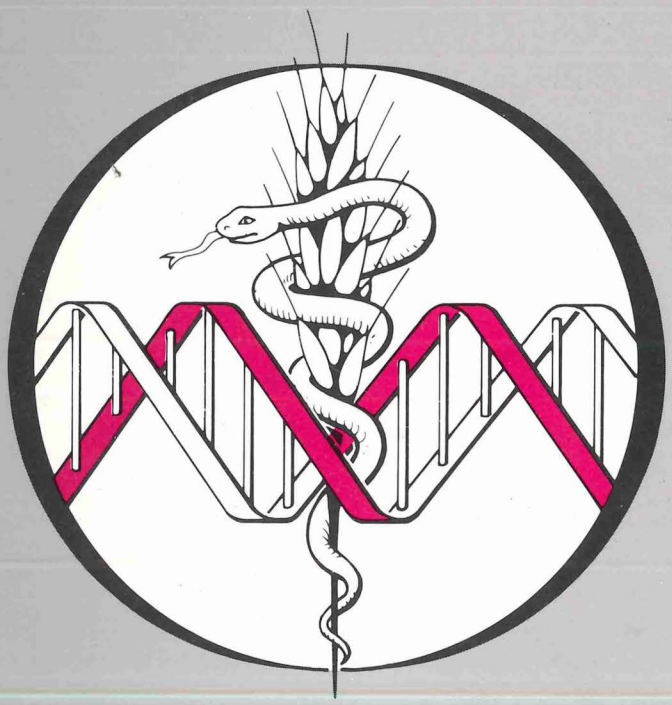
ECONOMIC IMPACT OF BIOTECHNOLOGY: THE EXPANSION OF EMPLOYMENT OPPORTUNITIES IN MINNESOTA



MINNESOTA COUNCIL ON
biotechnology

December, 1986

ECONOMIC IMPACT OF BIOTECHNOLOGY: THE EXPANSION OF EMPLOYMENT OPPORTUNITIES IN MINNESOTA

John E. Reeder, Linda Rochford, William Rudelius
University of Minnesota
Beverly Jones, Governor's Office of Science and Technology
Marilyn Bach, Minnesota Council on Biotechnology

December 1986

Preface

Before funding a 14.2 million dollar biotechnology plan in 1985, the North Carolina Legislature established an Economic Advisory Panel to analyze the economic benefits of such an expenditure. Similarly, it was necessary to perform an economic analysis of the biotechnology plan set forward by the Minnesota Council on Biotechnology.

A study coordinated by William Rudelius, Economic Advisor to the Council from the University of Minnesota, provides significant economic justification for Minnesota's biotechnology plan. The following analysis reveals the potentially large number of jobs that would result from state action to encourage expansion of employment opportunities in biotechnology related industries.

Acknowledgments

This study has been a joint effort between faculty and staff of the University of Minnesota, the Governor's Office of Science and Technology and the Minnesota Council on Biotechnology.

Acknowledgments and thanks to Stephen Young, Governor's Office of Science and Technology, Arthur Adiarte, Marianne Sapp and Brian Zucker, Minnesota Department of Energy and Economic Development and Gay Herzberg, Council on Biotechnology, for their assistance in this project.

Table of Contents

Executive Summary

For purposes of the employment projections in this analysis, Minnesota's biotechnology industry has two components: (1) firms producing biomedical devices and (2) firms engaged in biological engineering. The most current data available show that in 1985 Minnesota had about 83 biomedical devices firms with approximately 8,650 employees and about 11 biological engineering firms with approximately 350 employees. Thus, for the 1985 base year, Minnesota had about 9,000 employees in biotechnology firms.

Using data on past growth of biotechnology firms in Minnesota and the nation, and expected national growth in biotechnology, three sets of growth rate projections were developed for Minnesota through the year 2000: "pessimistic," "most likely," and "optimistic" outlooks. Assuming that Minnesota seeks to be competitive in biotechnology, the state's resulting employment projections for 1995 and 2000 are shown below:

Actual 1985 Employment	Three Growth Rate Assumptions	Resulting Employment Projections 1995	2000
9,000	Pessimistic	16,632	21,228
	Most Likely	25,359	40,840
	Optimistic	35,407	68,461

Taking the additional jobs beyond the 9,000 existing in 1985, under the "most likely" outlook for the future, and using a "multiplier" to reflect the additional employment in firms supplying goods and services to growing biotechnology firms and their employees, gives these results:

Source of Employment	Additional Jobs "Most Likely" by 1995	Additional Jobs "Most Likely" by 2000
Direct Employment	16,359	31,840
Indirect Employment	10,470	20,378
Total	26,829	52,218

By taking steps to implement the Council on Biotechnology's recommendations, Minnesota can use its existing strengths to build a competitive biotechnology industry and expand job opportunities in the State.

