 in the San Francisco Bay Area, including 300 in the East Bay Area and 70 in Solano County, and 630 in San Diego County.

### Offshoring

As noted in Chapter One, in general it becomes economically feasible for a company to build or acquire its own manufacturing facility only when it has a robust product pipeline and at least one approved product. Accordingly, the majority of firms have settled the "make or buy" decision in favor of outsourcing some or all of their manufacturing needs to a clinical manufacturing organization (CMO).<sup>157</sup> Less well settled, however, is the issue of offshoring. For the past decade, major U.S. pharmaceutical companies have increasingly outsourced the manufacturing of their active pharmaceutical ingredients (API) to contract factories overseas, particularly in Asia.<sup>158</sup> For instance, Pfizer announced in 2007 that it was planning to send 30 percent of its manufacturing overseas, on the heel of similar announcements by AstraZeneca,

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<sup>156</sup> The agency currently is working on new employment projections, which are expected to be released in late 2010.

<sup>157</sup> California also faces competitive pressure from other states, especially North Carolina, Massachusetts, and Texas, all of which have invested significantly in their biomedical industries (see BayBio 2010).

<sup>158</sup> Andrew Pollack. February 24, 2005. "Medical Companies Joining Offshore Trend," *New York Times*.



GlaxoSmithKline, and Bristol-Myers Squibb.<sup>159</sup> In the last several years, such companies have begun moving clinical trials development—and even research and development—offshore.<sup>160</sup>

Some biotech companies have followed Big Pharma's lead, moving manufacturing work to emerging biotech clusters in lower-cost countries, especially India, China, Singapore, and South Korea. Genentech, for instance, has opened manufacturing facilities in Spain and Singapore. Several factors, however, suggest that life sciences manufacturing may be less vulnerable than pharma to widespread offshoring.<sup>161</sup> First, the process of bio-manufacturing is different and much more complicated than that of traditional pharmaceutical manufacturing. Compared to traditional drug making, which involves chemically synthesizing small molecules, making biologics involves manipulating large biological molecules, like proteins, which are grown by cultivating genetically engineered organisms, such as bacteria. Hence, the process is complex because it involves the use of living organisms. "It's like winemaking," said an economic development specialist with the East Bay Economic Development Alliance. "If you change the vat size, you can change how things turn out entirely." It is widely assumed that this complexity might slow the shift to overseas production, since it remains highly important for R&D scientists to be situated near the manufacturing facility in order to monitor the process and

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<sup>159</sup> Already, however, there are reports that numerous U.S.-based pharmaceutical companies that manufacture critical ingredients overseas are returning these facilities to the U.S., due largely to safety concerns, logistical challenges, process compatibility issues, conflicts regarding intellectual property issues, and the huge costs necessary to monitor quality overseas. See, e.g., Gordon Graff. November 19, 2009. "Pharmaceutical Makers Look For Ingredients Closer To Home." *Purchasing.com*.

<sup>160</sup> A recent study showed that pharmaceutical companies were conducting one-third of Phase 3 trials outside of the United States. Glickman, Seth et al. 2009. "Ethical and Scientific Implications of the Globalization of Clinical Research," *New England Journal of Medicine*, Vol. 360: 816-823. See also Natasha Singer. February 18, 2009. "Outsourcing of Drug Trials is Faulted." *New York Times*; Jacob Goldstein. April 23, 2008. "Drug Research Jobs Following Manufacturing Overseas." *Wall Street Journal Health Blog*.

<sup>161</sup> Bernadette Tansey. April 18, 2004. "Are Biotech Jobs Next to Go? Stronghold of Bay Area Economy Not Immune to Trend." *San Francisco Chronicle*; and Bernadette Tansey. April 18, 2004. "Testing the Offshore Waters: Biotech Firms Experiment with Moving Work Overseas." *San Francisco Chronicle*.

troubleshoot when necessary.<sup>162</sup> Second, to produce drugs for the U.S. market, companies must receive FDA certification for their overseas manufacturing facility's processes, often a difficult hurdle for these sites (GAO 2008). Consequently, manufacturing tends to remain in the vicinity in which the drug products were developed. Finally, as a number of my industry interviewees noted, while financial decisions ultimately drive company location and expansion decisions, factors such as the agglomeration of companies and research institutions in the San Francisco Bay Area and San Diego clusters, and the lifestyle that these hotspots offer, simply do not exist to the same degree elsewhere, thereby making these locations attractive, despite the other barriers.

