The Biotechnology Industry

Identifying and Addressing Workforce Challenges in an Emerging Industry

Prepared by

New Economy Strategies, LLC

and

The Leonard Resource Group, Inc.

for

The U.S. Department of Labor
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Preface

The following report, prepared by New Economy Strategies and the Leonard Resource Group, Inc., for the U.S. Department of Labor (DOL), Employment and Training Administration (ETA), details the efforts around President George W. Bush's High Growth Job Training Initiative in the biotechnology industry. It provides an overview of the structure of the biotechnology industry, examines the workforce challenges facing the industry, and discusses possible solutions to address industry challenges.

Each year, the Federal Government invests over $15 billion in the public workforce investment system to provide employment and training services across the United States. As part of its ongoing efforts to use taxpayer dollars more effectively and efficiently, ETA is implementing the President's High Growth Job Training Initiative. The Initiative, of which this report is a part, is designed to demonstrate the power of a demand-driven workforce system that tailors local workforce investment activities to reflect the workforce needs of local employers. The Initiative models the power of this approach in 12 high growth industries.

In 2002, Assistant Secretary for Employment and Training Emily Stover DeRocco created the Business Relations Group (BRG) to implement the High Growth Job Training Initiative and demand-driven vision. The BRG develops innovative approaches to helping business and industry better access the services delivered by the state and local workforce investment system and increases the ability of the workforce investment system to provide solutions to the workforce challenges faced by business. Recognizing the relationship between workforce development and economic development, the BRG promotes partnerships between *education*, *employment*, and *economic development*. Through these partnerships, workers can gain the skills they need to succeed through training programs designed by local employers and delivered through community colleges and other education and training institutions. ETA's goal in promoting partnerships between education and economic development is to simultaneously provide benefits to both the nation's workers and employers.

The $33.6 billion biotechnology industry was selected for the President's High Growth Job Training Initiative because of the emerging nature of the industry, the need for quality workers, from technicians to Ph.D. level scientists, and the projection that the biotechnology industry will employ 814,900 individuals in the United States by 2007.[1]

[1] Figures from www.Economy.com.

The emerging nature of the industry affords employers the opportunity to offer jobs in biotechnology that are enticing to potential job seekers. Biotechnology occupations are attractive because they are located across the nation, provide a professional work environment, and include a range of higher wage levels above many traditional occupations. Further, the biotechnology industry is creating excellent and diverse opportunities in a wide range of areas. While many jobs in the biotechnology industry are in traditional life sciences, the industry also offers careers in computer science, information technology, regulatory affairs, quality control and assurance, sales and marketing, manufacturing, and facilities and infrastructure management.

ETA listened to many employers, industry association representatives, and others associated with the biotechnology industry regarding their efforts to implement effective workforce strategies. The industry recognizes the importance of workforce development and has made strides at the local and regional level to develop industry-driven solutions. Through the President's High Growth Job Training Initiative, ETA complemented industry efforts by providing a national forum through which industry leaders could share their workforce issues and activities. Through the Initiative, industry leaders connected with education and training providers, economic development, and the public workforce system for the purpose of building partnerships to develop and implement solutions that address the industry's workforce challenges. These partnerships are especially important because ETA repeatedly heard from the industry that the challenges they face are too complex for any one institution, or sector within the industry, to solve alone.

ETA is not alone in seeking to make these important connections. Other federal agencies are undertaking critical projects to improve the planning and distribution of resources for biotechnology industry growth and competitiveness. In 2003, the U.S. Department of Commerce's Technology Administration conducted an ambitious inquiry into the nation's biotechnology cluster and the future workforce demands by a wide variety of stakeholders. The Technology Administration gathered a vital set of responses to an extensive survey of the industry that has been incorporated into this report. Meanwhile, the U.S. Department of Agriculture, the U.S. Food and Drug Administration, and the U.S. Environmental Protection Agency are collaborating to facilitate the government regulatory process for the industry.

This report is a review and analysis of ETA's work with the biotechnology industry under the President's High Growth Job Training Initiative. It is intended, in part, to provide employers, educators, the workforce investment system, policymakers, and funding sources with a strategic guide to the most critical workforce challenges facing

the biotechnology industry and identify some of the preliminary solutions developed through the partnership of private industry, the public workforce system, and education.

To those who gave generously of their time, effort, and other resources for this work, thank you for your thoughtful contributions. To those reading about this Initiative for the first time, ETA looks forward to your input in building a system to train a world-class biotechnology workforce for our country.

Executive Summary

While many people associate the biotechnology industry with the widely publicized discovery and development of new drugs to treat cancer, heart disease, and other diseases, fewer people are aware of the major advancements the industry is making in other areas such as chemicals, agriculture, pharmaceuticals, medical devices and equipment, nanotechnology, information technology, and facilities and infrastructure management. Emerging scientific and technological discoveries have increased the rate of development and distribution of exciting solutions to problems U.S. citizens face with health and diseases, agriculture, and other areas. For example, state-of-the-art Bio-Imaging facilities contain a laser capture microdissection instrument which allows surgeons, through a three dimensional capability, to simulate real-life surgery, prior to its application.

The biotechnology industry is responsible for hundreds of medical diagnostic tests that keep blood supplies safe from the AIDS virus and detect other conditions early enough to be successfully treated, improves our food supply by reducing dependence on chemical pesticides, leads to cleaner processes that produce less waste and use less energy and water, and has more the 370 biotechnology drug products and vaccines currently in clinical trials that target more than 200 diseases, including various cancers, Alzheimer's disease, heart disease, diabetes, multiple sclerosis, AIDS, and arthritis.[2]

Since 1990, the biotechnology industry has experienced dramatic growth, with revenues jumping from $8 billion in 1992 to $39.2 billion in 2003.[3] The industry is projected to employ 814,900 people in the United States by 2007[4], which creates a pressing need for quality workers from the technician level to doctoral-level scientists, as well as other occupations that support the biotechnology industry.

The President's High Growth Job Training Initiative is a strategic effort of President George W. Bush's administration to prepare workers for new and increasing job opportunities in high growth and economically vital industries and sectors of the American economy. The Initiative is designed to provide national leadership for a demand-driven workforce system by identifying high growth/high demand industries, evaluating their skills needs, and funding demonstration projects that provide workforce solutions to ensure individuals can gain the skills to get good jobs in these

[2] All examples taken from Biotechnology Industry Hot Facts on the BIO Web site, www.bio.org/speeches/pubs/er/statistics.asp.
[3] Biotechnology industry statistics and facts from www.bio.org/speeches/pubs/er/statistics.asp.
[4] Figures from www.economy.com.

rapidly expanding or transforming industries. This Initiative is led by the U.S. Department of Labor's (DOL) Employment and Training Administration (ETA), which quickly identified biotechnology as one of the 12 industries on which it would focus.

Under the President's High Growth Job Training Initiative, ETA conducts a series of Executive Forums to offer leaders in business and industry an opportunity to share their current and future workforce needs with the workforce system. Using the information gathered at these meetings, ETA convenes a Solutions Forum with industry and public workforce system representatives to verify workforce challenges and devise solutions.

This report broadly details the challenges and solutions expressed by senior biotechnology industry representatives, community colleges and other education and training providers, and representatives from the public workforce system. The challenges expressed in the Executive Forums fell into three broad categories: Pipeline–Recruitment and Retention, Skills Competencies and Training, and Image and Outreach to the Public.

The following solutions were identified as priority solutions during the Forums to meet the industry's challenges with recruitment and retention, skills competencies and training, and image and outreach.

Issue: Pipeline – Recruitment and Retention

- Provide a variety of opportunities to students and faculty (elementary, secondary, postsecondary, and beyond) including job shadowing, summer camps, mentoring, industry speakers, tours, high school and college competitions, career clubs, and workshops.
- Create a separate funding stream or carve out a portion of WIA dollars that can be put towards meeting industry needs, as long as they are driven by the business community.[5]
- Create a national biotechnology workforce survey that is industry generated and validated. Start in one major state as a test-bed and distribute nationally through the Biotechnology Industry Organization (BIO).
- Create flexible, short-term training options to keep up with ongoing industry training.
- Create a system for portable, lifelong learning accounts for workers, promote the system, and support the use of the system.

[5] The Administration's Workforce Investment Act (WIA) Reauthorization proposal would allow for state flexibility to spend WIA dollars on these industry driven needs.

- Create a system for continuous skills-upgrade training, career enhancement, and well-documented career ladders and lattices allowing biotechnology companies to maintain their competitiveness and retain well-skilled workers.

Issue: Skill Competencies and Training

- Create a map and a matrix of existing competencies and models, assess gaps, and validate and update regularly. Define business and technology skills for all levels. Create a dynamic delineation of labor market information data that reflects the emerging biotechnology industry that uses a common language and is based on skill sets. Post on an industry-specific website.
- Develop models with incentives that make it easy for K – 12 institutions to work with college and corporate partners.

Issues: Image and Outreach to the Public

- Present information about biotechnology careers organized by different criteria, e.g., industry content, occupation, educational pathway, career ladder, and salary.
- Create a national media campaign.
- Create a universal formula that is disseminated by all agencies (federal, state, and local).
- Recognize the diversity of career options and apply scientific and distinct names to various bio-industries or categories, which will clarify larger concerns, e.g., what is biotechnology, and then outline entry-level occupations with industry and determine the basic skills and competencies needed.
- Create awareness at the elementary and secondary (K – 12) levels by creating partnerships between employers and schools that include: 1) mentorship and job shadowing, 2) employer-sponsored science fairs, 3) development of problem-based projects for K – 12 students to explain different areas that integrate academic standards, 4) school-based clubs, and 5) K – 12 and college programs.

Dealing with workforce challenges in the biotechnology industry requires collaboration at and among the national, state, and local levels. Biotechnology Industry Executive and Workforce Solutions Forum participants recommended an approach that identifies and determines common fundamentals to the industry at the national level while providing flexibility to regional and local levels to find solutions to better manage their local biotechnology workforce challenges. One goal of the President's High Growth Job Training Initiative is to foster collaborations between industry, the public workforce system, community colleges and other educational and training providers, and economic development entities in order to develop solutions to the needs of their local

biotechnology industry. These collaborations can build from, or work independently of, the President's High Growth Job Training Initiative, but should work towards implementing workforce solutions at the local level.

ETA supports comprehensive business, education, and workforce development partnerships to develop innovative approaches or replicate models that operationally demonstrate how a demand-driven workforce system can more effectively serve the workforce needs of business while also effectively helping workers find good jobs with good wages and promising career pathways. Grants awarded under the President's High Growth Job Training Initiative will implement unique and innovative, industry-driven skills training, certification, and career ladder development programs that support identified biotechnology workforce and economic development needs.

Based on the challenges identified by the biotechnology industry and highlighted in this report, the U.S. Department of Labor has made a series of investments totaling more than $17 million to address the workforce needs in the areas of Pipeline – Recruitment and Retention, Skills Competencies and Training, and Image and Outreach. The demonstrations bring to life the solutions identified during ETA's Forums and address the needs of the industry broadly, as well as those of specific industry sectors. The models developed and lessons learned through these demonstrations will help build the public workforce system's capacity to be demand-driven and meet the serious workforce challenges faced by the biotechnology industry.

I. Overview of the President's High Growth Job Training Initiative

The President's High Growth Job Training Initiative is a strategic effort of President George W. Bush's administration to prepare workers for new and increasing job opportunities in high growth and economically vital industries and sectors of the American economy. The Initiative is designed to provide national leadership for a demand-driven workforce system by identifying high growth/high demand industries, evaluating their skills needs, and funding demonstration projects that provide workforce solutions to ensure individuals can gain the skills to get good jobs in these rapidly expanding or transforming industries.

The foundation of this initiative is partnerships between the publicly funded workforce investment system, business and industry representatives, and education and training providers, such as community colleges. The purpose of these partnerships is to develop innovative solutions or replicate models that address a particular industry's workforce issues. These solutions demonstrate how a demand-driven workforce system can more efficiently serve the workforce needs of business while effectively helping workers find good jobs with good wages and promising career paths.

The High Growth Job Training Initiative process engages each partner in its area of strength. Industry representatives and employers define workforce challenges facing the industry and identify the competencies and skills required for the industry's workforce. Community colleges and other education and training providers assist in developing competency models and training curricula and train new and incumbent workers. The publicly funded workforce investment system accesses human capital (youth, unemployed, underemployed, and dislocated workers), assists with training programs, and places trained workers in jobs.

ETA is modeling the power of this partnership at the national level through investments in demonstration projects in twelve high growth industries, including the biotechnology industry. Each of the 12 industries was selected because it meets one or more of the following criteria: (1) is projected to add substantial numbers of new jobs to the economy; (2) has a significant impact on the economy overall; (3) impacts the growth of other industries; (4) is being transformed by technology and innovation requiring new skills sets for workers; or (5) is a new and emerging business that is projected to grow.

Investments in these sectors are designed to achieve four broad outcomes:

1. Targeted investment of workforce development resources and support for private and public sector partnerships to ensure the development of workers' skills in demand occupations based on industry need.
2. Increased integration of community and technical college efforts with business and the public workforce system activities to meet the skills training needs of high growth industries.
3. Increased opportunities for employers to use apprenticeship training as skills development methodology, combining on-the-job training and academics, to ensure a pipeline of skilled workers.
4. Providing workers with paths to career enhancing opportunities in high growth occupations.

By expanding the local workforce system's capacity to be market-driven, responsive to local economic needs, and a contributor to the economic well-being of the community, the Employment and Training Administration is promoting workforce quality, enhanced productivity, and economic competitiveness.

The High Growth Job Training Initiative Process

To achieve the desired outcomes of the President's High Growth Job Training Initiative for the biotechnology industry, ETA follows a detailed protocol to identify workforce challenges and solutions and demonstrate solutions nationally.[6] First, ETA conducts an environmental scan to understand the economic conditions and workforce challenges facing the industry. Then, ETA conducts a series of Executive Forums to offer leaders in business and industry an opportunity to share their current and future workforce needs with the workforce system. Using the information gathered at these meetings, ETA convenes a Solutions Forum with industry and public workforce system representatives to verify workforce challenges and devise solutions. In the final phase of the High Growth Job Training Initiative process, ETA makes a series of investments in innovative and industry-driven projects that reflect industry-identified challenges and solutions and demonstrate training initiatives and capacity building strategies to address the industry's unique workforce challenges. These projects make up a solution set tailored to each industry's specific needs.

During the ETA-led Executive Forums for the biotechnology industry, senior executives from many sectors of the industry expressed a wide range of workforce challenges confronting the industry. The challenges expressed in the Executive Forums fell into

[6] This process is described in greater detail in Appendix A.

three broad categories: Pipeline – Recruitment and Retention, Skills Competencies and Training, and Image and Outreach to the public.

