

Country Profile

A look at the
Pharmaceutical Industry in

SINGAPORE



Produced in collaboration
with ISPE Singapore



THE SOCIETY FOR
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This new feature in *Pharmaceutical Engineering* is designed so that you can tear it out, three hole drill (if desired), and keep it with other Country Profiles as they are published.

Look for the Country Profile on Belgium in the September/October issue of *Pharmaceutical Engineering*.

Dear ISPE Members and Readers,

It is with great pleasure that I present the Singapore Country Profile in this issue of *Pharmaceutical Engineering*. I am Italian, and as probably many of you know, Italians are very proud of the natural and artistic beauty of our country. However, even with such high standards, I have fallen in love with Singapore's tropical climate, green vegetation, high technology, culture, and people since my plane landed at Changi airport more than two years ago. Although the most endearing attribute to this city-state is the people who are always keen to smile, try to help you even for the most trivial things, and have a great capacity for learning. It is with this personal joy and conviction of the merits of Singapore that I introduce you to this short, but hopefully informative and interesting microcosm of the world of pharmaceuticals in 2003 and beyond in Singapore.



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Singapore is a young, vibrant country formed by a friendly split with Malaysia in 1965. Its primary assets are its location, harbor, stable climate, and people who at around 4.5 million (more than Ireland) have transformed it over this period into the world's busiest harbor, largest refinery area, and a top ten global economy. This is all based primarily on manufacturing and the process industries; and the bio-sciences have been targeted as one of the high technology intellectual property sectors for future growth.

While the first multi-national pharmaceutical company manufacturing semi-synthetic antibiotics came here in the early 1970s, our manufacturing industry has significantly grown in the last 5-7 years. Singapore, with a pharmaceutical plant investment of approximately \$3 billion, is probably the most dynamic and innovative biomedical hub in Asia outside Japan. Activities range from a growing basic research and development base, API, drug products, and parenteral biotech proteins manufacture to a large regional center for clinical trials.

Its Economic Development Board is actively selling around the world Singapore as an integrated, strategic global bio-science location. It is a politically stable, relatively low cost environment with an ethically strong business and government culture and hard working people. It has an equal or greater growing population of skilled staff (both for production and service industry) as any other equivalent pharmaceutical center, to meet the expected growth in new plants, and sufficient newly created land to support a trebling of the current plants at least. The Government Financial packages are more than attractive.

I hope you will find this Singapore Country Profile interesting enough to put Singapore in your sights when the subject of a new pharmaceutical development location is discussed. Who knows, a cold tiger beer, a bowl of tasty laksa, and the ancient culture of the Asian continent await you once your facility is completed and operational, together with a sound financial return on your investment!

Yours Truly,
Dr Ing Roberto Gardellin
Chairman, ISPE Singapore Affiliate



Singapore - The Premier Biomedical Hub of Asia

by the ISPE Singapore Affiliate

Singapore has enjoyed phenomenal growth over the last four decades despite its small size and population - just 4.5 million people - and lack of natural resources. Its per capita Gross Domestic Product (GDP) has been growing at an average annual rate of 10.5 %, swelling from \$512 in 1965 to nearly \$21,000 in 2002, and now trails behind only Japan and Hong Kong for the highest per capita income in Asia.

Despite its historical importance during its days as a British crown colony as a strategically located trading port linking the West with the East, Singapore's miraculous economic growth has been achieved by focusing on manufacturing and productivity. It built shipyards, attracted global oil refineries to build on reclaimed land, and later followed the technology wave onto manufacturing and now designs of disk drives and semiconductors.

Today, manufacturing and services are the twin economic engines of growth, with the chemicals, electronics, and the engineering clusters as the key pillars of Singapore's economy.

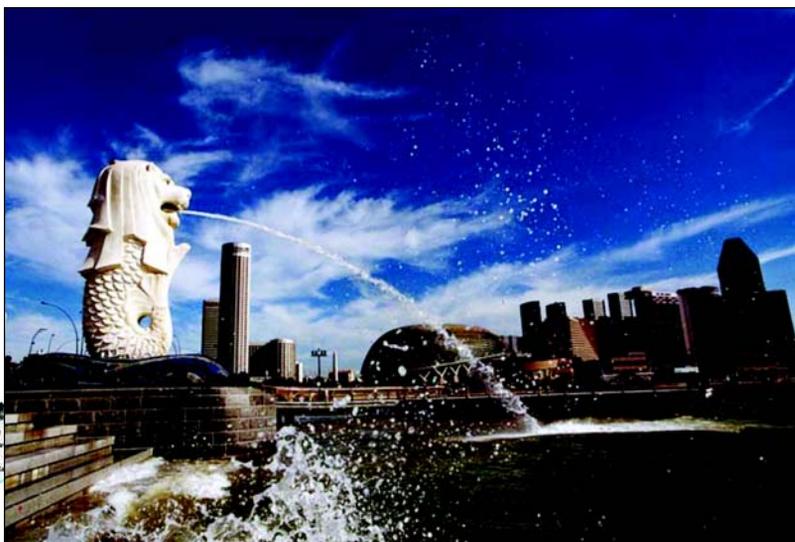
To diversify and strengthen Singapore's economic resilience, the government has been aggressively developing the Biomedical Sciences cluster as another key

