CHAPTER 4 DEVELOPMENT OF TAIWAN'S BIOTECHNOLOGY INDUSTRY

4.1. Introduction

Biotechnology at the dawn of the 21st century aids progress in treating and curing diseases; in providing more food for a growing world population; in reducing reliance on non-renewable energy sources; in sustaining escalating industrial production without harming the environment; in cleaning up existing pollution; and in saving endangered species. Applications for biotechnology are extensive, and cover the medical, pharmaceutical, food, chemical, environmental and agricultural industries and therefore have a great impact on people's livelihood and welfare. Therefore, it has been recognized as a key strategic technology holding the most potential in the 21st century. At present, most states are committed to promoting biotechnology industry in their countries, irrespective of the level of economic development.

Although Taiwan is a small island with a population of 22.4 million people and GDP of about US$300 billion[1], its emphasis on cutting edge technology has made it a household name in electronics and computer components - it is the number 3 producer of information technology (IT) products worldwide behind the United States and Japan. In recent years, however, the concept of manufacturing as the engine of Taiwan's economy has been losing favor. Taiwan's economy has reached a crucial point at which the transformation of the manufacturing industries has become essential as crises loom in the IT sector. Taiwan's IT industry peaked in 2000, and has been losing out to lower-labor-cost economies, particularly China. Therefore, it is necessary to upgrade the industrial structure and strengthen innovative capacity to revitalize the economy and boost national competitiveness. It is believed in Taiwan that the promotion of the biotechnology industry is one of the strategies to sustain economic prosperity.

With its proximity to the great Chinese market, abundant capital from the private sector, a sufficiently well-educated workforce domestically and numerous scientists having worked at pharmaceutical and university research labs in the U.S., as well as much industrial experience and entrepreneurship, Taiwan could act as a part of the

[1] The GDP of Taiwan is NT$9,663 (US$309) billion in 2000 and NT$9,507 (US$281) billion in 2001 respectively.

international R&D community in the biotechnology field. By attracting overseas Chinese professionals, and taking the advantage of the cross-straight division of labor with China, Taiwan could be the gateway to the 'Greater China' market[2], and the bridge between the West and Asia.

Taken altogether, developing biotechnology is crucial for Taiwan to jump out of manufacturing base into a knowledge-based economy. That's why there has been such a push from the government to make this one of its priorities.

4.2. Biotechnology as defined in Taiwan

The term 'biotechnology' has been controversial, so it is difficult to determine what exactly a 'biotech company' is. As a combination of 'biology' and 'technology', such a definition encompasses the vast range of life sciences and medical disciplines, and all related technologies. Although it has not reached the consensus for the scope of biotechnology yet, the Biotechnology and Pharmaceutical Industries Program Office (BPIPO), Ministry of Economic Affairs (MOEA) of Taiwan, has put forward the definition as follows:

> *"Biotechnology is a set of powerful tools that employ living organisms or parts of organisms to make or modify products, improve plants or animals, or develop microorganisms for specific uses. Examples of this new 'biotechnology' include industrial use of recombinant DNA, cell fusion, and novel bioprocessing."*

It has been generally understood in Taiwan as follows:

> "*The application of technological principles in life sciences.*"

According to this latter definition, pharmaceuticals, medical devices and even new agricultural technologies are involved in the biotechnology industry in the broad sense. Furthermore, because of its ethnic Chinese heritage, Taiwan's pharmaceutical industry has included the Traditional Chinese Medicine (TCM). In fact, many new biotech start-ups in Taiwan are conducting research on modern medical uses of traditional Chinese herbs.

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[2] With a culture and language similar to China, Taiwan is an ideal place to launch international joint venture aimed at the 'Greater China' market. Between Hong Kong, Taiwan and China, the 'Greater China' market has potential in its billions of dollars and 1.3 billion people.

4.3. The Evolution of Taiwan's Biotechnology Industry

By all accounts, Taiwan's medical biotechnology industry started in 1984, with the government funding the establishment of qualified laboratories to run recombinant DNA experiments as well as monoclonal antibody workshops. Then Taiwan's government first pushed biotechnology forward by setting up the Development Center for Biotechnology (DCB). By 1985, four companies fitting the description of 'modern biotech businesses' sprang up in Taiwan. The government, however, had not paid as much attention to biotechnology as other hi-tech sectors until the late 1990s.

Today there are a number of government organizations involved in the development of biotech in Taiwan. The Ministry of Economic Affairs (MOEA) has created a biotech promotion task force, the Biotechnology and Pharmaceutical Industries Program Office (BPIPO), which functions as a "one-stop window" to provide fast-track services and troubleshooting to biotech investors. The National Science Council (NSC) has even initiated six National Science and Technology Programs, three of which are for agricultural biotechnology, genomics, pharmaceuticals and medical biotechnology[3]. Moreover, the government has been dedicated to the establishment of technology transfer centers at designated universities in Taiwan. President Chen, particularly, specified biotechnology as a "national priority and key component" of his plans to convert Taiwan from a manufacturing-based economy into a knowledge-based economy, called "*Green Silicon Island*" (Table 4.1).

Table 4.1: Chronological Events for Taiwan's Biotechnology Industry

• 1982 – The government promulgated the "*Science and Technology Development Scheme*", specifying biotechnology as one of eight key technologies in Taiwan.
• 1984 – The Development Center for Biotechnology (DCB) was founded to promote R&D activities for the biotechnology industry in Taiwan.
• 1985 - Four biotech companies, partly sponsored by Taiwan's government, had been founded by then.
• 1995 – The "*Promotion Scheme for the Biotechnology Industry*" was proposed

[3] The spin-outs, patents and technology licensings of National Science and Technology Program for Agricultural Biotechnology (NSTP/AB) are more than those of the other two National Science and Technology Programs in 2003.

by Executive Yuan, Taiwan's cabinet.
• 1995 – The Advisory Committee for Promoting Biotechnology Industry[4] was formed by Executive Yuan.
• 1996 – The National Health Research Institute (NHRI) was founded by Department of Health (DOH), Executive Yuan.
• 1996 – The Biotechnology and Pharmaceutical Industries Program Office (BPIPO)[5], in order to promote Taiwan's biotechnology industry, was established by Ministry of Economic Affairs (MOEA), Executive Yuan.
• 1997 – Executive Yuan has convened the Strategic Review Board (SRB) meetings every year since then, to review and to draft the future development direction for Taiwan's biotechnology industry.
• 1997 – The second amendment of the "*Promotion Scheme for the Biotechnology Industry*" was passed by Executive Yuan.
• 1998 – The "National Science and Technology Program for Agricultural Biotechnology" was implemented by National Science Council (NSC), Executive Yuan.
• 1998 – The "National Science and Technology Program for Genomic Medicine", originally named as "Frontier Program on Medical Gene Research", was implemented by NSC.
• 1998 – The Investment Plan for Biotechnology was promulgated by the Development Fund of Executive Yuan.
• 1998 – The Center for Drug Evaluation (CDE) was founded by DOH.
• 1999 - The Bureaus of Patents, Trademarks, Standards, Metrology and Inspection were reorganized into the Intellectual Property Office, which demonstrates the importance the government attaches to intellectual property rights.
• 1999 - The "*Science and Technology Basic Law*" and the "*Guideline for Results*

[4] The Advisory Committee was formed by the Executive Yuan who assembled the deputies of related ministries at cabinet in Taiwan; the Vice Director of Academia Sinica; the Director of the Agricultural and Forestry Department, Taiwan Provincial Government; the Executive Secretary of the Science and Technology Advisory Committee, Executive Yuan; the Director of the Industrial Technology Research Institute (ITRI); the Executive Director of the Development Center for Biotechnology (DCB), and representatives from the industry.

