Feasibility Study of Korea Biocluster With Real Estate Perspectives

by

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Submitted to the Department of Architecture in Partial Fulfillment of the Requirements for the Degree of Master of Science in Real Estate Development

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Abstract

Globalization has created a dynamic and rapidly changing marketplace. A business must move quickly to capitalize on the changing environment. For example, many global biotechnology firms are seeking new geographical locations as part of their strategy to expand their business.

Korea's biotechnology reputation and prospects as a potential site for biotech businesses is attracting increase attention. The Yeongjong Project is one choice. For the ongoing development of Korean bioclusters, this study will demonstrate potential and the attractiveness of Korea's biocluster sites, which may help international biotechnology firms relocate and reposition in Korea.

Biotechnology is an umbrella term so this study identifies what the biotechnology and biotechnology industry are, as well as its characteristics and risks.

Secondly, the biotechnology market will be analyzed both globally and domestically to understand the industry trend. This paper compares successful international bioclusters such as Tuas Medical Park in Singapore and University Park at MIT in the U.S, along with Korea's Wonju Medical Valley and Daedeok Techno Valley. This study explains different innovations and success factors, and characteristics of each cluster and whether the success factors are applicable to the Yeongjong Project.

Finally, this thesis will identify the area and its characteristics suitable for a biocluster and propose appropriate product types through market feasibility.

Thesis Supervisor: Brian A. Ciochetti
Title: Professor of the Practice of Real Estate

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I would like to express my thanks to the MIT faculty members who have assisted me in the process of writing this thesis. I especially want to thank Professor Tony Ciochetti for his inspiring and experienced comments, attentive attitude, and logical advice.

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In addition, I cannot express how grateful I am to my father, Dungkyu Choi, and mother, Sooah Oh, who supported me while I worked to complete this program at MIT.

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I. INTRODUCTION

The biotechnology industry has humble roots. Before the founding of Genentech[1] 31 years ago, molecular biology was a relatively obscure field, where scientists toiled on work that was deemed academically interesting but of little perceived commercial application or value. But, if biotech is an industry of humble beginning, it is also one of noble ends, since the technology now has impacts on our daily lives. A familiar example of biotechnology's benefits is the new generation of home pregnancy tests that provide results more quickly and of greater accuracy than previous tests. In the agriculture industry, biotechnology can help improve crop production and meet ever-increasing demand by increasing yields, decreasing crop inputs such as water and fertilizer, and providing pest control methods that are more compatible with the environment.

There is no question that biotechnology has an impact on various industries and even drives innovation in certain development industries. As a result, almost all countries are interested in the technology and have developed a national strategy to improve and invest in it. However, because of high barriers to entry, each country has a different position and status. Some countries, such as the United States start to approach profitability while European countries pursue sustained growth, and Asian countries, such as Korea enter into emerging solutions.

According to Datamonitor, global biotechnology market value has increased by 13.4%[2] annually since 2002. Along with the growth of the biotechnology industry all over the world, the demand for real estate such as office, laboratory, R&D facilities and infrastructure is also increasing. As a result, real estate for biotech industry becomes an important factor for the continued growth and success of individual businesses. Due to the nature of the labor and materials involved, biotechnology requires innovative real estate designed for maximum efficiency. Selection and integration of the right product types in the cluster is also critical for the biotechnology business. Briefly, cluster is understood as the geographical concentration of different players such as interconnected companies, specialized supplies, service providers, and institutions which compete and

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[1] Considered founder of biotechnology industry

[2] Biotechnology Industry Organization (BIO), *Global Biotechnology* 2007

cooperate in the same industry. Detail explanation for the cluster will be showed in chapter Ⅳ.

In this thesis, the author will define biotechnology by way of an account of how it has been conceptualized, and a description of its characteristics. Next, the author will outline the market and trends of the global biotechnology field, and then turn to the specific case of Korea, assessing, again, the market, trends, demand, and opportunity. Finally, the author will analyze a real project, “Yeongjong Project”, sponsored by Federal Development LLC for market feasibility and provides a brief proposal for the candidate site.

II. WHAT IS BIOTECHNOLOGY

Because the biotechnology ("BT") industry is a relatively new one, most real estate developers are unfamiliar with biotechnology. In this chapter, the author outlines a definition, which varies by countries and institutions and offers a classification template, since biotechnology is umbrella term. In addition, risks and characteristics of biotechnology are explained.

A. **Definition**

What is biotechnology?
Using biological processes is hardly a noteworthy event. Humankind began growing crops and raising animals 10,000 years ago to provide a stable supply of food and clothing. We have used the biological processes of microorganisms for 6,000 years to make useful food products, such as bread and cheese, and to preserve dairy products.
Why is biotechnology suddenly receiving so much attention?

During the 1950s and 1970s our understanding of biology reached a point where we could begin to use the smallest parts of organisms - their biological molecules - in addition to using whole organisms.

A more appropriate definition for the more recent sense of the word would be as follw:
"*New*" Biotechnology – the use of cellular and bimolecular[3] processes to solve problems or make useful products.

We can get an even better understanding of the term *biotechnology* by simply changing the singular noun to its plural form, *biotechnologies*. Biotechnology is a collection of technologies that capitalize on the attributes of cells, such as their manufacturing capabilities, and put biological molecules, such as DNA and proteins, to work for us.[4]

According to the Organization for Economic Co-operation and Development (OECD), biotechnology is the application of science and technology to living organisms, as well

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[3] Consisting of or relating to two molecules

[4] Biotechnology Industry Organization (BIO*), Guide to Biotechnology* 2007

as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.[5]

What is the biotechnology industry?

The biotechnology industry is defined as "the high value added industry which reprocesses/reproduces the useful product and service for human being from the function and information such as inheritance, propagation, growth, self-control, and metabolism by taking advantage of biotechnology."[6] Ultimately, biotechnology industry can be summarized in the industry which produces the useful product for human being based on biotechnology and creates new products by integrating high biotechnology with various types of industrial fields including chemistry, electronics, energy, pharmaceutical, environment, agriculture, and food.

B. **A Framework of Biotechnology Industry**

1. Classification

Every country has a different definition of biotechnology industry. It is necessary to identify and lay out the range of biotechnology industry before discussing it by countries. Ernst & Young, which monitors global biotechnology industry and publishes annual reports, classifies the industry into medical diagnosis, genetic/proteinic technology, industry bio, new drug discovery technology/service, new drug discovery, regeneration medical science, bio agriculture, and others as shown in Table 1. This classification is based on the U.S. market, the world's largest, and focuses on the clinical and health field as it is based on current market size.

Table 1. Biotechnology Industry Classification in the U.S[7]

Health and Clinical	Medical Diagnosis, New Drug Discovery Technology/Service, New Drug Discovery, Regeneration Medical Science
Others	Genetic/Proteinic Technology, Industry Bio, Bio Agriculture, Others

[5] OECD, *A framework for biotechnology statistics* 2005

[6] Biotechnology Industry Organization (BIO), *Guide to Biotechnology* 2007

[7] Ernst & Young, *Global Biotechnology Report*

Korea Institute for Industrial Economics & Trade ("KIET") breaks down the biotechnology into eight industries as shown in Table 2. Major difference of the U.S and Korea classification is that the U.S. market is more sensitive to health and clinical whereas Korea is more focused on actual products.

Table 2. Biotechnology Industry Classification in Korea[8]

Classification		
Production	Products	Biopharmaceutical Industry
		Biochemical Industry
		Biofood Industry
		Bioenvironmental Industry
		Bioelectronics Industry
		Bioprocess and Equipment Industry
	Energy	Bioenergy and Bioresource Industry
Service	R&D	Bioassay, Bioinformatics and R&D service industry

2. A Conceptual Model Biotechnology Measurement

Biotechnology encompasses several different research technologies or methods and several sectors or fields of application. As an example of multiple applications, recombinant DNA technology can be used to produce large molecule medicines in the pharmaceutical sector, create new crop varieties in the agricultural sector, or create microorganisms that produce industrial enzymes for the chemical sector. The variety of methods plus the range of applications can lead to large differences in how survey respondents might interpret questions on "biotechnology". To avoid this problem, biotechnology must be carefully defined in order to produce reliable and comparable statistics and indicators.

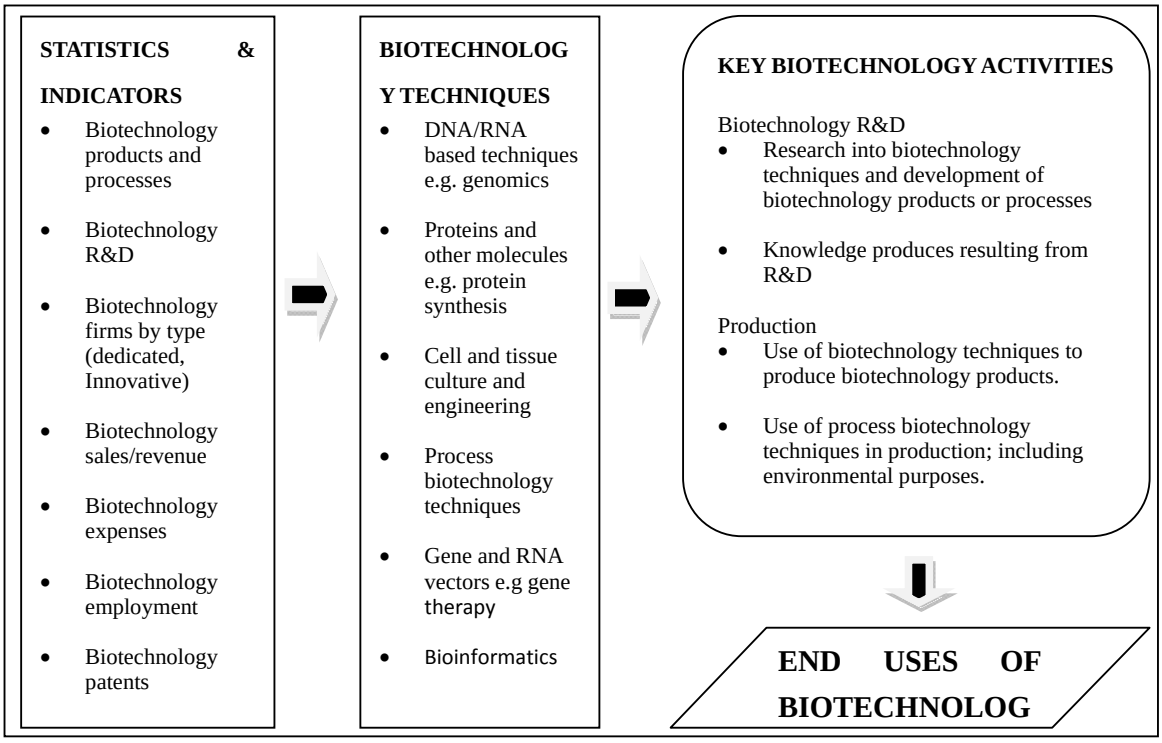
Figure 1 provides a conceptual model for biotechnology framework. Note that it lies within a broader conceptual model covering science and innovation generally. The

[8] KIET (Korea Institute for Industrial Economics & Trade)

circle in the top right-hand corner includes the key activities that are the focus of this framework: biotechnology R&D and the use of biotechnology techniques to produce goods or services. These activities produce end products (in the dotted hexagon) that are outside the current scope of this framework. End users, either firms or individuals, purchase biotechnology products as an input for manufacturing, agriculture or energy production. The central rectangle includes six main biotechnology techniques that are the focus of biotechnology R&D or which are used in production. The left-hand rectangle includes the different aspects of biotechnology that the framework is designed to measure. They include biotechnology techniques used in the key biotechnology activities.

It is important to note that some firms can be engaged in key biotechnology activities and also use biotechnology products. In such cases, only the firm's key biotechnology activities are covered in this framework. It is also possible for end users of biotechnology products to feed back to key activities, for instance GM[9] crops can be used as inputs to manufacturing processes based on biotechnology.

Figure 1. Biotechnology Conceptual Flow[10]



[9] Genetically Modified

[10] OECD

C. **Risks and Characteristics of Biotechnology**

The biotechnology industry is one of the major knowledge-based industries, which creates higher value-added business by investing intangible value, and is expected to continue to grow steadily in the 21st century. In addition, because biotechnology is a global industry it cannot complete the entire value-chain of the industry within one district or country, and absolutely requires the cooperation of multiple districts or countries. A large-scale international cooperation program where scientists and research centers are combined organically is on the rise as the field of R&D relevant to biotechnology business expands and large-scale investment is required through the Post-Genome[11] era. The innovative technology development is established for the period of Post-Genome era. In addition, the new lines such as Biochip, Nanobiotech, and Bio-information are created and the development of confusion of IT and BT is accelerated.

1. Risks and Characteristics

Ernst & Young summarizes the risks and characteristics of biotechnology as follows:[12]

Pricing Pressure and Access: The biggest risk facing the biotech industry is the prospect of increased price controls and access – a risk that could threaten the survival of the industry. The pressure of price controls could hurt commercial incentives and lower innovation. In the US in the mid-1990s, when President Bill Clinton's proposed healthcare reforms were under debate, the mere consideration of the possibility of price controls led to a significant decrease in the amount of capital made available to fund R&D investment, forcing several biotech companies to withdraw planned IPOs.

Raising Capital: Funding has always been a challenge for biotech companies, and many companies are now navigating a funding gap as venture capitalists increasingly favor investments with more predictable capital needs and exits.

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[11] The biotechnology company, Celera Genomics announced to solve human genome's map in 2001 since six different research teams including the U.S, the Great Britain got together for HGP (Human Genome Project) in 1990.

[12] Ernst & Young, *Strategic Business Risk* 2008

Strategic Alliances: From the earliest days, biotech companies have turned to strategic alliances to manage risk, access capital, and increase efficiency. However, in today's highly competitive deal environment, companies face increasing challenges and new risks related to deals.

Demonstrating Value: Biotech companies are facing considerable pressure to demonstrate not only efficacy from regulatory requirements but also economic value.

Product Development and Clinical Trials: Clinical trials are increasingly expensive, and higher drug development costs put pressure on capital raising and drug pricing.

Regulatory Compliance: Because panelists complain a lack of transparency of regulation, the pressures include operating new requirement areas such as post-marketing monitoring.

Monitoring Drug Safety: A number of recent drug withdrawals from the market after approval (e.g., Vioxx and Tysabri) have resulted in significant revenue losses, litigation and increased public awareness of drug safety.

Protecting Intellectual Property: Biotech companies face IP (Intellectual Property) risks in significant emerging markets.

Accessing Talent: The relatively lower numbers of science graduates, especially in the U.S, will result in biotech companies increasingly looking to source talent globally.

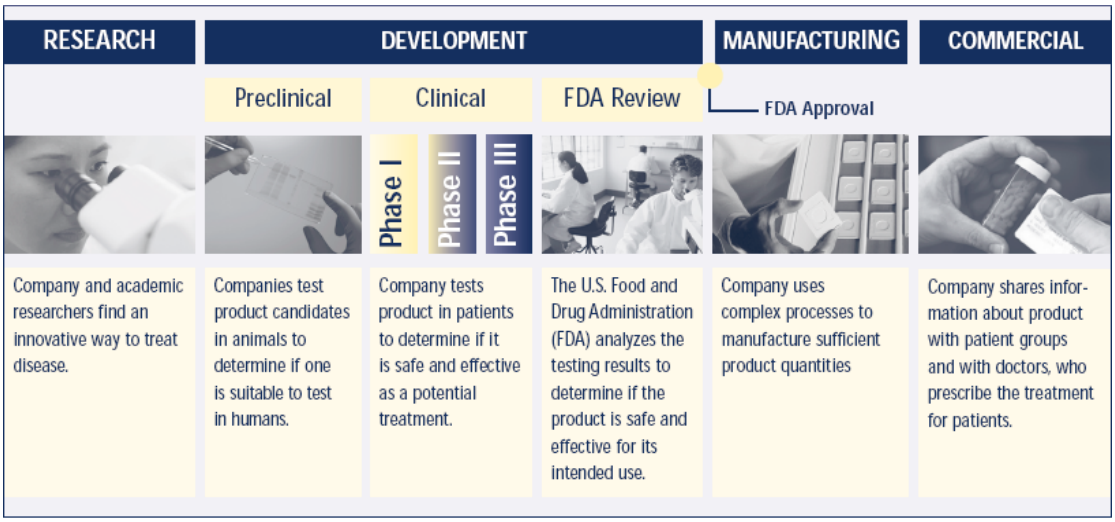
Harnessing Emerging Markets: Need to capitalize on the growing importance of emerging markets for sales, development and innovation

A single underlying factor is driving several of the biotech risks, and that is the issue of ensuring that the industry's innovation will be funded in the years ahead. It is essential that companies are able to price products at levels that provide adequate returns to investors so the industry remains innovative and financially healthy. Pricing pressures continue to increase in the U.S., and providing access for developing country populations will further compound this challenge. Entering emerging market especially providing a familiar environment for foreigner should be considered not only for potential markets but also for opportunity to expand business globally.

2. Drug Development Value Chain

To better understand biotech's development process more thoroughly, the author will describe the features of its primary exemplar: the drug development value chain. The drug-development value chain can be divided into four basic steps: research in which promising compounds to treat a particular disease are identified; development where the compound is refined and tested in clinical trials in animals and humans; manufacturing, where the compound is produced in large quantities; and commercial, including activities such as sales and marketing (see Figure 2).

Figure 2. The Drug Development Value Chain[13]



The FDA requires drugs to undergo three phases of clinical testing on humans. During Phase I, a small number of healthy people get moderate doses of the drug in order to test the drug's safety dosing range, and mechanism of action. If this initial test is successful, the subjects' dosage is slowly increased to determine its safety at higher levels.
During Phase II, a larger group of subjects, who have the disease or condition that the drug is intended to threat, is tested in placebo-controlled clinical trials. Phase II researchers look for efficacy and continue to study safety and optimal dosing.

