DEVELOPMENT OF
MOLECULAR BIOLOGY & BIOTECHNOLOGY
IN ASIA & THE PACIFIC RIM

REPORT OF THE
STRATEGIC VISION COMMISSION

2000

Asia Pacific International Expert Commission on Strategic Vision for Asia Pacific IMBN for the 21st Century

Report Framework

Considering the objectives of the Commission and the target audiences, the report will seek to provide clarity of understanding in relation to basic scientific and policy issues, as well as in-depth analyses and considerations of next steps. The proposed framework for the report is as follows:

Draft Report on Strategic Vision for Asia Pacific IMBN for the 21st Century

Chapter One: . Background to Asia-Pacific IMBN Expert Commission

1.1 Mission of Asia-Pacific IMBN

There is growing consensus that the first half of the 21st century will be shaped to a considerable extent by the application of discoveries in the biological field due to the advances made in molecular biology and biotechnology. Recognizing the potential of these new technologies, scientists from leading institutions throughout Asia and the Pacific Rim agreed in June 1997 to establish the Asia-Pacific International Molecular Biology Network.

The mission and objectives of Asia-Pacific IMBN are expressed in the opening statement of its constitution:

" The Asia-Pacific International Molecular Biology Network is founded in the belief that molecular biology and biotechnology can contribute greatly to the benefit of humankind, and that such benefit will accrue through close cooperation and collaboration amongst scientists and scientific institutions, supported by national and international agencies, and industry. The Network will provide a forum and mechanisms for such interaction through a range of activities including promoting collaborative research, the provision of training and skill enhancement opportunities, and the dissemination of information."

In line with its goals, Asia-Pacific IMBN has moved from strength to strength in terms of cooperation with leading international organizations and scientific bodies, including the European Molecular Biology Organization, APEC, UNESCO and IUBMB. It has launched major initiatives aimed at enabling the Asia-Pacific region to operate effectively at the forefront of molecular and biotechnology.

1.2 Aims and Guiding Principles

Asia and the Pacific Rim is home to over 60% of the world's population. The region's needs and concerns differ in type, range and scope from the rest of the world and many of the challenges facing the region can benefit from the application of molecular biology and biotechnology. With this in mind, the Network is committed to developing excellence in molecular biology and biotechnology in the region so as to meet the socio-economic needs of the region's population and to contribute to humankind's understanding of the mechanisms of life.

The Network intends to facilitate development in molecular biology and biotechnology through cooperation and collaboration with policy makers, industry, non-governmental organizations, academia and like minded individuals. In working towards its goals, the Network holds to the following aims and guiding principles.

1.2.1 Aims of Asia-Pacific IMBN

The Network is committed to maintaining and promoting the development of scientific and technical excellence amongst scientists and institutions dedicated to molecular biology and genetic engineering research, with particular focus on Asia and the Pacific Rim. Specifically, it will:

1. Promote study, research, innovation, development and dissemination of knowledge in molecular biology and genetic engineering and directly related areas of science and technology;

2. Undertake, in collaboration with relevant national and international institutions, facilities and training programs aimed at strengthening expertise and capacity for the conduct of work in the areas of the Network's interest and focus.

1.2.2 Guiding Principles for the Work of Asia-Pacific IMBN

1. The Network shall serve as an international resource devoted to developing competence and expertise in molecular biology and biotechnology in Asia and the Pacific Rim.

2. The Network will complement its activities with those of other international and national societies, associations and institutions, public and private, that have similar aims. Its activities will, wherever appropriate, be planned and implemented in collaboration with such societies, associations and institutions.

1.2.3 Functions

1. The Network shall have the following program areas:

    i) To encourage scientists and supporting institutions to conduct research and to provide training, educational and skills enhancement opportunities in molecular biology and genetic engineering;

    ii) To help coordinate the conduct of research and development activities in laboratories designated by supporting institutions as Asia-Pacific IMBN laboratories (IMBL);

    iii) to cooperate with industry to identify areas of common interest for promoting the work of scientists and institutions working with the Network.

1.3 The Development of Asia-Pacific IMBN

The development process for Asia-Pacific IMBN can be considered in terms of 3 major phases:

I. Establishment Phase – between conception and operationalization of the Governing Council [December 1996 – December 1998]
II. Early Operations Phase – between operationalization of Governing Council and formal establishment as an inter-governmental organization [January 1999 – December 2000]
III. Mature Operations Phase - between formal establishment of the organization and full operation [January 2001 onwards]

Phase I – Establishment Phase

During the Establishment Phase, the following elements and infrastructure were put in place:

- Establishment and Operation of the Establishment Taskforce
- Establishment and Operation of an Interim Secretariat
- Identification Process for the Membership of Asia-Pacific IMBN
- Initiation of Effort to Identify an Elected Governing Council for Asia-Pacific IMBN
- Establishment of the Advisory Group for Asia-Pacific IMBN
- Securing of Seed Funding Support

Phase II - Early Operations Phase

- Transition from Establishment Taskforce to Governing Council
- Transition from Interim Secretariat to Permanent Secretariat
- Formalization of Membership Development Process
- Inclusion of Associates and Student Associates
- Initiation of Program of Work and Value-Added Activities: Fellowships, Conferences, Commissions
- Expansion of Funding Base for Asia-Pacific IMBN

Phase III - Mature Operations Phase

- Consolidation of Role for Governing Council
- Operation of Permanent Secretariat
- Establishment of Support Conference
- Strengthening of Membership Base
- Consolidation of Programs and Activities
    - Launch of scientific collaborative programs working on the region's priority needs.
    - Establishment of long-term training programs
- Expansion of Funding Base

Current Membership Developmental Status

In terms of membership, Asia-Pacific IMBN currently consists of 215 individuals representing leading scientists and opinion leaders from 15 participating economies. A Governing Council, elected from among the members, guides the Network's efforts. The Governing Council consists Ken-ichi Arai (Japan), Nicos Nicola (Australia), Louis Lim (Singapore), Koh Chong-Lek (Malaysia), Filipinas Natividad (the Philippines), Obaid Siddiqi (India), Jisnuson Svasti (Thailand), Jeongbin Yim (Korea), Sangkot Marzuki (Indonesia), Gong Zuxun (China), Yoram Groner (Israel).

1.4 Objectives of this Report

This document has been developed to provide a clear vision of the future direction and focus of modern biology and, in particular molecular biology and biotechnology, and the potential involvement of the Asia-Pacific IMBN. It considers the mechanisms whereby the Network can work in close partnership with leading scientists, institutions, governments and industry groups, to help ensure that scientific and technological advancement in the region enable it to keep pace with new opportunities and directions in international science.

The Strategic Vision Document articulates the long term vision and aspirations of the Network and , with the Network's hopes and goals in mind, it makes clear recommendations for action for the next 3 year period (between January 2000 and December 2002). This document will guide the Network through the transition process between the Early Operations Phase and the Mature Operations Phase, and will, among other things, consider operational imperatives to ensure success and viability of Asia-Pacific IMBN as it strives to make maximum impact in moving things forward for the region.

