9-1-2001

The Biotechnologies Industry in New Mexico

Bureau of Business and Economic Research

THE BIOTECHNOLOGIES INDUSTRY

IN NEW MEXICO

This publication is made possible in part by the Carl D. Perkins Vocational and Technical Education Act Amendments of 1998 and the New Mexico State Department of Education, Career, Technical and Adult Services Division.

Prepared for

Albuquerque Technical Vocational Institute

By

BUREAU OF BUSINESS AND ECONOMIC RESEARCH
The University of New Mexico

September, 2001

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1 EXECUTIVE SUMMARY

This research utilizes both quantitative and qualitative analysis to describe key elements of the New Mexico biotechnologies industry to assist in efforts to develop educational training programs for the industry. The industry is composed of a diverse group of businesses with activities ranging from research and development and bioinformatics to the warehousing and distribution of medical devices. To facilitate data collection and analysis this study utilizes a more narrow definition focusing on activities at the core of the New Mexico biotechnologies sector.

Core activities include the following industries readily identified by the North American Industrial Classification System: pharmaceutical manufacturing, specialized medical and laboratory equipment manufacturing, and related research and development. In 1999, these industries collectively employed an estimated 2,348 at 102 private establishments in New Mexico. Medical equipment and supplies had the largest portion of the industry's employees (64.4%), followed by research and development in the life sciences (23.6%) and pharmaceutical manufacturing (11.6%). It should be noted that the manufacturing activities of the sector include a high proportion of relatively low-tech, low-skill employment such as sewing and cutting.

This industry also impacts the state's economy in other ways. In 1997 the value of the state's biotechnologies shipments was at least $325.2 million, the overwhelming majority coming from medical equipment and supplies shipments. The biotechnology industry also included an estimated 56 private establishments with no employees (e.g. sole proprietors) in 1998. Nonemployer medical equipment and supplies manufacturing increased from eight establishments with $742,000 in receipts to thirteen establishments with $1.1 million dollars in receipts between 1997 and 1998.

The occupational analysis indicates that technological innovation will have a profound impact on future employment opportunities. For example, professional specialty occupations, which include scientists and other occupations with high educational requirements, are projected to be among the fastest growing in both the national and state economy. Among life scientists, biologists are projected to capture a particularly high share of new openings driven in part by advances in biotechnology and the medical demands of an aging population.

The outlook for science technicians, however, is not as optimistic as it is for the scientists themselves. This is supported by both the data analysis and our discussions with local business representatives. The reduced demand for technicians (particularly those with less than a bachelors degree) is reflective of the increased automation and sophistication of the job setting and other factors.

Nonetheless, among science technicians, biological (which would include biotechnology) technicians are projected to be the fastest growing. As with biologists, this projection is also driven by advances in biotechnology and the demands of an aging population. These factors also stimulate the demand for a variety of health related professions which may have implications for the later design of a biotechnologies program. Another factor which fuels the biological

emphasis of the science technician occupation is the dwindling demand for petroleum and other technicians working in the extractive industries.

The most recent projection available for science technicians indicates that there will be 10 statewide openings annually through 2008. This figure may be considered conservative for a variety of reasons. First, recent growth both in technological advancement and other areas may not have been incorporated at the time of the projection. Second, and perhaps more importantly, is the likelihood that a biotechnologies program (either at TVI or UNM or both) would increase the likelihood that developing local firms would stay (and grow) in New Mexico. Likewise, the possibility of successful recruitment of future biotechnology-related companies would increase with the presence of a local biotechnologies program and the enhanced skills of the local workforce. And finally, the demand for the TVI program would likely attract individuals from other fields including health services, clinical laboratories, pharmaceutical sales, criminology and others.

Interviews were conducted with three distinct groups of individuals involved in various aspects of the biotechnology industry. One group, "industry insiders", includes both individuals involved in economic development efforts and representatives from the New Mexico biotechnology industry as a whole. One major point of agreement was that the biotechnology industry in New Mexico was "fledgling" or at a beginning stage of development. As a result insiders tend to emphasize the research and development aspect of the industry and consequently place a higher emphasis on the need for very highly educated personnel such as scientists and engineers at a present time.

Another set of interviews was conducted with representatives of individual businesses engaged in biotechnology-related activities. In terms of anticipated business growth the responses were mixed. Relatively few businesses readily anticipated significant employment growth over the next five years. Some indicated that they would grow in terms of revenue and product development but not necessarily in terms of employees. Others indicated that they expected employment growth but not necessarily in New Mexico. However, one key employer, the Los Alamos National Laboratory, was anticipating considerable growth in the bioscience field and a need for biotechnology technicians in the near future.

Individual business representatives also provided a range of responses to questions regarding the need for a biotechnology program at TVI. In general, establishments involved primarily in research and development (and bioinformatics) indicated that they needed personnel with advanced degrees. Some employers indicated a need for training in areas outs such as computers, optics, clinical areas (e.g. phlebotomy) and engineering-related activities but not necessarily "biotechnology." A few business representatives, including a pharmaceutical salesperson, expressed a high level of enthusiasm for the program. In general, industry insiders were more enthusiastic about the development of a biotechnology program then were representatives from individual businesses.

For the third set of interviews, we contacted industry, academic and government officials from five geographic locations: Arizona, Colorado, Utah, San Diego, California, and Austin, Texas.

We learned that Arizona, Colorado and Utah are in stages of biotechnology development similar to New Mexico, while Austin is somewhat ahead of New Mexico, and San Diego is way ahead.

Some common elements among the states include the critical role in training the workforce played by the community college system and the necessity of forming bonds between the industry and the academic research community. Also of importance is the availability of entrepreneurs and venture capital.

2 INTRODUCTION TO THE BIOTECHNOLOGIES INDUSTRY

Biotechnology is concerned with the processes through which living organisms are modified to meet human needs. It deals with cells and other objects derived from complex organisms in tissue culture, and their isolation, manipulation, and transfer of genetic material between cells. Activities encompassed by the biotechnologies industry, in general, include:

- pharmaceutical and medicine research and manufacturing.
- medical device, equipment and supplies manufacturing.
- analytical laboratory instrument manufacturing.
- research and development.
- agricultural engineering.
- forensics.
- diagnostics and clinical services.
- the study of the inherent structure of biological systems and biological information (bioinformatics).

Specifying the firms that comprise biotechnologies industry is difficult because the sector is still emerging and the activities within the industry cut across many existing industries. In addition, many of the firms that can be identified as engaging in biotechnology activities are also engaged in activities which cannot be considered to fall under the biotechnology umbrella.

By definition, an industry is a group of establishments that provide similar goods or services. For many established industries (e.g. manufacturing, finance, etc.), the Standard Industrial Classification system (SIC) or the more recent North American Industrial Classification System (NAICS) provide a readily understood and generally accepted definition. For established industries, the collection and application of statistical information is a relatively straightforward task. Unfortunately, neither the SIC or NAICS system establishes a biotechnologies industry and, though the NAICS system does make mention of biotechnology and related concepts. In developing the definition of the biotechnology industry in New Mexico, we used the following approach:

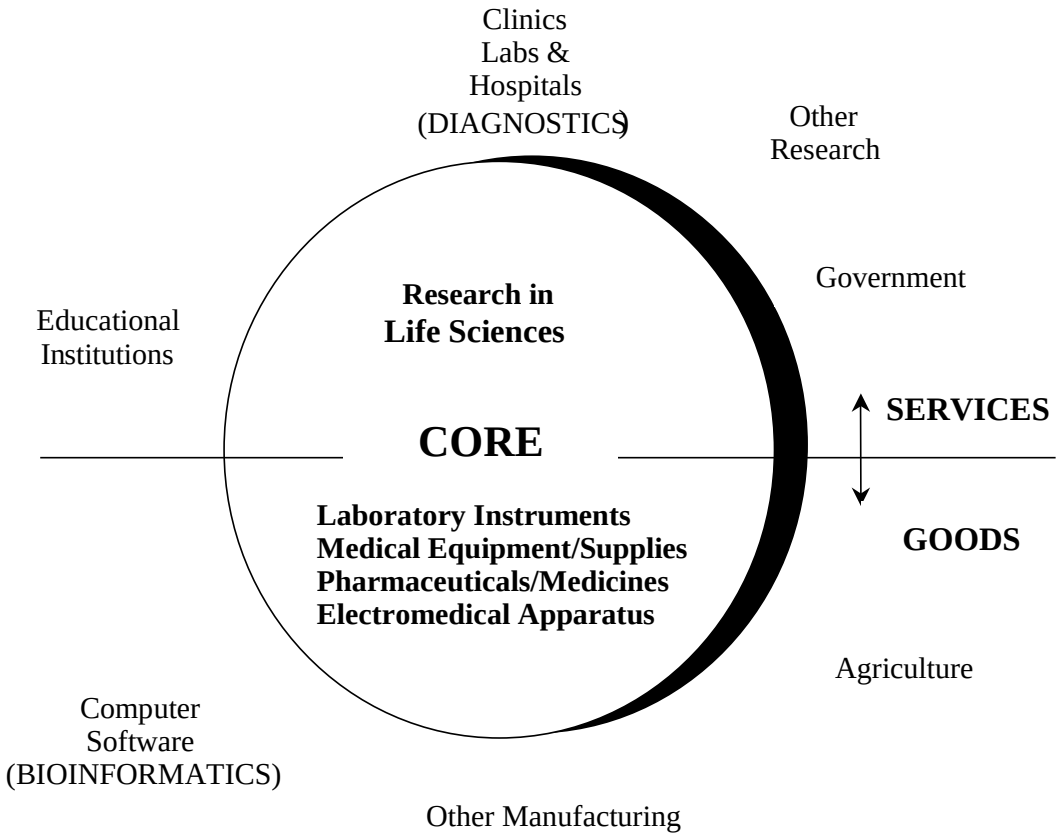
- A review of the establishments listed in the New Mexico Biotechnology Association Directory and biotechnology related organizations
- Conversations with industry insiders and business leaders
- An intensive review of SIC and NAICS
- An analysis of biotechnology related-occupations and the industries in which they are employed. This approach emulates a method used by the Bureau of Labor Statistics to identify high tech industries.

