BIOTECHNOLOGY MANUFACTURING PLANT LOCATION DECISIONS: MASSACHUSETTS CASE STUDIES

by

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ABSTRACT

The manufacturing plant location decisions made by five Massachusetts biotechnology firms were examined. Information was gathered from company literature and by means of questionnaire-based interviews with senior corporate staff involved in the decisions. The five companies were all in the biotherapeutic segment of the industry, and ranged in size from 90 to 1500 employees. In their location decisions, the factors most frequently cited as important were: labor availability; proximity to existing company facilities, and other agglomerization economies; taxes; business climate; economic development assistance; and overall costs. All firms quantified costs, but did not make their final decisions on the basis of cost alone; other considerations took precedence, in some cases. Risk-minimization appeared to be at least as great a concern as profit-maximization for this group of companies, perhaps reflecting the relatively great uncertainties with which their decision-makers were faced in product development, approval, and manufacturing. All five companies had urban headquarters and research and development facilities; three located their manufacturing plants in cities, two in the suburbs.

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CONTENTS

INTRODUCTION

This thesis examines the manufacturing locational decisions of five firms in the biotechnology industry in Massachusetts, in order to determine which location decision processes and locational factors are deemed important by these firms and how they are different from or similar to manufacturing decisions and factors of aggregate industry groups and of other high-technology industry groups. Several local biotechnology firms are currently moving to the manufacturing stage in the product development process, from being primarily engaged in research and development and pilot plant trials. Knowledge of where and how they decide to locate their manufacturing facilities is useful for other biotechnology industry decision makers, since the industry is in a phase of rapid growth, and other companies will soon need to expand into manufacturing facilities. These companies will be faced with difficult choices, because of the high cost of manufacturing space may be coupled with capital constraints. How some firms have managed their location decision-making process to address growth within their constraints is shown. Finally, the potential location in Massachusetts of these manufacturing facilities has important implications for high-wage manufacturing employment stability.

For this paper, the specific firms surveyed were in the biotherapeutic segment of the industry. The first chapter discusses the biotechnology industry in general, on a national and state basis, to provide a context for the case studies. The second chapter surveys the location theory and location decision-making literature, which is broadly catalogued in three methodologies: neoclassicist, behavioralist, and structuralist. To develop a framework for the case studies and analysis, this chapter examines important concepts in each methodology, and relates the biotechnology industry to these methodologies.

In view of the findings in locational literature, I hypothesized that if a firm's overall size is small, and if its manufacturing space needs, both short and long term, are relatively modest, then it will likely remain in an urban location. This likelihood is based on the known preference of biotechnology firms for proximity of their manufacturing facilities to their research and development sites, and a ability to expand in place, if expansion space needs are modest. However, much depends on the importance placed within the firm on cost-minimization criteria, and whether economic development assistance is available. I hypothesized that these small biotechnology firms will tend to stay in urban locations, take advantage of urbanization and localization economies such as proximity to skilled labor and availability of infrastructure, and make location decisions on an informal basis, unless costs are prohibitively high.

I also hypothesized that biotechnology firms with large manufacturing facility requirements will increasingly decentralize, moving intra-regionally to suburban locations where lower land costs predominate, but more importantly, land is more available. As with small firms, existing urban locations are attractive for large firm expansion because of labor availability and labor quality there, but the unavailability of appropriate land will discourage siting in urban centers unless government intervention occurs, particularly in the physical assembling of land and in assuming environmental liabilities. Urban land cost may be an issue; however, cost minimization criteria will not be as important as other business goals for these firms.

The third chapter presents five case studies of Massachusetts biotechnology companies which have made or are about to make a major manufacturing plant location decision. The companies range in size from 90 to 1500 employees; one of them is a division of an international company with over 100,000 employees. The case studies are based on a face-to-face

interview protocol; they cover company identity, history, nature of existing space and plant, nature of the manufacturing location decision or decisions, company financing, and business strategy.

The subjects of the five case studies are Massachusetts biotherapeutics firms, which were identified through a recent survey (Malaterre, 1993) as having recently made or being about to make a manufacturing location decision. Company contacts were individuals recommended by Professor Charles Cooney, co-director of M.I.T.'s Program on the Pharmaceutical Industry, as industry people willing to talk about their experiences. In one case, the name of the firm, my interview contacts there, and the community location were altered to protect confidential information.

A questionnaire was developed (see Appendix A) as an interview protocol, based on Roger W. Schmenner's (1982) questionnaire. Face-to-face interviews were conducted with senior corporate staff involved in the location decisions. Additional or follow-up data were gathered through telephone interviews. It became apparent that, because the biotechnology industry was in its infancy, manufacturing plant relocation questions were not relevant; in situ expansion or new plant location decisions were the main concerns. The questionnaire was also designed to ask about overall business strategy and goals, because it became clear that how and why location decisions are made are components of an overall business strategy and culture, whether explicitly or implicitly articulated.

The questionnaire has many open-ended, non-quantitative questions and I made an attempt to allow interviewees to tell the story, rather than prompt them for information. Insofar as possible, I asked companies the same questions. Prior to the interviews, I read about the industry both in Massachusetts and nation-wide, and also each company's annual report (all of

the case study companies are publicly held).

The firms selected do not necessarily represent a cross section of the biotherapeutic segment. They are not only all high growth firms, but three out of the five represent the largest Massachusetts firms in terms of employment. All have the explicit goal of vertical integration. As a result, functions from research and development through commercial production, at least to bulk protein manufacture, are desired as in-house activities. Other biotherapeutic firms and other biotechnology firms may choose to remain as research and development labs only, with revenues generated from licensing their proprietary technology, for example. Others may be forced to cede manufacturing autonomy in alliances or buy-outs because of capital constraints.

In all cases, specific cost data about location decisions were confidential and not available to me. I interviewed one major decision-maker in each company, and occasionally, a second person involved in the location decision. Firms typically had made several location decisions in their company history; the intent of my questions was to focus on a major plant decision, made recently, in which commercial-scale manufacturing was a significant component of the plan. For consistency, I limited the study to decisions that dealt with genetically-engineered biotherapeutics, as opposed to other products.

The fourth chapter presents the case study data in a summary matrix, which is analyzed according to the location theory concepts developed in Chapter 2. The analysis identifies common locational factors across all five firms, identifies differences, and attempts to elucidate the important distinctions across different firms' decisions.

The final chapter draws conclusions from the data and presents some generalizations about biotechnology firms' location decision-making. These generalizations may be useful for other firms about to make similar decisions.

Chapter 1: The Biotechnology Industry

Biotechnology as an industry segment generally includes "those firms which employ the techniques of genetic engineering and molecular biology in the manufacture of peptides, proteins, and other biological materials, for use in health care, chemical, agricultural, or environmental applications," according to Professor Charles Cooney. For the purpose of this study, biotechnology companies engaged in biotherapeutics were chosen for analysis. The following information is intended to provide an industry context.

In 1992, the national industry was composed of 1231 companies, with 225 companies publicly traded (Burrill and Lee, 1992). Companies were typically classified according to their primary markets, defined as follows:

Table 1

Segment	Percentage of companies
Human health care—diagnostics (disease detecting products)	28
Human health care—biotherapeutics (pharmaceutical drug development and manufacture)	38
Ag-bio (microbial crop protectants, plant genetics, food processing, animal health)	10
Suppliers to the industry (instrumentation, lab supplies, reagents, other supplies)	16
Chemical, environmental and services	8

Source: Burrill and Lee (1992)

As indicated, 66% of companies were in human health care. As well, human health care companies represented 83% of public companies. Total company growth in numbers from the previous year was modest, from 1107 to 1231, but

employees increased from 70,000 to 79,000. Revenues exceeded $5.9 billion, with research and development expenses at $4.9 billion, and net loss at $3.4 billion. However, product sales growth from the previous year, for public companies, was 31%.

Burrill and Lee (1992) categorized companies by size; small companies (1-50 employees) predominate, with a 76% share of the industry's overall employment.

Table 2

Company Size	% of Total Industry	% of Public Companies
small (1-50)	76	48
mid-size (51-135)	16	31
large (136-299)	6	10
top-tier (≥300)	2	11

Source: Burrill and Lee (1992)

Most companies in all size categories posted losses at the end of 1991, ranging from an average $2.4 million for small companies to $20.9 million for the top tier.

Geographic Distribution

Table 3 shows the distribution of biotechnology companies nationwide. As shown in the table, the San Francisco, New York-Tristate and Boston areas possess the largest concentrations of firms. Companies in these three areas alone employ 36% of the industry's total workforce.

Table 3

Geographic Segment Demographics

	Percent of industry within region		Public company size breakdown within geographic region (percent)				Public company market breakdown within geographic region (percent)				
	Public cos.	All cos.	Small	Mid-size	Large	Top-tier	Diag-nostic	Thera-peutic	Ag-bio	Supplier	Chem, Environ-mental and Services
San Francisco Bay Area	16	15	39	31	11	19	11	70	8	8	3
New York Tri-State Area	15	11	54	28	15	3	15	76	0	9	0
Boston Area	14	10	33	37	17	13	14	80	3	3	0
San Diego Area	10	8	29	62	9	0	14	67	14	5	0
Washington DC Area	6	9	39	39	7	15	15	54	15	8	8
Los Angeles/Orange Co.	6	6	50	25	0	25	33	67	0	0	0
Philadelphia/South NJ	5	3	46	18	18	18	0	73	18	0	9
Seattle Area	3	4	43	43	0	14	0	86	0	14	0
Florida	3	2	71	0	0	29	0	100	0	0	0
Minnesota	3	2	66	17	0	17	33	33	0	34	0
Colorado	2	2	60	20	20	0	0	80	20	0	0
Michigan	2	2	60	40	0	0	60	0	20	20	0
Texas	2	4	50	25	25	0	25	50	25	0	0
North Carolina	1	3	67	33	0	0	67	33	0	0	0

Source: Burrill and Lee (1992)

In part, these concentrations are a direct result of the history of biotechnology, which had its genesis in university research in molecular biology conducted at Harvard, MIT, Stanford and Caltech, and funded largely by federal agencies. Virtually all biotechnology start-up companies were founded, managed or directed by university professors, beginning with the founding of Cetus in California in 1971. A common model was for an academic to team up with venture capitalists; initially, public stock offerings were not common, nor were limited partnerships or alliances with chemical or pharmaceutical companies until the mid to late 1980's. Pharmaceutical companies (historically concentrated in the New York-Tristate area) entered the business actively beginning in 1983, in five ways: (1) in-house research labs, (2) contracts with universities and with the professor-initiated companies, (3) licensing and

marketing agreements, (4) limited research and development partnerships, and (5) equity purchases (Hall et al., 1988).

Financing/Commercialization Strategies

Currently, the biotechnology industry is primarily funded by the equity markets, through private placements, public stock offerings, and corporate partnerships. Partial acquisition by a pharmaceutical company is an example of the latter; for example, a substantial or controlling portion of a biotechnology company's stock may be purchased by a large pharmaceutical company. Biotechnology companies are also forging innovative alliances with other biotechnology firms, as well as pharmaceutical firms, combining resources with them, or initiating product swaps. In these alliances, companies place emphasis on royalty percentages and retention of U.S. manufacturing and marketing rights. In some alliances for research and development funding, benchmark payments for specific achievements are made, according to Professor Charles Cooney.

Public equity capital, both initial and secondary public offerings, has been a substantial source of funding. ($3.24 billion was raised in the July 1991 through June 1992 period.) Currently, however, market uncertainties have dampened these financing activities. President Clinton's signing of the Biodiversity Agreement, and prospective health care reform, with its cost containment provisions, have injected uncertainty into the capital markets. Many firms, even those with proprietary processes or products, fear facing reduction in prospective profits. (Gupta, 1993)

Unlike traditional pharmaceutical companies, biotechnology firms have very little debt financing or internal financing. The primary factors restricting asset debt financing are: lack of credit-worthiness of the industry due to its annual operating losses (despite its high capital reserves), restrictive Federal

Reserve-imposed bank lending practices on real estate in general, and potential lenders' unwillingness to lend on what are perceived as special purpose properties without potential resale value (NAIOP, 1992). Table 4 describes financing alternatives.

Table 4: Biotechnology Financing Alternatives

Type	Amount (millions)	Company Age	Company Stage	Advantages	Disadvantages
Grants and Gifts	$0-5	Inception to 5 yrs	Pre-seed	"Free-money"	Limited availability and size. Some grant-specific requirements
Venture Capital	$1-10	1-5 yrs	Pre-clinicals	Availability. Substantial VC involvement	Lower valuations. Substantial VC involvement
Private Placements	$1-35	1-10 yrs	Preclinical-advanced clinicals	Higher valuation	Limited availability
Strategic Alliances	$1-40	Unlimited	Clinical to maturity	Substitute for integration. Substantial size	"Futures" can be the most expensive financing.
Initial Public Offering	$15-100	3-10 yrs	Incubation	Large financings possible. No cash servicing required	Markets highly cyclical; public valuation not completely manageable
Secondary Public Offerings	$20-150	3 yrs +	Start-up to maturity	Same as IPO, but often at higher valuations	Infrastructure requirements
SWORDS	$20-50	Sponsor must be public	Pre-clinical to clinical trials	"Off balance sheet" Theoretically, avoids dilution	Repurchase can be costly. Technical difficulties
R&D Partnerships	$1-50	1 to unlimited	R&D	Same as SWORDS, but some tax leverage	Same as SWORDS—liquidity and transferability is limited
Debt:					
Convertible	$1-100	1-10	Clinical to maturity	Usually "cheap." Sold based upon convertibility. Generally not based on yield	Debt service requirements
Asset based	$1-50	1 to unlimited	Developing	No dilution	Initially for buildings and equipment, then receivables/ inventory
Unsecured	$1-10	Over 5 yrs	Operational	No dilution	Generally unavailable
Operations	Limited	1 to unlimited	Operational	Cheapest form of financing	Limited source of cash

Source: Burrill and Lee (1992)

In an Ernst and Young survey of biotechnology company CEOs, 42% said their goal was fully integrated facilities (conducting all phases from research and development through commercialization of the product) and 27% wanted to build their own manufacturing facility (Burrill and Lee, 1992). Such vertical integration suggests that the biotechnology firms would remain diverse and independent. Autonomy, retention of proprietary technology, quality control and full capture of profits are some of the benefits of vertical integration. More cautious growth strategies and simultaneous pursuit of multiple product developments are methods companies use to attain this goal. Financing arrangements are likely to be "hands-off" corporate partnerships or public stock offerings for these companies; they may also be more aggressive about seeking economic development assistance.

Production Processes

The industry is characterized by complex production processes, a long product cycle (see Table 5 below), and chronic shortage of working capital because of long lead times to commercial production. A noteworthy characteristic contributing to the long product lead time of the industry, particularly for the biotherapeutic segment, is the level of federal regulation, primarily through the Food and Drug Administration (FDA), whose product testing and approval criteria must be met before pharmaceutical products can be marketed. For these approvals, safety and efficacy of the product, and process and manufacturing consistency must be demonstrated. It is noteworthy that recently, the FDA has signaled that product cost effectiveness is an additional criterion for approval.

Table 5

Biotechnology Company Life Cycle

	Research 0-3 years	Development 4-7 years	Commercialization 8-12 years
Financing	$5-10 million	$25-60 million	$100+ million
Sources	Investor seed money, venture capital	Corporate partners, Initial public offering	Secondary financings, Product sales
Product Stage	Discovery	Clinical testing	Market introduction
Space Requirements	R & D lab space	Expanded administrative, Small manufacturing	Production facilities

Source: Feinstein Partners, NAIOP (1992)

The production process (through the developmental and commercialization phases) is defined and constrained by this regulatory framework, as well as the actual product outcome desired. The regulatory timetable has been described in more detail elsewhere (Belden, 1993; Webb, 1991). An example of the complexity of the production process for an enzyme (a potential biotherapeutic) is shown in Figure 1. Table 6 details the necessary regulatory steps during the developmental phase.

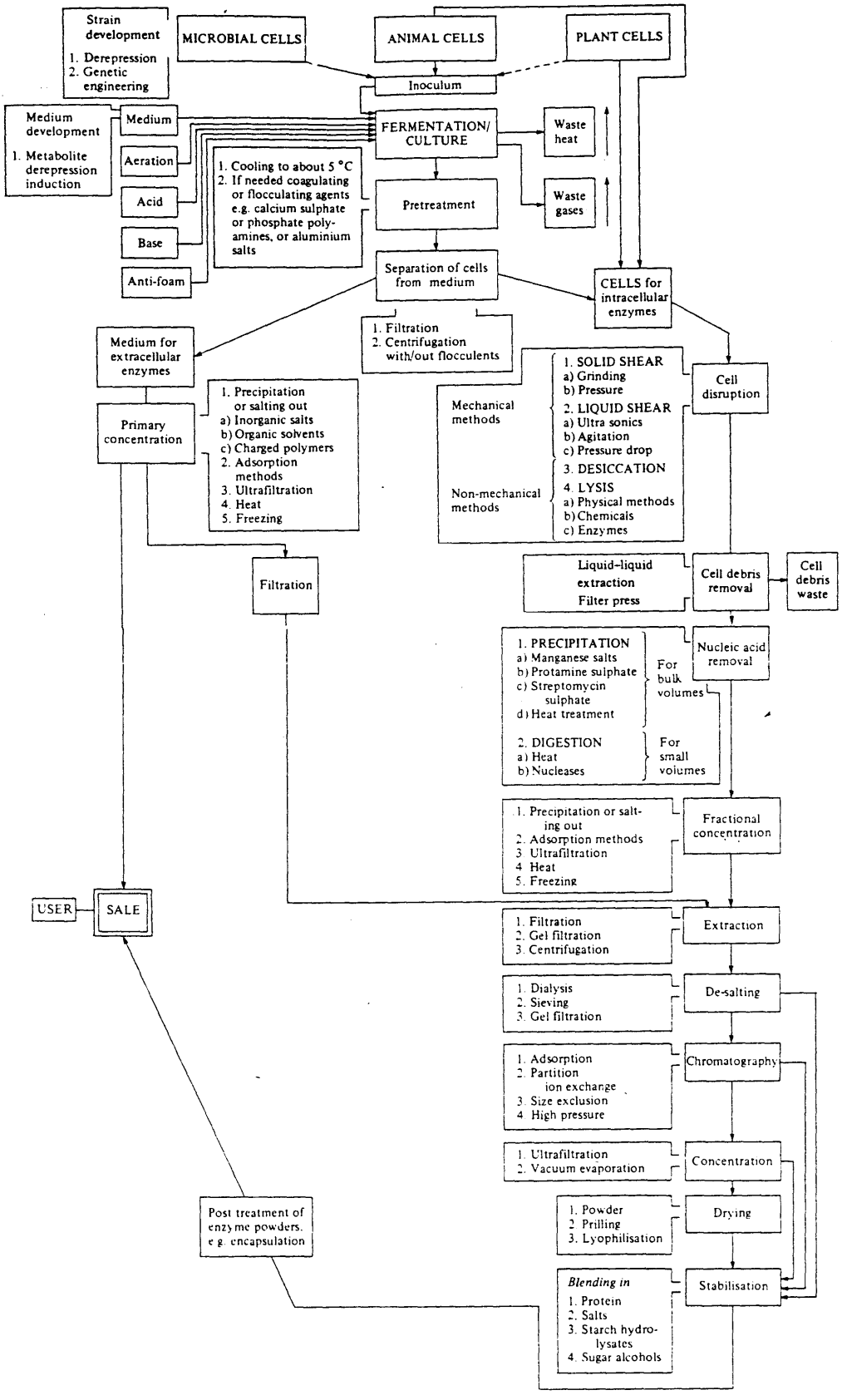

Figure 1. Stages in the production of purified enzymes (Jacobsson et al, 1986).