1.5 Target Audience

The target audience for this Commission's report is likely to include:

- Academia
    - Asia-Pacific IMBN's Membership (to develop consensus and a common sense of internal ownership of the direction and focus of the organization)
    - Other scientists and scientific institutions (both public and private sector) within and outside the region who might wish to collaborate with Asia-Pacific IMBN in its various activities and initiatives
    - Students and young scientists - to provide them with a sense of where developments in life science and technology are heading, and to encourage their active participation and contribution to working with Asia-Pacific IMBN
- Policy Makers
    - Governments and other prospective partners in facilitating the development of molecular biology and biotechnology
- Industry and Investment Community
- Public

- The media and educators – to help ensure that the public obtain objective and high quality information regarding developments and implications of new insights and approaches in molecular biology and biotechnology
- Interested individuals

1.6 The Approach

In developing this document, the Network examines the potential of modern biology and biotechnology and its implications on the needs of the global community, focusing on Asia and the Pacific Rim region with its socio-economic and scientific developmental status.

This macro approach is required as Network's aim to develop excellence in molecular biology and biotechnology in Asia and the Pacific Rim has to take into account the varying needs, concerns and constraints of the region at the regional, national, institutional and individual level. The Network strongly believes that the region's ability to benefit from and participate in the development of molecular biology and associated new technologies will depend not only on the ability and foresight of policy makers to invest in research and development but also on the commitment of individual institutions and scientist.

Chapter Two: Introduction

2.1 Challenges of the New Millennium

The world stands poised to enter the new millennium equipped with ever increasing knowledge of the world and increasingly sophisticated technology. However, the promise of the future can only be realized if humankind solves the problems of today and begins its preparation for the challenges of the future.

Over the last century, the accelerated rate of change to society and the environment has outpaced the ability of humankind to identify, understand and solve the impact of such changes. Given the web of connections between humankind and the world, it is imperative that governments, scientists and industrialists coordinate their efforts in understanding and developing solutions for existing and future problems. Furthermore, while more developed states may not yet be greatly affected by problems such as disease, hunger and environmental degradation, the growing interdependence of the global village does not exempt any state from having to deal with such issues of concern. Humankind cannot afford many more delays or mistakes if we are to ensure Earth's and humankind's survival in the future.

This chapter summarizes the major problems facing the world and the role of science and policy in solving/causing these problems.

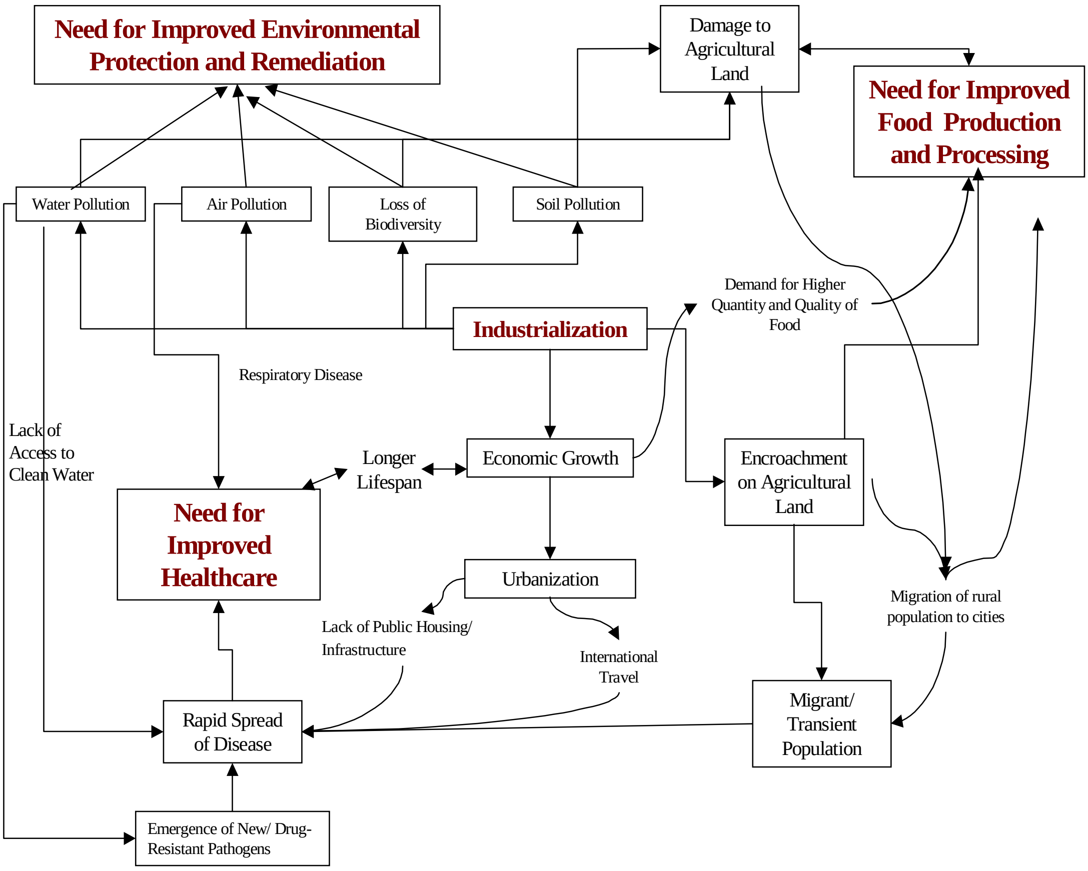


Figure 1: An illustration of some of the effects of socio-economic changes on the environment, healthcare and agriculture

2.2 Overview of Major Problems

Generally, the problems that humankind faces today have not changed very much over the centuries- population explosions, disease, food security and environmental pollution. The problem lies in the scale and intricate nature of today's challenges.

This section gives an overview of the major issues of concern, with a particular focus on Asia and the Pacific Rim.

Population Growth and Changing Demographics

World population at the time of World War II was 2.5 billion. By 1988, global population had doubled. Today, the world's population has already reached six billion people and is expected to reach 8 billion by 2020 and 11 billion by 2050 (*FAO 1998*). While the rate of population increase alone is enough to cause concern, there are more reasons for unease, including but not limited to:

(i) Increasing urbanization with the accompanying environmental changes. [Urban areas are expected to surpass rural areas in population around the year 2005 and to account for at least 60 percent of the global population by 2020. By 2015, 26 cities in the world are expected to have populations of 10 million or more. (1)

(ii) Demographic changes and accompanying social and economic pressures

Year / Region	1750	1800	1850	1900	1950	1998	2050
Africa	106	107	111	133	221	749	1766
Asia	**502**	**635**	**809**	**947**	**1402**	**3585**	**5288**
Europe	163	203	276	408	547	729	628
Latin America & the Caribbean	16	24	38	74	167	504	809
Norther America	2	7	26	82	172	305	392
Oceania	2	2	2	6	13	30	46
Total Population (Millions)	**791**	**978**	**1262**	**1650**	**2522**	**5902**	**8909**
Asia's contribution to world population (%)	**63%**	**65%**	**64%**	**57%**	**56%**	**61%**	**59%**

Figure 2: World Population Growth (2)

However, before these concerns can be addressed, a closer look at population and demographic trends makes it obvious that changes have not been taking place in a uniform manner around the world.

Of particular interest is the Asia-Pacific region - home to over 3.6 billion people, representing close to 60% of the world's population. As would be expected, there is tremendous diversity in terms of socio-economic development, strengths, challenges and concerns in a region of such size and diversity.