pillar of the country's economy. Since June 2000, this initiative is jointly driven by the Biomedical Sciences Group (BMSG) of the Singapore Economic Development Board (EDB) and the Biomedical Research Council (BMRC) of the Agency for Science, Technology, and Research (A*STAR). EDB is the Government body responsible for industrial development while A*STAR funds, coordinates, and directs public research, as well as promotes public awareness of science and technology in Singapore.

In addition, an International Advisory Council comprising pre-eminent scientists from the US, Europe, and Australia advises the government on various biomedical initiatives covering R&D, industry development, education, and healthcare. The Council is Chaired by Sir Richard Sykes of Imperial College in London and Co-Chaired by Dr Sydney Brenner of the Salk Institute for Biological Studies in California.

A Timely Boost To the Economy

As the country emerges from one of the worst recessions since its independence, the solid performance of the pharmaceutical industry has provided a timely boost to the economy. Measured on a year-on-year basis, the sector has shown strong and consistent growth in total manufacturing output, jobs creation, and value-added for the past five years.



Merlion overlooking Singapore River.

Singapore Fact Sheet (2002):

Physical Facts

Population: 4.5 million
Land Area: 682.3 sq km
Average Daily Temperature: 26.8 - 31°C
Annual Rainfall: 2345 mm

Economy

Currency: Singapore Dollars
(S\$1.79:US\$1)
GDP: US\$87 billion/S\$155.7 billion
Per Capita GDP: US\$20920
Unemployment 4.2%



Changi Airport control tower.

Manufacturing output from the sector demonstrated 58 % growth last year providing a bright spark amidst the global slowdown in the electronics industry. Last December saw a 131% increase in pharmaceutical exports as new plants were set-up to produce higher-value drugs. This helped the Singapore economy register positive growth, reversing the recession experienced in 2001. And, in a year of overall rising unemployment, the industry created about 1,040 jobs, representing a 136% increase over the previous year.

The pharmaceutical industry in Singapore may have had its beginnings all the way back in the 1970s, but the past five years have seen it being thrust into the limelight as the island-state seeks to become a global Biomedical Sciences hub in Asia. Today, the pharmaceuticals sector is a \$4.4 billion industry in Singapore with a strong critical mass of leading international companies.

Quality manpower, good infrastructure, global market networks, and strong intellectual property rights protection have led companies like Aventis, GlaxoSmithKline (GSK), Merck Sharp & Dohme, Schering-Plough, Pfizer, and Wyeth to invest more than \$2.4 billion in manufacturing facilities here to produce Active Pharmaceutical Ingredients (APIs) and finished products for global markets. With a steady pipeline of manufacturing investments by leading pharmaceutical players, Singapore is rapidly growing from strength to strength in its status as a key manufacturing launch pad for the global pharmaceutical market.

For instance, Schering-Plough officially opened its new \$100 million Biotech Sterile Manufacturing Facility and \$78 million Tablet Facility last November. These two facilities will complement its international product manufacturing operations to meet increasing global demand. Schering-Plough also announced that

it would invest a further \$200 million to build a third multi-purpose plant with commercial production from 2005. With this third plant, Schering-Plough's total investment commitments in Singapore would exceed \$1 billion and total staff strength would reach 800.

The Manufacturing Hub: Tuas Biomedical Park

The majority of the industry's manufacturing plants are located at the western end of the island at a specially designated area called the Tuas Biomedical Park. Its origins may be traced back to the mid-1990s when the Singapore government allocated a 50 hectare site at Tuas, the industrial hub of the country, as a pharmaceutical manufacturing zone, known then as the Pharma Zone.

It has to date proved successful in establishing a cluster of leading foreign companies such as Pfizer, Wyeth, and Merck, and has expanded into 170 hectares of prepared land for the further clustering of pharmaceutical and biotech manufacturing operations and other shared services.

Excellent infrastructures of roads, sewer lines, and drainage systems have been put in place. There also are future initiatives to provide third party services such as a centralized waste treatment and utility plant for the pharmaceutical facilities there. Due to strong demand, an additional 150 hectares has been developed.

Ingredients for Pharmaceutical Boost - Right Infrastructure and Capabilities

While the tremendous progress of the pharmaceutical industry in Singapore may appear to be an overnight success, in reality Singapore has devoted considerable effort toward developing the right infrastructure and capabilities for this industry to flourish. These include creating plug and play environments for R&D and manufacturing activities as well as providing a strategic mix of financial incentives and grants for R&D and manpower training to help companies jumpstart their operations.