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[13] BIO, *Guide to Biotechnology*

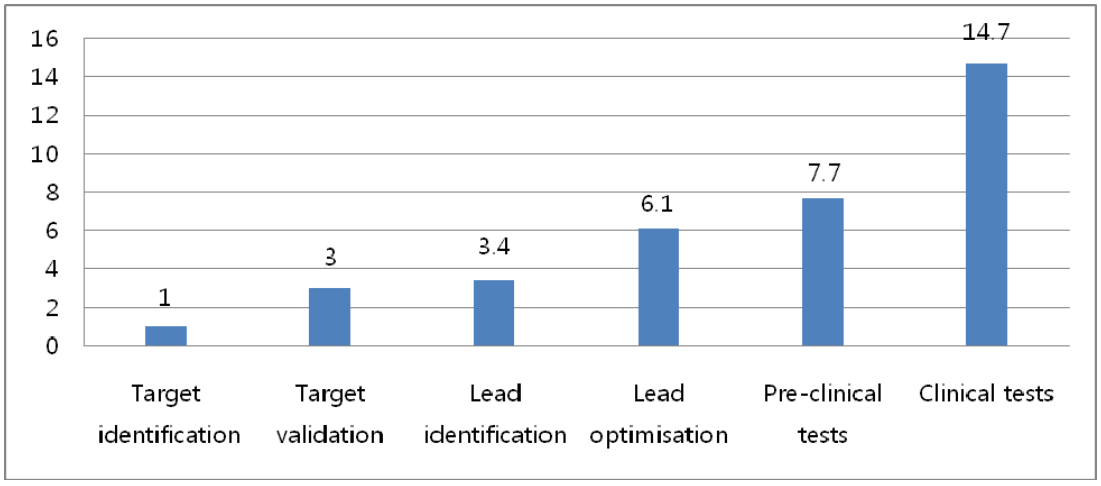
Drugs that pass the first two hurdles then undergo Phase III trials. At this level, the most complex and rigorous tests are performed on still larger groups of ill patients to ascertain the drug's safety, effectiveness, and optimum dosage regimens.

Usually, Phase III procedures employ randomized, double-blind studies with placebo control. This means that one group of patients is given the drug while another group receives an inert substance. Neither the patients nor their doctors are aware of which patients are actually receiving the drug being tested.

The FDA has estimated that, of 20 drugs entering clinical testing, an average of 13 to 14 will successfully complete Phase I, of those, about nine will finish Phase II, but only one or two are likely to survive the Phase III trials. Even after a drug successfully completes Phase III, there is the possibility that FDA will deem the data insufficient for approval. Ultimately, only one of the original 20 may be approved for marketing.

With the complex process of development, the drug discovery and development process requires a long time horizon (from 10 to 15 years). During the 1990's, moreover, because of the use of biotechnology, the time to gain the approval for a new drug significantly increased. Figure 3 shows the contribution of each phase to the overall completion time. Overall, it takes 14.7 years from target identification to clinical trial.

Figure 3. Approval Cumulative Years[14]



[14] The Boston Consulting Group, 2001

The top 10 risks for biotech are concentrated at the sector and operational levels. To some extent, this reflects the fact that biotech is truly different from other industries, and that the risks it faces reflect its unique challenges and circumstances. Biotech companies (and their pharmaceutical counterparts) are some of the most highly regulated businesses, and it can consequently take more than 15 years and $1 USD billion to bring a product to market. In the U.S. biotech market, there is currently the heavy pressure of pricing control, coupled with a high level of strict regulations, making it difficult for firms to remain competitive. The author believes it is time for U.S. biotechnology firms to set up different strategies for entering emerging markets where there is less pressure of pricing control, less regulation, and even high government support.

III. BIOTECHNOLOGY MARKET OVERVIEW

This chapter will discuss opportunities and how those opportunities are a result of global market trends. Furthermore, by introducing the biotechnology vision and plan established by the Korean government, the author assesses Korean biotechnology markets and trends. At the end, based on research of global and Korea market and trend, strengths, weaknesses, opportunities, and threats in the Korea biotech market will be analyzed.

A. Global Biotechnology Market and Trend

The biotechnology industry, which started with a handful of pioneering companies in the 1970s, was initially largely confined to the Boston and San Francisco areas. Since then, biotech has grown into a truly global industry, with an established European presence and emerging strengths in Asia.

1. Growth

Many research centers forecast that global biotechnology market will continue to grow more than 12.6% annually in terms of revenues. Table 3 provides the growth rate of the revenues of the global total market, and the number of employees for the period from FY2001 to FY2006. In terms of revenues, the growth rate of global biotechnology for last six years is steadily high as approximately 12.6%.

Table 3. Financial Data and Number of Companies of Global Biotechnology Market (FY2001-FY2006)[15]

(Units: in Millions of USD)

	2001	2002	2003	2004	2005	2006
Public Company Data						
Revenues	35,985	41,369	46,553	54,613	63,156	73,478
R&D expense	16,456	22,012	18,636	20,888	20,415	27,782
Net loss	5,774	12,483	4,548	5,304	4,388	5,446
Number of employees	191,864	193,753	195,820	183,820	-	190,500
Number of Companies						
Public companies	631	613	611	641	671	710
Public and private companies	4,267	4,362	4,471	4,416	4,203	4,275

[15] Ernst&Young, *Global Biotechnology Report*, 2003-2007

2. Segmentation of Global Market

The revenues and the number of employees in FY2006 by U.S., Europe, Canada, and Asia are shown in Table 4. The Asia market constitutes only 4% of total revenue, while the share of U.S. market is almost 75%.

Table 4. Financial Data and Number of Companies by Regions[16]

(Units: in Millions of USD)

	Global	U.S.	Europe	Canada	Asia-Pacific
Public Company Data					
Revenues	73,478	55,458	11,489	3,242	3,289
R&D expense	27,782	22,865	3,631	885	401
Net loss	5,446	3,466	1,125	524	331
Number of employees	190,500	130,600	39,740	7,190	12,970
Number of Companies					
Public companies	710	336	156	82	136
Public and private companies	4,275	1,452	1,621	465	737

The patents environment is a good indicator for predicting whether the biotechnology industry is growing or developing since intellectual property such as patents is critical to the growth of the biotechnology industry. In many cases, patents are a startup company's most valuable assets. As such, patents are essential to securing additional capital from investors as these companies and their science grow and develop.

Table 5 is very different when using two other measures – high school science proficiency and the growth in biotechnology patent applications. While the first two measures (scientific paper citations, share of global biotechnology patents) are indicators of an economy's past and current strengths in science and R&D, the last two measures (high school science proficiency, growth in biotechnology) are gauges of growth trends and investments in the future. The U.S ranks first using the first two measures, but it ranks near the bottom - 20 out of 23 countries – using the last two. Conversely, China, India, and Korea rank first, second, and third, respectively, in biotechnology patents growth. In other words, as emerging economies like China, India, and Korea invest in science education and biotech, it is worth asking where scientific

[16] Ernst&Young, *Global Biotechnology Report*, 2007

talent will cluster in the future and where the industry's growth will occur.

Table 5. Scientific competitiveness: Selected indicators[17]

Country	Scientific paper citations		Share of global biotechnology patents		High school science proficiency	Growth in biotechnology	
	Value	Rank	Value	Rank	Rank	Value	Rank
U.S.	37,822	1	43.3%	1	20	1.5%	20
UK	7,565	2	5.3%	4	-	2.8%	19
Germany	7,497	3	9.6%	3	14	10.1%	6
Japan	6,298	4	14.1%	2	1	8.2%	9
France	5,172	5	3.6%	5	12	6.3%	14
Canada	4,194	6	2.7%	6	8	5.2%	16
Italy	3,363	7	1.0%	15	22	8.1%	10
Netherlands	2,665	8	1.7%	9	5	5.8%	15
Austaralia	2,273	9	2.1%	7	5	3.9%	17
Switzerland	2,168	10	1.4%	12	10	9.0%	8
Spain	242	11	0.8%	16	22	12.9%	5
Sweden	1,960	12	1.2%	13	13	7.8%	11
China	1,481	13	1.7%	9	-	49.3%	1
Belgium	1,206	14	1.1%	14	12	6.4%	13
Denmark	1,052	15	1.8%	8	30	7.6%	12
Israel	1,039	16	1.6%	11	-	10.0%	7
Russia	1,019	17	0.2%	19	20	19.6%	4
Finland	893	18	0.5%	18	1	3.1%	18
Korea	841	19	0.0%	-	2	22.4%	3
India	789	below 20	0.8%	16	-	30.4%	2

3. Trends

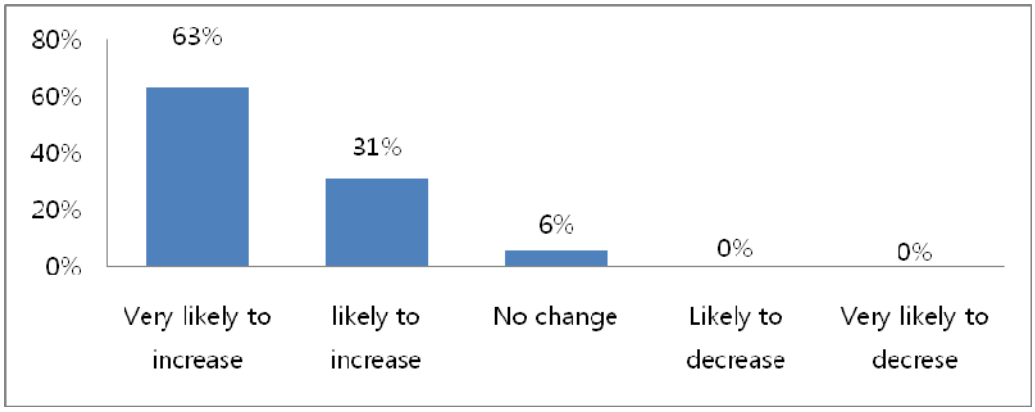
In late 2006 and early 2007, Ernst & Young surveyed biotechnology company executives in the United States, Europe, and Canada, to gather data on their company growth plans and global strategy over the next two years. Responses were received from more than 400 companies, representing a mix of early-stage companies and mature or newly maturing companies.

The survey reveals an industry with significant growth planned across several fronts. Some 94 percent of the respondents said they are "likely or very likely" to increase their

[17] Ernst&Young, *Global Biotechnology Report*, 2007

number of employees over the next 24 months. (Figure 4) This result means biotechnology market is promising, and most related companies plan to invest their businesses for a number of years to come, suggesting that the biotechnology market is likely to become even more competitive.

Figure 4. Expectation of Employment Increase in Biotechnology Industry[18]



In terms of global strategy, as the industry continues to mature, clinical development and contract sales forces companies anticipate significant growth in outsourcing. As shown in Figure 5, the survey reveals that 66% of America's companies are planning to expand global operations and 76% of European companies plan to go out. In terms of outsourcing trend in Figure 6, currently 65% of biotech companies already set up contract manufacturing for outsourcing, but they plan to increase that to up 77% from 65% for the next two years. That means many biotech companies are looking for the site to build their manufacturing plants by themselves or for companies who manufacture their products globally since 12% difference is significant rate for manufacturing.

[18] Ernst & Young, *Biotech CEO Survey* 2007

Figure 5. Expansion of Global Operations by Majority Biotech Companies[19]

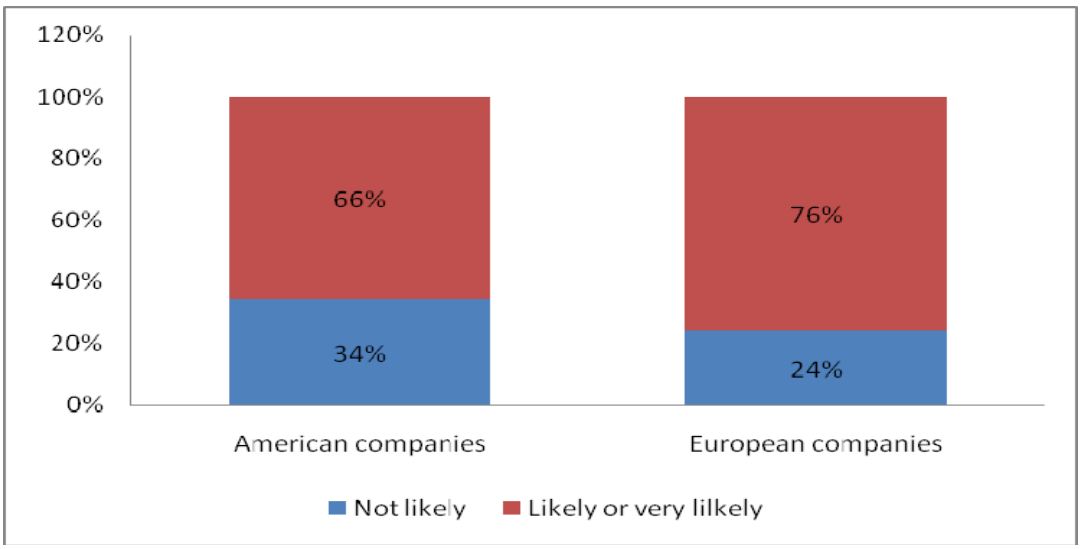
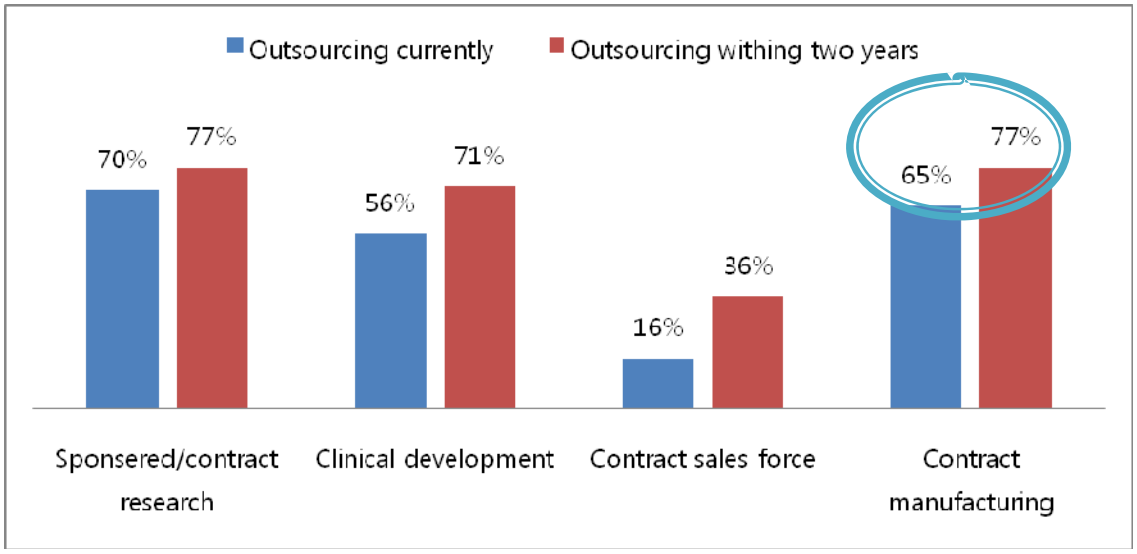


Figure 6. Increase in Outsourcing for Contract Sales Force and Contract Manufacturing[20]



[19] Ernst & Young, *Biotech CEO Survey* 2007

[20] Ernst & Young, *Biotech CEO Survey* 2007

To sum up the global biotechnology market and trends, it is clear that the market size is increasing annually and global biotechnology firms plan to invest more. In addition, as the top 400 biotech companies have responded to the survey, they determine to use more global outsourcing for manufacturing, sales forces, and the like as one way to expand their business.

B. **Korean Biotechnology Market and Trend**

Local biotechnology business in Korea is growing rapidly with the support of the government, which began in the early 1980s; however, the industry size is still insignificant compared to developed biotechnology countries such as the U.S., Japan, and the EU. Competitiveness in technology is about 60%-70% of the standard of developed countries, which is low level except for fermentation technology. In addition, local biotechnology business is only focused on the field of organism process and organism medicine; however, technology development in various other fields has made progress since the middle of the 1990s.

This section discusses the vision of the Korean biotechnology industry set by the government, along with the trends of the industry.

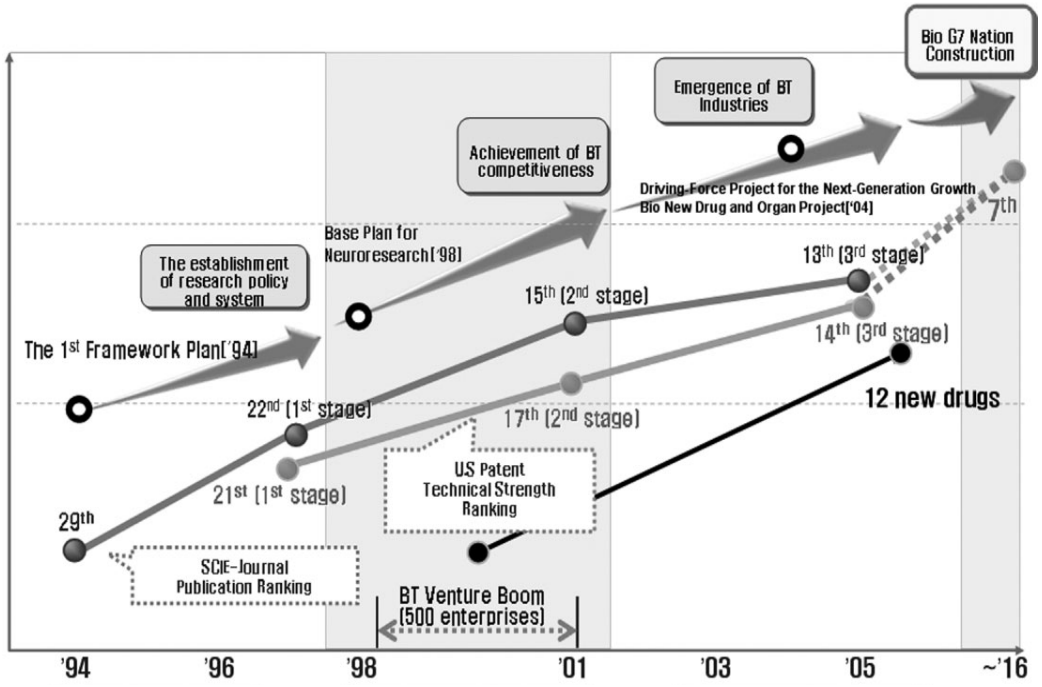
1. *Bio-Vision 2016*

For a clear understanding of the Korean bio industry, the first and second framework plans, as they are referred to by the Korean government, should be explained. *Bio-Vision 2016, Second Framework Plan for Biotechnology Promotion*, was established by the Korean government to enable Korea to lead the international trends in biotechnology in the 21st century. (Figure 7) As shown in Figure 7, the plan is aimed at strengthening the core infrastructure necessary to develop and commercialize world-class original technologies during 1990s. It is founded on the research basis established in the *First Frame Plan for Biotechnology Promotion*.

