

**Technology Administration**  
**SINGAPORE'S BIOMEDICINE INITIATIVE:**  
**PRESCRIPTION FOR GROWTH?**  
**(White Paper)**

**Prepared by Mr. David Brantley**  
**Technology Policy Analyst**  
**Office of Technology Policy, Technology Administration**

[I. INTRODUCTION](#)

[II. GOVERNMENT STRATEGY](#)

[III. LONG-TERM OUTLOOK](#)

[ATTACHMENT A](#)

[ATTACHMENT B](#)

[ATTACHMENT C](#)

[ATTACHMENT D](#)

[ATTACHMENT E](#)

[ATTACHMENT F](#)

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## **I. INTRODUCTION**

This report complements Technology Administration's interests in government policies which advance the goals of innovation, competitiveness and productivity. Because Singapore has grown a biomedical industry within a very short period largely through government policies, investments and incentives, useful lessons on technology-led economic development may be drawn from a closer examination of its model.

U.S. companies engaged in biomedical research, development, finance and production should have an interest in this report's description of who is engaged in Singapore's initiative and evolving opportunities for "partnership."

Individuals and organizations concerned with technology-led economic development may find Singapore's "systems approach," tax abatements, and other "fun and funding" incentives to be instructive.

Information used in this report was gathered during a round of meetings and interviews with government, research and development, and business executives that took place in Singapore in December 2001. A list of individuals interviewed is included as [Attachment A](#). Secondary sources include a report by the Commercial Section of the U.S. Embassy in Singapore, web sites and a few journal articles.

The report is structured to discuss the goals, strategy and programs of Singapore's economic development "model" as applied to its biomedical initiative, to describe the current biomedical sector, and to evaluate short and long-term implications for America's biomedical industry.

## **Background**

Despite a lack of natural resources, Singapore has achieved an impressive 8.37 per cent average annual GDP growth for the past 40 years.<sup>1</sup> Its economic success can be attributed to:

- Strategic location as a transportation, financial and commercial hub
- Significant investment in infrastructure
- A highly-motivated and well-educated workforce
- Consistently strong growth in foreign private investment
- Pro-growth and pro-business government policies and planning

As the government's development agency, Singapore's Economic Development Board (EDB) plays a leading role in policy formulation and planning. It was the EDB that developed the *Industry 21*<sup>2</sup> strategy in 1999 to make Singapore a "vibrant and robust global hub of knowledge-driven industries."

EDB's *Industry 21* program is described as a "blueprint to strategically position Singapore's manufacturing and exportable services for the next 10 years"<sup>3</sup> on five fronts:

1. To diversify among and within industry clusters for a balanced and robust mix of industries and markets;
2. To build up world-class capabilities and global coverage;
3. To promote innovation;
4. To develop local talent and attract foreign talent, and;
5. To create a conducive business environment and world-class infrastructure necessary for knowledge-driven activities

Other overarching parameters include:

- Dynamic mixed use
- Constant reinvention
- Seamless connectivity

Consistent with its tradition of *kaizen* (continuous improvement), the EDB is currently planning the following next steps to boost innovation, productivity and international competitiveness:

- Upgrade Singapore's scientific, technological and knowledge creation capacities
- Create advanced demand conditions

- Encourage private sector-led "cluster" development
- Widen the base of "clusters" in the economy around Singapore's unique advantages in the region<sup>4</sup>

Singapore recognizes its need to build innovation into its economic development strategies (the underlying theme in many [if not most] recent EDB and government initiatives). While emphasizing manufacturing for others over the past 30 years, the highest priority had been productivity. Its success with manufacturing productivity is perhaps without equal.<sup>5</sup> To move beyond manufacturing and become a "knowledge-based economy," however, performance must catch up with its economic ambitions by refocusing on innovation as a national priority.

In line with the *Industry 21* initiative to build a "knowledge-based economy," the "life sciences cluster" was selected by the government as the "4th pillar of Singapore's manufacturing sector."<sup>6</sup> Although foreign pharmaceutical firms have been manufacturing in Singapore since the 1970s, the EDB applied a systems approach to move the life sciences sector up the value-added chain. Since biomedical technology was selected as a "pillar" in 1999, progress has been dramatic.<sup>7</sup>

Strategic planning and development policies to create a biomedical sciences industry have been the core responsibility of EDB's Biomedical Sciences Group (BMSG). The BMSG is tasked with building Singapore into a "world class hub" for biomedical sciences, with capabilities across the entire value chain - from research to manufacturing to regional headquarters to innovation. The BMSG facilitates new companies' entry into Singapore by linking them with suitable local research organizations, facilities, and other supporting services. At the same time, the BMSG nurtures the growth of local start-ups and companies through a variety of incentives, grants and programs.<sup>8</sup> Singapore's biomedicine initiative can be described as a well-studied, strategic choice applying a "systems approach"<sup>9</sup> and an extraordinary commitment to mobilizing resources and action.

Why the biomedical industry? EDB Chairman Philip Yeo was quoted as saying "We were looking for something Singapore could be active in the post-genomic era. We've already got engineering industries, shipyards, semiconductors and chemical manufacturing, so we needed to do something else."<sup>10</sup> That something else was biomedicine.

### **Launching the Biomedicine Initiative**

The year 2000 marked the official launch of Singapore's biomedical initiative with the appointment of a Ministerial Committee, its Executive Committee, and the International Advisory Council for the Biomedical Sciences. Other Year 2000 milestones included:

- US\$600 million funding for investments in world-class biomedical firms doing R&D in Singapore.
- Four new programs for biomedical sciences education:
  - Postgraduate scholarships in key life sciences disciplines at leading

- universities overseas
  - MBBS-PhD scholarships to train "clinician-scientists" at leading clinical medicine and biomedical research institutions overseas
  - A fellowship program to support foreign PhD or post-doctoral students who commit to work in Singapore
  - An exchange program for Singaporean researchers with leading international institutions and companies
- The Singapore Genomics Program
- A Biomedical Research Council under the National Science & Technology Board to coordinate public sector R&D activities
- A Bio-Ethics Advisory Committee to examine legal, ethical and social issues.