Table 6

Biotechnology Industry
Approval Cycle for a Medical Therapeutic Product

PHASE	GENERAL ACTIVITY	TIME SPAN
(Preclinical)		
	Research and testing on animals for efficacy & toxicity as well as replicating production	1-2 years
IND	Filing of "Investigative New Drug" application. New data requests could require 6-12 months of additional testing	1-2 months
(Clinical Trials)		
Phase I	Tests on healthy humans at multiple centers to determine product safety	1-2 years
Phase II	Tests on limited group with the medical problem to determine product safety	1 year
Phase III	Test of large numbers of patients to determine product efficacy	2-3 years
Final FDA Approval (NDA)	Collection, correlation, preparation & submission of test data and product review	1-2 years
	TOTAL	6-10 years

Source: S. Brainard, M. Podsedly, L. Sutlif, "Biotechnology Industry Analysis", Boston College School of Management (1989); Webb (1991)

The Product-Cycle Concept

The product-cycle concept argues that each stage of a product's development has different requirements, in terms of management, technology, labor, external economies and capital. It is summarized in the figure below, for manufacturing generally.

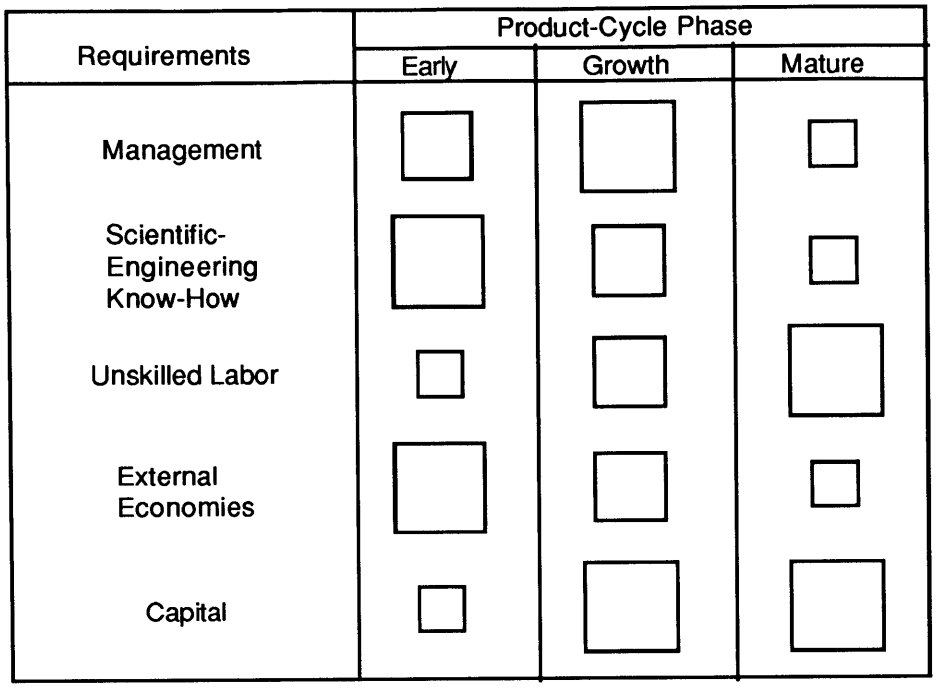

Figure 2. The product-cycle and production inputs. The relative importance of each category of input at each phase in the product-cycle is indicated by the size of the corresponding square. Source: Watts (1987)

Relatively fewer, or more, of various production inputs are required at different phases of the product cycle. The early stage typically requires high levels of scientific and technical inputs, and external economies derived from access to information sources and supplier linkages, for example. Capital investment is low relative to the later stages, because investment in fixed assets, for example, does not occur at the early stage (production runs are short and experimental). At this product stage as well, products and processes are undergoing constant creation and revision, requiring a high input of skilled labor. Greater management skills and capital are required in the growth phase of a typical company, relative to the early phase, to plan expansion and to invest in capital equipment. The mature phase is characterized by mass production using a stable technology. The major capital investment required to set up the mass production is offset at this stage by the labor input, which is less skilled relative

to that in the early and growth phases. (Watts, 1987)

Biotechnology Industry Product-Cycle

The biotechnology industry fits the product-cycle pattern overall, with some differences from manufacturing in general. Because of the long times to production, biotechnology firms require more capital in the early phase, relative to manufacturing in general, as well as in the highly automated mature phase. Scientific, engineering and technical inputs are higher for biotechnology than for a typical low-tech manufacturer through all three phases, and external economies are typically higher for biotechnology, relative to manufacturing in general, in the growth phase as well. For biotechnology, unskilled labor requirements are lower, relative to those in manufacturing in general, in all three phases. A suggested modification of the product-cycle for the biotechnology industry is pictured in Figure 3.

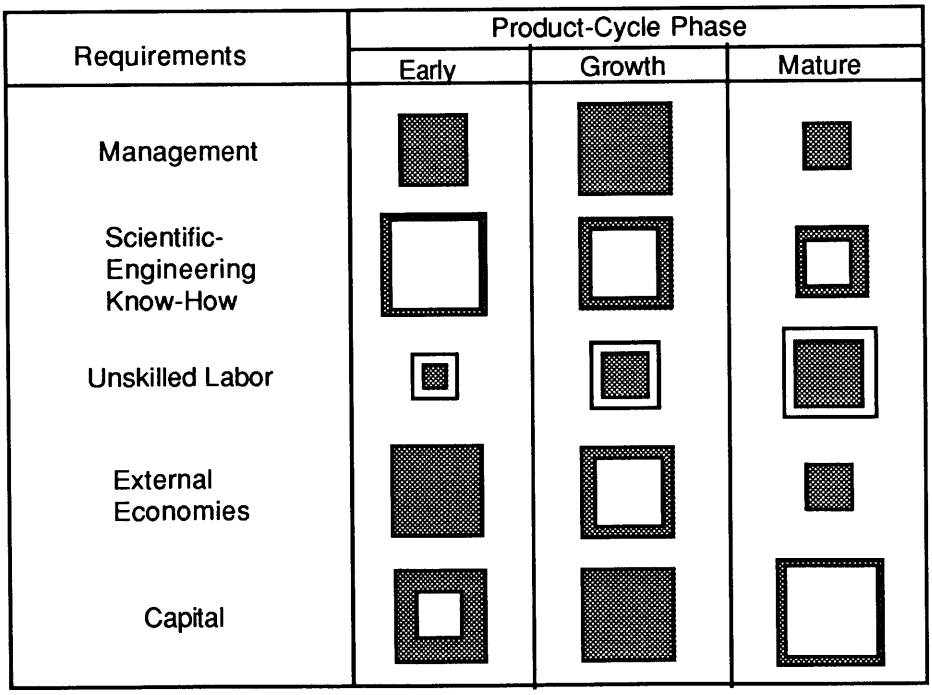

Figure 3. Biotechnology product-cycle and production inputs. Biotechnology is represented by the shaded squares; where the relative importance of a requirement in the biotechnology industry differs from that of the same

requirement in manufacturing in general, the latter is indicated by a blank square.

Comparison of Biotechnology and Microelectronics Industries

The California biotechnology industry has been compared to another industry in California, microelectronics, partly because both are high-technology industries, and are clustered in the same area (San Francisco). Further similarities between the two industries include dependence upon a highly skilled labor force, and proximity of both kinds of firms to universities and related research and developement facilities. (Watts, 1987)

Microelectronics differs from biotechnology in having not only a substantially shorter product cycle length, but lower capital requirements as well. In addition, microelectronics companies have had a different history. They were frequently started by engineers who had had prior corporate experience, unlike the biotechnology industry's academics, who generally had no production or product-marketing experience. (Blakely and Nishikawa, 1991)

> Microelectronics products are sold as components of more complex systems, whereas many biotech products are...sold to end users. The nature of research and development also differs. With microelectronics, variations and incremental changes in style and performance characteristics occur, with biotechnology, every product starts from original science...biotechnological innovation is not systemic in nature and compatibility among different processes and products is not an issue. (Blakely and Nishikawa, 1991, pp. 8-9)

Although the industries differ substantially, there are locational factors common to high-technology firms in general, as will be shown in the sections that follow.

Space Requirements

General spatial details should be highlighted: When companies start, lab bench space (2000-5000 square feet) for several research scientists is the space requirement. When clinical trials begin for fermentation-based products, for example, companies require pilot plants, ranging in size from 5000 to 20,000 square feet, to support 50-100 liter production batches for these trials. These

plants may be an expansion of the laboratory space used for basic research, or may be located in a separate pilot plant facility, often in the same building as the research and development function. After the FDA approves a product license, a 10- to 1000-fold scale-up of the production process occurs in a separate, dedicated manufacturing plant of 50,000 to 200,000 square feet. Before a plant can actually start marketable production, a GMP (good manufacturing practices) certification is required from the FDA, as well as a plant and process license, and an establishment license application approval (ELA), typically engendering an additional six-month delay in production after facility construction is completed. Once these FDA manufacturing approvals are gained, it is typically easier to amend them for new product manufacturing than to start the process anew at a new plant location. (Webb, 1991)

Costs associated with manufacturing plant construction range from $300 to $1000 per square foot (NAIOP, 1992). In general, functional areas at the manufacturing plant are divided into bioreactors, purification, quality control and quality assurance, HVAC, and warehousing. They are typically two- to three-story, new structures. Retrofitting of existing industrial buildings occurs, but is usually not cost-effective because of high floor-to-ceiling height requirements and high floor load requirements. Ceiling heights must be designed to accommodate specialized HVAC systems to control particulate flow, temperature and humidity in production areas. Energy and plumbing systems are specialized as well. For some products, sterility must be maintained through installation of seamless stainless steel equipment, provision of a sterile water processing plant and special treatment of waste before it is discharged into the public sewer system (Belden, 1993).

As noted above, the rigor and expense of plant requirements are dependent on the process used and product manufactured. In addition,

biotherapeutics are typically low-volume high-value products, and thus have low shipping costs. The effect of transport costs on the manufacturing location decision will be described in the section that follows.

Massachusetts Biotechnology Industry

The biotechnology industry in Massachusetts mirrors the industry nation-wide. The commonwealth possessed approximately 128 firms in 1992, representing 10% of all companies, with 80% concentrated in the biotherapeutics market segment. Fifty percent of the firms are small and mid-size companies, having 135 or fewer employees. Employment in 1992 was estimated at 13,530, with total sales of $471 million posted in 1991 (Malaterre, 1993; Burrill and Lee, 1992).

Figure 4 shows the location of Massachusetts biotechnology companies; firms are predominantly in urban areas or on major highways. Zoning or board of health regulations are formally in place in these communities (approximately 25 state-wide), explicitly to regulate genetic engineering research. These regulations typically incorporate by reference NIH guidelines regarding the use of recombinant DNA, and provide for a local inspection board. (Recombinant DNA technology is subject to an extraordinary degree of regulation because it is relatively new and radical; fermentation and enzyme technologies are older.) Adoption of such regulations by a community sends a signal to the biotechnology industry that it is encouraged to locate there (Griffith, 1992).

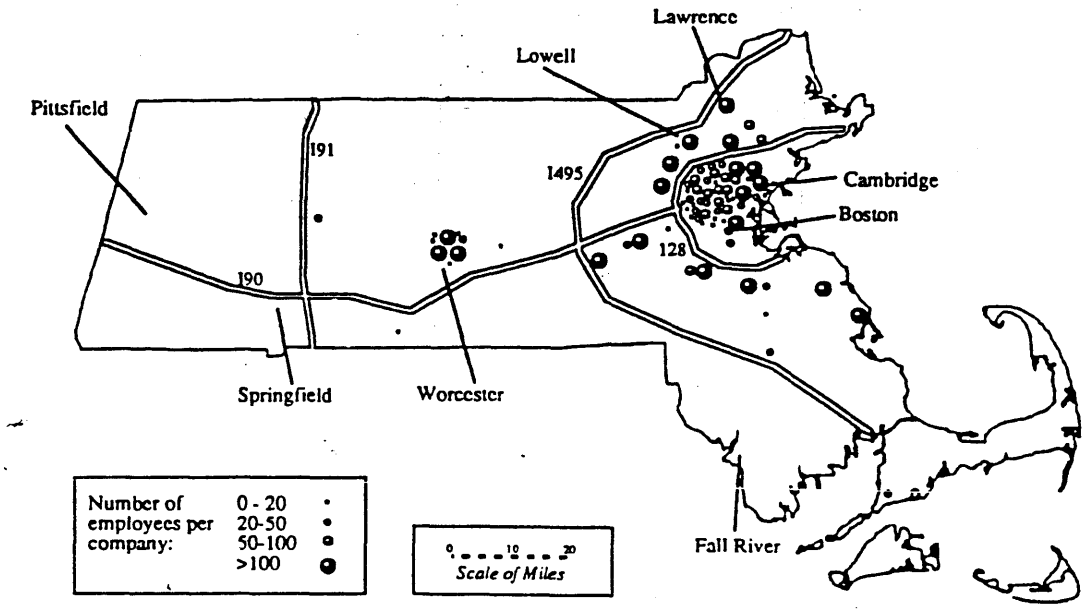

Figure 4. Location of Massachusetts biotechnology firms (Malaterre, 1993).

Massachusetts firms occupy about 7 million square feet of lab, office or manufacturing space, with 3 million square feet in institutional use in the Boston area around major research hospitals, and 4 million square feet in corporate use. Of this corporate square footage, 1.8 million are in Cambridge and 0.7 million are in the Worcester area. Institutions are usually owners and corporations typically lessees of the space. In Massachusetts, biotechnology laboratory space is fully occupied, with unmet demand estimated at 0.4 million square feet in Cambridge and 0.35 million square feet in Worcester. Projected additional demand is estimated at 8.1 million square feet by the year 2000 for all types of biotechnology facilities (NAIOP, 1992).

The real estate development community has already identified sites in Boston, Cambridge, Worcester/Shrewsbury and other communities. These

sites can support the 8-9 million square feet of projected demand (Feinstein, 1992). However, most Massachusetts firms are still in the research and development or clinical trials stage, and find it impossible to access asset debt financing for construction of base facilities or for tenant improvements. The lack of credit enhancement to secure such financing is seen by the Massachusetts real estate development community as one of the major obstacles to the construction of biotechnology facilities (NAIOP, 1992).

A variety of state and local economic development policies, financing and tax initiatives have been catalogued and recommended in other studies, to deal with the specific issue of credit enhancement, as well as the broader issue of the attraction/retention of biotechnology facilities. Economic development incentives have also been advocated for attracting and retaining manufacturing. The nature and quality of jobs generated, both directly and indirectly, from manufacturing employment (average salary of over $30,000 and up to 17.5 jobs per $1 million in activity, consistent with the traditional pharmaceutical manufacturers' job-multiplier effect) have been emphasized (Belden, 1993; Malaterre, 1993; NAIOP, 1992; Webb, 1991; Massachusetts has a variety of programs in place at the local and state level, described by Belden and NAIOP).

A recent development in Massachusetts economic development incentives has been the passage of legislation (M.G.L., Chapter 19, in March 1993). Three components of this new legislation that have important implications for the biotechnology industry are: the creation of an Emerging Technology Fund, an increase in the investment tax credit, and tax increment financing, according to Joseph Donovan of the Massachusetts Office of Business Development (Appendix B more fully describes these programs).

Labor Factors

Massachusetts biotechnology employment is currently at about 13,530,

as noted above. The projected employment in various functions is shown in Table 7.

Table 7

Employment Evolution in Massachusetts Biotechnology
(estimated number of employees)

	1992 Employ.	(%)	1995 Employ.	(%)	2000 Employ.	(%)
R & D	5,610	(42)	7,800	(41)	11,000	(36)
Manufacturing	5,370	(39)	7,500	(40)	13,200	(44)
Administration	2,550	(19)	3,450	(19)	5,700	(20)
TOTAL	13,530	(100)	18,750	(100)	30,000	(100)

Source: Malaterre (1993)

Skill levels of workers are estimated as over 90% with bachelors degree or higher at the research and development stage in the product cycle, 66% at the pilot plant stage and 43% at the commercial plant stage. Total employees in a pilot plant averaged 41, and at a commercial plant, 53. The commercial plant, with automated production processes and larger unit operations, requires fewer employees per unit of output than the pilot plant.