In the 1980s and early 1990s, the economies in Asia-Pacific made significant inroads in terms of economic and social development. During most of that period, the region saw rapid socio-economic advancement with annual growth rates of 8-10% being not uncommon amongst several countries in the region. The region was, for most of these 2 decades, the fastest growing region in the world in economic terms. Such growth has not, however, been evenly distributed. Some economies now have levels of wealth and infrastructure which rival those found in more developed regions (e.g. South Korea, Hong Kong, Singapore). Other countries in the region, such as India, Pakistan, Bangladesh and Laos are still among the poorest in the world. These economic changes had significant social and cultural impact.

In terms of population, the region as a whole remains one of the fastest growing regions in the world with population growth at a substantial 1.5% annually. However, there are significant variations between economies in terms of population growth rates and the populations' age structures. This is linked both to differences in economic developmental status as well as cultural differences. Furthermore, there are often marked differences in fertility, life expectancies, and causes of morbidity and mortality, depending on economic status within individual economies. These variations are to be expected from economies in transition and should be taken into account during development of policies and initiatives aimed at addressing socio-economic development and environmental protection.

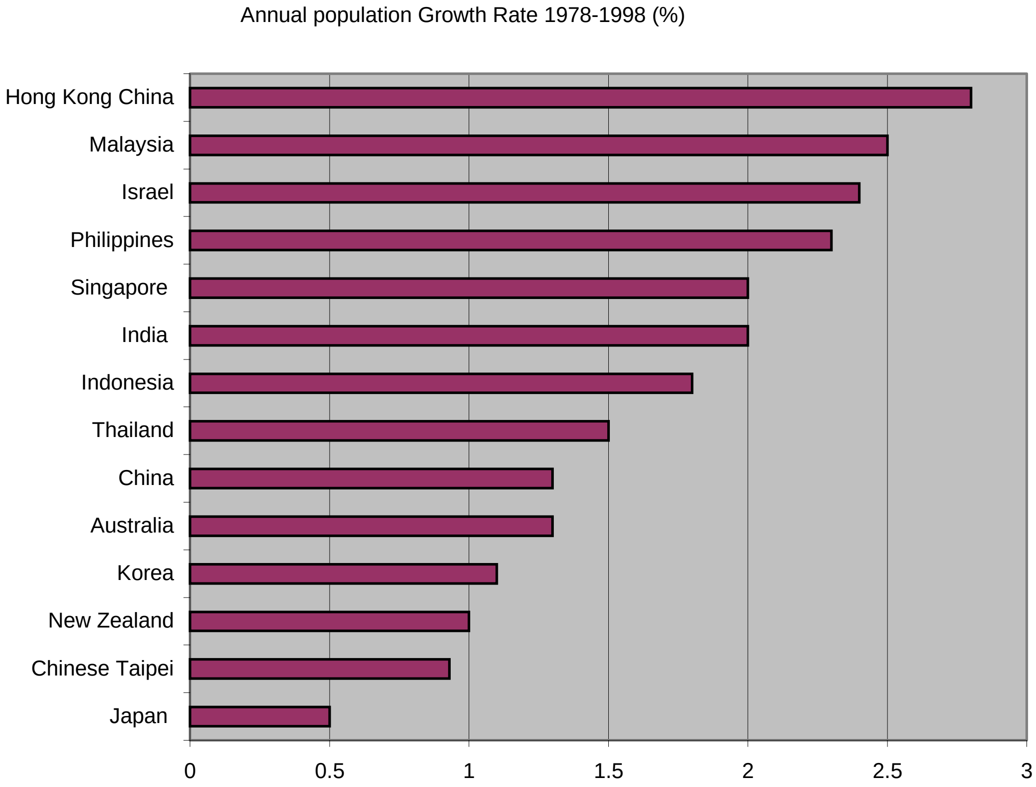


Figure 3: Population Growth Rates of Asia-Pacific IMBN Participating Economies (3,4)

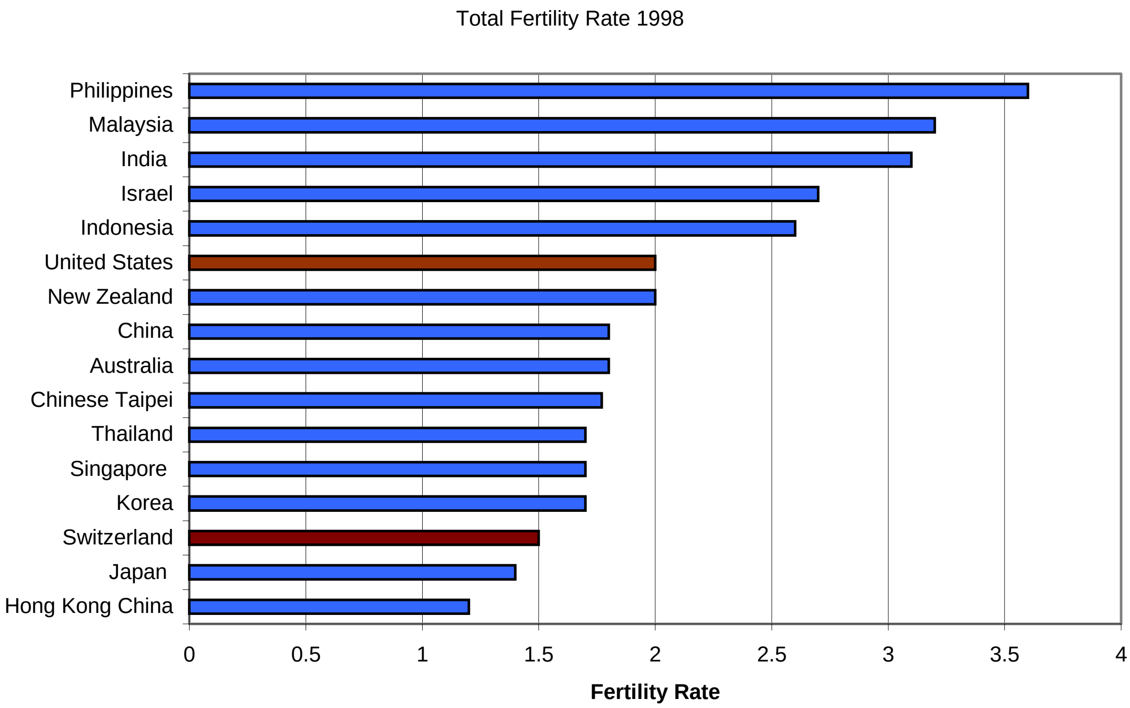


Figure 4: Fertility Rates in the Region in Comparison to USA and Switzerland (3,4,5)