In its first full year as a strategic priority (2001), Singapore's biomedical industry's manufacturing output grew even while the technology sector shrank. Rising 3.2% to US\$ 3.67 billion, biomedical's value-added grew by 3.6% to US\$ 2.2 billion. Manufacturing employment in the biomedical sector rose by 5.7% to 6,000 in 2001. The pharmaceutical sector's output of U.S.\$2.8 billion accounted for 76% of the total Biomedical Sciences manufacturing output (although that figure should change if research and development efforts grow as planned).

Technology also kept pace with a 3.4% growth in manufacturing output to reach nearly \$US\$1 billion. US\$470 million of investment in fixed assets was committed through 19 new projects to include investments by such U.S. companies Merck, Sharp and Dohme, GlaxoSmithKline, Baxter Healthcare, Eli Lilly, Novartis' "Institute for Tropical Diseases," Surromed, Quintiles and Chiron.<sup>11</sup>

By the end of 2001 and as of the period of this study, Singapore's biomedical initiative was well-established and drawing international attention.

[Top of Page](#)

## **II. GOVERNMENT STRATEGY**

A characteristic of Singapore's strategic approach is committing to the resources necessary up front, with flexibility to add resources or modify plans as needed. The EDB's "systems approach" features three primary components applied to every aspect of the biomedical industry: infrastructure, tax and capital incentives, and education and workforce initiatives.

### **A. Infrastructure**

A major component of the "systems approach" is creating a total infrastructure package to support a biomedical industry and to attract international players - both corporate and individual. While it may be too early to fully evaluate the success of this "build it and they will come" assumption for the biomedical initiative, that strategy has proven effective in other sectors (e.g. shipping, air transportation, electronics manufacturing, tourism, chemical

manufacturing, etc.).

## 1. Telecommunications and web resources

A major initiative running parallel to *Industry 21* is *Infocomm 21* for telecommunications described as a strategy to establish Singapore as "a dynamic and vibrant global Infocomm capital with a prosperous Net Economy and thriving InfoSociety."<sup>12</sup> The first priority of *Infocomm 21* is to guarantee that cutting edge telecommunications technologies are available to such other economic priorities as biomedical research and manufacturing. The strategy includes subsidies for broadband infrastructure and hardware, co-sharing the cost of international leased circuits, and "cyber-precincts" where commercial and industrial buildings are broadband-equipped.<sup>13</sup> Singapore claims 99% nationwide broadband availability<sup>14</sup> with a related goal of having the most integrated infrastructure for both broadband wire and wireless of any country.

It is worthy to note that Singapore is nearly a totally "wired" society with 99.9% of households having access to Internet dial-up. Most students are proficient with the Internet - officially encouraged by the government as an educational resource, and, in 2001, the government launched a program to create an "E-lifestyle" for all Singaporeans.<sup>15</sup> The government's "Singapore ONE" is a web site which links by broadband to several educational and entertainment sites to introduce citizens and consumers to the benefits of being Internet savvy.<sup>16</sup>

The Internet is also being applied specifically to the biomedical sector. In addition to job search web sites, a comprehensive bio-med web site (<http://www.biomed-singapore.com/bms/index.jsp>), allows users with passwords to access an on-line database of information on other researchers with the idea of establishing contact and cooperation. This web site includes a wide variety of other information linking Singapore's biomedical R&D community to counterparts and partners throughout the world.

The web is also used as a marketing tool by the EDB for foreign bio-med firms seeking information on Singapore's investment and/or trading market, regulations and incentives ([http://www.biomed-singapore.com/bms/sg/why\\_3.jsp](http://www.biomed-singapore.com/bms/sg/why_3.jsp)). Singapore companies can electronically communicate their interests in linking through the EDB network of overseas staff.

Singapore has become a regional E-commerce hub featuring over 1.2Gbps of internet bandwidth. In May 2000, the Economist Intelligence Unit (EIU) ranked Singapore as the world's seventh most "E-business ready" nation (the highest ranking in Asia).<sup>17</sup>

In December 2001, Singapore deployed an ultra wide-band link between Singapore research centers and a network of U.S. institutions. Their investment of US\$ 30

million is intended to "boost research in Singapore and provide a test facility for '*Singapore ONE*,' the national plan to link the entire island electronically." Singaren, the "Singapore Internet Next Generation Advanced Research and Education Network." connects researchers with the (U.S.) National Science Foundation, the exclusive 100 Mbps vBNS (the "very high performance Backbone Network Service)," and as a "peer network" with "Internet2" which links to 191 top U.S. research institutions through its Abilene center. Eight joint projects between Singapore and the U.S. are currently on-line, including the sharing of protein structural data.<sup>18</sup>

## 2. **Research facilities**

The government-built "Biopolis" is a dedicated science park providing state-of-the-art lab facilities for biomedical sciences companies near research institutes and universities. Companies at the Biopolis leverage common facilities such as shared utilities and animal compounds. The Biopolis will also be the focal point of a "biomedical grid" IT infrastructure.

In addition to physical infrastructure, part of Singapore's "systems approach" is to assure a "full system life cycle" of supporting industries. For example, the Centre for Drug Evaluation<sup>19</sup> performs the same functions as the (U.S.) Food and Drug Administration approving new drugs for local use based on primary data (and not the approval of FDA or a European counterpart). Current drug approvals take 8-12 months, a rate that Singapore hopes will be attractive to potential investors.<sup>20</sup> The Centre also provides pre-submission consultations on clinical trial protocols and other drug development issues related to registration requirements.

Another key to the biomedical life cycle is Singapore's possession of research samples. The Centre for Natural Product Research, supported by GlaxoSmithKline, focuses on the search for bioactive molecules from natural sources. State-of-the-art screening technology is combined with the vast biodiversity of Southeast Asia to discover compounds that will form the basis for new drug leads. Core research includes the acquisition and testing of diverse samples from natural sources, and preparation of high quality extracts. The group runs about 1.6 million primary assays each year in a variety of therapeutic areas.<sup>21</sup>

Planning is also underway for the "Singapore Tissue Network," a national tissue repository with state-of-the-art infrastructure for the accession of well-annotated human tissues for translational and population research.