As a result the *First Framework Plan for Biotechnology Promotion*, Korean biotechnology began to produce its own creative achievements rather than merely modifying the results obtained by other countries: this in turn led to other industrial and

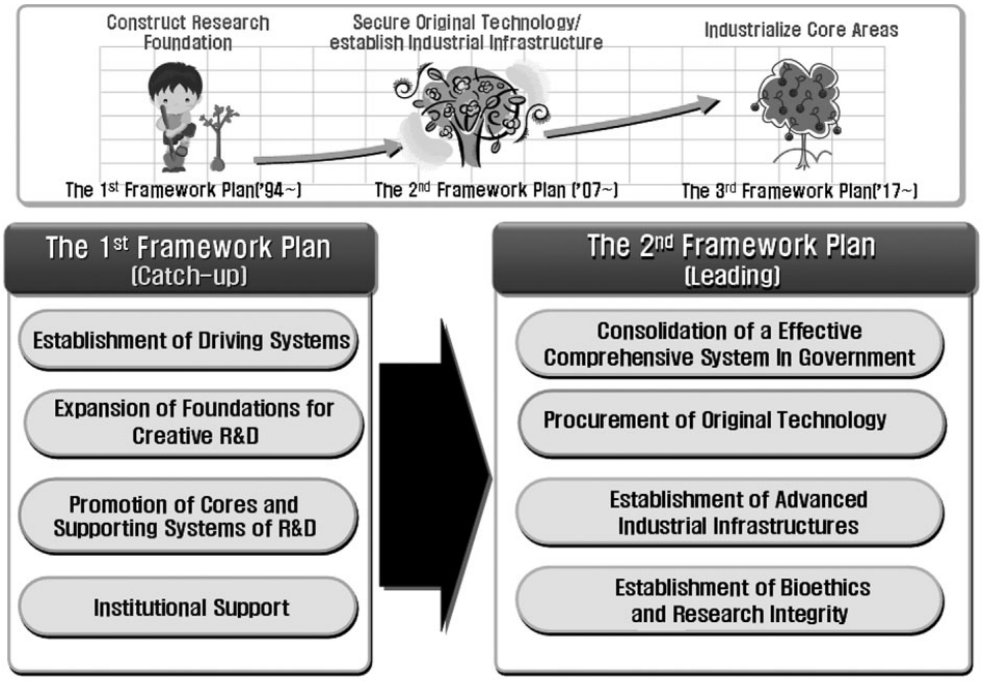
economic achievements. According to *Bio-Vision 2016*, by 2001 Korea biotechnology competitiveness achieved, by 2016 based on foundation of previous stage, Korea Biotechnology market occupancy ranks top 7th.

Figure 7. Bio-Vision 2016 Plan



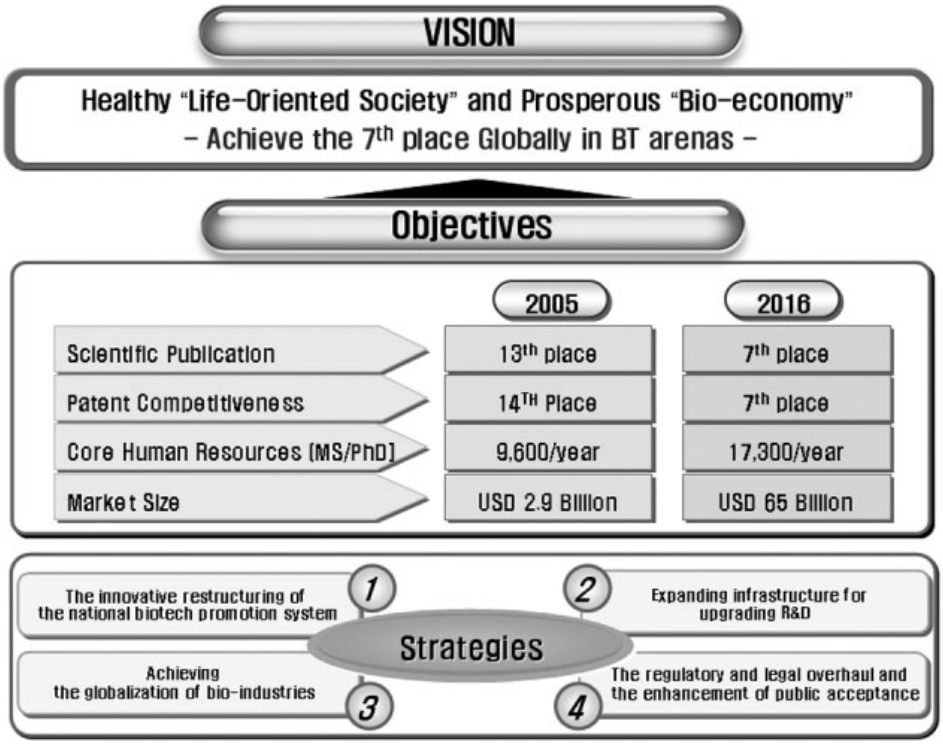
Based on the establishment of a solid research foundation during the first framework plan, the Korean government has implemented the *Second Framework Plan for Biotechnology Promotion* to secure original technology and upgrade the infrastructure for industrialization. Figure 8 explains the difference between the First Framework Plan and the Second Framework Plan. Whereas the first framework plan aimed to establish a research foundation of biotechnology with government, institutional support, the second framework plan focuses on industrialization of the field.

Figure 8. Bio-Vision 2016 Framework Plans



According to the *Bio-Vision 2016* in Figure 9, the vision of Korea bio industry is to create a life-oriented society and bio-economy within 10 years. *Bio-Vision 2016* is aimed at achieving the seventh place global ranking for Korea in terms of biotechnology. *Bio-Vision 2016* has also set the following targets for thesis, patents, human resources, and markets. First, the plan targets the seventh place by 2016 (from 13th in 2005). Second, as for patents, the plan targets the seventh place by 2017 (from 14th in 2005). Third, as regards to the number of holders of master degrees and doctorates, the plan is to employ 17,300 engineers in 2016 (up from the 9600 in 2005). Lastly, with regard to the market, the plan aims to increase market size to $65 billion USD by 2016 (from $2.9 billion USD in 2005).

Figure 9. *Bio-Vision 2016* Second Framework Plan



2. Trends

Korea Institute for Industrial Economics & Trade (KIET) announced that three major industries - advanced biomedicine, bioorgan, and biochip would be promoted intensively in Korea sine those industries is relatively well established and has founded good infrastructure. According to KIET, local biomedicine, bioorgan, and biochip businesses are expected to grow an average of 19% annually based on manufacturing standards until 2020, which well exceeds global market growth, 14.1%.

The competitiveness of local infrastructure, resource (basic research), product technology, and marketing was estimated at 55-75 compared to the U.S., which represents the standard at 100. This means that within the developed market, the U.S. reached 100 in terms of its competiveness, as compared to the degree of Korea's biotechnology development (Table 6). It is projected that local competitiveness will increase by 80-95 degree in 2020. For example, infrastructure and product technology is 95, which is almost equal to the degree of development by the U.S.; resource (basic

research) is expected to reach 80.

Table 6. The Competitiveness Change of Major Biotechnology Business by 2020[21]

	2005	2010	2015	2020
Infrastructure	75	80	90	95
Resource (Basic research)	60	65	70	80
Product Technology	75	80	90	95
Marketing	55	65	80	85

(U.S. market assumes 100 compared to Korea market)

According to KIET, the global market share of local biomedicine, bioorgan, and biochip, which are major biotechnology businesses, will increase from 1.4% in 2005 to 2.7% in 2020. Also the value-added amount in 2005 is estimated at USD 0.7 billion and this may increase by USD 1.8 billion in 2010 and USD 2.8 billion in 2020, which means that the value-added volume compared to the global market will be increasing from 1.9% in 2005 to 3.8% in 2020.

Table 7 shows projections for market size, manufacturing, and value added of major biotechnology business. Market share of manufacturing business in Korea starts from 1.5% in 2005 to 2.7% by 2020.

Table 7. The Market Size, Manufacturing, and Value Added of Major Biotechnology Business by 2020[22]

(Units: in Millions of USD, %)

		2005	2010	2015	2020
Market Size	Global	72,060.4	164,214.2	371,438.3	517,946.1
	Korea	1,224.0	3,137.6	7,463.0	11,594.5
	%	1.7	1.9	2	2.2
Manufacturing	Global	72,060.4	164,214.2	371,438.3	517,946.1
	Korea	1,040.0	2,964.5	7,816.4	13,967.9
	%	1.4	1.8	2.1	2.7
Value-added	Global	33,060.7	74,433.2	166,767.4	230,468.3
	Korea	628.9	1,825.4	4,885.3	8,792.7
	%	1.9	2.5	2.9	3.8

[21] Korea Institute for Industrial Economics & Trade, 2006
[22] Korea Institute for Industrial Economics & Trade, 2006

C. **Strength, Weakness, Opportunity, and Threat of Korea BT Market**

The following SWOT analysis Table 8 presents the Strength, Weakness, Opportunity, and Threat within Korea's biotechnology business. To sum up, Korean biotechnology has achieved significant new drug development, and there are many R&D centers and institutions to support research and development. In addition, advanced R&D and environment more familiar to foreigners exist. On the other hand, lack of experience entering the global market and lack of infrastructure constitutes clear weaknesses. Furthermore, strong competition with China and India expected, and while short-term investment vehicles are common in Korea industry, biotechnology industry requires long-term investment.

Throughout this chapter, the author has demonstrated that the worldwide biotechnology market is growing substantially, and most global firms seek strategic locations for outsourcing of manufacturing, sales forces, etc. Korea's BT has just constructed basic infrastructure for biotechnology development, but at the same time it does have highly-skilled manpower in a number of R&D centers and institutions. In addition, the Korean government has established plans to develop biotechnology nationally, with levels of supporting administration and finance. Under the circumstances, Korean BT market might be the opportunity for global BT firms in terms of saving operating costs and entering new market.

Table 8. SWOT Analysis of Korean BT

Strength	Weakness
- Korea has experienced to develop generic medicine, improved medicines based on the compounding technology of organic chemistry, and exported the products. - The R&D regarding the up-to-date bio products such as cell therapy products and gene therapy products is progressing and the products in clinic stage are increasing in domestic and foreign. - The performance of high-tech study is increasing by public organizations such as colleges and R&D centers, based on R&D investment with government support.	- Korea biotechnology business is still at the first stage quantitatively and qualitatively. - Many biotech firms are small businesses and most products are low value added or in R&D stage. - Manufacturing infrastructure and technology for industrialization are weak. - Few local firms have experienced overseas expansion, while global expansion is essential for biotech industry.
Opportunity	**Threat**
- Biotechnology market is expanding due to the environmental change such as aging and environmental pollution. - Developed technology development environment and technology comparing to competing countries, India and China.	- Biotech business needs high cost and long term R&D period, while local finance environment generally allows short term investment. - The separation between reality and expectation from rash commercialization and excessive advertising brought social disappointment. - The competition of key technology development among developed countries becomes intense more and more and price competitive is low comparing to competing countries, India and China. - Networking such as strategic cooperation and M&A is week.

IV. BIOCLUSTER CASES

This chapter discusses five biocluster cases: two cases for Korea, one each for Singapore, the United Kingdom, and the United States. By describing the approach of different regional and marketing locations, the author defines biocluster and the characteristics of the clusters.

Each cluster case is analyzed with different approaches in order to better understand success factors and considerations of the development. For example, some cases tell how to integrate the components of the cluster such as government, educational institutions, or industry, while others explain how the processes occur when developing, and the trend of the cluster historically to outlook next trend.

First of all, as most real estate developers are unfamiliar with biocluster, a definition of biocluster, and advantages and disadvantages of it will be explained.

A. **Understanding Biocluster**

Biocluster is a cluster focusing on the biotechnology sector, where cluster is understood as the geographical concentration of different players such as interconnected companies, specialized suppliers, service providers, and institutions, which compete and cooperate in the same industry. Cluster development is a complex process and usually involves a number of players that include governmental departments, economic development agencies, public administrations, universities and research centers, companies of different types, and financial institutions.

1. Advantage and Disadvantages

The definition of cluster itself suggests that clustering may lead to significant advantages for firms. They may take advantage of the strong demand in the location, the large supply of manpower (even highly qualified and specialized), and the network of complementary strengths in neighboring firms. Particularly in high technology industries, geographical proximity plays a pivotal role in the early stages of the life cycle of a product or technology, facilitating the use and transfer of tacit knowledge that is a key to successful development.

Porter in his Adam Smith Address (1998) identifies three kinds of advantages in clustering:

Productivity advantages: These advantages derive from the use of better and cheaper specialized inputs (components or services), which themselves come from minimal inventory requirements and lower transaction costs resulting from geographic proximity and the establishment of high trust relations among companies within a cluster. Moreover, joint purchasing services or shared infrastructures (particularly high-tech facilities) may reduce fixed costs for existing companies and initial investments for new ventures;

Innovation advantages: Proximity between customers and suppliers facilitates the transfer of tacit knowledge. Moreover, the proximity to a knowledge center offers a strong potential for innovation and, allowing critical mass to be gained, particularly for pre-competitive activities such as basic research. Finally, localized benchmarking among players in the cluster and the great availability of a qualified labor market can strongly improve the capacity to innovate.

New business advantages: Due to better circulation of information about market opportunities and potential, barriers and risks for new firms can be lower for the clear perception of unfilled needs.

Whereas major disadvantages concern is congestion and competition in output and input market according to Swann, Prevezer, and Stout (1998) in their book *The Dynamics of Industrial Clustering*.

Congestion and competition in output markets: According to microeconomic theories, a increased number of competitors in the same geographic area may reduce per-firm sales, prices, profits and growth. These effects, however, actually start to dominate demand side advantages when congestion becomes heavy, suggesting that there may be diminishing (and eventually negative) returns to locating in a cluster as it reaches its maturity.

Congesting and competition in input market: It is expected that effects of the cost of real estate or the cost of labor. It is expected that these effects come to dominate for new firms when the cluster reaches its maturity.

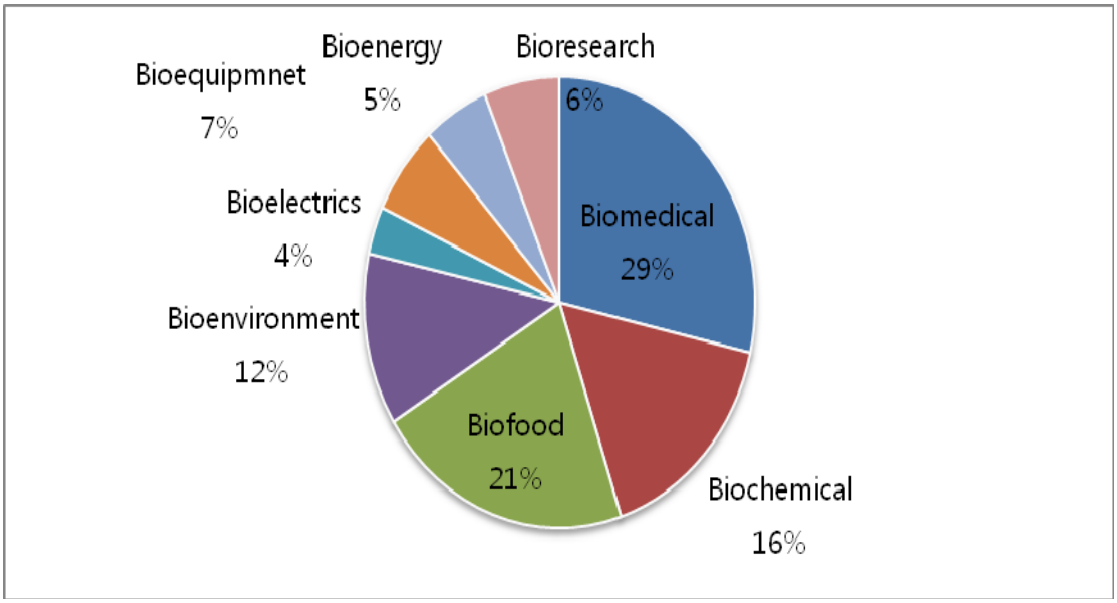
B. **Korean Biocluster Cases**

1. Statistics

a. Bioindustry distribution

Korea Institute for Industrial Economics & Trade (KIET) provided the information on bioindustry distribution is as shown in Figure 10. Biomedical industry takes the biggest share of this distribution and actual operating firms are 29% of the total. This means biomedical is dominant within the biotechnology industry in Korea.

Figure 10. Bioindustry Distribution by Industry[23]



b. Regional distribution

Most local bioindustry firms are centralized in metropolitan areas which include Kyunggi (32.9%), Seoul (21.5%), and Daejeon (8.9%). In case of Incheon, it has low portion around 3% but it also has strategic advantage since it is located adjacent to

[23] KIET, *Bioindustry Statistics (2006)*

Kyunggi, largest region, and Seoul.