There is plenty of anecdotal evidence regarding California life sciences companies that have chosen to maintain or expand their manufacturing in the state, thus countering reports of an impending mass exodus of manufacturing. For instance, Amgen, the world's largest biotech company, did not move Abgenix, the Fremont-based company that it acquired in 2006, either out of state or to its headquarters in Southern California. According to local economic development officials, this was because the R&D scientists who had developed the product were located on site in Fremont, and the parent company did not want to jeopardize the product's quality. In another example, though it has moved some manufacturing overseas, Genentech also completed construction a few years ago on the world's largest bio-manufacturing plant, located in Vacaville, part of the greater San Francisco Bay Area. In fact, Genentech recently planned to expand this facility, but parent company Roche rejected the plan due to cost concerns.

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<sup>162</sup> A recent report of contamination in a drug produced in a Genzyme manufacturing facility in Ireland highlights such quality control concerns. See, e.g., D.C. Denison. March 16, 2010. "Genzyme Inspection Finds Drug Impurity," *The Boston Globe*. Of course, safety violations can occur close to home, as evidenced by the FDA's recent notification that it intends to sanction Genzyme's Allston, Massachusetts manufacturing facility for its repeated violations of good manufacturing procedures.

The case of Genentech offers a perspective on the number of manufacturing jobs that potentially are at stake in this debate. The company recently announced that it has neared completion of its new \$400 million manufacturing plant in Hillsboro, Oregon.<sup>163</sup> The company already employs 250 workers in the site's distribution warehouse and finishing line, which it opened in 2008. Given the nature of this work, it would appear that most of these jobs would be suitable for graduates of the community college biotech programs.

Moreover, Genentech has begun early production of biologic drugs at the site as it undergoes the process of seeking FDA manufacturing certification. About half of this staff relocated from the company's South San Francisco location, which is shifting its manufacturing production to other locales in order to focus on clinical trials development work. The company has said that it plans to increase the Hillsboro workforce by 25 workers in 2010 and may add another 25 workers over the next few years. The company noted that the production workers at the site will earn from \$35,000 to \$65,000 annually.

The prevailing view is that the potential barriers to overseas manufacturing, noted above, are unlikely to halt or slow the offshoring trend. Nonetheless, no industry commentators have suggested that manufacturing will undergo a wholesale move out of the state, whether to another state or overseas. Instead, most observers claim that, given the presence of start-up innovation in the state's biotech clusters, a certain degree of manufacturing will always take place in California. According to these industry insiders, there will continue to be a demand for entry-level biomanufacturing technicians, enough to justify the existence of a certain level of community college biomanufacturing training. Given that biomanufacturing jobs represent an important first rung in the career ladder of a high-wage, high skilled industry, and importantly,

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<sup>163</sup> Lured by tax incentives and the state of Oregon's favorable corporate income tax structure, Genentech announced that it would relocate some of its manufacturing and distribution to the state in 2006. See Mike Rogoway. April 5, 2010. "Genentech Opens in Hillsboro, Fueling Oregon's Biotech Aspirations," *The Oregonian*.

that these programs reach many individuals who otherwise would not have the opportunity to enter the knowledge economy, the equity argument alone arguably justifies the continuation of the programs.

The question, of course, arises as to the number and type of such programs that the community colleges should support. As numerous industry staff have suggested, community college biotech programs must “look beyond manufacturing to stay relevant,” as one industry association official in Northern California put it. Indeed, most community college staff members emphasize efforts to ensure that their programs remain demand-responsive. First, many programs have diversified their certificate offerings. While some colleges specialize in biomanufacturing (e.g., Skyline College and Solano Community College), most programs offer certificates in a variety of bioscience-related fields. Ohlone College, for instance, offers certificates in biostatistics, computer applications in biotech, and quality control/research, in addition to bio-manufacturing and cell production/fermentation. City College of San Francisco offers a stem cell technology certificate, as well as a biotech certificate that prepares students for jobs in the research laboratory.

Second, as the statewide director of the California Community College Biological Technologies Initiative noted, the initiative continues to cultivate its industry connections so that the programs stay current. He stated: “We read the Burrill Reports,<sup>164</sup> we use our industry contacts to tap the pulse of what’s going on.” Importantly, the initiative strives to differentiate between pursuing “workforce trends” and “new technologies” when devising program strategies. For instance, the initiative has concluded that the new focus on bioenergy is not a viable workforce trend in California. The companies that are growing switch grass and bio-bulk for

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<sup>164</sup> Burrill & Company is a San Francisco-based life sciences venture capital, private equity, and consulting firm that issues ongoing reports on the state of the biotechnology industry.

fuels are located primarily in the Midwest; due to high transportation costs, the companies that are processing these materials are staying local and thus are drawing on local labor pools. By contrast, stem cell technologies finally have generated the need for a technician-level workforce. Working with its industry partners to gauge the potential for jobs in this industry, the City College of San Francisco started its stem cell certificate program even before the voter-approved California Institute for Regenerative Medicine became fully funded.<sup>165</sup> The Dean of the CCSF School of Mathematics and Science noted, in 2007, that the risk of setting up such a course had paid off as students were being placed in industry jobs.<sup>166</sup> With respect to new program development, the Dean stated: “We have been planning to start a nanotechnology program for several years, but we have not done anything because I have not been able to find a niche where we can place students [in jobs and internships]....We’re not giving up, because nanotech is supposed to be the next big thing” (Said 2007).