Pipeline – Recruitment and Retention. Pipeline issues refer broadly to an industry's ability to attract new workers, including youth, previously untapped labor pools, and individuals transitioning from other industries, as well as the retention of incumbent workers. To succeed and grow in the 21st century economy, biotechnology employers need to fill each position in their companies, from entry-level to the most advanced, with qualified, skilled individuals. Because the industry is experiencing such rapid growth, biotechnology firms often demand more skilled workers than are available and are projected to need more workers than are currently enrolled in training programs. Ensuring an appropriate supply of skilled workers, and retaining and retraining workers currently in the industry, is an important challenge identified by biotechnology industry executives.

Skills Competencies and Training. As with most of the High Growth Job Training Initiative industries, the biotechnology industry identified a need for clearly articulated skills competencies and career ladders as well as sources of training. However, the biotechnology industry's challenges in this area are complicated by the rapidly changing environment in which the industry operates. Advances in the underlying sciences continuously affect the technology and processes used by the biotechnology industry, making it necessary for employees working in the industry to continuously upgrade their skills to maintain productivity.

Image and Outreach to the Public. Youth, educators, and job seekers lack clear information about career options within the biotechnology industry and generally fail to understand the depth and range of the industry's activities. This disconnect is a challenge for the industry because the lack of definition and outreach limits the number of people who consider the biotechnology field to be a viable career option.

II. Biotechnology Industry

Biotechnology is an emerging and rapidly growing industry that impacts our lives daily. Advancements within the biotechnology industry have allowed for the emergence of exciting new technologies that have led to improvements in various disciplines of scientific research. From developing crops resistant to disease, to making new biomedical devices, to perfecting nanotechnology, creating lifesaving drugs, the breadth of the industry is far reaching. The industry traces its roots to the 1950's with the discovery of DNA by Watson and Crick and has evolved over the past 50 years from a rigid corporate model to a more fluid model comprised of thousands of companies, vendors, and suppliers that operate along a complex industry lifecycle. Today, the biotechnology industry is responsible for advances that combat human diseases, promote human health, combat animal diseases, fight hunger by resisting plant diseases and increasing crop yields, and help the environment by reducing pesticide use.

Definition

The U.S. Department of Commerce and the Biotechnology Industry Association (BIO) define the field of biotechnology as "*the application of molecular and cellular processes to solve problems, conduct research, and create goods and services.*"[7] As an industry, biotechnology is defined not by the products it produces but by the technologies it employs during production. The industry is based on the commercial application, research, and development of these technologies through firms that research, develop, manufacture, and market these new technologies.

The biotechnology industry includes firms that use cells and biological molecules for applications in medicine, agriculture, and environmental management. Health care provides one of the most lucrative applications for biotechnology, because our growing and aging population generates an ever increasing demand for drugs and medical devices. In its convergence with information technology, biotechnology also impacts upon bioinformatics, nanotechnology, biomanufacturing, and even the electronics industry.

For our purposes, the term life sciences is a larger, broader concept that deals with living organisms and their organization, life processes, and relationships to each other and their environment; whereas biotechnology is a specific example of one aspect of the

[7] U.S. Dept. of Commerce, "*Critical Technology Assessment of Biotechnology in U.S. Industry*," July 2002, p. 3.

Life Sciences, which is the application of the principles of engineering and technology to the life sciences.

Characteristics of the U.S. Biotechnology Industry

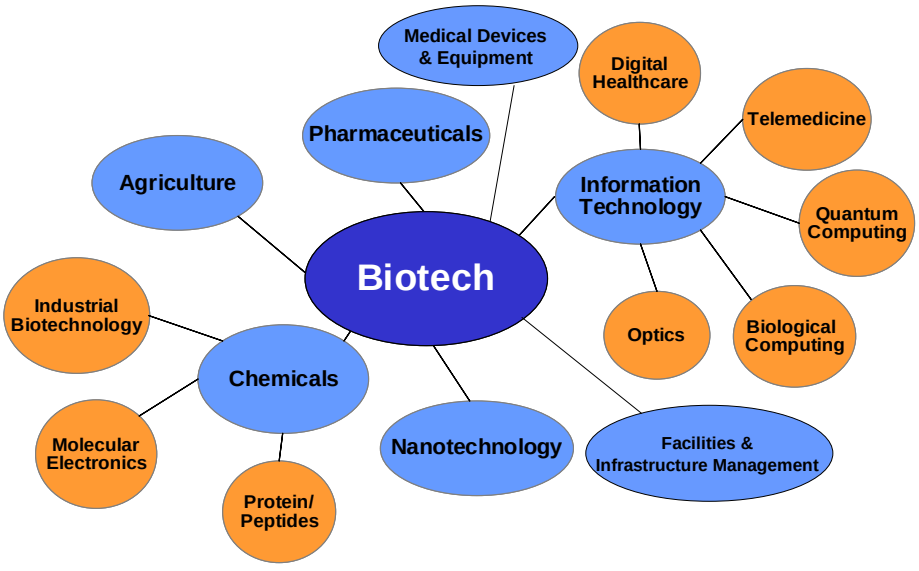
The business and economic models for the biotechnology industry include many layers of vendors and suppliers. The complexity of the biotechnology industry can best be illustrated by the reach of some 38 areas of sub-sector elements, from plant, animal, and marine life sciences to drug discovery and information technologies used to support gene research. Additionally, the development cycles for drugs, medical devices, and natural health care products have different stages of research, review, and approval by federal regulatory agencies. Before biotechnology products ever reach patients and markets, millions of dollars have been invested and spent along with years of clinical trials.

Industry Sectors

While many people associate the biotechnology industry with the widely publicized discovery and development of new drugs to treat cancer, heart disease, and other diseases, fewer people are aware of the major advancements the industry is making in other areas such as chemicals, agriculture, pharmaceuticals, medical devices and equipment, nanotechnology, information technology, and facilities and infrastructure management. **Figure 1** illustrates the general sectors of the industry, which reflect the divisions in the underlying science.

Figure 1

The Evolving 21st Century Biotech Industry



Source: New Economy Strategies

Each sector contains is own science, processes, competency and skills requirements, and outcomes. For example, ***Agricultural Biotechnology*** is a collection of scientific techniques, including genetic engineering, that are used to create, improve or modify plants, animals, and microorganisms. Using conventional techniques such as selective breeding, scientists have been working to improve plants and animals for human benefit for hundreds of years. Modern techniques now enable scientists to move genes (and therefore desirable traits) in ways they could not before with better precision.

A key feature of the ***Medical Devices and Equipment*** industry is the diversity of the products produced. At one end of the spectrum the products are highly invasive and technologically complex. These include electrically active implantable products such as pacemakers, artificial cochlear devices to help restore hearing, and implantable neurostimulators, used to control pain or incontinence. Non-active implantable devices include coronary stents for treating vascular disease and knee and hip replacement devices. At the other end of the spectrum, products include simple consumerables, such as bandages, dressings and drapes, barrier contraceptives, and disposable surgical instruments and syringes. Diagnostic and surgical equipment, such as Magnetic Resonance Imaging (MRI) machines, electrocautery devices and electrocardiogram (ECG) monitors are also classed as medical devices and covered by the same regulatory processes.

Pharmaceutical companies make medicines from plant and chemical based compounds. The U.S. pharmaceutical industry has achieved worldwide prominence through research and development (R&D) work on new drugs, and spends a relatively high proportion of its funds on many thousands of new substances, yet may eventually yield only 10 to 20 new prescription medicines.

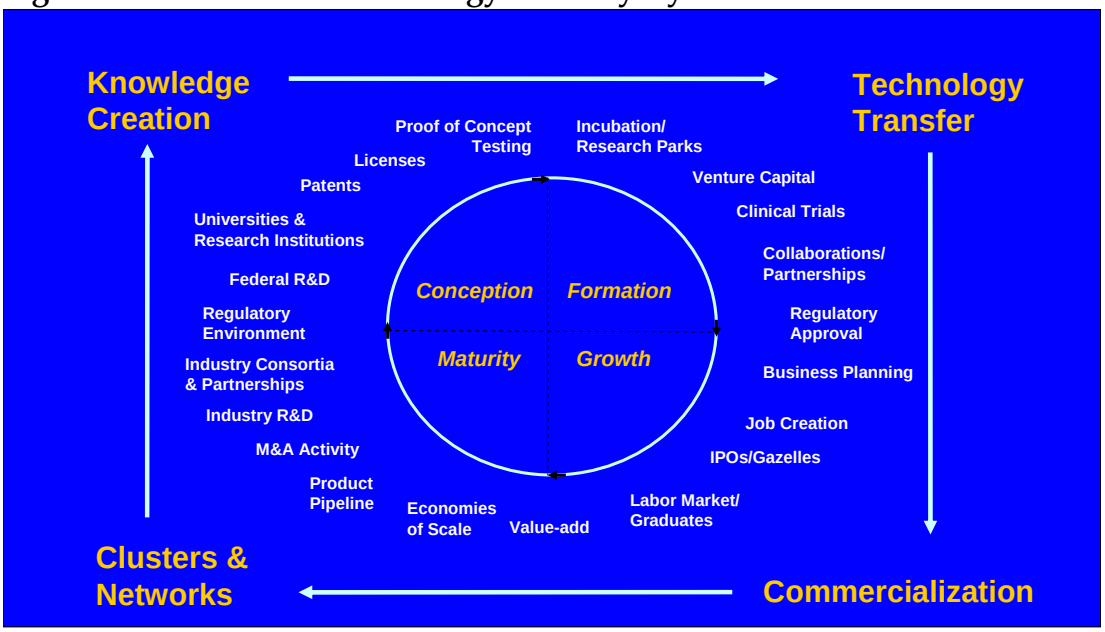
Nanotechnology involves work at the atomic and molecular levels that correspond to lengths of 1/100,000th the diameter of a human hair. Nanotechnology may one day enable the detection of disease at the cellular level and the targeting of treatment only to tissues where it is needed in a patient's body, potentially alleviating many unpleasant and sometimes harmful side effects. Nanotechnology, through nanosensors, can help monitor for chemical attacks and environmental leaks; it may also help provide clean energy.[8]

[8] White House Fact Sheet: President Bush signs 21st century Nanotechnology Research and Development Act, http://www.whitehouse.gov/news/releases/2003/12/20031203-7.html.

Changing Workforce Needs during the Life Cycle of Biotechnology Products

The biotechnology industry cycle is a framework comprised of four business models: knowledge creation, technology transfer, commercialization, and clusters and networks. Under this framework, there are four stages of development for the industry: Conception, Formation, Growth and Maturity. The cycle follows a product from the research and development stage to manufacturing and distribution. The Conception stage focuses on the research and discovery of new products, services, and ultimately, the opportunities for advancing novel solutions to address health care, agriculture, and other challenges that face the nation. Conception often occurs in small companies that employ between one and 49 people. The majority of these employees are typically directly engaged in the research and development process. Research under the Conception stage often occurs in the context of academic research institutions; however, some communities have set up research parks (e.g. Research Triangle Park, NC) and biotechnology incubators to enable small firms to develop and grow under the knowledge creation model.

Figure 4 The Biotechnology Industry Cycle



Source: New Economy Strategies

The Formation stage focuses on the creation of firms and technology to transfer products and services into the marketplace. During the Formation stage, companies seek out venture capital and investments from local communities to assist in the development of a product. Products are tested through clinical trials and then put forth

for regulatory approval. Individuals companies in the industry must overcome two significant challenges to progress beyond this first stage: securing sufficient venture capital and surviving the long regulatory approval process. Without the vital venture capital investments, the company cannot invest the time or resources necessary to develop a new product. However, the length of time and the uncertainty and risk surrounding regulatory approval complicates the process of finding investors. The industry is often asking investors to support projects which scientists believe have the potential to benefit society, but which will not see financial returns over the short term. Overall, the Conception and Formation stages can take as long as 10-15 years before a product is fully developed and receives regulatory approval.

During the Growth and Maturity stages, companies focus on expansion and commercialization as well as development of industry clusters and networks. During the Growth stage, a critical mass of products are placed into the market through sales and infrastructure. Companies engage in business planning to continue developing processes and products. A company that enters this stage of the life cycle may grow to employ between 50 and 149 people. Significant job creation and a high demand for workers with a variety of skills ranging from laboratory and biotechnology technicians to information technology, facilities maintenance, sales and marketing occurs during this stage.

The Maturity stage is defined by global competitiveness similar to a publicly traded corporation. Companies are larger, with 150 or more employees, and manufacture, distribute, and market products. The company contributes to product pipeline industry research and development, and develops consortia and partnerships within the industry. In essence, this stage represents a fully developed cluster or network.

The workforce needs of the biotechnology industry vary along the path of the industry lifecycle. These stages of growth require closer attention and a better understanding of the necessary resources, including specific workforce skills and competencies, required to ensure that products and services continue to reach the markets and in the end the needs of patients and citizens with health care and disease management demands.