Background

Realities of the international marketplace mean that there are no "quick fixes" to providing new jobs for a nation, region, or state. There will be few new General Motors' Saturn plants that will provide thousands of permanent jobs in a region or state. Regional economists now see the value of strategies that build on a state's existing strengths by fostering growth of firms in industries that already have comparative advantages in the world economy.

Even when such rare opportunities as a Saturn plant appear, the probability of Minnesota winning such a nationwide competition is low. Under such a competitive environment, it seems wise for Minnesota to build on its existing competitive strengths. Given the State's historic success in several fields of biotechnology, a reasoned strategy for providing jobs suggests Minnesota continue to build the foundation for this industry. This has been the goal of the actions suggested in the Four Year Plan of the Council on Biotechnology. The broad goal of the present economic study is to project the probable impact of an active, cohesive effort by the State of Minnesota, private businesses, and academic institutions to foster continuing growth in the biotechnology industry.

Objectives of the Report

This report on the employment impact of biotechnology on the State of Minnesota has four main objectives:

1. To define two major components of the biotechnology industry for purposes of this study.

2. To describe (a) the sources of employment related to a growing biotechnology industry and (b) the kinds of employment provided.

3. To identify the level of biotechnology employment in Minnesota for 1985 -- the most recent year for which data are available.

4. To project Minnesota's employment growth in biotechnology through the year 2000 under specified assumptions.

These objectives will be discussed in sequence during the remainder of the report.

Two Components of the Biotechnology Industry

The Minnesota Council on Biotechnology has defined biotechnology as the "application of the revolutionary advances in biology, chemistry, computers, engineering, materials science, and medicine to the understanding and improvement of living organisms."

For purposes of this report, employment in the "biotechnology" industry in Minnesota has two components: (1) employment in firms producing biomedical devices and (2) employment in firms engaged in biological engineering. Because of the difficulty of developing precise definitions, firms in this study were included in one of two groups based on how they categorized their own operations as follows:

- Biomedical devices employment includes firms defining their activity as primary research and development or manufacturing of medical devices that involve high technology for use in health care.

- Biological engineering employment includes firms defining their activity as primarily research and development or manufacturing of synthetic genetic or biological products.

In the remainder of the report, the term biotechnology will be used to include these two key components.

Sources and Kinds of Employment in Biotechnology

An understanding of the employment potential in the biotechnology industry requires an analysis of (1) the various sources of the jobs and (2) the kinds of jobs likely to be generated.

Sources of Employment

Minnesota is already home to many world-renowned biological engineering and biomedical device firms. A strategy to facilitate the growth of these firms and the successful startups of new ones is in the interest of all the State's citizens. This strategy will have three employment effects: (1) a direct effect of new jobs in the biotechnology industry; (2) a multiplier effect from these new jobs through increases in jobs in supplier firms and in retail and wholesale jobs serving the households whose main source of income is biotechnology firms; and (3) the indirect effect of increased competitiveness in world markets (through the application of new biotechnologies) of Minnesota's existing industries such as health care, agriculture, and food processing.

While it is impossible to project the impact of the indirect (third) effect, the first two can be estimated using some reasonable assumptions based on historic growth rates and on national projections for biotechnology growth. The number of jobs created from the third effect is particularly difficult to estimate because it requires assessment of future technological innovations -- an extremely subjective exercise. Therefore, we exclude this effect in the following projections, but believe biotechnology innovations can have significant employment impacts in Minnesota's traditional industries.

Kinds of Employment

The biotechnology industry provides a wide variety of employment opportunities for the State. Analysis of Minnesota occupational staffing patterns for biotechnology firms located in the State in 1985 show job opportunities in every occupational category. The biotechnology industry contains a mix of very highly trained and educated scientists and engineers; skilled scientific and engineering technicians, craft workers, machine operators, and clerical workers; and unskilled and semi-skilled laborers and service workers. A breakdown of the average occupational staffing pattern for Minnesota biotechnology firms for 1985 appears in Table 1.

TABLE 1

Minnesota Occupational Patterns for the Biotechnology Industry, 1985*

Occupational Category	Percent of Total
Managerial	14.5%
Scientists and Engineers	7.3
Scientific and Engineering Technicians	6.9
Sales Workers	3.9
Clerical Workers	16.5
Service Workers	1.9
Craft Workers	16.8
Machine Operators	29.9
Laborers	2.3
Total	100.0%

*Includes both the biomedical devices and biological engineering sectors, as defined earlier.