Another significant link in the research process is "bioinformatics." Two bioinformatics research and training institutes support the research community and train local specialists - the Bioinformatics Centre of the National University and the Bioinformatics Institute of the Agency for Science, Technology and Research (A\*STAR).<sup>22</sup> Both have extensive links with U.S. and other foreign universities and

research institutions.

### 3. **Technology Transfer**

The concept of transferring technology from one Singapore entity to another is a fairly recent development. [Exploit Technologies](#) Pte. Ltd.,<sup>23</sup> created in 2001 by A\*STAR, functions as a private agent for "managing" intellectual property created by the research institutes and centers, and facilitating technology transfer from Singapore's labs to industry producers. According to A\*STAR's description, Exploit is expected to create new companies, generate employment and produce additional wealth in Singapore by collaborating with the research centers to:

- Develop an efficient system for the management of assets, intellectual property and technology;
- Create a "tech transfer environment" to motivate tech interests;
- Spur progress of incubator units or spin-off companies;
- Establish close links with industry to facilitate exchanges, interactions and matching of technology with needs;
- Promote new technology to industry.

### 4. **Lifestyle**

A centerpiece in the Government's drive to create an "innovation lifestyle" is the Jurong Town Corporation's (JTC) "*One North*" project (its name reflective of Singapore's location at 1° North of the Equator). The 540-acre development adjacent to Singapore Science Park, National University, National University Hospital and Singapore Polytechnic will become a "new town" (although it would be better described as an "enclave") where biomedical scientists and researchers will live, work and interact.

Marketing materials for *One-North* include such phrases as "an exceptional place of vision and inspiration" and "a lifestyle choice for the most creative minds of the new economy" suggesting that housing, recreation and neighborhood facilities themselves contribute to technology and innovation.

Other lifestyle experiments include an on-line newsletter for the biomedical community - from pre-K to research scientist (See newsletter at <http://www.newsletter.biomed-singapore.com/site/biomed/>), and an "International Researchers Club" (social gatherings for "foreign researchers" and their families) formed by the government with the intent to "help our foreign researchers better integrate into our society."

A\*STAR publishes a Web-based magazine titled *Explosion* with the purpose of demonstrating to young readers that science is fun and scientists are fun-loving. The magazine's introduction sums up its mission: "Singapore's future will depend on our ability to become a Science-oriented nation with a knowledge-based economy." (See

magazine at <http://www.a-star.edu.sg/explosion/iss1/>).

## 5. Intellectual Property Rights Protection

Over the years, Singapore has achieved a credible track record for protection of intellectual property rights (IPR). In January 2000, Singapore became the first Asian country to become a signatory to the "Pharmaceutical Inspection Cooperation Scheme" or "PICS." PICS accession is important to establish Singapore's preferred status as a regional pharmaceutical and biomedical sciences hub, to facilitate mutual recognition process of Good Manufacturing Practices (GMP) inspection with other PICS countries, and to ensure acceptance of the quality of pharmaceutical products manufactured and exported from Singapore.

In addition, the Singapore government has in place one of the most comprehensive frameworks for intellectual property protection in Asia to include:

- Full compliance with the World Trade Organization's Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement
- Expedient and efficient enforcement of IPR by one of the toughest judiciaries in the world
- Ongoing educational programs to raise the Singapore public's awareness of the importance of IPR protection
- Ranking by the "Political and Economic Risk Consultancy (PERC)" as having the best IPR protection in Asia since 1997<sup>24</sup>
- Consultation with industry integrated into regular reviews of the government's IPR protection program to ensure that existing measures are relevant, effective and adequate to IPR owners, and reflect technological advances or changing circumstances
- Accession to the World Intellectual Property Organization, the Paris Convention, the Budapest Treaty and the Patent Co-operation Treaty
- A world-class IPR administrative capability providing comprehensive information on patent filing and issues in Singapore<sup>25</sup>

Singapore recognizes the importance of IPR and protection as an incentive to foreign investments as well as to the recruitment and retention of world-class research talent. Its impact and importance as an IPR leader is multiplied because many other countries where IPR has been a barrier to economic development view Singapore as an appropriate policy model.

## B. Tax and Capital Incentives

The Economic Development Board's (EDB) investment arm began investing in U.S. and European biomedical firms in 1987. It evaluates potential investments by analyzing the company's products, growth potential, and technologies. It is very careful to select companies that have established market potential, major market share, and limited

competition. EDB invests modestly (up to 10% of the firm's equity, which does not give them controlling interest but does make them a substantial "partner"). When the firms are ready to expand, EDB (as investor) suggests that the company establish a permanent presence in Singapore.<sup>26</sup>

The EDB provides some of the initial funding for "venture capital" firms as well. There are currently more than 30 venture capital firms in Singapore having interests in biomedical sciences or healthcare. In addition, the Government of Singapore invests in international "life sciences" venture capital companies through its investment arm, Temasek Holdings. It was Temasek's investment in an American venture capital firm, for example, that assisted in attracting Chiron Corporation to joint venture in Singapore.

The preferred status of foreign investors adds to Singapore's appeal. The best public relations campaign for new targets of opportunity are Singapore's current bio firms. EDB investment incentives (such as subsidized facilities and infrastructure, 5-10 year tax "holidays" and liberal exemptions for such expenses as expatriate staff and capital equipment) have made for enthusiastic investors. Corporate investor loyalty is also reinforced through frequent close contact between company management and its EDB and NSTB "relationship" managers. The status of foreign investors is reflected in EDB's awards program at three levels: "Distinguished Partners in Progress," "Distinguished Friends of Singapore" and "Business Friends of Singapore."<sup>27</sup>

The government of Singapore is also relatively liberal with grant funding. EDB will, for example, match corporate investments in R&D under its "Scientific Capability Development Program." As an example of Singapore's financial support to its existing investors and partners, Johns Hopkins University received a US\$2.2M grant from A\*STAR for research (its debt obligation amounting to 10% of its income to be paid to A\*STAR for royalties).

The Biomedical Research Council will provide any of the following research grants to individuals or firms whether Singaporean or foreign:<sup>28</sup>

- i. Seed funding for an individual investigator for up to 3 years.
- ii. Funding for an extension to existing research by established investigator(s).
- iii. Funding for interdisciplinary collaborative project involving 2 or more research groups for 5 years.
- iv. Five-year funding for a cohesive research unit where investigators engage in research that develops and/or strengthens core competencies.