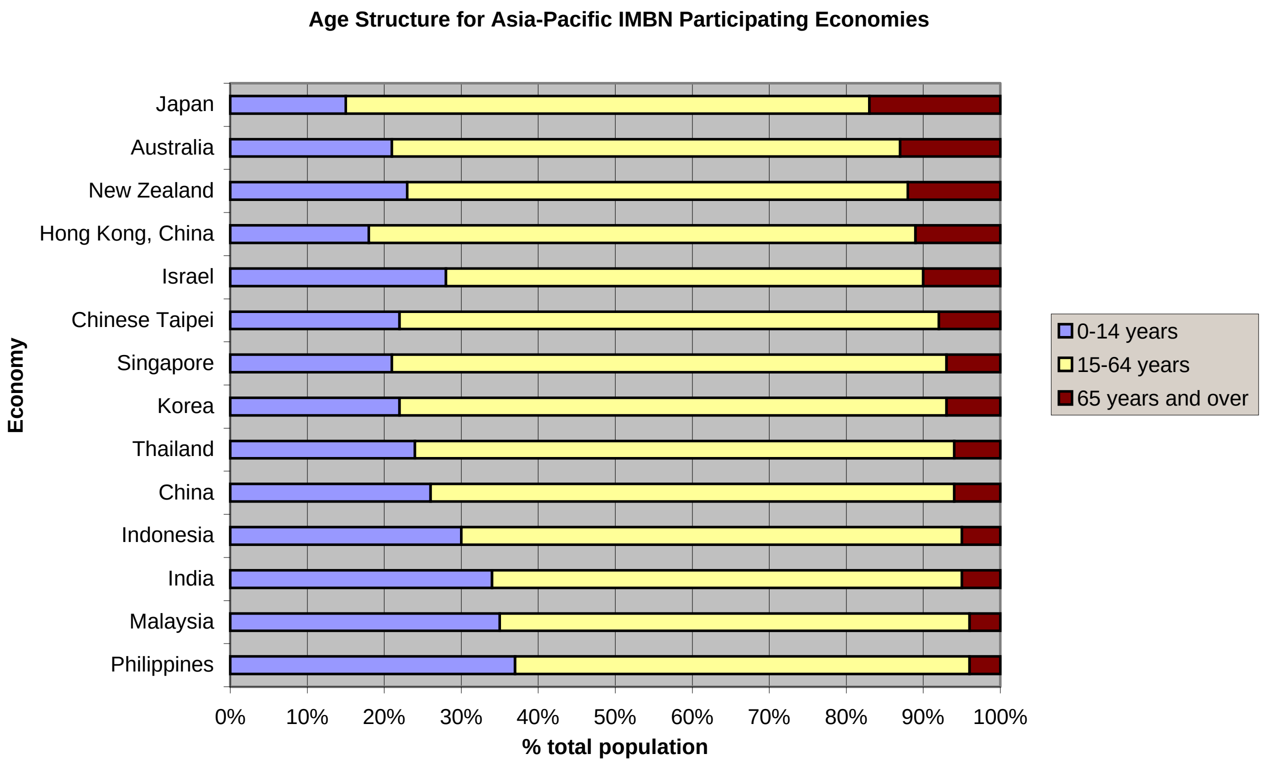


Fig 5: Age Structure in Asia-Pacific IMBN Economies (5)

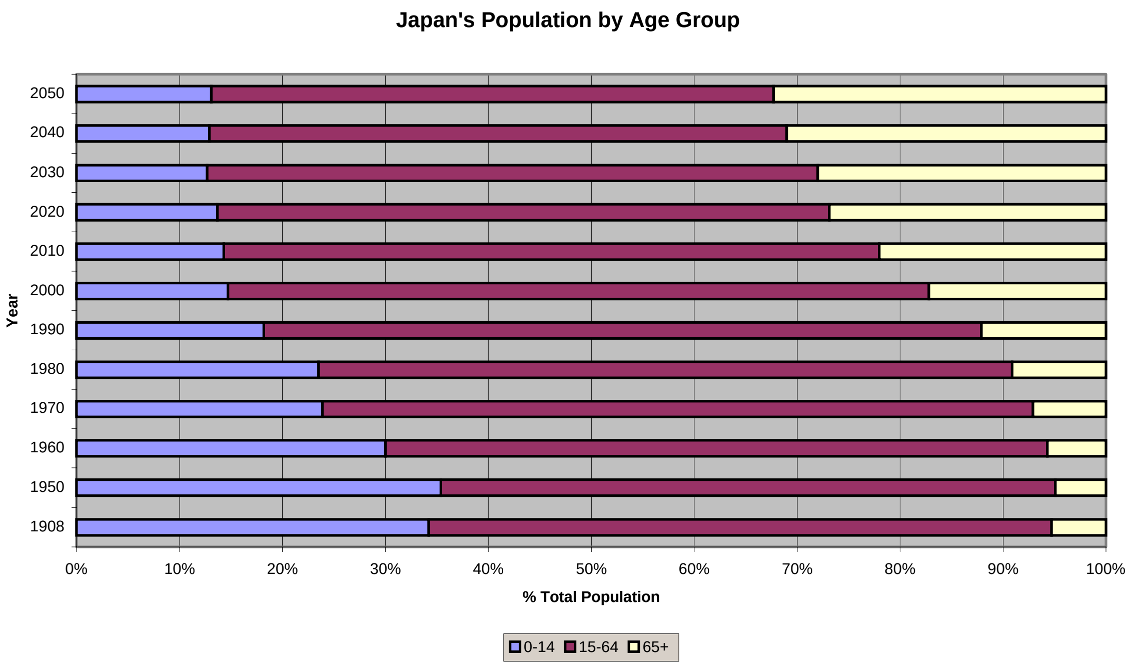


Figure 6: Japan's Population Age Structure (Historical and Projected) (7)

Burden of Disease

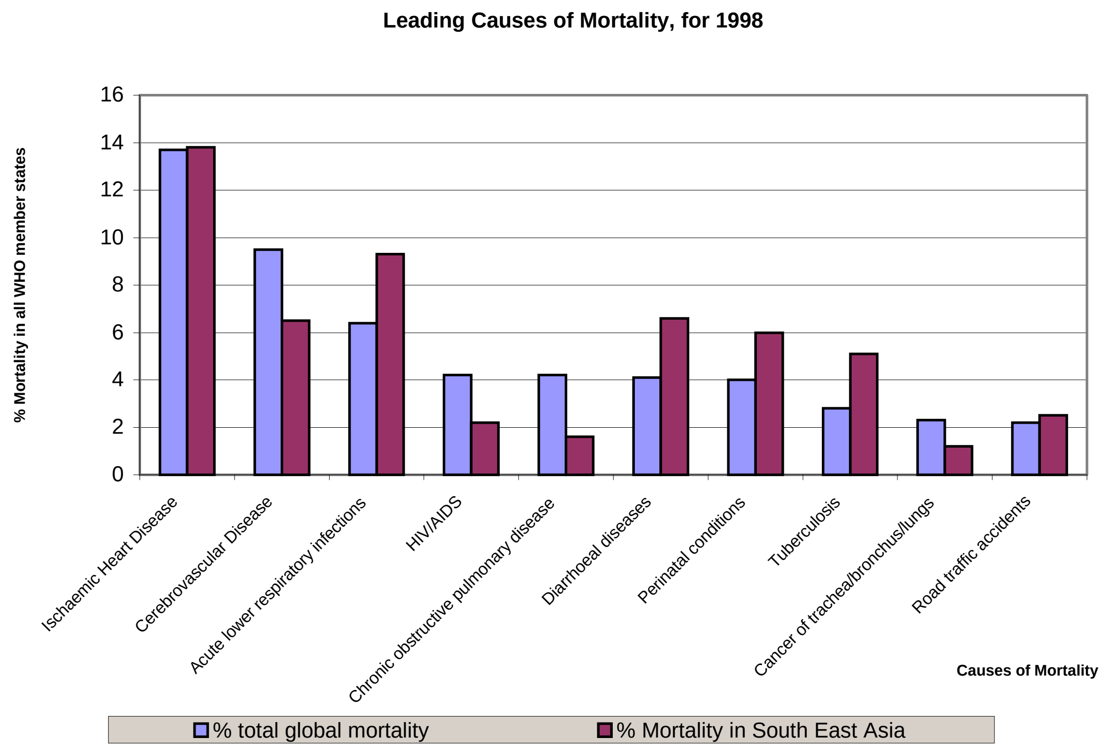


Figure 7: Leading Causes of Mortality in the World versus South East Asia (3)

Despite numerous advances in technology, health problems still abound. Today's healthcare providers, scientists, governments and populations have to tackle the burden of disease along three simultaneous fronts:

i. Resilient infectious diseases which were not eradicated in the previous decades and which may have evolved resistance to drugs and pesticides. In Asia, tuberculosis, malaria and hepatitis continue to take a very heavy toll in the region. While these diseases may be endemic, additional complications include:

   - The speed, frequency and volume of intercontinental travel today which renders the concept of infectious diseases as a "developing country problem" obsolete.
   - Increasing urban population density often in unplanned and overcrowded conditions.
   - Poor sewage treatment and inadequate or variable access to clean water, especially for the poor.
   - Political complacency brought on by the substantial progress made in the 1970s and 1980s which led to drop in funding for research into these diseases and decreased hands-on training for treatment and diagnosis of infectious diseases.