Indeed, the pharmaceutical industry in Singapore has a 30-year history - the first players actually arriving on the island as far back as 1973. In that year, SmithKline started the ball rolling with its antibiotics plant. Glaxo then started its operations in 1979 when it built its first active ingredients plant - a \$150 million chemicals plant.



While both companies raised their fixed asset investments in Singapore, they remained very much the only players in Singapore for another 14 years before Fisons opened its chemical plant in 1993.

And in 1997, US-based Schering-Plough set up a \$260 million multipurpose chemical plant, which opened the flood-gates for many other US drug companies to bring in their manufacturing operations to Singapore.

Beyond Manufacturing: R&D

In an industry where Research and Development (R&D) is critical to long-term sustainability, many companies, such as Novartis, Eli Lilly, and Bristol-Myers Squibb have invested in R&D activities ranging from basic research to clinical development, attracted by Singapore's multi-ethnic population, well-developed clinical and regulatory infrastructure, strong IP framework, easy access to regional patients as well as strict adherence to international clinical standards.

Some, like GSK and Schering-Plough, have augmented their manufacturing operations in Singapore by building capabilities in process development. Schering-Plough's Chemical R&D Center, which was recently completed, will carry out process development and process optimization activities.

In addition, pharmaceutical companies have broadened the scope of their clinical research activities in Singapore to include early phase trials. In March 2001, Pharmacia established a 24-bed clinical pharmacology center at Singapore General Hospital. It is the second company after Eli Lilly to invest in clinical pharmacology facilities with Singapore's hospitals.



Eli Lilly also launched its corporate R&D center last year dedicated to systems biology research. This is the first major commitment made by any pharmaceutical company in the field of systems biology with the specific purpose of accelerating the drug discovery process. With a \$140 million R&D budget over five years, Eli Lilly will employ approximately 50 scientists and information technology professionals.

And taking advantage of Singapore's tropical location, Novartis is setting up a research center to find new drugs and treatments for tropical diseases, initially focusing on tuberculosis and dengue fever.

Apart from the multi-national firms, local firms also have made significant progress in 2002. One such example is home-grown biotechnology firm - MerLion Pharmaceuticals, formed only in July last year, which has successfully raised \$13.5 million in equity funding despite a tough global financing environment, and secured collaborations with Abbott Laboratories,



Tuas Biomedical Park is located at the west end of Singapore.

Athelas, Fujisawa, Genome Therapeutics, KuDOS Pharmaceuticals, and Merck & Co. Boasting one of the world's largest and most diverse natural products libraries derived from bacterial, fungal, plant, and marine organisms, the company is looking for active molecules from natural products that work against diseases like cancer and diabetes.

R&D City: Biopolis

Singapore is building a dedicated biomedical research park, known as "Biopolis," to house BMRC's five biomedical research institutions as well as R&D laboratories of pharmaceutical and biotechnology companies. Targeted to start operating from mid 2003 onward, the 2 million square foot R&D complex will incorporate facilities tailored for the Biomedical Sciences, including laboratory space for private biomedical companies, incubators to nurture start-up companies, animal handling facilities, as well as laboratory support services. Central facilities such as shared R&D facilities, auditorium, and lifestyle amenities also will be easily accessible and available to the tenants at Biopolis.

Located near the National University of Singapore, National University Hospital, and the Singapore Science Parks, Biopolis aims to be a breeding ground for synergy and collaboration of new research discoveries between the public and private sector researchers.

Mr Philip Yeo, Chairman of A*STAR as well as Co-Chairman of EDB, highlighted: "Biopolis will be a vibrant community of Human, Intellectual, and Industrial Capital, with leading scientists and top-rate organizations from all parts of the world congregating at a focal point for cutting-edge research. Researchers will be able to interact and exchange ideas, collaborate,

and leverage on the different strengths available in both the public research institutes and the private companies."

The Future and Getting There

Moving forward, Singapore is on track to achieving its target of \$6.7 billion in Biomedical Sciences manufacturing output by 2005, according to Philip Yeo.

And not only will output continue to grow in volume, the range of activities undertaken by the industry is expected to expand further in terms of the breadth and depth of its manufacturing base. In particular, biologics manufacturing - the large-scale production of protein-based drugs - is likely to increase its presence here as such drugs are expected to account for 50 to 60% of new drugs in the future.

A-Bio Pharmaceuticals, a start-up contract biologics manufacturer will target leading pharmaceutical and biotechnology companies to provide contract manufacturing services, specializing in mammalian cell culture. Its proposed manufacturing plant in the Tuas Biomedical Park is expected to be ready by 2007.

Building Human Capital

To meet the growing need for skills and knowledge in both the manufacturing and R&D segments of the industry, Singapore is trying to attract scientific and technical expertise from around the globe. In addition to the country being a cosmopolitan place to live - with its high public safety, cleanliness, excellent public transport, and English-speaking community - research fellowships and grants are being provided to specialists in the biomedical field.



R&D City: Biopolis.