What is the payoff or return on the Singapore government's investment? Expectations seem to focus on sustained growth, jobs, workforce development, and status. According to the Genome Institute's Liu, EDB expects its effort and investments "to make each institution internationally recognized and to add value to the economy." Liu adds that "investors are given very wide latitudes and time horizons reflecting the government's long term commitment to the industry and its stakeholders."<sup>29</sup>

Johns Hopkins Singapore Pte. Ltd., a wholly-owned subsidiary of the Baltimore university, provides an example of how investment, grants and tax incentives "leverage" further growth and investor loyalty. Its 50/50 "International Medical Centre" joint venture with the National University Hospital began with a very modest investment of US\$60,000 supplemented by a US\$250,000 NUH investment, a US\$1.275M NUH loan, and a US\$3.3M EDB grant. In addition to joint ownership, Hopkins also benefits from a management contract and 100% control of the NUH Faculty HMO. Singapore benefits from its association with the number one hospital in the U.S. (according to *U.S. News and World Report*).<sup>30</sup> Johns Hopkins is building on its limited initial investment in research (to include its Center for Clinical Investigations, and Center of Immunology, Virology and Viral Cancer) to grow new companies through its incubator joint venture with Becton Dickinson - more evidence of long-term benefits of "partnerships" in Singapore.

### **C. Education and workforce initiatives**

The Ministry of Education and the Agency for Science, Technology and Research (A\*STAR) is now placing much greater emphasis on integrating life sciences into the more traditional hard sciences and math curricula and educational programs at all levels leading, at least indirectly, to a 50% increase in the number of university-level students enrolled in life sciences since *Industry 21* was initiated.

An example of this emphasis at the primary and secondary levels is *Science.O1*, a month-long series of events and activities in science, technology and biomedicine that includes scientific research and discovery, as well as the application of scientific knowledge, engineering and technological innovation for the public good.<sup>31</sup> In addition, public school (K-12) curriculum is changing to include classes and materials in the field of entrepreneurship in an attempt to blend science with business creation skills.

The "National Science Talent Search" identifies students aged 15-18 who have a strong aptitude for S&T and the potential to pursue careers in R&D. Each year, students are invited to submit a science or engineering research project to a panel of judges. The winners receive trophies, certificates, grants (of \$10,000 to be used for S & T related activities, including study tours to universities overseas), and a scholarship for tertiary studies in science or engineering up to the PhD level.<sup>32</sup>

At the University level, the National Science Scholarship program awards an increasing number of scholarship combinations for students of "key disciplines"<sup>33</sup> and to "selected overseas universities"<sup>34</sup> Scholarship recipients are required to return to Singapore to serve "bonding" requirements at a relevant research institute, university, hospital or industry. A\*STAR will assist in matching the employer with the student's interest. Another facet of this program is "attachment fellowships" to post graduate students in Singapore or overseas who "attach" themselves to foreign research institutions.

Singapore has traditionally looked to the West for linkages in business, education and technology recognizing that Europe and the U.S. represent the best in biomedical research

and education.<sup>35</sup> Each of the following Singapore institutions, for example, has been eager to seek collaborations with leading institutions worldwide:

<b>Degrees</b>	<b>Singapore partner</b>	<b>Foreign Collaborations</b>
Masters and PhD in BioInformatics	BioInformatics Centre	Stanford University, Uppsala and Karolinska Universities (Sweden), University of Western Cape (South Africa) and University of Sydney
MSc	Bioinformatics Institute	University of Chicago, Stanford University, Rutgers, National Institute for Science and Technology (NIST)
MSc, Phd	Institute of Molecular and Cell Biology	Cal Tech, Salk Institute, National Neuroscience Institute (Singapore), Scripps Research Institute (USA), Canadian Medical Research Council, University of London, University of Gothenberg (Sweden), Eijkman Institute (Indonesia), University of Cincinnati, Institute of Human Virology (USA) and the Walter and Eliza Hall Institute for Medical Research (Australia), Harvard Medical School (USA), National Cancer Institute (Bethesda, USA), University of Cologne (Germany), University of New York
PhD in Immunology and post graduate medical training	National University Hospital	Johns Hopkins University
A new College of Life Sciences	Nanyang Technological University	MIT, Carnegie-Mellon

The "Biomedical Sciences Manpower Advisory Committee" of educators and industry representatives is tasked with projecting workforce needs.<sup>36</sup> The "Biomedical Research Council" is charged with planning for, identifying and recruiting foreign talent. "Contact Singapore," a separate agency under the Ministry of Manpower, maintains an online jobs board for prospective foreign applicants as well as information on just about everything the applicant might want to know about working, studying and living there. This is supplemented by an exchange program of visiting scholars.

Critics have suggested that a move by a top researcher to Singapore would be "killing your career" by relocating far outside the R&D mainstream.<sup>37</sup> The head of the Biomedical Research Council is confident, however, that "good people will draw good people."<sup>38</sup> Other expatriate recruits suggest that Singapore's freedom to pursue research (and not worry about grant proposals), its first class facilities, and the expatriate lifestyle are sufficiently

attractive.

Some also suggest that it will take 5-8 years of recruitment success and a substantial increase in local scientists to firmly establish a sustainable research base. The government has set aside US\$300 million in scholarship funding over the next five years for Singapore students to study abroad, and to attach themselves to leading research institutions for a year or two to get high quality experience.

Some critics doubt Singapore will gain much from its huge investment in life sciences other than jobs and training. Retention of their world-class recruits is a major consideration. Scientific talent may view a position in Singapore as an interim step along a career path. One U.S. scientist says Singapore "has become a training camp for scientists from China. They use Singapore as a bridge to Europe, America and Australia."<sup>39</sup>

While aware that retention may prove difficult, one Singapore official counters that scientists are drawn to the combination of intellectual freedom, facilities and support that the biomedical initiative offers, a theory endorsed by Dr. Edison Liu, one of the biomedical initiative's leading talents recruited by EDB from NIH to head the Genome Institute.<sup>40</sup>

[Top of Page](#)

### **III. LONG-TERM OUTLOOK**

#### **A. From Singapore's perspective**

The matter of evaluating the success of or calculating a return on investment in Singapore's biomedical initiative may be somewhat premature. The sector is growing rapidly at present due mostly to the injection of government capital and foreign private investment. Several of those officials interviewed suggested that the number of researchers and firms must hit a "critical mass" before the industry sector becomes self-sustaining.