Source: Derived from unpublished data produced for the Governor's Office of Science and Technology by the U.S. Department of Census, Bureau of Labor Statistics.

1985 Biotechnology Employment in Minnesota

In order to develop employment projections for the future, it is essential to measure a "base year employment" -- the Minnesota employment for the most recent year for which such data are available. The "base year" was taken as 1985, because more recent data are not available for many firms in the two sectors that make up the biotechnology industry in Minnesota. The study used a two-step process: (1) identifying the names of firms in the biotechnology industry and (2) attempting to measure their employment.

Identifying Minnesota Biotechnology Firms

The identification of Minnesota firms in the biotechnology industry was based on their inclusion in two separate lists: "The 1986 Medical Alley Directory," and the "Fifth Annual Genetic Engineering News Guide to Biotechnology Companies."[1] Although nearly 61 percent of the firms for which employment data were available are classified under Standard Industrial Classification (SIC) 3841 (surgical and medical instruments) or 3842 (orthopedic, prosthetic, and surgical appliances), these categories include many firms that do not fall under the Council's definition of biotechnology and would not directly benefit from the Four Year Plan of the Council on Biotechnology. The firms included in the base year employment figure more ably meet the narrow definitions of biomedical devices or biological engineering given earlier than those included in the SIC 3841 and SIC 3842 industry sectors. Likewise, some firms meeting the above definitions were identified in other four-digit SIC codes and have been included in developing base-year employment estimates.

Employment in Minnesota Biotechnology Firms

Once Minnesota biotechnology firms were identified, employment information was gathered from four sources: The 1986 High Technology Data Base in the Governor's Office of Science and Technology; the 1985-1986 Minnesota Directory of Manufacturers; the 1986 Minnesota Manufacturers Register; and the 1986 Needs Assessment Survey of the Council on Biotechnology. Of 93 firms initially identified, employment data were found for 77, representing 83 percent. As shown in Table 2 (page 7), 69 biomedical devices firms were identified, together having a total Minnesota employment of 8,424 people. The table also shows that eight biological engineering firms have a total Minnesota employment of 308 people. Using new startup biotechnology firms as a reference, the research team assumed 10 and 15 employees for the biological engineering and biomedical device firms, respectively, for which employment data were missing.

Table 2 shows that allowing for the missing employment data adds 210 and 30 employees, respectively, to the total for biomedical devices and biological engineering employment. As shown in the bottom row of Table 2, adding and rounding the subtotals gives estimated 1985 Minnesota employment of 8,650 people in biomedical devices firms and 350 people in biological engineering firms, creating a total of 9,000 employees. This estimate is believed to be conservative, for it omits biotechnology employment in divisions of large Minnesota corporations, like 3M and General Mills, for which no published data are available.

Summaries of the number of firms and employment by four-digit SIC sector for biomedical devices and biological engineering appear in Table 3 (page 8) and Table 4 (page 9), respectively. The totals do not compare exactly with those in Table 2, because data in Tables 3 and 4 are only for Minnesota firms for which both SIC category and employment data were available. Listings of names of firms by SIC and employment size categories appear in Tables 5 and 6 in the Appendix.

TABLE 2

Calculation of Minnesota 1985 "Base-Year" Employment
in the Biotechnology Industry

	Biomedical Devices		Biological Engineering	
	Firms	Employment	Firms	Employment
Number of Firms Meeting Definition	83		11	
Number for Which Employment was Found	69		8	
Identified Employment		8,424		308
Value Used for Missing Employment Figures		15		10
Firms for which Employment Figures Missing	14		3	
Additional Employment Assumed		210		30
Total Employees (subtotal plus additional		8,634		338
Figure used for projection (rounded)		8,650		350

Projected Minnesota Employment in Biotechnology

The following projections of Minnesota employment in biotechnology through the year 2000 draw on the historic growth of Minnesota's biomedical equipment industry and on the U.S. Office of Technology Assessment's estimates for growth of the U.S. and international biotechnology market.[2] The analysis will project employment first in the biomedical devices sector and then the biological engineering sector. In each case projections will be based on annual growth rates derived from the recent past and based on "pessimistic," "most likely," and "optimistic" assumptions. Finally, these two groups of employment projections will be summed to estimate the total direct employment effects in the biotechnology industry in Minnesota. An "employment multiplier" will be used to estimate the jobs resulting in other sectors due to expansion of the biotechnology industry.