Singapore Fact Sheet (2002):

Living in Singapore
Literacy Rate: 93.7%
Life Expectancy: 78.7 years
Home Ownership: 93.6%
Population Density: 6055 per sq km
Official Languages:
English (for administration), Chinese, Malay, Tamil
Ethnic Composition:
Chinese: 76.5%
Malays: 13.8%
Indians: 8.1%
Others: 1.6%



At the same time, Singapore is aggressively building its own pool of local talent by strengthening the curriculum for the Biomedical Sciences at all levels.

The Ministry of Education has modified the country's primary and secondary school curriculum to provide foundational understanding of the Biomedical Sciences as well as basic training in modern scientific investigative skills.

At the post-secondary level, all four of Singapore's polytechnics, which provide tertiary-level vocational training, are now offering courses for biomedical lab technicians and research assistants. And at the university level, the National University of Singapore revamped its life sciences curriculum last year to put greater emphasis on research. The country's other university, the Nanyang Technological University, has recently established its School of Biological Sciences and had its first intake of 100 students in July last year.

Various scholarships for both undergraduate and postgraduate degrees also have been set up. A*STAR's National Science Scholarships, which was launched in 2001, will support undergraduate and postgraduate training up to PhD and postdoctoral level for about 600 research scientists in the Biomedical Sciences.

And to ensure that training is not restricted to theory, the EDB also has developed an industrial training program for biopharmaceuticals manufacturing. Under the Training and Attachment Programme (TAP), engineers and scientists will be sent for a period of between 12 and 18 months to leading companies in Europe and US where

they will be trained in the areas of process development, validation, and quality assurance.

Protecting Intellectual Property

To further encourage researchers to create intellectual property on the island, the Intellectual Property Office of Singapore was launched in 2001 to provide the infrastructure, platform, and environment for greater creation, protection, and exploitation of intellectual property.

Singapore has achieved full compliance with the World Trade Organization's Trade-Related Aspects of Intellectual Property Rights Agreement one year before the 2000 deadline. It also has been ranked by the Political and Economic Risk Consultancy as having the best intellectual property rights protection in Asia since 1997. Singapore is also a signatory to the World Intellectual Property Organization, the Paris Convention, the Budapest Treaty, and the Patent Cooperation Treaty. The Health Sciences Authority under Singapore's Ministry of Health also provides a comprehensive regulatory framework for the evaluation and marketing approval of all therapeutic products.

On Target

Since the launch of the Biomedical Sciences initiative in June 2000, Singapore has successfully built a growing reputation in the international biomedical community for its comprehensive plans, stringent IP protection, and strong commitment to develop the Biomedical Sciences cluster. Its success in both manufacturing and R&D are a clear signal that the island-state has the right mix of public research and industry involvement for the high value-added and technology-intensive Biomedical Sciences cluster. 



The Regulatory System of Singapore

by Dr. Clarence Tan, Chief Executive Officer,
Health Sciences Authority



Singapore's Regulatory and Industry Development

In the 1960s, the pharmaceutical manufacturing industry in Singapore comprised mainly the local generic manufacturers and Singapore had no regulatory GMP audit program then. It was not until 1973 that Beecham Pharmaceuticals, a UK-based company, became the first Multi-National Company (MNC) manufacturer to set up a plant in Singapore to manufacture bulk semi-synthetic penicillins.

Today, there are at least 10 MNC pharmaceutical manufacturing facilities in Singapore, including Schering-Plough, GlaxoSmith Kline, Aventis-Pharma, Wyeth Pharmaceuticals, Merck, Pfizer, and Baxter Healthcare.

Following the closure of the Government Production Laboratories in 1986, the licensing of pharmaceutical manufacturers and the registration of medicinal products commenced the following year under the framework of the Medicines Act.

A GMP Unit was established in 1997 within the Ministry of Health (MOH) to deal with the increasing types and number of manufacturers, and to manage the increasing specialization in the field of GMP. The licensing of Chinese Proprietary Medicine (CPM) also began in 1999.

More recently, on 1 April 2001, the Health Sciences Authority (HSA) was established as a statutory board of MOH. HSA comprises



Singapore Health Sciences Authority building.

eight professional centers, including the Centre for Pharmaceutical Administration (CPA), which administers the regulation of drugs and health-related products. The other professional centers include the Centre for Analytical Science (CAS), Centre for Drug Evaluation (CDE) Centre for Forensic Medicine (CFM), Centre for Forensic Science (CFS), Centre for Medical Device Regulation (CMDR), Centre for Radiation Protection (CRP), and the Centre for Transfusion Medicine (CTM).

CPA has four divisions, namely the Manufacturing and Quality Audit (upgraded from GMP Unit), the Product Evaluation and Registration, the Compliance and Complementary Medicine, and the Pharmacovigilance, Communications and Research Divisions.

The Manufacturing and Quality Audit arm of CPA comprises three Units, namely the GMP Audit Unit, the GDP Audit Unit, and the Certification Unit.