   These conditions, present in the "right" combination, are a formula for a regional and global health crisis.

ii. Emerging diseases- from the well-known AIDS epidemic to the new Nipah virus, are reminders of the possibility and speed at which pathogens can emerge and evolve and of the susceptibility of humankind. In Asia, as economic forces drive populations into previously unexploited environments and increase the intensity of livestock culture and its proximity to large populations, the chances for the emergence of new diseases increase.

Adding Fuel to the Fire: Tuberculosis and HIV

Governments around the world and international organizations such as the World Health Organization (WHO) are fighting to control the tuberculosis (TB) epidemic through public education, treatment through DOTS (Directly Observed Treatment-Short-Course) and by garnering political support to improve health systems and drug management. Progress is being made with success rates being boosted two and three fold even in the poorest countries. On the other hand, numbers of infected patients still remains high and the WHO recognizes that there is significant under-reporting of TB cases. For example, in the 14 Asia-Pacific IMBN economies, 1,908,274 cases were reported in 1996. In contrast, WHO estimates that there were actually 3.9 million TB cases during the same period.

However, progress faces a stumbling block when TB is combined with the HIV epidemic, especially in Africa and Asia. With the co-epidemic, TB is now the leading cause of death among HIV positive people and accounts for one third of HIV deaths worldwide and up to 40% of AIDS deaths in Asian and Africa. In addition to the increased susceptibility of HIV patients to TB, there are further difficulties in diagnosis and treatment. (The biological interaction between TB and HIV leads to less bacilli being coughed up for sputum analysis. Further, the vulnerability of immuno-compromised patients may lead to misdiagnosis and some commonly used anti-TB drugs have been known to have adverse reactions in HIV patients.)

Considering the above and the fact that

- 6.4 million people in Asia live with HIV today. (This represents over 1 in 5 of all HIV patients in the world.)
- The number of TB cases in Asia has remained high despite intervention (In 1982, 1,396,424 TB cases were reported and in 1997, 1,908,274 cases were reported).
- The rise of multidrug-resistance tuberculosis (MDR-TB) in TB/HIV infected patients

Tuberculosis is likely to remain a problem for the near future and complacency in terms of government commitment, funds for treatment, research and education, the need for hands-on training for medical doctors and public education is not advisable.

-Source: (8)

Nipah Virus-Malaysia and Singapore 1999

In late September 1998, an outbreak of what appeared to be Japanese Encephalitis (JE) occurred in Malaysia. Soon after, it was suspected that a new pathogen was responsible. In early March, the Atlanta based Center of Disease Control (CDC) was contacted for assistance and on March 13-19 1999, nine cases of similar encephalitic illness occurred among abattoir workers in Singapore that were in contact with pigs imported from infected areas in Malaysia. Subsequent testing identified the existence of a new Hendra-like paramyxovirus- the Nipah virus. From October 1998 to May 1999, more than 258 cases were reported in Malaysia with at least 104 deaths with most patients having had close associations with pig farms. Many survivors sustained some degree of cerebral dysfunction. Singapore doctors who treated the 9 abbatoir workers found that no anti-virals proved to be useful although Ribavirin showed some ameliorative effect. Fortunately, no human-to human transmission of Nipah virus was documented and the epidemic has tapered off. To date, the origin and reservoir of the virus is still under study.

In addition to the human loss of life, this outbreak has had major economic impact. It led to the collapse of the pig farming industry in Malaysia as, in an effort to control the outbreak, the Malaysian government culled 901, 228 pigs from 896 farms from 28th February to 26th April 1999 and a further 172,750 pigs were destroyed from infected farms from May to the end of July 1999. As of end of July 1999, the total standing pig population of Malaysia was reduced from 2.4 million to 1.32 million and the number of farms was reduced from 1,885 to 829. The end result was a dramatic change in the direction of the future of pig farming industry, with pig farming only being allowed in identified Pig Farming Area (PFA), as drafted by the Ministry of Agriculture, Malaysia and restocking of farms culled also being subject to State decision. Also, Singapore (a major buyer of Malaysian pigs) banned the import of pork from Malaysia.

Source: (9)

iii. At the same time, the region is undergoing an epidemiological transition in which the disease profile is changing – impressive investment in public health and growing socio-economic well-being has translated into ever rising life expectancies in the region, and a growing importance of dealing with such conditions as cancer and degenerative diseases as well as the so-called diseases of affluence which include diabetes, hypertension and cardiac disease. Yet, while the diseases are similar to those found in more developed nations such as USA and the European countries, there are differences in disease epidemiology, incidence, pathology and patient response to treatments. The basis of such differences needs to be understood and addressed as part of the effort to optimize healthcare management in the region.

Type of Cancer	**Northern America Male**	**Types of Cancer**	**Western Europe Male**	**Types of Cancer**	**Australia/New Zealand Male**	**Types of Cancer**	**Eastern Asia Male**	**Types of Cancer**	**South-Eastern Asia male**	**Types of Cancer**	**South Central Male**	**Types of Cancer**	**Western Asia Male**
Prostate	26.8%	Lung	18.7%	Prostate	17.0%	Stomach	24.9%	Lung	21.1%	Lung	10.6	Lung	22.0%
Lung	18.6%	Prostate	14.5%	Lung	15.4%	Liver	18.3%	Liver	13.7%	Oral Cavity	10.5	Bladder	7.5%
Colon/Rectum	12.2%	Colon/Rectum	14.0%	Colon/Rectum	14.7%	Lung	17.9%	Colon/Rectum	8.8%	Oesophagus	7.9	Stomach	6.7%
Bladder	6.6%	Bladder	5.9%	Melanoma of Skin	8.5%	Oesophagus	9.8%	Stomach	6.5%	Other Pharynx	7.6	Colon/Rectum	6.3%
Non-Hodgkins Lymphoma	4.0%	Stomach	5.8%	Bladder	4.8%	Colon/Rectum	9.0%	Nasopharynx	5.1%	Stomach	6.1	Larynx	6.2%
Kidney,etc	2.8%	Oral Cavity	3.6%	Oral Cavity	4.7%	Leukaemia	2.6%	Leukaemia	4.4%	Larynx	6.1	Non-Hodgkin Lymphoma	4.9%
Melanoma of skin	2.7%	Kidney, etc	3.6%	Non Hodgkin Lymphoma	4.0%	Bladder	2.1%	Non-Hodgkin Lymphoma	4.0%	Colon/Rectum	4.6	Leukaemia	4.6%
Leukaemia	2.7%	Other Pharynx	3.1%	Stomach	3.5%	Pancrease	1.8%	Prostate	3.8%	Leukaemia	3.9	Prostate	4.4%
Stomach	2.3%	Non-Hodgkin Lymphoma	3.0%	Leukaemia	3.3%	Nasopharynx	1.6%	Bladder	3.0%	Bladder	3.8	Liver	3.6%
Pancreas	2.2%	Larynx	2.9%	Kidney,etc	2.5%	Non-Hodgkin Lymphoma	1.2%	Oral cavity	2.8%	Prostate	3.7	Brain,nervous sytems	2.9%
Oral Cavity	2.0%	Leukaemia	2.6%	Pancrease	2.2%	Prostate	1.1%	Larynx	2.6%	Non-hodgkin Lymphoma	3.6	oral cavity	2.8%
Other Cancers	17.2%	Other cancers	22.3%	Other cancers	19.5%	Other cancers	9.8%	Other cancers	24.1%	Other cancers	31.6	other cancers	27.9%