TABLE 3

MINNESOTA EMPLOYMENT IN BIOMEDICAL DEVICES[a], 1985

Industry Sector		Number of Firms	Total Employment	% of Total Employment
SIC	Description			
3841	Surgical and Medical Instruments	32	3943	48
3842	Orthopedic, Prosthetic, and Surgical Appliances and Supplies	15	1923	23
3693	Electromedical, Electrotherapeutic and X-ray Equipment	6	858	11
3851	Ophthalmic Goods	2	636	8
2831	Biological Products	3	400	5
3822	Automatic Controls for Regulating Residential and Commercial Environments and Appliances	1	250	3
3599	Machinery, Except Electrical, Not Elsewhere Classified	1	87	3
3811	Engineering, Laboratory, Scientific, and Research Instruments	2	51	1
3825	Instruments for Measuring and Testing Electricity and Electrical Signals	1	30	-
3662	Industrial Controls	1	16	-
7392	Management, Consulting, and Public Relations Services	1	12	-
Totals		65	8206[b]	102[c]

[a]Biomedical devices employment includes firms defining their activity as primarily research and development or manufacturing of medical devices that involve high technology for use in health care.

[b]Includes employment only in firms for which both SIC and employment data were available.

[c]Does not add to 100% due to rounding.

Sources: 1986 High Technology Data Base, Governor's Office of Science and Technology; 1985-1986 Minnesota Directory of Manufacturers; 1986 Workforce Needs Assessment Survey, Council on Biotechnology; 1986 Minnesota Manufacturers Register.

TABLE 4

MINNESOTA EMPLOYMENT IN BIOLOGICAL ENGINEERING,[a] 1985

Industry Sector		Number of Firms	Total Employment	% of Total Employment
SIC	Description			
8911	Engineering, Architectural and Surveying Services	1	115	38
3811	Engineering, Laboratory, Scientific, and Research Instruments and Associated Equipment	1	80	27
2831	Biological Products	3	49	16
3679	Electronic Components, Not Elsewhere Classified	1	30	10
8922	Noncommercial Educational, Scientific and Research Organizations	1	25	8
Totals		7	299[b]	99%[c]

[a]Biological engineering employment includes firms defining their activity as primarily research and development or manufacturing of synthetic genetic or biological products.

[b]Includes employment only in firms for which both SIC and employment data were available.

[c]Does not add to 100% due to rounding.

Sources: 1986 High Technology Data Base, Governor's Office of Science and Technology; 1985-1986 Minnesota Directory of Manufacturers; 1986 Workforce Needs Assessment Survey, Minnesota Council on Biotechnology; 1986 Minnesota Manufacturers Register.

Minnesota Employment in Biomedical Devices

Minnesota's biomedical devices industry has grown at 13 to 14 percent annually from 1972 to 1986.[3] Biomedical devices employment for the entire U.S. has increased 5 to 6 percent anually from 1972 to 1986. The pessimistic, most likely, and optimistic annual growth rates in Minnesota from 1986 to 2000 are assumed to be 5 percent, 10 percent, and 14 percent, respectively. Under these three growth rate scenarios, Minnesota employment in the biomedical devices industry is projected to be:

Actual 1985 Employment	Three Annual Growth Rate Scenarios	Resulting Employment Projections 1995	2000
8,650	Pessimistic: 5%	14,090	17,983
	Most Likely: 10%	22,436	36,133
	Optimistic: 14%	32,067	61,743

These projections suggest an increase in jobs in the biomedical equipment industry in Minnesota (beyond the 8,650 existing in 1985) of about 5,400 to 23,400 jobs for the year 1995 and about 9,300 to 53,100 jobs for the year 2000.

Minnesota Employment in Biological Engineering

Minnesota's biological engineering industry employment is currently estimated at 214, based on the 1986 employment figures reported in the 1986 Corporate Report Fact Book[4] for five Minnesota firms defining themselves primarily as utilizing biological processing for manufacture. The more extensive search described above results in a 1985 base-year estimate of about 350 people for Minnesota employment in biological engineering. Employment for firms involved in biological engineering, but not defined primarily as manufacturers of synthetic genetic products, were not included due to the difficulty of estimating the proportion of total employment in these firms represented by biological engineering. U.S. biological engineering employment increased by 54 percent annually from 1976 to 1982, and R&D employment is estimated to grow about 30 percent annually to 1992.[5] This 30 percent per year growth rate is used in projecting Minnesota biological engineering employment from 1986 to 1992.

However, this R&D employment growth rate is not expected to be sustained through the year 2000.[2] The need for marketing and sales personnel, and the growth of potential spinoff industries, is difficult to assess at this time but could be significant growth areas for biotechnology. Biological engineering technology is less labor intensive than traditional manufacturing industries or even biomedical devices production, so it will likely produce relatively fewer numbers of jobs. Since the biological engineering industry is currently in the developmental stage, the greatest short term demand in jobs will come in the technical research and development areas. As the industry commercializes more new products, the demand for sales, service, clerical, and production positions will grow and will more closely approximate the occupational mix shown earlier in Table 1.