- The principal functions of the

GMP Unit include the audit and licensing of manufacturers of sterile and non-sterile medicinal products, CPM, cosmetics, as well as CLS.

- The principal function of the GDP Unit is the audit and licensing of importers, wholesale dealers, and the retail and hospital pharmacies.
- The Certification Unit processes and grants various certificates such as the Certificate of a Pharmaceutical Product and Certificate of Licensing Status (under the WHO Certification Scheme), the Free Sales Certificate and other Export Certificates, as well as GMP certificates

Accession of Singapore to the Pharmaceutical Inspection Co-operation Scheme (PIC/S)

In line with the national goal of Singapore to be a life sciences hub, the GMP Unit embarked on a quality journey to benchmark itself against overseas centers of excellence in the field of GMP audit and licensing of pharmaceutical manu-

facturers. In July 1997, a formal application to accede to PIC/S was submitted.

PIC/S comprise countries with equivalent high standards of GMP inspection system, and include the European Union countries, Switzerland, Australia, and Canada. Two PIC/S delegations visited Singapore in April 1999 and November 1999 respectively to assess its system of GMP inspection and licensing of pharmaceutical manufacturers. The PIC/S delegations concluded that the Singapore system of GMP inspection and licensing can now be considered to be "equivalent to that of PIC/S member authorities, and Singapore has set a benchmark for other GMP inspectorates in the region to match." *With effect from 1 January 2000, Singapore became the first Asian country to accede to PIC/S.*

With HSA's membership of PIC/S, Singapore is now in a position to pursue Mutual Recognition Agreements (MRAs) with other PIC/S countries, beginning with Australia. An MRA on GMP Inspection was signed between the Governments of Singapore and Australia on 26 February 2001. The signing of this MRA means that the Therapeutic Goods Administration (TGA) of Australia now accepts the GMP audit reports and the conclusions of the GMP Auditors of HSA and vice-versa.

Singapore and Japan also have signed an Economic Partnership Agreement on 13 January 2002, which also included a Joint Statement on Pharmaceutical GMP Inspection, which provides for the exchange of GMP audit reports between Singapore HSA and the Japanese Ministry of Health, Labour, and Welfare (MHLW).

With these developments, the status of Singapore as a regional life

sciences and pharmaceutical hub has been enhanced considerably.

The GMP Audit System of Singapore

The GMP inspection system of Singapore follows closely the international practice of PIC/S. The risk assessment approach for determining the frequency of GMP audits is used.

For finished dosage forms, Singapore has adopted the PIC/S GMP Guide for Medicinal Products as its GMP standard. In the case of Active Pharmaceutical Ingredients (APIs), the PIC/S GMP Guide for API (equivalent to the International Conference on Harmonization Q7A Guidelines) has been adopted by Singapore as the corresponding standard.

Licensing of Pharmaceutical Manufacturers in Singapore

The Medicines Act of Singapore states that no person shall manufacture or assemble any registered medicinal product unless he has a manufacturer's license, and the licensing authority shall take into consideration the following criteria before granting a Manufacturer's License:

- proposed manufacturing operations
- details of the premises
- equipment used for manufacturing and QC
- qualifications of key personnel
- Security of the premises and the maintenance of adequate written procedures and records

Standard Provisions for a Manufacturer's License

The standard conditions or provisions for a manufacturer's license are set out in the Fourth Schedule to the Medicines (Licensing, Standard Provisions, and Fees) Regu-

lations. The holder of a Manufacturer's License must comply with the specified provisions, which includes complying with the PIC/S Guide to GMP for Medicinal Products, as revised or amended from time to time.

Strategic Directions and Challenges

HSA will continue with its domestic program to internationalize the local pharmaceutical manufacturing industry standards, in particular the generic product suppliers and the manufacturers of CPM.

Seminars and workshops will continue to be organized on quality topics. The risk-based GMP audit program will continue, and where necessary, the appropriate regulatory actions taken against recalcitrant companies and non-conforming manufacturers.

In the near future, HSA also will have to pay attention to new categories of products such as biotechnology products, new types of APIs, clinical trial products, and health supplements. It is very likely that HSA will participate more actively in international harmonization of GMP standards and audit systems through PIC/S.

More bilateral government-to-government MRAs on GMP inspection, which will result in greater industry benefits, are expected to be negotiated and signed. An overseas GMP audit program involving more than 1000 overseas manufacturers also is expected to be implemented soon.