Instead, the California Community College programs are evolving to focus on training technicians for the home market, especially for the emerging personalized medicine industry. For instance, the American River College (home to the statewide initiative director) in Sacramento is in the early stages of developing a genetic counseling program with Stanford University. A faculty member at the community college noted that the University of California system is deemphasizing laboratory training, particularly in its genetics courses, due largely to state budget cuts. Hence, the community college initiative intends to build on its success in

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<sup>165</sup> California Voters approved a statewide ballot measure in November 2004 to establish the California Institute for Regenerative Medicine (CIRM), which provides \$3 billion in funding for stem cell research at California universities and research institutions. See <http://www.cirm.ca.gov>.

<sup>166</sup> See Caroline Said. April 1, 2007. “No Degree Required: Technical Courses Gain Favor for Those Interested in Finding a New Career Path,” *San Francisco Chronicle*.

providing hand-on laboratory training, especially wet lab training, to meet the needs of companies for students trained in genetic counseling.<sup>167</sup>

### **8.3 Areas for Further Research**

#### Career Advancement in the Biotechnology Industry

The recruitment and hiring outcomes data presented in this study suggests that the community college biotechnology programs under study open up opportunities for program graduates as entry-level technicians in the biotechnology industry. Although a number of biotech programs and other organizations have outlined career ladders in the industry, this study did not examine the extent or rate of advancement in the industry for community college graduates. As Fitzgerald (2006) notes, and as my interviewees repeatedly mentioned, there is a “culture of advancement” in the industry, such that companies strongly support efforts at lifelong learning, often providing generous tuition reimbursement program. As the director of Bio-Link observed:

Program graduates usually advance three to four times during their tenure. The companies are good about that. So, where there is retention, there is advancement! If people are retrained, they are advancing. People are not staying in the same job forever, and if they do stay a while, they get more money. Industry does reward its employees.

However, there does not appear to be any available data on the advancement prospects of community college graduates, which would help determine whether the program training provides a sufficient foundation for career mobility.<sup>168</sup> Hence, an important next question is the extent to which community college program graduates advance in the field, as well as the particular career paths that they follow. The issue of whether increased pay accompanies

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<sup>167</sup> At a recent event co-sponsored by the CCC Biotech Initiative at the American River College, experts testified about the growing demand for genetic testing, noting that there are only about 3,000 genetic counselors currently working in the U.S. November 8, 2009. “DNA Testing: It’s Just a Click Away,” *Sacramento Bee*.

<sup>168</sup> WIA regulations required the WIB-funded, displaced worker programs under study here to track employment retention for two years after job placement, not career advancement.

advancement should also be addressed. Finally, it is not clear whether the associate's or certificate level training is sufficient to enable graduates to advance in the field without the need to obtain an additional, formal degree, either a bachelor's or master's degree. Further research should seek to determine whether community college graduates need more re-schooling or retraining than their bachelor-degreed counterparts. Among program graduates who must retrain in order to advance, future study should probe the extent of industry support, financial or otherwise, for such efforts.

At a minimum, a longitudinal study of community college program graduates should seek to gather the following data: the graduate's specific biotech program; year of graduation; educational background; work history/experience; length of time before entering (first) biotech job following graduation; subsequent career paths (employers, position titles, length of tenure, area of responsibility); and, among a sample of graduates who did not enter the biotechnology industry, their reasons for entering another industry.

### Reaching the Underserved

As noted in Chapter One, the knowledge and skills needed by technician-level workers in the biotechnology industry include the fundamentals of biology, chemistry, math and physics, in addition to the soft skills of communication and teamwork. Consequently, the perception (if not the reality) is that the biotechnology industry draws a more educated, experienced, and perhaps economically advantaged workforce than do industries targeted by conventional sectoral programs, such as traditional manufacturing or health care. Indeed, the student survey conducted as part of this dissertation study showed that nearly half of the student respondents enrolled in the biotechnology programs under study in the Spring 2009 semester held a bachelor's degree or

higher. The survey also suggests, however, that these students matched the racial and ethnic diversity of California's population groups.

As Chapter Three elaborated, five programs comprising two models explicitly target underserved populations within the two regions under study. The community college bridge programs, which seek to recruit academically underprepared and underemployed adults into the community college system and prepare them for biotech industry jobs or further education, include the Community College of San Francisco's (CCSF) Bridge to Biotech program and the East Bay Career Advancement Academies (formerly, the CCC Gateway Program). The school-to-career programs, which seek to increase the pipeline of underrepresented high school students who are prepared to enter the biotechnology field, include Biotech Partners, the LAB program at Ohlone, and the BETSI program at Southwestern College.