Massachusetts Survey

Malaterre completed a survey in late 1992 of 40 Massachusetts biotechnology firms, asking them to rank the importance of various locational factors, for both research and development and manufacturing facilities. The strengths and weaknesses of Massachusetts vis à vis locational factors were also surveyed. His summary tables are reproduced below:

Table 8

R & D Facility Location Factor
(ranked by mean response of the total sample)

	Locational Factors (1=very important, 5=not important)		Massachusetts Strengths/weaknesses (1=strength, 3=weakness)	
	Mean	Variance	Mean	Variance
Proximity to universities	1.5	0.4	1.1	0.1
Proximity to medical institutions	1.7	0.7	1.1	0.1
Availability/cost of space for expansion	2	0.9	2.3	0.5
Availability/cost of existing facility	2.1	0.9	2.2	0.4
State government attitudes	2.1	1	2.3	0.6
Local government attitudes	2.1	1	2.2	0.4
History of local regulations	2.3	1.1	2.2	0.4
Reasonable cost of living	2.4	0.9	2.7	0.3
Availability/cost of land	2.5	1.1	2.4	0.4
Proximity to other R&D biotech firms	2.6	0.9	1.2	0.1
Founder/CEO wanted to live in area	2.8	2.2	1.7	0.3
Infrastructures/Transportation	2.8	0.7	1.8	0.5
Cultural facilities	2.8	1.3	1.2	0.2
Access to venture capital funds	3.1	1.8	1.6	0.3
Availability/cost of incubator facility	3.1	1.9	2.1	0.4
Proximity to technology transfer center	3.3	1.5	1.6	0.3
Proximity to post-high voc./tech. schools	3.3	1.4	1.8	0.2

(Total sample = 40)

Source: Malaterre (1993)

Table 9

Manufacturing Facility Location Factor
(ranked by mean response of the total sample)

	Locational Factors (1=very important, 5=not important)		Massachusetts Strengths/weaknesses (1=strength, 3=weakness)	
	Mean	Variance	Mean	Variance
Availability/cost of space for expansion	1.8	0.7	2.4	0.5
Availability/cost of land	1.9	0.7	2.4	0.4
Proximity to firm R&D facility	2	0.7	1.6	0.4
State government attitudes	2	1	2.4	0.5
Availability/cost of existing facility	2.1	1	2.3	0.3
Labor cost	2.1	0.6	2.4	0.2
Reasonable cost of living	2.1	0.8	2.4	0.3
Local government attitudes	2.2	1	2.2	0.3
Cost of utilities	2.3	0.6	2.3	0.3
Majority of employees live near site	2.3	0.8	1.7	0.3
History of local regulations	2.4	1	2	0.3
Infrastructures/Transportation	2.4	0.6	1.9	0.4
Proximity to post-high voc./tech. schools	2.5	1.1	1.9	0.4
State/local training programs	2.6	0.6	2.1	0.3
Proximity to universities	2.6	0.7	1.4	0.2
Proximity to other manufacturing biotech firms	2.8	0.7	1.6	0.4
Proximity to medical institutions	3.2	1.2	1.4	0.2
Cultural facilities	3.2	1.3	1.4	0.3
Founder/CEO wanted to live in area	3.3	2	1.7	0.2
Proximity to major customers	3.4	0.9	1.9	0.2

(Total sample = 40)

Source: Malaterre (1993)

For research and development facilities, the most important location factors were: proximity to knowledge centers (universities and medical institutions); availability and cost of both existing space and space for expansion; and government attitudes, described in the questionnaire as taxes, financing, or regulations. In contrast, for manufacturing facilities, availability and cost factors, for expansion space and land, had priority. Proximity to the firm's research and development facility was rated as the third most important location factor, and state government attitudes fourth. Significantly, labor and utility

costs, which were not considered important locational factors in research and development facility siting, were viewed as important for manufacturing.

Another finding of the Malaterre survey was that manufacturing expansion was planned more frequently on new sites, while research and development expansion was planned on existing sites. This finding is logical, given the greater space requirements of manufacturing over research and development. Table 10 presents siting data.

Table 10

	Siting Consideration[1] (number of site expansions[2])	
Purpose	Expansion on existing site	New site
R & D	17	10
Manufacturing	9	20
Administration	15	9

[1]Companies were asked if they were planning a site expansion, on their existing site or on a new site. The answers were not designed to be exclusive. Thus, a very entrepreneurial company could perfectly respond that they were planning to expand at their existing site for all purposes, as well as at a new site for the same reasons.

[2]Total sample = 40

Source: Malaterre (1993)

Malaterre also found that Massachusetts is ranked by 92% of the companies as the preferred site for manufacturing siting; however adjoining states, California, Puerto Rico and foreign countries (Ireland, France) were also highly rated as potential industrial location choices.

Chapter 2: Industrial Location Theory and Locational Decision-Making

Why and how firms make the location decisions they do, and what factors are important determinants of the decision, are the subjects of an extensive literature of location theory and locational decision-making. The literature can be divided into three general methodologies, neoclassicist, behavioralist, and structuralist; the first part of this chapter is a brief description of each. In a second part, I review studies of the locational decisions of manufacturing firms, large and small, general and high-technology. The cited studies, while not exhaustive, provide a conceptual framework for analyzing the locational decisions of biotechnology firms in Massachusetts, the subject of the third and final part of this chapter.

METHODOLOGIES

Neoclassicist

Studies employing this methodology are highly quantitative, and follow the seminal econometric work of Alfred Weber (1929). Weber posited that firms would locate in response to transport, labor availability and the advantages/disadvantages of clustering with other industries, at least cost locations, for assembling raw materials and distributing output. Weber theorized that if labor productivity gains (savings in labor cost per unit of output) exceeded the extra transport cost involved, a firm could be attracted to a different location. He also noted the possibility that agglomeration economies can lure a firm away from its minimum transport and labor cost location. Weber considered that these economies (or diseconomies) arose from internal or external economies of scale, concentration or diffusion of labor skills, selling and buying patterns, the importance of infrastructure, and rising urban land

prices (cited by Cooper, 1974).

To explain why economic activity is attracted to certain locations, Hoover further refined agglomeration into three distinct components: localization, urbanization, and scale (cited by Ó hUallacháin and Satterthwaite, 1992). Localization economies are the tendency in some industries for a firm to have lower costs if located in the same area as others in its industry. Urbanization economies are the advantages large cities have in infrastructure, available services, and larger labor markets. Economies of scale lower unit production costs as the rate of production increases.

Later theorists criticized Weber's assumptions of given production costs, perfect competition, and given market conditions. Alonso (1964, 1967) showed that transport costs are not proportional to distance and theorized that the price of land is the most important determinant of location. He interpreted the suburbanization of automated manufacturing firms as a Weberian cost-minimization strategy, but with land price driving the location decision.

Further econometric elaborations in the Weberian tradition, at both the intrametropolitan and interregional scale, followed. Goldberg (1969) and Keeble (1984) found that space constraints limit the growth a plant can experience, and that lack of land availability is usually considered the premier reason for a firm's relocation. Foster (cited by Pacione, 1985), in a 1972 interregional study, found that labor costs can vary significantly in space and employers will have to pay more the further they are from labor's residence. Struyk and James (1975), in an intrametropolitan study, noted that manufacturing employment exhibits a high degree of mobility; that increased decentralization was found in manufacturing firms; and that the spatial clustering of related firms and the employment characteristics of the urban area influence locational behavior of firms. Czamanski (1974) refined the

agglomeration economies theory by studying industrial clusters. They developed the argument that major cities derive capital benefits from close proximity and short linkages between related industries. The main influences shaping modern location decisions, in their view, are technical and societal characteristics of the man-made environment (such as what industries are already present, and what technical competencies exist within them), rather than physical features like raw material availability or transport costs.

Moriarty (1980) noted the importance of cost of labor and availability of labor in locational choice. However, Czamanski (1981) asserted that it is not the cost or availability of labor, but rather the "distribution of skills, productivity and lack of labor disputes" that is important. Lever (1972) pointed out that the ultimate rationale in neoclassicist theory is that firms will locate where profits are highest, and that firms avoid large urban centers where land costs are highest. Labor costs may be higher away from cities, but more efficient use of labor is possible there. (In a more recent study, Kowalski and Parakevopoulos (1990) showed that submarket segmentation, as well, was an important determinant of land price, as was the land's expressway exposure.)

Wasylenko (1980) found that local property tax differentials were important determinants of manufacturing relocation. In addition, Mullen and Williams (1990) note that the educational profile of the workforce can partially account for labor efficiency growth and thus for interurban variations in productivity gain.

The costs of land, labor, taxes, and transport—as well as agglomeration economies associated with industry clustering, infrastructure, and the educational level, skill, and productivity of labor—all affect the locational decision. Urban space constraints also play a role. These factors are in general viewed by the neoclassicists as producing a cost-minimizing location

result. It should be emphasized here that in the location decision, these factors typically do not all point in the same direction. For example, economies associated with skilled labor clustered in an urban setting are typically offset by higher urban land prices, resulting in a manufacturing move to a suburban location. However, the localization economies associated with the biotechnology industry may offset the urban land cost factor. This issue will be discussed in more detail below. A mixed result, with some biotechnology firms remaining in urban locations, and others moving to suburban locations, can be expected, depending on the individual firms' needs and constraints. Neoclassical factors are not discarded in the theoretical frameworks of the behavioralists and structuralists that follow, but rather are embedded in them.

Behavioralist

Criticisms of the neoclassicist models of location, viewing an omniscient, rational "economic man" as an impossible decision-making ideal, resulted in a series of behavioral studies. Pred (1969) used a behavioral matrix to illustrate that the better the information that is available and the better the ability to use it, the more likely the location chosen would be the point of maximum profit. However, he pointed out that firms work with imperfect information and information availability. His work was based on that of Simon (1955), who found that some firms (optimizers) seek to maximize profits, while others (satisficers) seek to make sufficient profits; and on that of Rawston's (1958) concept of spatial margin to profitability—the idea that different process technologies have different cost and revenue structures, which can direct location. Krumme & Wood (cited by Pacione, 1985) found that firms use little information in locational choice decision-making. They distinguished between large and small firms, and noted that large firms do not have to make locational choices on cost minimization criteria. Cyert & March (1963) took the position

that multiple business goals exist (particularly in a large organization): growth, security, risk minimization, entrepreneurial satisfaction, self-preservation, as well as profit maximization. These goals will affect locational choice, even if full information is available about a profit-maximizing location. They also found that social and environmental preferences may weigh more heavily with small firms' locational decisions than with large ones'. Duncan (cited in Pacione, 1985) viewed the location decision-making environment in terms of a scale of increasing uncertainty and risk. The more firms can control external environmental elements (including price of inputs, products and flow of capital, labor and land), the more they can reduce the element of risk.

Thus, while acknowledging the neoclassicists' view that factor cost minimization criteria were important, the behavioralists incorporated the individual decision makers' values and preferences. At the same time, they recognized the imperfection of information use, particularly in forecasting the future.

Structuralist

Massey (1974, 1984) felt that the behavioralists did not take an adequately wide view of social forces and the macro-economy. As an alternative approach to neoclassicist theory, Massey's new conceptual view was that firms are part of a wider societal structure where labor and capital are in conflict. The firm is not abstracted as a model in itself, but "explanations of locational change are sought in the structure of the capitalist society in which the firm works" (Watts, 1987, p. 14). Massey recognized that different types of firm react in different ways. Large firms create their own distinctive patterns, and smaller firms react to the existing environment. Bluestone & Harrison (1982) noted firms were fleeing from unionized areas in the U.S. on a regional level. Bull (cited by Pacione, 1985) found that suitable labor, premises and relative

accessibility are important, and that most manufacturers rent. Thus, in the short and medium term, the property available for rent places constraints on manufacturing. Fothergill & Gudgin (1982), like the neoclassicists Goldberg and Keeble, also noted spatial constraints on in situ expansion in urban areas, typically leading to firms leaving urban premises. They also found growth in the number of multi-plant firms, which are less constrained locationally because national or international profitability decisions are made outside of existing locations (for example, decisions are based to some degree on lower tariffs, access to international markets, and lower factor costs).

Locational studies dealing with capital issues are not numerous, in large part because of the perception that capital operates in a national market. One, Estall's 1972 study, showed that venture capital promoted science research and development in Boston and Philadelphia, however (cited by Watts, 1987).

All three conceptual frameworks deal either explicitly or implicitly with factor cost minimization, labor force quality, and agglomeration economies. However, the behavioralists acknowledge the human element of preference and imperfect use of information, and the structuralists incorporate the firm's situational dynamics within the macroeconomy—politics or capital market conditions, for example.

MANUFACTURING LOCATION SEARCH AND DECISION-MAKING

Once a decision to locate a manufacturing plant at a new location has been made, the subsequent location decision-making process typically proceeds in three stages, according to Watts (1987). The process is diagrammed in Figure 5.

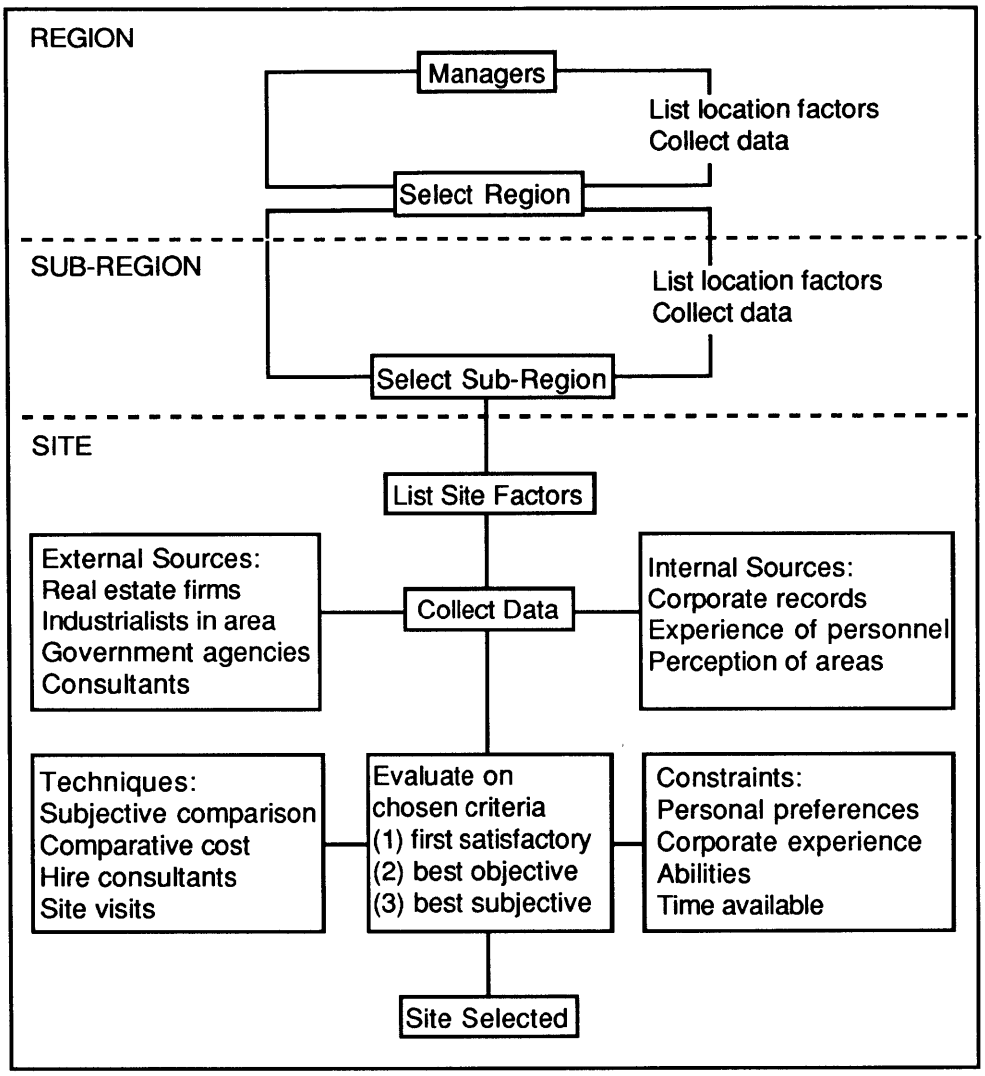

Figure 5. A three-stage industrial location decision sequence. This assumes a decision to move has already been made, and that a new facility, or relocation of an existing facility is needed. From Watts (1987).

In this section, I review the literature on the particular factors influencing location decisions in industry in general, and in high-technology industry. This review forms the basis of a comparison with the studies of locational factors in the biotechnology industry cited in Chapter 1.

Location Factors in Industry in General

The manufacturing location search and decision-making processes have been described by Schmenner (1982), Stafford (1974), and Cooper (1975). In

a survey of 484 executives, Schmenner found that the location decision was actually three decisions: whether to add capacity, how to add it (through in situ expansion, new plant construction or relocation) and where to site. In situ expansion was preferred because lower costs were associated with it. Both formal and ad hoc planning for the location decision occurred, with ad hoc planning most likely in smaller firms, which were also most likely to stay close to their initial sites.

Schmenner identified six dominant concerns or factors in the decision: labor costs, labor unionization, proximity to markets, proximity to suppliers/resources, proximity to other facilities of the company, and an area's quality of life. Stafford's study also found amenities and personal contacts to be important in the search, and that firms frequently confined their searches to areas where they already operated. Thus, Schmenner and Stafford's findings are consistent with the work of the neoclassicists in their cost and proximity concerns; of the behavioralists in the importance placed on quality of life, amenities and personal contacts; and of the structuralists in labor unionization concerns.

Schmenner also found that different factors were emphasized differently depending on the scale (i.e. regional, state, or site) of the decision. For example, he found that taxes had little effect on short-distance movers and land costs were less important for them as well, compared to long-distance movers. (See Tables 11, 12, and 13). He also found that 40% of location decisions were not formally costed out, and that government regulations and their cost, as well as the retention or attraction of managerial talent, were sometimes neglected in location decisions.