From this review an analytical framework was developed (see diagram). This framework places biotechnologies related NAICS industries into one of two categories:

> (1) Core Industries: NAICS industries with activities that are primarily or exclusively related to a biotechnology activity. These NAICS industries include pharmaceutical and medicine manufacturing, electromedical and electrotherapeutical apparatus manufacturing, analytical laboratory instrument manufacturing and medical equipment and supplies manufacturing, and research and development in the life sciences.
>
> (2) Peripheral Industries: Industries that may support or provide or produce biotechnology related services or products as a secondary activity. These include both goods producing and service activities including computer program and software development, manufacturing, agriculture and other activities.

The framework also illustrates which sectors are involved in the production of goods (e.g. manufacturing or agriculture) and which are associated with the provision of services (e.g. research and clinical laboratories). This framework provides an indication of the diversity of the industry.

Figure 1



3 METHODOLOGY AND DATA SOURCES

This research assesses key elements of New Mexico's biotechnologies industry and occupations to assist Albuquerque Technical Vocational Institute in their pursuit of an educational program in the biotechnologies. These elements include defining the biotechnologies industry, gathering insights and perspectives from industry officials and analyzing important employment-related trends.

3.1 Methodology

This research incorporates the following techniques to research the biotechnology industry in New Mexico:

(1) Analysis of published data on specific variables including employment, establishments, revenues, value of shipments and current and projected employment levels for key occupations; and

(2) Qualitative analysis based on interviews with business leaders, industry members, economic developers and other persons knowledgeable about biotechnology.

3.2 Data Sources

Data used to conduct the secondary data analysis included figures on employment, number of establishments, payroll, output, and occupational staffing patterns and projections. The data sources used include reports from the *1997 Economic Census, Nonemployer Statistics* and *County Business Patterns*, all of which are produced by the U.S. Bureau of the Census. Also used were various publications and tables produced by the U.S. Bureau of Labor Statistics, including the *Occupational Outlook Handbook* and occupation projections and other data from the BLS web page, and New Mexico Department of Labor publications on occupational staffing patterns and projections.

A critical issue in the secondary data analysis was choosing meaningful industry and occupational classifications for inclusion in the study. The most widely used industrial classification system, which classifies establishments by type of product produced, is the SIC system, described in detail in the *Standard Industrial Classification Manual* (1987), from the Office of Management and Budget. The US is in the process of converting over to NAICS, a new industrial classification system which better captures some emerging industries. The new system is described in detail in a 1997 volume also produced by the US Office of Management and Budget.

Occupations, like industries, are classified using a hierarchical system that is subject to change as the occupational structure of the country changes. The 1998 Standard Occupational Classification System (SOC) replaced the 1980 SOC. Unfortunately, many data products from the new system, most notably occupational projections, were not available at the present. Therefore, most of the analysis used here reflects classifications based on the older system.

The analysis of published data contains a number of limitations.

- Industry Classification System Change
  The industrial classification system used by County Business Patterns changed from the SIC to NAICS in 1998, allowing analysis by NAICS only for 1998 and 1999. Economic Census data are published both in SIC and NAICS in 1997, though only in SIC in 1992. This prevents using Economic Census data for an analysis of change over time by NAICS.

- Classification
  Industrial classifications group establishments based on their product, which in some cases prevents the identification and measurement of specific activities. For example, a bioinformatics establishment that produces software will be classified as under software development.

- Disclosure
  Many of the industries relating to biotechnologies activities are published at the 5, 6 and sometime 7 digit NAICS level (the most detailed level), which often do not have adequate activity to have data published.

- Occupational Projection Assumptions
  The accuracy of projections for individual occupations is subject, of course, to error because of the many unknown factors that will affect the economy over the projection period. All projections incorporate certain assumptions about the national and state economy.

Additionally, both the survey and published data analyses are augmented by other sources to identify specific businesses, the types of activities taking place, and other business characteristics such as employment levels, location, etc. Sources of this information include:

- New Mexico Biotechnology & Biomedical Association Member List.
- Biotechnology & Biomedical Industry Workforce Needs Assessment
- Reference USA On-line Database

4 RESEARCH FINDINGS FROM PUBLISHED DATA

This section presents the findings of the analysis of published data on the most recent employment, establishment and output levels of New Mexico's biotechnologies industry, the industry's nonemployers, and the occupational composition of the industry and occupational projections.

4.1 Private Sector Biotechnologies Industry

The NAICS industries included in this report's analysis of the biotechnologies industry include "medical equipment and supplies," "medical laboratories," and "commercial nonphysical

research" (SIC codes 3840, 8071, and 8732 respectively). The pharmaceutical and medicine manufacturing industry is also included on this list based on our understanding of these businesses in this sector in New Mexico. The NAICS definition of each of these industries is included as Appendix A.

Table 1 shows the 1999 estimates for private sector employment and establishments in New Mexico's biotechnologies industry by NAICS subsector. Total estimated employment in the biotechnologies industry is 2,348, with 105 establishments. The largest subsector in the industry is medical equipment and supplies with over 1,500 employees (64.6% of the biotechnologies industry total) at 63 (60.0%) New Mexico establishments. Biotechnological Research and development is the next largest sector, with 553 (23.8%) employees at 32 (30.5%) establishments. Estimated employment in pharmaceutical and medicine manufacturing in 1999 is 272 (11.7%) at New Mexico's 6 (5.7%) establishments. Electromedical and electrotherapeutic apparatus and analytical laboratory instrument subsectors combine for approximately 20 employees at 4 establishments. The average number of employees per establishment in the biotechnologies industry is 22. This average varies from 5 in the electromedical and electrotherapeutic apparatus and analytical laboratory instrument manufacturing subsectors to 45 in the pharmaceutical and medicine manufacturing subsector.

Table 1

New Mexico Biotechnology Industry: Estimate of Private Sector Employment and Establishments, 1999[1]

NAICS Code	Description	Employees	Establish-ments	Employees per Estab.
32541	**Pharmaceutical and medicine mfg.**	272	6	45
334510	**Electromedical and electrotherapeutic apparatus***	10	2	5
334516	**Analytical laboratory instrument***	10	2	5
3391	**Medical equipment and supplies**	1,503	63	24
5417102	**Research and development in the life sciences[2]**	553	32	17
	Total	2,348	105	22

1- please refer to the attached methodology. Estimates were derived from 1997 Economic Census and 1999 County Business Patterns data. Depending upon the definition of biotechnology used, the NAICS subsectors may or may not capture all biotechnology employment and establishments. 2 - includes firms both subject to and exempt from federal income tax.

* 1999 County Business Patterns data provided employment ranges of 0 - 19 employees, establishment counts are actual.

The state's biotechnologies industry's average payroll per employee and value of shipments in 1997 are shown in Table 2, on the following page. Excluding shipments from the electromedical and electrotherapeutic apparatus and analytical laboratory instrument manufacturing subsectors, the 1997 value of shipments is $325.2 million. Shipments of the medical equipment and supplies subsector accounted for 94.0 percent ($305.5 million) of total industry shipment. The value of shipments from pharmaceutical and medicine manufacturing establishments was close to $20 million (6.0%), non taxable establishments in research and development in the life sciences is $33.4 million (10.3%), and taxable establishments in research and development in the life sciences is $8.2 million (2.5%).

Table 2

New Mexico Biotechnology Industry: Average Payroll per Employee and Value of Shipments, 1997

NAICS Code	Description	Average Payroll per Employee	Value of Shipment ($mil)
32541	**Pharmaceutical and medicine**	$28,030	$19.7
334510	**Electromedical and electrotherapeutic apparatus**	D	D
334516	**Analytical laboratory instrument**	D	D
3391	**Medical equipment and supplies**	$25,202	$305.5
5417102	**Research and development in the life sciences**	$46,800	$8.2
5417102	**Research and development in the life sciences[1]**	$31,584	$33.4

1 - exempt from federal income taxes. D - not disclosed.

Source: U.S. Department of Commerce, Bureau of the Census, Economic Census, New Mexico, 1997.

4.2 Nonemployers in Biotechnologies

Table 3 shows nonemployer establishments in the biotechnologies industry in New Mexico in 1997 and 1998. Nonemployer establishments consist of individual proprietorships, partnerships, and corporations with no employees. Nonemployers make up only a small part of the output in the biotechnologies, with manufacturing receipts totaling less than one million dollars in 1997, compared to employer establishment value of shipments in excess of $325 million. Nonetheless, nonemployers do provide an indication of the amount of activity taking place in the industry.