Figure 11. Bioindustry Distribution by Regions in Korea[24]

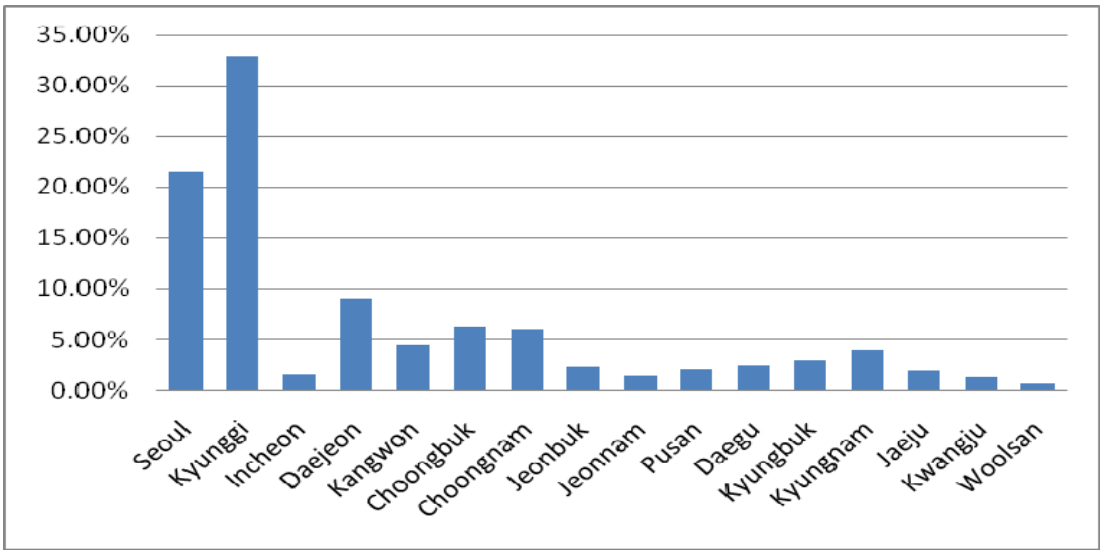


Figure 12. Map of South Korea

Left illustration, Figure 12 shows map of South Korea. Following Korea two cases are located at Wonju for Medical Techno Valley and Daejeon for Daedeok Techno Valley. Incheon for Yeongjong Project is located at the west coast of Korea.

[24] KIET, *Bioindustry statistics (2006)*

2. Case 1, Wonju Medical Techno Valley

Wonju Medical Techno Valley is the largest medical equipment manufacturing cluster in Korea. Here the author gives a story of the birth, history, conditions surrounding the area, product types of the cluster, and how components such as government, industry, and schools have been integrated.

a. History and Overview

Wonju Medical Industry Techno Valley ("Techno Valley") benchmarked Tuttlingen, a medical equipment specialized city in Germany. Techno Valley selected the specialized industries focusing on electric medical equipment and remedial medical equipment and targets an independent industrial complex with its nourishing autogenous firms and its support and cooperation from those companies.

In addition, the Techno Valley helped the medical industry stabilize and build a network in the cluster by supporting R&D, marketing and management, funding, training and education, information, business incubation, and the like.

The city of Wonju and Yonsei University established Techno Valley at Wonju which is a mostly barren city with some medical equipment business. The city of Wonju needed new innovative strategies to survive and Yonsei University needed a solution to prevent a decrease in the student population and revitalize R&D. Multiple projects have been developed since the Techno Park R&D Center Development, which was promoted by the Ministry of Commerce, Industry and Energy. In 1999, the Wonju campus of Yonsei University received permission from RRC businesses to conduct studies of core technologies for nine years in addition to the central government and it was nominated officially as Business Incubator ("BI") by the Small and Medium Business Administration that same year. In addition, the 10,000㎡ (2.47 acres) Techno Park for post-BI was established within the Taejang Industrial Complex of rural areas and about 20 firms incubated there by the time BI moved in.

b. Conditions surrounding the area

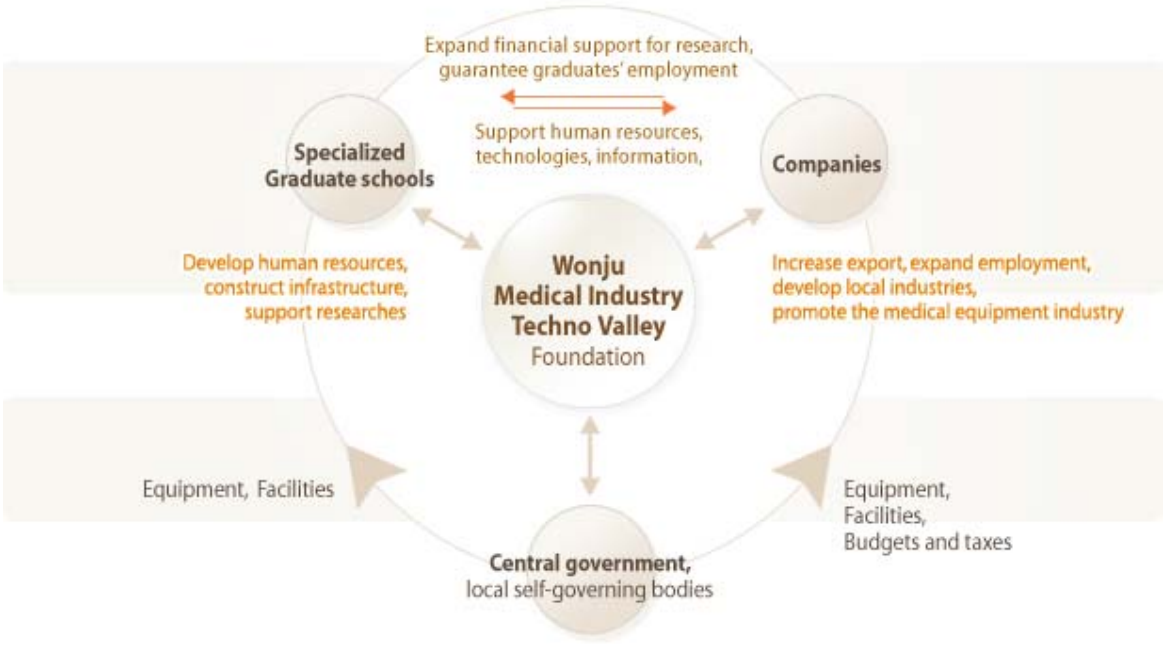
There are five universities that supply high-quality researchers and technicians and, three general hospitals support clinical researches around the area. The cluster is designated a venture promotion district by the Small and Medium Business administration and as an innovation cluster model complex.

To assist international firms in getting established in the cluster and to assist local firms to better communicate with international firms, Yonsei University provides language courses by each native speaker and campus facility.
For transportation, the cluster is at a strategic center of logistics and transportation with gjong and Jungang Expressways and there is a daily flight between Wonju and Jeju Island.

c. Basic concepts for the development of medical equipment industry

Figure 13 shows how the cluster develops as a medical equipment industry. The core business of the cluster is the Techno Valley that controls each component. Schools provide human resources, and play a role in constructing infrastructure and supporting R&D. Local government helps establish the infrastructure to make the area a friendly environment with a medical equipment cluster and taxes benefits. Companies promote the medical equipment industry and start businesses by taking advantage of the schools' resources and government support.

Figure 13. The Development of Wonju Medical Equipment Industry



d. Product type

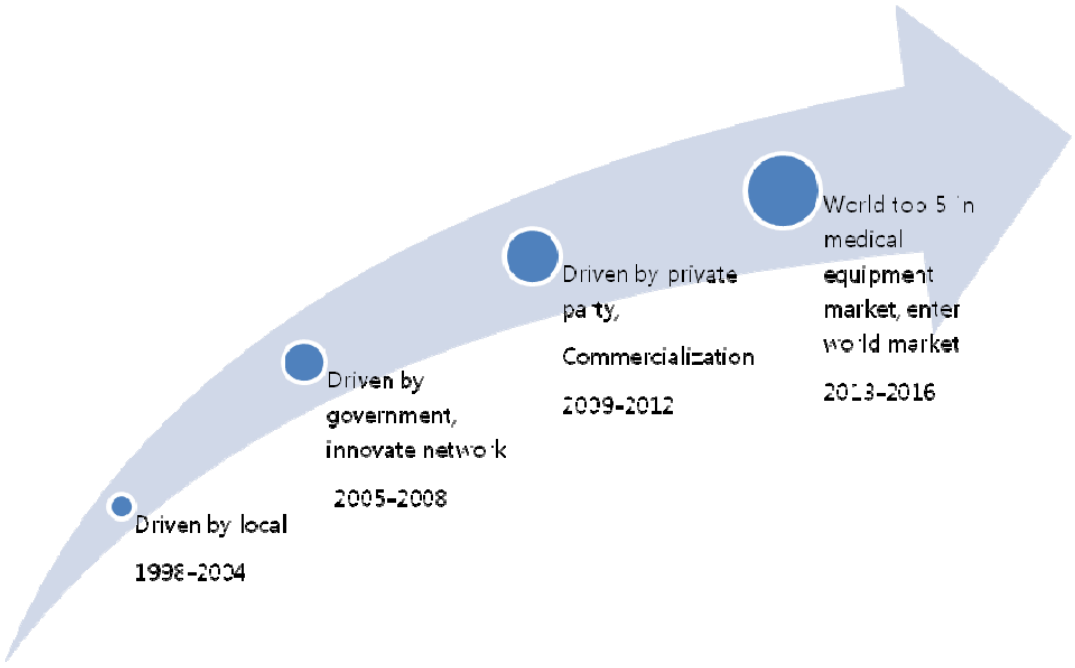
Wonju Medical Clusters consists of the following three complexes:

- Medical Industry Techno Tower – AHSOL, AIRMED et al: total 12 tenants
- Wonju Medical Technology Techno-park – BeEAUTO, ELBIO et al: total 26 tenants
- Donghwa Medical Instrument Complex – AILAB, BIOPROTECH, etc total 16 tenants
- Medical Venture Industry

e. Vision of the cluster

The cluster started in 1998 with no infrastructure and business but now in 2008 employs 1,500 and produces medical equipment valued at $250 million (USD). By 2016, the cluster plans to become the world's fifth leading producer of medical equipment manufacturing and produce $1.2 billion USD. Figure 14 illustrates details this vision step by step.

Figure 14. Vision by years of Wonju Medical Equipment Industry



The characteristics of Wonju Meical Cluster are initiated by the government and educational institution. Because Yeonsei Uni has strong research of medical industry, the government could easily coorperate with the university to support to establish infrastructure of medical equipment. Moreover, the cluster that has similar medical equipment concept didn't exist any location in Korea other than Wonju. These characteriscs could lead the cluster be a leading medical equipment cluster in Korea.

3. Case 2, Daedeok Techno Valley

This case study explains more about the development process of a large scale cluster in Korea from a real estate developer's point of view.

Daedeok Techno Valley ("DTV") is established by special corporations that consist of private company (Hanwha), national bank (Korea Developmen Bank), and local government (Daejeon city). The Hanwha is responsible for the DTV development project and management, KDB (Korea Development Bank) administers the development fund loan, and Daejoen Metropolitan City is interested in bio and high-tech venture companies.

a. Development Phases

Daedeok Techno Valley is constructed on a 4,257,000 m2 (1,051 acres) site near Gwanpyeong-dong, Yeseong-gu, Daejeon Metropolitan City, Korea. It is a three-phase project, which began in 2001 and was scheduled for completion in 2007 as shown Table 9.

Table 9. Development Phases of Daedeok Techno Valley

Classification	**Area**		**Period**
1st Phase	924,000 m2	228 acres	Nov 2001 ~ Jul 2004
2nd Phase	1,584,000 m2	391 acres	Jun 2003 ~ Jun 2006
3rd Phase	1,749,000 m2	432 acres	Apr 2005 ~ Dec 2007
Total	4,257,000 m2	1,051 acres	

b. Development Layout

The project includes industrial, residential, commercial, leisure and public sites.

- Industrial

The industrial site (red area) is in the Gapcheon area of the north complex and is composed of general industrial and semi-industrial complexes, which includes factories and offices. Research institutes of venture companies equipped with cutting-edge technologies including IT, BT, NT, and RT, are moving there. Daedeok Techno Valley (DTV), which is at the center of Daedeok R&D special district and forms a dynamic high-tech industrial cluster with 1,000 venture companies and 200 research institutes in the Daedeok research complex. It attracts the top-level graduates from KAIST, ICU, etc. and creates an infinite synergy based on industry-university-research cooperation. This makes DTV the best productive domestic high-tech venture industrial complex equipped with a first-rate industrial base.

- Residential

The DTV residence complex (red area) is a combination of high-rise apartment buildings, townhouses, and detached houses. It offers superior residential conditions including 10 new elementary, middle and high schools equipped with state-of-the-art facilities, as well as the Gwanpyeong River Ecological Part and a waterside park. The residents in the hi-tech apartments and suburban-style houses will enjoy the pleasures of nature and the convenience of the city. The project brings new value and satisfaction to their quality of life.

- Commercial, Leisure and Public

The various commercial facilities (red area) are strategically located in the complex to facilitate self-sufficiency, efficiency and balance among the multiple functions of this well-planned urban development.

In addition, tourism and on-site recreational facilities will develop into a place for leisure activities within the complex. It will also include a cluster of landmark facilities such as hotels for foreign buyers visiting the enterprises housed in the complex and domestic business tourists, using the water park and theme parks.

A high level of education is demanded in the residential complex. Therefore, five elementary schools, three middle schools, and three high schools are planned. The schools are expected to exceed OECD standards in terms of the number of students in a class. A foreigner's school will be built for foreigner laborers as well.

Finally in Daedeok Techno Valley, 10 neighborhood parks and children parks will be constructed on a site 24,000 m^2. The neighborhood park at the center of the complex will be a venue for outdoor cultural activities including festivals and events. It will be accessed and used by various classes of residents and utilized as a place for X-games and ecological learning.

c. Characteristics

Its absorption is currently more than 95% in most phases. What characteristics and factors lead to such successful results will be explained.

- Distinct project initiators

The synergy effects are maximized thanks to the complementary nature offered by the respective expertise of each of the stakeholders, including Hanwha Group's business-

acumen and management know-how, Daejeon City's administrative services contribution, and Korea Development Bank's capital strength

- Carefully phased development approach

A three phase development approach was adopted, taking into consideration initial investment risks and the macro economy. In addition, the phased promotion of the project helps reduce investment risks, minimize unsold land, and prevent long-term negative ripple effects

- Providing a new model for an industrial complex

This type of complex environment reminds people more of a research complex rather than a typical industrial complex. In addition, a new concept is introduced into this complex, which harmoniously combines the elements of an industrial complex (production) and a residential/commercial complex (consumption) in a synergistic entity. A pleasant environment and culture-friendly city is designed, taking into consideration the quality of life of its constituents by following:

1. The introduction of varied skylines in the residential complex;
2. The presence of Gwanpyeong River ecological park and waterside central park;
3. The added beauty of splendid lighting of bridges and overpasses;
4. The preservation of a mountain-type neighborhood park;
5. The installation of underground power lines, and
6. The planned construction of leisure and multi-function sports facilities.

- Unique marketing strategies

First, pre-marketing activities shall be conducted after thorough investigation of demand and of comparable prices. Secondly, a drop in real estate demand and local limitation shall be overcome through encouraging potential demand. In other words, their target market is not only local but also national through aggressive market.

This mega development represents the different market strategy. Previously, the target market was limited to local but now their target tenants are not only local but also national even global. For another characteristic of the development, in order to meet national and global standard, the development also provides high quality residential, office and entertainment complex. The development now focuses on more amenities for

resident and employees. The trend tells the development should consider not only property itself but also people who use the properties to be successful.

C. **International Biocluster Cases**

1. Case 3, Tuas Biomedical Park in Singapore

a. Overview of Tuas Biomedical Park

Singapore's government has developed biomedical industry seriously upon the slogan of "The Biopolis of Asia" to create new R&D, business opportunity, and employment since 1990s. In 2000, the Singapore government announced the BMS Initiative[25] and makes every effort to attract foreign investment and overseas labor. This is done by publicizing the advantage of geopolitical characteristics, located in the center of ASEAN[26], the protection system of intellectual property rights, the global standard educational system, and cultural facilities.

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[25] Economic Development Board (EDB)'s BMS group and Bio-One Capital, as well as A-STAR's BMRC (Bio Medical Research Council) work in close partnership. The goal is to develop the BMS cluster – comprising pharmaceuticals, medical technology, and biotechnology and healthcare services – into a key pillar of the Singapore economy. The three groups adopt an integrated approach to develop Singapore's industrial, intellectual and human capital to support the BMS initiative.

[26] Association of Southeast Asian Nations

The biomedical sciences industry is a one of the Singapore's missions and a key growth engine for Singapore's economy. Manufacturing capacity has been expanding along with the rapid development of R&D expertise and capabilities. By locating their business operations in Singapore, companies are able to leverage Singapore's strong intellectual property (IP) protection; strong government support and thriving biomedical sciences community.

JTC[27] has developed a wide spectrum of industrial facilities in Singapore catering to the specific needs of biomedical manufacturing activities. The 183 hectare Tuas Biomedical Park 1 (TBP 1) and the 188 hectare Tuas Biomedical Park 2(TBP2) are dedicated to manufacturing-related activities for pharmaceuticals, biopharmaceuticals, biologics, vaccine, medical devices and nutritionals related companies. Biopolis at One-North[28] is a research and meeting point for talent in the biomedical sciences. Scientists and researchers work together in vibrant R&D environment to spur new discoveries and advances in the biomedical sciences.

Tuas Biomedical Park is designed for bulk active pharmaceutical and biopharmaceutical manufacturers. Key infrastructural provisions of power, water, telecommunication, gas and sewer requirements are available in the park. In addition to hard infrastructure, JTC has invested approximately $6 million in landscaping to create a conducive and inspiring environment for the knowledge based cluster in the park. As part of the

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[27] JTC Corporation ("JTC") is established as the affiliated organization of Ministry of Trade and Industry on June 1968 and takes charge of planning, development, and management of business infrastructure and business parks. JTC developed 38 industrial complex (approximately 7,000 company residents), 2 business parks, 3 semiconductor complexes, 1 biomedical park, and chemistry complex of Jurong Island. In 2000, JTC is chosen as the Master Developer of One-North project. JTC, an affiliated organization of government manages the price of industry sites to make companies competitive by connecting with the market price. Providing the innovative business environment which integrates 'work, residence, culture, and education' in one community is JTC's goal from now on.