The growth rates selected to estimate Minnesota biological engineering employment beyond 1992 are based on assumptions of 5 percent, 10 percent, and 15 percent growth per year for the pessimistic, most likely, and optimistic cases.

Under these three growth rate assumptions, Minnesota employment in the biological processing industry will be:

Actual 1986 Employment	Three Annual Growth Rate Assumptions (1992 to 2000)	Resulting Employment Projections 1995	2000
350 (30% from 1986 to 1992)	Pessimistic: 5%	2,542	3,245
	Most Likely: 10%	2,923	4,707
	Optimistic: 15%	3,340	6,718

These projections suggest an increase in jobs in biological engineering in Minnesota (beyond the 350 existing in 1985) of about 2,200 to 3,000 jobs for the year 1995 and about 2,900 to 6,400 jobs for the year 2000.

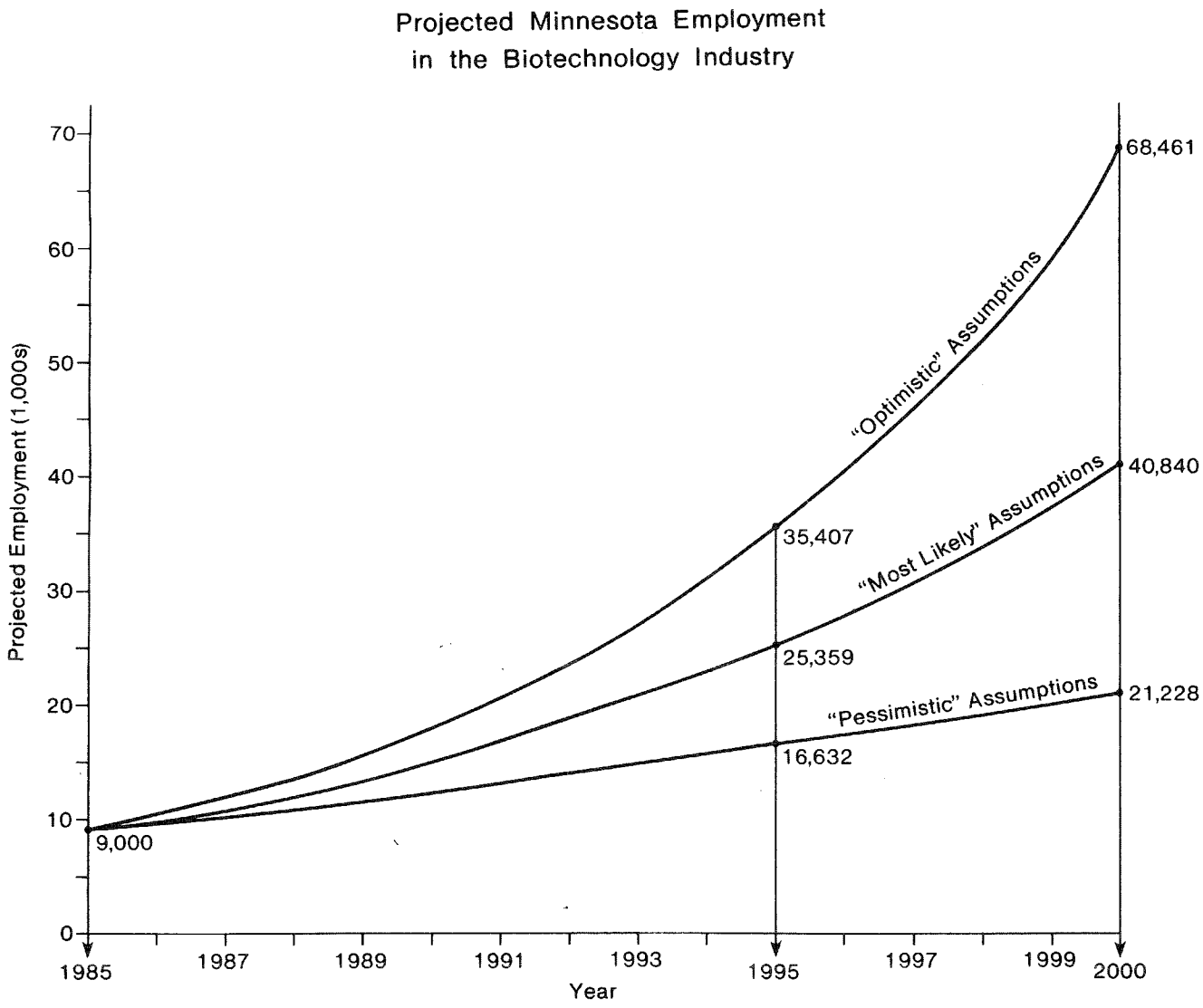
Total Minnesota Employment in Biotechnology