Table 11

Constraints on the Region/State Choice: Factors Viewed as "Musts"—All Industries

Factor	Percent of Plant Openings Citing at Least 1 Factor	Percent of Movers Citing at Least 1 Factor
Favorable labor climate	76	39
Near market	55	0
Attractive place for engineers/ managers to live	35	19
Near supplies, resources (includes energy	31	28
Low labor rates	30	19
Near existing facilities of division/ company	25	17
Environmental permits	17	8
Facility/land already available	3	6
Better transportation	2	0
Taxes, financing	1	0
Retaining current labor force	0	56
Community attitude	0	3

Source: Schmenner (1982)

Table 12

Constraints on Final Site Selection: Factors Viewed as "Musts"—All Industries

Factor	Percent of Plant Openings Citing at Least 1 Factor	Percent of Movers Citing at Least 1 Factor
Rail service	47	25
On expressway	42	31
Special provision of utilities (gas, sewerage, water)	34	22
Rural area	27	19
Environmental permits	23	3
Within metropolitan area	21	39
On water	16	11
Available land/building	8	11
Transportation (airport truck service	3	3
Community financing, support	1	0
Proximity to other division plant	1	3
Minimum acreage	1	0
Non-union site	1	0

Source: Schmenner (1982)

Table 13

Influences on Site Selection: Factors Viewed as "Desirable, if Available"—All Industries

Factor	Percent of Plant Openings Citing at Least 1 Factor	Percent of Movers Citing at Least 1 Factor
Favorable labor climate	76	44
Low land costs	60	50
Near markets	42	22
Low taxes	35	19
On expressway	35	28
Rail service	30	22
Low construction costs	29	33
Low wage rates	28	25
College nearby	26	14
Low energy costs	25	14
Government help with roads, sewerage, water, labor training	25	3
Near suppliers	23	25
Government financing	13	6
Available land/buildings	3	11
Near other division facilities	3	3
Air transportation	1	0
Quality of life	1	0
Retain labor force	0	3
Number of plants citing at least one factor	159	36

Source: Schmenner (1982)

In addition, Schmenner pointed to the apparent importance of "business climate", a factor which he described as follows:

> I am persuaded that personal preference and "business climate" still play a role in at least some location decisions. "Business climate" constantly eludes precise definition because it means different things to different people, yet for all it remains a rough metric of a location's expected ability to maintain a productive business climate: the attitude of working people to hard work, to quality work, to unionization; the attitude of government to business, as reflected in government aid in solving joint problems, and in regulations, tax rates, and financing; the attitude of government in managing itself, its services, its schools. A location's perceived business climate is markedly self-perpetuating and hence difficult to turn around, but there is no doubt that it does exert influence on new plant location decisions. (Schmenner, 1982, p. 53)

Schmenner (1982) also found that a variety of organizational forms were used to make decisions within the firms; most capital-intensive industries are likely to adopt a centralized large group study, and more entrepreneurial ones a centralized small group study. In the large group study, the location search is begun by a senior management committee, and studied by a staff group, which is taken from various functional areas. In the small group study, the location search is initiated by the CEO, or by a small group of senior managers; the analysis here is more informal.

In terms of economic development incentives, Schmenner found that help on the physical aspects of the site (as opposed to financial aspects) was highly valued by large manufacturers. Specifically, rapid, accurate information about potential sites, permitting assistance, and help with infrastructure (roads, water, sewerage), as well as help with labor training was viewed as desirable.

Schmenner's findings differed somewhat from Rees's and Weinstein's (1983) finding that economic development assistance has little impact on locational decisions since most states offer similar packages. Ó hUallacháin and Satterthwaite (1990) also found tax subsidies and issuance of industrial development bonds to be ineffective in stimulating employment growth; however university research parks and enterprise zones were useful for attracting service jobs. They concluded that focused development incentives that emphasize infrastructure improvement designed for specific industries were most effective for information-intensive industries, a finding not inconsistent with Schmenner's.

Ó hUallacháin's and Satterthwaite's study also confirmed the importance of localization economies, and wage costs, union strength and labor force quality as determinants of locational choice. However, unlike Schmenner, these authors did not find amenities to be important. They noted that

localization economies, insofar as they concentrate firms, increase the skill intensity of the local workforce, an important factor in the growth of information-intensive high-technology firms. These findings are consistent with the neoclassicists' work cited above.

Location Factors in High-Technology Industry

Premus (1982) looked at the factors influencing the location decisions of high-technology firms. Tables 14 and 15 show his identifications of the most important factors in the selection of both the region and a specific site. For the latter, like Schmenner, Premus found that labor availability is the top concern, followed by tax structure (in disagreement with Schmenner). Local business climate, cost of land, transportation accessibility, room for expansion, and a variety of quality of life measures were ranked next. (Cited in National Council for Urban Economic Development, 1984).

Table 14

Factors that Influence the Regional Location Choices of High Technology Companies

Rank	Locational Attribute	Percent rating Significant or Very Significant
1	Labor skills/availability	89%
2	Labor costs	72
3	Tax climate within the region	67
4	Academic institutions	59
5	Cost of living	59
6	Transportation	58
7	Access to markets	58
8	Regional regulatory practices	49
9	Energy costs/availability	41
10	Cultural amenities	37
11	Climate	36
12	Access to raw materials	28

Source: Premus, Robert. *Location of High Technology Firms and Regional Economic Development.* Joint Economic Committee, U.S. Congress, Washington, DC: U.S. Government Printing Office, June 1982, p. 23. Cited in National Council for Urban Economic Development (1984).

Table 15

Factors that Influence the Location Choices of High Technology Companies Within Regions

Rank	Locational Attribute	Percent rating Significant or Very Significant
1	Availability of workers	96%
2	State and/or local tax structure	86
3	Community attitudes toward business	82
4	Cost of property and construction	79
5	Good transportation for people	76
6	Ample area for expansion	75
7	Proximity to good schools	71
8	Proximity to recreational/cultural opportunities	61
9	Good transportation for materials and products	57
10	Proximity to customers	47
11	Availability of energy supplies	46
12	Proximity to raw materials/supplies	36

Source: Premus, Robert. *Location of High Technology Firms and Regional Economic Development.* Joint Economic Committee, U.S. Congress, Washington, DC: U.S. Government Printing Office, June 1982, p. 25. Cited in National Council for Urban Economic Development (1984).

Comparison of Location Factors in Biotechnology, High-Technology, and General Industry

Table 16 shows a comparison of major site factors influencing location from Schmenner (all industries), Premus (high-technology companies), and Malaterre (biotechnology companies; described in Chapter 1). Comparison of the three lists is complicated by their use of different terms for related concepts For instance, "state/local tax structure", and "community attitudes towards business" in the high-technology list correspond most closely with "state

Table 16

Comparative Site Location Factors

All industries Schmenner "dominant concerns"	High-tech firms Premus "significant"	Biotech firms Malaterre "important"
Labor costs	Availability of workers	Availability/cost of space for expansion
Labor unionization	State/local tax structure	Availability/cost of land
Proximity to markets	Community attitudes towards business	Proximity to firm R&D facility
Proximity to suppliers	Cost of property and construction	State government attitudes (taxes, financing, regs.)
Proximity to other company facility	Good transportation for people	Availability/cost of existing facility
Quality of life	Ample area for expansion	Labor cost
	Proximity to good schools	Reasonable cost of living
	Proximity to recreational/ cultural opportunities	Local government attitudes (taxes, financing...)
	Good transportation for materials and products	Cost of utilities
	Proximity to customers	Majority of employees live near site
	Availability of energy supplies	History of local regulations
	Proximity to raw materials/ supplies	Infrastructures-transportation
		Proximity to post-high vocational/technical schools
		State/local training programs
		Proximity to universities
		Proximity to other manufacturing biotech firms
		Proximity to medical institutions
		Cultural facilities
		Founder/CEO wanted to live in the area
		Proximity to major customers

government attitudes (taxes, financing, regs.)" and "local government attitudes

(taxes, financing...)" in the biotechnology list. The lists differ in length as well, ranging from six to twenty items. Still, by lumping some categories and truncating the longer lists, it is possible to extract six general areas of concern, and compare the relative importance ascribed to them in the three industry groupings. The six areas are: labor, taxes, space/land, the structuralist macroenvironment, clustering of company facilities, and transportation.

Labor concerns, in the form of "labor costs" and "availability of workers", rank first in importance in the all-industry and high-technology lists, respectively. Curiously, although they appear (as "labor costs") in the biotechnology list, they are accorded less relative importance (sixth place). This observation may underestimate the importance of labor concerns as location factors in biotechnology, though. The survey did not include labor availability or labor quality (Malaterre, 1993); industry sources indicate that these considerations are of primary importance.

A category designated "structuralist macroenvironment", encompassing labor unionization, as well as community and government attitudes shows up near the top of each list. It is reasonable to conclude that biotechnology differs little from industry overall in this concern. On the other hand, taxes evidently are more of a concern for high-technology and biotechnology than for industry overall. The reason for this difference is not obvious.

The primary location factor for the biotechnology industry is space/land. There is a continuum of variation in the relative importance of this factor, which appears to be moderately important for high-technology firms, and of little importance for industry overall. The extreme relative importance of the cost and availability of space and land may be a reflection of two characteristics of the biotechnology described in Chapter 1: capital constraints (lack of access to debt financing, and a strong tendency to locate manufacturing plants near the

(largely urban) research and development facilities.

Proximity to markets and suppliers are key location factors for industry in general, secondary factors for high-technology industry, but barely mentioned in the biotechnology list. Presumably, the differences reflect transportation costs. In the case of the high-technology and, especially, biotechnology industries, with their relatively low-volume, high-cost supplies and products, transportation costs are of relatively minor importance.

Interestingly, both the biotechnology industry and industry in general, but not high-technology industry, ascribe importance to clustering of company facilities. This tendency is indicated as "proximity to firm R & D facility" in the biotechnology list, and "proximity to other company facility" in the all-industry list. The non-appearance of this factor in the high-technology list suggests that its importance has different sources in the two cases where it does show up. In the case of industry in general, proximity most likely translates into relatively low costs for transporting supplies or products between company facilities. In the case of biotechnology, the industry is new, and the technology rapidly emerging. Under these circumstances, there is a strong tendency to cluster where the knowledge is: locating the research and development facilities near universities and medical centers, and, in turn, locating the manufacturing plants near the research and development facilities. Proximity, in this case, may translate into taking advantage of skilled labor and information linkages.

LOCATION FRAMEWORK FOR THE BIOTECHNOLOGY INDUSTRY

How does the location theory and locational decision-making literature integrate with what we know about the biotechnology industry, in particular the biotechnology industry in Massachusetts, as it moves into its manufacturing phase?

Neoclassicist Issues

1. Transport costs/Market proximity

Since most Massachusetts firms are in the biotherapeutics segment, in which both inputs and outputs are generally low volume and high value goods, transport costs both from suppliers and to final markets should not be a major cost factor, or an important factor in the manufacturing location decision. The Malaterre survey indeed indicated this, ranking proximity to major customers last in its list of manufacturing location factors. (The factor of supplier proximity was not included in this survey. The factor "infrastructure, transportation" in the survey does not reveal if transport costs or accessibility to transportation is intended.) However, specific firms, that have major transport costs associated with production may not locate their manufacturing facilities in Massachusetts. They may prefer to be located centrally, or near their suppliers; an ag-bio company which requires proximity to large quantities of corn would be an example (Webb, 1991). Because the biotechnology industry encompasses such a wide array of production processes and products, it is difficult to make a generalization about the importance of supplier/market proximity as location factors; however, for the biotherapeutics segment, such proximities are not important in the decision-making process.

2. Labor factors

Given the need for highly skilled and semi-skilled labor by biotechnology firms, the neoclassicist issue of labor availability is an important location factor. It was ranked first in the Premus survey of high-technology firms. As discussed above, it was not directly ranked by Malaterre; however, the factor "majority of workers live near site" was considered important. Labor quality (concentration of labor skills and educational profile) is also an important issue for biotechnology firms, and was indirectly addressed in Malaterre's survey through

the rankings of the factors "proximity to technical schools" and "state/local training programs". Labor costs were ranked sixth in importance in the Malaterre survey; the biotechnology industry would like to minimize labor costs, given that operating losses are the norm.

3. Agglomeration economies

The biotechnology industry seeks internal economies of scale, as indicated by its desire for proximity to existing research and development facilities to aid in manufacturing scale-up processes (Malaterre, 1993). It also seeks to cluster near related industries: other biotechnology firms, universities, and medical institutions. The concentration of labor skills, discussed above, is also a localization economy issue, and an expected location decision factor. The influence of infrastructure is also significant, since the biotechnology industry has high water usage rates, particularly in its manufacturing facilities, and needs a public sewer system for water discharge (Belden, 1993). These factors would tend to favor urban locations for plant siting.

4. Land

Biotechnology firms view land price and availability as important in the location decision and some suburbanization of firms has occurred, due to lack of land availability and higher urban land prices relative to the suburbs (Rosenberg, 1993). However, the Malaterre survey revealed that in situ expansion is preferred by biotechnology companies for research and development and, in turn, proximity to research and development is preferred for manufacturing. The Malaterre survey ranked the availability and cost of space and land as primary factors affecting the location decision. Similarly, Premus viewed the cost of property and construction as important location factors for high-technology firms overall. Land accessibility (expressway exposure, for example), aids labor mobility, and may also be a factor in

biotechnology firms' plant decisions, if a decision to leave an urban location is made. Premus ranked good transportation, and Malaterre "infrastructures—transportation", as important site location factors. Parking costs, in addition, have been taken into account in location decisions (Rosenberg, 1993).

5. Tax climate

Premus ranked state and local tax structure as important high-technology location factors. Malaterre's survey ranked "state government attitudes (taxes, financing, regs)" and "local government attitudes (taxes, financing)" as important manufacturing location factors. If the survey respondents interpreted these questions primarily as tax cost factors, then the locational paradigms based on cost minimization have applicability

Behavioralist Issues

1. Preferences

Biotechnology firms view state and local attitudes as important location factors (Malaterre, 1993). Premus viewed community attitudes towards business as an important location factor. If these factors are interpreted as state or local receptivity to biotechnology firms, then some firms may prefer to locate where such receptivity exists. As the case studies that follow show, biotechnology firms do view such preference factors as important determinants of the manufacturing location decision. In addition, Malaterre's finding that 92% of Massachusetts firms preferred to stay here, and that some founder/CEO's wanted to live here, supports this view.

2. Other behavioralist issues

Biotechnology companies' use of information and alternative business goals (other than profit maximization) will be discussed in the case studies and analysis that follow.

Structuralist Issues

1. Social forces

Labor unionization is not a factor influencing biotechnology firms. As noted previously, most biotechnology labor is skilled or semi-skilled, and the number of manufacturing workers are relatively low (Webb, 1991). Unions have never been a presence in the Massachusetts biotechnology industry, according to industry sources.

As previously noted, the political climate at the national, state, and local levels, can be considered a structuralist issue (Gupta, 1993). The availability of economic development assistance in Massachusetts, insofar as it reflects the political nurturing of biotechnology, can also be considered a structuralist issue. However, an argument can also be made that if economic development assistance takes the form of financing or infrastructure improvements, these are factors that reduce costs, and are therefore neoclassicist issues.

2. Capital availability

Capital constraints, particularly the lack of access to debt financing for small biotechnology firms, can affect those firms' location decisions. Several studies found financing to be a barrier to growth (Malaterre, 1993; NAIOP, 1992). Biotechnology stock offerings can also be affected by the capital markets, which in turn can affect whether a manufacturing plant is constructed or not (Gupta, 1993).

3. Regulations

Federal regulations, which govern the licensing of products and plants, and local regulations, are part of the structure in which a firm must operate. FDA regulations, in particular, are viewed by biotechnology firms as a barrier to growth, because product and plant licensing must occur simultaneously (Malaterre, 1993). On the other hand, local regulations governing the use of

recombinant DNA, in the form of zoning or board of health statutes, are seen by biotechnology companies as indicating a community's suitability as a manufacturing location (Griffith, 1992).

4. International/national scope

Some Massachusetts biotechnology firms possess international plants, or are part of a larger, international company. This suggests access to international markets and other factors affecting international operations may affect their location decisions.

Summary

Because the biotechnology industry in Massachusetts is a largely urban and capital-intensive industry, land and space expansion issues are concerns. Unlike other high-technology firms surveyed, biotechnology firms exhibit a strong preference for locating manufacturing facilities close to the firms' research and development facilities. This can be viewed as either a cost-minimization strategy (if the manufacturing facility can be built as an in situ expansion), or as a locational economy factor, because of the information-intensive nature of the biotechnology industry. As I hypothesized, high urban land prices or rents must be factored against such cost savings or economies by the biotechnology firms' decision makers. Because of the industry's capital constraints, state and local economic development financing incentives, coupled with physical siting assistance, may well be critical location factors. Tax structure and land accessibility are also expected to be considered in the location decision.

The behavioralists' studies suggest that large biotechnology firms are less likely to locate based on strict cost-minimization criteria, but rather based on other business goals. In part, this is because many have already accessed the equity capital markets and/or have capital reserves to tap for facility

construction. They may also view the location decision as just one component of an overall business strategy. In the case studies that follow, some of these behavioralist issues will be illustrated.

Some Massachusetts biotechnology companies are international in scope, and possess multiple plants. According to the structuralists' studies, they may respond locationally to a different set of factors than smaller firms, who may only operate in the national market. Smaller firms are also more likely to have difficulty accessing the debt and equity markets; this may affect or constrain their locational choices.