It would be fair to say that Singapore's investment in human capital, regardless how well planned by the EDB, is the most significant risk factor and, therefore, the most serious question about the future of Singapore's biomedical initiative. Expansion and retention of local and imported research talent will likely be the key determinant of the initiative's sustainability. Further analysis must include a discussion of return on investment, the development of local research capacity, and international competitiveness.

Of equal concern is the related need for local research and scientific management and administrative capabilities. Another well-planned and funded initiative to train administrators would be expected from the EDB/A\*STAR in the not too distant future.

Can Singapore succeed? The same strategy was applied in the 1970s and 1980s to the electronics sector with dramatic (and sustained) results. The continued success of the electronics "pillar" has been due to EDB flexibility in adapting policies and incentives to the

global market and industry changes, and, its commitment to "stay the course" despite economic and sectoral ups and downs.

Although early in the life cycle of this initiative, there have been several promising results. The Centre for Natural Product Research, for example, claims to have ten new drug leads from its screening of tropical samples.<sup>41</sup> New and expanded investment in research, development and production by multi-national pharmaceutical and medical device firms reflects their confidence in Singapore's claim to be a regional hub. The Bioinformatics Centre has become a major node in the worldwide bioinformatics network, and a local leader in the application of IT technologies. The joint venture between Johns Hopkins University and U.S. medical device firm Becton Dickinson to create "bio-venture" spin-offs from Singapore research suggests that research, development and innovation can be sustained in the long-run with less government intervention (and continued corporate relations).

## **B. From the U.S. perspective**

Why is the study of Singapore's biomedical initiative important to U.S. technology policy? Very simply, Singapore can provide some of the world's leading examples of technology-led economic development.

Its continuing interest in forming partnerships with European and other Asian (competitor) multinational firms and its ability to react quickly to market forces give Singapore the advantage of competitive connections, shared resources, speed and flexibility.

Its approach to ethical issues (such as stem cell research) may allow for advances in areas impacted in the U.S. by current policies.

Regulation of biologics and drugs may also prove a competitive advantage for Singapore. Although fully conforming to FDA regulations, Singapore's drug, biologics and device approval processes may prove competitive with FDA's due to less volume. Faster approvals for overseas distribution may prove attractive to U.S. companies concerned with "time-to-market" realities in the Asia-Pacific region.<sup>42</sup>

There are several other advantages to a "partnership" which may take the form of joint ventures or cooperative agreements at institutional and corporate levels:<sup>43</sup>

1. Practically unlimited flexibility to design, staff, finance and quarter a research and development program in the least possible time and with the least possible investment. The EDB's "Whatever it takes" slogan is very real - if the foreign partner has what Singapore wants!
2. Availability of talent from worldwide sources. The biomedical initiative described above is evidence that the Singapore government is prepared to purchase, train, and/or subsidize whatever talent the R&D organization or academic institution needs. In the global account of intellectual capital, Singapore shows a continually

positive balance. And, the rapid growth in graduating local researchers and scientists at the National University of Singapore and Nanyang Technological University mixes imports with locals into a diverse blend of talent.

3. Relatively easy and corruption-free business practices. An EDB "relationship manager" acts as agent and advocate for his or her investor clients, assuring that the company, its management and staff are well looked after. Moreover, its record on free trade and the world's most efficient air and sea transportation facilities make Singapore an attractive partner for manufacturing and distribution as well.
4. The range of tax incentives and subsidies available to the "right" foreign partners as well as an adequate and willing source of venture capital.
5. Singapore's status as regional centers for biomedical and healthcare technology, education and trade, and as an economic development model for virtually the entire non-Organization for Economic Cooperation and Development (OECD) universe (to include China).<sup>44</sup> Both features make Singapore a natural partner in marketing U.S. products and services to three-fourths of the world's healthcare consumers.

The CEO of Johns Hopkins Singapore described the island/city/state as a "node in the global life sciences community."<sup>45</sup> His enthusiastic endorsement of Singapore policies and performance was repeated often in the interviews leading up to this report. The U.S. has much to share (and, perhaps, something to learn) with Singapore as a partner in biomedicine research and development.

There are also significant lessons or "best practices" which justify consideration of Singapore's Economic Development Board as a "model" for economic development. Its success in building a biomedical industry practically from scratch is essentially due to the following:<sup>46</sup>

- Independence from politics and bureaucracy
- Ability to lead by coordinating various activities
- Ability to lead by achieving consensus among competing interests
- Pool of some of Singapore's best and brightest researchers, planners and thinkers
- Wide latitude to act to include creating or changing policies when appropriate
- Broad authority to commit government resources to include funding, staff, infrastructure
- Virtually unlimited investment capital<sup>47</sup>
- Understanding of and respect within the (global) private sector
- Dedication to principle and Singapore's economic success
- A global vision

U.S. economic development initiatives that might parallel Singapore's "systems approach" might include the regional biotech "clusters" at San Francisco, Pittsburgh and Research Triangle. In addition, some states are beginning to apply a "systems approach" to tech-led economic development, such as Ohio's "Third Frontier" project. An important role for the Federal government in these initiatives is the coordination of national and inter-governmental policies, rules, regulations and legislation to insure a climate conducive to

research, innovation and global competitiveness - a role Singapore's EDB has become very effective in executing.

Another lesson that could be drawn from the Singapore model is their approach to creating a biomedical research workforce practically from scratch. Its strategy was essentially the same "systems approach" used to create their biomedical industry. It began with the EDB convening policy and decision-makers from universities, research institutes, government and private industry, then working hand-in-hand with advisors and investors to develop policies, programs and incentives.