Table 3

New Mexico Biotechnology Nonemployers: Establishments and Receipts, 1997 and

		1997		1998	
NAICS Code	Description	Total Establish-ments	Receipts ($1,000)	Total Establish-ments	Receipts ($1,000)
Manufacturing					
32541	**Pharmaceutical and medicine**	4	177	5	147
3391	**Medical equipment and supplies manufacturing**	8	742	13	1,092
Professional, Scientific and Technical Services					
5417102	**Research and development in the life sciences[1]**	34	D	38	D
	Total	46	D	56	D

1 - estimates of establishments derived by applying the distribution of establishments for employers from the 1997 Economic Census.
D - not disclosed.

Source: U.S. Department of Commerce, Bureau of the Census, Economic Census, New Mexico, 1997 and Nonemployer Statistics, 1998.

There was an increase in the number of establishments in both manufacturing subsectors, though pharmaceutical and medicine manufacturing saw a decline in the amount of receipts. Nonemployer medical equipment and supplies manufacturing increased from eight

establishments with $742,000 in receipts to thirteen establishments with $1.1 million dollars in receipts. The nonemployer establishment count in biotechnologies research and development was derived from the broader research and development in the physical, engineering and biotechnologies using the 1997 Economic Census. This analysis assumes that the nonemployers in research and development in the biotechnologies are in the same proportion as the establishments with employees.

4.3 Public Sector Biotechnologies

A large portion of the biotechnology related activities in New Mexico are carried out at the national laboratories, the vast majority at Los Alamos. Their Bioscience Division is engaged in a variety of activities including computational biology, environmental biology, genomics and medical applications.

We spoke with a LANL representative from the Bioscience Division who indicated that this division will grow at a considerably faster rate than other divisions over the next few years. In addition, this division currently employs over 50 persons at the technician level. Their demand for this occupation is expected to increase due to the growth of the division and through retirement of current personnel. Technicians typically posses either a Bachelor degree or an Associate degree. The representative indicated a high level of enthusiasm for the prospect of a biotechnologies program at TVI.

4.4 Biotechnologies Occupations

From the perspective of a worker (or future worker), an industry describes the economic activity conducted by his or her employer. An occupation, on the other hand, describes the nature of the work the person performs in the workplace. For some industries, occupations and industries are tightly tied together. According to the BLS:

> *An occupation is a set of activities or tasks that employees are paid to perform. Employees that perform essentially the same tasks are in the same occupation, whether or not they are in the same industry. Some occupations are concentrated in a few particular industries, other occupations are found in the majority of industries.*

Occupations are first classified by occupational groups. Among the nine major groups, technicians and related support occupations are of primary concern for this analysis, although it is recognized that graduates of a biotechnology program may be employed in a production or similar occupation not classified as “technical”. Occupations classified in these major group include health technicians and technologists, engineering technicians, science technicians and others ranging from air traffic controllers to library technicians. Among these, science technicians are most applicable here.

Another major group of interest are professional specialty occupations. These include occupations ranging from engineers and scientists to lawyers and teachers. Of interest here are scientists, in particular life scientists, which include agricultural and food scientists, biological

scientists, conservation scientists and foresters, medical scientists, and other life scientists. Since science technicians generally work with scientists in a particular field, an understanding of data relating to science should also be beneficial to the current assessment.

The term "biotechnology technician" did not exist at the time of the 1980 system nor does it exist as an explicit occupation in the newer 1998 system. However, certain BLS databases and products do make reference to biotechnology. From an on-line search of the BLS website, the occupations most related to biotechnology include: life science technician, biological and medical scientist; agricultural food scientist; and chemist.

4.4.1 National Occupational Trends

The most recent occupational projection series available from the BLS and the New Mexico Department of Labor is for the period 1998-2008. The U.S. economy is expected to add 20.3 million jobs, an increase in employment of just over 14 percent during the period. In the 1988 to 1998 period, the economy grew by 17 percent and added 20.5 million new jobs.

Table 4 presents current, historical and projected employment trends for the nine major occupational categories. Since occupational groups are of different sizes, it is important to analyze a variety of indicators to better understand past and future growth trends. In general, occupational groups which grew at a slower rate over the 1988-1998 period will continue to grow at a slower rate over the 1998 to 2008 period. These major groups include administrative support, agricultural, precision production and operators.

Table 4

Employment by Major Occupational Group: United States 1998 (estimate) and 2008 (projection)

	Percent Distribution			1998 to 2008 Projected Change		
Occupational Group	**1988**	**1998**	**2008**	**Number (000s)**	**Percent**	**Percent of New Jobs**
Total	**100.0**	**100.0**	**100.0**	**20,281**	**14.4**	**100.0**
Executive, administrative, managerial	10.3	10.5	10.7	2,426	16.4	12.0
Professional specialty	12.5	14.1	15.6	5,343	27.0	26.3
Technicians and related support	3.2	3.5	3.8	1,098	22.2	5.4
Marketing and sales	10.3	10.9	11.0	2,287	14.9	11.3
Administrative support	18.5	17.4	16.6	2,198	9.0	10.8
Service	15.5	16.0	16.4	3,853	17.1	19.0
Ag., forestry and related	3.5	3.2	2.8	71	1.6	0.4
Precision production, craft, repair	11.9	11.1	10.5	1,252	8.0	6.2
Operators, fabricators and laborers	14.2	13.2	12.7	1,753	9.4	8.6

Source: U.S. Bureau of Labor Statistics, 2000.

The two fastest growing major groups are professional specialty and technicians and related support. Professional specialty occupations are expected to grow by 27 percent, nearly twice the national rate and capture more than one quarter of all new jobs. Technician occupations are projected to grow by 22 percent. However, since the size of this group is small, technician occupations will account for just over 5 percent of new jobs created in the 1998 to 2008 period.

Notably service, administrative support and similar occupations requiring relatively low levels of education will continue account for the largest portion of new jobs despite growth rates that are lower than the national average.

In 1998, there were approximately 173,000 life scientists in the United States, accounting for less than 1 percent of all professional specialty occupations. Collectively, these occupations are projected to grow at a rate slightly lower than other professional specialties but still nearly twice the national average for all occupations. Driving this growth are biological scientists which will account for nearly 61% percent of all new scientist jobs created.

Table 5

Estimated and Projected Growth for Life Scientists: United States 1998 and 2008

	Employment (000s)		Percent Distribution		Percent of New Life Scientist Jobs
Occupation	**1998**	**2008**	**1998**	**2008**	
All Life Scientists	173.0	219.0	100.0	100.0	100.0
Agricultural and food	21.0	24.0	12.1	11.0	6.5
Biological	81.0	109.0	46.8	49.8	60.9
Conservation (foresters)	39.0	46.0	22.5	21.0	15.2
Medical	31.0	39.0	17.9	17.8	17.4
All other	1.0	1.0	0.6	0.5	0.0

U.S. Bureau of Labor Statistics.

There were approximately 227,000 science technicians in the U.S. in 1998, accounting for just under 5 percent of all technical and related support employment. The projected employment for this group in 2008 is 243,000 reflecting a growth rate that is much smaller than for both technical occupations and all occupations. This rate reflects projected growth for all science technicians and may not be indicative of growth for particular specialty areas such as biotechnology.

Science technicians are typically defined in accordance with the scientist they support. They include the occupational title most associated with the current needs assessment is the biological technician:

- Biological technicians: Work with biologist studying living organisms and may be involved in medical or pharmaceutical research. These technicians generally work as lab assistants and may analyze blood, food or drugs. Some biological technicians examine evidence for crime laboratories. Those working in biotechnology apply gene splicing and other techniques to assist other scientist in product development;

Most data using the 1980 SOC system group biological technicians along with agricultural and food technicians and technologists, other occupations that are likely impacted by advances in biotechnology:

- Agricultural technicians: work with agricultural scientist in food, fiber and animal research and production. May conduct tests to improve the quantity and quality of crops and livestock. May also work directly in animal breeding and in the field of nutrition.

Other science technicians include:

- Chemical technicians: work with chemists and chemical engineers to develop new chemicals and chemical products. Some monitor air and water pollution. Other may operate equipment or monitor processes that occur within chemical or other plants.

- Environment technicians: perform laboratory and field tests to monitor environmental resources and sources of pollution. May be responsible for a variety of waste management operations.

- Nuclear technicians: operate nuclear testing and research equipment, monitor radiation and may assist nuclear scientists and physicists in research.

- Petroleum technicians: measure and record conditions in oil and gas wells.

Table 6

Science Technicans by Type: United States 1998

Type of Technician:	Number (000s)	Percent of Total
All science technicians (non-health)	228.0	100.0
Biological, agricultural, and food	40.5	17.8
Chemical	76.2	33.4
Nuclear	3.6	1.6
Petroleum	8.0	3.5
All Other	99.7	43.7

Source: U.S. Bureau of Labor Statistics.