Chapter 3: Case Studies

STUDY A: BASF BIORESEARCH CORPORATION

Company Identity

In 1993, BASF Bioresearch Corporation was considered "a department within a division" of the BASF Group, which is composed of BASF Aktiengesellschaft and its affiliated companies (350 total), headquartered in Germany. The BASF Group produced a diversified array of products—chemicals, oil, gas, agricultural and consumer products—and had over 130,000 employees internationally. The parent company was 127 years old; its U.S. headquarters was in New Jersey. Chemicals, crop protection products, plastics, fibers, dyestuffs, finishing products, and consumer products, including pharmaceuticals, were produced in different U.S. divisions. Over 18,000 BASF employees worked in the U.S.; 130 were employed by BASF Bioresearch Corp. in a 39,400 square foot research and development facility in Cambridge, Massachusetts, conducting pharmaceutical research in oncology and immunology, using recombinant DNA technology. A 250,000 square foot combined research and development, administrative, and pilot plant manufacturing facility was under construction in Worcester, Massachusetts. All BASF Bioresearch employees expected to be located there in the fall of 1993, when construction was expected to be completed. It was a mid-size, growing biotechnology company, anticipating employing 450 people in the year 2000.

Company History

BASF Bioresearch Corporation was started in 1988 because of BASF AG's desire to get into recombinant DNA research. Its initial location was planned for Germany; in fact, preliminary engineering was done at a site there. However, the regulatory environment became restrictive—several federal

German laws, including the national law on emission standards, were applied to restrict genetic engineering (recombinant DNA) research, making it "a long and tedious process," according to Peter Moesta, Vice President of Process Development and Operations, "to receive permits." Later, in 1989, a German "Gene Law" was passed, with stringent restrictions governing university as well as industrial research. This regulatory environment caused the parent company to evaluate locating such a facility in another country. Research and development space in Cambridge was leased in 1988. A site in Cambridge was under serious consideration for purchase in 1989, but liability concerns arose over possible environmental contamination under an existing industrial building on the site.

The $90 million facility under construction in 1993 was on a 30-acre green field, purchased by BASF, in the Massachusetts Biotechnology Research Park in Worcester. The 75-acre park, dedicated to "growing biotechnology", was originally state-owned land adjacent to the University of Massachusetts Medical Center. (45 acres remain in the park, after the 30-acre sale to BASF.) Ownership of the land passed to the Worcester Business Development Corporation in 1984, and state and federal economic development funds of about $3 million have paid for infrastructure improvements at the site. Along with other companies at the park, BASF has benefitted from the improvements. In addition, Moesta said, "we requested state assistance to help speed the state permitting process, (but) it's difficult to know whether two months or six months were saved by asking... They [the Executive Office of Economic Affairs] are highly bureaucratic."

The multi-story facility was to be left one-third unfinished in the interior, to permit future expansion either for additional pilot plant trials (three products will be tested initially) or for batch production of the final proprietary products. In

1993, approximately 10% of the built-out facility was planned to be dedicated to administrative functions, 30% to manufacturing, and the rest to research and development.

Manufacturing Location Decision

According to Moesta, the restrictive German regulatory environment in 1988 triggered an evaluation of where BASF AG wanted to site its bioresearch facility. Four major criteria were used for the initial global evaluation:

(1) The regulatory environment. In response to its experience in Germany, BASF excluded other countries (e.g., Switzerland, Denmark) from consideration because of restrictions on recombinant DNA research. This level of restriction did not exist in the United States.

(2) Scientific environment. An attempt was made to evaluate quality of science in various countries. University rankings, numbers of Ph.D.'s, literature citations, Nobel laureates, and federal support of science were used as quantitative measures. (Some of these measures turned out not to be quantitatively meaningful, however. "How do you measure the scientific contribution of an 89 year-old Nobel laureate?" Moesta asked.) U.S. science was considered of the highest quality.

(3) Proximity to major markets. The U.S. was the second largest market for the BASF group. It contained company production and marketing facilities, but no research facilities of any type. BASF wanted to diversify its research and development effort out of Germany and into this major market. "The [U.S.] regional marketing head had a lot of power in the decision," according to Moesta.

(4) Communication to Germany. The western U.S. was excluded because the time differences between German headquarters and California meant company colleagues could not be reached during office hours.

The result of this evaluation was that the eastern U.S. was considered the appropriate global choice.

A regional evaluation was then performed on five areas: Greater Boston, New Jersey, Greater Washington DC, Philadelphia, and Raleigh, NC. It was based on:

(1) Regulatory environment. All five areas had similar regulatory environments.

(2) Scientific environment. Boston had the highest scores in "cutting edge, basic discovery science," according to Moesta.

(3) Availability of staff.

(4) Access to Frankfurt, Germany. An international airport within a one hour drive was considered a necessity.

(5) Overall business environment. This category included taxes, wages, and utility costs. Moesta said the Boston area fared second worst in this category, but "you pay what you have to pay", for labor, for example. He also said a tax analysis was completed on each area.

A qualitative scoring system was set up; it resulted in Greater Boston scoring highest, primarily because of the strength of its scientific environment. The final level of site selection involved the following criteria:

(1) Local support. The Worcester site had local support through the way in which it was created and through local zoning ordinances.

(2) Availability of water and sewer.

(3) Proximity to universities and other biotechnology companies.

(4) Permits already in place.

(5) Transportation accessibility for employees (road, rail, and air).

(6) Attractiveness of site.

(7) Cost of living for employees.

Moesta said land and building costs were not an issue, but could have become

one. He mentioned that the construction is within schedule and on budget, and that the site purchase price was less than those of alternative sites reviewed. About 50 sites were looked at, using a commercial broker. About five or six were seriously considered, although none was explicitly costed out. "We view this as an investment," Moesta said.

General Business Strategy

BASF was pursuing a capital investment strategy. Backward vertical integration, from research and development through pilot plant and small manufacturing, and proximity to the U.S. market, were goals to be furthered by locating its biotechnology company in Massachusetts.

Financing

The construction was financed through earnings of the parent company.

STUDY B: GENZYME CORPORATION

Company Identity

In 1993, Genzyme Corp. was a top-tier "health care products" company, with four primary business areas: biotherapeutics, diagnostic services, diagnostic products, and pharmaceuticals and fine chemicals. It had over 1500 employees in four locations. Its 86,000 square foot headquarters provided administrative, research and development, and diagnostic product manufacturing facilities, in Cambridge, Massachusetts. A second Cambridge location provided 21,000 square feet of manufacturing space. It leased a 120,000 square foot manufacturing plant in Framingham, where three products, including Ceredase, its proprietary biotherapeutic, were produced using conventional extraction methods. In addition, for process engineering and pilot plant capacity, two other Framingham buildings were leased, making a total of 233,000 square feet in Framingham. Generic pharmaceuticals were produced

at two locations in the U.K. A true bio-manufacturing facility of 130,000 square feet was under construction in Allston, Massachusetts, where genetically engineered Ceredase was planned for production in 1994, assuming FDA approval. Ceredase was an enzyme used to treat Gaucher's disease. Genzyme was a growing company, with 200 employees to be added in 1993; 550 were added in 1992. In 1993, in Massachusetts, 705 employees worked for Genzyme, 212 of them in manufacturing. In its biotherapeutics division alone, nine products were in the production pipeline in 1993.

Company History

Genzyme was founded in 1981 in Massachusetts by a Tufts Medical School professor, whose goal was to develop diagnostic enzyme products. With $3 million in venture capital, he and CEO Henri Termeer, who was hired in 1983, set up a parallel business strategy (Rossi, 1993). First, to generate near-term revenues, products—enzymes, assays, reagents used in diagnostic tests, and fine chemicals—were produced at a small manufacturing plant purchased in the U.K. While generating revenues in this way, the company pursued research work in genetically-engineered biotherapeutics. (Recombinant Ceredase has been in product development since 1981). The first space used by the company was leased research space in Boston's Chinatown, adjacent to Tufts. Later, in 1989, the company leased its headquarters space in Cambridge, at One Kendall Square. In 1990, it leased additional space in a separate building at that address.

In 1992, as noted above, additional space was leased in Framingham. In 1991, however, plans were made to locate a manufacturing facility in Allston. This facility would include large scale bioreactors for mammalian cell culture, protein purification suites, sterile filling operations, and laboratory space. It was expected to be completed in 1993, with validation and start-up in 1994. In the

long-term, consolidation of the company's Cambridge headquarters operations and Framingham manufacturing operations was planned for the Allston site. The $100 million, multi-story facility lay on 3 acres controlled by Genzyme under a 60 year ground lease from the Massachusetts Turnpike Authority. An additional 6.4 acres was also ground-lease controlled provided that specified expansion requirements were met. Base rents would vary depending on whether the portion was developed or in holding status. Genzyme was planning a staged, multi-year build-out, to a maximum of 800,000 square feet (see Table 17). One-half of the plant's capacity was to be geared toward production of recombinant Ceredase and of Thyrogen, a thyroid-stimulating hormone; subcontracting to other manufacturers was considered possible for the remainder of the plant's capacity. Previous site uses were as an abattoir and, later, as a Conrail railroad yard.

Table 17

Genzyme's Ground Lease Terms with the Massachusetts Turnpike Authority

Term:	60 years, renewable
Area:	9.4 acres, approximately
Rent:	$0.50/sq. ft., until occupancy permit $1.80/sq. ft. of building area on first 2.5 acres $1.60/sq. ft. of additional building area Rest adjusted by CPI every 5 years Maximum CPI - 6%, minumum - 3%
Minimum building area:	1.3 FAR for 1st 160,000 sq. ft. 1.6 thereafter 2.0 is maximum FAR
Minumum build-out to retain land:	80,000 sq. ft commenced within 8 months 280,000 within 5 years 380,000 within 7.5 years 480,000 within 10 years Additional 100,000 sq. ft. every 3 years
Maximum build:	800,000 sq. ft.

Source: Genzyme

Manufacturing Location Decision

David J. McLachlan, Chief Financial Officer and senior vice president, said the location decision was made in two stages: a look at twelve different states across two major criteria, then a focus on Massachusetts and sites within Massachusetts. The twelve states (California, Connecticut, Illinois, Maine, Massachusetts, Minnesota, New Hampshire, New Jersey, North Carolina, Rhode Island, South Dakota, and Texas) were qualitatively selected for one or more of three major reasons: they were in New England, known for concentration of biotechnology or pharmaceutical firms, or known low tax cost states. A tax analysis and permitting analysis were performed for all twelve states, and the states ranked. The key criteria for ranking were:

- whether the state had a corporate income tax
- geographic distribution of sales
- whether the state allowed nowhere sales
- weighting of sales in a state's income sourcing formula
- personal property tax exemptions for manufacturing machinery and equipment
- real property tax rates.

Based on these criteria, Massachusetts ranked fifth out of twelve, and first among the New England states. The permitting analysis revealed no major differences among the states.

McLachlan said, "We didn't want to go too far. It became a risk issue—we had never built [such a plant] before and had no idea of hiring...it is not routinized. But, we wanted a proactive response [from state and local governments]. In Rhode Island and North Carolina we took tours, met the governors...we didn't get a response from Weld until we announced we were going to North Carolina. He was in our office the next day, with economic

development officials. We wanted a public, pro-business commitment."

Using a real estate developer, Genzyme's site selection process in Massachusetts narrowed to four sites: Boston (Allston), Cambridge, Worcester, and Shrewsbury. All but Shrewsbury were formally costed out, both in terms of operating costs and capital costs. Other criteria—permitting, biotechnology zoning, expansion capacity, public transportation, economic development grants (both local and state), and "public presences"—were evaluated as well. A concern in 1993 was the Massachusetts Water Resources Authority's water rates, which were expected to increase. This increase was not expected at the time the alternative operating budgets were developed.

The key cost difference between the Allston site and the others was a Chapter 121A agreement which provided for a stable 15-year payment in lieu of property taxes. The value of this tax difference between Boston and the other alternatives was approximately $2 million. In addition, "the state, Boston Redevelopment Authority, and turnpike all worked together so that we had all state and local construction permits (32 in all) in 60 days," according to McLachlan. An additional $3 million in state landscaping funds and a $100,000 state training grant were to be used at the site, and the City of Boston promised traffic improvements. According to McLachlan, they were currently negotiating for the Turnpike Authority to pick up the costs of the Environmental Impact Statement on the undeveloped portion of the site. The construction was slightly behind schedule (about 6 weeks), and there were cost overruns because of engineering problems. However, McLachlan said, "our Chairman is European; he lives and works in the city and wants to have political influence by being in Boston. [He] wants influence to try to shape the biotechnology industry in Massachusetts."

General Business Strategy

McLachlan noted that the general strategy of Genzyme was risk minimization, not cost minimization, with "the goal of becoming a diversified, fully integrated health care products manufacturer and marketer."

Financing

Genzyme had had a total of eight financings since its inception. The money used to finance the Allston manufacturing facility was $100 million of convertible subordinate debentures at 6.75%. The company had other public stock offerings in 1986 and 1989. It also raised $47 million through two off-balance sheet limited partnerships and had created two separate public companies, as multi-product funding vehicles.

The company had been marginally profitable, showing a profit intermittently over the last five years. Net losses in 1992 were attributable to special charge-offs.

STUDY C: ALPHA-BETA TECHNOLOGY

Company Identity

In 1993, Alpha-Beta Technology was a mid-size biotechnology company with headquarters and approximately 90 employees in two buildings in Worcester's Massachusetts Biotechnology Research Park, where it conducted research and development, as well as pilot plant trials for its carbohydrate-based therapeutics, in approximately 40,000 square feet of leased space. It was constructing a manufacturing facility of 50,000 square feet in Smithfield, Rhode Island for Phase III clinical trials and commercial production of Betafectin, its first product based on a novel carbohydrate polymer, which was to be used to treat infections.

Alpha-Beta's focus was on carbohydrates, β-glucans and "the company's patent portfolio include[d] key technology relating to the β-glucan receptor on

certain white blood cells and the ability of carbohydrate compounds to target this receptor and treat diseases of the immune system." (Company annual report, page 4). Seven β-glucan-related products were in various stages of product development. Betafectin, a biotherapeutic used to treat wound infections, was closest to commercialization. The company was growing, with 265 employees expected to be employed by the year 2000, and 40-50 hired in 1993 alone.

Company History

The company was founded in 1988 by two M.I.T. doctoral graduates, who remained as company owners in 1993. It originally located its administrative and research and development facility in Worcester because the Massachusetts Biotechnology Research Park provided it with inexpensive "incubator" space there, at a reasonable rent. It had also received its seed venture capital of $350,000 from an on-site venture capital firm. (Other benefits at Massachusetts Biotechnology Research Park are described under BASF above).

In 1992, Alpha-Beta expanded into 10,000 square feet at a separate address in the park (Two Biotech) for early stage pilot plant operations. In early 1992, the owners recognized the need for a Phase III clinical trial and product manufacturing plant for Betafectin. In order to ensure control of the proprietary process technology, they did not consider licensing the manufacture to another company, but rather preferred to vertically integrate. The $38 million Smithfield plant under construction in 1993 was planned to be dedicated to commercial manufacturing after successful completion of Phase III trials, expected in mid-1994.

Manufacturing Location Decision

According to D. Davidson Easson, a company co-founder and executive vice president, and Braden Bohrmann, the company's chief financial officer, the

initial criterion for the location decision was proximity (within a one-hour drive of the Worcester headquarters). Although a geographic radius within a one-hour drive encompassed five New England states, only Massachusetts and Rhode Island were seriously considered as possible sites. An accounting firm completed a tax analysis, comparing various tax costs, short- and long-term, of building in Massachusetts or Rhode Island. "But, the results of the tax analysis really didn't matter; the financing deal really drove the decision," said Bohrmann. At about the same time, according to Easson, economic development officials in Rhode Island were approached, with the result that Rhode Island Port Authority industrial revenue bonds were offered by that state to finance 80% of the manufacturing facility construction, at 9.5% for 20 years. This proposal compared favorably with a more complex, less certain financing arrangement offered by the Massachusetts Biotechnology Research Park (see Table 18). Thus, the facility financing arrangement became the main driving force behind the choice of state location.

Table 18

Massachusetts-Rhode Island Proposal Comparison

	Massachusetts (Worcester Business Development Corp.)	Rhode Island
Loan amount:	Fixed	Flexible
Equity contribution:	Uncertain	20%
Credit enhancement:	H.U.D. 108	RI Moral Obligation
Structure:	Complex	Proven
Warrants:	No	Yes, but nominal
Expected rate:	10%	10%
Term:	Uncertain	20 years
Lease vs. loan:	Lease	Option

Source: Alpha-Beta Technology

Within Rhode Island, three sites were reviewed, two intensively. These two were costed out for construction. The main site criteria were:

- availability of skilled workforce/labor rates
- taxes
- utility rates
- expansion capability
- regulatory environment.

The local community had biotechnology regulations in place. The chosen site also offered easy access to a major state highway, Route 146, and had public utilities available. It was also part of an incipient biotechnology industrial park, with one other occupant at the time. According to Easson, proximity to other biotechnology companies was a desirable factor. The other site under serious consideration had possible environmental engineering problems; however, it would have been eligible for the industrial bond financing as well, had it proven acceptable.

The specific incentives offered by Rhode Island to induce Alpha-Beta to locate its manufacturing facility there were: the state's acquiring the site, building the facility on a turnkey basis, on 20 acres; providing the company with an option to purchase an additional 10 acres; floating the taxable bonds to finance the facility, as noted above; and providing credit enhancement through Sumitomo Bank for the bonds (which were Rhode Island moral obligation bonds). Job-training assistance was also offered by Rhode Island, and property tax concessions were negotiated by the state with Smithfield.

General Business Strategy

Alpha-Beta wanted to maintain the lead in carbohydrate-based biotherapeutics, and to retain world-wide manufacturing rights to all its pharmaceutical products. Bohrmann said, "The strategy [to acquire and build

the facility] had two parts: to find the available financing, and then to defer the cash obligation...Our 20-year amortization period with Rhode Island was an exercise in risk management. The only reason why we are in Rhode Island is because we were enticed there by cheap financing. We intend to expand our research and development [and other functions] in Worcester. We now have an even better deal from the research park and state of Massachusetts, which includes the state's Emerging Technology Fund, H.U.D. Section 108 monies and a Chapter 121A tax agreement."