[28] One-North project is a long term project (183-hec) that provides a biomedical, IT, knowledge-based cluster supported by the Singapore government.

landscape enhancement project, a landmark sculpture now stands at the park's entrance to mark the gateway into Asia's premier Biomedical Park.

b. Information on Companies in Tuas Biomedical Park

The biggest tenant of the park is Merck Sharp who entered in 1998 and then Abbott who recently joined in the park. Along with the development of Tuas 2 Park, the science park has become more famous and attractive to global pharmaceutical firms.

Table 10. The Companies located in Tuas Biomedical Park

Bio Pharmaceutical Companies	Land Allocated (ha)	acres	Year of Entry
Merck Sharp & Dohme (Singapore) Ltd	19.4	48	1998
Wyeth Nutritionals (Singapore) Pte Ltd	8.6	21	1999
Pfizer Asia Pacific Pte Ltd	9	22	2000
CIBA Vision Asian Manufacturing and Logistics Pte Ltd	5	12	2003
Novartis Singapore Pharmaceutical Manufacturing Pte Ltd	8	20	2004
GlaxoSmithKline Biologicals (Singapore) Pte Ltd	8.8	22	2005
Lonza Biologics (Singapore) Pte Ltd	4.2	10	2006
Abbott Manufacturing Singapore Pte Ltd	16	40	2006
Lonza Biologics Tuas Pte Ltd	4.2	10	2007
Genentech Singapore Pte Ltd	8.2	20	2007

Figure 15. Overall Feature of Tuas Biomedical Park

Figure 15 shows the location of Tuas Park 1 (TBP), and Tuas Park 2 (TBP2) including tenant lists of the site.

Overall, Singapore is efficiently connected among government ministry, private and public R&D, institutions, and universities. In addition the culture is willing to freely adapt new technology and research either from domestic or international sources.

Regarding finance, the government supports the cluster under public-private partnership since the government recognizes that initial investment to develop biotechnology requires large amounts of capital. They also do not hesitate recruiting professionals from other countries if they think the professionals are qualified. These are the reasons the cluster is renowned internationally.

2. Case 4, Cambridge Cluster in United Kingdom

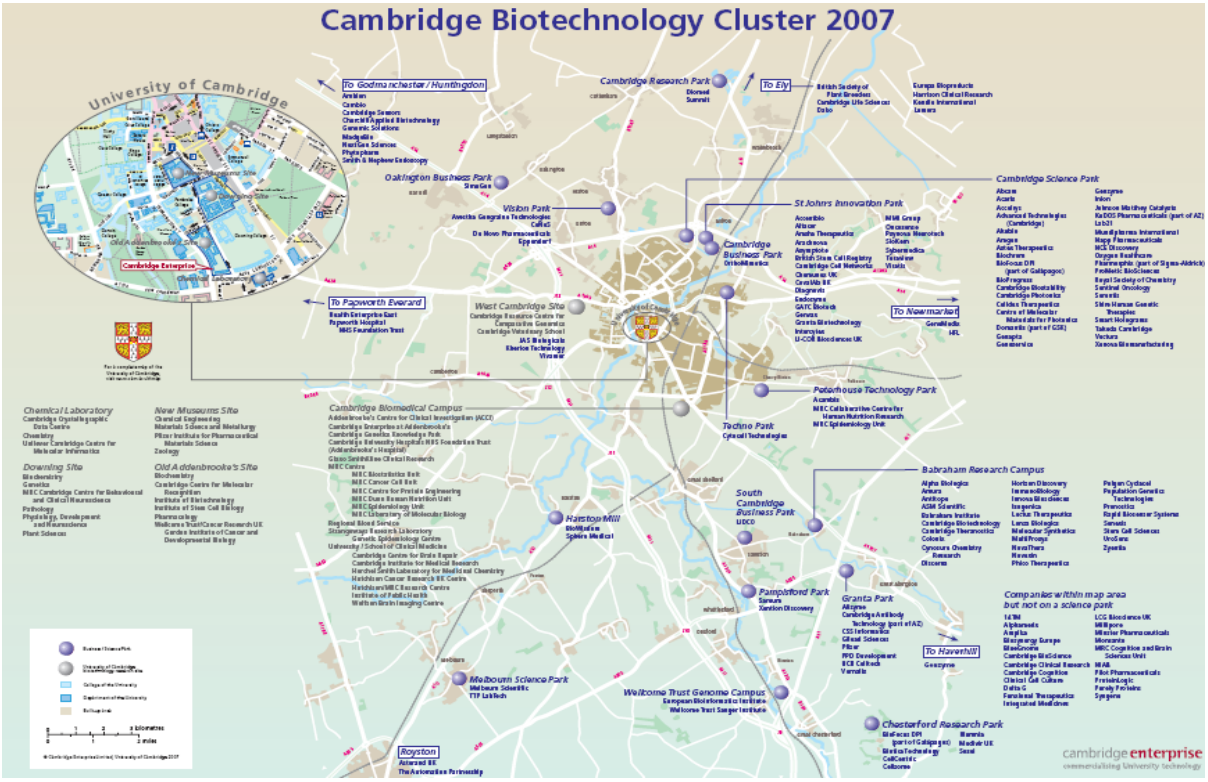
a. Overview of the Cluster of Cambridge

The industrial biotechnology cluster within Cambridge emerged in the early 1980s in a high-tech environment created by existing electronics and computing industries. Initial companies were founded within the Cambridge Science Park (owned by Trinity College and the University of Cambridge), which itself was built to attract computing companies. A national strategy paper was published in the mid 1970s by the British government with the intention of making universities more proactive in industry, and this resulted in the creation of initial science park buildings by Trinity College. There were no buildings specifically for biotechnology companies and college did not build with the college acting as landlord only. Now, the Park is dominated by biotech companies and viewed primarily as a biotech location. The availability of scientific premises was supported by a change in attitude from some major investors within the Cambridge area. Barclays Bank, one of the largest banks in Britain started investing in more high-tech industry and venture capitalists followed suit. The number of biotech companies grew steadily until the mid 1990s, when a global explosion of investment in high-tech industries accelerated company creation at a sustained rate.

Figure 16[29] illustrates of the location and geographic information of the cluster. The cluster consists of 16 science parks including laboratory and R&D facilities and two large educational institutions

[29] . The illustration's complexity makes it hard to read, so the following link provides a PDF version of the map. http://www.cambridgenetwork.co.uk/docs/Biotech_Map.pdf

Figure 16. Cambridge Biotechnology Map



b. Major actors in the cluster

This analysis takes into account three players; the biotech firms (BFs), the industrial and research environment and the financial environment.

- Biotech Firms (BFs)

Cambridge currently has over 215 biotech companies, over 350 specialist service providers with biotech expertise, over 30 research institutes and universities, over 20 multi-nationals in pharmaceuticals, agriculture and food, and four leading hospitals involved in research and working with biotech.

They have built a strong cluster profile as a center for early stage companies with high growth rate and innovative technologies. There are also large biotech companies scattered throughout the region. Traditionally, large companies such as Celltech and

Cambridge Antibody Technology have been classified as large companies based on a total number of employees exceeding 250. These companies have a very different profile from pharmaceutical companies, operating on biotechnology models rather than the classical pharma structure. For example, Cambridge Antibody Technology has no large-scale manufacturing and its first product for registration is being handled through a partner.

Figure 17 depicts the biotech companies' segments in the cluster. The largest sector is pharmaceutical products and services around 55%.

Figure 17. Biotech Companies' Segments[30]

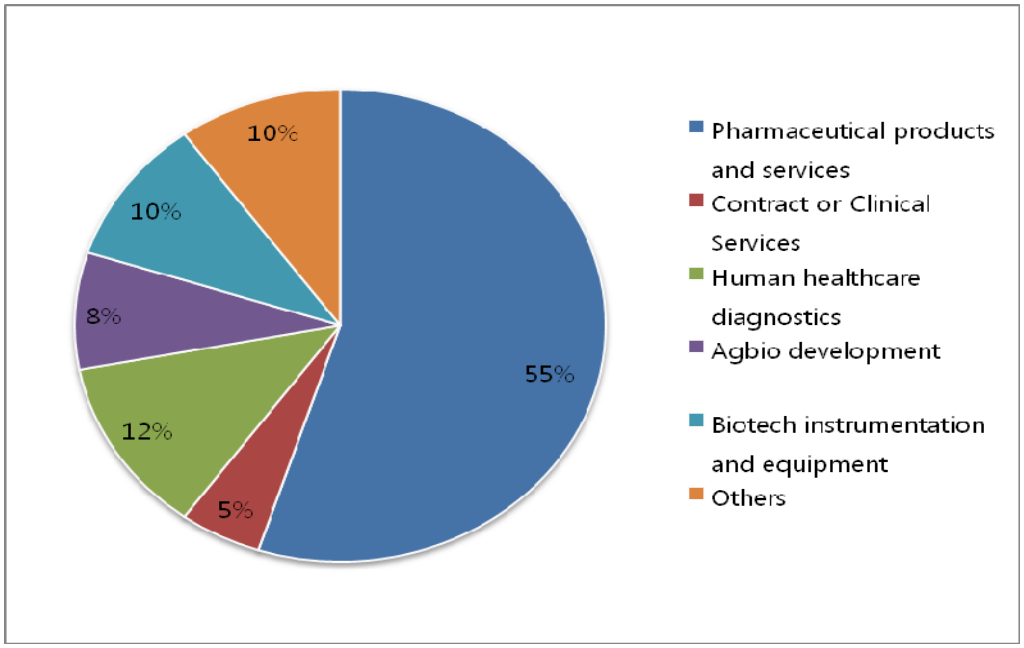


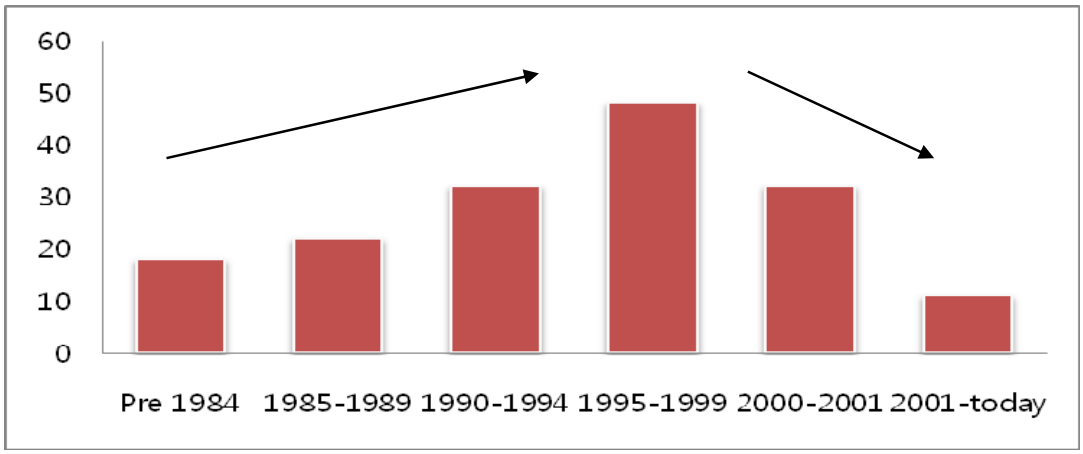
Figure 18 illustrates the speed at which the Cambridge cluster developed. As indicated by the number of pre-1984 companies, clusters originated were in the early '80s. Each column indicates an increasing number of firms each year. However, the most rapid period of growth is 1995-1999. The growth is a result of two main factors; first,

[30] ERBI (Europe's leading regional biotechnology industry group)

commercial awareness of biotechnology boomed during this period and it suddenly became feasible to start a biotech company either from academic start-ups or big pharma origins; and secondly, a rapidly growing global economy fuelling large venture capitalist investment in a broad range of companies.

Overall number of development of the area is now decreasing since 1999 because most biotech firms strategically have been seeking location having lower costs and less regulation.

Figure 18. Increasing number of firms at Cambridge Cluster[31]



- Industrial and Research Environment

Besides a strong industrial base, the research environment in the area of Cambridge represents a key driver for the development of the cluster itself. The Cambridge cluster is synonymous with the University of Cambridge and is closely linked with the biotechnology cluster. It could not be described as having been instrumental in the formation of the cluster from a commercial angle; the University has been slow to realize the commercial potential of its research and only now do we see startup

[31] ERBI

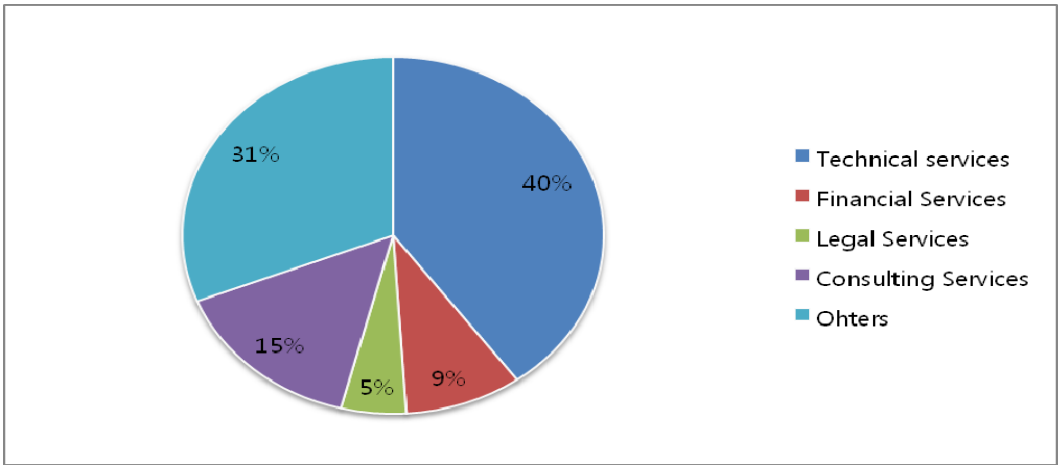
companies in significant numbers from the university. Trinity College, within the University has the strongest commercial links with the biotechnology cluster as it developed and owns the Cambridge Science Park.

- Financial Environment

With few exceptions, startup money is provided by national and international venture capital. Business Angels are beginning to take an interest in biotechnology funding, particularly with the opening of Library House (a facility designed to act as a focal point for investors) but their contribution is still low compare to venture capital. Commercial banks play little or no role in staring up biotechnology companies because of their high-risk nature and this shows no sign of altering. Finally, public funding is not available in Cambridge and this represents quite an exception in the European biotech clusters. The British Government does not invest in UK biotechnology firms. Small-scale research programs are available but these are for individual research projects and are relatively low cost programs.

Figure 19 indicates the nonfinancial environment of the Cambridge cluster. Technical services account for 40%, and financial services around 9%. It reasons that other service providers, besides the financial sector are very important factors to the success of the cluster.

Figure 19. Specialists Service Providers' Segments



c. Driving forces and the key factors of the cluster

Availability of seed and venture capital: Despite the lack of effective public funding programmes in the area, there was a great number of venture capitalists (both local or international, with businesses in the area) investing in biotech, along with business angels and other small investors focused on the seed stage financing.

Presence of mechanisms to attract key scientific people: This contributes in creating a leading-edge scientific base. The University of Cambridge strongly invested in the specialization of its biotech-based departments, reaching the excellence in different scientific and technological fields.

Environment of entrepreneurial culture among scientists: Even if, as noted, the direct creation of spin-offs from the University of Cambridge came later, since from the beginning the commercial "taste" of its researchers led to the birth of many independent start-ups, which exploited the results of earlier successful researches.

Networking culture: Networking culture is the establishment of close relationships within universities and research centers and between the research centers and existing companies in the geographical area of the cluster.

International promotion of the cluster: This is achieved through a centralized strategy that includes the creation of "cluster representatives". This strategy helps to attract new sites form external companies, offering them a clear motivation to move to the cluster of Cambridge.

3. Case 5, University Park at MIT in the United States

The United States is the largest biotechnology market in the world. It accounts for more than 75%[32] in terms of revenues, which means the U.S market is one of the important cases and should be considered a market for Korea to enter.

The 27-acre University Park at the Massachusetts Institute of Technology (MIT) is the place where the author resides. The author believes it is well designed and eco-friendly,

[32] Table 4

since residents including the author do not readily recognize that laboratory and R&D facilities are located adjacent to the living area. This cases study examines the process and phases of development of the cluster and what are the factors should be considered when developing biocluster.

a. Overview of University Park at MIT

University Park at MIT is a mixed-use urban campus that features offices, R&D focusing on biotechnology, and residential, hotel, and retail structures. Adjacent to the campus of the Massachusetts Institute of Technology, the development was initiated by MIT and undertaken through a joint venture with Forest City Enterprises.

Conceived as a technology-oriented business park providing state-of –the-art, high tech, flexible, first-class facilities in a thriving campus environment, University Park has evolved into one of the premier centers for biotech and biomedical research in Cambridge. When fully developed in 2005, University Park will comprise 213,755 m2 (2.3 million square feet), including more than 148,700 m2 of office and research space, a 210 room hotel and executive conference center, 100,000 m2 of retail space and 9,300 m2 restaurants, 460 rental housing units, three structured parking facilities for 2,800 cars, and 1.6 hectares of parkland.

b. Marketing for Biotech firms

Forest City's strategy for University Park—with its proximity to MIT and Harvard—was to develop buildings flexible enough to address the evolving needs of high-tech companies, while responding to fundamental shifts in the high-tech industry over time. The first buildings targeted high-tech industries such as defense, computer, and software firms. In the late 1980s, however, just as these first buildings were completed, demand from these previously hot sectors in Cambridge slowed and a new technology-based industry—biotechnology—was emerging from university research laboratories. Startup biotech companies may require as long as a decade to achieve significant revenues, let alone a profit, so many developers and lenders were not inclined to risk their capital to build facilities for the fledgling biotech industry. Forest City, however, while recognizing the inherent risk, also understood this opportunity to serve an emerging market niche during a time when other sectors of the economy were in decline.