Type of Cancer	Northern America Female	Types of Cancer	Western Europe Female	Types of Cancer	Australia/New Zealand Female	Types of Cancer	Eastern Asia Female	Types of Cancer	South-Eastern Asia Female	Types of Cancer	South Central Female	Types of Cancer	Western Asia Female
Breast	29.3%	Breast	29.2%	Breast	26.4%	Stomach	18.1%	Breast	19.9%	Cervix uteri	21.9%	Breast	22.6%
Colon/Rectum	13.5%	Colon/ Rectum	16.4%	Colon/ Rectum	15.0%	Breast	12.2%	Cervix uteri	16.1%	Breast	19.6%	Colon/Rectum	6.7%
Lung	12.4%	Corpus uteri	5.1%	Melanoma of Skin	9.1%	Lung	10.9%	Lung	7.3%	Oral Cavity	6.0%	Ovary, etc	5.8%
Corous uteri	5.4%	Stomach	4.7%	Lung	6.8%	Colon/Rectum	10.8%	Colon/Rectum	7.2%	Oesophagus	5.9%	Stomach	5.7%
Ovary, etc	3.8%	Ovary,etc	4.6%	Cervix uteri	3.8%	Liver	9.1%	Ovary etc	5.7%	Ovary	5.0%	Corpus uteri	5.6%
Non-Hodgkin Lymphoma	3.7%	Lung	4.1%	Corpus uteri	3.7%	Oesophagus	6.7%	Liver	4.7%	Stomach	3.4%	Cervix uteri	5.2%
Pancreas	2.7%	Cervix uteri	4.1%	Ovary etc	3.7%	Cervix uteri	5.7%	Thyroid	4.2%	Colon/rectum	3.4%	Lung	4.6%
Cervix uteri	2.7%	Non-Hodgkin's lymphoma	2.9%	Non-Hodgkin's lymphoma	3.5%	Leukaemia	3.0%	Stomach	4.1%	Leukaemia	2.4%	Non-Hodgkin's lymphoma	4.2%
Melanoma of Skin	2.4%	Melanoma of Skin	2.8%	Leukaemia	2.5%	Ovary,etc	2.9%	Leukaemia	3.4%	Lung	2.2%	Leukaemia	3.4%
Bladder	2.2%	Leukaemia	2.5%	Pancreas	2.2%	Pancreas	1.8%	Corpus Uteri	3.0%	Corpus uteri	1.9%	Thyroid	3.1%
Leukaemia	2.2%	Kidney, etc	2.5%	Kidney, etc	2.2%	Corpus Uteris	1.7%	Non-Hodgkin's lymphoma	2.9%	Non-Hodgkin's lymphoma	1.9%	Liver	2.6%
Other cancers	19.6%	Other cancers	21.1%	Other cancers	21.3%	Other cancers	17.3%	Other cancers	21.6%	Other cancers	26.4%	Other cancers	30.4%

Source: GLOBOCAN 1. Cancer Incidence and Mortality in 1990, (IARC, WHO 1998)

Groupings

Northern America: Canada, USA

Western Europe: Austria, Belgium, France, Germany, Luxemburg, Netherlands, Switzerland

Eastern Asia: China, Hong kong, Japan, North Korea, South Korea, Mongolia

South-Eastern Asia: Brunei, Cambodia, Indonesia, Laos, Malayisa, Myanmar, Philippines, Singapore, Thailand, Vietnam

South Central Asia: Afghanistan, Bangladesh, Bhutan, India, Iran, Kazakhstan, Kyrgyztan, Nepal, Pakistan, Sri Lanka, Tajikstan, Turkmenistan, Uzbekistan

Western Asia: Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab, Turkey, Arab Emirates, Yemen

Figure 8: Comparison of cancer incidence among males and females in various regions of the world

Feeding the World

The concept of **sustainable development** is based on the conviction that it should be possible to increase the basic standard of living of the world's growing population without unnecessarily depleting our finite natural resources and further degrading the environment in which we live.

Considering the rate of regional and global population growth and Earth's finite natural resources, humankind's efforts to attain food security have been focused on increasing yields, increasing land and farming efficiency and decreasing wastage (i.e. from spoilage, pests ,diseases, etc. The wide array of approaches taken over the years, has met with varying success and a continuous barrage of problems:

- In the 1950s-1970s, the investments into development of new disease and pest resistant high-yield breeds of crops bore fruit. This first "Green Revolution" boosted yields of key food crops and played a critical role in helping to ensure that food production in the Asia-Pacific region grew at rates which either matched or exceeded rates of population growth. However, this revolution came at a price. These new hybrids relied heavily on chemicals and inorganic fertilizers. Over the years, frequent application and overuse of these chemicals has been linked to a wide range of ecological problems from soil infertility due to chemical pollution to pesticide poisoning and increasing resistance to pesticides.
- While food production must increase dramatically to feed the world's population, most land suitable for cultivation is already in use. Furthermore, soil erosion and degradation through agricultural mismanagement, overgrazing, deforestation urbanization, and pollution are amongst the factors that decrease available arable land by 5-7 million ha per year. In Asia alone, it is estimated that approximately 38% of agricultural land has been degraded. (11). Considering that Asia is home to 60% of the world's population with only 35% of the world's arable land, this issue is of serious concern. With this pressure on arable land, it is likely that further growth in harvests will have to be derived from yield increases through new technologies and improved management.
- With the decrease in cultivated land and growing consumer demand for larger quantities of protein there has been increased "industrialization" of livestock production. Together with this comes the increased potential for disease outbreaks and environmental pollution. This growing demand for meat also means an increased demand for cereals for feeding livestock.
- Strain is also becoming evident in the once bountiful ocean with estimates that catches of 70% of marine species have reached or exceeded sustainable levels (12).

Food production has so far exceeded the rate of population growth. However, it is debatable if current practices would be sustainable in the long term and if they would be able to keep abreast of population growth, income growth and changing dietary preferences in the future. As we enter the 21st century, food security is still an issue for concern and significant improvements in agricultural production, management and food production that would help producers meet consumer demand while alleviating stress on the environment and potential risks to public health would not be unwelcome.