Figure 1 (page 12) combines the pairs of pessimistic, most likely, and optimistic scenarios for Minnesota's biomedical devices and biological engineering sectors to give their combined employment projections for the biotechnology industry as a whole through the year 2000. The projections show that by the year 2000, a total of 12,228 to 59,461 additional direct jobs will be produced in biotechnology in Minnesota if the assumptions are realized. These growth-rate projections are generally consistent with the needs assessment survey of the Minnesota Council on Biotechnology. The survey found that the 54 firms responding (about one-third of the sample) expected to have growth in scientific personnel about 14 percent annually for the five years from 1986 to 1991.[6]

Resulting Multiplier Effect

The employment occurring in supplier firms, retailers, and wholesalers due to growth in biotechnology can be estimated by applying industry multipliers. Multipliers measure the ratio of total jobs generated in the economy to the direct employment change in a specific industry. A 1984 study by the U.S. Chamber of Commerce suggests that 100 new manufacturing jobs in a community creates 64 new non-manufacturing jobs for a multiplier of 1.64. This is believed to be a conservative value for a multiplier applied statewide because community multipliers do not capture the spillover employment created within the state that occurs outside of the community. A composite multiplier of 1.73 for biotechnology statewide was derived from industry-specific multiplier values from the Minnesota Forecasting and Simulation Model of the Minnesota Department of Revenue. The above multipliers reflect values for broad industries in which biotechnology firms are often classified. The biological engineering industry itself is thought to have much larger multiplier effects. A study in California places the multiplier effect for the "biotechnology" industry at 4 to 5.[7] However, this value is based on a more narrow definition of biotechnology than the one used by the Council on Biotechnology.

Figure 1.


Projected Minnesota Employment
in the Biotechnology Industry
Projected Employment (1,000s)
70
60
50
40
30
20
10
0
1985
1987
1989
1991
1993
1995
1997
1999
2000
Year
"Optimistic" Assumptions
"Most Likely" Assumptions
"Pessimistic" Assumptions
9,000
35,407
25,359
16,632
68,461
40,840
21,228

Using the more conservative multiplier of 1.64 gives the following Minnesota employment projections for 1995 and 2000 for the "most likely" scenarios of the combined biomedical devices and biological engineering industries:

Source of Employment	Additional Jobs "Most Likely" by 1995	Additional Jobs "Most Likely" by 2000
Direct Employment	16,359	31,840
Indirect Employment	10,470	20,378
Total	26,829	52,218

These projections indicate a significant employment potential for Minnesotans in industries serving the biotechnology sector.

Biotechnology in Total Minnesota Employment Growth

The biotechnology industry will represent a significant proportion of total job growth in Minnesota if the "most likely" scenario occurs. The total employment in Minnesota is projected to increase from 2,101,000 jobs in 1985 to 2,606,600 jobs in the year 2000.[8] These additional 505,600 jobs represent an annual growth rate of approximately 1.5 percent during the 15 year period. The number of direct additional jobs in biotechnology is projected to be 31,840 for the year 2000. This represents 6.3 percent of the 505,600 new jobs in the State for the year 2000. Because of the relatively high growth rate of biotechnology, the industry will more than triple its share of total Minnesota employment from less than 0.5 percent in 1985 to nearly 1.6 percent in year 2000. This means that about 1 of every 63 Minnesotans will be employed in biotechnology in the year 2000.

Relation of Future Employment to Biotechnology Council Recommendations

Implementing the Biotechnology Council's recommendations will help supply Minnesota's biotechnology industry with the trained personnel and competitive edge it needs to compete in the national and international markets of the 1990s. The Council firmly believes that Minnesota can meet the competition, provided its recommendations are supported by both public and private sectors. As an international and national competitor in the biotechnology industry, Minnesota should experience growth in this industry that matches or exceeds national growth.

This analysis uses reasonable rates of growth and does not include the economic impact of the resulting innovations on agriculture, food processing, health care, forestry, waste and water management, mining, and other Minnesota industries. The growth rate scenarios are based on the following assumptions: (1) that the biotechnology industry, as defined, will continue its robust growth relative to the rest of the economy; (2) that the national and regional economies maintain growth rates similar to those of the period 1972 through 1985; and (3) that the State of Minnesota implements the recommendations of the Minnesota Council on Biotechnology, enabling the State to build a competitive biotechnology industry. Provided these assumptions hold, Minnesota will expand job opportunities by building on existing industry and academic strengths.