Thus, Alpha-Beta did not plan to consolidate its functions in Rhode Island, but rather to maintain and expand its headquarters in Massachusetts, "because that's where our labor base is," according to Bohrmann. Only the commercial manufacturing activities of the company were considered likely to be expanded in Rhode Island.

Financing

The company's approximately $7-8 million portion of the facility investment was financed through an initial public offering in late 1992. The remainder of the facility financing is described above.

STUDY D: COMPANY X

Company Identity

In 1993, Company X was a top-tier biotechnology firm specializing in using recombinant DNA/genetic engineering technology to create genetically altered proteins for use as human therapeutic agents. It had 770 employees (595 technical—including approximately 200 in manufacturing and quality assurance—and 175 administrative) at four locations: a 190,000 square foot corporate headquarters and discovery research facility in Cambridge, a 210,000 square foot product development and manufacturing plant in Suburbia,

Massachusetts, and branch offices in Tokyo and Paris. It was a growing company; 100 employees were added in 1992.

Company History

Company X was founded in 1980 by two Harvard professors. One founder remained on the Board of Directors in 1993. It originally rented space in Boston from a medical institution for a research and development facility. It considered itself a "research boutique", using recombinant DNA technology to clone and manufacture purified proteins, which would be used to treat human diseases. Its intention was to "forward integrate" in this area, according to the company vice president of manufacturing. In 1984, it purchased its headquarters building in Cambridge, and later rented the building next door to this facility. Administrative, research and development, and a small GMP-capable pilot plant were all located in Cambridge. In 1986, the company purchased a 51 acre site in Suburbia, Massachusetts, which contained an instrumentation lab building on the site. This two-story, 186,000 square foot building was retrofitted and expanded. The retrofitting was "a very costly process, which we would probably not repeat," according to the vice president, to accommodate product development laboratories and manufacturing facilities. The retrofitted (and slightly expanded) building was 206,000 square feet in area; approximately 30,000 square feet of this space was taken up by four independent manufacturing suites. A master plan for the Suburbia site, showing a build-out of 1 million square feet, received local approval in 1989-90.

The company's pilot plant manufacturing capacity was moved from Cambridge to Suburbia; however, the company headquarters, and research and development ("discovery research") divisions were maintained in Cambridge. As well, an additional research and development building of 43,000 square feet in Cambridge was purchased from a now defunct

biotechnology company in late 1992 for $10 million.

Research scientists were left in Cambridge, "for cultural reasons," according to the vice president. "We figured they would be happier there."

The $50 million Suburbia facility in 1993 was undergoing an expansion for a 113,000 square foot preclinical research and development building and 42,000 square foot energy plant. These additions were valued at $55 million. The Suburbia manufacturing facility ran two full-time shifts and one "lightly staffed shift" to produce bulk protein for shipment to a California "finish and fill" plant, under a licensing agreement with a major pharmaceutical company. The bulk protein was sold to the pharmaceutical company for final sterile manufacture and distribution. Four other products were licensed to other companies for manufacture and sale. Five others were being produced at the Suburbia plant in small quantities for preclinical trial use.

Manufacturing Location Decisions

The vice president was not familiar with the factors or processes involved in this decision. He said the company wanted "to maintain a Massachusetts presence." The Suburbia site was a 20 minute drive from the company headquarters, and close to Interstate 495. Approximately 450 people were employed there. The workforce was predominantly semi-skilled and skilled.

A real estate specialist with the company discussed the reasons for selecting the Suburbia site for manufacturing in 1986. According to the specialist, the high cost and lack of land availability in Cambridge were major factors for looking outside Cambridge. Only in-state sites were considered. Three sites in Massachusetts were formally costed out. Factors considered in the location decision were:

- cost of land
- nature of land availability. Two sites were for sale; one for lease; and all had

existing buildings.

- transportation accessibility. The ease and directness of the commute from Cambridge headquarters were considered. All sites under evaluation had access to Route 2, Route 128, or Interstate 495.
- qualities of the site itself. Available infrastructure (water, sewer, power, road systems) was evaluated.
- local receptivity, both in terms of the existence of local recombinant DNA regulations and positive reception from local government and business leaders.
- expansion capabilities. Both the amount of land available and nature of existing on-site building (an instrumentation lab), in the case of Suburbia, provided opportunities for building expansion.
- attractiveness of site.

The real estate specialist said, "Labor cost and availability issues were not major factors because of proximity to existing company facilities." The Suburbia site chosen was not the least cost site, based on the operating or capital cost budgeting, "which turned out not to be realistic anyway." Qualitative factors played a role in the decision, primarily the perception that it was the best commute for existing staff, local community receptivity, and site attractiveness. It was a wooded, campus-like setting. Interestingly, the original intention was to look for a three, five, or ten-acre site, not a site as large as that in Suburbia; however, its expansion potential and availability for purchase (which was deemed preferable to a leasehold) tipped the scales in its favor.

No economic development assistance was requested from the state. "The state business climate [during the Dukakis administration] was not as receptive as it is now," according to the real estate specialist. Nor were any tax or utility rate negotiations conducted with Suburbia or utility companies. In-

house staff was used for cost evaluation, with the help of a commercial broker.

Future Manufacturing Plant Siting

According to the vice president, the company was considering adding additional manufacturing capacity within the next two years. An 80,000 square foot, $60 million shell would be constructed, to include warehousing, quality control assurance facilities, and labs, as well as manufacturing capacity. The intention was to build out the space over 10 years. The exact square footage to be dedicated to manufacturing was unknown in 1993.

The manufacturing location decision became a question of whether to expand at Suburbia or to go off-shore to Puerto Rico or Ireland to: (1) take advantage of tax incentives offered in these locations; (2) help establish an international market presence (in the case of Ireland, in the European market); (3) enter a different regulatory environment; and (4) avoid "disaster issues" (not having all manufacturing capacity at one location, in case it is destroyed by a natural disaster. The vice president said, "we have to think of ourselves as more mature than we really are" because of the long product-to-market cycle.

Ultimately, the Board of Directors tentatively agreed to proceed with near-term expansion at Suburbia for the following reasons:

- the flexibility of the site for phased development. The master plan had already been designed to build out an expanded manufacturing capacity, and the site characteristics supported a highly interactive company culture—"internal synergies," according to the vice president.
- the Suburbia regulatory experience. The company had a consistent record with local review and approval authorities and understood the timelines and requirements of the development process in Suburbia. Also, ELA approval had already been received in December 1992.
- start-up timing. The master plan and facilities infrastructure (water, sewer,

road, etc.) were already in place, which would reduce time to build the facility and allow central facilities to be used. The company already had a track record of development at the Suburbia site and understood the site's history and characteristics.

- Suburbia's "climate"/local receptivity. The community had consistently supported and worked with the company and had a track record with the company and with the biotechnology industry.

Other issues considered in reaching this decision were: (1) The importance of the research/manufacturing linkage at initial commercialization and scale-up of a product. Such a linkage speeds up commercialization. The technical personnel can iron out "bugs" in the scale-up process. (More routine manufacturing can occur in off-shore locations where the need for technical adjacency is not so necessary, but first manufacturing was emphasized on-site.) (2) The presence of local expertise in both biotechnology and biotechnology facility construction. (3) Awareness that other communities might be hostile to biotechnology companies.

The vice president noted that the siting decision alternatives were not formally costed out; however, a cost estimate was prepared for the the proposed Suburbia expansion, and a consultant's help was used to reach the decision, "which was based on [the] qualitative reasons [mentioned above]."

General Business Strategy

The vice president said, "We like to hedge our bets, but we consider ourselves an entrepreneurial growth company, which is risk-minimizing." The company had a variety of product licensing agreements and joint ventures with "heavy-weight" partners. As noted above, eleven different proprietary protein products were in licensing agreements or clinical trials. Five distinct research programs were being conducted. Over the long-term, the strategy was to

become fully integrated, pursuing "global product development and establishing world-wide commercialization capabilities."

Financing

The company had two stock offerings in the 1980's. As a result of unsuccessful patent litigation, it was unable to manufacture one product, and, as a consequence, was acquired by a large health products company in 1992. The alliance gained Company X new capital of over $300 million, which permitted it to pursue its expansion plans. To date, the health products company has allowed Company X autonomy in its major investment decisions.

STUDY E: BIOGEN

Company Identity

In 1993, Biogen was a top-tier "biopharmaceutical company principally engaged in developing and manufacturing drugs for human health care through genetic engineering" (1992 Biogen Annual Report, p. 16). It had 360 employees in five leased locations totalling 198,000 square feet in Cambridge, all clustered in the Kendall Square area (see Table 19). Approximately 45,000 square feet of this space was dedicated to pilot plant manufacturing or bulk manufacturing. Five of its products were on the market, sold internationally through licensees (one was a hepatitis diagnostic, the others were biotherapeutics). Its sole agricultural product, porcine somatotropin, was awaiting U.S.D.A. approval. Five additional products were at the pre-clinical or clinical testing stage, including Hirulog, which controls blood clotting through thrombin regulation, and β-interferon, a potential hepatitis and multiple sclerosis antiviral treatment. Biogen was a growing company, expecting to add approximately 70 employees (expanding its existing workforce by 20%) in 1993-94.

Table 19

Biogen Real Estate

Site	Square feet	Use
14 Cambridge Center	67,000	R & D, manufacturing
241 Binney Street	54,000	Process development Quality control
345 Vassar Street	26,000	R & D
4 Cambridge Center	34,000	Office
190 Fifth Street	17,000	Warehousing
	198,000	
12 Cambridge Center	130,000	R & D, Office

Source: Biogen

Company History

Biogen was founded in 1978 by Walter Gilbert, a Harvard professor and Nobel laureate, and six other scientists, including some Europeans. Its original place of founding was Geneva, Switzerland; however, it had always had a Massachusetts research presence, because of Dr. Gilbert. Since 1980, it had leased lab space in Kendall Square, initially approximately 30,000 square feet. An initial public offering in 1983 raised $58 million. "The approach to research was a shotgun approach [in agriculture, chemicals, and biotherapeutics]," according to James Mullen, Vice President of Operations, "and, as a consequence, Biogen teetered on the edge of bankruptcy until [current chairman and CEO] James Vincent was hired in 1985."

Vincent focused the company's mission on biotherapeutics and it remained focused on molecular biology and protein-based products. He sold the Geneva plant in 1987 and consolidated research and development in Cambridge in that year, when the company was reincorporated in Massachusetts.

The company's major source of revenues became royalties from its licensees, who sold products based on Biogen-developed technology, primarily α-interferon and hepatitis B products. Bulk manufacturing was limited to one location, 14 Cambridge Street, where two products were produced for sale to licensees for final finish and fill prior to marketing. This facility was leased, like the others, but "with option to purchase, because of the manufacturing," according to Mullen.

In 1993, with five products in the pipeline, expansion plans were contemplated for additional research and development, office, and manufacturing space. Since the company had been profitable since 1989, flexibility was desired to be able to forward integrate into commercial manufacturing, for in-the-pipeline proprietary products.

A $35 million, 135,000 square foot facility for offices and research and development in Cambridge at 12 Cambridge Center, adjacent to the company's existing facilities at 14 Cambridge Center, was planned, with construction to start in the fall of 1993. Purchase of the land for this, and a five-year, renewable option to purchase nearby parcels, totalling approximately six acres (for an additional 600,000 square feet of space for manufacturing as well as other functions), was part of the arrangement. The parcels were originally part of a late 1960's urban renewal area in East Cambridge, assembled for a NASA Space Center, and title was held by the Cambridge Redevelopment Authority. Prior uses in the area included both heavy and light industry.

Manufacturing Location Decision

The current decision to locate an additional 135,000 square feet (and, possibly, 600,000 square feet more) was not strictly a manufacturing location decision, but rather was driven by the need for research and development and office space first, with long-term manufacturing use incorporated into the

planning. Mullen said, "we have chosen to put in manufacturing capacity late [relative to other companies], in late Phase II or early Phase III trials...I've seen five companies [forced to] walk away when manufacturing capacity was constructed too early; then product approvals did not come through at all, or not on time.

"We also plan on making bulk pharmaceuticals [via fermentation, purification, and recovery] and subcontracting out the final formulation and filling, since there is no competitive advantage for us [to perform sterile fill and finish]." Mullen also noted the difficulties in pre-planning for manufacturing space and capacity. "Right up the the end [of the regulatory process] you have three unknown variables, the dosage, the size of the market, and the technological process. For example, we have had a tenfold increase in efficiency in producing one product [now at Phase III pilot plant stage]." Thus, the space requirements for production have been reduced, and an existing research and development floor could be converted for commercial production. In one case, the pilot plant area was successfully converted to commercial production.

When trying to locate for its upcoming expansion, Mullen said, Biogen performed a national review of regions, "based on the availability of skilled labor in both pharmaceutical research and pharmaceutical manufacturing. However, research quality [represented in the workforce] drove the decision." Five areas (outside of Cambridge) were qualitatively evaluated:

- New Jersey/Philadelphia
- North Carolina Research Triangle
- Chicago
- Greater Denver
- San Francisco Bay

These areas were considered based on Mullen's knowledge and experience of where pharmaceutical research concentrations existed, as well as by talking with companies who had located in them. Puerto Rico was not considered because it was considered "too remote, culturally different, and the whole tax code [in terms of tax incentives there] is under attack," according to Mullen.

New Jersey and San Francisco were discarded as choices because the cost of living and doing business in these locations was considered prohibitively high, although the labor pool was large in both areas. Chicago "was not considered an attractive locale" by any of the decision-makers, according to Mullen, and Denver did not have a large enough labor pool, although costs were lower. North Carolina had a sufficient labor pool, ample land, low land and construction costs, as well as a low cost of living and a positive regulatory and business climate. A site was identified in North Carolina and formally costed out, while concurrent negotiations were ongoing with the Cambridge Redevelopment Authority and Boston Properties, which had site control at 12 Cambridge Center. A commercial broker was used in the negotiations; internal staff developed the cost alternatives.

Despite a 40% cost premium at the Cambridge location over the North Carolina site, Mullen said, "we decided we didn't have enough critical mass, not enough people, to be able to relocate some [to North Carolina]. Proximity [to existing facilities] was an issue and there were hidden expenses in trying to manage two [disparate] locations...management control issues led to the decision to stay in Massachusetts."

Biogen was hoping for a 121A tax agreement for a stable 15-year property tax payment to the City of Cambridge, and zoning variances to permit manufacturing use and some dimensional changes at 12 Cambridge Center. Mullen said the local and state political reception has been helpful and positive,

since relocation to North Carolina was discussed as a possibility. Manufacturing capacity decisions were to be made in 12 to 24 months.

General Business Strategy

Risk minimization and growth management, to develop a vertically integrated, global company presence were key components of Biogen's business strategy.

Financing

Construction of the new facility was to be financed through company earnings. Biogen had been profitable for the last four years, as noted above. Mortgage financing was to be used as the permanent financing vehicle.

Chapter 4: Analysis

The data gathered in the case studies is analyzed in this chapter using the concepts developed in Chapter 2. The data from the interview protocol of Appendix A were summarized, insofar as possible, in a matrix form (Appendix C). Common and disparate elements of neoclassic, behavioralist and structuralist theory, as well as comparisons of individual firms' decision-making are discussed below.

All five companies surveyed were high growth biotherapeutics firms which had multiple products in research and development and product development nearing commercialization. Three companies were at the commercialization stage. All had been established within the last 15 years (BASF's parent company was considerably older, though). Three companies were not profitable, one was intermittently profitable, and one had shown profits consistently over the last four years. All were publicly held, had urban headquarters in Massachusetts cities, and had made or were planning a manufacturing location decision. Four of the five had an historical, academic connection with the Boston area. The founder or founders were professors or had trained in local universities. All desired vertical integration, perceived growth and capacity management as issues, and most viewed risk-minimization as a primary company goal. All companies were developing proprietary products.

INDIVIDUAL COMPANIES' LOCATION DECISIONS

BASF Bioresearch Corporation

The method used to make the location decision was systematic, and conducted on three scales—international, national, and local. Cost

minimization was explicitly discounted as a major decision criterion. However, labor availability and skill intensity were the two most thoroughly researched location factors. These are neoclassicist issues. Structuralist concerns were apparent in the company's sensitivity to the regulatory environment, the result of BASF's history of excessive regulation in Germany. However, BASF's ability to exploit economic development assistance was limited.

Proximity to a major market, a neoclassicist issue, was a distinguishing feature of the location decision. However, the choice of the U.S. was in part a preference of an influential company executive, a behavioralist issue. Moreover, in the final site selection, preference factors, such as local support and site attractiveness, played a role. Planning for the decision was ad hoc, with corporate control of the decision, and with major consultant input.

Genzyme Corporation

The location decision was conducted at two scales, across states and within Massachusetts. Comparative regional cost issues and comparative regulatory climates (neoclassicist and structuralist issues) were carefully evaluated by outside consultants. The political climate (a structuralist issue) was a dominant concern, and the company not only gauged it to ascertain state and local receptivity (behavioralist issues), but also exploited it actively to garner help with both implicit and explicit costs (neoclassicist issues), through permitting speed, site expansion flexibility, and tax concessions.

Cost factors at three sites were compiled and evaluated; operating cost differences were not found to be substantially different among the sites, with the inclusion of the Chapter 121A tax payments at the Boston location. Most significantly, the CEO's strong preference for a highly visible public presence in Boston played a determining role in the locational decision (a behavioralist issue). Availability of capital (a structuralist issue) was not a major issue, since

the ability to arrange financing was a company strength.

Alpha-Beta Technology

The location decision was driven by cost-led neoclassicist issues, on both the state and local scales. Lack of capital and the political climates of both Massachusetts and Rhode Island (structuralist issues) were major contributing factors in the location decision. Although financial risk management was a stated strategy, cost minimization apparently was the overriding goal.

Company X

The two major location decisions, whether to move to Suburbia in 1986 and then, whether to expand manufacturing there in 1993 and forward, were based on different criteria. The first was cost-led, based on the neoclassicist issues of land price and availability, but costs in the end did not determine the final location, but rather site preference (a behavioralist issue), based on ease of commute (not distance from Cambridge), site attractiveness, and local receptivity. To some degree, structuralist issues were ignored, since no proactive economic development was requested, and capital issues were not a stated concern.