The flexibility built into the structures at University Park—generous floor-to-ceiling

heights, large ventilation shafts, and greater-than-average power capacity—was originally geared toward high-tech users but also met the functional needs of the growing biotech sector. In addition, biotech research facilities have significant HVAC, plumbing, and electrical distribution requirements, driving the cost of improvements to a level three to four times that of traditional office space. Working creatively with lenders, Forest City identified ways of financing tenant improvement allowances of $75 to $90 per square foot, achieving commensurately higher rental rates in return. Experience has proven that despite the high initial investment they require, biotech research facilities hold their value well and, in fact, are generally adaptable by second- and even third-generation occupants with very little modification necessary. Although Forest City did not initially intend to develop a biotech park, biotech firms now occupy 90 percent of the 700,000 square feet of R&D space offered at the park.

Although the quality of the project and the master plan always have been important components of the University Park marketing program, prospective tenants generally have not been willing to pay higher rents to acquire them. In fact, some discounts had to be offered until the University Common was finished and the master plan could be experienced firsthand. The costs associated with the parks and streetscape, as well as the significant private investment in infrastructure, have been absorbed into the overall cost structure of the project.

Marketing was accomplished by establishing a relationship with Meredith & Grew, a premier Boston brokerage firm. It participated in building planning and is a renowned, so anyone looking for space in the Boston region would consult the firm. Thus, Forest City did not advertise locally or nationally. Moreover, the hotel has served as a marketing tool.

All buildings were preleased prior to start of construction. For example, in Phase III, Millennium Pharmaceuticals and Cereon Genomics, the tenants of 45 and 75 Sidney Street, approached the developer looking for space with a time deadline. In Phase IV, two buildings provided expansion space for Millennium, including one that was its corporate headquarters and one building that was expansion space for Alkermes, a biotech company that was a startup in the first phase. Millennium occupied about 50 percent of the total R&D space in University Park and has become a campus within a

campus. Thus, many of the tenants in later phases are the result of internal growth of early tenants.

Figure 20. University Part at MIT Project Layout

Table 11. University Park at MIT Project Data[33]

LAND USE INFORMATION			
Site area (acres/hectares): 27/10.9 **Gross building area,** square feet (square meters): 2,300,000 (213,670)			
LAND USES			
	Existing	**Planned**	**Total**
Office net rentable area, square feet (square meters)	702,100 (65,318)	681,000 (63,265)	1,382,000 (128,583)
Retail gross leasable area, square feet (square meters)	92,800 (8,621)	0	92,800 (8,621)
Residential units (not including Auburn Court)	142	360	502
Hotel rooms	210	0	210
Structured parking spaces	1,550	1,130	2,680
Floor/area ratio	7.4		

LAND USE PLAN		
Use	**Acres (Hectares)**	**Percentage of Site**
Buildings	2 (0.8)	7
Landscaped open space	2.5 (1.0)	9
Open space	22.5 (9.1)	84
Total	1.50 (10.9)	100

BUILDING INFORMATION				
	Building	**Use**	**Size**	**Cost**
Phase I 1987-1996	26 Landsdowne Street	R&D	100,000 square feet (9,290 square meters)	
	38 Sidney Street	R&D	122,000 square feet (11,334 square meters)	

[33] Urban Land Institute, 2005

	64 Sidney Street	R&D	126,000 square feet (11,705 square meters)	
		Total R&D	348,000 square feet (32,329 square meters)	$57,600,000
	Kennedy Biscuit Lofts	Residential	142 units	$21,200,000
	Auburn Court*	Residential		
Phase II 1996-1998	350 Massachusetts Avenue	Office	76,400 square feet (7,098 square meters)	
	350 Massachusetts Avenue	Retail	42,600 square feet (3,958 square meters)	
	20 Sidney Street	Hotel	210 rooms	
	20 Sidney Street	Market	50,200 square feet (4,664 square meters)	
	55 Franklin Street	Garage	950 spaces	
		Total Phase II		$78,700,000
Phase III 1997-1999	45/75 Sidney Street	R&D	276,700 square feet (25,705 square meters)	
	30 Pilgrim Street	Garage	600 spaces	
	University Park Common	Open space	1.25 acre (0.5 hectare)	
		Total Phase III		$70,000,000
Phase IV 2000-2002	65 Landsdowne Street	R&D	122,400 square feet (11,371 square meters)	$37,500,000
	35 Landsdowne Street	R&D	201,300 square feet (18,701 square meters)	$59,400,000
	88 Sidney Street	R&D	145,300 square feet (13,498 square meters)	$48,300,000
	40 Landsdowne Street	R&D	212,000 square feet (19,695 square meters)	$66,000,000
	80 Landsdowne Street	Garage	1,130 spaces	$20,800,000

	91 Sidney Street	Residential	135 units	$36,200,000
	100 Landsdowne Street	Residential	225 units	$64,300,000
	Auburn Court, Phase II*	Residential	60 units	N/a
	Landsdowne Quadrangle	Open space	0.5 acre	(0.2 hectare)
		Total, Phase IV, estimated		$332,500,000
Phase V 2002-2003	23 Sidney Street**	In planning		

*Developed by Homeowners Rehab, Inc. (HRI), a not-for-profit developer. Forest City subleased this land to HRI for $2,000 per unit.

**23 Sidney Street is the last University Park parcel to be developed. Its use and building size are not yet determined.

DEVELOPMENT COST INFORMATION

Total development cost: $560,000,000

TENANT INFORMATION

Residential	**Units**	**Area, Square Feet (Square Meters)**	**Monthly Rent Per Unit**
Kennedy Biscuit Lofts	142	692-1,800 (64-167)	$1,550-3,100
Auburn Court	77	670-1,200 (62-111)	$1,700-2,600

Office

Percent of net rentable area (NRA) occupied: 100

Number of tenants: 18

Range of tenant space: 2,000-200,000 square feet (186-18,580 square meters)

Annual rents: $12-41 per square foot ($129-441 per square meter)

Average length of lease: 5 to 10 years

Typical terms of lease: Triple net

Retail/Entertainment (Major Tenants Only)

Star Market: 50,200 square feet (4,664 square meters)

CompUSA: 32,000 square feet (2,973 square meters)

Austin Grill: 5,800 square feet (539 square meters)

Cambridge Trust Bank: 3,400 square feet (316 square meters) Espresso Royale Caffe: 1,400 square feet (130 square meters) Percent of GLA occupied: 100 Annual rents: $25-30 per square foot ($269-323 per square meter) Average annual sales at Star Market: $434 per square foot ($4,672 per square meter) Average length of lease: 10 to 15 years
DEVELOPMENT SCHEDULE
Planning started: 1982 **Developer selected:** 1983 **Zoning district approved:** 1987 **Master plan approved:** 1988 **Phase I:** 1987-1990 **Phase II:** 1996-1998 **Phase III:** 1997-1999 **Phase IV:** 2000-2002 **Projected project completion:** 2003

In conclusion, there are three critical factors involved in establishing a successful biocluster regardless of region. First of all, an initiative from either government or educational institutes is necessary to develop a biocluster. For example, Singapore and Korea's bioclusters have been created by strong government will.

Secondly, human resources are essential. Most bioclusters are located adjacent to universities or educational institutions and are continually supplied with skilled human resources.

A final critical factor is availability of seed and venture capital. Due to the peculiar nater of biotechnology as an industry, it takes at least 15 years to produce a product. To sustain the long period of business enough capital is essential. The Singapore and Korea cases lacked venture capital. Instead, a government agency played a key role through regulations and financing. In the U.K, there were a great number of venture capitalists and angels investing in biotech. Most successful bioclusters have been developed by

means of these three main factors.

Trends can also be analyzed in the case study. In the U.K, the evolving number of firms at the Cambridge cluster has been decreasing since 1999. It doesn’t mean the Cambridge cluster’s revenue and size is shrinking, but they have started outsourcing for their business line such as manufacturing and sales forces. It could that the intention behind outsourcing is to save operating cost and recruit more intelligent scientists and market share as a way to enter new markets strategically.

V. YEONGJONG PROJECT

With previous biotechnology market overview and biocluster cases study, this chapter will discuss a specific Korea biocluster development, which is "Yeongjong Project". This project case is sponsored by the Federal Development LLC[34], who is a master developer of the project, so that for their request, this chapter will proposes the optimal product and demonstrate the candidate site doable for the biocluster. In additions, by the analysis of a real case study, our understanding of biocluster development can be enhanced considerably

The Korean local government, IFEZA[35], decided to develop 81 acres next to the international airport to be a biocluster but they questioned what products should be on the site, how big the project should be, and what types of tenants are appropriate for the site.

A. **Overview**

1. Project

Adjacent to Incheon International Airport, which is ranked number one in the world[36] indicated by the orange circle, the 81.6-acres project is located on Incheon Yeongjong Island, South Korea. It is shown here by the blue polygon. It is under IFEZA and its master developer is the Federal Development LLC who provided the project information

[34] Federal Development LLC is a national real estate development firm specializing public/private partnership development, based on Washington D.C. Its service includes all development procedure such as asset management, marketing, financing, development, and construction.

[35] IFEZA (Incheon Free Economic Zone Authority) – The owner of the candidate site

[36] Airport Council International, 2006

for this thesis.

The objectives of the project are as follows:

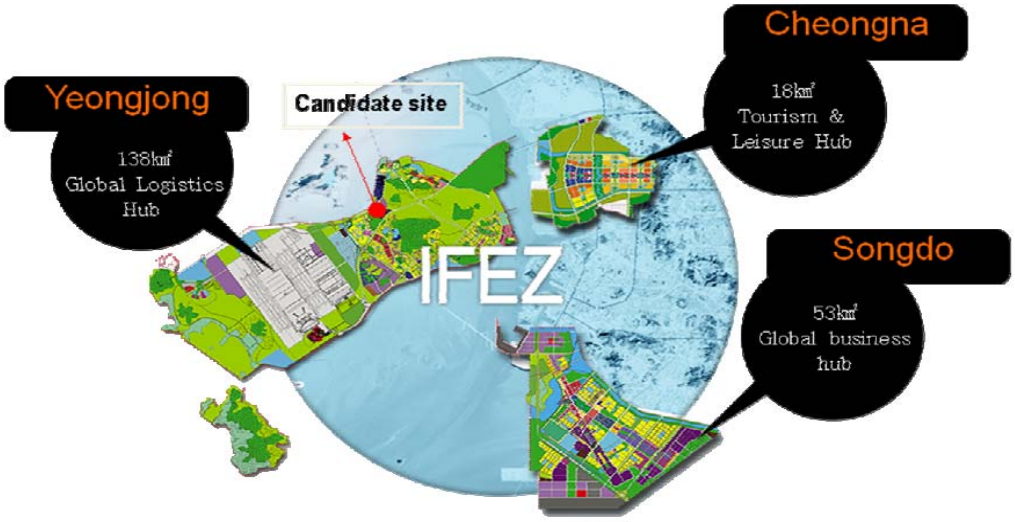
- Develop a mixed-use commercial and residential complex relating to biotechnology industry
- Build flexible, institutional-quality buildings to support those uses over time
- Respond to evolving market parameters.

2. What is IFEZ and Upcoming Projects Surrounding the Candidate Site?

a. IFEZ

The Incheon Free Economic Zone (IFEZ) consists of three different Incheon city districts with a total area of 209 km^2 (51,739 acres). Those area are: Songdo (13,162 acres) , Yeongjong (34,183 acres), and Cheongna (4,394 acres). Its goal is to transform these areas into the logistics, international business, leisure and tourism hub of the Northeast Asian region. The term "Free Economic Zone" applies to the development in these three areas with the aim of improving the business environment for foreign-invested enterprises and the living conditions for foreigners. The zone is a specially designated area to create the most favorable business and living environment where foreign nationals can live and invest freely and conveniently. Incheon's Free Economic Zone, the first in Korea, was officially designated by the federal government in August 2003. IFEZ is planned to be a self-contained living and business district featuring air and sea transportation, a logistics complex, an international business center, financial services, residences, schools, hospitals, shopping and entertainment centers.

Figure 21. IFEZ Overview[37]



Songdo International City District began development in 1994 and is being built on 13,162 acres of reclaimed land. It is a center of diverse international businesses, a hub for international trade, an area for knowledge-based technologies, and a place for eco-friendly urban living. At build-out in 2020, the population is expected to reach 252,000.

Yeongjong International City District includes 34,183 acres on the Incheon International Airport. The city will be developed as an eco-friendly airport city by 2020 with an expected population of 144,800 persons. It will be a functional city with residential amenities for airport staff and visitors, as well as logistics, commercial and distribution facilities. Yeongjong will provide an optimal environment for logistic, tourism and leisure in conjunction with the Incheon International Airport.

The Cheongna District, on the mainland adjacent Yeongjong Island, will focus on entertainment and will feature a world-class theme park. The 4,394-acre district is a residential area with sports facilities, a floriculture complex, and a business area specially designed for international finance. By the end of 2008 the population is expected to reach 90,000 persons.

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[37] Incheon Free Economic Zone Authority (IFEZA)

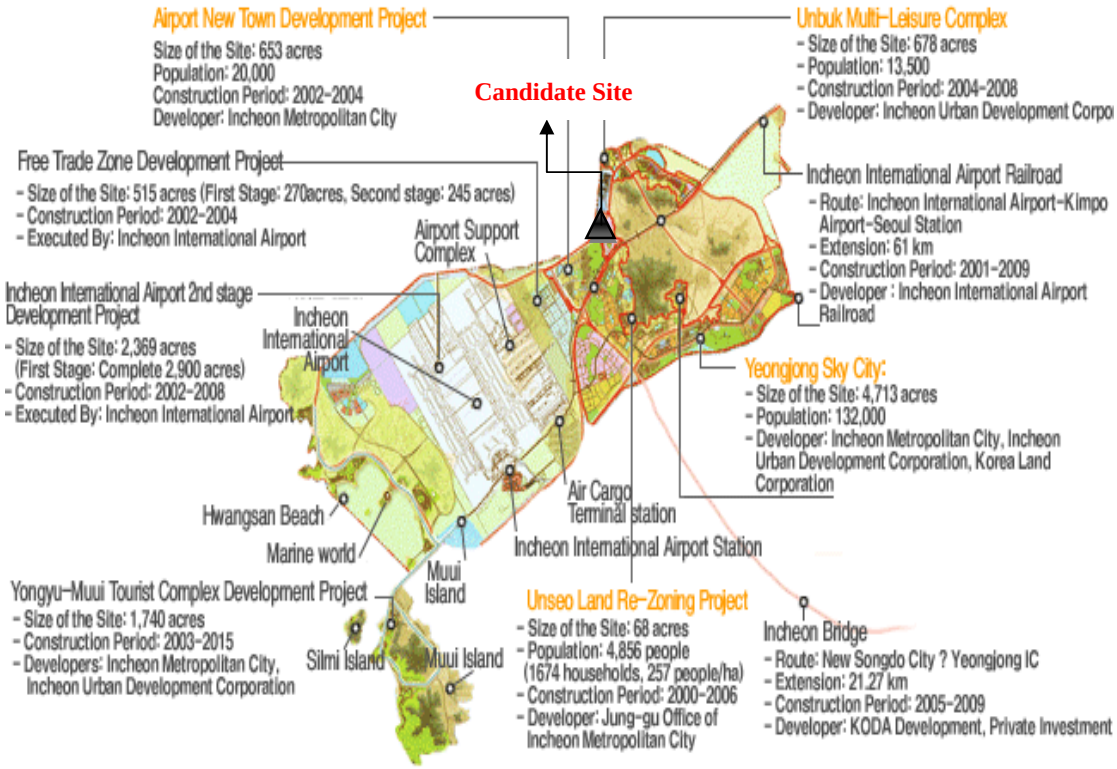
The following section specifically discusses the Yeongjong island projects where our candidate site is located. The candidate site represents the triangle on the map. Besides our project, it also discusses ongoing and upcoming projects on the island to get a sense of the environment and effects around the candidate sites. Based on the surrounding infrastructure for biotechnology, the environment, and the regulations of the Yeongjong Island, the author proposes appropriate product types and a plan for biotechnology are proposed.

b. Yeongjong Island developments in progress

There are six major developments in progress in the island. They include the Youngyu, Muui Tourist Complex project, and the Unbuk Multi-Leisure Complex project. The goal is to create environmentally sustainable urban environment and improve settlement condition for foreigners by providing world class hospitality (educational, medical, and residential facilities) and coastal entertainments areas. The goal of the four projects is an international hub of logistics with an advanced airport and harbor.

Infrastructure development is also in progress. The length of Incheon Bridge is 21.48 km (13.35 miles) and connects Incheon International Airport with Songdo International City, No. 2, 3 Seoul-Incheon Highway, and the Seoul Outer Circulation Road. Construction of the Incheon Bridge allows residents on Yeongjong Island to connect and communicate easily and directly with Songdo and Seoul City. It also secures competitiveness for logistics collection and delivery at the airport, harbor, and industrial zone. Figure 22 shows the location, size, construction period, and developer of each project on the island.

Figure 22. Projects in progress on Yeongjong Island[38]



B. Geographical Information, Infrastructure, Tax Zone and Government Support of IFEZ

1. Geographical Information

IFEZ is the right place to cover the East Asia market geographically. IFEZ is strategically situated between the world's largest market, China, Japan, and Russia. People can fly to Beijing, Shanghai, Tokyo, and Vladivostok within two hours and even Hong Kong within three hours. See Figure 23. The Seoul-Incheon metropolitan area has a population of 23 million.