REFERENCES

1. "Fifth Annual Genetic Engineering News Guide to Biotechnology Companies," Genetic Engineering News (November/December 1986)

2. Commercial Biotechnology: An International Analysis, (Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-BA-218, January 1984).

3. Employment figures from Corporate Report Fact Book (cited below) and selection of medical equipment manufacturers from Minnesota Medical and Health Care Resource Guide, (Edina, MN: Medical Alley Directory, 1986) and The Medical and Health Care Marketplace Guide, International Biomedical Information Service, Inc., 1986.

4. Corporate Report Fact Book, 1986 Edition, Ninth Federal Reserve District, (Minneapolis: Dorn Communications, Inc., 1985).

5. Impacts of Applied Genetics: Micro-Organisms, Plants and Animals, (Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-HR-218, April, 1981).

6. Adiarte, A.L., "Findings and Results: Minnesota Council on Biotechnology Needs Assessment Survey," in Four Year Plan of the Minnesota Council on Biotechnology (St. Paul, Minnesota Council on Biotechnology, December, 1986, p. 62).

7. Feldman, M., and O'Malley, E.P., "The Biotechnology Industry in California," contract paper for the California Commission on Industrial Innovation, Sacramento, CA, (August, 1982).

8. 1985 employment data from the Research and Statistical Services Office of the Minnesota Department of Jobs and Training. Projections for the year 2000 are from Bureau of Economic Analysis, OBERS, U.S. Department of Commerce, 1985.

Appendix: Minnesota Biotechnology Firms

- Table Five. Minnesota Firms Providing Employment in Biomedical Devices, 1985

- Table Six. Minnesota Firms Providing Employment in Biological Engineering, 1985

TABLE 5

MINNESOTA FIRMS PROVIDING EMPLOYMENT IN BIOMEDICAL DEVICES,[a] 1985

Industry Sector			Employment					
SIC	Description	Name of Firm	NA[b]	1-24	25-99	100-249	250-499	500+
3841	Surgical and Medical Instruments	Aequitron Medical Inc.				X		
		Angiomedics Inc.			X			
		Arcon Corp.			X			
		Biosensor Corp.		X				
		Bio-Medicus Inc.			X			
		Centrimed Corp.		X				
		Creative Research and Manufacturing		X				
		Dagan Corp.		X				
		Daig Corp.			X			
		Deltec Systems Inc.			X			
		Derata Corp.		X				
		DiMed Inc.		X				
		Edentec		X				
		Empi Inc.				X		
		Immuno Nuclear Corp.			X			
		Implant Technologies Inc.		X				
		Ivy Medical Inc.		X				
		Lake Region Mfg. Co. Inc.					X	
		Marcom Inc.			X			
		Med Lab Systems Inc.		X				
		Medtronic Inc.						X
		Medical Devices Inc.		X				
		Mentor Corp.				X		
		Minnesota Scientific Inc.	X					
		PMT Corp.		X				
		Possis Medical Inc.		X				
		R & D Systems Inc.			X			
		Renal Systems Inc.				X		
		SciMed Life Systems Inc.				X		
		SenTech Medical Corp.			X			
		Surgidyne Inc.		X				
		Uni-Patch Inc.		X				
3842	Orthopedic, Prosthetic, and Surgical Appliance and Supplies	American Medical Systems				X		
		Argosy Electronics Inc.				X		
		Dacomed Corp.			X			
		Dalberg Electronics Inc.					X	
		Genetic Laboratories Inc.			X			
		Hearing Services Inc.			X			
		Lang Hearing Instruments			X			
		LecTec Corp.			X			
		Maico Hearing Instruments Company				X		
		Medical Inc.				X		

TABLE 5 (Continued)

Industry Sector			Employment					
SIC	Description	Name of Firm	NA[b]	1-24	25-99	100-249	250-499	500+
3842 (Cont.)	Orthopedic, Prosthetic, and Surgical Appliance and Supplies	Qualitone Corp.				X		
		St. Jude Medical Inc.				X		
		Starkey Laboratories Inc.					X	
		Skin Technologies		X				
		WR Medical Electronics Company		X				
3693	Electromedical, Electrotherapeutic and X-ray Equipment	Angicor Limited		X				
		Cardiac Pacemakers Inc.						X
		Cardio-Pace Medical Inc.			X			
		Electreat Inc.		X				
		Rochester Electro-Medical Inc.		X				
		Waters Instruments Inc.				X		
3851	Ophthalmic Goods	Precision-Cosmet Inc.						X
		Surgidev Corp.		X				
2831	Biological Products	Biomedical Dynamics Corp.		X				
		Kallestad Labs Inc.					X	
		Wilfer Laboratories		X				
3822	Automatic Controls for Regulating Residential and Commercial Environments and Appliances	TSI Inc.					X	
3599	Machinery, Except Electrical, Not Elsewhere Classified	RMS Company			X			
3811	Engineering, Laboratory, Scientific and Research Instruments	GV Medical Inc.			X			
		MCT Diagnostics Inc.		X				
3825	Instruments for Measuring and Testing Electricity and Electric Signals	Medical Graphics Inc.			X			
3662	Industrial Controls	Audiobionics Inc.		X				