The 1993 in situ expansion plans were more directly preference-based; a risk minimization strategy was preferred over a cost minimization strategy. The company's sensitivity to the larger political climate had increased (a structuralist issue). The company intended to negotiate some infrastructure and tax concessions from the state and Suburbia.

Biogen

The location decision was made on two scales, across specific states, and then between one local and one out-of-state site. The initial state selections were based on general industry knowledge, and the specific site comparison was quantitative. Comparative site costs (neoclassic issues) were

evaluated. Biogen decided to stay in Massachusetts, despite a cost premium. Its reasons included the positive political climate in Massachusetts (a structuralist issue), as well as risk-minimizing preference (a behavioralist issue). Availability of capital was not a concern.

CORRESPONDENCE OF OBSERVATIONS WITH THE THEORETICAL FRAMEWORK

Neoclassicist Issues

1. Transport cost/market proximity

Since all five firms surveyed were in the biotherapeutics segment, as a major product or sole product segment, transport costs for supplier and markets were not major factors, as expected. Product markets for all companies were international, with truck and air shipments the most frequent modes of transportation.

2. Labor factors

Labor availability was consistently cited by all firms at either the state or site level as an important factor in the location decision. One firm, BASF, had also evaluated labor quality carefully across states. Labor cost was cited less frequently (three out of five firms). When other states were considered for the plant location, the two alternative states most frequently evaluated were North Carolina and the New Jersey-Philadelphia area, where concentrations of pharmaceutical or biotechnology firms already existed. (North Carolina also had lower overall costs.)

3. Agglomeration economies

Four of the five firms cited proximity to existing company facilities, other biotechnology firms, and universities as a factor in the location decision. All implicitly viewed localization economies as important by limiting consideration

to Massachusetts and other states with high biotechnology firm concentrations, and therefore, labor skills concentrations. The influence of urbanization economies was more mixed, since two firms (Alpha-Beta and Company X) moved their manufacturing facilities to suburban locations. All five firms' manufacturing locations have the necessary infrastructure (water, sewer, roads), however.

4. Land

All firms looked at capital costs, including land price, when evaluating the location decision. For only two firms (Alpha-Beta and Company X), did land price (or financing) drive the decision (to suburban locations). Two firms (BASF and Biogen) specifically viewed land costs as a minor factor when making the decision, viewing agglomeration economies as more important. Accessibility of land for transportation was viewed as an important location factor by four of the five firms.

5. Tax climate

Costs of doing business, particularly taxes, were evaluated by all the companies at the state or site level, or both. However, companies that seriously considered other states also required that these lower cost states possess biotechnology or pharmaceutical industry concentrations. North Carolina was the favored alternative to Massachusetts.

6. Costs overall

Most companies performed either a capital cost or operating cost evaluation, or both, when making the location or expansion decision, to assure themselves that costs were reasonable. These cost evaluations were done for the selected sites, or alternative sites (three companies formally costed out site alternatives).

The interesting finding was that for three of the five companies, the site

selected within Massachusetts was not the least cost site, according to company officials. Although the cost evaluations assured all companies that costs were within reason, other factors played a role in the location decision.

Behavioralist Issues

1. Use and availability of information

Biotechnology firms gather extensive quantitative information on costs, for use in their manufacturing location decisions; however, they frequently do not base the decision on strict cost minimization criteria. The utility of information used to make location decisions is inherently limited by inaccuracies in forecasting; this limitation was explicitly acknowledged by officials at two companies.(Genzyme and Company X).

2. Preferences

Four of the five firms cited a positive local business climate as a factor in the site selection. Other preferences that influenced location decisions included: urban areas and a public presence (Genzyme), attractive sites (Company X and BASF), and the known versus the unknown in the case of expansion decisions (Company X and Biogen)

3. Alternative business goals

All the biotechnology firms had goals other than profit-maximization. Risk minimization, or financial risk management, and growth, were cited as business goals by four of the five. Managing growth, for example, in a risk-minimizing way, led three companies to a choose locations with explicitly quantified costs that were greater than those of alternative locations.

Structuralist Issues

1. Social forces

As expected, labor unionization was not an issue affecting any of the biotechnology firms surveyed. The German political climate was important in

BASF's decision to site its plant in Massachusetts. The state political climate was important in Genzyme's decision to remain in Massachusetts, and the national climate vis a vis tax incentives was considered in Company X's and Biogen's decisions not to move off-shore.

Economic development assistance was used or sought by all firms except Company X (in its initial 1986 location decision resulting in the move to Suburbia). For Genzyme and Biogen, the role of the Boston Redevelopment Authority and Cambridge Redevelopment Authority in retaining these firms in urban locations was key. The stability of the Chapter 121A tax agreements for these firms, and, particularly for Genzyme, the cost savings generated by the tax agreement, played an important role in the location decision.

2. Capital availability

None of the companies, except for Alpha-Beta Technology (the smallest and youngest of the five), had difficulty accessing sufficient capital for its plant needs. Even Alpha-Beta had alternatives (if less certain or desirable) in the proposal made for expansion at the Massachusetts Biotechnology Research Park. However, only the one consistently profitable company, Biogen, was able to plan permanent financing of its new plant through asset debt financing, an indication of the credit-worthiness problems which still plague the industry. It should be noted again here that the companies surveyed, with the exception of Alpha-Beta, were among the largest in the state. They did not necessarily have the capital availability problems that most Massachusetts companies face.

3. International/national scope

Only BASF, a division of a large international company, used location criteria that were significantly different from those of the other firms. It was the only firm to search initially at an international scale. Despite the international plants owned by Genzyme, its criteria were similar to those of other, historically

locally rooted firms.

Because of its international characteristics, BASF was the sole firm to cite proximity to the U.S. market, and communication with its headquarters. Compared to the other companies examined in this study, it also more carefully evaluated labor force characteristics through a study of the scientific environment across various states, and deliberated for a longer time over the decision. It was the least obviously cost-sensitive firm as well, and had sufficient staff capacity to manage international operations.

LOCATIONAL DECISION-MAKING

All firms conducted the first or subsequent manufacturing search at different scales, generally state-wide and local. (Company X made two searches; the first was limited to Massachusetts, the second considered off-shore locations). For those firms with available land, or adjacent sites (Company X and Biogen), on-site expansion or extension was preferred over a move to another state, despite the substantial cost savings that could be made with such a move. Known labor availability; economies associated with centralized facilities, a familiar regulatory environment, and better information flow between manufacturing and research and development were the reasons most often cited for in situ expansion.

All firms used a corporate small group to direct the location decision, with the exception of BASF, which used a larger corporate study group. In all cases, outside consultants were involved. At a minimum, a commercial broker was used. Some firms also had accounting, legal, and management consulting firms performing tax, permitting, and strategic analysis. In general, the decision-making by firms generally followed the model shown in Figure 5.

All firms had provided for growth by incorporating shell expansion space,

or additional site area, or both into their plant programs. Because of past growth, most firms had acquired multiple sites (primarily leased) where various functions were performed. Functional consolidation was planned (or at least, had been considered) by four of the five companies, because of the perceived advantages of direct research pilot plant and commercial plant proximity in increasing the speed of commercialization.

Chapter 5: Conclusions and Suggestions for Further Research

CONCLUSIONS

1. Firms used neoclassicist, behavioralist and structuralist factors in making their manufacturing location decisions. All firms quantified costs, but did not make their final decisions on the basis of cost alone. Availability or proximity to labor was a key concern.

There appeared to be a relationship between a firm's position in its product cycle, and the relative weights it assigned to neoclassicist, behavioralist, and structuralist factors. The firms studied were in the growth phase of their product cycle; most appeared to place relatively more emphasis on behavioralist factors than on neoclassicist factors, as compared with the same firms in the early phase of their product cycle, when behavioralist factors were less significant, and neoclassicist factors more dominant. Examples of the early dominance of neoclassicist factors included Company X's initial decision to locate in Suburbia, and Alpha-Beta's decision to go to Rhode Island (Alpha-Beta was still transitioning from its early phase to its growth phase when the location decision was made). The growth phase also revealed an increasing awareness of the importance of structuralist issues, with firms dealing more proactively with state and local governments as they increased their space requirements and presence in the community.

2. The five firms studied generally cited as important the same primary location factors as high-technology companies overall. For example, availability of workers was the top concern in the high technology firms surveyed by Premus (see Chapter 2); as noted, this was also a major concern for the biotechnology firms. Premus also viewed state/local tax structure as

important in the decision; similarly, the biotechnology firms all evaluated taxes at the state and/or site level. Community attitudes towards business (ranked third by Premus) was cited by all firms as well. Cost of property and construction, and transportation accessibility, were similarly cited by both the high-technology survey and the five biotechnology firms.

3. All firms were risk-averse in their location decisions, seeking to control or minimize, whenever possible, internal and external uncertainties. Known inputs (for example, known state and local regulatory climates, existing labor competencies) were valued greatly over unknowns at other locations. In part, this occurred because of the complexity and uncertainty in each firm's product lines: each had multiple products in various stages of development. Each firm also faced uncertainty in technological processes (the feasibility and costs of scale-up), in the Federal regulatory maze (approval or disapproval of products, and, if approval were to come, when?), and in the manufacturing capacity needed (because of dosage, size and share of market, and final technological efficiency unknowns). Precise space planning was difficult, with so many uncertainties, which are represented graphically in Figure 6.

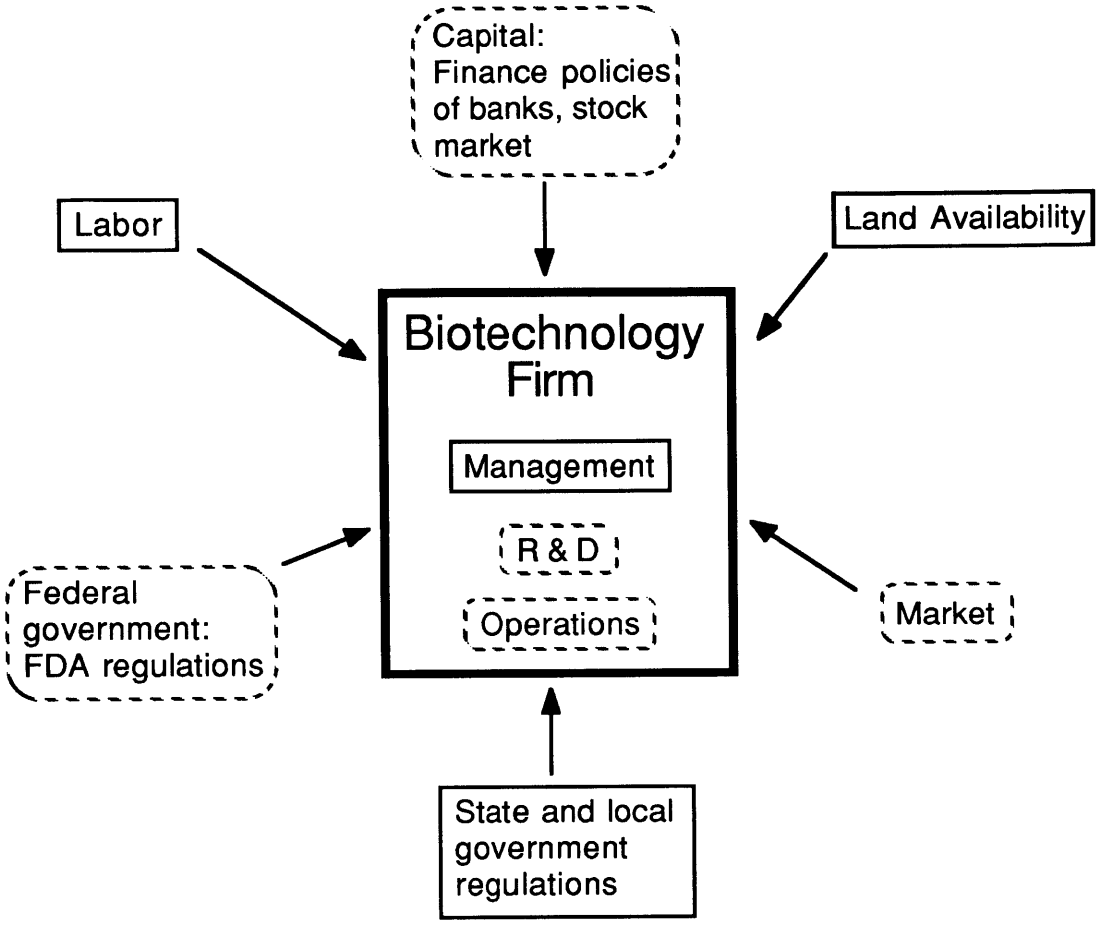

Figure 6. External and Internal Uncertainty (adapted from Cooper, 1974). Biotechnology firms face relatively high external uncertainty in the FDA approval process, in market size and share, and in capital availability (especially for small firms). Internal uncertainty with regard to manufacturing location and space requirements arises from estimates of dosage requirements (which are difficult to project early on in product development) and of technological efficiencies (which are subject to large and unpredictable increases as a consequence of ongoing process improvement). Internal uncertainty also arises from the unpredictable pace of discovery in the development of new products. Firms often try to reduce the external uncertainty in other areas, by staying within a known labor market, a known state and local environment, and with appropriately zoned and permitted land. Firms deal with internal uncertainties by staying with known management competencies.

4. Firms were dealing with managing growth, and frequently were making the transition from leasing to purchase of facilities, because of the non-fungibility of manufacturing space. Flexibility in conversion of space from

research and development/pilot plant to commercial plant scale was desirable. This flexibility was also attained through provision of expansion space (partial shell building) or expansion land. Research and development space "led" the siting decisions in two cases, with actual manufacturing planned for 12-24 months in the future, or even later.

5. Most plant siting was facilitated by economic development, or other government assistance; plant siting in Boston and Cambridge, in particular, required such assistance. In 1993, all firms surveyed found it desirable to ask for some level of assistance in their future expansion plans. The level of attention that local and state governments gave to the firms was partly a function of the negotiating skills and political astuteness of the individual firms' CEO's. Firms which were not publicly committed to Massachusetts, but which announced that they were relocating to other states received the most positive attention from the state and their communities. As of this writing, Massachusetts and its communities, through the newly created Emerging Technology Fund, and H.U.D. Chapter 108 loan guarantee program, appear to be on an economic development-financing parity with Rhode Island and its industrial revenue bonds. More significantly, the future holds the emergence of tax increment financing, which has been a powerful redevelopment tool in other states (Frieden and Sagalyn, 1989). Regulations for administering this program are at a preliminary stage. Experience with such financing in other states suggests that it will influence location decisions in favor of urban sites.

6. The evidence of suburbanization of manufacturing is mixed. The nature of biotechnology manufacturing plants—frequently multi-story, with research and development as well as pilot plants incorporated, and with high infrastructure requirements—would seem to recommend large or small urban areas, as exemplified by Boston, Cambridge, and Worcester. However, as seen

in the cases of Company X and Alpha-Beta Technology, campus-like settings are also desirable for cost, space, and highway accessibility reasons. No dichotomy of urban vs. suburban tendencies was seen between large and small firms.

7. Given the current growth stage of the biotherapeutics segment of the biotechnology industry, manufacturing is still not sufficiently routinized to lead to stand-alone, distant plants. Firms' perceived lack of capacity to staff a completely separate plant further argues against out-of-state manufacturing location choices. It is likely that manufacturing will be retained in Massachusetts, at least in these early stages of commercialization. However, as the industry matures, and manufacturing becomes routinized, a shift may occur to lower cost locations.

SUGGESTIONS FOR FURTHER RESEARCH

Impact of New Legislation

The emerging effects of M.G.L. Chapter 19 on the biotechnology industry, particularly the locational impacts of tax increment financing, should be an interesting research topic within two to five years, as appropriate regulations are put in place and implemented. The locational effect of this statute could lead to urban sites for manufacturing. Malaterre (1993) has already recommended evaluating investment tax credits and other tax incentives; these could now be researched within the specific framework of Chapter 19.

Other Segments' Locational Decision-Making

Other biotechnology industry segments (e.g., ag-bio or equipment) may differ from the biotherapeutics segment in the locational factors they consider in manufacturing plant siting. Research into other industry segments' decision-making would highlight the similarities and differences between the

biotherapeutics segment and these other segments. Analogously, a comparison of Massachusetts biotechnology firms and their locational decision-making with firms in other states (the San Francisco and New York-Tristate areas, particularly) could reveal structuralist differences between the regions. Understanding these differences from firms' perspectives could be useful for other companies.

Focused Development Comparison

As noted in this paper, Worcester and Shrewsbury, as well as, more recently, Grafton and the Charlestown Navy Yard, have been identified by the real estate community as potential sites for biotechnology industry development. The Massachusetts Biotechnology Research Park in Worcester is successful and expanding, but whether the other sites will be successful real estate developments is unknown. As these new sites undergo development in the next few years, elements leading to their success or failure could be researched and evaluated. Two criteria on which one could evaluate these sites are profitability of the development and the scale of biotechnology industry attracted to the sites.

Longitudinal Study

Biotechnology manufacturing facilities decisions have been rare, and are just now becoming more common. Within a few years, the firms in this study could be revisited to try to evaluate the success of the decisions they have made.

Appendix A: Questionnaire

I. Company Identity

Person completing survey

Position within company

Company name

Company division(s) at site

Address

CEO of parent company (if applicable)

Year and place of company founding

Whether company's founder lived in Massachusetts prior to founding

Was plant located to offer the CEO a short commute?

Can company be characterized as mature or growth company?

Are you making a profit overall; from products manufactured at manufacturing plant?

II. Nature of this manufacturing plant

Major product lines manufactured

Number of product lines manufactured

Products made under patent protection?