[5] In February 1996, BPIPO was formally established to promote the biotechnology industry and act as a bridge for communication, coordination, and integration among government agencies in Taiwan. The Director of the Industrial Development Bureau (IDB), MOEA, acted as convener of the Program Office and formed a committee including the heads of the Ministry of Education; Department of Health; the Environmental Protection Administration; Council for Economic Planning and Development; National Science Council; Council of Agriculture; Fair Practices Committee; Technology Advisory Committee, Executive Yuan; Development Fund Management Committee; Technical Section of the MOEA; Central Bureau of Standards, MOEA, as well as experts and academics invited by the MOEA.

and Implementation of Science and Technology Research and Development" were passed, which have allowed intellectual property right vested in the research institutes carrying out national projects, and R&D results to be transferred from academia to industry.
• 1999 – Biotechnology was specified as one of newly emerging industries in Taiwan
• 1999 – The Biomedical Research Center was established by Industrial Technology Research Institute (ITRI), the largest research institute in Taiwan.
• 1999 – The "National Science and Technology Program for Biotechnology and Pharmaceuticals", originally named as "National Program for Pharmaceuticals and Biotechnology", was implemented by NSC.
• 2000 – The 4th chromosome of the human genome sequence is partly completed by the research team led by National Yang-Ming University and Veterans General Hospital.
• 2001 – The "Genomic Research Center" was established by Academia Sinica, the most important academic institute in Taiwan.
• 2001 – The third amendment of the "*Promotion Scheme for the Biotechnology Industry*" was passed by Executive Yuan.
• 2001 – Medical devices were included as part of Taiwan's biotechnology industry to be promoted by BPIPO.
• 2001 – The Economic Development Advisory Conference arrived at a consensus to establish "One-Stop-Service Office for the Biotechnology Industry", which BPIPO is responsible for the operations.
• 2002 – The world's first transgenic pig, a cloned pig with a human gene inside, was successfully created by the Animal Technology Institute of Taiwan (ATIT)**.**
• 2002 – Biotechnology, as well as digital content, were selected as two of the most potential industries for Taiwan in the "*Two Trillion, Twin Star" Project*[6].
• 2002 – The "*Promotion Program for Industrial Innovation and R&D Center*",

[6] The "***Two Trillion***" is a slogan to grow Taiwan's *semiconductor* and *display* sectors to NT$1 trillion (US$30B) industries in the near future. Taiwan's semiconductor production totaled NT$527 billion (US$15.6B) in 2001. The plan calls for expanding its chip production to NT$1.59 trillion (US$46.8B) by 2006, rendering Taiwan into the central player in the global semiconductor industry. On the other hand, the "Two Trillion" plan calls for increasing Taiwan's display production from NT$290 billion (US$8.7B) in 2001 to NT$1.37 trillion (US$41B) in 2006. Taiwan is already the world's largest producer of LCD monitors and ranks second, after Korea, in TFT LCD panel production. The "***Twin Star***" part of the plan is to promote the *digital content* and *biotechnology* industries into the next-generation drivers for economic development. In the digital content business, Taiwanese companies will develop unique software and digital content and localize foreign content (such as Japanese game software) into Chinese language in an attempt to grab the share of the rapidly growing content market in Chinese-speaking economies. For the biotechnology to grow, Academia Sinica, will play a key role in biomedical research and development and promote technology transfer.

was passed by Executive Yuan.
• 2002 – The "*Challenge 2008, The Six-year National Development Plan*" [7], was passed by Executive Yuan, which specifies the promoting biotechnology industry as one of key tasks.

Sources: Adapted from BPIPO (2003) and news reports… etc.

4.4. Current Status of Taiwan's Biotechnology Industry

4.4.1. Revenues

According to ***White Paper for Biotechnology Industry in Taiwan 2003***, the biotech-related industries in Taiwan, basically, include biotechnology (in the strict sense)[8], pharmaceuticals and medical devices. In 2002, the revenues for the three industries totaled approximately NT$110.9 billion (US$3.36 billion), of which NT$54.1 billion (US$1.64 billion) was for pharmaceuticals, with 425 companies, some of which are grounded in Traditional Chinese Medicine (TCM); NT$31.8 billion (US$0.96 billion) was for medical devices, with 380 companies; NT$25.0 billion (US$0.76 billion) was for biotechnology, up from the previous year's NT$22.5 billion, with 165 companies, covering genomics, reagents, agricultural biotechnology, environmental biotechnology, protein drugs, drug discovery, biotech-based R&D services, bio-chips and bio-informatics[9]. The biotechnology workforce is approximately 29,959, of which 6,609 are for biotechnology, 13,000 are for pharmaceuticals, and 10,350 are for medical devices (Table 4.2).

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[7] Taiwan government has formulated the "***Challenge 2008***" comprehensive six-year national development plan to foster the creativity and talent Taiwan needs to transform itself into a "*Green Silicon Island*". The three major reforms include government, banking, and finance. The four major investments include cultivating talent; research, development, and innovation; international logistics; and a high-quality living environment. The six-year national development plan will cost an estimated NT$2.6 trillion (approximately US$75 billion) and expect to reach the following targets: (1) expanding the number of products and technologies which meet the world's highest standard to 15; (2) doubling the number of foreign visitors; (3) increasing R&D expenditures to 3 percent of the GDP; (4) reducing the average unemployment rate of the next 6 years to less than 4 percent; (5) increasing the average economic growth rate of the next 6 years to over 5 percent; (6) increasing the number of broadband internet users to over 6 million; and (7) creating approximately 700,000 jobs.

[8] Please check Chapter 5 for the definition of Biotechnology industry (in the strict sense).

[9] According to MOEA, Taiwan's biotech industry (in the strict sense) grew to 90 companies in 2002. These companies are engaged in research and development of products including diagnostic kits, genomic- biotech products, biomedical materials and recombinant DNA. The American Institute in Taiwan (AIT), a trade office acting as the US government's semi-official embassy, places the number of 'genuine biotech' companies in Taiwan closer to 40 firms, due to differing views on what 'biotech' means and what a private business entails.

Table 4.2: The Biotech-related Industries in Taiwan in 2002

Industry	Biotechnology	Pharmaceuticals	Medial devices	Total
Revenues	25.0 *(22%)*	54.1 *(49%)*	31.8 *(29%)*	**110.9**
Number of Firms	165 *(17%)*	425 *(44%)*	380 *(39%)*	**970**
Size of Workforce (Number)	6,610	13,000	10,350	**29,960**
Export Value	8.0	2.0	22.0	**32.0**
Import Value	12.0	30.1	41.0	**83.1**
Domestic Sales vs. Export	68:32	96:4	31:69	**71:29**
Domestic Market Demand	29.0	82.2	50.8	**162.0**

Unit: NT$ Billion (NTD/USD: 33, NTD/GBP: 55)

(Percentage share in each category in parentheses)

Note: Please check Chapter 5 for the definition of Biotechnology industry (in the strict sense).

Source: IDB, MOEA (2002), ***White Paper for Biotechnology Industry in Taiwan 2003***.

4.4.2. R&D Expenditures and Performances

In Taiwan, Academia Sinica as well as government agencies such as the National Science Council (NSC); the Council of Agriculture (COA); the Department of Health (DOH); and the Ministry of Economic Affairs (MOEA) have been increasing their R&D budgets each year to support the development of biotechnology. They invested NT$17.1 billion (US$494.93 million) in life science research in 2002. Compared with expenditures of NT$11.7 billion (US$346.15 million) in 2001, there was a 46% annual growth, accounting for about 30% of the government's science and technology budget. This R&D expenditure has led to the achievements shown on Table 4.3.

Table 4.3: Achievements of Taiwan's Biotechnology, Selected

• 2001 – National Taiwan University Hospital developed a new protein chip able to cheaply and effectively detect lung, breast, intestinal and oral cancers.
• 2001 – The Biomedical Engineering Center (BMEC) of the Industrial Technology Research Institute (ITRI) announced 41 patents on a set of platform technologies, covering phalanx arrays, chips detecting the cause of fevers, micro fluidic chips, bioinformatics and micro reactors.
• 2002 – The Animal Technology Institute of Taiwan (ATIT) successfully developed the world's first transgenic pig, a cloned pig with a human gene inside. The pig produces milk that can be purified to produce a human protein, which can be used as a blood-clotting agent for hemophiliacs.
• 2002 – Academia Sinica, joining the international rice genome project, completed the sequencing of rice genome.
• 2003 – National Cheng Kung University successfully developed "Lab-On-a-Chip" (LOC) technology for medical diagnostics, with 7 patents associated with its development already granted in Taiwan and the U.S, while another 12 patents having been filed.
• 2003 - Veterans General Hospital found the correlation between the 1st chromosome of the human genome and liver cancer, a disease common to the Chinese.