Geographic Clusters

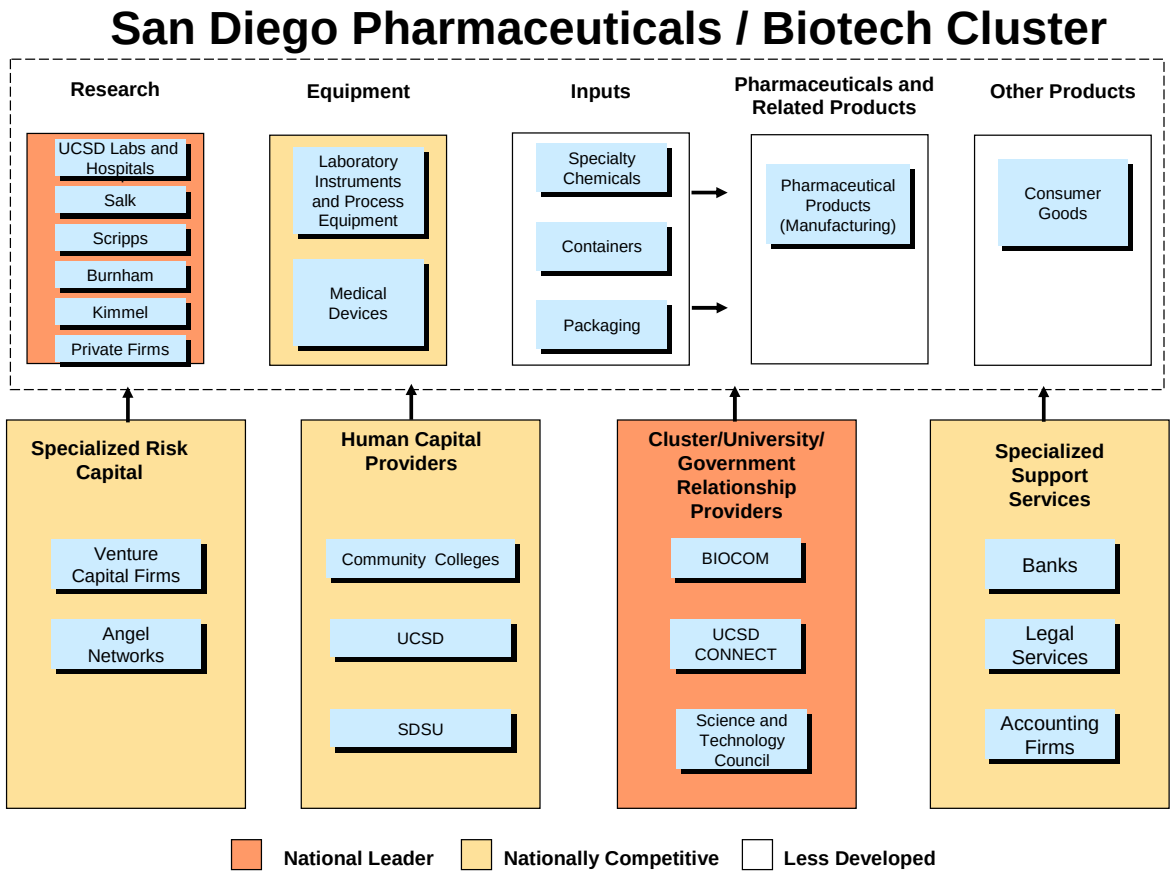
The growth of the biotechnology industry has been concentrated in a small number of geographic areas. Major biotechnology regions include the metropolitan areas of: Boston, MA; Chicago, IL; Newark, DE; New York, NY; Research Triangle Park, NC; San Diego, CA; San Francisco, CA; Seattle, WA; and Washington, D.C./Baltimore, MD. The

clusters include not only biotechnology firms themselves, but also other competing, complementary, and interdependent firms. These industry cluster models highlight the overall network of front-line job creation as well as the ancillary and indirect employment patterns of the emerging 21st century biotechnology sectors that will continue to drive more and more of the U.S. economy.

A number of factors have contributed to the growth of the industry in these particular areas. Because of the strong research component endemic to the industry, biotechnology firms tend to organize around strong academic research institutions. The presence of large pharmaceutical companies and the presence of key investors also play a role. In general, industry executives indicate that it is the proximity to critical elements such as research, equipment, and supplier inputs, and services that determine the pace of product development and economic results.

San Diego is an example of a strong biotechnology cluster and serves as an example of how the presence of key inputs can produce sustainable growth in jobs and economic opportunity. As **Figure 3** illustrates, a number of key critical inputs already present in the San Diego area contributed to the biotechnology industry's success in the region.

Figure 3 **Example of a Biotechnology Cluster**



Source: New Economy Strategies

San Diego's biotechnology cluster includes research and development, pharmaceuticals (including pharmaceutical manufacturing), and medical devices. According to a report issued by the Milken Institute, and reported on in *Forbes Magazine*, entitled "America's Biotech and Life Sciences Cluster,"[9] San Diego ranks first among biotechnology clusters in the United States. Following closely behind San Diego are Boston, Raleigh-Durham-Chapel Hill, NC, San Jose CA, and Seattle-Bellevue-Everett, WA. The study ranked the metropolitan areas using 44 measurements within two broad categories: the biotechnology innovation pipeline, which includes research and development dollars and the quality of the workforce; and the assessment of impact, or how successful an area has been at bringing ideas to market and creating companies, jobs, and products.

Clusters bring together inter-related institutions, organizations, and individuals and cause the export of goods and services beyond the region while creating demand for localized services and infrastructure. From real estate development of wet-labs,

[9] Dolan, Kerry A., "Top Ten U.S. Biotech Clusters," *Forbes Magazine*, June 2004.

research facilities to manufacturing and production campuses, there is a strong need for expertise in the operations of these specialized buildings and the maintenance of the equipment and information systems. For example, *Forbes* reports that San Diego's biotechnology cluster is directly and indirectly responsible for 55,600 jobs and $5.8 billion in income. It ranked highest among all metro areas in R&D inputs and the impact of turning ideas into companies. It boasts branches of big Pharma, such as Pfizer, Johnson & Johnson, and Novartis, as well a numerous smaller biotech and medical device companies.[10]

While many clusters focus on industry and economic activity, certain demographic populations can also bring about a clustering effect; for example, the impact resulting from a critical mass of Hispanics for important genomic clinical trials in diabetes, cancer, and hypertension. In turn, this critical mass affords unique opportunities for connecting with workforce skill development, serving the healthcare interests of both U.S. and international communities. As a result, industry representatives noted that if one were to overlay scientific, technological, and demographic data, high concentrations of resources in each area would signal the fastest growing economies in the U.S. where biotechnology is engaged at a higher proportion than other industry sectors.

Impact on the Economy

National

It is the nature of the U.S. economy to undergo waves of technology, market, and product development that are driven by demographic trends. An aging population on one end of the spectrum, coupled with the influx of young immigrant populations at the other end of the spectrum, has created a confluence of both challenges and opportunities.

The U.S. biotechnology industry, which is currently comprised of 1,473 companies, spent about $17.9 billion on research and development in 2003.[11] The Biotechnology Industry Association (BIO) reports that "market capitalization, the total value of publicly traded biotechnology companies (U.S) at market prices, was $311 billion as of mid-March 2004."[12]

[10] Ibid.
[11] Biotechnology Industry Facts on the BIO Web site: www.bio.org/speeches/pubs/er/statistics.asp
[12] Ibid.

Emerging scientific and technological discoveries have increased the rate of development and distribution of exciting solutions to problems U.S. citizens face with health and diseases, agriculture, and other areas. The U.S. is now the perceived global leader in biotechnology, a reality that makes the current challenges and opportunities even sharper and more dramatic.

Since 1990's, the industry has experienced dramatic growth, with revenues jumping from $8 billion in 1992 to $39.2 billion in 2003.[13] Because it is such a fast-changing industry, statistics regarding employment, investment, and revenues fluctuate significantly. Future growth estimates are predicted based on the biotechnology lifecycle and the anticipation of a number of products moving from the Creation and Formation stages into the Growth stage in the next several years. The industry is projected to employ 814,900 people in the United States by 2007, which creates a pressing need for quality workers from the technician level to doctoral level scientists, as well as other occupations that support the biotechnology industry. [14]

The integration of research knowledge, along with new development methodologies, has begun to influence the workforce skills and competencies in the biotechnology industry. Although such integration is a more localized activity, the biotechnology sectors are global industries, and as such, workforce skills and competencies have become a national priority for U.S. competitiveness.

The vote of confidence in the biotechnology industry and related products can be identified along the path to the market, through investment in the basic research, proof of concept, animal and human testing, manufacturing, and, ultimately, patient and doctor introduction. Considering that this pathway is a 10-15 year process, the number of jobs required to meet the demand of the fastest-growing economic driver at the regional and national levels is astounding. Further, the amount of cross-disciplinary knowledge that will be necessary to meet this demand has already begun to foster a new discussion among regional institutions and organizations throughout the U.S. ETA's approach to industry-driven workforce demand has begun to respond to these new discussions as a national priority within a global competitiveness scenario.

However, the U.S. is facing stiff competition from several countries currently amassing billions of dollars towards research and development and creating workforce programs to address their own challenges. The United Nations, the Organization for Economic Competitiveness and Development, and the World Bank are among non-government

[13] Ibid.
[14] Figures from www.economy.com.

organizations and institutions drafting strategies and tactics in workforce areas to meet the global reach of biotechnology and the life sciences.

Local

Local governments, through research parks, incubators and other economic development programs, recognize the potential of biotechnology to drive a local economy. Beyond the industry's ability to positively impact lives of residents through advances in medical and pharmaceutical products, disease-resistant crops, and nanotechnology, investments in biotechnology can promote job creation in a local economy. Depending on the local labor and economic market, attracting new biotechnology firms to a state or local area is a key part of state and local economic development strategies.

Following the biotechnology lifecycle, companies need significant time and investment to develop to the point where the job growth can occur. A local community that assists small companies in the Conception and Formation stages may reap the rewards when a company reaches the growth stage and expands it size. Revenue will be poured back into the community and there will be significant job creation in order to support the production, manufacturing, and distribution of new products. Companies in the Creation and Formation stages also demand workers with particular skill sets, ranging from scientific to regulatory processes, information technology, and facilities maintenance in laboratories, clean rooms, and other specialized conditions.

Impact on Our Daily Lives

The biotechnology industry impacts our daily lives in ways that are critical to the health of the nation broadly. The Biotechnology Industry Association (BIO) highlights examples of the reach and impact of the industry including: [15]

- There are more the 370 biotechnology drug products and vaccines currently in clinical trials that target more than 200 diseases, including various cancers, Alzheimer's disease, heart disease, diabetes, multiple sclerosis, AIDS, and arthritis.
- Biotechnology is responsible for hundreds of medical diagnostic tests that keep blood supplies safe from the AIDS virus and detect other conditions early enough to be successfully treated.

[15] All examples taken from Biotechnology Industry Facts on the BIO Web site: www.bio.org/speeches/pubs/er/statistics.asp.

- Consumers are already enjoying biotechnology foods, such as papaya, soybeans, and corn. Hundreds of biopesticides and other products are improving the food supply and reducing dependence on chemical pesticides.
- Environmental biotechnology products make it possible to clean up hazardous waste more efficiently by harnessing pollution-eating microbes without the use of caustic materials.
- Industrial biotechnology applications have led to cleaner processes that produce less waste and use less energy and water in industry sectors as chemicals, pulp and paper, textiles, food, energy, and metal and minerals. For example, laundry detergents produced in the U.S. contain biotechnology based enzymes.
- DNA fingerprinting, a biotechnology process, has dramatically improved criminal investigation and forensic medicine, as well as afforded significant advances in anthropology and wildlife management.

To better the current and future business models of the biotechnology industry, it is necessary to understand the interwoven realities of health care delivery in the U.S. and the promise of biotechnology as a means to address the rising costs of health care. The link between biotechnology and health care is strong. Rising health care costs, a population of increasingly expensive coverage factors, and a system of highly regulated institutions lead to significant challenges. At the same time, the promise of biotechnology and life science research and development affords a response to overcome these potentially negative economic conditions. While the ETA has addressed the workforce demands of health care services, including the severe nursing shortage affecting the nation, it is the biotechnology and life science sectors that demand immediate attention to ensure that the industry can respond effectively to the dual challenges of fighting disease and finding a solution to the rising costs of health care.

The U.S. and global biotechnology and life science sectors continue to evolve. Industry representatives often describe several possible ways in which health care and medicine will be delivered in the future. The practice of medicine is fast becoming more integrated, multi-disciplinary, and inclusive of a broad range of skills and competencies. According to senior representatives during the three ETA regional forums, in the future, the biotechnology industry will become a major component of health care in the U.S. and, thus, the lines of activities and resources will become blurred.

III. Biotechnology: Struggling to Attract, Retain, and Train Workers

Through its Executive Forums, ETA heard from senior biotechnology industry representatives about the workforce challenges across industry sectors and clusters. The following provides an overview of the workforce challenges voiced by senior executives, human resources professionals, and industry associations (hereafter referred to as industry representatives) during ETA's forums.

The biotechnology industry broadly struggles with recruitment. Of particular concern is the lack of new youth and career changers entering the industry, resulting in a limited pipeline of new workers. Additionally, the industry is strongly driven by the life sciences and is in need of individuals with strong math and science backgrounds. However, industry representatives indicated that they are interested in looking to programs to "recapture" youth that may not have been exposed to math and science in secondary school programs and that will enhance awareness to help "champion" biotechnology as a career.

While the biotechnology industry, like all other knowledge-based industries, is in need of qualified workers at all levels, an additional challenge has been in finding experienced workers with specialty skills that align with a highly regulated work environment. Businesses seek experienced employees with a working knowledge of Good Laboratory Practices (GLP), Good Manufacturing Processes (GMP), quality control, quality assurance, and Food and Drug Administration (FDA) regulatory issues. The competency and skill requirements for these specialized positions are interdisciplinary in that they cross all sub-sectors of the biotechnology industry.

The industry expressed a desire to increase outreach efforts towards diverse populations. Some industry representatives indicated they are working with inner-city schools while others are looking towards career transitioners, including transitioning military personnel and individuals transitioning out of declining industries, such as tobacco, textiles, and furniture. Outreach to registered nurses to fill workforce gaps, particularly in the product and clinical development professional area, was also highlighted as a need.

The industry also struggles with retention of workers due to the rapidly changing skill requirements resulting from the industry life cycle and advances in technology. Community colleges do play a role in training incumbent workers; however, to provide appropriate training, colleges need more collaboration with industry to develop curricula and training to meet industry demands. The industry recognizes the need for

increased funding directed towards incumbent worker training and encouraged ETA to increase flexibility for Workforce Investment Act dollars to support incumbent worker training of the industry.

Another challenge facing the industry is difficulty finding workers with adequate skills to meet industry requirements. This ranges from lack of math and science preparation at the secondary and post-secondary level to a shortage of people who have specialty skills, such as knowledge of Good Laboratory Practices (GLP), Good Manufacturing Processes (GMP), quality control and quality assurance, and Food and Drug Administration (FDA) regulatory issues. Industry representatives also want to assist community colleges and other education and training providers in their efforts to develop training programs for their highly regulated work environments in specialty skill areas, such as quality control, regulatory affairs, and facilities maintenance. To assist in skill development, the industry is looking to increase internship programs for students considering careers in biotechnology. The industry is interested in developing apprenticeship programs in operations and facilities maintenance, a sub-specialty that is in high demand but that has no current training programs; instead, individuals are forced to learn on the job.

The capacity of education and training providers to offer courses and training in areas needed by businesses was another area of concern to industry representatives. There was interest in building the capacity of community colleges to support efforts to develop additional biotechnology and life sciences programs. In order to do this, the industry recognized the need to establish common definitions that cut across industry sectors that allow for the development of baseline curriculum that will prepare new entrants into the industry. Additionally, the industry was concerned that educators at the secondary and post-secondary levels need a better understanding of the occupations, competencies, and skill requirements in the biotechnology industry. Industry representatives proposed teacher externship programs that enable instructors to identify firsthand the skills and competencies needed in a particular occupation, thereby allowing them to refine and enhance their curriculum to align more closely with industry standards. Industry representatives also saw value in reaching out to transitioning health care professionals to fill biotechnology-related faculty positions at high schools and community colleges.

Closely related to the industry's recruitment challenge is the image of the industry and misperceptions about its occupations and skill requirements. The lack of knowledge about industry opportunities, as well as the misperception that only doctoral level scientists work within the industry, contributes to the challenges the industry faces with recruitment and skills competencies. Because students do not understand what courses

are needed to prepare them for careers in biotechnology, they frequently lack the skills to apply for industry positions or post secondary programs.