While the U.S. may not need to go to the extent of recruiting researchers and scientists, it should, perhaps, examine the effectiveness of similar policies and incentives for encouraging American citizen students in critical fields of study. In addition to Singapore's many "fun and funding" programs at every academic level, the capacity for its researchers to take ownership of their research, their intellectual property, and, to spin off their innovations into private sector "bio-ventures" may ultimately prove the most attractive policy and incentive "models" for America's biomedical institutions and companies.

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<sup>1</sup>See Singapore Department of Statistics report for 1961-2000 at <http://www.singstat.gov.sg/FACT/HIST/gdp1.html>

<sup>2</sup>For more information on Industry 21, visit their web site at <http://203.81.45.8/edbcorp/programmeindustry21.jsp>

<sup>3</sup>Ibid

<sup>4</sup>Ibid

<sup>5</sup> Singapore ranked fourth of 75 nations in the World Economic Forum's 2001-2002 Global Competitiveness Index

<sup>6</sup> The other "pillars" being electronics, engineering, and chemical manufacturing

<sup>7</sup> The EDB expects growth of 4% to 5% per year in the fields of pharmaceuticals, medical devices, healthcare service and biotechnology. In the year 2000, the biomedical industry's manufacturing output grew by 2.1% to US \$3.5 billion. By the year 2010, EDB's goals are Singapore as a key business base for 15 world-class companies, and a regional center for clinical trials and drug development. "Biomedical Sciences Industry Maintained Growth Trajectory in 2001," A\*Star press release dated February 6, 2002 at [http://www.biomed-singapore.com/bms/detailed\\_press.jsp?artid=237&bSubmitBy=false](http://www.biomed-singapore.com/bms/detailed_press.jsp?artid=237&bSubmitBy=false)

<sup>8</sup> See below

<sup>9</sup> See discussion at Attachment B

<sup>10</sup> As quoted in "Medicine for the Economy" by Trish Saywell, Far Eastern Economic Review, November 15, 2001

<sup>11</sup> Joint A\*STAR and EDB press release "Biomedical Sciences Industry Maintained Growth Trajectory in 2001" February 6, 2002

<sup>12</sup> Presentation on "Infocomm 21 - Singapore's Strategic Plan for Infocomm in the New Economy" by Ms Yong Ying-I, CEO of Infocomm Development Authority at <http://www.ida.gov.sg/Website/IDAhome.nsf/Home?OpenForm>

<sup>13</sup> "Multi-pronged approach to develop Singapore's InfoComm industry," a press release

from the InfoComm Development Authority, June 5, 2000

at <http://www.ida.gov.sg/Website/IDAhome.nsf/Home?OpenForm>

<sup>14</sup>"Fact Sheet on Wireless Initiatives for Singapore"

at <http://www.ida.gov.sg/Website/IDAhome.nsf/Home?OpenForm>

<sup>15</sup>For more information, see "Helping Singaporeans Go On-Line" at [Attachment D](#)

<sup>16</sup>For more information, visit the Singapore One web site at <http://s-one.net.sg/>

<sup>17</sup>[http://www.ebusinessforum.com/index.asp?layout=rich\\_story&doc\\_id=3331&country\\_id=&title=The+EIU%27s+e%2Dbusiness+readiness+rankings%2C](http://www.ebusinessforum.com/index.asp?layout=rich_story&doc_id=3331&country_id=&title=The+EIU%27s+e%2Dbusiness+readiness+rankings%2C)

<sup>18</sup>For more information on SINGAREN, visit their web site

at <http://www.singaren.net.sg/singaren/aboutus.shtml>

<sup>19</sup>For more information on the Centre, visit their web site at [http://www.biomed-singapore.com/bms/detailed\\_copofile.jsp?artid=91&bSubmitBy=true](http://www.biomed-singapore.com/bms/detailed_copofile.jsp?artid=91&bSubmitBy=true)

<sup>20</sup>"Singapore can now approve drugs more quickly," Singapore Straits Times, May 6, 2000

<sup>21</sup>For more information on the Centre, see its website

at [http://www.cnpr.nus.edu.sg/Netscape/main\\_aboutcnpr.html](http://www.cnpr.nus.edu.sg/Netscape/main_aboutcnpr.html)

<sup>22</sup>The Institute signed an MOU with Intel in January, 2002 to collaborate in the development of a biomedical grid, a early indication of their strategy for tech transfer through "partnerships" with industry leaders. For more information on the Institute, visit their web site at <http://www.bii-sg.org/about.html>

<sup>23</sup>For more information, visit the Exploit web site at [http://www.a-star.gov.sg/exploit\\_focus.shtml](http://www.a-star.gov.sg/exploit_focus.shtml)

<sup>24</sup>For subscription to the Asian Intelligence Unit, see <http://www.asiarisk.com/>

<sup>25</sup>For more information on the Intellectual Property Office of Singapore, visit their web site at <http://www.ipos.gov.sg>

<sup>26</sup>From a discussion of EDB strategies taking place during interviews with individuals shown at Attachment A

<sup>27</sup>For a list of recipients, visit the EDB web site

at <http://www.sedb.com/edbcorp/corprelpartners.jsp>

<sup>28</sup>"New Grants to Boost Biomedical R&D" from a National Science and Technology Board press release, June 4, 2001

<sup>29</sup>From an interview with Dr. Edison Liu, CEO of the Genome Institute of Singapore, December 19, 2001

<sup>30</sup>See U.S. News article on "Best Hospitals Honor Roll"

at <http://www.usnews.com/usnews/nycu/health/hosptl/honroll.htm>

<sup>31</sup>For more information on Science.01, visit their web site

at <http://www.sciencemonth.org.sg/>

<sup>32</sup>For more information on the National Science Talent Search, visit their web site

at <http://nsts.w3labs.com/>

<sup>33</sup>For a list of key disciplines in biomedicine, see [Attachment E](#)

<sup>34</sup>For a list of selected overseas universities, see [Attachment F](#)

<sup>35</sup>opus cit

<sup>36</sup>opus cit

<sup>37</sup>opus cit

<sup>38</sup>opus cit

<sup>39</sup>opus cit

<sup>40</sup>opus cit

<sup>41</sup>opus cit

<sup>42</sup>opus cit

<sup>43</sup> "Viva la Singapore" by K. Bhalaji for Frost.com, February 2002 or see article at <http://www1.frost.com/prod/news.nsf>

<sup>44</sup> Singapore is a leading player in two major regional economic blocs - the Asia-Pacific Economic Council (APEC) and the Association of Southeast Asian Nations (ASEAN). For a detailed treatment of Singapore's participation, see Attachment F

<sup>45</sup> His Baltimore-based university is a key player in Singapore's biomedical sector with 12 applied research projects and two research facilities, clinical services, a joint PhD program and "International Medical Centre" (a "private medical wing") with National University Hospital, and a "bio-incubator" for spin-off companies.