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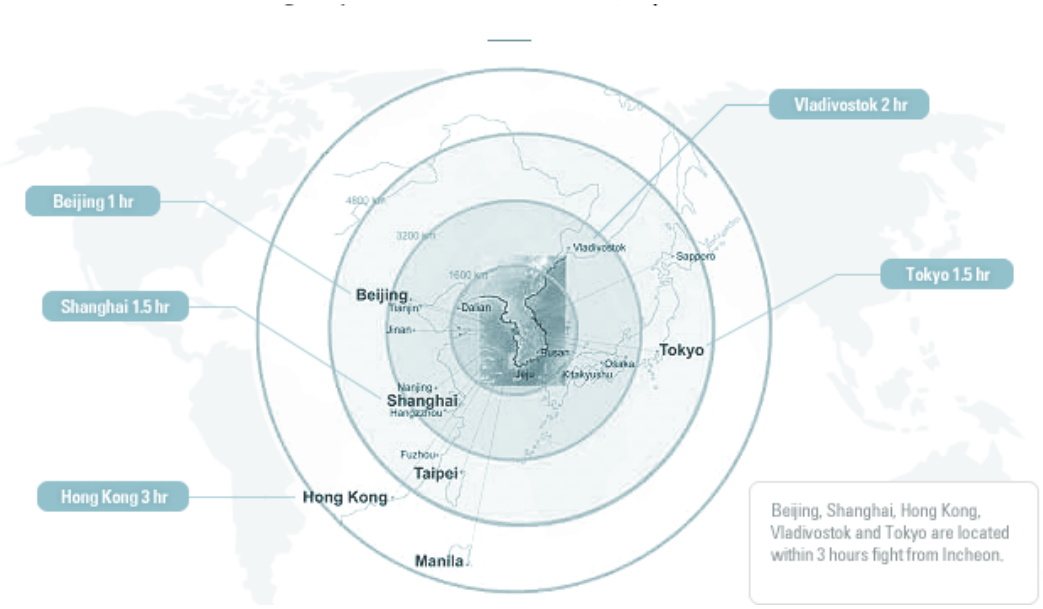
[38] IFEZA

Figure 23. IFEZ Market Overview



2. Infrastructure of IFEZ; Incheon Airport and Harbor

According to Airport Council International[39], Incheon Airport is ranked No 1 in the world for airport service. It currently serves 59 airlines, with routes to 133 cities in 41 countries and is the largest transshipment rate in Asia and the Pacific. The size of the cargo terminal is 270 acres and is expanding by an additional 261 acres. Incheon International Port is a port having sea and air multi modal network with Incheon International Airport. It has currently 78 ship berths, to be expanded to 135 berths by 2011.

3. Tax Zone

Foreign investment takes advantage of significant tax benefits and tax incentives in the area. Since the candidate site is located in the FEZ, the corporation tax and corporate income tax is exempt at 100% for the first 3 years and levied at 50% in the following 2 years. In addition, local taxes such as acquisition, registration, and property taxes are

[39] Air Cargo: Worlds No. 3, Passenger: World's No. 10

exempted 100% for the first 10 years. Detailed information of the tax zone is shown in Table 12.

Table 12. IFEZ Tax Zone Information

Beneficiary	Type of Tax		Tax Incentives	Requirements (Amount of Investment)
Foreign Investment Companies located in the FEZ	National tax	Tariff	100% for 3 years	Imported capital goods
		Corporation Tax and Corporate Income Tax	3 years: 100% of Following 2 years: 50%	Logistics: More than USD 5 million Manufacturing: Over USD 10 million Tourism: More than USD 10 million
	Local tax	Acquisition Tax, Registration Tax, and Property Tax	10 years: 100% Following 3 years: 50%	

Manufacturing companies with more than $ 10 million USD of foreign investment, logistic companies with more than $5 million USD of foreign investment will be exempt corporate tax, income tax, acquisition tax, registration tax, and property tax for 3 years, and reduce them by 50% for subsequent 2 years.

4. Government Support

There are three types of administrative supports. First, in terms of the financial environment, the government allows direct payment of costs arising from current transactions within the range of $10,000 USD. The main currencies including the dollar, Euro, and Yen will be used freely.

Second, the government provides guidance on zoning issues, investment, and starting a business. Specifically, the IFEZ authority will provide integrated and end-to-end support for administrative supports required for the various permissions/licenses issued by local governments.

Third, there is an ombudsman available to deal with business and personal disputes involving foreign firms. A branch of the central arbitration authority is also available for facilitating commercial dispute resolutions.

C. **Biocluster Business Environment surrounding IFEZ**

The R&D and manufacturing infrastructure of the biocluster at Incheon are well equipped compared to other territories, even though the number of companies and their revenue is low. Three colleges at Incheon are highly focused on the R&D related to bio industry and Incheon Bio Industry Center ("IBIC"), founded by the City of Incheon supports the R&D operation of each firms and generates substantial human resources. This environment provides a good infrastructure for biotechnology in Incheon compared to other regions in Korea.

Korea Biotechnology Commercialization Center is a consignment manufacturing facility for the public and the Korea Environment & Merchandise Testing Institute, which conduct all clinical animal trials under the international standard. It also conducts the toxicity tests of new chemicals, agrichemicals, and medicines. Inha University's College of Medicine and Gachon University of Medicine and Science have also built a clinical trial center fitting to international standards. Finally, Celltrion and TS Corporation's R&D center lead the biotechnology industry within the Incheon area.

Following examples are facilities surrounding the candidate site. In this section, the author identifies optimal product types for the candidate site in terms of taking advantage of these facilities efficiently and achieving synergy through them.

1. Public R&D Centers

There are three universities at Incheon, University of Incheon, Inha University, and Gachon University of Medicine and Science. They offer 17 biotechnology industry-related academic programs including biology, life science, and chemistry. There are also 30 research centers within each university that work on biotechnology basic and applied research. Table 13 shows the program examples of each university.

Table 13. IFEZ Public R&D Information

University	Programs
University of Incheon	Chemistry, Biology, Materials Science & Engineering
Inha University	Chemical Engineering, Biology, Textile Materials Science & Engineering, Chemistry, Life Science, Marine Science & Engineering, Food & Nutrition, Medical Science
Gachon University of Medicine and Science	Life Science, Food & Nutrition, Public Health & Environment System Science, Medicine & Science

2. Korea Biotechnology Commercialization Center

Korea Biotechnology Commercialization Center ("KBCC") in Songdo New City is a growing contract manufacturing organization with a state-of-the-art bio-manufacturing facility that complies with the latest U.S. and EU current Good Manufacturing Practices ("cGMP") Regulations and Guidelines. KBCC is dedicated to meeting client manufacturing needs for the production of genetically engineered proteins and monoclonal antibody therapeutics. The four acre center has a cGMP plant capable of 500 liter fermentation and 500 liter for animal cell culture.

KBSS offers a wide range of bio-manufacturing services that include Active Pharmaceutical Ingredient (API) and biopharmaceuticals manufacturing. Its main services are contract manufacturing service such as API manufacturing, clinical trial sample and therapeutics manufacturing, pre-clinical and testing sample manufacturing, contract testing service, contract process development, and research assistance.

3. Incheon Bioindustry Supporting Center, Songdo Techno Park

IBIC systemizes the use and management of public equipment owned by IBIC. Also IBIC supports small and medium and venture firms that lack an R&D infrastructure. These types of companies are able to use IBIC's equipment and strengthen the

manufacturing operation and their R&D capacity. There is an analysis lab (refining and analysis) and a cultivation lab in the Get-Pearl Tower. In addition, IBIC maximize the synergy with the Korea Biotechnology Commercialization Center by taking advantage of the sterilization machine and culture medium.

4. Clinical Trial Center, Inha University Hospital

In 2006, the Inha University College of Medicine established a clinical trial center. The center operates scientific and ethical clinical trials under the Korea Guideline for Good Clinical Practice ("KGCP") and the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceutical for Human use by Korea Food and Drug Administration ("KFDA") and the Good Clinical Practice ("GCP") by the U.S. Food and Drug Administration. It obtains the clinical trial expertise from University of Washington Hospital, which expands the number of professionals and helps accumulate clinical research experience, which is essential to becoming a globalized clinical research institute.

5. Celltrion, Biophamaceutical Company

Celltrion is a leading biopharmaceutical company dedicated to providing high quality services to accelerate product development and manufacturing capabilities for clients and business partners focused on the treatment and prevention of human diseases. Celltrion is a joint venture between a group of Korean investors and VaxGen to provide manufacturing solutions for the large-scale production of mammalian cell culture derived biologics. Celltrion is now evolving into a fully integrated biopharmaceutical company through the development of biologics via in-licensing and co-development relationships.

Celltrion's 23-acres facility is in the center of the high-tech park in Songdo New City in IFEZ. Construction of Celltrion's 50,000 liter capacity biopharmaceutical manufacturing facility is underway in the Songdo New City. It is expandable to 150,000 liters based on client demand. This facility is designed to comply with the cGMP Standards of the U.S. Food and Drug Administration.

6. TS Corporation R&D Center

TS Corporation is one of the leading food companies in the field of sugar, food, agriculture business, and animal feed. It is expanding its vision to include biotechnology and genetic engineering. TS Corporation's R&D center is focused on developing animal cell biotechnology by 2010. The center will be a leader of biotechnology and nanotechnology, having already developed a significant compound for the treatment anemia called Aropotin[40]

7. Plans in Progress for Biotechnology, Driven by Incheon Government

The four plans here represent the potential development opportunity and could contribute to the Yeongjong Island cluster, which becomes more efficient and productive by establishing better infrastructure connecting to these clusters for synergy.

a. Establishing the East Asia Bio-Medical Hub ("EABMH") at Songdo

East Asia Bio-Medical Hub is a 611-acres project that consists of seven R&D Centers and four bio medical and biotechnology clusters. The components of the R&D centers are: Well-Being Center, Therapy Center, Fusion of Eastern and Western Medicine Center, Pharmaceutical Center, East-Asia Gene Center, and Revival Medical Center. The four clusters consist of Medical Tour, Customized Pharmacy, High-Technology Medical Equipment, and Transplantation Medical. The medical hub is planned for maximizing synergy among each center and cluster by putting star scientists at the each center and cluster.

b. IFEZ Science Center

In May 2007, the mayor of Incheon City and Dean Lewis, CEO of Science Center[41] in

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[40] Medical cure of anemia

[41] The Science Center started in 1963, Philadelphia and is the first, and one of the largest, urban research and technology park in the world. Throughout its 45 year history, the Science Center's reach and influence has increased significantly with 2 mil square

Philadelphia agreed to a MOU (Memorandum of Understanding) regarding an establishment and operation of Incubation Center in IFEZ.

c. Gachon University Gil Hospital, Clinical Research Center

This clinical research center develops new biomedicines for export to the European market. Gachon University Gil Hospital signed a MOU with Charite Hospital, an affiliatied hospital of Germany's Humboldt University's College of Medicine, to organize an association clinical research center to obtain a clinical trial system within a developed country.

d. Cheongna B-port Project

This 148-acres project is affiliated with Seoul National University and KIST, which is the most popular technology university in Korea.

As mentioned earlier, educational institutions and government involvement around the cluster is important to the cluster's success. In Incheon, especially IFEZ, the biotechnology R&D centers, hospital, and government support center for establishing business in the area provides either local or international biotechnology players with a fewer errors, cost, and more productive business. In addition, several mega-biotech related developments in progress justify the site as a good environment for biocluster.

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feet of research space, the creation of more than 26,000 jobs, and the raising of more than $150 million (USD) in government and venture funding

D. **Proposed Business Plan for Pharmaceutical Manufacturing Facilities**

The author proposes that pharmaceutical manufacturing facilities would be the best product type on the candidate site for the following reasons.

1. Reasons Why Pharmaceutical Manufacturing Facilities is the Optimal Product for the Candidate Site

1) Market, shift in the industry's focus and investment priorities

Emerging markets in Asia (excluding Japan) were the biggest drivers of global growth. Pharmaceutical industry is also one of them. According to IMS Health[42], sales in Asia-Pacific (excluding Japan) and Africa advanced 10.5% to 56.1 billion (audited) in the 12 months through June 2007. China, among the world's top 10 markets, experienced an increase of 15.9% in pharmaceutical sales to $12.0 billion, and the Korean market increases by 23.5%. Because they are experiencing double-digit growth, countries such as China, Korea, and Russia are gaining ground in the global pharmaceutical market. IMS Health expects this momentum to continue, which will force important shifts in the industry's focus and investment priorities.

2) Government Support: Tax benefit, Administration

The 100% income tax redemption for the first three years, 50% for next two years, and 100% local tax for the first 10 years are remarkable incentives. Furthermore, government is willing to provide support with finance and administration so the company could set up more effectively.

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[42] IMS is the provider of business intelligence and strategic consulting services for the pharmaceutical and healthcare industries.

3) Great geographical advantages

Adjacent to the Incheon international airport, and the international harbor, it takes minimal time for the site to import and export a manufactured and finished product. In addition, because the site is close to the airport (10 minutes by car), management and staff are able to reach the site and communicate with the local manufacturing facility efficiently and easily.

4) Security

According to William B. Wiederseim (PharmaBioSource, May 2003), *in a recent survey of 14 parenteral site acquisition candidates, my client rejected the best candidate because the site could not be secured.* Providing a safe and secure work environment is a critical determinant for a candidate site in terms of physical security measures, administrative controls, and personal ownership. The Korean government including Incheon introduced the Alien Land Acquisition Act in 1998 for equal ownership for foreigners. In addition, IFEZA, which controls the area, cooperates on facility design, building modifications, or physical security improvements.

5) Right Location for a Pharmaceutical Manufacturing Facility

The candidate location is surrounded by mountains and sea and is away from the residential area. This is an important matter since manufacturing facilities needed to be sensitive to distances to the residential area because of the hazardous wastes.

6) Substantial human resources

According to Korea Science Foundation's forecasting[43], the demand of PhD or Post-PhD of biotechnology is 1,275 but the supply is 2,681 so there is a 52.4%

[43] Korea Science Foundation, Forecasting of R&D human resource, 2000

surplus over demand during 2000 to 2010. In addition, there are high-performing educational institutions around the candidate site.

7) Good Environment for Pharmaceutical Manufacturing Facilities

Adjacent to the candidate site, there are universities dedicated to biotechnology, Korea Biotechnology Commercialization Center supporting cGMP, Clinical Research Center helping clinical trials research, and various other organizations that help international firms set up more efficiently. In addition, a world leading pharmaceutical company, Celltrion is evidence that the candidate site area is an excellent environment for a pharmaceutical manufacturing facility.

8) Cost cutting

Globally, pharmaceutical companies are searching for ways to reinvigorate growth and grapple with assorted risks. In addition to dealing with biotechnology firms, they are employing new tools to improve their R&D efficiency and searching geographically to save operating cost in manufacturing facilities. Under the circumstances, the IFEZ offers relatively low labor cost but similar qualified labor to cut overall operating costs. In addition, tax benefits and lower delivery cost play a role in improving the financial situation.

9) Opportunity to Enter the Asia Market

Setting up a pharmaceutical manufacturing facility in Asia, especially in Korea is an opportunity to acquire more local information such as market conditions, political issues, even newest technologies developed locally since the Asian market grows the fastest and is a one of the major markets.

10) Patent Safety

China, India, and other developing countries in Asia have been particularly notorious for ignoring foreign companies' patents [44]. However, Korea has already set up the environment and law to protect international patents.

11) Friendly Environment for Foreigners

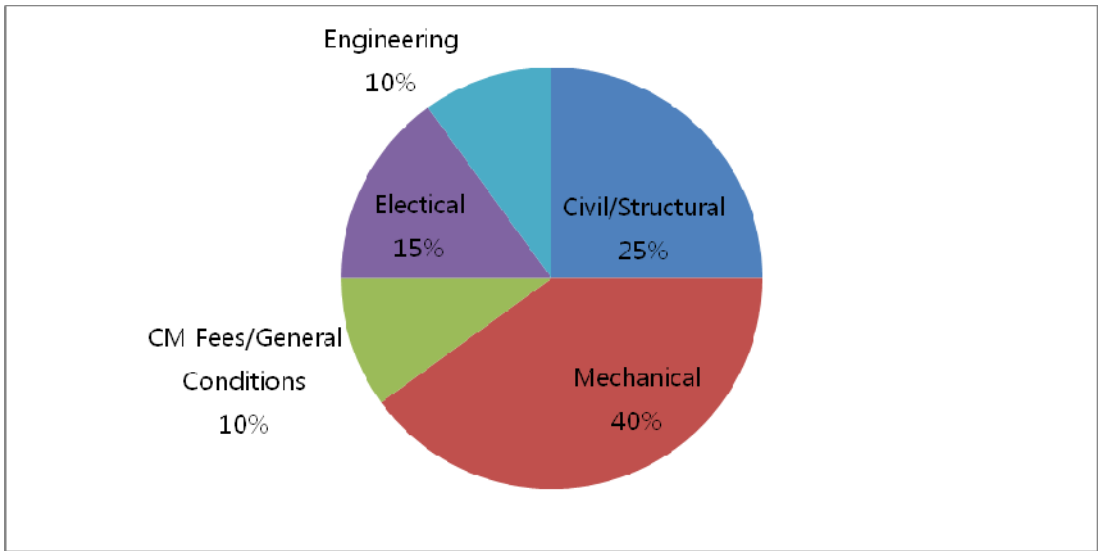
IFEZ area consisting of Songdo New City, Yeongjong, and Cheongna is well known to foreigners. Every year, number of foreigners is increasing more and more that means friendlier environment to foreigners is establishing for their needs. Near the candidate site, there are already 1,881 households sold to foreigners and 2,877 households leased by foreigners. In addition, near Yeongjong Island, Cheongna district provides with entertainment and a world-class theme park.

2. Characteristics of Pharmaceutical Manufacturing Facilities

Pharmaceutical manufacturing facilities are charged with meeting two significant objectives: performance and conformance. Facilities deliver increasingly complex and valuable products configured in evolving, technically complicated dosage forms and therapies. Facilities must also comply with ever-changing and demanding regulatory regimes within the world's statutory bodies. These are two fundamental challenges faced by facility professional's whose keen appreciation of the dynamic forces shaping the industry and prudent facility designs contribute to the enterprise's strategic long-term viability.

[44] Standard & Poor's Industry Survey report, 2007.

Figure 24. Typical Pharmaceutical Manufacturing Facility Cost profile



Delivering modern pharmaceutical manufacturing facilities typically takes between six months and three years, and can cost hundreds of millions of dollars when considering the building, facilities, complicated equipment, and sub-systems necessary to achieve the intended production output and quality. Figure 24 shows the cost profile when building pharmaceutical manufacturing facilities. Mechanical occupies the highest portion of total cost and then civil/structural cost.