Finally, it is important to note that the data on the industry is incomplete and changes frequently due to its emerging nature and fluid business model. The industry struggles broadly with the compilation of data regarding career ladders, competencies, and skill requirements within and across industry sectors. The lack of defined models results in challenges with recruitment and retention, skills competency development, and image and outreach.

Pipeline – Recruitment and Retention

Careers within the biotechnology industry are anticipated to grow rapidly over the next ten years (**see Figure 6**). More than 190,000 people were employed directly by biotechnology firms in 2002. This figure represents a growth rate of 14-17% annually from 1998 to 2002, and is expected to reach around 500,000 by 2010.[16] **Figures 7 and 8** illustrate the diversity of positions within the industry by illustrating the percentage of individuals employed in that occupation as well as the projected growth for those positions.

The industry recognizes the need to build a pipeline of workers to meet their future workforce demand.

POTENTIAL SOLUTIONS IDENTIFIED BY INDUSTRY, EDUCATION, and WORKFORCE REPRESENTATIVES at FORUMS

- Provide a variety of exposure opportunities to students and faculty (elementary, secondary, postsecondary, and beyond) including job shadowing, summer camps, mentoring, industry speakers, tours, high school and college competitions, career clubs, and workshops.
- Create a separate funding stream or carve out a portion of WIA dollars that can be put towards meeting industry needs, as long as they are driven by the business community.
- Create a national biotechnology workforce survey that is industry generated and validated. Start in one major state as a test-bed and distribute nationally through the Biotechnology Industry Organization (BIO).
- Create flexible, short-term training options to keep up with ongoing industry training.
- Create a system for portable, life long learning accounts for workers, promote the system, and support the use of the system.
- Create a system for continuous skills-upgrade training, career enhancement, and well-documented career ladders and lattices allowing biotechnology companies to maintain their competitiveness and retain well-skilled workers.

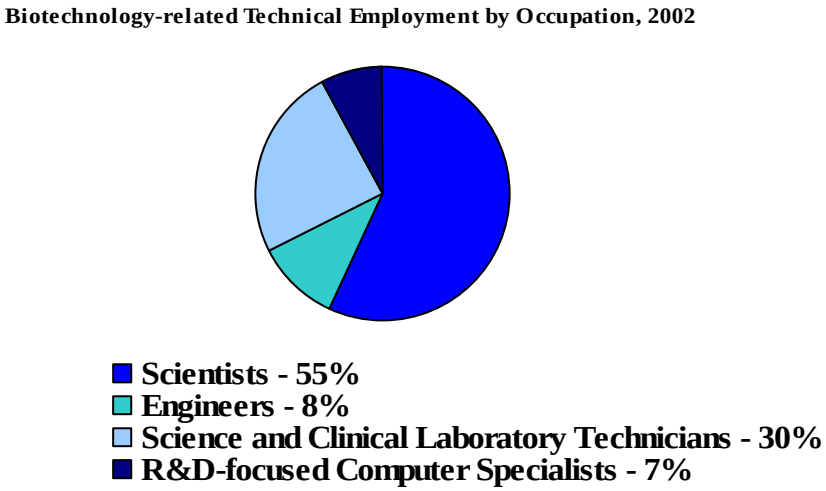
[16] Cortright, J. and H. Mayer (2002) *Signs of Life: the Growth of Biotechnology Centres in the U.S.*

Figure 6 **Biotech Related Occupations and their Projected 10 Year Growth**

Occupation Title	Number Employed 2002 (000's)	Number employed 2012 (000's)	Numeric Change (000's)	Change %	2002 Median Annual Earnings	Postsecondary Education & Training
Medical scientists, except epidemiologists	58	73	16	26.9	56,980	Doctor's degree
Biomedical engineers	8	10	2	26.1	60,410	Bachelor's degree
Environmental scientists and specialists, including health	65	80	15	23.7	47,600	Master's degree
Biological scientists, all other	27	33	6	22.3	53,300	Bachelor's degree
Biological technicians	48	57	9	19.4	29,040	Associate's degree
Chemist	84	95	11	12.7	52,890	Bachelor's degree
Agricultural & food science technicians	20	22	2	9.3	28,580	Associate's degree
Chemical technicians	69	72	3	4.7	37,430	Bachelor's degree

Source: U.S. Bureau of Labor Statistics

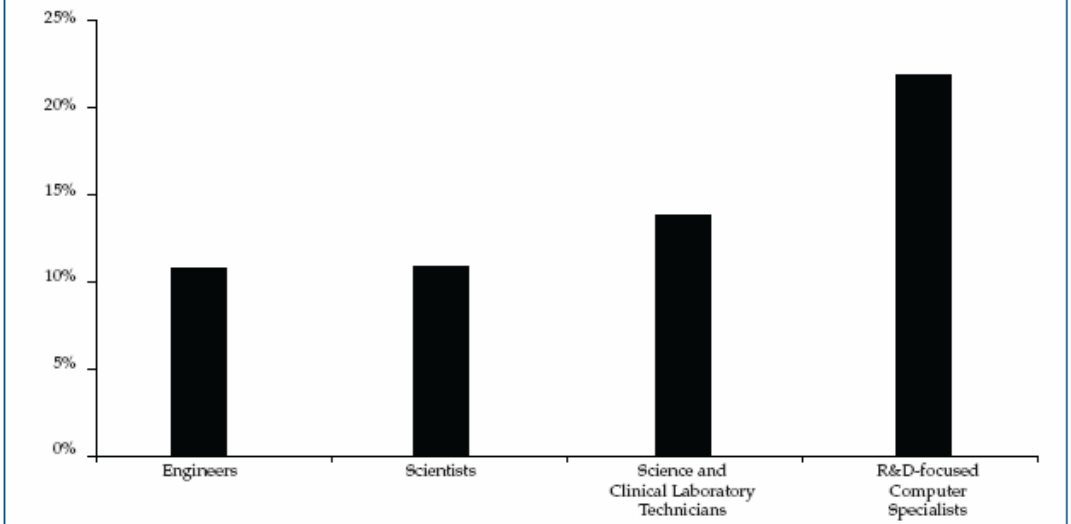
Figure 7



Source: U.S. Department of Commerce Technology Administration and Bureau of Industry Security *Critical Technology Assessment of Biotechnology in US Industry,* question 14, pg. 4, August 2002.

Figure 8

Annual Growth Rate in Biotech-related Technical Occupations, 2000 - 2002



Source: U.S. Department of Commerce Technology Administration and Bureau of Industry and Security, *Critical Technology Assessment of Technology in U.S. Industry*, question 14, p. 4, August 2002.

Industry Occupations

The occupations that make up the biotechnology industry are diverse and require a wide range of skills and experience levels. While math and science training are essential for research and development positions, other occupations along the industry cycle require familiarity with the Research and Development (R&D) process along with additional skill sets, such as knowledge of the regulations governing R&D, including Good Laboratory Practices and Good Manufacturing Practices (GMP).[17]

Although R&D occupations require workers with strong experience in science and math, significant employment possibilities arise as the product moves through the lifecycle around the creation of products such as operations, finance, administration, information systems, sales, and marketing. **Figure 9** provides an overview of positions in a small biotechnology company. Additionally, complementary jobs indirectly tied to biotechnology demand skills and competencies in laboratory facility construction and management, equipment and supplies to support R&D, and new information tools. These positions are particularly important to the industry as it maintains a constant flow of abundant data and knowledge and maintains its rapidly changing pace of discovery.

[17] Gundersen, Larry E. "It's time to update the Graduate," *Biochemistry and Molecular Biology Education*, Vol. 31, No. 4, 2003, pp. 264.

Figure 9

Overview of Jobs in a Small Biotechnology Company (1-49 Employees)			
Research: Discovery and Pre-clinical	**Operations: Process/Product Development**	**Quality: Control and Assurance**	**Finance, Administration and Information Systems**
➢ VP of R&D ➢ Senior Scientist ➢ Scientist ➢ Research Associate ➢ Laboratory Support	➢ Director ➢ Supervisor ➢ Associate ➢ Technician ➢ Facilities Manager ➢ Facilities Technician	➢ Director ➢ Supervisor ➢ Analyst ➢ Technician ➢ Documentation Coordinator	➢ Chief Financial Officer ➢ Accounting Manager ➢ Application Systems Specialist ➢ Accounting Clerk ➢ HR Manager ➢ Receptionist ➢ Administrative Assistant
Source: Feena D. Hanes, New England Board of Higher Education, for MassBio, Cambridge MA			

Occupations in the biotechnology industry can be grouped into seven broad categories:[18]

Research and Development: Jobs in this category focus on basic and applied research in the biotechnology field. Individuals employed in these occupations may be required to develop theories, test hypotheses, create models, and clarify knowledge. Depending on the type of science required, research and development may take place in a laboratory, greenhouse, an animal care facility, or in a field of agricultural crops. Education requirements for R&D occupations range from community or technical college training in science and laboratory skills to advanced Ph.D.'s.

Clinical Research: This class of occupations is responsible for research in a health care setting. This may involve clinical trials of pharmaceuticals investigated for use by humans, or of veterinary drugs tested before being approved for use in domestic animals and livestock. As with R&D, education requirements range from community or technical college training in science and laboratory skills to doctoral degrees.

[18] This categorization was generated by the State of California's Employment Development Department in its 2004 report, "Biotechnology Jobs in California: Under the Microscope." The report is available online at http://www.calmis.cahwnet.gov/file/occmisc/Biotech-Part1.pdf.

Manufacturing and Production: These occupations are responsible for the large-scale manufacture of new drug or biotechnology products or devices. This group of occupations accommodates a range of skill and experience levels. While production associate and engineer positions require training at the bachelors, masters, or Ph.D. level, technical positions relating to production scheduling or equipment maintenance, operation, and repair are often filled by individuals with community college training and experience. Employers often seek out individuals with knowledge of the government regulations that describe the methods, equipment, facilities, and controls required for production.

Regulatory Affairs: Individuals employed in these occupations guide products through the steps companies must take to prove that their particular products meet U.S. Federal Government standards for safety and efficacy. These occupations may require close collaboration with government officials.

Quality Systems: Individuals employed in these occupations are responsible for monitoring products to ensure they meet company and regulatory standards.

Information Systems: Individuals employed in these occupations design and maintain the computer databases and data storage necessary to organize and maintain the information generated by research and development of new products.

Marketing and Sales: Individuals in these occupations work with completed products that meet regulatory and quality standards. Because the industry offers highly specialized products and services, the industry often seeks out individuals with a unique combination of marketing and sales skills as well as a background in science and technology. Marketing and sales personnel may also help customers troubleshoot problems with the company's products.

Education and Training Requirements

Education and training requirements for positions in the biotechnology industry vary greatly depending on the type of position, the size of the company, and the industry sector. As part of such a rapidly growing industry, biotechnology firms often demand a greater number of skilled workers than are available and are projected to need more workers than are currently in training programs. While historically, the biotechnology industry has been in need of intellectual talent at the masters degree and doctoral levels, the growth of the industry has seen a shift in the types of workers needed to fill critical skill gaps. **Figure 10,** based on the life sciences cluster in San Diego, CA, shows an estimate of the education level needed sorted by job type for life sciences positions within the biotechnology industry. While many positions in quality control and assurance, as well as information technology, Human Resources, and manufacturing do require four year degrees, a significant number of positions in now require two-year degrees or, under manufacturing for example, require only a high school degree and training.

Biotechnology industry organizations are now conducting outreach efforts geared towards individuals that possess Bachelor of Science, Associate of Arts degrees, and education and training in such interdisciplinary areas as GMP, quality control, quality assurance, regulatory processes, and facilities maintenance.

Industry representatives were clear in expressing their need to attract individuals with strong math and science skills as well as formalized training in computer and life sciences, but the exact level of education and training necessary varies based on employer requirements. For example, in recruiting for science technician jobs in the pharmaceutical and medicine manufacturing industry, many companies prefer to hire graduates from technical institutes and junior colleges, or those who have completed college courses in chemistry, biology, mathematics, or engineering, while others require science technicians to hold a bachelor's degree in a biological or chemical science.

Figure 10

Job Types by Education Level (estimates)			
Job Type	**High School Degree**	**2-year College Degree**	**4-year College Degree**
Quality			
• Quality Assurance	0	40%	60%
• Quality Control	0	40%	60%
Manufacturing			
• Operations	25%	50%	25%
• Logistics	0	60%	40%
• Materials Control	40%	40%	20%
• Maintenance & Facilities	45%	50%	5%
Engineering	0	0	100%
Process Sciences	0	0	100%
Compliance	0	0	100%
Support Services			
• Purchasing/Finance	0	40%	60%
• IT	0	30%	70%
• Human Resources	0	30%	70%
Source: IDEC Pharmaceuticals, San Diego CA			

Retention: Incumbent Worker Training

The rapidly evolving technology in the industry results in challenges to a businesses ability to retain its employees. An employee who starts a job with state-of-the-art skills may quickly find his or her skill sets outdated due to technology upgrades or new product development. This forces employers to either lay off the individual, seek a different qualified candidate, or look into re-skilling employees to meet the new skill requirements of the position.

Additionally, new product development and advances in the knowledge base require companies to constantly change and upgrade skill requirements for employees while the biotechnology industry is challenged by a limited capacity for employee training. Biotechnology firms, particularly smaller firms, have immediate needs for highly skilled workers, but often cannot afford the cost of training new employees or upgrading the skills of existing employees to meet new requirements.

Industry representatives expressed concern that the current focus on entry-level skill training through the One-Stop system does not reflect the biotechnology industry's need to provide continuous training to incumbent workers. The industry representatives indicated a need to discuss disparate interests concerning the stages of growth and the skills competency challenges associated with that stage in order to increase their competitiveness in the world economy.

While community colleges are a significant source of biotechnology-related training, limited state funding often prevents these colleges from providing enough courses to meet local employer demand. Additionally, a lack of standardized certification programs for the biotechnology industry makes it difficult for employees to follow a clear career advancement path, or transfer skills from employer to employer. Employers within the industry have identified skill sets and competencies needed in high-demand occupations within the industry; however, there is still a need for common definitions of skill-sets and competencies across industry sub-sectors that would let the industry market its positions and allow for education and training providers, as well as the public workforce system, to develop biotechnology and life sciences training programs to meet the needs of business.

Common definitions and increased funding would allow community colleges and other education and training providers to create a baseline curriculum that would better prepare new entrants for employment within the industry and allow incumbent workers to continuously upgrade their skills, thereby helping the industry retain and promote incumbent workers. This would significantly help the industry develop a pipeline of workers to fill positions.