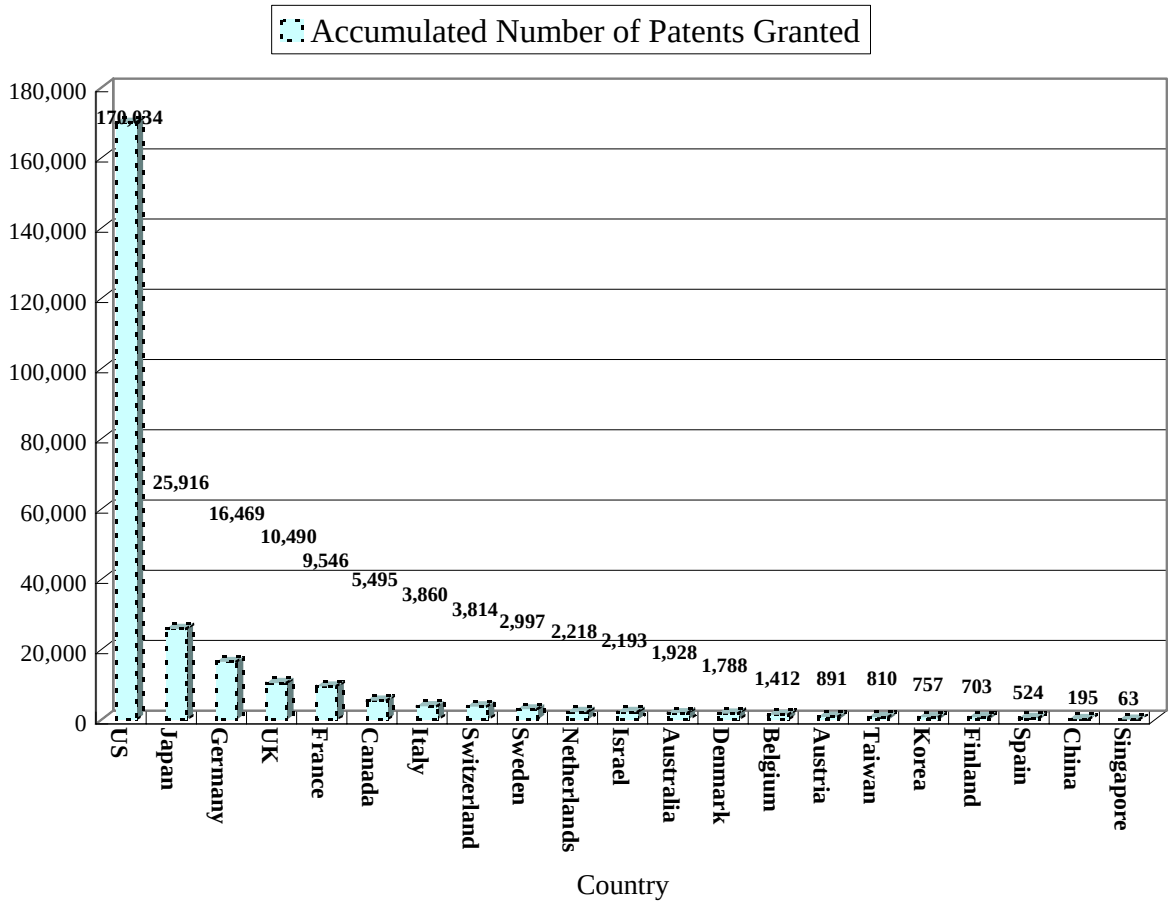
Sources: Compiled from the news.

The numbers of patents granted, technology transfers, scientific papers and technical reports have been increasing each year in Taiwan. Although none of single measurement above is ideal for R&D performance, the number of patents granted is relatively easier to get than the others. It is, therefore, used below to measure the realized innovative performance, as a proxy of the innovation's potential economic value because of the costs of filing and maintaining a patent involved[10]. During the period from 1980 to 2001, Taiwan got 810 biotech related patents granted in the U.S., ranked 16th in the world but ahead of other Asian countries. South Korea, China, and Singapore

[10] It, however, must be careful in interpretation when we use patent-related indicators to measure an economy's innovation capacity. Most of the small firms do not file for patents to protect the results of their research. Moreover, it may lead to some bias because some of the technologies are more easily patentable than others. For example, process innovations are generally less patented than product innovations. Particularly, in biotechnology, patent analysis would probably overestimate the importance of genetic-related technologies and underestimate technologies linked to instruments or process improvement (Lemarie, De Looze and Mangematin, 2000).

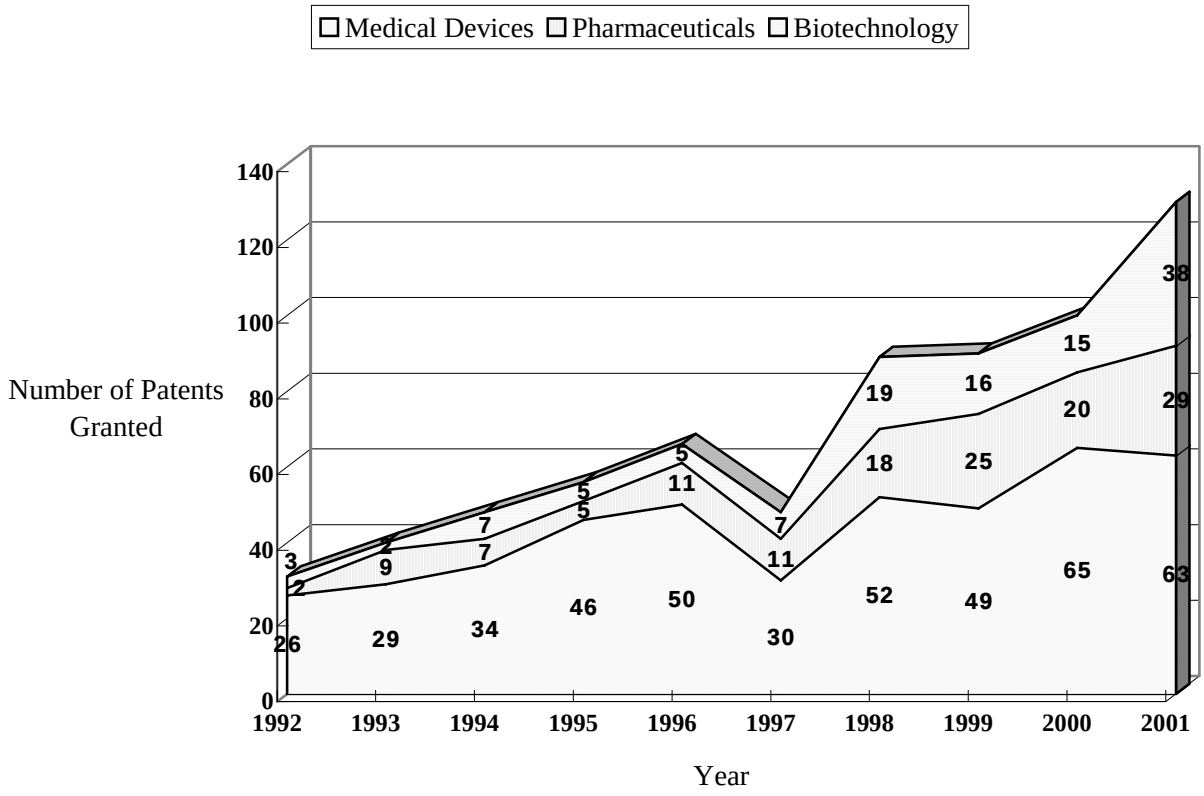
got 757, 195, and 63 respectively (Figure 4.1). If decomposed into medical devices, pharmaceuticals and biotechnology, 63, 29, and 38 patents were granted to Taiwan in the U.S. in 2001 alone. Taiwan had been good at manufacturing electronics, so it is not a big surprise that medical device sector has outperformed the other two, based on the time series data from 1992 to 2001 (Figure 4.2).

Figure 4.1: 1980-2001 Patents Granted in the US



Note: The definition of biotechnology, including pharmaceutical and medical device, is based on USPTO.
Source: Taiwan Institute of Economic Research (2002).