<sup>46</sup>opus cit

<sup>47</sup> One individual interviewed estimated the Singapore government's commitment to date at US\$ 3 billion.

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[Top of Page](#)

## **ATTACHMENT A**

### **INDIVIDUALS INTERVIEWED IN SINGAPORE FOR THIS REPORT**

Dr. Edison Liu  
Executive Director, Genome Institute of Singapore (GIS)

Dr. Tony Buss  
Head, Centre for Natural Product Research (CNPR)

Mr. Spencer Lim  
Deputy Director, Development & Marketing Department,  
Jurong Town Corporation (JTC)

Mr. James Wessel  
President, Asia Pacific Region  
Mr. David Capes  
R&D Director, Asia Pacific Region  
Becton Dickinson Singapore Pte. Ltd.

Mr. Howard Califano  
CEO, Johns Hopkins Singapore Pte. Ltd.

Ms. Tricia Huang  
Assistant Head, Economic Development Board (EDB)

A/P Tan Tin Wee  
Director, BioInformatics Centre (BIC)

Prof. Miranda Yap  
Director, Bioprocessing Technology Centre

Mr. Derrick Tan W.M.  
Operations Manager, S\*Bio Pte. Ltd.

**Technology Administration would also like to thank Ms. Luanne Theseira-O'Hara, Commercial Specialist, U.S. Commerce Service at the American Embassy, Singapore for making these interviews possible and productive.**

[Top of Page](#)

## **ATTACHMENT B**

### **THE ECONOMIC DEVELOPMENT BOARD'S "SYSTEMS APPROACH"**

A systems approach is defined here as active consideration of all the requirements, activities and effects of every dimension of a major undertaking viewed as a whole or "system." It is their systematic response to every facet of an undertaking that, to this author, is the primary reason for the Singapore "miracle."

As with its successful electronics manufacturing strategy of the 1970s and 1980s, the Economic Development Board (EDB) is responsible for planning and managing a systems approach to the biomedical initiative as a "pillar." EDB has employed a three-tier strategy to planning:

1. A "Ministerial Committee" supported by a working level "Executive Committee. This Committee assures political consensus through the policy and program development process.
2. A Life Sciences "International Advisory Committee" (IAC) consisting of key biomedical industry leaders and renowned biomedical scientists recruited from the US and Europe. The IAC acts as a "think tank" with the following key roles:
  - a. To advise on major global Life Sciences research and industry trends
  - b. To critique current initiatives and provide advice for improvements or enhancements
  - c. To share knowledge and experience in Life Sciences research and industry to guide Singapore's development in these areas

- d. To provide inputs on legal and ethical issues in biomedical research, based on the experience of other countries
3. The EDB's Biomedical Sciences Group (BMSG) is responsible for planning and managing the "systems approach" across the entire value chain - from research to manufacturing and regional headquarters to include:
  - a. Conducting research into biomedical industries in Europe and the US to develop an effective "model" for Singapore. In studying American and European experiences, the EDB will identify strategies and policies that advance the industry and those which impede, then develop a "hybrid" model based on "best practices."
  - b. At the same time, the EDB/BMSG will:
    - study export markets for biomedical products and services to assure that investors will have potential sales. The EDB/BMSG (in conjunction with the International Advisory Committee) will identify technological "niches."
    - identify and establish contact with biomedical companies in Europe and the US which have demonstrated the potential for leading-edge research, products and technologies. These "niche" companies are then selected as targets of opportunity.
    - identify and develop policies and incentives which serve to cause targets of opportunity to take an interest in Singapore. The strong enforcement of intellectual property rights by the Singapore government has proven to be an important investment incentive.
    - provide assistance to companies that are considering Singapore as a location for investments in R&D, manufacturing or headquarter services.
    - facilitate new companies' entry into Singapore by linking them with suitable local research organizations, industrial land/facilities agencies and other supporting services.
    - nurture the growth of local start-ups and companies.

[Top of Page](#)

## **ATTACHMENT C**

### **RESEARCH AND DEVELOPMENT**

Examples of current research and development projects include:

**Johns Hopkins University** is on the verge of beginning clinical trials, and, is doing research into "complementary and alternative medicines," applying FDA's rigorous standards. This required developing an association with the alternative medicine group at

NIH. They are also doing research on anthrax on behalf of the Singapore military.

The **Center for Natural Product Research** is owned by the IMCB and Glaxo with the latter having first rights for licensing discoveries based on the biodiversity in Southeast Asia. The Center has eight early phase drug leads to date, and is expecting investment from EDB and venture capital as it privatizes later this year.

**S\*BIO**, a fully integrated drug discovery company conducts research and development based on Chiron Corporation's technologies in genomics and small molecule drug discovery. S\*BIO is independently discovering and developing targets and drug leads and therapeutic, diagnostic, vaccine candidates and products. By locating in Singapore, S\*BIO can tap into modern genomics and drug discovery technologies to understand the molecular basis of diseases prevalent in Asia.

**Schering-Plough** broke new ground in 2001 on a S\$170 million bio-tech lyophilization plant for the finishing processes for biological drugs such as Remicade (Crohn's disease) and PEG-Intron (anti-viral/anti-cancer). Schering-Plough invested in manufacturing of biotechnology-derived products because of its good experience in Singapore with manufacturing of pharmaceuticals, the availability of skilled manpower and strong infrastructure.

**ES Cell International**, another local start-up that is currently developing and commercializing human embryonic stem cell technologies, this company's pioneering work will contribute to developments in biopharmaceuticals, tissue engineering and transplantation medicine. ES owns 6 of the 64 stem cell lines sanctioned by the Administration in 2001 and plans to establish a production facility to supply laboratories worldwide.