Skills Competencies and Training

POTENTIAL SOLUTIONS IDENTIFIED BY INDUSTRY, EDUCATION, and WORKFORCE REPRESENTATIVES at FORUMS

- Create a map and a matrix of existing competencies and models, assess gaps, and validate and update regularly. Define business and technology skills for all levels. Create a dynamic delineation of labor market information data that reflects the emerging biotechnology industry that uses a common language and is based on skill sets. Post on an industry-specific website.
- Develop models with incentives that make it easy for K – 12 institutions to work with college and corporate partners.

The need for identified skill competencies and career ladders within the industry and building the capacity of the education and workforce systems to train individuals for careers in the industry were two additional areas recognized as challenges by industry representatives.

As previously discussed, clearly identified career ladders with corresponding competencies would enable community colleges and education and training providers

to develop entry-level and incumbent worker training programs. Career ladders and incumbent worker training afford the industry the opportunity to "grow their own" workers to meet new and changing occupational and skill demands. This is especially important given the projected level of growth and the shrinking of the labor pool that is anticipated with the retirement of the baby boomer generation.

Additionally, the need to map the competencies and career ladders of the biotechnology industry to those of related industries in order to help with recruitment was identified by industry executives as a challenge. This is especially true for the industry as it struggles to find workers with specialty skills that align with a highly regulated work environment, such as knowledge of GMP, quality control and assurance, facilities maintenance, and FDA regulatory issues.

The industry also struggles with the limited capacity of the education system in the United States to create a qualified labor pool. As previously noted, there is a lack of science education occurring at the elementary and secondary education levels. The result is fewer numbers of individuals pursuing post-secondary degrees in science and engineering and fewer qualified candidates for positions within the biotechnology industry. One cause is the fact the teachers, guidance counselors, and parents do not understand the occupations available or the competencies and skills required, and therefore cannot direct students to applicable science and mathematics courses to prepare for careers in the biotechnology industry. Industry representatives suggested teacher externships as a possible remedy to this situation as they would expose elementary and secondary educators to the diverse possibilities and necessary skill requirements of the industry while also affording post-secondary educators an in-depth look at the competencies and skills requirements for occupations. This would allow them to modify their curriculum to meet industry needs.

Developing an understanding of the complexity of the job characteristics for the typical biotechnology firm by educators, counselors, parents, youth, and career changers was identified as an important goal during the Forums. In particular, continued industry-wide discussions are necessary in order to identify the different stages of growth and skills and competencies that cross industry sectors. For instance, some of the most vital positions in biotechnology firms now involve emerging interdisciplinary skills and competencies that include engineering, information technology, and technician requirements.

Overall, what was once an industry heavily laden with science is now increasingly impacted by evolving information and software tools, data mining, parallel computing, and digital imaging. The need for a strong background in math and science, coupled

with increasingly specialized skills (e.g. regulatory, quality control), crosses industries and requires close examination by the education and public workforce communities to ensure that they can provide the education and training programs necessary to meet the industry's workforce needs

Image and Outreach to the Public

Finally, this complex industry struggles to overcome popular misconceptions about the depth and range of its activities and corresponding job opportunities. As highlighted in **Figures 6-10**, there are a multitude of areas that build off the biological-driven science and technology necessary for future growth and global competitiveness. However, during the Workforce Solutions Forum, some public workforce system representatives acknowledged that misconceptions about the scope of the industry do exist, particularly the perception that drug discovery and development is the industry's only activity.

POTENTIAL SOLUTIONS IDENTIFIED BY INDUSTRY, EDUCATION, and WORKFORCE REPRESENTATIVES at FORUMS

- Present information about biotechnology careers organized by different criteria, e.g., industry content, occupation, educational pathway, career ladder, and salary.
- Create a national media campaign.
- Create a universal formula that is disseminated by all agencies (federal, state, and local).
- Recognize the diversity of careers and apply scientific and distinct names to various bio-industries or categories, which will clarify larger concerns, e.g., what is biotechnology, and then outline entry-level occupations with industry and determine the basic skills and competencies needed.
- Create awareness at the elementary and secondary (K – 12) levels by creating partnerships between employers and schools that include: 1) mentorship and job shadowing, 2) employer-sponsored science fairs, 3) development of problem-based projects for K – 12 students to explain different areas that integrate academic standards, 4) school-based clubs, and 5) K – 12 and college programs.

Limited awareness of the range of positions available in the industry by potential job seekers, high school graduates, and educators is another barrier to entry. In many instances, educators are also unaware of the skills and competencies needed to successfully transition to careers within the biotechnology industry. The misperception that a doctoral degree is required to enter the field is widespread. In reality, biotechnology positions range in educational requirements from associate through doctoral degrees and occupations range from those in the life sciences field to positions involving information technology, facilities management, sales, and marketing.

For life sciences positions, job seekers often believe that it is difficult to break into the field and obtain career advancement without previous biotechnology or life sciences related experience. However, individuals who have a background in scientific work,

but not necessarily life sciences, or those who possess several years of industrial experience, are candidates for advancement to managerial positions in the industry.

Overall, youth, educators, and job seekers lack clear information about career options within the industry and generally fail to understand the industry. This disconnect is a challenge for the industry because the lack of definition and outreach limits the number of people who consider the biotechnology field to be a viable career option.

IV. Solutions

ETA supports comprehensive business, education, and workforce development partnerships to develop innovative approaches or replicate models that operationally demonstrate how a demand-driven workforce system can more effectively serve the workforce needs of business while also effectively helping workers find good jobs with good wages and promising career pathways. Grants awarded under the President's High Growth Job Training Initiative will implement unique and innovative, industry-driven skills training, certification, and career ladder development programs that support identified biotechnology workforce and economic development needs.

Based on the challenges identified by the biotechnology industry and highlighted in this report, the U.S. Department of Labor has made a series of investments totaling more than $17 million to partnerships between businesses, community colleges, Workforce Investments Boards, and others to address the workforce needs of the biotechnology industry. These investments address the following challenges:

- Attracting a pipeline of youth to employ in the industry while ensuring that teachers understand the industry, allowing them to better counsel students preparing to pursue biotechnology careers;

- A chronic and growing shortage of qualified biotechnology worker at all levels stemming from a lack of high school preparation and solid knowledge base in the life sciences;

- Attracting untapped labor pools into the biotechnology industry, including workers from declining industries, veterans, and persons with disabilities;

- Lack of a comprehensive set of industry standards and corresponding training material, particularly at the technician level;

- Building the capacity of community colleges to deliver new curriculum and training models that include apprenticeship;

- Curriculum development to assist in upgrading the skills of incumbent biotechnology employees;

- Developing the capacity to collect industry-specific information on the different jobs and skills needed in this industry.

Solutions are national, regional, state, and local in scope and address the industry challenges in unique and innovative ways. The following are brief summaries of solutions in which ETA invested in order to address the aforementioned industry challenges. For more detailed information on these investments, including grantees, partners, and outcomes, please visit www.doleta.gov/BRG.

- Establish a collaborative, statewide approach to growing the biotechnology industry as part of the state's economic base. This includes educating middle and high school students and Job Corps participants about biotechnology/bioprocessing career options, as well as coordinating multiple opportunities for science teachers to build curriculum and skills in the field. The project will also develop and deliver training programs for the state's rapidly growing ethanol industry. In addition, the grant will develop curriculum for biotechnology technicians specializing in proteomics, a new field that seeks to identify and understand the proteins that cells produce in different situations.

- Develop a National Center for a Biotechnology Workforce through five community college partners located in different regions across the country. They will work with employers to identify industry skill needs and develop training curricula for a range of biotech sectors. Each community college and their respective faculties will be responsible for the skill standards and workforce data.

- A four-year university will retrain employed and unemployed workers to build careers in biotechnology. The program will establish a biotechnology career ladder and develop curriculum as well as a program for participants to obtain a postgraduate level certificate in Biotechnology and Bioinformatics. A B.S. or M.S. degree in Molecular Biology and Biotechnology also will be offered. The program will include distance education and employer-supported apprenticeship opportunities. The initial certificate training program will be relatively short, with program completion achieved in one year. Participants that excel will advance to a one-year lab research program.

- The State Workforce Investment Board will engage the state education system and the biotechnology business community to enhance youth participation in life sciences through both school based and after school programs. The school based program will use two vans to transport science equipment to classrooms

throughout the state. The vans will be driven by experienced science instructors who will assist the classroom teacher along with volunteer mentors in conducting laboratory activities. Classroom visits will last 4 to 6 days. The After-School program will be a hands-on science experience targeted at children ages 9 – 13 and will provide science kits that contain all the materials for children to conduct science experiments. Biotechnology employees and additional volunteer mentors from the local community college will provide all the tools and materials needed to lead the younger students through various science experiments.

- Two local Workforce Investment Boards will develop career pathways in bio-technology manufacturing, facilities management, quality control, and product engineering with the objective of further expanding and refining a successful pilot to train entry-level biotechnology manufacturing workers. Targeted populations for this initiative include dislocated workers from the airline, aerospace, and information technology industries, and economically disadvantaged individuals. Additionally, the program will work with area community-based organizations (CBOs) to create a "bridge" program to prepare lower skilled individuals for entry-level employment by offering English, math, and communication skills training, as well as career orientation and social support.

- A workforce and industry partnership will serve as a clearinghouse for local and national labor market research related to the biotechnology industry. This center also will serve as a national site for conducting focus groups, gathering and analyzing data, and generating reports and ideas. Information will be shared electronically with communities throughout the country who are developing or advancing biotechnology initiatives. A second strategy will coordinate student internships (from high-school to post-doctoral levels) and teacher externships for the regional biotechnology community.

- An industry, education, and workforce system partnership will combine industry-identified skills and vocational/academic disciplines to shape potential biotechnology workers with a variety of qualifications. The goal of the project is to rapidly deploy professionals into biotechnology employment. Biotechnology organizations will work directly with the community college and technology council through an "information channeling" program to create customized training programs. These classes will be melded into the core biotechnology

curriculum. As a part of its efforts to support the growth of their life sciences employers, the project will provide training for new entrants into biotech as well as retraining for workers affected by declining industries.

- A community college is partnering with industry to create training and curriculum for four levels of training: a high-school technician program, an Associate of Science research assistant degree, a Bachelor of Arts degree, and a research scientist Master's Degree. The grant will also support the development of a BioCenter, as well as a national biotechnology career coaching model. The BioCenter will be equipped with industry-standard equipment and be available to students and teachers to strengthen their knowledge and interest in biotechnology. The national biotechnology career management model will provide access to career information via a "Biotechnology Career Coach" Web site. The career ladder will focus on recruitment and training of entry-level biotechnology workers, with an emphasis on basic scientific knowledge and good laboratory and manufacturing practices.

- A state biotechnology council will launch BioCareer Labs in 25 urban and high-needs public schools (as defined by the No Child Left Behind Act). The labs will include new equipment, ongoing teacher training, a mobile biotechnology laboratory, access to curricula developed with National Science Foundation funds, and school-to career pathways in partnership with Workforce Investment Boards and colleges. A state biotechnology foundation will lead the effort to identify and test an industry-defined standard of quality for facilities, teaching and learning of biotechnology in high schools. The overall goal of the project is to spark interest in the life sciences at the high school level.

Conclusion

The results and knowledge gained from these demonstrations are invaluable to informing ETA's broader efforts under the President's High Growth Job Training Initiative efforts for the biotechnology industry. Equally important, the models developed and lessons learned through these demonstrations help build the public workforce system's capacity to be demand-driven, as well as shape and enhance ETA's technical assistance activities in these areas. Accordingly, demonstration grantee learning and achievement will be translated into replicable, sustainable, and responsive training and skills development models that will be shared with and implemented by the state and local public workforce investment system to meet the workforce challenges industry representative articulated to ETA and that are presented in this report.

Appendix A

The President's High Growth Job Training Initiative: Biotechnology Industry

ETA follows a three-phase process to identify workforce challenges, prioritize solutions, and demonstrate solutions nationally in the biotechnology industry (see **Figure 9**). In the first phase, ETA gathers information about the industry and its current workforce needs. Through an environmental scan, ETA identifies the industry's economic and employment picture, policy and legislative issues, and key associations and labor organizations of each industry, as well as determines the extent of interaction with the public workforce system.[19] Then, ETA convenes a series of Industry Forums to offer leaders in business and industry an opportunity to share their current and future workforce challenges with the workforce system.

In the second phase, ETA validates and analyzes the information gathered in the first phase. In a second round of meetings called Workforce Solutions Forums, ETA applies its demand driven, "Power of e^3" philosophy by bringing together representatives from industry, the workforce system, and educational institutions to validate the industry challenges identified during Executive Forums, as well as to brainstorm solutions, propose foundation models, and prioritize key solutions that will address the workforce issues of the industry. Attendees also document critical attributes and key stakeholders, resources, implementation barriers, and other pertinent information onto a "solutions matrix" that offers strategic guidance and suggests where public and private resources should be invested.

In the third and final phase of the process, ETA funds a series of demonstration projects that model the most promising solutions identified in the Workforce Solutions Forum and demonstrate how a demand-driven workforce system can more efficiently serve the workforce needs of business while effectively helping workers find good jobs with good wages and promising career paths. Together, these projects make up a solution set tailored to each industry's specific needs.

These projects take place in the context of partnerships between the publicly funded workforce investment system, business and industry representatives, and education

[19] ETA is not alone in seeking to learn about the biotechnology industry and its workforce challenges. Other federal agencies are gathering their own information and knowledge so as to improve the planning and distribution of resources for industry growth and competitiveness. In 2003, the U.S. Department of Commerce's (DOC) Technology Administration conducted an ambitious inquiry into the nation's biotechnology cluster and the future demands by a wide variety of stakeholders. The DOC Technology Administration gathered a vital set of responses to an extensive survey of the industry that has been incorporated into this report.

and training providers, such as community colleges. The process engages each partner in its area of strength. Industry representatives and employers define workforce challenges facing the industry and identify the competencies and skills required for the industry's workforce. Community colleges and other education and training providers assist in developing competency models and training curricula and train new and incumbent workers. The publicly funded workforce investment system accesses human capital (youth, unemployed, underemployed, and dislocated workers), assists with training programs, and places trained workers in jobs.

Figure 9

The Executive Forums

ETA conducted three Biotechnology Industry Executive Forums in different regions of the country: the East Coast (Delaware), the Midwest (Illinois), and the West Coast (California). Chief Executive Officers and senior-level executives from industry organizations were invited to meet with Assistant Secretary of Labor for Employment and Training Emily Stover DeRocco to discuss the current and future workforce issues and concerns of the biotechnology industry. These Executive Forums afforded the Assistant Secretary the opportunity to share the Administration's goals and plans to meet the 21st century economy's needs for a skilled workforce. Attendees were also provided with an overview of the public workforce system, how it can be used to provide employment services and training, and its eagerness to establish strong, effective partnerships with business. Ultimately, these forums provided a venue for industry leaders to voice their workforce challenges to ETA and fostered debate and discussion to revise thinking about the industry from the perspective of the public

workforce system. Industry leaders had the opportunity to organize an approach to foster sustainable planning to improve the public workforce systems services to the biotechnology industry, and ultimately the Forums sparked ideas and pilot projects that could be initiated and then replicated across regions and the nation.