Available outcomes data suggests that these programs are improving students' retention in the programs, their graduation rate, and rate of enrollment in post-secondary education (see presentation in Chapter Six). Somewhat surprisingly, there appears to be little publically available data on student demographics, which would permit an assessment of the program's ability to reach the underserved. Instead, the evidence is primarily anecdotal. For instance, a Biotech Partners newsletter from 2007 states that "nearly all current program participants are minority and over half are female, with most coming from low-income households."<sup>169</sup> The current director recently said that 80 percent of the current class is composed of people of color, and most students are academically challenged ("They're not the AP or honors students"). She explained that, while the program keeps demographic data, it has not had the staff time or resources to compile and analyze it, although it has plans to do so.

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<sup>169</sup> See <http://www.biotechpartners.org/documents/Spring2007Newsletter>.



The only available demographic data that I have been able to obtain documents the race/ethnicity of students in the Ohlone LAB and the CCSF Bridge to Biotech programs. Within Ohlone’s 2008 LAB class, 33 percent were Latino, 27 percent were White, 16 percent were Asian, 9 percent were Filipino, 5 percent were African American, 5 percent were Pacific Islander, and 5 percent were of multiple races. The CCSF Bridge program also enrolls a highly diverse class. Data compiled over a four-year period shows that the percentages of each race/ethnic group have fluctuated across semesters, with percentages of Blacks and Latinos declining in recent years:

**Table 8.1  
CCSF Bridge Student Race/Ethnicity, Fall 2004 – Spring 2008**

Race/ Ethnicity	Percent, Fall 2004 (n=45)	Percent, Spring 2005 (n=54)	Percent, Fall 2005 (n=42)	Percent, Spring 2006 (n=41)	Percent, Fall 2006 (n=41)	Percent, Spring 2007 (n=41)	Percent, Fall 2007 (n=38)	Percent, Spring 2008 (n=32)
Black	30	22	26	29	22	15	18	13
Asian	28	35	24	29	39	27	32	44
Latino	30	22	29	24	22	24	26	19
White	13	20	21	17	17	34	24	25
Native Hawaiian	0	0	0	2	0	0	0	0

Source: “Final Evaluation Report: Bridge to Biotech,” November 2008. Document on file with author.

Clearly, much more needs to be done to document the demographics of students enrolled in the biotechnology bridge and school-to-career programs (as well as all programs), including information on students’ socioeconomic status. In addition, longitudinal data should be collected on these students’ job placement and retention rates, as well as on their career mobility. This data would help determine whether the biotechnology training partnerships are, in fact, helping to expand employment opportunities in the biotech industry for disadvantaged students and/or students traditionally underrepresented in the sciences, as well as diversifying the biotechnology workplace in California.

### Role of industry networks in disseminating information on program graduates

Among other things, this study examined the role of interorganizational collaboration in the development of effective partnership programs. Within this area, the study's primary focus was on the efforts that intermediaries make to outreach to employers and cultivate their active involvement in the programs. As such, it did not explicitly examine employer networks and their role in raising awareness about community college training programs and promoting acceptance of program graduates as an alternative labor pool. Given the importance of employer involvement in and ownership of the programs, however, the intermediaries' ability to tap these networks to disseminate information about the programs and reach out to potential partners is critical and a subject of further study. Below I offer a few preliminary thoughts on this subject.

Many of my industry interviewees noted that they belong to various associations that facilitate communications and relationships among HR personnel, scientists, and engineers. With regard to human resources, I spoke with members of three active networks and best practice groups for HR professionals in the two regions under study: the Biotech Human Resources Network (BHRN) in Northern California; Biotech Organization Learning and Development (BOLD) in the San Francisco Bay Area, organized by "micro-communities" in four surrounding areas: Emeryville, Palo Alto, Fremont, South San Francisco; and BIOCOM's HR network in San Diego County. Regarding science-related networks, the most prominent include the Parenteral Drug Association (PDA), which provides science, technology, and regulatory information and education for pharmaceutical and biopharmaceutical professionals, as well as global forums for its 11,000 members worldwide; and the International Society for Pharmaceutical Engineering (ISPE), the world's largest society serving pharmaceutical science and manufacturing professionals, with 25,000 members. Both HR and scientific staff mentioned

their colleague's widespread use of LinkedIn, the online, interconnected network of professionals, representing 150 industries and 200 countries.