There were an estimated 40,500 biological and agricultural technicians in the U.S. in 1998, accounting for just under 18 percent of all science technicians. Nearly one third of all science technicians nationally were chemical technicians. A large proportion (44%) of science technicians were categorized as "all other" and include a diverse group including laser technicians, biomedical equipment technicians, pollution control technicians and a variety of laboratory assistants. Although most of these occupations come from the physical sciences, biomedical technicians and other occupations may be relevant to the current analysis.

According to the BLS Occupational Outlook Handbook the educational requirement s for science technicians range from a one-year certificate program to a bachelor's degree. However, the *Education Level Report* of the BLS indicates that the typical educational training for a science technician is an associates degree. (Note this does not generally correspond to the education requirements specified by local employers). Occupations requiring an Associate degree are

expected to grow by 31 percent in the 1998-2008 period, more than twice the rate for all occupations (14%).

Notably, among the 19 occupations identified as requiring an Associate degree, science technicians had the lowest projected growth rate at 7%. Other slow-growing occupations with similar educational requirements include law clerks and nuclear medicine technologists, both projected to grow by only 12%. Occupations with the highest projected growth rate include: computer support specialists (102%); paralegals (62%); medical records technicians (44%) and physical therapy assistants (43%).

Despite the low growth rate, the BLS Occupational Outlook handbook indicates that the growth of scientific research and technology should stimulate growth for science technicians in all areas. The BLS further states:

> "In particular, the growing number of agricultural and medicinal products developed using biotechnology techniques will increase the need for biological technicians."

The *Educational Level Report* also indicated that despite low levels of projected growth, science technician had a low probability of being unemployed and working less than full-time.

4.4.2 New Mexico Occupational Trends

According to the New Mexico Department of Labor, the New Mexico economy is expected to produce approximately 185,000 new jobs between during the 1998 to 2008 period. This reflects a growth rate of 23 percent considerably higher than the national rate of 14 percent

Many relevant occupation trends for New Mexico reflect national trends. Fueled by technological innovation, jobs in professional, paraprofessional and technical occupations will grow at a faster rate than total jobs statewide. The demand for highly educated workers is reflected the high growth rate for these occupational groups. Despite this high growth rate, a large proportion of job openings will be for less skilled occupations including service, administrative support, production and constructions, and operator and laborers.

Key occupations and occupational groups are presented in Table 7, on the following page. Employment for life scientists is projected to grow by 19 percent, considerably lower than the rate for all professional occupations and slightly lower than the rate for all occupations. Employment growth for biological scientists, however, will be the highest among all scientists reflective of innovations in that field and changes in other aspects of the economy.

Reflecting the trend at the national level, growth rates for science technicians will generally be lower than the rates for scientists in corresponding fields. Among science technicians, biological and agricultural technicians are expected to have the highest demand. Nonetheless, the percentage and numerical growth for biological technicians remains low relative to other occupations in general.

Table 7

Selected Biotechnology Related Occupational Employment Levels: New Mexico 1998 and 2008

	Employment		Employment Change		
Occupation	**1998**	**2008**	**Number**	**Change**	**Total Openings**
All Occupations	**797,680**	**982,480**	**184,800**	**23**	**37,580**
Professional, paraprofessional, technical	186,650	237,120	50,470	27	8,650
Life scientists	1,290	1,540	250	19	*
Biological scientists	390	520	130	33	20
Physical & life science technicians	1,640	1,850	210	13	*
Biological & agricultural	370	430	60	16	10
Chemical	260	290	30	12	10
Petroleum	90	90	0	0	*
Technicians NEC	910	1,040	130	14	30

Source: New Mexico Department of Labor.

According to the projection series, there will be approximately 10 openings each year statewide for biological and agricultural technicians. This number should be looked at cautiously when evaluating the need for biotechnology education trainings for several reasons:

- Sampling and other sources of error is inherent in Occupational Employment Survey. In general, sampling error is compounded for any variable with a relatively small occurrence. The detailed occupation, biological technician, in a relatively small state like New Mexico would be associated with considerable error.

- Although extensive efforts are made to include representation from large employers, small employers are often not captured in the survey. Since the New Mexico biotechnology industry has many small employers (and non-employers), it is possible that additional technician occupations are missed by the survey.

- Many technicians of interest may be classified under technicians "not elsewhere classified."

- The occupational projections produced by the New Mexico Department of Labor are closely tied to national staffing patterns and historical trends and therefore may miss certain elements unique to New Mexico.

- Occupational forecasts, like all forecasts, are based primarily on historical trends and cannot generally predict discrete events such as the successful recruitment of a large biotech firm. The mere creation of a biotech training program may increase the likelihood of landing a new employer of biological technicians.

Despite these cautionary notes, the number of projected openings presented here reflects the best projection available at the present.

5 RESEARCH FINDINGS FROM INTERVIEWS

To augment the findings from the published data, we conducted several sets of telephone interviews. Three groups were targeted: biotechnology firms in New Mexico, biotechnology industry insiders in New Mexico, and biotechnology industry insiders in other locations around the country. We have summarized the results from these interviews.

5.1 Biotechnology Firms in New Mexico

In order to get a better feel of what was out there, we conducted a survey of biotechnology firms in the Albuquerque and Santa Fe areas. A total of forty firms were included, twenty-three of which we contacted directly, and the remaining seventeen we gathered information about from published reports and web sites. Most of the firms we selected were listed in the directory of the *New Mexico Biotechnology & Biomedical Association*.

The primary activity of the surveyed firms broke down as follows (includes some overlap): manufacturing (14, 35.0%), research and development (19, 47.5%), bioinformatics (5, 12.5%), diagnostics (3, 7.5%), manufacturing/research and development (1, 2.5%), sales (1, 2.5%), manufacturing/research and development/sales (1, 2.5%).

The manufacturing firms produced primarily instruments and supplies. The types of instruments included surgical cameras, optical imaging microscopes, indoor air quality detection and purification devices, and various kinds of high-energy and analytical products. Supplies included contact lenses, tracheostomy supplies, medical hoods and gowns, medical isotopes, and laser protective eyewear.

Most of the firms engaged in research and development did not have another business activity (manufacturing or sales). Much of the research was in medical equipment, including drug delivery systems, non-invasive glucose monitors and blood sampling systems, HIV and cancer detectors, lasers and electro-optical systems, and cardiovascular devices. Other research activities included optical and spectral imaging, and medications.

The bioinformatics firms were concentrated in software development for chemical, biological and pharmaceutical discovery, and data mining and analysis. The diagnostics firms were primarily clinical laboratories.

The firms indicated mixed success in hiring locally. Some were unable to locate anyone, while others were very successful. They found a plentiful supply of computer personnel, but a shortage of optical and engineering talent, and of technicians. A majority of the firms were mostly interested in hiring at the bachelors degree level and higher, and some wanted only to hire at the masters and doctorate levels. When asked if they would hire graduates of a 2-year program in biotechnologies, only five of twenty two firms responded in the affirmative. A few others conceded that they might, but it would really depend on the specific skills the graduates had.

A list of the firms interviewed is contained in Appendix B, while Appendix C is an interview guide including a compendium of the question-by-question responses to the survey.

5.2 New Mexico Biotechnology Insiders

In order to obtain a fairly comprehensive perspective concerning the state of the biotechnologies industry in Albuquerque and New Mexico, we conducted telephone interviews with some people from the industry or from the high-technology community in general who we thought would possess an "insiders view" in some respects. Each interview lasted 20-30 minutes. We told each interviewee up front that what we were interested in was an assessment of "the biotechnology industry/cluster in Albuquerque and New Mexico, what they thought the term 'biotechnology' encompassed, where it was now, where they thought it might be heading, what factors were holding it back, and what sorts of things were necessary to move it forward toward a larger or deeper presence in New Mexico."

One major point of agreement among the interviewees was that the biotechnology industry in New Mexico was "fledgling", that is, very much in its infancy, although some thought early in the infancy stage, still crawling, while others were convinced that it was close to the walking stage. Because the industry is fledgling, research & development firms constitute a higher-than-average proportion, and therefore have less need for biotechnology technicians.

As to what constitutes the industry, the responses ran from the very narrow to the very broad. At the narrow end, the "core" industry consists of "wealth-creating" firms only. That is, firms who have a product (not a service) to sell, predominately sell outside of New Mexico and therefore bring new money into the state, and are not dependent upon government money. Under the narrow definition, there would be about 10 firms in New Mexico who qualify. At the other end of the spectrum, the industry was thought to consist of all firms with any connection to medicine in any way, including research and development, bioinformatics, device manufacturing, clinical testing and diagnostics, medical care, and hospitals. The middle-of-the-road position included research and development, bioinformatics, device manufacturing, and clinical testing and diagnostics. Among the middle-of-the-roaders, the general consensus was that there are about 100 biotechnology firms in the state.

Most stated that there was a geographical split among the firms, with bioinformatics and genome research firms concentrated in Santa Fe, while non-genome research and development and medical device manufacturers are mostly in Albuquerque. No one mentioned any other location within the state.

All agreed that there is a shortage of communication among firms in the industry, although it seems that the New Mexico Biotechnology & Biomedical Association has done a good job in addressing this deficiency. Still, there is a whole lot more which needs to be done. Particularly, there is a need for people who know the business world, know how to create a business plan, and know the steps necessary to develop a product and bring it to market. Such folks also need to find a way to get the researchers to listen to them. There was a perception that many small biotech firms, particularly engaged in research and development, are not cognizant of the business aspects of a startup.