Questions relating to the article may be directed to:

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R&D In Singapore: A New Challenge



A personal perspective from Dr. Miranda Yap, Director of Bioprocessing Technology Centre, Professor of National University of Singapore (NUS), Department of Chemical and Environmental Engineering

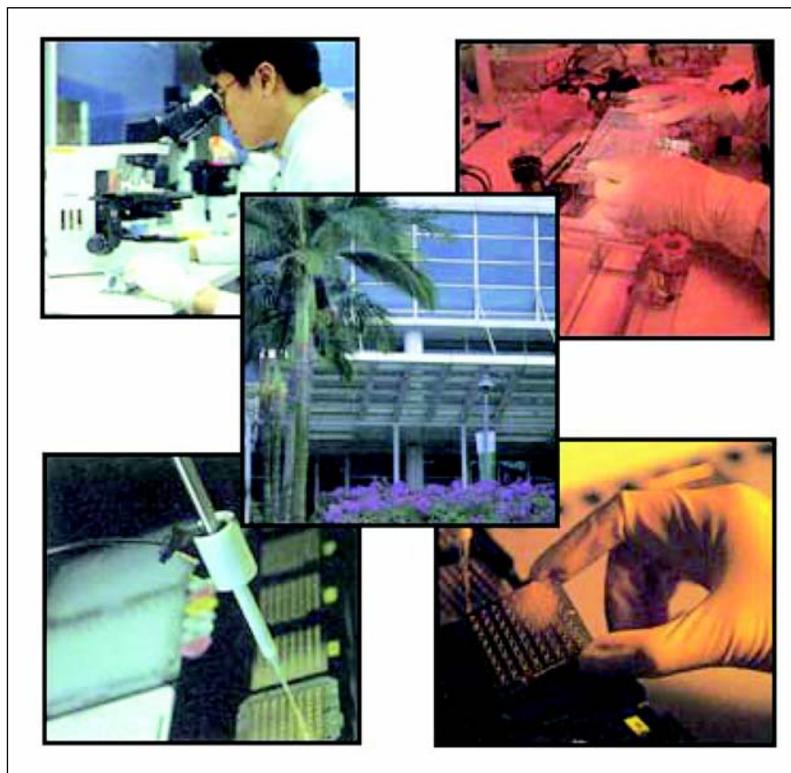
The Early Days

Dr. Miranda Yap is a Director of one of Singapore's public research institutes - the Bioprocessing Technology Centre (BTC) - and is considered by many to be a pioneer in the nation's burgeoning biomedical sciences research efforts. Her interest in bioprocess science and technology was kindled while she was pursuing a Master's degree in biochemical engineering at University College London in 1973, after earning her basic degree in applied chemistry from the National University of Singapore (NUS), then known as the University of Singapore.

Following her Master's degree, she joined Singapore Petroleum Company, a local oil refinery, as a chemical engineer just as many of her peers were working for the oil and gas industry, which was booming in Singapore during the 1970s.

Recalls Dr. Yap: "Many of my undergraduate classmates worked for petroleum companies and upon retirement, were given great golden handshakes! But candidly, I found such a 'regular' job rather stifling."

And so in 1975, she embarked on a doctorate program in chemical engineering at the University of Toronto. After earning her PhD in four years, Dr. Yap spent another three years in the United States conducting postdoctoral research. But even as career opportunities abound for her in the North Ameri-



Bioprocessing Technology Centre Building (BTC).

can continent, her heart yearned for home and her family. In 1982, she returned to Singapore and joined NUS.

"I recall that as an undergraduate I was always harboring thoughts of a teaching career in NUS," she says, "So in 1982, my husband and I made a conscious choice to return to Singapore."

Fortunately for her, the early 1980s were a good time for academics to return to Singapore. Research money was readily available as the Government was then seeking to build up the nation's local universities. In addition to ample

funding, researchers also were given relatively free reign in defining their research areas, she says. But even with the early support of the Government, Dr. Yap's journey into research was not an entirely smooth one.

Bioprocessing Technology Centre (BTC) and Manpower Training

As Dr. Yap continued in her academic career over the next few years, the government soon identified a need to initiate manpower training in the area of bioprocess technology as it sought to attract and anchor biopharmaceutical companies to Singapore in a bid to



Institute of Molecular and Cell Biology Building (IMCB).

expand the island's manufacturing base.

A task force comprising of NUS faculty from various departments and industry representatives was set up to look into establishing a center, which would complement the upstream activities of the Institute of Molecular and Cell Biology. The IMCB had been set up in 1987 and was Singapore's first public biomedical sciences research institute, focusing on basic research in molecular genetics, including cell regulation, cell cycle control, and genomics.

Being a member of the task force, Dr. Yap was instrumental to the formation of the Bioprocessing Technology Unit (BTU). Her proposal to initiate the unit in NUS' Chemical Engineering department was accepted in 1990 and the BTU was born with a \$6 million grant from the Singapore Government and 3,000 sq feet of laboratory floor space. The BTU was subsequently renamed the BTC and took on the additional role of a national R&D center, with funding from Singapore's National Science and Technology Board.

In starting up the BTC, the main challenge that Dr. Yap faced was the sourcing for experienced senior scientists. At that time, bioprocessing technology was still a nascent research area in Singapore, and so it was difficult to attract the right people then, she recalls. Nonetheless, she eventu-

ally managed to find enough senior scientists from overseas and bright local graduates also helped to fill places as they became attracted to new career choices in the biopharmaceutical sector.