Outside technical consultants are increasingly deployed in response to demands for expertise in certification validation, high purity materials, process application, and automation. Facilities professionals are challenged with the integration of many delivery options. Timing and budgeting processes for new facilities are complicated by issues flowing from partners and alliances, as well as market entry dates dependent on R&D and regulatory approvals. Anticipating launch dates and production requirements for sample production and market entry has an impact on capital deployment.

a. Current Good Manufacturing Practices (cGMP)[45]

The need to meet the current Good Manufacturing Practices regulations is paramount in the pharmaceutical industry especially when expanding to international business even though cGMP is a U.S. FDA's regulation. Facilities that effectively incorporate the GMP requirements are easily licensed and thus bring the project to market in a timely fashion. The corporation of the GMP requirements into Good Design Practices ("GDP") at the onset of the project ensures that this aspect of regulatory requirements is met. Facility designs that do not adequately or that poorly address cGMP requirements, face more regulatory scrutiny and possibly will not be licensed without significant changes.

From a real estate perspective, cGMP and GDP are critical factors for a facility to meet an international standard when building a pharmaceutical facility. Therefore, the author reviews and selects some of the regulations be considered importantly, especially the FDA's 21 CFR[46] Part 211 subparts C and D to ascertain the agency's requirements and expectations in real estate design issues.

211.42 Design and construction features

a) Any building or buildings used in the manufacture, processing, packing, or holding of a drug product shall be of suitable size, construction, and location to facilitate cleaning, maintenance, and proper operations
b) Any such building shall have adequate space for the orderly placement of equipment and materials to prevent mixups between different components, drug product containers, closures, labeling, in-process materials, or drug products, and to prevent contamination. The flow of components, drug product containers, closures, labeling, in-process materials, and drug products through the building or building shall be designed to pre vent contamination.

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[45] The reason of small "c" in cGMP: the FDA tells a manufacturer what must be done, but not how to do it. This fact has led to a variety of interpretive solutions to achieve the desired result relative to facility design. Utilizing this approach enables technologies to develop that can more effectively achieve the desired goals and objectives set forth by the agency.

[46] Code of Federal Register (CFR) issued by FDA

c) Operations shall be performed within specifically defined areas of adequate size. There shall be separate or defined area for the firm's operations to prevent contamination or mixups.
d) Operations relating to the manufacture, processing, and packing of penicillin shall be performed in facilities separate from those used for other drug products for human use.

211.44 Lighting

Adequate lighting shall be provided in all areas.

211.46 Ventilation, Air filtration, Air heating and Cooling

a) Adequate ventilation shall be provided
b) Equipment for adequate control over air pressure, micro-organisms, dust, humidity, and temperature shall be provided when appropriate for the manufacture, processing, packing, or holding of a drug product.
c) Air filtration systems, including prefilters and particulate matter air filters, shall be used when appropriate on air supplies to production areas. If air is recirculated to production areas, measures shall be taken to control recirculation of dust from production. In areas where air contamination occurs during production, there shall be adequate exhaust systems or other systems adequate to control contaminants.
d) Air-handling systems for the manufacture, processing, and packing of penicillin shall be completely separate from those for other drug products for human use.

211.63 Equipment design, size, and location

Equipment used in the manufacture, processing, packing, or holding of a drug product shall be of appropriate design, adequate size, and suitably located to facilitate operations for its intended use and for its cleaning and maintenance.

211.65 Equipment construction

a) Equipment shall be constructed so that surfaces that contact components, in process materials, or drug products shall not be reactive, additive, or absorptive so as to alter the safety, identity, strength, quality, or purity of the drug product beyond the official or other established requirements.
b) Any substances required for operation, such as lubricants or coolants, shall not come into contact with components, drug product containers, closures, in-process materials, or drug products so as to alter the safety, identity, strength, quality, or purity of the drug product beyond the official or other established requirements.

b. Validation

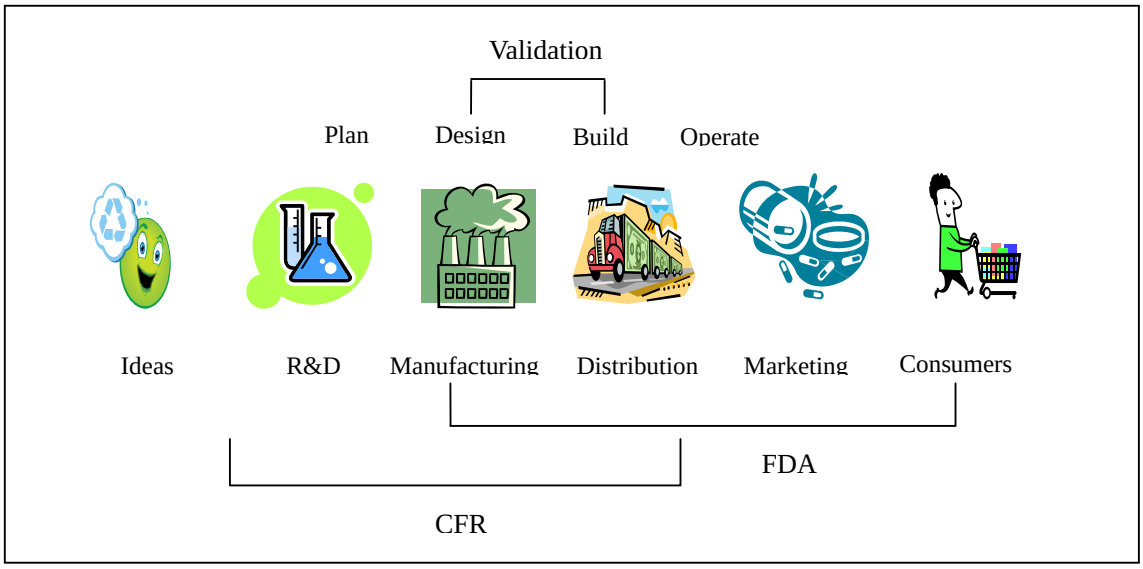
An important regulatory issue affecting of a pharmaceutical facility is validation. The FDA requires that all processes producing drug substances be validated. The FDA's definition for process validation, as stated in the Guideline on General Principals for Validation is:

> *Establishing documented evidence which provides a high degree of assurance that a specific process will consistently produce a product meeting its predetermined specifications and quality attributes.*

This statement not only requires that manufacturing processes be validated, but the facility systems that support production as well. For example, an aseptic processing operation requires a "clean" room. Consequently, the heating, ventilating, and air-conditioning system must be validated in order to ensure that the process is truly aseptic. Furthermore, all critical utility systems (e.g. water, steam, compressed air) need to be tested to ensure proper operation.

Figure 25 shows a project cycle that explains the timing of validation, FDA, and CFR approval. During the design/construction of the facilities, developers should consider the project cycle so that effective collaboration specialty construction contractors and managers is possible.

Figure 25. Typical Project Cycle



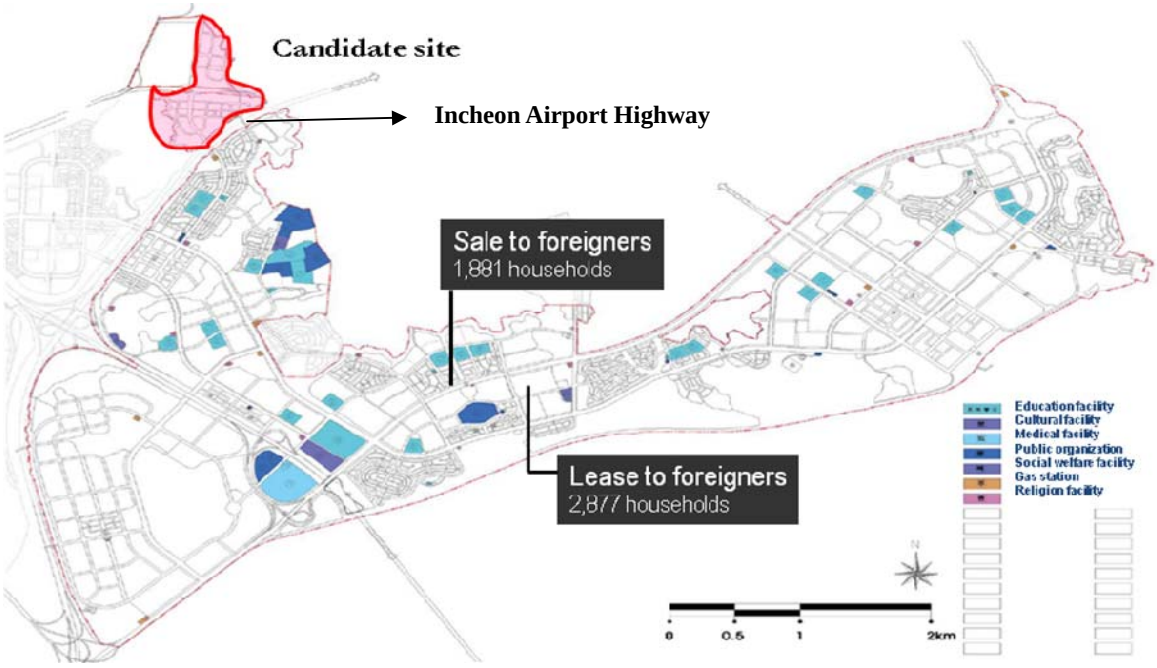
3. Site Survey of the Candidate Site

The author visited the site for the site survey to observe physical conditions. It is away from residential areas and surrounding low mountains. Accessibility is limited and there is no direct road from the highway abutting the site. In addition, all roads to the site are off-road. The upper right illustration shows the upper side of the map which depicts wildland. The middle illustration shows the condition of the road divided into two parts and it appears that there is a bridge since there is a small pond under the road. In figure 26, the lower right illustration shows the lower side of the left map and there appears to be an agricultural area. However, there is an IFEZA sign from 2007 describing a restriction of any usage of the land. Overall, the topography of the candidate site is flat.

Figure 26. Candidate Site Features

Figure 27 shows the environment around the candidate site regarding medical, educational facilities, entertainment facilities and residential areas. Across the 10 lane Incheon Airport Highway from the candidate site, there is a residential area. Some 1,881 households were sold to foreigners and 2,877 households leased by foreigners.

Figure 27. Environment of the Candidate Site



4. Case Study for Design as the Candidate Site

AstraZeneca's site has similar physical conditions and government support as the candidate site. With similar size, geographic conditions and government initiatives for the development, the AstraZeneca's headquarters will provides a sense of the post development environment of the candidate site.

AstraZeneca in Delaware is a global healthcare, pharmaceutical company committed to enhancing patient health. It has more than 66,000 employees' worldwide.

Figure 28. View of the AstraZeneca Site

Figure 28 is an overview of the AstraZeneca Site from the sky. The red circle is approximately 86 acres, which is similar in size as the 81-acres candidate site. It is also divided into two sections by the highway, but the site is connected by a sky bridge as illustrated in Figure 29.

Figure 29. View of the Sky Bridge

Figure 29 shows how to connect two sections.

This list indicates the conditions State of Delaware offered AstraZeneca

- State, County, or local tax incentives;
- Community support by business, education, scientific, and non-profit leaders;
- Support by top political leaders to maintain the economic vitality of a location; and
- Quality of life for employees such as distance to work, education, adequate housing, cost of living, and good roads/traffic, etc.

Tax incentives and government support was considered a key component of the project. The General Assembly introduced and passed legislation, and the governor signed it into law – in just 10 days. Since other states have taken as long as 3 years to pass similar legislation, this was a clear statement to AstraZeneca of the responsiveness of "smarter, quicker, more flexible" Delaware. It is true that Delaware offered enough incentives to attract pharmaceutical firms but the incentives were, in fact, fewer than those of IFEZA's

5. Potential Tenants for the Candidate Site

As mentioned in Chapter Ⅲ, Biotechnology Market and Trend, 66% of U.S. biotech companies and 76% of European Biotech companies plan to expand operations globally. One of the business lines is contract manufacturing. Both European and U.S. global pharmaceutical companies currently contract for manufacturing around 66% but they plans to increase up to 76% from 66%. It is clear that many global pharmaceutical firms want to set up their manufacturing facilities overseas.

The author looked at the top the pharmaceutical firms' pipelines to find out specific tenants as shown in Table 14. New drug pipelines require new manufacturing systems and facilities. In addition, new drugs should be manufactured at efficient and innovative facilities in terms of saving cost savings and safety.

As mentioned earlier, it is reasonable to look at top global firms' pipelines in order to find potential tenants since global companies plan to go overseas. However, company lists might not be directly related to real results since there is a lack of industrial survey and interview results with representatives of the firm.

As shown in a Singapore case, since Abbott, Merck &Co, Phizer, and Wyeth already went to the Asia market, Bristol, Johnson & Johnson, Eli Lilly & Co, and Schering-Plough having a red circle of the lists would be the target tenant.

Table 14. Top Pharmaceutical Companies New Product Pipeline[47]

Company	Name of Product	Treatment	Status	EST 2012 Sales($ Mil)
Bristol-Myers Squibb Co.	Saxagliptin	Diabetes	Phase III	620
	Ixempra	Cancer	Approved	850
	Apixaban	Thrombosis	Phase III	350
	Belatacept	Immuno-suppression transplants	Phase III	300
	Ipilimumab	Cancer	Phase III	250
Abbott Laboratories	Vicodin CR	Pain	Filed	400
	ABT-335	Cholesterol and tryglycerides regulation	Filed	150
	ABT-874	Psoriasis	Phase III	600
Johnson & Johnson	CNTO 1275	Psoriasis	Filed	1100
	Paliperidone palmitate	Schizophrenia	Filed	950
	Ceftobiprole	Bacterial infections	Filed	600
	Dapoxetine	Premature ejaculatio	Filed	400
	Tapentadol IR	Pain	Filed	350
	Xarelto	Thrombosis	Phase III	500
	CNTO-148 (partnered with Schering-Plough)	Rheumatoid arthritis	Phase III	850
Eli Lilly & Co.	Effient	Acute coronary syndrome	Filed	450
	Zyprexa Adhera (olanzapine depot)	Psychosis	Filed	500
	Arzoxifene	Osteoporosis	Phase III	350
	Byetta LAR	Diabetes	Phase III	380
	Enzastaurin	Cancer	Phase III	180
Merck & Co.	Cordaptive	Cholesterol regulation	Filed	300
	MK-0524B	Cholesterol regulation	Phase III	400
	MK-0974	Migraine	Phase III	800
	MK-0364	Incontinence	Phase III	100
	Deforolimus (MK-8669)	Cancer	Phase III	30
	MK-0759	Pain	Phase II	80
Pfizer Inc.	Zeven	Skin infections	Approvable	400
	Axinitib	Cancer	Phase III	410
	Fesoterodine	Incontinence	Approved in Europe	500
	CP-675	Skin cancer	Phase III	550
	Apixaban (partnered with Bristol-Myers Squibb)	Thrombosis	Phase III	350
	CP-751	Cancer	Phase III	200
Schering-Plough	Golimumab CNTO-148 (partnered with Johnson & Johnson)	Rheumatoid arthritis	Phase III	850
	Sugammadex	Novel anesthetic	Filed	800
	TRA	Acute coronary synd	Phase III	375
	Bocepravir	Hepatitis C	Phase III	400
	Asenipine	Schizophrenia	Filed	150
	Org 36286	Infertility	Phase III	200
Wyeth	Relistor	Constipation	Filed	400
	Pristiq	Depression	Approved	200
	Pristiq	Vasomotor sympton	Approvable	300
	Viviant	Osteoporosis	Approvable	150
	Aprela	Osteoporosis & men	Phase III	200
	Bapineuzumab	Alzheimer's	Phase II	550

[47] Standard & Poor's: Industry Surveys Healthcare (Pharmaceuticals, 2008)

VI. CONCLUSION

The biotechnology industry, which started with small U.S. pioneering companies in 1970s, is a global industry. Today, more attention is placed on this industry than any other industry. Many developing countries such as Singapore, Korea, and China, and even developed countries, such as the United States and the European Union have designated the industry as a driver of their economies and have started and to heavily invest in the industry.

Because of this trend, real estate developers should pay attention to this unique opportunity. With the economic growth in the 1980s in the U.S., developers would do well to recall the high demand in the office space and office centers. This author believes that the real estate demand of the biotechnology industry is the same as the office market demand in the U.S. in the 1980s. Along with high growth and investment in the biotechnology industry, the demand for offices where people can work, laboratory space to sustain the biotech business, space where people can research and develop products, and related facilities such as housing, and manufacturing plants should also increase. However, most real estate developers are unfamiliar with biotech real estate and the unique design and demand requirements for of the facilities.

This thesis is for those developers who need assistance in understanding the biotechnology industry and assistance in determining the global need and this opportunity that biotechnology offers.

From the case study of the Yeongjong Project, developed by the Federal Development LLC, the author conveys an understanding of the Korean biotech market and methods to find the right opportunity.

To find the right development opportunity, developers should recognize that the biotech trend involves global pharmaceutical firms that seek global strategic locations for expanding market occupancy, saving operation costs, finding secured locations for business, and substantial human resources. The Yeongjong Project provides global pharmaceutical firms with all these reasons to set up business. The region is calling.

For a comparison, Singapore is aggressively promoting and developing its biotechnology industry. Hundreds of millions of dollars were invested into the sector to

build up infrastructure, fund research and development and to recruit top international scientists to Singapore. As a result, leading drug makers, such as GlaxoSmithKline, Pfizer, and Merck & Co., have set up plants in Singapore. Pharmaceuticals now account for more than 16% of the country's manufacturing production. The industry is now an engine of Singapore's economy. Korean government also pursues opportunities to develop its biotechnology industry. In addition, Korea has a good environment for global biotech firms to establish themselves and draw others into the area.

The author believes that Korea is the right location for those biotech companies that seek new locations for expanding business globally or entering this new market. Moreover, Yeongjong Project will be a successful for pharmaceutical manufacturing facilities and create demonstration effects to other global pharmaceutical firms to follow so that Korea will become a hub of pharmaceutical industry in Asia.

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