There are also deficiencies in obtaining government support. There is no clear agenda for legislative lobbying. There are not enough incentives for the small firm. More tax breaks and tax credits are needed. A couple were of the opinion that the existing tax structure is oppressive, particularly the gross receipts tax and the high-income personal income tax. And there is a clear lack of "enabling" efforts from government. Indeed, it seems at times that the government does not take seriously its role in bringing folks together, of "clearing the way." Indeed, the perception is that the government folks really don't care at all if things progress. There were several anecdotes as illustrations of this. In an informal survey conducted by the New Mexico Biotechnology & Biomedical Association, respondents identified three major areas of concern: capital, training, and the gross receipts tax. Also mentioned was the tax credit issue for research and development. Some felt that the legislature is not responsive to industry needs because industry proposals are geared to development in the state's urban areas, with little or no provision for the rural economy, which does not sit well with the rural legislators. When pressed further, they admitted that there was little if any likelihood that biotechnology firms have any motivation to locate in rural areas. There was also perceived to be a lack of "bandwidth" in the rural economy. On the venture capital issue, they believe that the state must work more closely with venture capital firms, particularly to give venture capital firms a "better deal."

There is a lack of leadership within the industry, a lack of individuals both interested and qualified to create agendas and carry them forward. Most felt various levels of frustration at trying to get people and institutions to coordinate. One institution all were familiar with is the Next Generation Economy Initiative (NGEI). They generally had a good impression of NGEI, but thought that it was just now becoming effective. They also noted that NGEI is more oriented towards other sectors (electronic manufacturing, MEMS, lasers and optics) with little left over for biotech.

A list of those persons and agencies in New Mexico that interviewed is provided in Appendix D.

5.3 Biotechnology Insiders in Other Locations

The following sections summarize information gathered through interviews with representative of biotechnology organizations, economic developers and other persons familiar with each area's biotechnology industry. A list of those persons and agencies interviewed is provided in Appendix E.

Arizona

There are an estimated 10,000 workers in the Arizona biotechnology industry. Both major universities (Arizona State University in Tempe and the University of Arizona in Tucson) have pushed biotechnology research and technology transfer. Biotechnology firms have located near the universities for this reason.

The state has not really provided any incentives to the biotechnology industry. A recent venture capital initiative was brought before the state legislature, but it failed. The legislature did approve funding for biotechnology research in the universities and for workforce development in

the community colleges, but is too early to tell what affect this will have. A need exists for a medical school in the Phoenix area to support clinical trials.

Colorado

The biotechnology industry in Colorado is in the early development stage, and the push to develop it is primarily the result of the efforts of Dr. Marv Crothers of Amgen. The state has not really provided any incentives. The educational system is just beginning to develop programs in biotechnology and to define a role for itself. Aurora Community College has a research laboratory assistant program in genomics, and Metro Community College has planned a bioinformatics program. There is little coordination at present among the state, the industry, and the universities.

Utah

Utah has an estimated 11,000 employees at 120 biotechnology firms. They have not tracked growth, but it appears that there have been a number of small start-ups recently. The majority of biotechnology firms are medical device manufacturers. Future growth in genetics and cancer research is anticipated, stimulated by the provision of data for research from the Family History Library of the Mormon Church and donations from a local philanthropist. The most recent legislative session passed a workforce initiative to increase engineering graduates and provide funding for workforce training in the community colleges.

Austin, Texas

Texas has seen the biotechnology industry grow from 38,000 jobs to 51,000 jobs in the last three years, with annual salaries increasing from $40,000 to $48,000. Statewide, the industry breakdown is 54 percent in laboratory services, 34 percent in medical devices and 12 percent in pharmaceuticals. The state of Texas provides $45 million in product development funds. The Texas Health and Bioscience Institute I provided over $1 billion in venture capital possibilities/information last year to biotechnology industry. Community colleges are critical to workforce development in Texas. They work directly with industry to provide on-the-job-training and special courses to meet immediate needs. The perception is that Texas is tuned in to the needs of biotech industry and emerging clusters.

Austin had about 70 biotechnology firms employing 4,500 in mid-2000, with 40 percent engaged primarily in research and development, 30 percent in manufacturing, and the remainder in pharmaceuticals. The biotechnology sector has its roots in the Austin branch of the University of Texas, which generated many small start-ups. Further impetus came from the City of Austin, which provided infrastructure to support development, although it does not offer any special incentives to biotechnology firms. The Chamber of Commerce also made the development of the biotechnology cluster a priority. Venture capital has been readily available.

Austin Community College has a strong biotechnology program and has worked closely with industry to develop the workforce. The city is a recent recipient of a grant from the National Health Service to initiate the teaching of biotechnology subjects in the local high schools. Austin

appears to be positioning itself to link computer/information technology with biotechnology and develop into bioinformatics, nanotechnologies, biomedical applications, and pharmaceuticals.

San Diego, California

San Diego has one of the largest biotechnology clusters in the world, with more than 1,300 firms and 20,000 employees. The city's biotechnology activities are concentrated in research and development of medical devices and diagnostics (55%) and pharmaceuticals (40%). The initial push for the industry came from the University of California at San Diego, aided by an ample supply of entrepreneurial types. Later development came from spin-offs of local industry. The community has been heavily involved in biotechnology development. San Diego is the biotechnology center of southern California, and is developing a manufacturing technician training center to supply all of that region. Two local community colleges provide technicians for local industry, although it is believed that technicians comprise only 7 percent of the biotechnology workforce.

An interesting sidebar from one of the San Diego respondents is a perspective on the national biotechnology industry. The respondent believes that there are currently only four or five mature clusters in the country (San Diego, the Bay Area, Boston, and the North Carolina Research Triangle among them), with about 15 intermediate-level clusters and 50 wannabees. In his estimation, the U.S. has room for only about 12 or 13 mature clusters, so the race is on.

6 SUMMARY AND CONCLUSIONS

This section combines the findings presented in the previous sections of this report. First, an analysis of the biotechnologies sector as a whole is presented. Subsections follow this section on New Mexico businesses in manufacturing, research and development and bioinformatics. These subsections will identify the unique characteristics of New Mexico businesses in these each of these activities and explore potential implications they have for the future of the biotechnologies sector in New Mexico. The final portion of this section explores some of the factors that are important to the health of the state's lifesciences industries.

New Mexico's biotechnology industry is composed of a diverse group of businesses and activities. These activities range from research and development and bioinformatics to the warehousing and distribution of medical devices. While somewhat resembling the array found at the national level, the relatively small number of biotechnologies businesses in New Mexico means that while a variety of biotechnology activities are present in the state, their presence is thin and in some cases amounts to only one business having no employees. Biotechnologies related activities are found in a number of industrial sectors, including manufacturing, professional, scientific and technical services, health care, agriculture, as well as retail and wholesale trade.

New Mexico's biotechnologies industry appears to be on the cusp of potential change. The factors that will help determine if New Mexico biotechnologies will evolve to a larger and more diversified industry are varied and difficult to predict. They include the availability of venture

capital, national policy decisions, local development initiatives and New Mexico quality of life issues. The state's biotechnologies industry is characterized by a relatively active research and development emphasis. Many of the businesses in this industry are spin-offs from LANL or Sandia. Also present in New Mexico are a few manufacturers producing medical equipment and supplies and related products and pharmaceuticals. This handful of manufacturers constitutes a large portion of the employment in the biotechnologies industry. The portion of this continuum that appears to be lacking is the mid-size establishment that develops and applies the products of the research and development efforts.

6.1 Research and Development

The research and development activities of New Mexico biotechnologies businesses range from imaging technology for research microscopes to medication for rheumatoid arthritis. Many of these companies were started either directly or indirectly by employees and ex-employees of LANL or Sandia. The proximity of the labs, the ability to hire or consult with lab employees and the direct involvement of the labs is a key factor in biotechnologies research and development activities. Additionally, collaboration with the University of New Mexico and the University of New Mexico School of Medicine are important factors in the growth of the industry, offering research and development organizations services such as clinical testing of products.

Establishments dedicated to research and development – as opposed to manufacturers that engage in research and development activities - are generally small and in a number of cases had no employees. Additionally, most of the current employees are highly educated and hold advanced degrees. One company conducting research and development on a pharmaceutical stated that after approval they expected to sell the rights to their drug and not manufacture or market it themselves, and then continue on with further research. While this would certainly qualify as success and would contribute to state's biotechnologies industry, employment in the industry would be impacted only slightly.

Interviews with these establishments generally saw little potential for hiring employees, and, in their current state, these activities indicated few immediate plans for expansion. Interviews indicated that these businesses anticipate growth, but this growth would not necessarily translate into a large increased employment, but rather products on the market or revenues. A reason for this is that when a product goes to market it often leaves the research and development location, and the manufacturing and distribution is contracted out to a large company, or the rights to the product are sold.

One key player in local biotechnology research and development is the Lovelace Respiratory Research Institute (LRRI). This institute is a private not-for-profit corporation that specializes in research relating to asthma, emphysema, inhalation drug delivery and other areas of respiratory health. The LRRI was founded in 1947 and currently employs 40 Ph.D. level scientists and 220 technicians and support staff. Their annual budget is $20 million and is derived from grants, contracts and donations of which 100% are used to fund respiratory research. Numerous attempts to interview key personnel were unsuccessful. Nonetheless, the LRRI is an important player in the further development of a local biotechnologies technician program.