Figure 4.2: 1992-2001 Taiwan's Biotech Patents Granted in The US

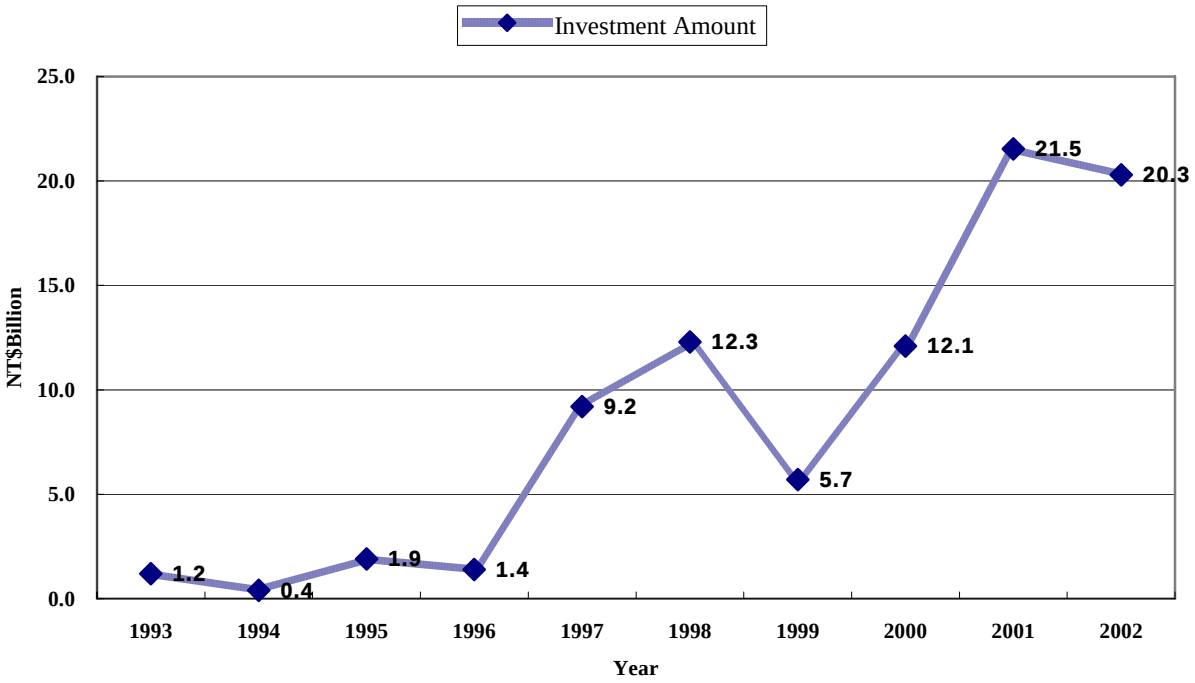


Note: The definition is based on USPTO.
Source: Taiwan Institute of Economic Research (2002).

4.4.3. Investments

While the overall investment sentiment in Taiwan has been low since 2000, the biotech sector has remained robust, with start-ups investing huge amounts in diversified projects. According to the statistics released by BPIPO, local and overseas companies had invested NT$20.3 billion (US$650 million) in biotechnology projects in 2002 (Figure 4.3). The period from January to August in 2002 saw the approval of 56 new biotech companies, with a combined investment exceeding NT$15 billion. Among the new investment projects, there are five companies each investing over NT$500 million. These companies are mostly involved in the development and manufacture of herbal medicines. State-run Taiwan Sugar Corporation also invested NT$1 billion for setting up a biotech facility in Chiayi County, southern Taiwan.

Figure 4.3: The Investment of Taiwan's Biotechnology Industry



Note: NTD/USD: 33, NTD/GBP: 55
Source: The Biotechnology and Pharmaceutical Industries Program Office (BPIPO), (2002).

The "*Promotion Scheme for the Biotechnology Industry*" of the Executive Yuan, Taiwan's cabinet, has invested NT$105 billion (US$3.04 billion) in mid- and long-term projects since it was launched in 1995. The Development Fund of the Executive Yuan plans to pour more than NT$20 billion (US$600 million) into biotech operations during the period of 2001 to 2003[11]. The Council of Economic Planning and Development (CEPD) also proposes setting up 50 new funds with a budget of NT$100 billion (US$2.90 billion), which are aimed at providing seed money for the knowledge-based industries in Taiwan, with particular emphasis on biotechnology. In addition, the President Chen announced that the government set aside NT$52 billion (US$1.51 billion) over five years from 2001 to 2005 to develop biotechnology in Taiwan. Taiwanese venture capitalists and large companies in traditional manufacturing sectors have also invested nearly US$4 billion to fund promising research ventures in Taiwan and abroad.

[11] The Development Fund originally started a 5-year, NT$20 billion venture fund in 1998 to sponsor the biotech industry. As of the end of 2001, however, the fund had invested only NT$4.26 billion in 14 local biotech and venture capital firms.

(1) Traditional Manufacturing Sectors

Traditional manufacturing sectors play an important role in the development of biotechnology in Taiwan as well. Many of Taiwan's largest corporations invest in biotechnology, including Formosa Plastics, Uni-President Enterprises[12], and China Steel. The state-run companies, such as Taiwan Sugar, Taiwan Salt, Taiwan Tobacco & Wine, China Petroleum, and Taiwan Fertilizer, are also active in biotech investment. They are big players with lots of cash to invest in the biotechnology. Though their investments are supposed to be within their own industry for innovation, many of cases appear to be for capital gains.

(2) Venture Capital Sector

There are over 200 venture capital firms in Taiwan. Fresh off years of investment success throughout Silicon Valley in computer technology, semiconductors and information systems, some of these investors turned to biotechnology in the late 1990s. In 2000, biotechnology accounted for 4.3 percent (NT$2.94 billion) of all venture capital money spent. The amount set aside by those who have invested in the biotechnology was between NT$721 million (US$21.9 million) and NT$1.2 billion (US$36.5 million) per firm. In recent years, specialized venture capital firms have been growing in number and have provided abundant capital for Taiwan's biotechnology industry. They include Shen Ya Venture Capital, First Bio Venture Capital Corp., Shen Hwa Venture Capital, VitaTech Venture Capital Investment Corp., and the joint venture between the Executive Yuan's Development Fund and the Canadian company MDS. Besides, China Development Industrial Bank (CDIB) [13], particularly, was the seventh biggest biotech

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[12] Uni-President Enterprises, the largest food manufacturer listed on Taiwan's Stock Exchange, has already invested US$100 million in biotech ventures worldwide, and set up a new branch of the company, President Life Sciences, with another US$100 million. It will invest NT$165.2 million more into Scino Pharm Taiwan, a biotech-based pharmaceutical manufacturer located at Tainan Science-based Industrial Park. In addition, Uni-President will invest US$11.8 million into its health food manufacturing subsidiary in Kunshan of Jiangsu Province, mainland China, to set up a production base of dairy products to tap the mainland market.

[13] CDIB was established in 1959 as China Development Corporation under the auspices of the World Bank and the Economic Stabilization Committee of the Executive Yuan Taiwan. Its birth brought together public- and private-sector resources to create Taiwan's first privately chartered financial institution devoted to economic development. In the 1980s CDIB actively involved itself in the information industry at a time when the government was encouraging its development, and from 1984 on it began developing its investment banking business, to provide advisory services for project finance, corporate finance, securities issuance and underwriting, and real estate development. In 1987 CDIB

investor in the world, with total unrealized profit of NT$1.7 billion, according to VC DealWatch (28 January 2002). CDIB has invested in 68 biotech cases, of which 74 percent were overseas while 26 percent were in Taiwan. CDIB invested in nine biotech cases, with a total value of US$26.2 million for the year 2001.

In 2001, the Executive Yuan worked with the private sector on a plan to establish a new venture capital fund with NT$2 billion (US$58.1 million) to spend. The Development Fund of the Executive Yuan invested NT$600 million toward the fund for a 30 percent stake. The remaining portion of the fund was invested by the companies in private sector, including Quanta Computer, Taiwan's largest notebook computer maker, and the Fubon Group, Shin Kong Group, Goldsun Development and Construction, and the Walsin Lihwa Corporation. Each company invested NT$200 million (US$5.8 million) in the fund. This fund is aimed to set up biotech firms to commercialize the results of a genome project led by the Academia Sinica. The project conducts research into brain genes, rice genes, and the use of animals to develop drugs for human diseases like diabetes and asthma.

4.4.4. International Strategic Alliances

Many big international businesses come to Taiwan, seeking partners for cooperation. GlaxoSmithKline planned to work with Academia Sinica on a research project to investigate the underlying genetic basis of five major diseases common to Asia, including type II diabetes, cardiovascular disease and asthma (20 April 2002).