TABLE 5 (Continued)

Industry Sector		Name of Firm	Employment					
SIC	Description		NA[b]	1-24	25-99	100-249	250-499	500+
7392	Management Consulting and Public Relations Services	Applied Membrane Technology Inc.		X				
7391	Research and Development Laboratories	Vivatron Inc.	X					

[a]Biomedical devices employment includes firms defining their activity as primary research and development or manufacturing of medical devices that involve high technology for use in health care.

[b]Not available.

Source: Firms selected from Medical Directory based on primary products manufactured.

TABLE 6

MINNESOTA FIRMS PROVIDING EMPLOYMENT IN BIOLOGICAL ENGINEERING,[a] 1985

Industry Sector		Name of Firm	Employment					
SIC	Description		NA[b]	1-24	25-99	100-249	250-499	500+
8911	Engineering, Architectural and Surveying Services	Molecular Genetics Inc.				X		
3811	Engineering, Laboratory, Scientific, & Research Instruments and Associated Equipment	Endotronics Inc.			X			
2831	Biological Products	Diagnostic Inc. American Biosystems Inc. Genesis Labs Inc.		 X X	X			
3679	Electrical Components Not Elsewhere Classified	Sys-tec Inc.			X			
8922	Non-Commercial Educational, Scientific and Research Organizations	Bio-Metric Systems Inc.			X			

[a]Biological engineering employment includes firms defining their activity as primarily research and development or manufacturing of synthetic genetic or biological products.

[b]Not available.

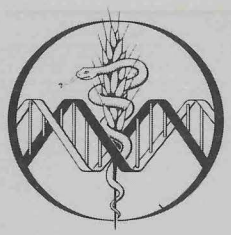
Source: Genetic Engineering News.

The Council's Four-Year Strategic Plan, individual Task Force reports, and other supporting studies may be obtained by contacting the:

Minnesota Council on Biotechnology
Department of Energy and Economic Development
9th floor - American Center Bldg.
150 East Kellogg Blvd.
St. Paul, Minnesota 55101 U.S.A.
(612) 297-2701

The Four-Year Strategic Plan of the Minnesota Council on Biotechnology contains:

- **Summary: Four-Year Strategic Plan**
- **Reports of the Task Forces on Education, Incentives / Disincentives, and Media / Public Relations**
- **Economic Impact of Biotechnology**
- **Economic Benefits of Investments in Biotechnology Related Research & Development**
- **Proposed Structure and Functions of a Continuing Biotechnology Council**



Advances in biotechnology will significantly impact Medicine and Agriculture, two major Minnesota industries. The caduceus signifies Medicine, and wheat symbolizes Agriculture. DNA, represented by the double helix, is the basis of life and underlies all biotechnology.

Design and production: Biomedical Graphic Communications.

MINNESOTA COUNCIL ON
biotechnology
900 American Center Building, 150 East Kellogg Boulevard, St. Paul, MN 55101 (612) 297-2701

MEMO

DATE: March 6, 1987

TO: Members and Contributors, Minnesota Council on Biotechnology

FROM: Marilyn L. Bach, Excutive Director M.L.B.

RE: Report, Economic Impact of Biotechnology: The Expansion of Employment Opportunities In Minnesota, is presented to House Future and Technology Committee.

The Council on Biotechnology was asked to conduct a detailed presentation of the Council's plan to the House Future and Technology--Subcommittee on Biotechnology on February 23, 1987. As part of the presentation, William Rudelius, economic advisor to the council, outlined the major findings of the enclosed economic impact study. Along with a description of the biotechnology industry in Minnesota, the report shows projected employment in biotechnology on the assumption that the Council's plan is implemented. Biotechnology employment is projected to increase by 32,000 between the years 1985 and 2000. Multiplier effects may result in an additional 20,000 jobs for a total increase of 52,000.

This report provides another useful tool as the Council on Biotechnology works toward implementing its comprehensive biotechnology development plan for Minnesota. Please call (612) 297-2701 if you need additional reports.

Thank you.