The three Forums were held in the East Coast, the West Coast, and the Midwest to reflect the clustered nature of the industry. By hosting forums in three different regions, ETA obtained a true cross-section of the industry and its workforce challenges. Additionally, every attempt was made to include all of the biotechnology sectors in every Forum, including pharmaceutical, medical device, agricultural biotech, and manufacturing firms, as well as vendor-supplier chains. Industry associations, such as the Council of State Biotech Associations, were also invited to the Forums to provide counsel and guidance on the broader stakeholder interests.

The East Coast Biotechnology Industry Executive Forum was held at the Delaware Biotechnology Institute in Newark, DE, on May 16, 2003. The Forum was co-hosted by AstraZeneca Pharmaceuticals, L.P. and DuPont Agriculture and Nutrition. Twelve biotechnology executives representing different sectors of the industry, including pharmaceutical, agriculture, medical device and manufacturing attended the East Coast Executive Forum. Additionally, student representatives from Delaware Technical and Community College and Wesley College participated in the Forum in order to share their experiences and perspectives on preparing for careers in the biotechnology industry. Among the biotechnology companies, workforce and economic development entities and education and training providers represented at the Forum were:

- AstraZeneca Pharmaceuticals, L.P.
- Capintec, Inc.
- CB Research & Development, Inc.
- Christiana Care Health System
- Chromatin, Inc.
- Coriell Institute for Medical research
- Delaware Advisory Council on Career and Vocational Education
- Delaware Biotechnology Institute
- Delaware Broadcasting Company
- Delaware Economic Development Office
- Delaware Healthcare Association
- Delaware Technical and Community College
- Delaware Workforce Investment Board
- Discovery Genomics, Inc.
- DuPont Agriculture & Nutrition

- Forsyth Technical Community College
- Franhofer USA Center for Molecular Biotechnology
- Franhofer Gesellschafi
- Incyte Corporation
- KamTek, Inc.
- Minnesota Department of Economic Security
- New Jersey Technology Council Education Foundation
- Pharmacopeia Drug Discovery, Inc.
- University of Delaware
- Wesley College
- W.L. Gore & Associates
- Xechem International, Inc.

The West Coast Biotechnology Industry Executive Forum was conducted on November 10 and 11, 2004, in San Diego, CA. ETA Assistant Secretary Emily Stover DeRocco co-hosted the Biotechnology Industry Executive Forum with BIOCOM, the University of California at San Diego, and San Diego State University.

The following biotechnology companies, representing pharmaceuticals, manufacturing, and research and development, as well as education and training providers, workforce and economic development representatives, and local city officials, were in attendance:

- ActiVix
- Amylin Pharmaceuticals
- Andays Pharmaceuticals, Inc.
- Arena Pharmaceuticals, Inc.
- BIOCOM
- Cancervax Corporation
- Canji, Inc.
- Digirad Imaging Solutions
- Gen-Probe Incorporated
- IDEC Pharmaceuticals Corporation
- Idun Pharmaceuticals, Inc.
- Invitrogen
- IriSys Research and Development, LLC
- Ligand Pharmaceuticals
- Maxim Pharmaceuticals
- Metabasis Therapeutics, Inc.
- MiraCosta Community College
- San Diego Regional Development Corporation

- San Diego State University
- San Diego Workforce Partnership
- Smith and Nephew, Inc. Wound Management
- University of California at San Diego

The Midwest Biotechnology Industry Executive Forum was conducted at the Chicagoland Chamber of Commerce in Chicago, IL, on March 23, 2004. The Forum, co-hosted by IBIO, the Illinois-based state biotechnology association, was conducted immediately prior to the Workforce Solutions Forum, and thus included a broader audience than the first two Industry Forums, including biotechnology firms, industry associations, education and training providers, and the public workforce system. Those in attendance included:

- BIOCOM
- Bio-Link, Northeast Region
- Chicago Public Schools
- Chicago Technology Park
- Chicago Workforce Board
- City Colleges of Chicago
- City of Chicago
- Collegiate Consortium for Workforce and Economic Development
- Coyne American Institute
- Delaware Economic Development Office
- Employment Security Office of North Carolina
- Florida Workforce Commission
- Forsyth Technical Community College
- Illinois Biotechnology Industry Association
- Illinois Department of Commerce & Economic Opportunity
- Illinois Department of Commerce, Bureau of Workforce Development
- Indian Hills Community College
- Iowa Biotechnology Association
- Ivy Tech State College
- Kansas City Area Life Sciences Institute, Inc.
- Kentuckiana Works
- Lakeland Community College
- Massachusetts Biotechnology Council
- Missouri Department of Economic Development, Division of Workforce Development
- National Association of Workforce Boards
- North Carolina Biotechnology Center

- Northern Illinois University
- San Diego State University, Biotech Workforce Programs
- TEC Services, Inc.
- Texas Healthcare and Bioscience Institute
- Texas Workforce Commission
- Truman College
- Workforce One, Florida
- Xomix, Ltd.

The Biotechnology Industry Workforce Solutions Forum

Following the Midwest Executive Forum, employers, educators, and representatives from the public workforce system participated in a Workforce Solutions Forum for the biotechnology industry.

The goal of the Biotechnology Industry Workforce Solutions Forum was to assure a shared understanding of the biotechnology industry workforce challenges by participants, generate solutions for these challenges, and select the higher priority solutions and explain them more fully.

The Biotechnology Industry Workforce Solutions Forum followed the Midwest Executive Forum in Chicago, IL, on March 24, 2004. Individuals from the following organizations were in attendance:

- BIOCOM
- Bio-Link, Northeast Region
- Chicago Public Schools
- Chicago Technology Park
- Chicago Workforce Board
- City Colleges of Chicago
- City of Chicago
- Collegiate Consortium for Workforce and Economic Development
- Coyne American Institute
- Delaware Economic Development Office
- Employment Security Office of North Carolina
- Florida Workforce Commission
- Forsyth Technical Community College
- Illinois Biotechnology Industry Association
- Illinois Department of Commerce & Economic Opportunity

- Illinois Department of Commerce, Bureau of Workforce Development
- Indian Hills Community College
- Iowa Biotechnology Association
- Ivy Tech State College
- Kansas City Area Life Sciences Institute, Inc.
- Kentuckiana Works
- Lakeland Community College
- Massachusetts Biotechnology Council
- Missouri Department of Economic Development, Division of Workforce Development
- National Association of Workforce Boards
- North Carolina Biotechnology Center
- Northern Illinois University
- San Diego State University, Biotech Workforce Programs
- TEC Services, Inc.
- Texas Healthcare and Bioscience Institute
- Texas Workforce Commission
- Truman College
- Workforce One, Florida
- Xomix, Ltd.

Process

To begin the process, biotechnology associations and organizations, the American Association of Community Colleges, the National Association of State Workforce Agencies, the National Association of State Workforce Boards, and workforce leaders were asked to nominate participants. Thirty-three of the nominees were chosen to be Forum participants.

Forum participants were assigned to one of three challenge clusters: Pipeline – Recruitment and Retention, Skill Development and Training, or Image and Outreach to the Public. Each group, led by a facilitator trained in the Nominal Group Process, clarified its workforce issues and generated a list of solutions.[20] Finally, the groups ranked the solutions in order of greatest importance.

[20] A.L. Delbecq, A.H. Van de Ven & D.H. Gustafson, Group Techniques for Program Planning: A Guide to Nominal Group and Delphi Processes, 1975.

In total, 137 solutions were put forward from the three workgroups.[21] The participants were unaware of solutions generated by other workgroups; therefore, a number of similar solutions to workforce challenges were developed. ETA analyzed the solutions and synthesized those that were similar in the way they address workforce challenges. Participants then prioritized the solutions in order of importance to the industry. Thirteen solutions were identified as "priority solutions" and were the focus the remainder of the Workforce Solutions Forum.

Small teams worked to develop a matrix for the priority solutions. The matrix identifies by the overall challenge (e.g., Skill Development and Training), followed by the issue (e.g., Competencies and Career Ladders), and then the suggested solution. The teams also identified critical attributes for a successful solution, key stakeholders and resources, the policy barriers that exist at the local, state, and national level, and any other necessary clarifications.

Product

The full products of the workgroups are located in Attachments B and C. The thirteen priority solutions include the following:

- Issue: Pipeline – Recruitment and Retention
    - Provide a variety of opportunities to students and faculty (elementary, secondary, postsecondary, and beyond) including job shadowing, summer camps, mentoring, industry speakers, tours, high school and college competitions, career clubs, and workshops.
    - Create a separate funding stream or carve out a portion of WIA dollars that can be put towards meeting industry needs, as long as they are driven by the business community.[22]
    - Create a national biotechnology workforce survey that is industry generated and validated. Start in one major state as a test-bed and distribute nationally through the Biotechnology Industry Organization (BIO).
    - Create flexible, short-term training options to keep up with ongoing industry training.
    - Create a system for portable, life long learning accounts for workers, promote the system, and support the use of the system.

[21] The large number of solutions is useful for readers who have a workforce challenge and who are seeking a range of ideas for solutions. Attachment B contains a complete listing of the 137 solutions developed at the forum. Of the 137 solutions in Attachment B, only the 13 highest ranked were expanded upon by the Workforce Solutions Forum workgroups.

[22] The Administration's Workforce Investment Act (WIA) Reauthorization proposal would allow for state flexibility to spend WIA dollars on these industry driven needs.

- Create a system for continuous skills-upgrade training, career enhancement, and well-documented career ladders and lattices allowing biotechnology companies to maintain their competitiveness and retain well-skilled workers.

- Issue: Skill Competencies and Training
  - Create a map and a matrix of existing competencies and models, assess gaps, and validate and update regularly. Define business and technology skills for all levels. Create a dynamic delineation of labor market information data that reflects the emerging biotechnology industry that uses a common language and is based on skill sets. Post on an industry-specific Web site.
  - Develop models with incentives that make it easy for K – 12 institutions to work with college and corporate partners.

- Issues: Image and Outreach to the Public
  - Present information about biotechnology careers organized by different criteria, e.g., industry content, occupation, educational pathway, career ladder, and salary.
  - Create a national media campaign.
  - Create a universal formula that is disseminated by all agencies (federal, state, and local).
  - Recognize the diversity and apply scientific and distinct names to various bio-industries or categories, which will clarify larger concerns, e.g., what is biotechnology, and then outline entry-level occupations with industry and determine the basic skills and competencies needed.
  - Create awareness at the elementary and secondary (K – 12) levels by creating partnerships between employers and schools that include: 1) mentorship and job shadowing, 2) employer-sponsored science fairs, 3) development of problem-based projects for K – 12 students to explain different areas that integrate academic standards, 4) school-based clubs, and 5) K – 12 and college programs.

Review

ETA's Business Relations Group then reviewed the solutions generated during the Workforce Solutions Forum. The purpose of this review was to:

- Identify for referral the solutions that are the responsibility of other entities and not in the domain of the Department of Labor;
- Identify solutions that are jointly in the domain of the Department of Labor and another federal department;

- Identify solutions where the Department of Labor or the public workforce system already have program commitments;
- Identify solutions within the Department of Labor's domain that, if implemented effectively and widely, could have a significant impact on managing the present and future workforce challenges of the biotechnology industry.

Appendix B:

137 Solutions Generated in the Biotechnology Industry Workforce Development Forum

Total number of solutions generated at the Forum: 137

The following is a complete list of the solutions generated at the Workforce Solutions Forum held in Chicago, in conjunction with the last of three executive forums among industry and workforce interests.

Pipeline Challenge/Issues: Recruitment and Retention
Create Industry Awareness and Increasing the Available Labor Pool

1. Have industry representatives create a single, industry-validated national workforce survey instrument that is relevant to the industry, not the perceptions of DOL, state workforce agencies, WIBs or other non-biotechnology organizations

2. Generate a bi-monthly electronic industry reporting mechanism for announcing filled and unfilled positions.

3. Create a separate funding stream (or carve out a portion of WIA dollars) that can be put towards meeting industry needs at the discretion of the business majority of the board.
(Possible solution for Sustainable Workforce Leadership, Policy and Infrastructure Challenges/Issues: Opportunities to Leverage Funding)
NOTE: The Administration's Workforce Investment Act (WIA) Reauthorization proposal would allow for state flexibility to spend WIA dollars on these industry driven needs.

4. Create mentoring programs and marketing campaigns directed towards elementary school students. Recruit exciting adult role models and mentors linked to youth to help educate them and build excitement about science and technology. Link them with college ACE mentors and continuously promote the need for education and lifelong learning.

5. Work with the public school system to create "Biotechnology" segments for their math and science curriculum from elementary school through high school including industry speakers, worksite tours for students and teachers, job shadowing opportunities on rare occasions (rather than Ground Hog Job Shadow Day), and competitions like the ones currently in Robotics, etc.

6. Conduct Biotechnology summer camps for elementary, middle and high school students and teachers.

7. Offer classes at local community college campuses to students and teachers that focus on allowing them to experience Biotechnology in fun way.

8. Develop summer camp-like programs at universities for early high-school students with a propensity for science to introduce the lab environment. Teach classes that support Biotechnology interests.

9. Work closely with universities or colleges to ensure that the students get the appropriate training to be employable and hired upon graduation.

(Possible solution for Skills Development Challenge/Issues: Entry-level worker preparation.)

10. Enhance person-to-person recruiting through mentoring by pairing industry individuals with interested trainees. .
11. Have the Departments of Labor and Education jointly fund intermediary work in order to jumpstart what oftentimes is the very slow alignment of industry needs and education provider capacity.

12. Create interest in the life sciences in primary and elementary school-age children through enhancing teacher education and career counselor programs at colleges and universities, which will help stimulate the interest of parents and children in Biotechnology.

13. Develop "Bridge" programs between secondary and post-secondary education so that individuals with an interest in the field, but not the prerequisites, can enter Associate Degree programs. Solicit support from the community, offer remediation if necessary, and assign coaches to help individuals navigate the system successfully.

14. Develop teacher externships for science and technology teachers in the elementary and high school systems, as well as in the community college and four-year university systems. Externships should provide a variety of hands-on, industry-specific experiences that they can bring back to the classroom and integrate into the curriculum.

15. The Departments of Labor and Education should jointly fund and work with national and state Biotechnology associations to produce and distribute videos, CD-ROMs, and other materials introducing the industry to potential workers.