Today, the BTC continues to play a pivotal role in manpower training with core strengths in expression engineering, animal cell culture, downstream purification, and analytics focused on enhancing product yields and quality.

Biomedical Research Council (BMRC)

Together with the IMCB and three other research institutes - the Genome Institute of Singapore, the Bioinformatics Institute, and the Institute of Bioengineering and Nanotechnology, the BTC is one of the five pillars of Singapore's Biomedical Research Council (BMRC), which was established in October 2000 to coordinate and support biomedical research in the public sector. Apart from funding public biomedical research initiatives, the BMRC's other role is to build up a talented pool of biomedical researchers in Singapore. It has established several manpower development initiatives that include scholarships and exchange programs.

Next up, the BMRC will be moving its member research institutes into a new dedicated biomedical research park called "Biopolis." The 194 hectare research center, which is expected to be completed in June 2003, will house all of BMRC's R&D activities from basic drug

discovery research to clinical development to medical devices research. Sited near NUS, hospitals and other research institutes, the BMRC research arms hoped to seed a vibrant research community by attracting private industry research from both multi-national drug firms and local biotechnology start-up companies.

Indeed, the story of biomedical sciences research in Singapore would not be complete without acknowledging the growing number of leading pharmaceutical companies, which have set up R&D operations on the island.

For example, Eli Lilly recently established its state-of-the-art center for systems biology, its first outside of the US to look into the development of computational tools for drug discovery.

Local start-up companies also have not been left out of the fray. These include ES Cell International - a stem cell company - that arose from research done at NUS, Monash Institute of Reproduction in Australia and Development and Hadassit Medical Research Services and Development in Israel.

As Dr. Yap aptly sums it up, "Research is more than just a passing fancy, but is a life line for Singapore. This is because there is a great need to couple manufacturing and R&D in high knowledge-based industries.

"The key attractions for such companies to locate here for manufacturing are the availability of a highly qualified manpower pool and relevant technologies which will add value to the industry.

"Thus, it is critical to meet these needs through the research institutes and universities to build up relevant manpower and technologies to attract them." 



A Thriving Biomedical Sciences Industry



by Ms. Chu Swee Yeok, Director of the Biomedical Sciences Group; Executive Director of the Biomedical Sciences Investment Fund, Singapore Economic Development Board (EDB)

Singapore is positioned as the choice location for global manufacturing, supply chain management, distribution, as well as upstream activities including process development, clinical development, and R&D for Biomedical Sciences. In close partnership with industry, EDB's Biomedical Sciences Group (BMSG) focuses on broadening and diversifying the range of Biomedical Sciences activities in Singapore and ensuring that a sound supporting infrastructure is in place.

Over the years, Singapore's base of pharmaceutical manufacturing activities has expanded from primary manufacturing by companies such as Aventis and GlaxoSmithKline to include secondary manufacturing such as tableting, formulation and finishing by Merck and Wyeth, and nutritional manufacturing by Wyeth. Schering-Plough also has added biotechnology lyophilization into Singapore's host of high value-added manufacturing activities. Singapore's ability to extensively support production and manage the supply chain of high-value pharmaceutical products to the global markets through its excellent infrastructure, strong IP framework, and availability of skilled manpower has been strengthened through the breadth and depth of such manufacturing activities.

Promising growth areas such as the biopharmaceuticals sector will continue to be nurtured as Singapore extends its BMS industry capabilities. The recent opening of the small-scale \$19 million cGMP facility of the Biopharmaceutical Manufacturing Technology Centre will introduce clinical-grade biologic manufacturing capabilities for the production of monoclonal antibodies and other biopharmaceuticals.

Singapore is also an attractive and strategic location for companies to conduct and manage clinical development activities in Asia. Pharmaceutical companies like Bristol-Myers Squibb, GlaxoSmithKline, Eli Lilly, Merck Sharp and Dohme, and Novo Nordisk base their clinical development teams in Singapore to oversee clinical trials in the region. Success factors include Singapore's multi-ethnic population, well-developed clinical and regulatory infrastructure, easy access to regional patients, as

well as strict adherence to international clinical standards. These companies work closely with the local hospitals and Contract Research Organizations (CROs) such as Covance, Icon, and Quintiles to conduct early to late stage trials in Singapore and in the region. Such developments are further bolstered on the regulatory front, where the Health Sciences Authority (HSA) under Singapore's Ministry of Health ensures that there is a strong regulatory framework that is supportive of clinical research.

Apart from manufacturing and clinical development, the Singapore government has been nurturing the growth of a critical mass of companies undertaking R&D in Singapore. In 2000, a \$600 million fund was introduced to encourage companies to establish their R&D centers or spin-off research projects. This has attracted large pharmaceutical and smaller biotechnology companies to undertake R&D in Singapore, including Novartis, Eli Lilly, Pharmedicals Research (a joint-venture between Chugai Pharmaceuticals and Mitsui & Co), and Agenica.