My interviews with the directors of the HR networks, as well as with numerous HR personnel, indicated that recruiting tends to be a small part of what HR staff do; responsibilities such as managing employee relations and compensation systems collectively occupy a greater share of their time. Hence, it is unlikely that any one HR staffer will know a great deal about alternative labor pools, such as community college programs. This is particularly the case in smaller companies, when the HR department typically is composed of one person. These staffers tend to have time to recruit only by word of mouth and typically turn to production managers, scientists, and technicians within the company for information on potential applicants. Indeed, the vast majority of respondents to my survey of HR personnel (see Appendix C) indicated that their primary source of recruitment was recommendations by current staff. As one HR network director put it, these "beleaguered staffers" want "instant gratification." As she explained, if the staffer posts an online query to the HR network asking for help finding an entry-level technician and the response is, "Try Ohlone College, that's not good enough. They won't take the time to follow up on who the contact is, etc." Even the HR Director who administers the network—and who has partnered actively with community college programs in the Bay Area—admitted that she could not possibly field queries from each member regarding available candidates, nor know enough about the different biotech programs in order to steer interested companies in the right direction. While she always refers such calls to the Director of the California Applied Biotech Center-Bay Area (one of the community college biotech initiative's regional centers), she has found that such connections still typically fail to occur due to time constraint issues.

An important HR recruitment tool is the applicant tracking system, which can range from a simple excel spreadsheet that the HR staff manages to expensive online “talent management” software.<sup>170</sup> The more sophisticated software allows applicants to create and store their resume on the company’s website, which HR can then search according to the characteristics they are looking for in a candidate. Usually only larger companies can afford such a system, which allows the company to recruit from a larger base of applicants, including community college job seekers who post their resume to the company’s site.

The HR Director mentioned above has recommended that the community college biotech programs jointly purchase and administer a similar applicant tracking system or job seeker database, which all program students should be encouraged to use. The colleges could allow companies to use the system to browse resumes or post job listings at reduced rates, of special benefit to smaller companies. Of course, given the current California budget crisis, which has precipitated severe cuts to the state’s higher education systems, including the community colleges, such an expenditure is unlikely at the present time.

Regarding networking and information sharing among scientists and production/hiring managers, my interviews with such personnel sought to probe their understanding of the community college biotech programs, as well as their experiences, if any, with program graduates. The conversations underscored how problematic communications can be within firms, particularly the larger ones—precisely those most likely to hire sizable numbers of community college graduates and thus have the greatest awareness of the programs. Numerous interviewees remarked that, due to the size of the companies and the insularity of the scientific

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<sup>170</sup> For the annual career fair in the South San Francisco convention center, co-sponsored by the California Applied Biotech Center-Bay Area and the Biotech Human Resources Network, the talent management software company, Taleo (<http://new.taleo.com/>), agreed to provide its software for free to enable the sponsors to easily track the over 900 job seekers who regularly participate in the event.

disciplines, they frequently do not know staff in other groups or divisions of the same company, and often are unaware of the work that other groups are performing. Moreover, when these professionals do convene in formal or informal network settings, they typically discuss science, not their staff. Hence, these particular networks may not be the most effective source of diffusion regarding information about the programs.

### The Role of Temporary/Recruitment Agencies

While there has been extensive research on contingent workers and the use of private-sector intermediaries in high-tech industries in Silicon Valley and elsewhere (Benner 2002, 2003), there does not appear to be much research examining the role of such intermediaries in placing entry-level manufacturing and biological technicians within the biotechnology and life sciences industries. It is likely, of course, that use of temporary placement or recruitment/staffing agencies within the biotech industry is high.<sup>171</sup> For instance, in the San Francisco Bay Area, over 85 percent of the biotech companies responding to a 2006 survey indicated that they hired temporary workers as a recruitment strategy for hiring permanent employees (PriceWaterhouseCoopers 2006). My interviews indicate that many of the major biomanufacturing companies in the two regions under study contract with area recruitment agencies, some of which locate their staff on the company's premises. In turn, some of these agencies recruit from community colleges. With regard to smaller companies, which often have an HR department of just one person, it is possible that reliance on recruitment agencies is even higher.<sup>172</sup> One interviewee suggested that most companies that have between thirty and fifty

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<sup>171</sup> Prominent temporary help and recruitment agencies in the life sciences industry include AeroTek, Kelly Services, OnLab Support, and K-Force.

<sup>172</sup> Start ups and very early stage companies typically do not have any HR personnel.

employees outsource their recruitment function to firms such as “HR To Go,” a Sacramento-based human resource consulting firm that provides “outsourced Human Resources management.”<sup>173</sup>

This dissertation examined only the direct relationships between community college-based intermediaries and companies, and thus did not focus on the role of temporary help and recruiting agencies in supplying a life sciences workforce to California employers. Given how important private sector intermediaries are to the way corporations work in the new economy, further research should probe the role of recruitment agencies in supplying a technician-level workforce, and especially their impact on the opportunities available to workers without advanced degrees.