Merck Taiwan and ScinoPharm Biotech[14] signed an agreement to work together in supplying DNA oligonucleotides. The agreement calls for ScinoPharm to produce synthetic oligonucleotides to custom specifications, and for Merck Taiwan to market the

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began rolling out an overseas business development plan. CDIB's total assets have been increasing from NT$2.5 billion in 1971 to $203.2 billion in 2003, and laying down the foundations of CDIB's financial strength. CDIB was judged Taiwan's best investment bank by *Euromoney* magazine in 1993, and in 2000 it was ranked as Taiwan's most profitable bank by Taiwan's *CommonWealth* magazine and the Chung Hua Money and Banking Association. Now Taiwan government is only a minority shareholder (7%~8%) and the chairman is Mr. Angelo K.Y. Koo, from the private sector.

[14] Located in southern Taiwan's Tainan Science-based Industrial Park, ScinoPharm Biotech is a new R&D offshoot of active pharmaceutical manufacturer (API) ScinoPharm Taiwan Ltd., which Uni-President Enterprises has invested NT$165.2 million. The technology for producing oligonucleotides was acquired by ScinoPharm from both Merck and US biotech company SynGen.

product to both current and new customers through its established marketing channels (3 September 2002).

IBM Taiwan set up a new R&D facility in Taipei's Nankang Software Park, the Life Science Center of Excellence in Taiwan, which aims to offer information technology solutions, the biology-specific 'grid' computer systems, to Taiwan's biotechnology industry. The center planned to collaborate with both research institutes and biotech firms in Taiwan, such as Academia Sinica, the Institute for Information Industry, National Yang-Ming University, Taichung Healthcare and Management University, Hsing-Kuo University, East Wind Life Sciences Systems and Agnitio[15] (4 September 2002).

4.4.5. Laws and Regulations

The laws and regulations for the biotech-related industries include *Pharmaceutical Affairs Laws, Guidelines for Registration of New Chinese Herbal Medicines and Criteria for the Evaluation Thereof, cGMP (current Good Manufacturing Practice) for Pharmaceuticals and Medical Devices, Guidance for Safety Assessment of Genetically Engineered Food*, …and so on[16]. In order to meet the requirements of Food and Drug Administration (FDA) in the United States, pharmaceutical firms in Taiwan have been prodded by the government to upgrade their manufacturing processes. As a result, a lot of companies have got FDA approval for their manufacturing of ingredients for certain drugs. The government expects more firms to gain FDA approval and a 'critical mass' is reached whereby the name 'Taiwan' comes to mind when people look for high quality, FDA approved products. Today, all 160 local pharmaceutical manufacturers supplying generic drugs have met the cGMP standards for packaging and labeling operations as well as testing and quality control of drug products.

[15] Agnitio is a local biotech firm in Taiwan.

[16] Please see the website of BPIPO, http://www.biopharm.org.tw.

4.5. Human Resources for Taiwan's Biotechnology

4.5.1. Survey Population for Taiwan's Biotechnology

In Taiwan, the biotech-related sectors include academic and research institutes of life sciences, biotech firms located in incubators or science parks, biotech research units of the companies in the other related industrial sectors[17]. Based on the population comprised of the above, what follows is a large-scale survey for human resources, which was conducted by Taiwan Institute of Economic Research (TIER) between June and July in 2002 with responses of 253 biotech firms, 77 companies in other industrial sectors, and 94 research institutes, in addition to an estimate of workforce related to biotechnology research in universities. The research project was sponsored by the Council for Economic Planning and Development (CEPD), Taiwan, in 2002[18].

4.5.2. Human Resources for Taiwan's Biotechnology Industry

Based on the survey responses received, it is found that there were ***6,061*** persons with biotechnology-related responsibilities, where 2,389 persons were for biotech firms, 613 persons for other industrial sectors, and 3,059 persons for research institutes (Table 4.4). When the relevant academic staffs[19] in universities were included, the total added

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[17] The survey population included the members of the following associations in the other industrial sectors in Taiwan.

(1) Taiwan Pharmaceutical Industry Association
(2) Taiwan Medical Devices and Supplies Industry Association
(3) Taiwan Agricultural Engineering Industry Association
(4) Taiwan Plant Preservation Industry Association
(5) Seeds and Plant Breeding Association
(6) Central Livestock Association
(7) China Animal Husbandry Association
(8) Taiwan Animal Drugs Industry Association
(9) R.O.C. Aquaculture Association.

[18] The project number is (91) 078.809. I, on behalf of TIER, was the coordinator and single researcher for the project. I designed the survey questionnaire and analyzed the data myself.

[19] They are assistant professors, associate professors, and professors, totaled ***3,682***, in the *core* biotech fields, such as Medical Chemistry, Molecular Medicine, Medical Engineering, Molecular Biology, Biochemistry, Pharmacy, Life Science, Immunology, Biomedicine, Traditional Medicine, Cell Biology, Biology, Microbiology, Pharmacology, Genetics, Agro-Chemistry, Medicine, and Agro-Engineering, as well as in the *peripheral* biotech fields, such as Chemistry, Chemical Engineering, Livestock Studies, Clinical Medicine, Food Science, Gardening Technology, Agronomics, Veterinary, Botanic Pathology, Aquatic Cultivation, Nutriology, Preventive Medicine, Botany, Marine Science, Toxicology, and Pathology. Post PhD research staffs are not included.

up to ***9,743*** persons in the biotech-related sectors in Taiwan, which seems equivalent to the employment of one large pharmaceutical company in the West.

Table 4.4: Human Resources in Taiwan's Biotechnology Industry

	Biotech Firms	Related Industry	Research Institutes
Number of Respondents	***253***	***77***	***94***
Total employees	14,537	42,258	N.A.
With PhD Degree	454	105	N.A.
With Master Degree	1,451	1,597	N.A.
With Biotech Responsibilities	*2,389*	*613*	*3,059*

Sources: Derived from the survey of CEPD project No. (91) 078.809 (2002).

It is a typical industry made up of small- and- medium sized firms. Based on the survey data of 253 biotech firms, the average size of Taiwan's biotech firms in the strict sense was 58 employees, and more than 67% of biotech firms were of less than 50 employees (Table 4.5). For the 77 companies in other industrial sectors classified by application category, the average sizes were as follow: 288 employees for *Industrial Biotechnology*, 106 for *Agricultural Biotechnology*, 75 for *Medicine*, 61 for *Medical Devices*, 34 for *Enabling Technologies and R&D Services*, and 25 for *Environmental Biotechnology* (Table 4.6).

Table 4.5: Taiwan's Biotech Firms, by Size

Number of Employees	Number of Firms	Percentage of Total
Less than 26	121	*47.8%*
Between 26 and 50	49	*19.4%*
Between 51 and 75	24	*9.5%*
Between 76 and 100	14	*5.5%*
More than 100	43	*17.0%*
Missing	2	*0.8%*
Total	253	*100.0%*
Average	**58 employees per firm**	

Note: The survey was conducted by TIER between June and July 2002 with a sample of 253 biotech firms only.

Sources: Derived from the survey of CEPD project No. (91) 078.809 (2002).

Table 4.6: Biotech-related Industries in Taiwan, by Application Category

Application Category	Number of Firms	Number of Employees Average
Medicine	156	*75*
Medical Devices	93	*61*
Industrial Biotechnology	72	*288*
Agricultural Biotechnology	40	*106*
Environmental Biotechnology	15	*25*
Enabling Technologies and R&D Services	60	*34*

Note: The survey was conducted by TIER between June and July 2002 with a sample of 253 biotech firms, and 77 companies in other industrial sectors. In the survey, all respondents were asked to indicate at most six major items of biotechnology activities in bio-related industries, and thus classified into at least one of different application categories. So some of the biotech firms can be considered in several different areas, resulting in multiple application categories for a single respondent.

Sources: Derived from the survey of CEPD project No. (91) 078.809 (2002).