16. Offer career counselor training (including elementary and high school counselors, college career advisors and One-Stop Career Center system staff) on a regular basis. Brining industry leaders in to educate the counselor community on the industry's needs and demographics, hiring trends and other general information needed to help better advise youth and adults on training options and employment within the industry.

17. Work with national labs to develop more programming on Biotechnology, Nanotechnology and other cutting-edge industries and related occupations to use with secondary school systems. Look to the summer "AP Chemistry" program for a program example.

18. Invite Biotechnology industry organizations to conduct assessments at high schools and community colleges to tell students whether or not they would qualify for various positions and explain skill gap areas.

19. Industries should link with academic institutions to create "webinaries" of outreach materials that make the Biotechnology industry more accessible to potential jobseekers.

20. Offer high school students in advance placement classes dual enrollment in college programs.

21. Allow students to take English and math prerequisites first so they can focus on Biotechnology classes sooner.

22. Help young people get "high-end" entry-level jobs in Biotechnology so that they can afford further training at community colleges.

23. Create better connections between academia and the job market. For example, have academic institutions focus on dynamic business and industries in which there are jobs.

24. Ask Biotechnology workers to review 4th, 5th and 6th grade class work and projects for the purpose of inserting real samples of Biotechnology work into the curriculum. Speak with teachers about how to present them for the appropriate level of understanding.

25. Develop and enhance partnerships with high school student associations to increase exposure to career opportunities in the Biotechnology industry.

26. Increase visibility for the Biotechnology industry by creating a movie or television program, e.g., CSI for Biotechnology.

27. Partner with all players (WIBs, industry, different levels of education) to enhance the Biotechnology pipeline.

28. Have companies internally encourage employees in support and non-Biotechnology roles to study to move into new Biotechnology jobs – a "grow your own" concept.

29. Contact current and former Biotechnology employees and offer accelerated certificates or degrees related to competencies necessary to return to job or move up the career ladder. Offer courses on weekends and evenings.

30. Build an industry-driven model program for training that includes high schools, community colleges, 4-year institutions, retrainees, incumbent workers, displaced workers, and homemakers. *(Possible solution for Pipeline Challenges/Issues: Recruitment and Retention, Increasing Diversity and Seeking Workers from Non-Traditional Labor Pools. Possible solution for Skill Development Challenge/Issue: Entry-level worker preparation and incumbent worker training.)*

31. Create national Biotechnology training awards for different levels of participants to help make training more exciting.

32. Set a base wage so that people can survive while in training.

33. Create more awareness at the high school level.

34. Create a membership pool of high school and higher education programs that have cross-industry workforce programs.

35. Hold simulations with Biotechnology representatives so people can "try on" the field before committing to training.

36. Help people become learners so they will understand they will have many careers in one lifetime.

37. Link school and business partnerships to teacher training (see the Mass Bio model). When providing funding, equipment and resources to schools, make teacher training a mandatory part of the package.

38. Work with Biotechnology businesses to create incentives for higher educational institutions to create "seamless" pathways through the pipeline. This could make worker training more cost effective.

39. Create job banks for internships so that individuals can discover where job/industry-based training is available.

40. Work with industry associations, the chamber of commerce and all of the educational institutions to create an internship program that fosters cooperation instead of competition between particular companies for qualified workers.
41. Create youth internships that get young people excited about this industry by putting them inside the work environment, linking them to adult mentors and helping them to link what they are learning in the classroom to what they need to be successful in the workplace.

42. Develop flexible, short-term incumbent worker training programs to help individuals continuously increase their skills, move up career ladders and keep up with industry changes.
(Possible solution for Skills Development Challenges/Issues: Incumbent Worker Training.)

43. Provide information (virtual and otherwise) to incumbent workers on career ladders, options for changing jobs and advancing within the industry – with a clear focus on the education and training needs for each rung of the ladder or lattice.
(Possible solution for Skills Development Challenges/Issues: Incumbent Worker Training.)

44. Include position descriptions in career path models for a particular jobs and supplemental information on Knowledge, Skills, and Abilities (KSA's) that are necessary to move up the ladder.

45. Provide companies with an adequate staff to orient and train new workers to take the burden of orientation off of incumbent workers.
(Possible solution for Skill Development Challenge/Issue: Entry-level worker preparation)

46. Create long-term employee exchanges so employees can work under one employer.

47. Develop worker readiness training focusing on critical thinking and teamwork.
(Possible solution for Skill Development Challenge/Issue: Entry-level worker preparation.)

48. Remove the "pigeonhole" tendency. Develop a clear path to move up through alternative certifications developed through partnerships with industry and academia.
(Possible solution for Skill Development Challenge/Issue: Entry-level worker preparation.)

49. Develop a working knowledge of the industry by state, including a picture of the local job market. Conduct an evaluation of the jobs and careers that are growing versus the jobs or careers that are not growing and work at building interest in or training in the needed fields of interest.

50. Offer tax credits to companies.

51. Study the industry and pass along findings. Find out what businesses need to know, find information and answers for them, and work in collaboration with business to remain competitive. Build models and programs to address findings.

52. Ensure companies become known as great places to work (like many of the IT companies did). Have programs in place to help students and employees deal with life issues such as on-site childcare, transportation options, and flexible hours and job share. There is a need for funding for these types of programs, especially at the entry-level.
(*Possible solution for Pipeline Challenges/Issues: Reducing Turnover.)*

53. Fund training at the real cost, where trainees make $20-$50 per hour.

54. Provide incentives to workers and businesses to encourage degree programs.
Possible solution for Pipeline Challenges/Issues: Reducing Turnover.)

55. Work with industry to provide students with the opportunity to shadow mentors to learn jobs and careers. Let industry provide the pull for both recruitment and retention.

56. Encourage companies to provide "volunteer" time for workers to do outside mentoring of students. This would include career talks, because the more workers tell students that biotechnology offers great careers the more they will believe.

57. Offer allowances to technologists to take time from work and participate in career days at local schools. This would allow professionals to participate more often.

Pipeline Challenges/Issues: Recruitment and Retention
Increasing Diversity and Seeking Workers from Non-Traditional Labor Pools

58. Make information about Biotechnology jobs available in multiple languages.

59. Develop English as a Second Language (ESL) programs targeted at individuals with advanced degrees.

60. Enhance partnerships with the U.S. Armed Forces for potential workers, especially in the area of bioterrorism. Align training with industry training.

61. Encourage lifelong learning by developing opportunities and providing financial aid to older workers so they can pursue Biotechnology degree programs.

Pipeline Challenges/Issues: Recruitment and Retention
Reducing Turnover

62. Create tax incentives for both workers and companies to make continuous retraining more accessible.

Image and Outreach to the Public Challenge/Issues:
Create Industry Awareness and Increasing the Available Labor Pool

63. Create a corporate/public sector partnership with a media campaign that focuses on how Biotechnology industry affects everyone.

64. Publicize the works of the scientist's DaVinci, Pasteur, Salk, and Archimedes by creating video vignettes that have actors portraying their lives, their contributions, and their quirks. Put this information on trading cards as well.

65. Develop a marketing campaign to educate the public as to career options in the Biotechnology field.

66. Emphasize biotechnology's role in science developments that have been made public.

67. Work with the press to distribute constructive information about Biotechnology research, production and accomplishments.

68. Coordinate with national and state trade associations and workforce boards to improve data collection and distribution in order to create a seamless continuum for information.

69. Create a compendium, by state, of major businesses, openings by occupation, training/education needed, and transferable skills and education from other professions.
70. Create Web-based interactive organization charts to explain various employment classifications and educational requirements.

71. Develop partnerships that include industry employers and associations, elementary and secondary school systems, the media, and workforce boards to create career awareness programs that focus on the functions of the biotechnology industry. Answer the question of how does one person can make a difference, what courses students should take in high school, and engage and targeting parents.

72. Create information resources that, beyond standard definitions, include strategies that can be applicable in different local settings and advise on how to choose communication strategies.

73. Create an industry compendium of information by setting and occupation, i.e., wage, career potential, first steps, key skills and training/education needed.

74. Encourage industry to work with broader industry coalitions to promote implementation of school-age career development standards in states that define learning objectives and determine what materials need to be provided for what purposes.

75. Develop effective "image" communication and educational programs to create an integrated curriculum.

76. Produce career information materials aimed at elementary school students that will easily fit into the curriculum.

77. "Dedicate" funding for Biotechnology careers.

78. Establish a certification program in Biotechnology for teachers and related educational curriculum. Provide incentives for teaching this curriculum.

79. Work with industry to gain specifics about what competencies and skills will be taught and the type of position and work to be done.

80. Create a Biotechnology solutions database website that describes solutions in place throughout the country including a short abstract with contact information and the website URL.

81. Encourage industry to move all appropriate operations into public view.

82. Treat the diversity of the industry as a plus. Extol Biotechnology as the ultimate interdisciplinary craft with opportunities for all students.

83. Portray Biotechnology as an industry that has not yet matured and thus offers more diverse career opportunities than more established industries. Emphasize that, for this reason, industry work is also less likely to be outsourced.

84. Establish "commercialization centers" for donated technologies for from industry, universities, and not-for-profits.

85. Community college sponsored elementary and high school-age Biotechnology camps in cooperation with industries to educate kids on the Biotechnology industry.

86. Test the image of the Biotechnology industry by region to determine what differences may exist. Create tailored solutions.

87. Gather data on the public perception (image) of the industry.

88. Promote a clear image of the use of tools and the scope of applications not only those which are "on the fringe."

89. Establish mentoring programs and internships with industry partners that are provided incentives through reimbursement or tax benefits.

90. Offer incentive programs to those workers willing to upgrade their skills with new training.

91. Promote Biotechnology as the infrastructure supporting a diverse array of commercial end products.

92. Have industry partners, public school educators and post-secondary educators, thus creating another resource for the student's decision-making process.

93. Develop awareness and training strategies to insure that local One-Stop Career Center staff are knowledgeable about the industry and can identify good career change candidates from declining industries by matching skills sets. One-Stop Career Centers need to know the general industry definition, career opportunities, basic prerequisites and training options.

94. Conduct summer workshops at community colleges for elementary and high schools and provide curricula and experiments to take back to their schools.

95. Offer a Biotechnology "Career Academy" at community colleges to high school students to allow them to begin Biotechnology study that will guide them into a 2-year college program.

96. Create a universal formula by which to capture and distribute data.

97. Establish an industry-wide function-based definition with national and state industry organizations and the Department on Labor, Commerce and Education that is cross-walked with NAICS and SICS.

98. Apply scientific and distinct names to various bio-industries that will clarify their product category; that is, clarify Biotechnology specialties, e.g., bio-agriculture, bio-pharmaceutical and sub-sets within each.

99. Recognize the industry and create categories for Biotechnology.

100. Convene BIO and other organizations to agree on "definitions" for different purposes.

101. Create a Biotechnology sitcom.

102. Conduct student "community" meetings to highlight opportunities available at all educational levels. Bring in alumni from community representing AD, BS, MS-level opportunities and

demonstrate attainability and prospects of a career in science. Partners are the industry, educators, and students.

103. Create enrichment activities integrating sports and science.

104. Have the industry develop its own certifications for industry professionals that will drive activity and focus by educational institutions (at college level), as well as definition of career paths. *(Possible solution for Capacity of Education and Training Providers Challenges/Issues: Lack of alignment between employer requirements and curricula, and specialized skilled areas.)*

105. Provide articulated pathways for Adult Education providers.

106. Tell the story of how a product is developed and have a vignette of its impact. For example, show the creation of a pharmaceutical and a story of someone whose life was changed … the story about the creation of a new strain of vegetable and the story of how it reduced hunger or saved lives.

107. Create awareness at elementary and secondary school level through partnerships between employees and schools including mentorship, job shadowing, and employee sponsored science fairs/current curriculum integration. Identify whether there is currently a student association for biotechnology or life sciences, something like Health Occupation Students of America (HOSA).

108. Develop problem-based projects for elementary and high school students to explore different areas that integrate each level's academic standards.

109. Work with small advisory groups representing major "biotechnology" industry groups, (e.g., BIO, Pharma, etc.) to define the range of occupations (by research, process engineering), educational pathways and then publish consolidated career materials.

Skills Competencies and Training Challenges/Issues:

110. Create a map and matrix of existing competencies and models, assess gaps and develop/fill in gaps and "vet" and update regularly. Define business and technical skills at all levels and link to other industries.

111. Create a modularized curriculum around three components: core science and technical skills, core general education and soft skills, special technical skills used to develop various levels of training and education certification. A Bachelor of Science degree should be a part of the career ladder.

112. Fund the facilities component of the '65 Higher Education Act through a target that could change every 24 months. Revolving focus and funding improve the capacity of education and training and makes providers a part of the process.)

113. Redefine apprenticeship so that industry is provided incentives for funding two partners with applied programs at community colleges and universities.

114. Create bridge programs for incumbent workers that will combine mentoring, internships and academics.

115. Develop models with incentives that make it easy for educational institutions to work with government and corporate partners.

116. Fund expansion of existing leaders in workforce development and develop a website to capture this information.

117. Allow existing successful organizations to test new initiatives.

118. Create more sustainable and industry-led partnership models for incumbent pipelines, with worker development coordinated by industry associations.

119. Create a model that creates "quick track action" from industry training needs survey data to provide to college programs.

120. Outfit high schools with science labs and teacher training – "no dumping grounds."

121. Streamline and modernize workforce system training funding guidelines.

122. Create skills boards for each cluster where industry will develop or compile competency lists and keep them updated.

123. Offer industry and academia teacher training and incorporate mandatory continuing education; from elementary to secondary school, as well as and post-secondary institutions.

124. Create demonstration project for public education piece on career opportunities and image of Biotechnology for use in multiple venues (middle and high school, college), grassroots, government and lifelong learning.

125. Include community colleges in all solutions.

126. Create and require industry advisory boards that will create a model elementary and secondary school credit courses in higher education.

127. Make competencies accessible and the standards appropriate.

128. Identify industry-specific competency training for and on-the-job training opportunities.

129. Ensure a job placement.

130. Create and use an industry-specific aptitude test, e.g., ACT, National Work Keys Exam.

131. Identify intersecting technologies (IT, Nanotechnology, Clinical Health) and match common competencies.

132. Ensure infrastructure of education and training providers by providing resources.

133. Provide a model and funding source for capacity development for teachers that includes curriculum development.

134. Create a teacher externship in support of mapping to other industries and career ladders.

135. Establish a demonstration project to promote and establish awareness and professional matrix participation in state middle and high school science fairs.

136. Create a nationwide industry driven competency certification program that includes career tech education, basic academics and soft skills.