How production is triggered (order, forecast, inventory levels)

Process type (batch, line flow, continuous flow)

How plant is controlled (profit center, cost center)

Management functions performed at the plant (e.g. R & D, sales)

Where warehousing and distribution for the plant is done

Year company/division first occupied plant

Area of plant site in acres

Square feet of plant

Number of manufacturing structures on-site

Type of major structure (single story, multistory)

Character of space required (e.g.., special construction, almost any type of structure, etc.)

Is company/division sole occupant of site?

How structure and site were acquired (e.g., built, purchased, leased)

Nature of site's previous use

Room for expansion on-site? (substantial, modest, none)

Average employment over the past year (full and part-time)

Predominant skill level of the workforce

Are most workers unionized?

Characterization of union attitude

Number of shifts typically run at the plant

Plant's use of water

Plant's use of various public utilities

Any disappointment with present site

III. Multi-plant Questions

Does company have more than one plant? If yes,

This plant relative to other company plants

Plant charters:

The "charter" for the plant (e.g., a particular product line shipped over the division's entire domestic market area, a pilot plant to a full production plant, etc.)

This plant's charter relative to others in the company

This plant's profitability/efficiency relative to others in the division

Dependence on other company facilities

- Distance to division's headquarters
- This plant "spun off" from another company plant? If yes,
- How far away is that "mother" plant?
- Comparison with that mother or base plant
  - What fraction of the employment
  - Product line (broader, narrower, same)
  - Products (more mature, newer, same)
  - Growth (faster, slower, same)
  - Production process (more capital-intensive, more labor-intensive, same)
  - Production runs (longer, shorter, same)
  - Labor (more skilled, less skilled, same)

New product introduction (more, less, same)

Labor productivity (better, worse, same)

Labor unionization at mother plant

Labor situation at mother plant

IV. Markets, supplies and transportation

What is plant's market area? (international, national, regional, etc.)

Percent of output value shipped to other company plants

Where are plant's suppliers' located?

Percent of supplies value shipped to other company plants

Important transport modes other than truck

Relative importance of transportation costs

V. Some statistics

Approximate sales from this plant

Wage and salary costs plus fringes as a percent of sales

Materials costs as a percent of sales

Value of land and structures if owner (in $), if renter (in $/sq. ft.)

Value of equipment and inventories.

VI. ON-SITE PLANT EXPANSION

Information sought only for manufacturing plant expansion on site

Plant capacity considerations

Years in past decade when plant was expanded

Total square feet added

Operations this plant absorbed from other plants

Operations this plant spun off to new plants

As an alternative to on-site expansion, did company consider opening a new branch or relocating this plant?

What factors argued most persuasively for on-site expansion?

What problems at the plant did on-site expansion cause or aggravate?

VII. NEW PLANT OPENINGS

Information sought only for new manufacturing plant openings

Capacity and location consideration for this plant

Has plant expanded since it was first occupied?

When was the expansion?

Total square feet added

Since its opening, has plant absorbed operations which were then closed or sold?

As an alternative to opening, did company seriously consider expanding on-site elsewhere?

As an alternative to opening, did company seriously consider relocating another plant?

What factors argued most persuasively for opening a new plant?

What states were seriously considered for this plant's location?

What factors were perceived as "musts" in selection of region and state? Of site itself?

What factors were perceived as "desirable, if available" and helped to tip scales in favor of this site?

Means by which labor climate was assessed

How town was first identified as possible site

State/local government aid taken advantage of (e.g., industrial revenue bonds; help with environmental permits; tax concessions; new roads, sewerage treatment, etc; zoning changes; training programs)

Relative to expectations, how plant fared on: costs of construction/staffing, speed of construction/staffing, government regulatory delay, speed/effectiveness of start-up, labor costs, labor productivity, absenteeism/turnover/attitudes

Who first proposed a new plant? Division or corporate management

Was joint division/corporate staff team formed?

Who led site selection process? Division or corporate management

How many months was need for new plant debated?

How long did site search take?

Once site selected, how long was start-up for plant?

How many managers became involved in the decision to locate? In planning the start-up?

Over how large an area was the search conducted? (locally, state, etc.)

How many sites were considered?

Were these sites explicitly costed out?

How did sites get identified?

What kinds of outside consultation were engaged in for the search itself?

How is investment financed?

Characterize dealings with state and local officials

How did transition to new site occur? (e.g., warehousing first)

VIII. BUSINESS STRATEGY

Do you have a formal business plan?

What are your overall business goals?

Appendix B: Summary of Chapter 19

Emerging Technology Fund

The Emerging Technology Fund will provide $15 million in the near-term in bonding capacity through the Massachusetts Government Land Bank for new manufacturing, research and development facilities, particularly in the fields of biotechnology. The Fund will also make matching grants to public instrumentalities and universities to induce federal and industry funding of advanced research and development activities in emerging technologies and in the new application of existing technologies in the Commonwealth. The Fund has a $45 million limit; Massachusetts moral obligation bonds will be used for the remaining bonding capacity over the first $15 million.

The Land Bank, in cooperation with an advisory council, will administer the Fund, which allows for loans, guarantees, loan insurance or reinsurance, equity investments and other financing or credit enhancing devices.

Investment Tax Credit

The legislation increases the current investment tax credit from one to three percent. The provision has a three year sunset. The act also authorizes the Department of Revenue to study the tax credit's effectiveness.

Economic Opportunity Areas

The legislation targets development projects within areas of high poverty and unemployment to be eligible for various tax incentives and real estate tax abatements, including: a 5% investment tax credit for tangible personal property used in a certified project within an Economic Opportunity Area; and a 10% deduction of the cost of renovating any abandoned building within an Economic Opportunity Area; both available to all businesses. The legislation establishes an Economic Assistance Coordinating Council that will oversee the creation of economic opportunity areas in the state. The legislation also establishes eligibility criteria for municipalities an development projects.

Tax Increment Financing

The act also authorizes municipalities to use tax increment financing (TIF) to support economic development projects. TIF is is premised upon specific development commitments by property owners, and is designed to promote particular projects. A TIF plan, subject to state approval, describes proposed public and private investments in a TIF area, and is agreed upon by the municipality and all private land owners in the TIF area. The municipality agrees to "freeze" taxes at an established level for an agreed upon number of years (no more than 15). TIF will pass the tax savings on to property owners for use in project development, while ensuring that the development risk is borne by those parties as well.

Sources: The Commonwealth of Massachusetts, Joint Committee on Commerce and Labor, and the Massachusetts Office of Business Development.

APPENDIX C 1	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Company Identity & History					
Company headquarters address	Germany (parent) Cambridge (current) Worcester (4Q93)	Cambridge	Worcester	Cambridge	Cambridge
Divisional company?	Yes	No	No	No	No
Average number of employees, 1993	130 (Mass.) 118,000 (tot.)	705 (Mass.) 1500 (tot.)	90	770	360
Year/place of company founding	1988, Mass. (parent 1866, Germany)	1981, Mass.	1988, Mass.	1980, Mass.	1978, Geneva
Founder(s) lived in Mass prior to founding?	No	Yes	Yes	Yes	Yes (one)
Subsidiary/Division of Another Company?	Yes	Yes	No	No	No
Was plant located to offer CEO short commute	No	Probably	No	Yes	No
Growth company?	Yes	Yes	Yes	Yes	Yes
Company profitable?	No	Yes (intermittent)	No	No	Yes-4 years
Nature of manufacturing					
Major product lines	Biotherapeutics	Biotherapeutics (also diagnostics, others	Biotherapeutics	Biotherapeutics	Biotherapeutics
Biotherapeutic plant location	Worcester	Allston	Smithfield, RI	Suburbia	Cambridge
Number of products manufactured in-house	None yet	3 now, 1 more expected in 1994	None yet, 2 in process	1 now, 5 in process	2 now, 5 in process

APPENDIX C 2	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Nature of manufacturing, cont.					
Patent protection?	Yes (expected)	Yes, plus orphan drug status	Yes	Yes	Yes
Production triggered by:	N/A	N/A	N/A	Forecast	Forecast
Process type	Batch	Continuous flow	Batch	Batch refeed	Batch
Cost/profit center?	N/A	Cost	Cost	Cost	Cost
Management functions performed at plant	Anticipated admin., R & D	Anticipated QA, QC, some admin.	Anticipated QC, some admin.	QA, QC, manufacturing admin.	Admin., R & D
Warehousing & distribution	Will be at plant	Will be at plant	Will be at plant	GMP warehousing at plant; other at leased warehouse	From nearby leased building
When existing or proposed plant first occupied	Expected 3Q93	Expected 3Q93	Expected 1994	1988	1981 existing, 1995 proposed
Area of plant site (acres)	30	3 now, option to 9.4	20 now, option to 30	51	5 to 6
Square feet of plant					
All functions (existing)	39,400	340,000	40,000	400,000	198,000
Manufacturing (existing)	None	185,000	10,000	30,000	45,000
All functions (proposed)	250,000	130,000 plus option for 670,000	50,000	158,000	135,000 plus option for 600,000
Manufacturing (proposed)	up to 75,000	up to 130,000	up to 50,000	Unknown	Unknown

APPENDIX C 3	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Characteristics of plant/site					
Number of manufacturing structures	1	1	1	1 existing, 1 proposed	2 existing, 1 proposed
Type of space	Multi-story special construction	Multi-story special construction	1 story + mezzanine, special const	Multi-story special construction	Multi-story special construction
Nature of acquisition (existing)	R & D is leased, will be terminated	Leased	Leased	Purchased	Leased, with purchase option
Nature of acquisition (proposed)	Purchased	60-year ground lease, structure owned	Purchased, with purchase option on 10 acres	Expansion on purchased site	Purchased, with purchase option on expansion parcels
Site's previous use	Green field	Railyard, abattoir	Green field	Instrumentation lab and green field	Heavy/light industrial, retrofit
Room for expansion?	Substantial	Substantial	Substantial	Substantial	Substantial
Skill level of workforce	High	High	High	High	High
Unionized?	No	No	No	No	No
Number of shifts	None yet	None yet, 3 expected	None yet, 3 expected	2 full, 1 lightly staffed	3
Plant's use of water	50,000 gal/day expected	55,000 gal/day expected	50,000 gal/day expected	50,000 gal/day	70,000 gal/day
Other public utility use	Moderate	High steam use	Moderate	Moderate	Moderate
Disappointment with present site?	Limited airline service to Worcester	Uncertainty of MWRA rates	"Fairly engineering intensive"	Retrofit not cost effective	Retrofit, urban environment, local regs

APPENDIX C 4	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Characteristics of plant/site, cont.					
Manufacturing plant charter	R & D center and pilot plant, commercial production possible	R & D space, Ceredase production, 3 other products, subcontracting possible	Betafectin trials, commercial production; space for new products	Bulk protein production; 5 products on trial scale	Commercial production of 2 products; pilot plant for multiple biologics
Dependence on other company facilities	Yes	Yes, but consolidation anticipated	Yes	Yes	Yes
Distance to headquarters	250 mi. to division HQ	2 mi.	30 mi.	20 mi.	next door
Distance to research and development facility	0 (expected)	2 mi.	30 mi.	20 mi.	next door
Market area	International	International	International	International	International
Suppliers	International	National	National	National	International, most in US
Important transport mode other than truck	Air	Air	Air	Air	Air
Relative importance of transport costs	Low	Low	Low	Low	Low
Value of proposed land, structures, equipment	$90 million	$100 million (equip. & bldg. only)	$38 million	$135 million	$35 million
Future on-site expansion of manufacturing facilities					
Status	Space available	Space available	Space available	Planned	Planned
When?	N/A	N/A	N/A	1995	1994-95

APPENDIX C 5	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Future on-site expansion of manufacturing facilities, cont.					
Square feet to be added	N/A	N/A	N/A	Unknown, see text	Unknown, see text
New plant considered as alt. to expansion	N/A	N/A	N/A	Yes	Yes
Major factors cited for on-site expansion					
Ability to use in-place facilities				X	X
Better information flow, esp. with R & D				X	X
Better mgmt control/lower staffing necessary					X
Friendly local regulatory environment				X	X
Receptive local business climate				X	
Labor availability				X	X
Known/stable costs				X	X
Flexibility of site for phased development				X	
Manufacturing plant already licensed				X	
Problems caused/aggravated by on-site expansion					
Limited by space constraints					X
Disaster risk				X	
Retrofit problems (in past expansion)					X
Higher costs relative to new plant elsewhere					X
No ability to establish international market presence				X	
No ability to use offshore tax advantages				X	

APPENDIX C 6	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
New manufacturing plant openings					
Expanding on-site considered as alt. to new plant?	No	No	Yes, wanted to stay in MA	No	See previous section: decision is for new plant, but similar to in-situ expansion
Factors that argued for opening new plant					
Growth/capacity needs	X	X	X	X	X
Existing site's space constraints					X
Desire for vertical integration	X	X	X	X	X
Proximity to US markets	X				
Restrictive home regulatory environment	X				
Maintain control of proprietary technology			X		
States/areas considered for plant location					
Massachusetts	X	X	X	X	X
New Jersey/Philadelphia area	X	X			X
North Carolina	X	X			X
Illinois		X			X
Washington, DC area	X				
Greater Denver					X
California		X			X
Texas		X			X

APPENDIX C 7	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
States/areas considered for plant location, cont.					
Rhode Island		X	X		
Minnesota		X			
New Hampshire		X			
South Dakota		X			
Maine		X			
Connecticut		X			
Factors perceived as "musts" in selection of state				N/A: only MA considered	
Labor availability	X	X			X
Costs of doing business (taxes, wages, utilities)	X	X (taxes)	X (taxes)		X
Attractiveness of locale					X
Cost of living for employees					X
Positive regulatory climate	X	X			X
Scientific environment	X	X			
Ease of access to international HQ	X				
Available financing			X		
Factors cited as "musts" in selection of site					
Adequate infrastructure (water, sewer, roads)	X	X	X	X	X
Room for expansion	X	X	X	X	X
Low or reasonable operating/capital costs, including taxes, utilities, land		X	X	X (land cost especially)	
Positive local regulatory climate	X	X	X	X	X
Positive local business climate	X	X		X	X

APPENDIX C 8	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Factors cited as "musts" in selection of site, cont.					
Labor availability/cost			X		
Transportation accessibility	X	X	X	X	
Nature of land availability (purchase or lease)				X	
"Desirable, if available" site factors					
Proximity to existing company facilities				X	X
Proximity to other biotech firms or universities	X		X		
Economic development assistance		X	X		X
Attractiveness of site	X			X	
Costs of living for employees	X				
Permits already in place or readily available	X	X			
Public presence		X			
Means by which labor climate assessed	Demographic measures of education level, literature citations, educational institution quality, no. of Ph.D.s per capita	Proximity of known biotech/pharmaceutical industry concentration	Demographic study	Not assessed	Interviews with companies in states evaluated

APPENDIX C 9	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
How town was first identified as a possible site					
Pre-existing relationship with site owner					X
Commercial broker identified	X		X	X	X
Proactive government response		X	X		
State/local government aid used				1986, none used	
Industrial revenue bonds			X		
Help with environmental and other permits	X	X	X		
Tax concessions		X	X		X (applying for)
New infrastructure	X, indirect	Promised, not delivered	X		
Zoning changes					X
Training programs		X	X		X
Public land ownership/assembly		X	X		X
Turnkey construction			X		
Relative to expectations, how has plant fared in:					Not yet built
Costs of construction/staffing	On budget	Higher	On budget	Higher	
Speed of construction/staffing	On time	delay	On time	On time	
Government regulatory delay	As expected	Permitting faster than expected	As expected	As expected	

APPENDIX C 10	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Relative to expectations, how has plant fared in: (cont.)					Not yet built
Speed/effectiveness of start-up	Not yet opened, but skeleton crew on site in trailer	Not yet opened	Not yet opened	As expected	
Labor costs	Higher	N/A	N/A	As expected	
Labor productivity	Lower	N/A	N/A	As expected	
Absenteeism/turnover/attitude	"Less loyal, more afraid"	N/A	N/A	Better than expected	
Location decision process					
Who first proposed new plant?	Corporate	Corporate	Corporate	Corporate	Corporate
Staff team formed?	Yes, 6-10 in house	Yes, 6 in house	Yes, 4 in house	Yes, 6 in house	Yes, 5 in house
Who led site selection process?	VP	Manufacturing VP	Chairman and VP	Senior VP	VP, operations
For how many months was need for new plant debated?	N/A	7	3 to 4	12	2
How long did search take?	1.5 year	2-3 months	4-6 months	3 months	6 months
Construction period	Summer 1993	Summer 1993	March 1994	May 1988	Winter 1995
How many managers involved in planning the startup?	6 to 10	6	4	6	2
Over how large an area was search conducted?	International	Several specific states	2 states	Within state	Several specific national regions
How many sites considered?	50 total, 5-6 seriously	4 total, 3 seriously	3 total, 2 seriously	5 or 6	2 seriously

APPENDIX C 11	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Location decision process, cont.					
Sites explicitly costed out?	No	Yes	Yes, for construction only	Yes (1986) No (1993)	Yes
How were sites identified?	Commercial broker	Site owner approached company	Through state officials	Commercial broker	Commercial broker
What kinds of outside consulting were used?	Management consultant for regional search, commercial broker for site	Accounting firm, legal firm, commercial broker	Accounting firm, commercial broker, engineering firm, legal firm	Commercial broker	Commercial broker
How investment financed	Earnings of parent company	Stock offering, 6.75% subordinated convertible debentures	Rhode Island industrial bonds	Stock (IPO), stock buy-out	Company earnings for construction, mortgage financing
Characterize dealings with state/local officials	"Disappointing"	Positive, but "Lots of communities don't have staff"	Responsive: "MA didn't have power to do anything like this"	Good, but frustration with environmental permitting	"Generally positive"
How did transition to new site occur?	closing of leased R&D space in Cambridge	Management	Management	Management	Management

APPENDIX C 12	BASF Bioresearch	Genzyme	Alpha-Beta Technology	Company X	Biogen
Business Goals	Growth, market presence	Risk minimization, growth	"Risk management strategy" (interpreted here as cost minimization)	Entrepreneurial growth with risk minimization	Risk minimization, growth

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