**Cell Transplants Inc.** is developing an innovative cell-based treatment for muscular dystrophy and has set up a pilot production facility in Singapore to extend the use of its cell-based treatments to other diseases including cardiovascular diseases.

[Top of Page](#)

## **ATTACHMENT D**

### **"HELPING SINGAPOREANS GO ONLINE"**

*A PRESS RELEASE Issued by the Corporate Communication Department Infocomm  
Development Authority of Singapore*

Over the next 3 years, the Infocomm Development Authority of Singapore (IDA) will take an intensive and targetted approach to help Singaporeans go online. This was announced

today by the Minister for Communications and Information Technology, Mr Yeo Cheow Tong, at the launch of *eCelebrations Singapore*. A total of S\$25 million has been set aside to support the 3-year culture promotion initiative spearheaded by the IDA. Under this initiative, IDA will undertake several programmes in phases to target low-income households, different ethnic groups and the late adopters of infocomm technology. These programmes are aimed to raise their awareness about how infocomm technology can enhance their quality of life.

### **Programmes to improve accessibility**

Help will be extended to 30,000 low-income households with a combined income of less than \$2,000 each. IDA will equip these families with used computers bundled with free Internet access and some basic training. This will be done through the community self-help groups such as the Chinese Development Assistance Council (CDAC), the Singapore Indian Development Association (SINDA), Mendaki, and the Eurasian Association.

To encourage active industry participation, IDA will seek tax incentives for vendors and e-service providers that donate equipment, professional services and Internet access to the community through civic organisations.

Basic public infrastructure will be enhanced by the provision of free broadband access to the Singapore ONE clubs at community centres. IDA will also work with other government agencies such as the Housing Development Board (HDB) and private sector property developers to facilitate the deployment of public infrastructure for Internet access, for example, Internet kiosks; and infrastructure that supports e-Commerce fulfillment, for example, locked boxes to hold deliveries.

### **Programmes to bridge the language barrier**

IDA will work with industry and community groups to develop relevant content in different languages to cater to different population segments. We will sustain the promotion of the National Chinese Internet programme and elevate the ongoing community Malay and Tamil Internet initiatives to national levels. Incentives will be provided for the development of useful applications and relevant content to bridge the language barrier and generate interest in infocomm among all Singaporeans.

### **Programmes to motivate widespread adoption of an e-lifestyle**

Beginning 1 March 2000, *e-Celebrations Singapore*, a month-long public outreach programme, aims to get everyone to go online. The interactive and experiential activities will raise awareness of how infocomm technology can change people's lifestyles and prepare Singaporeans for the technological challenges ahead. For the inaugural year, a total of 27 events have been organised to reach out to both individuals and businesses, urging all to get connected and reap the benefits of online services.

The e-Ambassadors programme aims to recruit 2,500 volunteers amongst early adopters of infocomm technology to guide late adopters in their use of infocomm services and applications at the ONE Learning Place, Singapore ONE clubs and public libraries. The e-Ambassadors will be recruited from community groups such as the People Association's Youth Movement (PAYM), the Retired & Senior Volunteer Programme (RSVP) and the Parents Advisory Group for the Internet (PAGi). IDA will provide funding for skills certification training and accord the e-Ambassadors due recognition for their volunteer services.

### **e-Shopping and e-Transactions**

IDA will initiate virtual shopping malls where online shoppers can buy basic necessities like groceries, lifestyle items such as music, movies and games, and services like on-line tuition. The aim is attract 200,000 shoppers to shop online. To further encourage merchants to get their customers to adopt online shopping, tax incentives will be explored with the relevant government agencies. IDA's efforts will be focused on building consumers' confidence in online shopping. For a start, TRUSTe, the online privacy seal programme will be made an industry 'trustmark' seal.

"For Singapore to realise the vision of an Information Society, a broad-based movement by multiple players and groups in society is required. While IDA can support and complement the movement, it will not be able to develop a vibrant Information Society on its own. Getting people and industry involved in the process of transformation is important. It is the active and committed Singaporean who will make the difference," said Ms Yong Ying-I, Chief Executive Officer of IDA.

The initiatives announced today by Minister Yeo to help Singaporeans go online, is the second in a series of recommendations under the Infocomm21 Masterplan. The first announcement made in January 2000, was on the liberalisation of the telecommunications market. The Infocomm21 Masterplan contains a series of initiatives by the government to develop and establish Singapore as a key global info-communications centre.

[Top of Page](#)

## **ATTACHMENT E**

### **KEY DISCIPLINES (BIOMEDICINE)**

Bioinformatics  
Biochemistry  
Biomedical Engineering  
Biophysics  
Chemistry and Biology

Genetics  
Immunology  
Neuroscience  
Pharmacology  
Developmental Biology  
Structural Biology  
Tumor Biology  
Molecular and Cell Biology  
Microbiology  
Virology  
Other Biomedical Sciences

[Top of Page](#)

## **ATTACHMENT F**

### **SELECTED OVERSEAS UNIVERSITIES**

Brown University  
California Institute of Technology  
Cambridge University  
Carnegie Mellon University  
Case Western Reserve University  
Columbia University  
Cornell University  
Duke University  
Eindhoven University of Technology  
Georgia Institute of Technology  
Harvard University  
Imperial College of Science, Technology and Medicine  
Johns Hopkins University  
Massachusetts Institute of Technology  
Northwestern University  
Oxford University  
Princeton University  
Purdue University-West Lafayette  
Stanford University  
Technical University of Munich  
University of British Columbia  
University of California- Berkeley  
University of California - Los Angeles  
University of California- San Diego  
University of California- San Francisco

University of Colorado-Boulder  
University of North Carolina-Chapel Hill  
University of Illinois, Urbana-Champaign  
University of Pennsylvania  
University of Melbourne  
University of Michigan-Ann Arbor  
University of New South Wales  
University of Texas - Austin  
University of Toronto  
University of Washington  
University of Wisconsin-Madison  
University College London  
Washington University in St. Louis  
Yale University

[Top of Page](#)

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