For instance, one interviewee noted that companies with 10 to 30 positions to fill often turn to contract recruiters to recruit such positions within a six month period. However, while these recruiters are tied in to the company’s business cycle, they are not as tied in to the local community as companies as employers are—they are “on the fly,” as the interviewee put it. Hence, such recruiters are less likely to develop long-term relationships with specific sources of labor, such as community colleges.

### The Organization of Work

As elaborated in Chapter Six, the prevailing view with regard to the nature of entry-level laboratory work in smaller, research-oriented companies is that such work is generally too advanced for community college students. While much of manufacturing production work tends to be routine or repetitive, laboratory work tends to support a more varied and complex

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<sup>173</sup> See <http://www.hrtogo.com/>.

array of tasks. Although many of the basic skills in the manufacturing and research lab settings are similar—and community college biotech program graduates learn these core competencies—the lab technician is expected to be able to “think outside the box,” particularly when things go awry. Thus, the bar for entry level employment in the research setting is higher than in manufacturing because research technicians are presumed to need more independence, creativity, and theoretical knowledge than the typical community college student possesses. Moreover, with regard to the many routine tasks that are essential elements of research work, e.g., cleaning glassware, companies, especially start ups, often cannot afford to hire an entry-level laboratory assistant or technician to perform such work. Instead, all staff persons, including the Ph.D. scientists, must perform their own routine tests and prepare the materials used in their experiments. A similar rationale is used to explain why smaller companies, in particular, are not able to support student internships. Even if the internships are subsidized by the school or a workforce intermediary, the logic goes, the time involved in supervising interns serves as a barrier to taking them on.

This study has argued that employers’ concerns regarding the suitability of hiring community college graduates in smaller research settings are rooted in legitimate factors related to the company’s stage of production, the company’s economic model and organization of work, and the larger economic climate, as well as in industry and employer misperceptions regarding the qualifications and preparedness of community college graduates. However, this research also demonstrated that companies possess discretion in the way that they organize their work. A number of companies in my sample—even those with as few as four employees—have managed to organize their work in such a way that they can support the laboratory positions for which the community college programs, especially the specialized R&D certificate programs, train

students. All of these companies have hired program interns, sometimes paying the students' stipends themselves, and several have hired these interns as full-time employees. The companies insist that the interns add value by undertaking the lower-level work, which frees up the scientist to perform additional, higher-level experimentation. Significantly, company staff claim that these interns and/or new hires engage in as much critical thinking and troubleshooting as their bachelor-degreed counterparts, and hence can be relied on to "wear many hats," a necessary skill in the changing and variable environment of the research lab. In addition, they possess better practical, hands-on skills that enable them to perform their tasks more effectively. As such, the work that the community college graduates were hired to undertake was not considered "deskilled."

Moreover, companies that reach the clinical/developmental stage in their development, in which they usually employ between 50 and 300 employees, often find that they can capture efficiencies by establishing a "core facility," a centralized unit within the firm that specializes in certain key functions. The work performed in such a facility often is highly suitable for community college-trained technicians. Indeed, one company in the research sample has created a new career ladder for research technicians that will target community-college trained workers.

Hence, further examination of the factors that inform the hiring decisions of smaller, research-oriented biotechnology companies with respect to an entry-level technician staff can make a significant contribution to the organization of work literature. Untangling the legitimate from the perhaps illegitimate concerns regarding the suitability of community college graduates for entry-level laboratory work in a sample of smaller companies promises to shed light on the strategic decisions that companies make about how to organize and manage their workplaces.



The undertaking also promises to illuminate the role that employers' expectations and perceptions play in their understanding of the complexity of many science-related tasks.

Finally, further research should investigate the role that workforce intermediaries can play in convincing research-oriented companies to take on community college interns and hire program graduates. Workforce intermediary staff may need to demonstrate to employers that by reorganizing their less-advanced research laboratory work they can benefit from the hands-on, practical, and problem-solving skills of community college graduates. As this dissertation research has demonstrated, a number of partnership program staff and community college faculty have built strong relationships with smaller, R&D companies, and these ties have helped to change the perceptions of scientists, hiring managers, and HR staff about the productivity and retainability of community college students, even those without a prior bachelor's degree. These efforts, I have argued, go to the heart of demand-side work in the biotechnology industry. Hence, by probing the unique challenges and opportunities that intermediary staff face vis-à-vis these employers, future research promises to shed additional light on the ability of intermediaries to make the labor market for entry-level biotechnicians more effective and equitable.