Environmental Crisis

The economic growth and development that the world has seen to date has come at a high price. Globally, the last century has seen tremendous loss of Earth's biodiversity, rising levels of air pollution in cities, coastal degradation, deforestation, unsustainable use of freshwater sources and the use of natural waterways as dumps for garbage. There is a growing need for remediation of present environmental problems and prevention of future situations. This has become not just an ethical or moral issue, it is now an issue linked to the survival of humankind.

In Asia, the key areas of concern include:

- The **increasing pressure on land resources** as 60% of the world’s population depends on 30% of the world’s land area. While the problem of decreasing agricultural land has been moderated by improvements in agricultural yields, food security remains a high priority in most countries. This is driven by population growth as well as extensive soil degradation (e.g. In India, as much as 27% of the soil has been affected by severe erosion. Further, irrigated agriculture has degraded existing arable lands and the Asia-Pacific region in responsible for around 75% of all human-induced salinization in arid, semi-arid and dry sub-humid areas).
- **Increasing demand for fresh water** for agriculture and safe drinking water (Currently at least one in 3 Asians have no access to safe drinking water and at least one in two has no access to sanitation).
- **Depletion of forests** through excessive logging, clearing for agriculture and fire. (e.g. About one million ha of Indonesia’s national forests were destroyed in the 1997 forest fires. In 1996, Mongolia lost more than 3 million ha of forests also due to fire).
- **Loss of biodiversity.** The Asia-Pacific region contains parts of 3 of the world’s eight biogeographic divisions and 4 (i.e. Australia, China, Indonesia 7 Malaysia) of the world’s 12 “mega-diverse” countries. On the other hand, UNESCAP has estimated that about two-thirds of Asian wildlife habitats have already been destroyed; about 70% of the major vegetation types in the Indo-Malayan realm (South Asia, Mekong Basin and Southeast Asia) lost; and around 15% of terrestrial species have been lost. Further, many species are threatened (e.g. Of the 640 species protected under CITES, 156 are found in China; in Australia approximately 5% of angiosperms and 9% of terrestrial vertebrates are either endangered or vulnerable).

2.3 Addressing the World's Problems

Internationally, there is a spectrum of acknowledgement and knowledge of the problems listed above. Governments, organizations and industry around the world, understanding the gravity of the situation, have made commitments to address present and future challenges via:

- Changes in policies and regulations
- Investment in research and development
- Investment in education.

These three approaches are interlinked and, given the intricate web of connections between trade, environment, industry, health and agriculture, the challenge to policy makers is to identify and assess the full impact and significance of state, national and international policies and legislation.

Policies and Regulations

Industrial policy is the deliberate attempt by a government to influence the level and composition of a nation's industrial output. Industrial policies can be implemented through measures such as allocation of R & D funds, subsidies, tax incentives, industry regulations, protection of intellectual property and trade actions.

Science and technology policy complements industrial policy in terms of providing a vision, direction and focus for science and technology development and exploitation. Often, science and technology vision is implemented through steps such as directed research grants, focused human resource development, establishment of incubator facilities and/or science parks, provision of venture capital or loans for technology based companies, and national scientific programs.

Regulations imposed by the government are intended to minimize social, economic, and environmental risks while maximizing benefits. With regards to molecular biology and biotechnology, countries have taken a range of regulatory approaches ranging from no regulations to limited restrictions and to stringent biotechnology specific regulations. These include regulations for research and development; release of genetically engineered organisms; import and export; trade; and labeling. This also includes regulations and legislation pertaining to intellectual property protection and exploitation.

2.4 The Role of Science

The history of humankind has been and continues to be driven by technological revolutions (invention of tools, agriculture, and recently the industrial revolution) which supported an incredible increase in the global population from just a few millions tens of thousands of years ago, to the current size of 6 billion.

Humankind is currently going through another revolution, different from all previous ones in the sense that it dominated by scientific research. This revolution is often referred to as the "high-tech revolution". It spans different disciplines of research, and one of its major directions is the development of molecular biology-based biotechnology.

This "high-tech" period is characterized by increasing blurring of the border between traditional scientific disciplines, and, in particular the border between basic and applied research (e.g. between molecular biology and biotechnology). The tight inter-relationships are manifested at different levels- scientific research is becoming increasingly technological and dependent on sophisticated equipment and reagents. Similarly, industry is becoming more and more dependent on basic research. Often, the time interval between an original discovery and application has become quite short.

As science moves from the laboratory to the real world, there are increasing signs that that molecular biology and biotechnology will provide solutions to meeting the needs of the world's population and to solving the environmental problems plaguing the world today. For example:

- Recent advances in the laboratory have led to a growing array of plants and animals with increased resistance to disease and substantially higher yields than ever before.
- New microbes engineered in laboratories are demonstrating the ability to break down petrochemicals and plastic into non-toxic components.
- Gene therapy offers the exciting possibility of treating or preventing disease at the most fundamental level.
- Genome science is advancing rapidly towards completing the human DNA sequence.

On the other hand, there is growing concern regarding the potential socio-economic, health, ethical and environmental impact of this new technology.

As such, it becomes obvious that research and the subsequent translational process need to be re-examined and assessed against the backdrop of the needs and views of the world and the global community, if the full benefits of molecular biology and biotechnology are to be accrued. Furthermore, as modern (molecular) biology provides the foundation of knowledge upon which biotechnology is built and as biotechnology holds such promise and significance for the world, investment in biological research should be recognized as an investment into the future. This has to be brought to the attention of and be acknowledged by the public and policy makers.

If molecular biology and biotechnology is to realize its potential as an agent for change, governments, scientists and industrialists will have to answer the questions of:

- How can molecular biology and biotechnology be best applied?
- Where can this new technology add the most value?
- What is required for success?
- When are results (i.e. solutions) expected?
- What are the short term and long term implications of such research?

2.5 Factors affecting the development of molecular biology and biotechnology

Research and application of molecular biology and biotechnology are knowledge intensive activities which are dependent on the existence or access to scientific infrastructure (human and physical), modern research equipment, reliable telecommunications and information technology networks, highly skilled manpower and financial support. As such, the factors affecting the development of molecular biology and biotechnology include:

1. Infrastructure Development
   - Development of physical infrastructure at various levels-institutional, national, regional and international. These include the establishment and maintenance of transportation networks, existence of reliable power supplies, a modern telecommunications network and the existence and access to powerful, widely accessible information nodes.
   - Scientific Infrastructure such as the establishment and maintenance of expert institutions, instrumentation centers, and research teams focusing on the creation of fundamental and applied knowledge and technologies.
2. Regulatory/Cultural Environment
   - Development of regulations and enforcement procedures which encourage the development of life sciences (e.g. intellectual property rights regulations)
   - Local environment/attitudes towards research and development, entrepreneurship and risk/failure.
3. Policy towards research and development and exploitation of the results
   - Development of national policy for promoting modern biological research, properly balanced between basic and applied work.
   - Institutional policies and guidelines towards promotion of scientific excellence and application of scientific discoveries (e.g. assessment systems, career development programs, encourage of scientific entrepreneurship)
4. Human resources development
   - Promotion of science and technology education at the school level
   - Strengthening the academic infrastructure (including the promotion of university education and research at the graduate and undergraduate levels)
5. Finance and Resource Mobilization
   - Promotion of biological and biotechnological research through allocation of research funding via national, regional, international and private sources
   - Encouragement of investment in biotechnology industry, with a particular emphasis on the link between academia and industry.

For an economy to develop excellence in molecular biology and biotechnology, all the above factors must have been considered and acted upon in an integrated manner. The impact of guidelines, policies and legislation has to be considered both on the ability to conduct research and on the ability to apply the fruits of research.