6.2 Manufacturing

In 1999 there were approximately 70 establishments that employed close to 1,800 employees in manufacturing activities related to the biotechnologies. The activities of these manufacturers include the production of medical devices and optical tools such as research microscopes and cameras, as well as manufacturers of gowns and booties to be worn in laboratories. Also, a number of manufacturers indicated that their products have biotechnologies applications, though at the time of the interview they had no clients that were in biotechnology.

Interviews with manufacturers indicate that while these businesses are in the biotechnologies sector, the occupations in these businesses are not necessarily skilled. At least two large manufacturers said they had no need for employees with an associates level education, instead stating a need for employees with a high school education.

6.3 Bioinformatics

Bioinformatics is a small but highly visible portion of New Mexico's biotechnologies sector, and are for the most part located in Santa Fe. Interviews conducted with bioinformatics businesses show that they are mostly staffed with a few highly skilled persons, usually with advanced degrees. Bioinformatics appears to hold little potential for employing a significant number of persons at the associates degree level. That being said, computer occupations are projected to be among the fastest growing occupations, and some interviews emphasized the need for employees with basic and sometimes advanced computer skills. This is in part due to the increasingly computerized and automated biotechnologies work places.

6.4 New Mexico Economic Development Efforts

The relationship between the growth of the sector and the presence of a focused educational program is a "chicken-or-the-egg" scenario. Representatives of both the City of Albuquerque and the State of New Mexico emphasized the importance of an educational program that offers an existing, trained workforce, employee training opportunities, internships, and collaborative efforts. This position is supported by existing literature. The desire to provide these conditions must be balanced by the desire to provide a curriculum that addresses local employment needs and will enhance an individual's employment opportunities.

State and local economic development activities will potentially impact many of the local attributes that are important for the growth in the biotechnologies sector, which include human capital capacity, low business costs and venture capital[1]. These activities take place at a number of levels and some general observations can be made.

Many of the economic development efforts in Albuquerque in recent history have been focused on "back office operations" and industrial recruitment, and did not have much in the way of biotechnology and biomedical initiatives, though these opportunities are viewed as important to pursue. Some of the local attributes the department identified as valuable to a biotechnologies

[1] Devol, Ross. Blueprint for a High-Tech Cluster: The Case of the Microsystems Industry in the Southwest, August 2000.

business include quality of life issues, the presence of TVI and UNM and the willingness of these institutions to work with local employers, in-plant training funds, and the City's workforce. Additionally, the presence of the labs and other technology oriented industry in the area contributes to the advantage the area offers to some biotechnologies firms, such as those in bioinformatics.

The State of New Mexico offers assistance with business relocation and expansion. At the state level, there is an impression that the state is approaching the critical mass of biotech and biomedical activities and that it is now the time to expand and build upon the existing base. This base is composed of local start-ups in high-level research and development and bioinformation, which are generally small, exclusive businesses that may not significantly impact employment in the state. Biotechnologies businesses are viewed as beneficial to the state because they offer good paying jobs and are environmentally friendly. There are a number of potential programs that can be used by the state to help recruit these businesses, including technology jobs tax credits, gross receipts exemptions and a research and development tax reduction, job mentorship programs, existing networks in biomedics, engineering, optics and increased access to venture capital.

Now, instead of focusing on "back office operations" and industrial recruitment, the Next Generation Economy Initiative (NextGen) is focusing on "cluster development". Clusters are geographic concentrations of industries and the public and private institutions that support them, such as universities, national laboratories, financial institutions, workforce development programs, and government. NextGen seeks to maximize cluster growth by identifying and analyzing the specific needs of the firms in the cluster, identify the issues affecting the cluster, and design efforts to address those needs. Additionally, NextGen's approach includes involving stakeholders from education, industry and government and fostering synergy between the firms in the cluster.

Santa Fe Economic Development, Inc. (SFEDI), has a number of activities in place to support the clusters that have "naturally developed in the region," including a biotechnology cluster. Designed to assist in the start-up and the expansion of existing businesses, SFEDI believes that this cluster will add to Santa Fe's economic diversity, inject dollars into the local economy, provide quality jobs and respect Santa Fe's special character. In their efforts to promote the biotechnology cluster, SFEDI has assisted in the creation of the local chapter of the New Mexico Biotechnology and Biomedical Association; works with Los Alamos National Laboratories, the Santa Fe Institute, and the National Center for Genome Resources to identify spin-off companies for the cluster; participates in and provides a forum for biotechnology companies; have marketed Santa Fe as an attractive location for biotechnology companies; and have explored workforce, venture capital, and employee recruitment issues.

Technology Ventures Corporation (TVC) also has economic development activities in place that may impact the future of the biotechnologies sector. TVC, self defined as "a bridge between the public and private sectors for the commercialization of technologies developed at the Department of Energy's national laboratories and regional research universities" is involved in both recruitment and the business start-up. Offering services to both investors and client companies, existing TVC efforts that apply to biotechnologies industries include advising and assisting

entrepreneurs in preparing business cases to commercialize technology, has assisted bringing investors to New Mexico, hosts monthly forums of small technology company executives, and has formed a corporation to manage and develop Sandia Science and Technology Park.

6.5 The Future of the New Mexico Biotechnologies Industry

The New Mexico biotechnology industry is still in its infancy. According to at least one industry expert, there are no less then 50 other locations in the United States in a similar situation. The same expert suggests that not all of the fifty can grow into a mature industry, because there is not room in the national economy for them. In addition to the 50, there are at least 20 more which are currently in more advanced states of development.

If the New Mexico industry is to blossom, it will require some shepherding. The competition among states and cities to attract biotechnology businesses is very intense. New Mexico has some unique resources, such as the national labs and the attractive quality of life, which it must learn to exploit in its development efforts. Economic development initiatives at both the state and local levels are also important. Public/private partnerships, private/private partnerships, and industry leadership cannot be over emphasized. New Mexico must also seek out and attract entrepreneurial and leadership talent. Not to say that such does not exist here, but not enough does exist here. Finally, venture capital must be readily accessible.

Nationally, employment in the biotechnology industry is expected to increase 19.3 percent between 1998 and 2008, although this growth rate depends upon a different definition of the industry than used earlier in this report. This particular definition consists of four SIC three digit codes: 382, measuring and controlling devices manufacturing; 384, medical equipment, instruments and supplies manufacturing; 283, drug manufacturing; and 873, research and testing services. Not exactly an accurate description of the industry, but an operational one.

Will New Mexico biotechnology grow as the national industry grows? Perhaps, perhaps not, but whatever comes to pass, it will be a reflection of our ability and our actions to make it happen. A proactive stance is absolutely necessary..

Appendix A: NAICS Industries in Biotechnology

Definitions of NAICS Industries in the Biotechnology Industry

The biotechnologies industry is primarily composed of two NAICS sectors, manufacturing and professional, scientific and technical services. Again, this narrow definition of the biotechnologies industry limits the representation of non-biotechnologies employment, though some non-lifesciences establishments are undoubtedly represented. While the composition of the lifesciences industry used in this analysis is similar to the one used in the industry trend analysis, they are not directly comparable.

The manufacturing activities in the biotechnologies sector involve the manufacturing of pharmaceuticals and medicine, analytical laboratory instruments, and medical equipment and supplies. Each of these activities is represented in manufacturing as individual NAICS industry groups (the four digit NAICS level) and industries (the more defined five digit NAICS level). The manufacturing sector (NAICS 31-33) is broken down into the chemical manufacturing subsector (325), which is then broken down into the pharmaceutical and medicine manufacturing industry group and industry (32541 and 325411). This analysis includes the pharmaceutical and medical manufacturing industry group as part of the biotechnologies industry.

The pharmaceutical and medical manufacturing industry group is defined as:

> Establishments primarily engaged in one or more of the following: (1) manufacturing biological and medicinal products; (2) processing (i.e., grading, grinding and milling) botanical drugs and herbs; (3) isolating active medicinal principals from botanical drugs and herbs and (4) manufacturing pharmaceutical products intended for internal and external consumption in such forms as ampoules, tablets, capsules, vials, ointments, powders, solutions and suspensions.[2]

Manufacturing is also broken down into computer and electronic product manufacturing (NAICS 334), which is broken down into navigational, measuring, electromedical and control instrument manufacturing (NAICS 33451), which is once again broken down into electromedical and electrotherapeutic apparatus manufacturing (NAICS 334510) and analytical laboratory instrument manufacturing (NAICS 334516) and five other national industries (the NAICS six digit level). This analysis includes electromedical apparatus manufacturing and analytical laboratory instrument manufacturing national industries as part of the biotechnologies industry.

The electromedical and electrotherapeutic apparatus manufacturing national industry is defined as:

> Establishments primarily engaged in manufacturing electromedical and electrotherapeutic apparatus, such as magnetic resonance imaging equipment, medical ultrasound equipment, pacemakers, hearing aids, electrocardiographs, and electromedical endoscopic equipment.

The analytical laboratory instrument manufacturing national industry is defined as:

[2] NAICS Manual, U.S. Office of Management and Budget, 1997.