4.5.3. Biotechnology-related Human Capital in Taiwan

Taiwan has abundant human resources for biotech research, and along with government supporting, has led to the establishment of numerous research institutes for biotechnology. Academia Sinica, National Health Research Institute (NHRI), Industrial Technology Research Institute (ITRI), Development Center for Biotechnology (DCB) and universities can provide the high-talented manpower for Taiwan's biotechnology. The top 20 academic and research institutes in Taiwan, in terms of size measured by workforce with biotechnology-related responsibilities, are as follows (Table 4.7). In particular, a lot of outstanding scientists and professionals with overseas experiences have returned to Taiwan in recent years to devote themselves to the domestic biotechnology and pharmaceutical industries. Their experiences from working at the big biotech firms, at the well-established pharmaceutical companies, or at the leading science labs in the West are quite valuable for the development of biotechnology in Taiwan.

Table 4.7: Top 20 Academia and Research Institutes for Taiwan's Biotechnology

Academia / Research Institute	Biotech-related Workforce
National Taiwan University	642
Institute of Biomedical Sciences, Academia Sinica	351
Institute of Molecular Biology, Academia Sinica	330
Biomedical Engineering Center, ITRI	279
National Chung-Hsing University	254
Development Center for Biotechnology	240
National Cheng-Kung University	231
Kaohsiung Medical University	204
National Health Research Institutes	204
Chang Gung University	198
National Yang-Ming University	163
Taipei Medical University	137
Animal Technology Institute of Taiwan	134
China Medical College	131
National Chiayi University	122
Taiwan Fisheries Research Institute	116
Institute of Bio-Agricultural Sciences, Academia Sinica	110
Food Industry Research and Development Institute	109
Institute of Biological Chemistry, Academia Sinica	101
Chung Shan Medical and Dental College	101

Sources: Derived from the survey of CEPD project No. (91) 078.809 (2002).

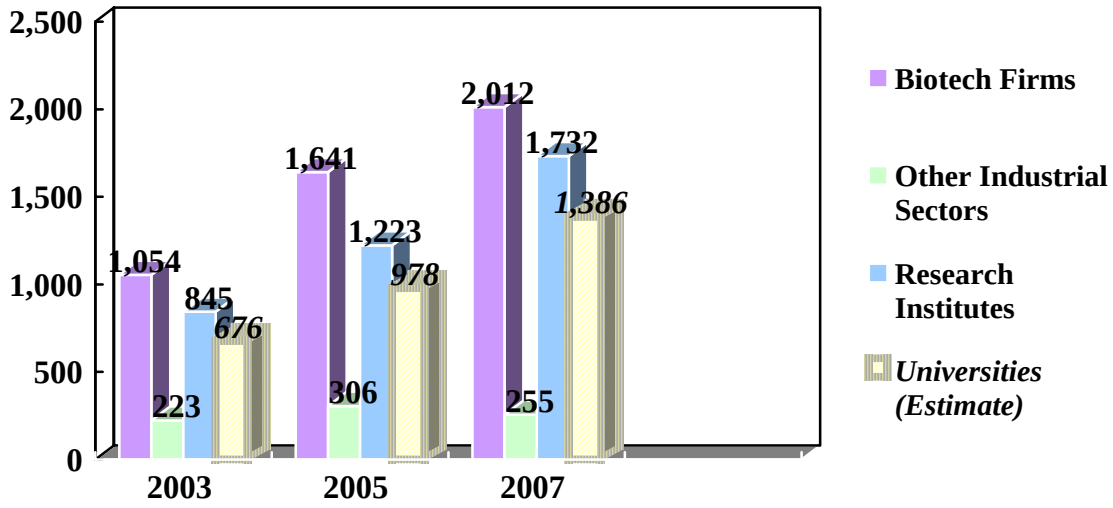
4.5.4. The Demand for Biotech Manpower in Taiwan

The demand for human resources in the biotechnology has not been as significant as in the other high-tech sectors in Taiwan yet. Based on the survey responses, the demand flows for biotech manpower in industrial and research sectors were 2,122, 3,170, and 3,999 for the year of 2003, 2005, and 2007 respectively. Furthermore, given the assumption that the demand flow for biotech manpower in universities is 0.8 times that in research institutes[20], the demand flows for biotech manpower in all of sectors were estimated at ***2,798***, ***4,148***, and ***5,385*** for the year of 2003, 2005, and 2007 respectively[21] (Figure 4.4).

[20] The assumption is based on the findings of CEPD (2002).

[21] The demand flows for Ph.D. and Master degrees in all of sectors are estimated at ***2,121***, ***3,080***, and ***4,035*** for the year of 2003, 2005, and 2007 respectively, and accounting for 76%, 74%, and 75% of all biotech manpower.

Figure 4.4: The Demand for Biotech Manpower in Taiwan



Sources: Derived from the survey of CEPD project No. (91) 078.809 (2002).

Noticeably, among the figures above, the demands for overseas high-talented staffs in all of the sectors were estimated at ***168***, ***290***, and ***592*** in 2003, 2005, and 2007 respectively, which were considered as the key to the development of the biotech industry in Taiwan.

It also shows different demand patterns among the sectors according to the survey data. The research institutes had great interest in recruiting those who majored in the fields, such as Medical Chemistry, Molecular Medicine, Statistics, Computer Engineering, Medical Engineering, Molecular Biology, Livestock Studies, Cell Biology, Biochemistry, and Life Science. In contrast, the biotech and other industries highly demanded the following skills, namely Pharmacy, Biochemistry, Molecular Biology, Chemistry, Chemical Engineering, Traditional Medicine, Life Science, Biomedicine, and Medical Chemistry. By application category, in particular, the *Medicine* sector highlighted the need for Pharmacy and Chemistry; the *Medical Devices* for Molecular Biology and Engineering; the *Industrial Biotechnology* for Traditional Medicine and Pharmacy; the *Agricultural Biotechnology* for Aquatic Cultivation and Molecular Biology; the *Environmental Biotechnology* for Microbiology; and the *Enabling Technologies and R&D Services* for Life Science. Companies engaged in different biotech applications have different demand pattern, related to their core technology.

4.5.5. The Supply of Manpower for Taiwan's Biotech-related Sectors

In keeping with the government's promotion of the biotechnology industry, numerous universities have established life science-related departments to cultivate highly educated workforce in Taiwan.

Based on the previous findings that the demands for Ph.D. and Master degrees accounted for three fourths of all biotech manpower, what follows therefore in the research focuses on the supply of the graduates with Ph.D. and Master degrees for biotechnology in Taiwan. According to the statistics of Ministry of Education, Taiwan, (2002)[22], there were 4,973 students and 1,264 graduates of Ph.D. and Master degrees for *core subjects*[23] of biotechnology, which could be regarded as the main source of manpower supply for biotech research activities[24]. And there were 7,999 students and 2,030 graduates of Ph.D. and Master degrees for *peripheral subjects*[25] of biotechnology, as well as 21,344 students and 5,596 graduates of Ph.D. and Master degrees for *supporting subjects*[26] of biotechnology although they would not necessarily have jobs related to biotechnology after graduation (Table 4.8). Biotechnology requires the abilities to exploit knowledge across different scientific disciplines and technical skills, and in particular, emphasizes trans-disciplinary, where disciplines merge in search of solutions to the problems related to life. Therefore all of the graduates above, irrespective of their major, are potentially sources of biotech manpower in Taiwan.

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[22] It is for the school year from August 2000 to July 2001.

[23] Core subjects of biotechnology involve Medical Chemistry, Molecular Medicine, Medical Engineering, Molecular Biology, Biochemistry, Pharmacy, Life Science, Immunology, Biomedicine, Traditional Medicine, Cell Biology, Biology, Microbiology, Pharmacology, Genetics, Agro-Chemistry, Medicine, and Agro-Engineering.

[24] Foreigners for biotech research in Taiwan are negligible for the time being.

[25] Peripheral subjects of biotechnology involve Chemistry, Chemical Engineering, Livestock Studies, Clinical Medicine, Food Science, Gardening Technology, Agronomics, Veterinary, Botanic Pathology, Aquatic Cultivation, Nutriology, Preventive Medicine, Botany, Marine Science, Toxicology, and Pathology.

[26] Supporting subjects of biotechnology involve Statistics, Computer Engineering, Computer Science, Electronic Engineering, Electrical Engineering, Business Administration, Mechanical Engineering, and Law… and so on.

4.5.6. The Excess Demand of Biotech Manpower in Taiwan

To simplify the calculation, further, the supply of biotech manpower each year was supposed to be the same as the figures above under the assumption of zero net growth rates of Ph.D. and Master graduates for all subjects. The demand for Ph.D. and Master degrees in 2003, 2005, and 2007 could be found by the survey results and the estimates as shown in Table 4.8. The excess demand can be derived from the difference between demand and supply, which is said to be significant when the supply is less than the demand by at least 10%[27].