## Appendix A

### **Biotechnology-Related Sub-Industry Titles and NAICS Codes**

<b>Segment</b>	<b>Industry Title</b>
Agricultural Biotechnology	NAICS 111191 Oilseed and grain combination farming
Agricultural Biotechnology	NAICS 111421 Nursery and tree production
Agricultural Biotechnology	NAICS 111920 Cotton farming
Agricultural Biotechnology	NAICS 111998 All other miscellaneous crop farming
Agricultural Biotechnology	NAICS 311211 Flour milling
Industrial Biotechnology	NAICS 325193 Ethyl alcohol manufacturing
Industrial Biotechnology	NAICS 325199 All other basic organic chemical manufacturing
Industrial Biotechnology	NAICS 325221 Cellulosic organic fiber manufacturing
Industrial Biotechnology	NAICS 325222 Noncellulosic organic fiber manufacturing
Industrial Biotechnology	NAICS 325611 Soap and other detergent manufacturing
Industrial Biotechnology	NAICS 325612 Polish and other sanitation good manufacturing
Industrial Biotechnology	NAICS 325613 Surface active agent manufacturing
Medical Devices	NAICS 334510 Electromedical apparatus manufacturing
Medical Devices	NAICS 334516 Analytical laboratory instrument manufacturing
Medical Devices	NAICS 334517 Irradiation apparatus manufacturing
Medical Equipment and Supplies	NAICS 339111 Laboratory apparatus and furniture manufacturing
Medical Equipment and Supplies	NAICS 339112 Surgical and medical instrument manufacturing
Medical Equipment and Supplies	NAICS 339113 Surgical appliance and supplies manufacturing
Pharmaceuticals and Related Manufacturing	NAICS 325411 Medicinal and botanical manufacturing
Pharmaceuticals and Related Manufacturing	NAICS 325412 Pharmaceutical preparation manufacturing
Pharmaceuticals and Related Manufacturing	NAICS 325413 In-vitro diagnostic substance manufacturing
Pharmaceuticals and Related Manufacturing	NAICS 325414 Other biological product manufacturing
Research Services	NAICS 541710 Physical, engineering and biological research

Source: National Advisory Committee, San Diego Workforce Partnership (Egan and Johnston 2006).

The National Advisory Committee has categorized these 23 NAICS codes into six industry segments:

- Agricultural Biotechnology,
- Industrial Biotechnology,
- Medical Devices,
- Medical Equipment and Supplies,
- Pharmaceuticals and Related Manufacturing
- Research Services.

## **Appendix B**

### **Interview Protocol: Community College Faculty/Staff**

1. What is your current position and department?
2. Please explain the different degree offerings of your biotech program.
3. Approximately how many students enroll and graduate from this program each year?
  - Of these students, approximately how many transfer and how many enter industry?
  - Of those who join industry, do you track (or else know) where most have gone?
4. Please describe the origins/history/evolution of the biotech program.
5. If you teach both in a certificate and an Associate's degree program, please discuss the preparation that each program offers, and the different types and level of job positions for which each programs trains students.
6. Do you feel that your students are able to perform work that is similar in content and level of difficulty to that performed by technicians coming from 4-year colleges? Please explain.
7. Please describe the nature and level of your interactions/involvement with industry personnel (e.g., curriculum review, guest lectures, company tours, student internships, faculty externships, equipment donations).

## Appendix C

### **Biological Technician Workforce Survey: Questions for HR Staff**

Aziza Agia, Ph.D. Candidate

aziza.agia@gmail.com

You have been asked to participate in a research study conducted by a Ph.D. candidate at the Massachusetts Institute of Technology. The purpose of the study is to understand the role of biotechnology training partnerships in the recruitment and hiring of entry-level biological technicians. The data from this survey will be used to analyze trends in company sourcing of manufacturing and research support staff, as well as the effectiveness of community college programs in meeting industry demand for a well-trained technician workforce. Survey results will be included in the researcher's dissertation.

*Please note that your answers will be kept confidential and all data will be reported in the aggregate so that your company's information will not be identifiable to others.*

Thank you very much for your participation.

1. Please list the occupational titles of all entry-level technician positions in your workforce for which a community college Associate's degree (A.S.) or Certificate is *typically* the minimum or preferred educational requirement.

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2. What is the size of your current entry-level technician workforce? \_\_\_\_\_

3. How many entry-level (EL) technicians in your current workforce have a certificate or two-year A.S. degree from a community college biotechnology program?

Number of EL technicians with an A.S. degree \_\_\_\_\_

Number of EL technicians with a Certificate \_\_\_\_\_

4. How many entry-level technicians were hired in the last three years?

2008 \_\_\_\_\_

2007 \_\_\_\_\_

2006 \_\_\_\_\_

5. Of the entry-level technicians hired in the last three years, please indicate the number that has a community college certificate or A.S. degree.