> Establishments primarily engaged in manufacturing instruments and instrumentation systems for laboratory analysis of the chemical or physical composition or concentration of samples of solid, fluid, gaseous, or composite materials.

The manufacturing sector also contains a miscellaneous manufacturing subsector that contains a medical equipment and supplies manufacturing industry group (NAICS 3391). This analysis includes the medical equipment and supplies manufacturing industry group.

The medical equipment and supplies manufacturing industry group is defined as:

> Establishments primarily engaged in manufacturing medical equipment and supplies. Examples of products made by these establishments are laboratory apparatus and furniture, surgical and medicinal instruments, surgical appliances and supplies, dental equipment and supplies, orthodontic goods, dentures, and orthodontic appliances.

The NAICS professional, scientific and technical services sector contains NAICS industry 54171, research and development in the physical, engineering and biotechnologies. This analysis uses the research and development in the physical, engineering and biotechnologies industry to represent the research and development activities of the biotechnologies industry.

The research and development in the physical, engineering and biotechnology industry is defined as:

> Establishments primarily engaged in conducting research and experimental development in the physical, engineering, or biotechnologies, such as agriculture, electronics, environmental, biology, botany, biotechnology, computers, chemistry, food, fisheries, forests, geology, health, mathematics, medicine, oceanography, pharmacy, physics, veterinary, and other allied subjects.

Appendix B: Businesses Interviewed

Biotechnology Companies	Description
Advanced Industrial Chemistry	Custom analytical chemistry instruments & analytical support.
Aerospace Consulting Corporation	High technology battlefield non-intrusive virus identification.
Applied Biosytems	Provider of software solutions for pharmaceutical discovery and development.
Bi Ra Systems	Manufacturer of high energy instruments with some biomedical applications.
Bio-Laboratories	Contract research organization that focuses on food safety and animal health.
Biomoda	R&D in cancer diagnostics.
Bioreason	Automated reasoning systems for drug discovery.
Biotech Imaging	R&D in HIV detection.
Cardinal Associates	Medical diagnostic products.
Cell Robotics Inc.	R&D in medical devices.
Chromex Inc.	R&D in Raman and imaging spectroscopy with bioapplications.
CIC Phontonics	Analytical and industrial instrumentation with pharmaceutical and specialty chemical applications.
CPR Medical Devices	R&D for cardiovascular devices.
Cytoprint	Bioinformatics, data mining and computational intelligence technology.
CVI Lasers Corporation	Optical instruments, analytical instrumentation.
Daylight Chemical Information Systems	Chemical information management systems including applications for drug discovery.
Decade Optical Systems	R&D of lasers and electro-optical systems.
Deputy Orthopedics	Manufacture hoods and gowns for orthopedic industry.
DNA Mining Informatics Software	Bioinformatics and data mining.
Ethicon Endo-Surgery (Division of Johnson & Johnson)	Endoscopic medical device manufacturer.
General Technology Corporation	Contract and electronic manufacturer.
Genzyme Genetics	Cytogenic testing laboratory.
Glaxo Smithkline Laboratories	Pharmaceutical consulting.
ITS Corporation	Consulting in the areas of health and safety and information technology.
Kestrel Corp.	Research in spectral imaging.
Lase-r-Shield	Manufactures and distributes laser protective eyewear.

Biotechnology Companies	Description
Los Alamos National Laboratory	National research laboratory.
Marpac	Medical device manufacturer.
Mesosystems	Manufactures and services indoor air quality detection and purification devices.
New Mexico Resonance	Application and development of nuclear magnetic resonances for flow applications.
Nova Homeopathic Therapeutics	Homeopathic remedies.
Occular Sciences Inc. (Sunsoft)	Contact lens manufacturer.
Olympus America	Manufacturer of optical products, including surgical cameras and handheld instruments.
Optical Insights	Optics research in instrumentation, including biomedical applications.
Protalex	R & D for rheumatoid arthritis medication.
Quest Diagnostics	Clinical laboratory services.
Rio Grande Medical Technologies	R&D in non-invasive glucose monitoring.
Seraf Theraputics	Drug delivery device R&D.
TECMED	Non-invasive glucose monitors using polar imagery, R&D.
Tech Commercialization International	R&D, including breast cancer detection.

Appendix C: Interview Responses

The questions used in the survey instrument are listed below. Following each question, the (slightly edited) responses are shown. The activities of the businesses have been categorized into primary categories by the interviewee.

SURVEY QUESTIONS/RESPONSES

1. Can you give me a quick idea of what your business does? (How the business fits into the biotechnologies industry? manufacturing, research, informatics) Who is your market?

Manufacturing

- Manufacturer of high energy instruments for federal labs with some biomedical applications. Do work and sell materials to bio-med, mainly RD.
- Analytical and industrial instrumentation with pharmaceutical and specialty Chemical applications. (No biotech clients or applications yet!)

- Manufacturer of hoods and gowns for orthopedic and tourniquets.
- Contact lens manufacturer
- Manufacturer of indoor air quality detection and purification devices.
- Manufacturer of medical devices and tracheostomy supplies
- Manufacturer and distributor of laser protective eyewear.
- Manufacturer of optical products, including surgical cameras handheld instruments etc., Albuquerque plant closed in 95, rumored to return, currently only one person in state.
- optical imagining tech for research microscopes and drug discovery (microscopes to study the skin)

R & D, bioinformatic, and diagnostic

- Research, design and development of lasers and electro-optical systems - not currently. Defense Contractor - spoke to bio-tech field and explored going there, but till now have done nothing but defense.
- Conducting R & D for rheumatoid arthritis medication which is almost ready for clinical trials.
- High technology battlefield identification. Currently they do purely defense contracting. Though they do have some bio-tech projects in the future. Activities are primarily R&D.
- Cancer diagnostics. Makes abnormal "cancerous" cells light up to detect cancer in lung secretion.
- Medical isotopes manufacturer, breast cancer detector in R&D
- Drug delivery device R&D
- Non-invasive glucose monitors using polar imagery, R&D
- Non-invasive glucose monitors, R&D
- Research in spectral imaging
- contract research organization which focuses on food safety and animal health. Do pharmaceutical testing and animal health testing (drugs in animals). International market

- Bioinformatics, data mining and computational intelligence technology. To the pharmaceutical industry, help evaluate drugs and determine if they are working.
- Software - for medical application, just sold first product to research organization.
- Contract research organization that focuses on food safety and animal health. Does pharmaceutical testing and animal health testing for the international market.
- International clinical laboratory; also does clinical trials.

2. How long have you been in operation in New Mexico?

The responses to this question ranged from ranged from 1982 to February 2001. A majority of the companies started operations in the 90's and six with the past five years.

Manufacturing

- Founded 1982.
- Founded in 1999
- Fifteen years
- Founded in 1992
- 2 years in NM, 5 years total

R & D, bioinformatics, and diagnostic

- One year
- About 10 years ago
- 11 years
- Founded in 1996
- Founded in 1999
- Founded in 1995
- Founded in 1993
- Founded in 1992
- Founded in 1985
- February 2001
- Since 2000

3. Why did your business decide to locate in New Mexico? (local start up? branch of larger business located elsewhere?)

Manufacturing

- Local company, started here. They are from here, expect to stay here. -Jobs coming right out of the labs.
- Near Labs.
- Company purchased here in 1994
- Local startup
- originally corporate officials liked NM after touring, availability of skilled workers
- Founders from Tucson, One worked at Phillips. Support from labs and TVC

R & D, bioinformatics, and diagnostic

- Started out of UNM, truly was here, local start-up.
- Local start-up. Not sure, have very many attractive offers from other states. The transition to manufacturing may be much better to do elsewhere.
- Developed here, offshoot from LANL. Not at this point, could be induced to relocate to another area by economic incentives, but at this point they are not thinking.
- Founder lives here
- Family lives here
- Founder lives here
- Founder lives here
- Local startup
- Formed from other NM company, President thought he'd like to investigate this area. They wont be manufacturing, expect to stay in NM
- Representative is on leave from LANL. There are concerns about staying here. Tax structure, though he has only heard that this may be a problem. No specific reason, but feels he may eventually move.
- Local startup

4. How has your business has grown in this time?
(Number of employees, revenues, patents, funding)

Manufacturing

- On a growing stage now, after a slow period (5-6 employees) now have 14-15 employees.
- Employment=230.
- Employment has grown from 8 to 36
- Employment=10
- Employment=3, parent employment=7,000.
- rumored to return to NM
- Now has 5 employees, revenues have doubled, and they occupy three times more space.

R & D, bioinformatics, and diagnostic

- Now have four full-time employees and about 5 part-timers. Have moved through most of the R & D and is now ready for trials.
- Employment has pretty much remained the same, though they have expanded the areas of R&D the are involved in.
- Still small, if the product gets to market they may hire a few more people but not many.
- Employment=10 + 100 in Russia
- One principal only, no employees.
- Employment=5 + support staff.
- Grows 25-40%/yr. Employment=83.
- 5 employees - seed fund round, pretty much R & D now, seeking funding, getting

product to market.
- No, still small, works with consultants, but has gotten product to market
- Employment and revenues both grow at 5-10%/year.
- Local employee base has decreased based on decision to centralize operations in Denver.