To further facilitate the growth of Biomedical Sciences companies with innovative technologies, EDB has set up Bio*1 Capital to manage a \$600 million BioMedical Sciences Investment Fund (BMSIF) and other Biomedical Sciences funds. Bio*1 Capital plays a key role in investing in selective companies, commercializing indigenous technology



Singapore - Best for Business

- Best Asian City for Business - EU 2002
- Tops in Physical Infrastructure - PERC 2002
- 1st in Asia in Entrepreneurial Framework - EIU Report
- 2nd in Economic Freedom - Washington based Cato Institute 2002
- No. 1 in Labor Force Evaluation Measure - BERI Report 2001
- 3rd Most IT Savvy Nation - World Economic Forum 2003

| Sectors | Employment | | |
|--------------------|------------|-------------------|----------|
| | 2001 | 2002 ^P | % Growth |
| BMS Total | 6,477 | 7,177 | 10.8% |
| Pharmaceuticals | 2,375 | 3,123 | 31.5% |
| Medical Technology | 4,102 | 4,054 | (1.2%) |

2002 Pharmaceuticals Employment (Source: Singapore Economic Development Board). [P = Projected]

| Manufacturing | Value Added (\$ million) | | |
|---------------------|--------------------------|-------|----------|
| | 2001 | 2002 | % Growth |
| Biomedical Sciences | 2,131 | 3,746 | 76 |
| Pharmaceuticals | 1,613 | 3,157 | 96 |
| Medical Technology | 517 | 589 | 14 |

*All figures are based on EDB's preliminary estimates.

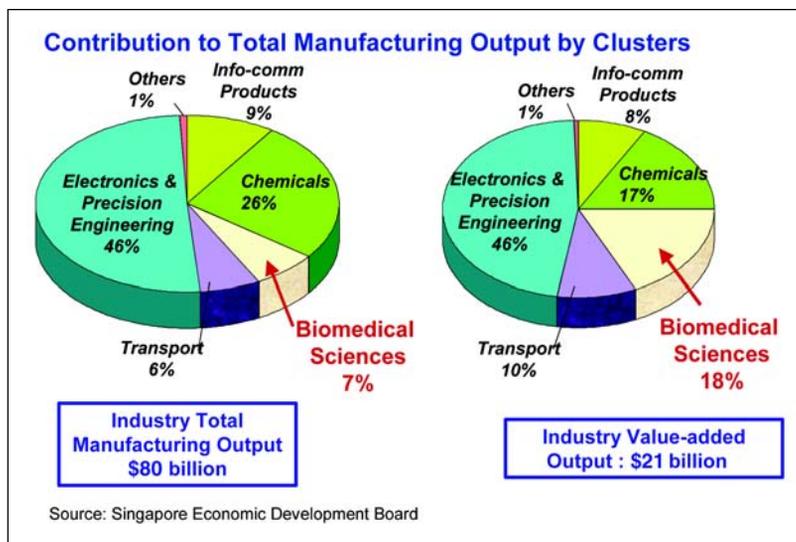
2002 Industry Performance: Value-Added (Source: Singapore Economic Development Board).

gies from local universities, or forming strategic joint ventures entities in Singapore. To date, it has invested its funds in more than 80 companies in Singapore as well as overseas.

In addition, other programs have been initiated to promote and commercialize indigenous technologies in the Biomedical Sciences. These include the EDB SEEDS (Startup Enterprise Development Scheme) program which provides matching equity funds of up to \$160,000 for start-ups in the seed stage of enterprise formation, and the Biomedical Sciences Innovate 'N Create Scheme (BMS INC) under Bio*1 Capital, which provides start-up funding specifically to viable business ideas in the Biomedical Sciences. Under the BMS INC scheme, qualifying companies are eligible to receive up to \$1.1 million of seed capital.

At present, Singapore is home to some 30 biotechnology companies, including international companies like ViaCell and Proligo, as well as a growing number of local start-ups such as S*BIO, CordLife, ES Cell International, and MerLion Pharmaceuticals. This growing pool of both local and international biotechnology companies involved in drug discovery and development clearly reflects Singapore's attractiveness and growth potential as an excellent breeding ground for new research discoveries to take off.

Comprehensive infrastructural support is aggressively being put in place for the BMS sector as well. Expansion of prepared land for manufacturing in the Tuas Biomedical Park, and a fully integrated R&D complex at Biopolis, which can house more than 2,000 scientists promotes physical clustering. This allows for economies of scale and significant savings through shared services and collaboration.



2002 Industry Performance: Investment Commitments.

Singapore - Valued Partner for the Long Term

Within a relatively short span of time, Singapore has demonstrated significant progress and is on track to achieving its target manufacturing output of \$6.7 billion by 2005. The government is committed to the Biomedical Sciences sector, and will continue to actively provide a sound investment climate, a pro-business and vibrant research environment for leading biomedical companies and talents to set up base in Singapore. 

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