2008:	_____	A.S. Degree	_____	Certificate
2007:	_____	A.S. Degree	_____	Certificate
2006:	_____	A.S. Degree	_____	Certificate

6. What are your company's primary recruitment methods for entry-level technicians?  
Please check all that apply.

- Recommendations by current staff
- Company website
- Recruiters and third party agencies
- Which ones? \_\_\_\_\_
- \_\_\_\_\_
- Job Boards
- Which ones? \_\_\_\_\_
- \_\_\_\_\_
- Local newspapers
- Student internships
- Job fairs
- Community College biotechnology programs

7. Do you work directly with community college program staff or faculty to fill your entry-level technician positions?

If "yes," please describe any specific relationship(s) you have with program staff or faculty.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

If "no," please explain why you do not work with community college programs.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Appendix D

### **Interview Protocol: Production Managers**

1. What is your current position and department?
2. What are the top skills that entry-level (EL) technicians must have in order to successfully compete for and, once hired, to perform their jobs?
3. What educational qualifications and/or training best prepare EL technicians for their jobs?
  - Bachelor's degree in math/sciences field
  - Associate's degree in biotechnology or other math/sciences field
  - Short-term (intensive) certificate in biomanufacturing, stem cell, or other.
4. What makes applicants more competitive beyond the minimum job requirements, or helps differentiate them from other applicants?
  - Additional education
  - Hand-on training (e.g., laboratory courses and/or internships)
  - Work experience
  - Other
5. Are you familiar with community colleges (CC) and their skills training programs?
6. Have you ever supervised entry-level technicians who were trained in CC biotech programs?
  - Approximately how many such technicians have you supervised total, and how many do you typically supervise per year?
  - Do you know whether any of your employees graduated from the shorter (e.g., 13-week) certificate programs or the longer two-year associate's degree program?
7. Do you find that the CC graduates whom you have supervised are well prepared for their jobs?
  - If "yes," how you feel about their:
    - Level of knowledge and technical competence?
    - Hands-on, laboratory experience?
    - Other measures of their level of preparedness (please describe)?
  - If "no," how could the CC programs improve to better prepare students for these jobs?
8. What parts of the CC training do you find most relevant and useful? Is there any additional training that you wish these graduates had?

9. Based on your experience, do you find that EL technicians with both the AS degree or the certificate have adequate training?
10. Please describe the different categories or profiles of EL technicians you have supervised, based on their experience, educational backgrounds, and training.
11. How do entry-level technicians who have trained in hands-on, laboratory courses at CC compare to these other entry-level technicians (e.g., are they more competent, and do they “hit the ground running,” contributing sooner than others)?
12. Do entry-level technicians coming from CC perform work that is similar in content and level of difficulty to that performed by technicians coming from 4-year colleges?
13. CCC biotech programs typically include GMP training. Do you find that EL technicians trained at CC tend to require less GMP training than their counterparts coming from four-year colleges?
14. In your experience, how long do the following types of EL technicians tend to stay in their jobs?
  - Employees coming from CC programs
  - Employees coming from four-year programs
  - Other

What, in your view, accounts for any differences in tenure?

## Appendix E

### Community College Biotechnology Program - Student Profile

#### About the survey

You have been asked to participate in a research study conducted by a Ph.D. candidate at the Massachusetts Institute of Technology. The purpose of this study is to understand the role of community college-industry partnerships in improving employment opportunities for graduates of community college biotechnology programs. The data from this survey, which will be kept confidential, will provide important information about the educational pathways of community college-trained biological technicians. The data will be aggregated across biotech programs for use in the researcher's dissertation.

THIS SURVEY SHOULD TAKE NO MORE THAN 10 MINUTES TO COMPLETE.

Please note that your participation in the survey is voluntary; you may decline to answer any question, without adverse consequences; and your responses will be kept anonymous.

Thank you very much for your participation.

#### Please tell us about yourself

##### 1. In what community college program are you currently enrolled?

Name of program

Name and location of community college

##### 2. Please indicate your:

Age

Gender

Race or ethnicity

#### Educational Background

##### 3. Do you have a previous Associate of Arts/Science degree or a community college Certificate? If so, please indicate the following:

Name of certificate or degree

Field of study

Name and location of community college

Date of degree or certificate



## Community College Biotechnology Program Survey - Student

**4. Do you have a Bachelor of Arts/Science degree? If so, please indicate the following:**

Name of degree

Field of study

Name and location of college

Date of degree

**5. Do you have a graduate or professional degree? If so, please indicate the following:**

Name of degree

Field of study

Name and location of school

Date of degree

**6. If you have already a Bachelor's degree or higher, why did you enroll in the current community college biotechnology program?**

### Work History

**7. Please list your last two jobs, indicating for each job your:**

**a) occupation and position; and**

**b) approximate dates of employment.**

### Future Plans

**Community College Biotechnology Program Survey - Student**

**8. What do you intend to do after you receive your community college degree or certificate?**

- Enter the workforce
- Continue my education by pursuing an Associate's degree
- Continue my education by pursuing a Bachelor's degree

Other (please specify)

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