5. What factors have positively impacted how your business is doing? (funding? skilled employees? economic development policies? business environment characteristics? networking and industry associations? successfully gaining contracts? clustering of industry?)

Manufacturing
- Were able to do R & D, they have developed a much CAMAC - Computer Automatics Measuring and Controls- has been good. Many consultants who worked with us, work with engineer.
- Labs. Ardesta microsystems
- Local clients: Labs, R&D firms,
- Labs and TVC support

R & D, bioinformatics, and diagnostic
- Relationships with UNM (for finding employees), the bio-tech scene is pretty small here so it is easy to get attention, quality of life is good relatively, cheap labor. The VA human clinical trials program has been helpful.
- There is nothing in NM, just the DOE. He believes that the concentration of the lab employees and smart folks presents excellent opportunities for R&D, but the transition to manufacturing has many disincentives in NM.
- Finding funding is the key to the company's success. Science and technology part of NM EDD, helpful. Capital commission, New Mexico investment commission has been helpful.
- Adequate private funding
- Good talent here
- Finding good employees.
- Federal interest in high-tech
- To soon to tell, he really is just starting up
- Started with 3 employees, now has over 40. Have diversified their activities. Positive influence is overall market.

6. What factors have negatively impacted how your business is doing? (Funding? Lack of employees and investment?)

Manufacturing
- Seems like tax credits and incentives are focused on big firms.
- Lack of funds

- Poor telecommunications, unmotivated labor (e.g. office manager), can't handle fast pace

R & D, bioinformatics, and diagnostic.

- Had perception of Alb. by outsiders, think our schools are bad and city is unsafe, making it hard to bring people here. Some infrastructure is missing (labor force and physical things such as bio-tech parks) The efforts of the public sector seem to be uncoordinated and somewhat repetitive.
- Feels the workforce in NM is inadequate for manufacturing and that the quality of life in NM prevents people from relocating here (schools, wages, business opportunities). People are scared to move here.
- Dependent on investigation, not really negatives about NM, but with getting investment before getting the product to market and permitting revenue.
- But still not enough funding
- Lack of funds. Local business ethics needs upgrade.
- Lack of funds.
- Shortage of senior optical engineers
- Lower GRT, more local marketing contacts
- Having hard time finding employees, the market is generally elsewhere (only 1 other in NM), concentrated in the research triangle and Midwest, starting to pick up on the west coast.
- Investors have questions as to why they are in SF. Some general tax policies.
- Believe there is a lack of biotech training in the region.

7. What is your vision for your business in the next five years?

Manufacturing

- Stay in NM & grow
- Stay in NM & grow
- Same as now
- Hopes to grow to 8 to 10 people, might stay in NM depends on labor pool

R & D, bioinformatics, and diagnostic

- Get the product to market, develop nest product. They will likely outsource the manufacturing of their pharmaceutical. Will try to do it locally, but… R & D efforts will stay here.
- Get product on the market. Getting revenue. Auxilliary products, developing other products based on this technology
- Intends to manufacture detector and more isotopes.
- Find contacts, get grants, get into production
- Expand into Far East. License technology.
- Hope to have products to market.
- Stay in NM & grow
- Getting their product to market and having the data mining being done by others

- Probably moving to Santa Fe or Albuquerque, getting a couple software programs to the market
- Introduce more products into the HIV detection line.
- Denver business will increase, but not here.

8. Have you been able to find the workers you need locally?

Manufacturing

- Local workforce is adequate - currently growing slow.
- Has had fair success locally
- Yes
- Yes
- Don't hire locally
- He needs technicians that are not easily found. Labs have technicians but they are very expensive to attract.

R & D, bioinformatics, and diagnostic

- Have been successful so far, but limited needs
- Most employees are currently advanced degrees which is in supply in NM
- Not sure, haven't needed to do much local hiring for the bio-tech occupations.
- No hires
- Has had good success locally
- Not much success locally
- Shortage of optical and engineering talent locally.
- Mix, sometimes they are available. Right now there are bio-tech companies downsizing so there are employees available.
- Santa Fe has a surprising number of computer folks, hasn't had a problem yet.
- Has not found the workers it needs locally.
- Having tough time finding techs, lab techs and animal techs

9. How could the government better support your business?

Manufacturing

- Tax credit for smaller businesses. -Programs with UNM / TVI that would collaborate, help the business with specific contracts. -Here's a device, you look at, develop it, market it. -Funding to R & D and advance.
- Lower GRT
- The state's job training subsidy requires at least 3 persons to hire. He would like that number reduced.

R & D, bioinformatics, and diagnostic

- Address the GRT issues, coordinate efforts a bit better, continue with the cluster efforts which he feels are working well in Santa Fe.

- Financial assistance to train and have employees. Low tax brackets for a couple years while starting up. Mechanisms to help the transition to manufacturing. Loans for construction, growth related costs. He believes New York has an excellent, aggressive economic policy.
- Money (financing) is the thing
- More tax incentives.
- More state investment funds
- Reduce GRT, capital gains tax
- Remove GRT.
- Business incubation in SF, is a good example (they are currently there).
- Better schools, if he has to recruit from elsewhere he is concerned that the public schools may present a problem.
- Address the GRT issues, coordinate efforts a bit better, continue with the cluster efforts which he feels are working well in Santa Fe.
- State Medicare regulations have hurt business

10. TVI is considering developing an associates degree program in the biotechnologies. Would such a program benefit your business?

Manufacturing

- Would be good, they would want to work with groups of students as sort of "studio."
- Minimal. Uses HS grads (OJT) and BS, MS
- Absolutely
- Manufacturing technology only
- No
- Company needs employees with engineering and optics skills
- He needs engineers with knowledge of optical systems, overall does not need program.

R & D, bioinformatics, and diagnostic

- Would be helpful in establishing the bio-tech "mass," help attract manufacturers. Program should focus on basic biology cell work, lab skills, instrumentation, computer and data statistical analysis skills. He expects to do some degree of OJT, but wants the basic skills covered.
- He likes the idea very much, wants to see New Mexico Advance and develop, would hire some of these folks once the manufacturing activities have begun. He believes that these skilled employees are currently leaving the state to others where they get paid better.
- Needs employees with skills in cytopathology.
- Probably not, but depends on skills.
- Yes
- Probably not. BS min.
- No. MS and PhD primarily.
- Lab techs would help. Also they are finding they need more people with more computer skills which are becoming increasingly important

- They will probably be able to use techs with associate degrees in the future, but not now. She thinks it will help the industry as a whole.
- Looking probably for folks with masters degrees, believes it to be difficult to find qualified bio informatics techs. Perceives a shortage in bio-informatics. Probably no need for associates, mostly masters and PhDs.
- Feels a 4 year program is the most needed, thinks TVI program would be very important.
- This would be a huge benefit for drug company representatives like himself. (There are 8000 nationwide and 50 in NM). He has a communications background and would benefit from technical training. By 2003 first biotech drug based on human genome will be released. This stuff is big, real big.
- Not important. Didn't believe there is a shortage of biotech training in the local (6 states) region.
- The program would be extremely important.
- Doesn't think program would work for them; they need more specialized employees such as phlebotomists; the skills I mentioned to her were not adequate.

Appendix D: List of New Mexico Interviews

Persons Interviewed

The following persons were interviewed:

Mark Benak
Vice-President, Rio Grande Medical Technologies
President-elect, New Mexico Biotechnology & Biomedical Association

Perry Bendicksen
Attorney, Sutin, Thayer and Brown
Adviser to and *pro bono* attorney for the New Mexico Biotechnology & Biomedical Association

Carroll Cagle
President, Carroll Cagle & Associates
Executive Director, Technology Industries Association of New Mexico

Andrea D'Ambrosia
Consultant to the biotech/biomedical industry
President, New Mexico Biotechnology & Biomedical Association

Dave Durgin
President
Quatro Corporation

Diedre Firth
Economic Development Department
City of Albuquerque

Melanie Hasslinger
Recruiter
Albuquerque Economic Development

Leslie Padilla,
Director, Office of Science & Technology
New Mexico Economic Development Department

Martha Reagan
Economic Researcher
Santa Fe Economic Development, Inc.

Ellen Veseth
Senior Business Recruiter
Office of Science and Technology
New Mexico Economic Development Department

Appendix E: List of Interviews: Other Locations

Arizona

Bob Case
Chairman
Arizona Bioindustry Cluster
(480)-614-5884

Dr. Michael Berens
Neuro-Oncology Lab
Barrows Neurological Institute
(602)-406-3648

Colorado

Dan Magnie
Executive Director
Colorado Biotechnology Association
(303)-316-7731

San Diego, California

Leane Marchese
Director
Biocom
(858)-455-0300

Dr. A. Stephen Dahms
Director
CSUPERB
San Diego State University
(619)-594-5578

Rich Buecheler
Director
Advanced Technical Center
San Diego City College
(619)-388-3081

Austin, Texas

Tom Kowalski
President
Texas Health & Bioscience Institute
(512)-708-8424

Susan Davenport
Director
Austin Chamber of Commerce
(512)-322-5657

Dr. Alice Sessions
Professor
Austin Community College
(512)-223-3284

Utah

Brian Moss
President
Utah Life Sciences Association
(801)-584-8706

Appendix F: Bibliography

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