137. Identify an intermediary that follows the individual or organization to ensure consistency throughout the process.

Appendix C: Biotechnology Industry Workforce Solutions Forum Solutions Matrix

Biotechnology	**Critical Attributes (What attributes are needed for success?)**	**Key Stakeholders (Who are needed for success?)**	**Resources (Financial, Human, and Technology)**	**Policy Barriers**	**Miscellaneous**
Issue/Challenge: Recruitment and Retention					

Issue: To provide authentic exposure to industry students and faculty to ensure a better understanding of the career path.
 	
Solution: Provide a variety of opportunities to students and faculty (elementary, secondary, postsecondary, and beyond) including job shadowing, summer camps, mentoring, industry speakers, tours, high school and college competitions, career clubs, and workshops.
 	
Priority Solution 1
	• Industry buy-in
	• Student interest
	• Educational institution support
	• Need overall direction
	  o Someone needs to be in control and coordinate
		• Industry
		• K – 12
		• Colleges and universities
		• Parents/community
		• (Teachers/Counselors)
		• School-to-Work
			• Need organizational structure
			• Money to fund program
			  o Pay teachers
			  o Produce PR
			• Time
			  o Classroom
			  ▪ Need to work around academic standards
				• Lack of funds available
				• Lack of organizational structure to implement
				• Political opposition to school-to-work	

Issue: WIA funds are severely limiting in who can be served and how long they can be trained. **Solution**: Create a separate funding stream, or carve out a portion of WIA dollars, that can be spent on meeting industry needs, as long as they are driven by the business community. **NOTE:** The Administration's Workforce Investment Act (WIA) Reauthorization proposal would allow for state flexibility to spend WIA dollars on these industry driven needs. **Priority Solution 2**	• Flexibility • Business-led initiatives • Entrepreneurial	• Business • Education • Workforce Investment Boards (WIBs) • DOL	• DOL wants to be industry-driven and responsive	• Current WIA law does not allow this • Training dollar levels are too low to allow high level training that would be needed for Biotechnology	• DOL culture does not foster flexibility • DOL history has favored targeted populations and low skilled jobs.

Biotechnology	Critical Attributes (What attributes are needed for success?)	Key Stakeholders (Who are needed for success?)	Resources (Financial, Human, and Technology)	Policy Barriers	Miscellaneous
Issue/Challenge: Recruitment and Retention					
Issue: Need for a single Biotechnology workforce survey instrument consistent with industry language, coding, benchmarking and standards **Solution**: Create a national biotechnology workforce survey that is industry generated and validated. Start in one major state as a test-bed and distribute nationally through the Biotechnology Industry Organization (BIO). **Priority Solution 3**	• Industry driven and responsive • National in scope • Consistent with industry HR survey firms and their job descriptions, career laddering and coding • Easily tabulated • Electronic survey instrument • Easily updated • Move eventually into a E-version of filled and unfilled positions => industry snapshot	• Regional Biotechnology industry trade organizations and clusters • State employment Development Departments, ETFs, Workforce Investment Boards (WIBs) • Regional Workforce Investment Boards (WIBs) • National industry trade organizations • NSF, DOL, NIH, DOE • Educational institutions	• Funds to create the survey instrument o Test-bedding o Move to pilot in other states • Industry evaluation costs • Website marketing • Website administration • State deployment will assess regional salaries … regional data will be necessary	• Any proprietary data • Any state regulations	• Dependency upon foreign nationals and H-1B's and visas • Export controls on foreign nationals
Issue: Lack of new, flexible training courses and modules to keep up with rapid industry **Solution**: Creating flexible, short-term training options to keep up with ongoing industry training. **Priority Solution 4**	• Strong linkages between industry and education to communicate ongoing changes • Labor market information and resources to help in identifying needs and changes • Corporate culture that promotes thinking • Capacity to deliver training	• Employees • Educational institutions • Employers/industry • Public Workforce system	• Money and incentives • Dedicated staff (leveraged through education) • Teams that are working together in cross-functional fashion • Technology	• Organized labor on college campuses • Certification of training	

Biotechnology	Critical Attributes (What attributes are needed for success?)	Key Stakeholders (Who are needed for success?)	Resources (Financial, Human, and Technology)	Policy Barriers	Miscellaneous
Issue/Challenge: Recruitment and Retention					
Issue: Building a funding stream for portable, life long learning accounts for workers. **Solution**: Create a system for portable, life long learning accounts for workers, promote the system, and support the use of the system. **Priority Solution 5**	• Portability • Equitability from company to company • Industry buy-in and leadership • Incentives for business and industry • Ability to bank resources for immediate use	• Industry/associations • Labor • Public Workforce System • Education • Community Based Organizations (CBO's)	• Money and incentives • Human capital to lead this effort • Structure • Technology	• Federal and state regulations • Lack of commitment • Lack of established financial resources	
Issue: To create and/or maintain a competitive organization, biotech companies need to retain well-skilled workers. **Solution**: Create a system for continuous skills-upgrade training, career enhancement and well-documented career ladders and lattices, allowing biotechnology companies to maintain their competitiveness and retain well-skilled workers. **Overall Solution 6**	• Training in broader skills, base skills and transferable skills on which specialty skills can be layered • Create and promote an environment for continuous life long learning – lead by management • Through this process, create and promote career ladder and lattice opportunities	• Industry/associations • Economic Development • Management • Employees • Labor • Educators and trainers • Workforce Development • Community Based Organizations (CBO's)	• Money • Flexibility • Industry Intelligence • Creativity and Innovation	• Federal and state regulations • Venture capital climate • Lack of financial resources	

Biotechnology	Critical Attributes (What attributes are needed for success?)	Key Stakeholders (Who are needed for success?)	Resources (Financial, Human, and Technology)	Policy Barriers	Miscellaneous
Issue: Skills Competencies and Training					
Issue: Skills Competencies and Training **Solution:** Create a map and a matrix of existing competencies and models, assess gaps, and validate and update regularly. Define business and technology skills for all levels. Create a dynamic delineation of labor market information data that reflects the emerging biotechnology industry that uses a common language and is based on skill sets. Post on an industry-specific website. **Priority Solution 7**	• Lead organization must survey what already exists • Identify lead organization • Publication of end result Development of common language (LMI) • Recommend to BLS as new LMI standards • Advisory group of stakeholders to "vet" draft report • Must be dynamic and updated • Must be sustainable • Model has cross-industry application	• BIO • BRG • Biotech Associations • CBSA • Industry (driver) • NSF • Community colleges • Biotech Institute • Universities • Workforce Investment Boards (WIBs) • K – 16 • Community organizations	• Staff: Project Manager, Admin., IT person • Web Development • Focus Group Events • Travel • Require timely updates		
Issue: Skills Competencies and Training **Solution**: Develop models with incentives that make it easy for K – 12 to work with college and corporate partners. **Priority Solution 8**	• K – 12 and post-secondary alignment • Life Long Learning • Professional development units for teacher professional development • Equip schools – laboratories, provide supplies and re-training • Partner with existing teacher training (student training & "bio bus") • Enhance curriculum that align with national standards • Create a map of best practices (especially industry-funded) • "Reverse" science fair • Summer paid "sabbaticals" for teacher training	• Workforce Investment Boards (WIBs) • Career Centers • Industry Associations • Companies • Boards of Education • K – 12 Community Colleges and 4-Year Colleges/Universities • Community Based Organizations • Teaching Hospitals • Research Institutes • Teacher Training Institute	• Increased funding for dual enrollment (HS/College) • Industry Funding • DOL & State Workforce Entities • State Education Organizations • Funding	• Funding rules regarding training eligibility • "Siloed" funding is too restrictive	• Encourage under-age groups to participate • Web-enabled teacher training

Biotechnology	Critical Attributes (What attributes are needed for success?)	Key Stakeholders (Who are needed for success?)	Resources (Financial, Human, and Technology)	Policy Barriers	Miscellaneous
Issue: Image and Outreach to the Public					
Issue: Image and Outreach to the Public: Image - Basic Career Information **Solution:** Present information about biotechnology careers organized by different criteria, e.g., industry content, occupation, educational pathway, career ladder, and salary **Priority Solution 9**	• National project • Modularize so can be tailored to local needs • Strong industry participation • Evaluate impact on different audiences	• Industry • Educational institutions, K – 12, post secondary institutions (e.g. colleges) • WIA • Adult education providers • Students • Target Audience Requirements • State Representatives	• Industry • Government Funding (Federal/State) • Communication Professionals • Database Expertise	• Restricted K – 12 curriculum development ✓ Conflicting state workforce information	
Issue: Image and Outreach to the Public: Image **Solution:** Create a national media campaign **Priority Solution 10**	• Identify target audience • Identify key messages • Media/mechanisms for delivery o TV o Radio o Print o Web • Public Speaking • Enlist professional PR and publication experts	• General public • Biotech Industry • Student at all levels • Unemployed • Legislators • Healthcare professionals • Education professionals • Legislators • Industry • Private Foundations • Department of Labor • Public Workforce System • Higher Education • Proprietary Schools	• Federal, state, and local dollars • Philanthropic dollars • Industry dollars • Production house	• Public names supporting industry campaign • Legislative interpretation at State and local level	
Issue: Image and Outreach to the Public: Industry Definition **Solution:** Create a universal formula which is promulgated by all agencies (federal, state, and local) **Priority Solution 11**	• Building consensus of defining codes	• Appropriate federal agencies • State trade associations • National trade associations • State workforce boards	• Federal and dollars • Appropriate representatives from state and federal agencies	• Federal legislative needs	• Change mind sets

Biotechnology	Critical Attributes (What attributes are needed for success?)	Key Stakeholders (Who are needed for success?)	Resources (Financial, Human, and Technology)	Policy Barriers	Miscellaneous
Issue: Image and Outreach to the Public					
Issue: Image and Outreach to the Public: Industry Definition. Industry is diverse and does not lead itself to definition so that standards occupations and curriculum can be standardized and eventually competencies developed. **Solution:** Recognize the diversity and apply scientific and distinct names to various bio-industries or categories, which will clarify larger concerns, e.g., what is biotechnology, and then outline entry-level occupations with industry and determine the basic skills and competencies needed. **Priority Solution 12**	• Move at the speed of business • Industry input • Needs assessment • Agreement of what sectors • Greater "consensus among the stakeholders" • Industry cluster consensus • Understand all sectors and job types • Forums for dialogue • Job task analysis	• BIO, ISPE, Pharma, PDA, other Industry Organizations • National and state trade associations • Appropriate federal agencies • Industry • Education		• Create framework for variations • Industry defined specific categories	
Issue: Career awareness for K - 12 **Solution:** Create awareness at the K – 12 levels by creating partnerships between employers and schools that include: 1) mentorship and job shadowing, 2) employer-sponsored science fairs, 3) development of problem-based projects for K – 12 students to explain different areas that integrate academic standards, 4) school-based clubs, and 5) K – 12 and college programs. **Priority Solution 13**	• Local partnerships • Materials developed will be shared • Materials based on industry-driven competencies • Assessment component	• K – 12 schools • Colleges and universities • Industry	• Funding • Teachers • Industry mentors • Facilities • Information for teachers and administrators	• Space in curriculum in particular states • School districts won't make it a priority • Need incentives for teachers to teach	

Appendix D: Biotechnology Industry Solutions Matrix – Condensed

Overarching Issue/Challenge	Specific issue/Challenge	Potential Solution	Solution Number (All Solutions Developed in Chicago, IL)
Recruitment and Retention	Create Awareness/Increase Available Labor Pool	Provide a variety of opportunities to students and faculty (elementary, secondary, postsecondary, and beyond) including job shadowing, summer camps, mentoring, industry speakers, tours, high school and college competitions, career clubs, and workshops.	**Overall Solution 1**
Recruitment and Retention	Opportunity to Leverage Funding and Other Resources	Create a separate funding stream, or carve out a portion of WIA dollars, that can be spent on meeting industry needs, as long as they are driven by the business community. **NOTE:** The Administration's Workforce Investment Act (WIA) Reauthorization proposal would allow for state flexibility to spend WIA dollars on these industry driven needs.	**Overall Solution 2**
Recruitment and Retention	Increase Available Labor Pool	Create a national biotechnology workforce survey that is industry generated and validated. Start in one major state as a test-bed and distribute nationally through the Biotechnology Industry Organization (BIO).	**Overall Solution 3**
Recruitment and Retention	Entry-level worker preparation	Creating flexible, short-term training options to keep up with ongoing industry training.	**Overall Solution 4**
Recruitment and Retention	Create Awareness/Increase Available Labor Pool	Create a system for portable, life long learning accounts for workers, promote the system, and support the use of the system.	**Overall Solution 5**
Recruitment and Retention	Skills Development/Incumbent Worker Training	Create a system for continuous skills-upgrade training, career enhancement and well-documented career ladders and lattices, allowing biotechnology companies to maintain their competitiveness and retain well-skilled workers.	**Overall Solution 6**
Skills Competencies and Training	Sustainable Workforce: Leadership Policy and Infrastructure Challenges – Planning Tools (data, projections, and information systems that are useful in projections of demand)	Create a map and a matrix of existing competencies and models, assess gaps, and validate and update regularly. Define business and technology skills for all levels. Create a dynamic delineation of labor market information data that reflects the emerging biotechnology industry that uses a common language and is based on skill sets. Post on an industry-specific website.	**Overall Solution 7**
Skills Competencies and Training	Need for sustainable and adaptive partnerships	Develop models with incentives that make it easy for K – 12 to work with college and corporate partners.	

Overarching Issue/Challenge	Specific issue/Challenge	Potential Solution	Solution Number
Image and Outreach to the Public	Create Awareness/Increasing the Available Labor Pool	Present information about biotechnology careers organized by different criteria, e.g., industry content, occupation, educational pathway, career ladder, and salary	Overall Solution 9
Image and Outreach to the Public	Create Awareness/Increasing the Available Labor Pool	Create a national media campaign	Overall Solution 10
Image and Outreach to the Public	Sustainable Workforce: Leadership Policy and Infrastructure Challenges – Planning Tools (data, projections, and information systems that are useful in projections of demand)	Create a universal formula which is promulgated by all agencies (federal, state, and local)	Overall Solution 11
Image and Outreach to the Public	Create Awareness/Increasing the Available Labor Pool	Recognize the diversity and apply scientific and distinct names to various bio-industries or categories, which will clarify larger concerns, e.g., what is biotechnology, and then outline entry-level occupations with industry and determine the basic skills and competencies needed.	Overall Solution 12
Image and Outreach to the Public	Create Awareness/Increasing the Available Labor Pool	Create awareness at the K – 12 levels by creating partnerships between employers and schools that include: 1) mentorship and job shadowing, 2) employer-sponsored science fairs, 3) development of problem-based projects for K – 12 students to explain different areas that integrate academic standards, 4) school-based clubs, and 5) K – 12 and college programs.	Overall Solution 13