The research found that if the number of graduates each year remained constant in the future, the excess demands for PhD and Master graduates of the *core* biotech subjects were ***14***, ***673***, ***1,342*** for the year of 2003, 2005, and 2007 respectively[28]. In particular, there would be excess demands for biotech manpower in most of the *core* subjects, such as Medical Chemistry, Molecular Biology, Molecular Medicine, Medical Engineering, Biomedicine, Pharmacy, Cell Biology, Immunology, Biology, Genetics, Traditional Medicine, as well as in some of the *peripheral* subjects, namely Clinical Medicine, Preventive Medicine, Agronomics, Nutriology, and Pathology. The supply of manpower seems to be quite sufficient for the demand for Ph.D. and Master graduates in *supporting* subjects and in other *peripheral* subjects, but it would still be tough to recruit people if the biotechnology industry cannot develop as well as other high-tech sectors in Taiwan in the near future (Table 4.8).

[27] It is defined by the project, entrusted by the CEPD, No. (91) 078.809.

[28] The excess demand is significant in 2005 and in 2007 but insignificant in 2003.

Table 4.8: Demand and Supply of PhD and Master Graduates for Taiwan's Biotechnology

Category	Subject	Supply*	2003 Demand	2005 Demand	2007 Demand
CORE	Medical Chemistry	18	214	244	276
	Molecular Medicine	22	160	186	204
	Medical Engineering	106	122	152	198
	Molecular Biology	14	118	238	286
	Biochemistry	137	100	171	294
	Pharmacy	71	100	112	140
	Life Science	97	74	143	235
	Immunology	17	58	98	121
	Biomedicine	38	56	102	182
	Traditional Medicine	44	51	49	66
	Cell Biology	19	48	113	169
	Biology	40	45	73	105
	Microbiology	86	39	88	114
	Pharmacology	54	28	49	54
	Genetics	13	25	61	102
	Agro-Chemistry**	258	19	38	37
	Medicine	142	12	14	18
	Agro-Engineering	88	10	6	4
Subtotal		***1,264***	***1,278***	***1,937***	***2,606***
Peripheral	Chemistry	509	80	95	107
	Chemical Engineering	656	52	61	65
	Livestock Studies	57	50	48	57
	Clinical Medicine	16	41	63	103
	Food Science	247	35	57	52
	Gardening Technology	81	31	36	37
	Agronomics	26	31	35	39
	Veterinary	80	26	40	38
	Botanic Pathology	40	23	24	24
	Aquatic Cultivation	79	23	39	54
	Nutriology	15	20	32	18
	Preventive Medicine	0	18	52	73
	Botany	51	15	13	12
	Marine Science	139	14	13	14
	Toxicology	31	8	16	22
	Pathology	3	7	28	27
Subtotal		***2,030***	***474***	***652***	***741***
Supporting	Statistics	167	108	122	141
	Computer Engineering	818	71	90	108
	Computer Science	154	20	55	80
	Electronic Engineering	627	20	26	37
	Electrical Engineering	1,472	18	21	81
	Business Administration	1,138	12	21	39
	Mechanical Engineering	1,220	9	12	22
Subtotal		***5,596***	***258***	***346***	***508***
Total* **		**8,890**	**2,009**	**2,935**	**3,855**

*：The number is for the PhD and Master graduates in June, 2001.

**：The demand side is for Agro-Chemistry, while the supply side involves all of the departments named biotechnology, including Agro-Chemistry.

***：The above is shown the top 41 out of 60 subjects originally investigated in the research.

Sources: Derived from the survey of CEPD project No. (91) 078.809 (2002).

4.6. Innovation Policies in Taiwan

4.6.1. Intellectual Property Rights

A well-defined legal framework and protection of intellectual property rights (IPR) is the prerequisite for building an ideal environment for the development of research-based industries. Therefore, Taiwan government has approved the amendment and execution of related laws and regulations for intellectual property rights in recent years, including *Patent Law*, *Plant Seed Law*, …and so on. Besides, the "*Science and Technology Basic Law*"; and the "*Guideline for Results and Implementation of Science and Technology Research and Development*" have allowed the results of government-sponsored R&D to be transferred from research institutes to firms, so as to promote the industrialization of R&D for knowledge-based industries. Moreover, the government allows intellectual property rights of biotech companies to be used as collateral to apply for bank loans.

4.6.2. R&D Subsidies, Tax Benefits and Incentives

To promote the development of biotech industry in Taiwan, the government has incorporated biotechnology into related laws and regulations for investment tax benefits and incentives, including *Rules for Encouraging Pharmaceutical Technology Research and Development*, *Statute for Upgrading Industry*, and *Regulations Governing Tax Incentives for Operations Headquarters and Bylaws*, … and so on[29]. And there are several subsidy programs, endorsed by the Ministry of Economic Affairs (MOEA), for industrial R&D activities[30]. The Council of Agriculture (COA) also encourages firms

[29] Other investment tax benefits and incentives for the biotech industry in Taiwan are as follow.
(1) Accelerated depreciation on fixed assets for R&D
(2) Tax Deduction on Investment in General Assets
(3) Tax deduction on the expenditure for R&D and personnel training
(4) Tax deduction for manufacturing and technical service industry within the scope of newly emerging important and strategic industries
(5) Tax exemption for fifty percent (50%) of the royalty for personal creation or invention
(6) Outward investment loss reserve
(7) Income tax withheld for foreign individual or profit-seeking enterprise
(8) Exemption of income tax on the overseas salary of expatriates
(9) Exemption of income tax of set-up for logistics and distribution center
(10) Encouragement of merger or consolidation of companies
(11) Incentive for bonus
(12) Incentive for operations headquarters

[30] The R&D subsidy programs are as follow.
(1) Industrial Technology Oriented Service Development Program
(2) Industrial Technology Development Program

engaged in R&D through tax breaks and benefits, starting 2002[31]. Besides, in order to increase the capital available for cash-starved researchers, the government also eased the stock market listing requirements for biotech firms.

To build up the innovation capacity of the biotech firms in Taiwan, the Biomedical Engineering Center (BMEC) of ITRI, the Development Center for Biotechnology (DCB), universities and other non-profit organizations have opened their laboratories to industry professionals, providing technology, information, resources and laboratory facilities for joint developments of specific technologies or products by public-private partnership (PPP). And the government implements the "*Promotion Program for Industrial Innovation and R&D Center*" to attract multinational businesses to establish regional R&D centers in Taiwan. It is expected to build an innovative culture and construct an R&D community in Taiwan by introducing R&D resources world-wide. Moreover, the government furthers to refine the R&D strategies, by prioritizing the development items and reallocating the resources. Now Taiwan encourages Contract/clinical Research Organization/outsourcing (CRO), Contract Manufacturing Organization/outsourcing (CMO), Biochips, Bioinformatics, Agricultural Biotechnology and Traditional Chinese Medicine (TCM), so as to differentiate itself from other competitors in the biotech world.

4.6.3. Bio-clusters

Academic and research institutions are working more and more closely with private firms in order to help build Taiwan's biotechnology industry. In this arena, Taiwan is attempting to mimic the clustering of industries and academic organizations in a similar manner to the United States, such as in the Boston area and San Diego.

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(3) Small Business Innovation Research Program (SBIR)
(4) Program for Assistance in the Development of New Leading Products
(5) Innovation Research Program
(6) Industrial Technology Innovation Center Program
(7) Industrial Technology Development Alliance Program

[31] Companies are eligible for the incentives if they have capital of over NT$50 million, or if they utilize a R&D budget of more than NT$15 million over three years during the period prior to the company's proposal. Furthermore, companies developing genetic resources, or germplasm, cultivated using the applied specific pathogen-free technology, will now be eligible for tax and rent benefits. Incentives will also be given to companies growing genetically engineered seedlings in biotechnology labs, operations and cultivation facilities.

The government, the Ministry of Economic Affairs (MOEA), has sponsored universities and organizations in the private sector to establish innovation incubators for small and medium-sized businesses (SME) since 1996. In 2003, there are 61 incubators in Taiwan[32], 35 of which accommodate 160 biotech-related firms with the investment of NT$2.45 billion, accounting for 12.21% of all. Among them, National Taiwan University, National Chung-Hsing University, National Yang-Ming University, National Cheng-Kung University and National Chung-Shan University are quite active in turning biotech into business.

With the largest numbers of venture capital firms, teaching hospitals, academic institutes for life sciences, and highly-talented human resources, Taipei is thought to be the best place for medical biotechnology in Taiwan. The government has established a biotechnology incubator in the Nankang Software Park, Taipei[33]. The related government agencies, such as the Biotechnology and Pharmaceutical Industries Program Office (BPIPO) and Taiwan Technology Marketplace Service Center (TWTM), as well as R&D organizations, such as the National Health Research Institutes (NHRI), the Development Center of Biotechnology (DCB), Academia Sinica set up their subsidiaries there for facilitating the biotech firms.

The government has also constructed several science-based parks and industrial zones for biotechnology and pharmaceutical firms elsewhere. The Biotechnology Industrial Zone located in the Chu-Nan base of Hsinchu Science-based Industrial Park is adjacent to the National Health Research Institute (NHRI) and the Animal Technology Institute of Taiwan (ATIT). The environmental impact assessment and detailed planning has been completed, and firms' applications for admission started to be taken from July 2000.

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[32] Please see the website of the Small and Medium Business Administration, MOEA (April, 2003).

[33] Formed as a collaborative effort between the government and the private sector, the Nankang Software Park focuses mainly on software development, IC design and biotechnology. Under a government program, the park offers low-rent incentives that have brought in investment from well-known domestic and international companies such as Advanced Micro Devices, Sony, Phillips, and IBM. Covering 8.2 hectares of land, the Nankang Software Park was constructed in two phases. Phase I development of the park was completed in July 1999, quickly reaching nearly 100% occupancy within the first year. Phase II was completed in 2003, and reached close to 90% occupancy in its first six months. The park has nearly 13,000 employees from 260 companies.

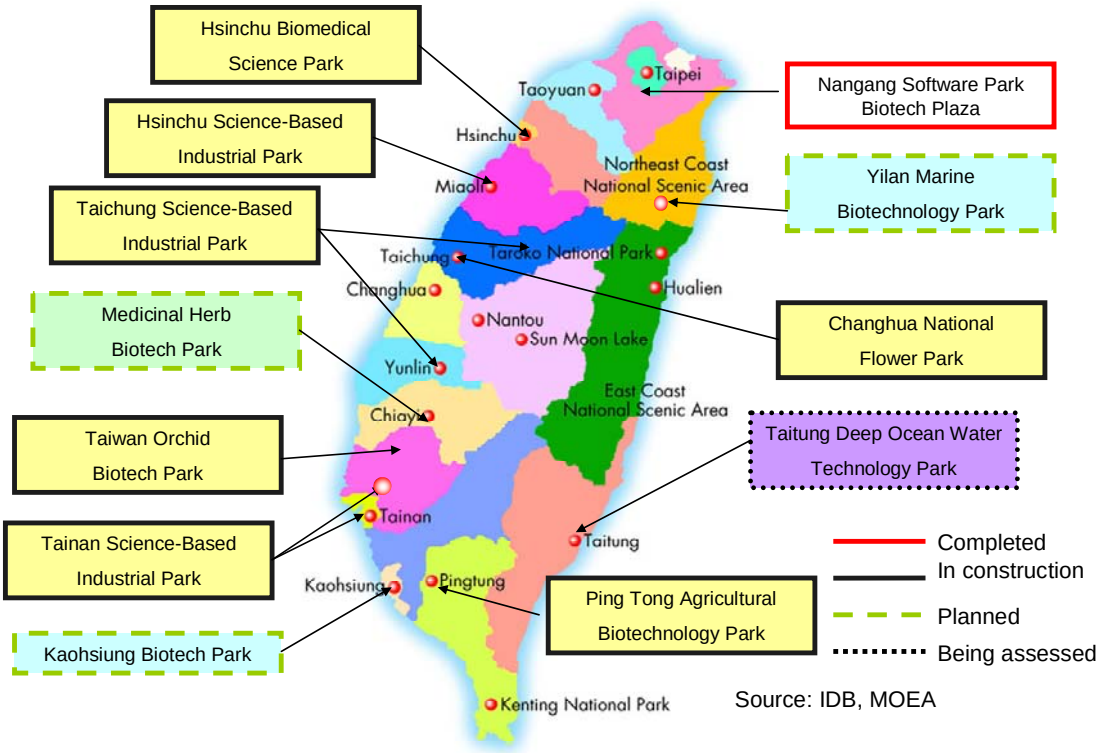
Bio-Medical Park in Chu-Bei, Hsinchu County[34], is also under construction, which occupies around 39 hectares and costs approximately US$800 million to complete, including property and construction expenditures. It will focus on cancer research, by setting up a hospital and a medical research center, and will integrate resources from academia, industry and government in the hopes of developing new discoveries. National Taiwan University will have a campus in the park and will convert its current biotech incubator, which is designed to support start-ups and facilitate technology transfers, into a company set up in the biotech park in 2003.

In addition to the development of the medical biotechnology industry, the Tainan Science-based Industrial Park has planed a zone for agricultural biotechnology. The National Science Council (NSC), particularly, plans to set up branches of its national laboratories, such as the National Center for High-performance Computing, National Nano Device Laboratories, and the Animal Breeding and Research Center in the park to help boost the prospects of the biotech industry in the south of Taiwan.

In 2003, the Council for Economic Planning and Development (CEPD) approves of a NT$20 billion (US$576 million) plan to develop five agricultural biotech parks in Taiwan over the next six years, three of which are in Pingtung, Tainan and Changhua counties in southern Taiwan. Led by the Council of Agriculture (COA), the Pingtung park, the biggest of the five parks, will be a composite agricultural center for cultivating seedlings, producing health food and animal vaccines, and for developing aquiculture. The park in Tainan will be centered on the cultivation of orchids, while the one in Changhua will become a national center for flower-breed development, both of which are developed by local governments.

[34] National Taiwan University cooperates with Japan's Nomura Research Institute to propose a plan for the biotechnology park, with a plan delivery date to the government of March 2002.

Figure 4.5 Bio-clusters in Taiwan



4.7. The Prospects of Taiwan's Biotechnology Industry

According to "*Promotion Scheme for the Biotechnology Industry*", the government has a five-year plan, to attract capital investment of at least NT$150 billion and to see growth rates of 25 percent per year in the industry. Taiwan is dedicated to the establishment of *a frequently-occurring Asian disease research*[35] *and clinical trial hub*[36]*; a mass production base for biotechnology and pharmaceuticals; a medical engineering application and manufacturing hub; an Asian flora and fruits technology hub; and a key location for Asian biotechnology and pharmaceutical venture capital* so as to become an Asia-Pacific hub for biotechnology R&D, manufacturing and operation activities. In all, the government hopes to create 500 new biotech firms, 18 of which are considered to be successful[37], and 25,000 related jobs for Taiwan over the next decade.

With its proximity to the great Chinese market, abundant capital from the private sector, a sufficiently well-educated workforce and numerous scientists with work experiences at pharmaceutical and university research labs in the U.S., considerable industrial experiences and entrepreneurships, and most importantly, the government's commitment and support, Taiwan could act as a part of the international R&D community in the biotechnology field, attracting overseas Chinese professionals, and taking the advantage of the cross-straight division of labor between Taiwan and China. Developing biotechnology is crucial for Taiwan to jump out of a manufacturing-base into a knowledge-based economy. Taiwan hopes to see the biotechnology take off in the same manner the semiconductor industry has.

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[35] The National Health Research Institutes (NHRI) is expected to have Taiwan's first ever drug ready for market by the year 2005. NHRI is developing a drug to defeat the liver cancer (hepatoma) resulting from Hepatitis B, an ailment much more common in Asia than in the West.

[36] The government is actively promoting contract research organizations (CROs) as an area for local firms to key in on. As US, Japanese, and European firms move on to focus more specifically on drug development and genetic R&D, more CRO work will be contracted to areas of the world where highly skilled workers earn less. Human resources in Taiwan cost merely one third in the countries above, it is believed that with this advantage, more emphasis should be focused on building a local CRO industry.

[37] A successful case is defined as a biotech company with capital of NT$500million, and with market capitalization increased fivefold by the year of 2010.