Chapter 3. Where Molecular Biology and Biotechnology are Headed

3.1 Brief history of the Biological Sciences

Historically, the study of the biological sciences was based on phenomenological observations which subsequently developed into the study of biological mechanisms. The progress in biochemistry and biophysics in the past three-quarters of this century provided a major impetus to the characterization of proteins and their role in cellular activity, thereby paving the road to the development of molecular genetics.

The last quarter of this century was progressively dominated by genetic approaches, which revolutionized the scope of biological research. These approaches, commonly referred to as "molecular biology", enable not only the systematic identification and characterization of all genes and their products, but also the analysis of the activity and specific roles of individual genes within living organisms. This is being achieved by the creation of cells or whole organisms which are genetically engineered (i.e. the addition, change or deletion of specific genes). These new approaches and technologies are being successfully applied to a wide variety of organisms, from bacteria to man, culminating in the global effort to characterize the entire human genome and eventually, the genomes of all other organisms of importance.

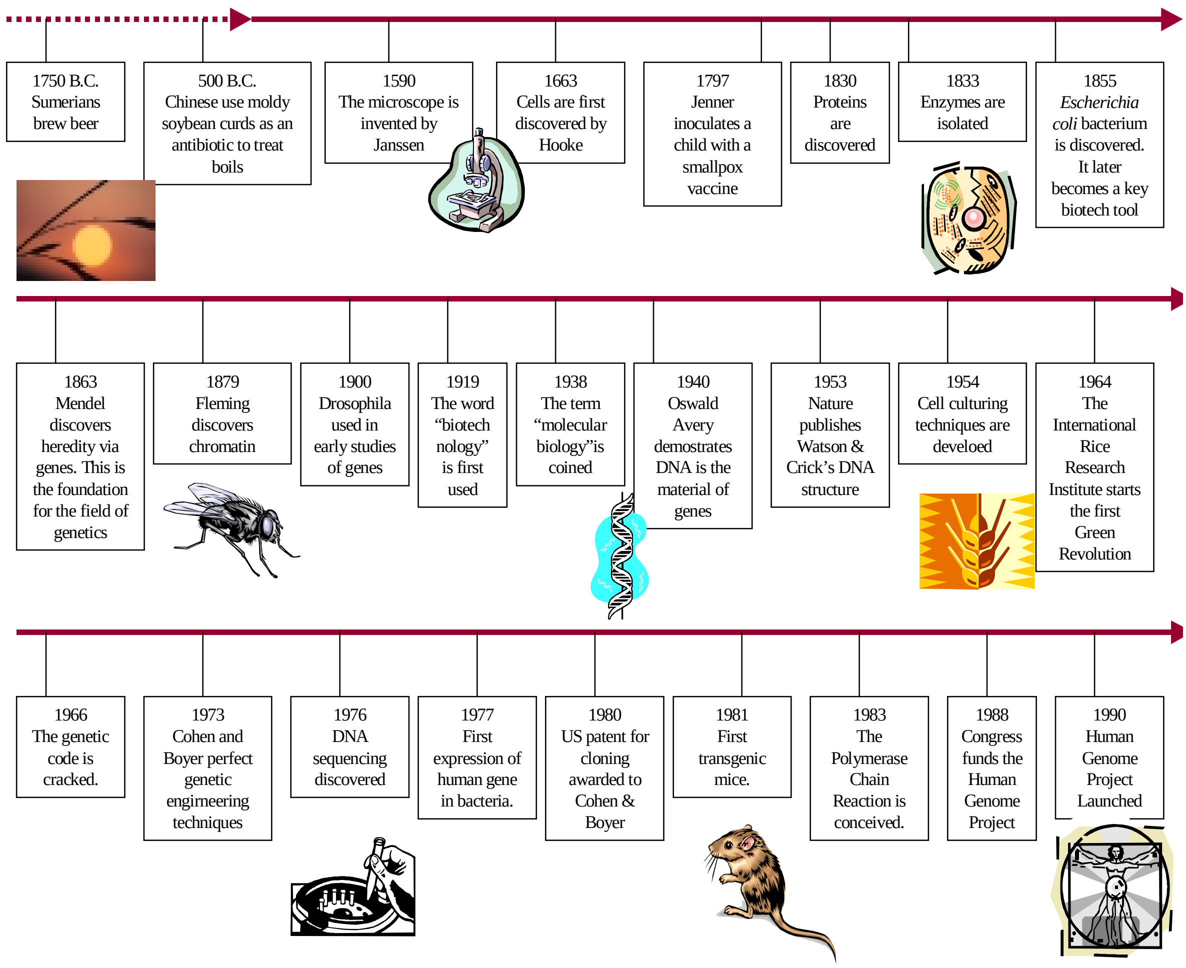


Figure 9: The evolution of molecular biology and biotechnology

3.2 Definition of Molecular Biology and Biotechnology

There are various definitions of molecular biology and biotechnology- varying in scope and specificity. In this report, the broadest definitions of both terms are adopted.

Molecular biology is defined as the knowledge and development of an understanding of the basic mechanisms of life at a molecular level. This encompasses disciplines such as cell biology, developmental biology, microbiology, plant sciences, biomedicine, physiology, genetic engineering and biochemistry.

Biotechnology refers to the use of various technologies (e.g. information technology) to develop applications for commercial or research reasons and use, based on the findings of molecular biology. Examples of subsets of biotechnology include but are not limited to, genomics, proteomics, fermentation, tissue engineering, gene therapy, and production of transgenic/gene targeted animals and plants.

3.3 Trends in Molecular Biology and Biotechnology

Efforts in the field of biology have always been concentrated on understanding the mechanisms of life and working towards the application of this understanding to improving the quality of life for humankind. In the past two decades, armed with the knowledge that DNA contains the code for life and aided by advances in information technology and engineering, molecular biology and biotechnology has made rapid advances in furthering humankind's understanding of life.

Today, the large body of knowledge available has reach a critical mass- enabling scientists to rapidly visualize applications of their discovery research. This has resulted in a growing integration between molecular biology and biotechnology and a seamless two-way flow of knowledge between discovery and application.

These interactions between the various fields of endeavor (e.g. cell biology, gene expression, structural biology, developmental biology, cell regulation, environmental science), enabling technologies[1] and potential applications and implications have resulted in:

- A move from data generation to data analysis
- A shift towards multidisciplinary research
- An increased reliance on automation and information technology for data generation, management and analysis.
- Growing preference for directed/target-specific approaches for development of novel therapeutics, vaccines, biomaterials, etc.
- A gravitation towards gene based approaches.

Examples of such trends are elaborated below. (e.g advances in genome sciences[2], gene therapy, cell culture)

[1] **Enabling Technologies**: This refers to the set of tools which enable scientists to carry out their research. These are rapidly evolving and involve substantial research and development in their own right.. Examples include microarray technology, information technologies, equipment development (e.g. high through put sequencers, bioprocessing facilities), etc.

[2] The **genome sciences** refers to the integration of various disciplines (e.g. bioinformatics, genomics, proteomics) that is driven by the vision of being able to unravel and understand the genetic make-up of entire organisms with the aim of being able to utilize this knowledge for the benefit of humankind and the environment.

Advances in the Genome Sciences

Internationally, there are large-scale ongoing efforts in the public and private sector to obtain the sequence of organisms of interest. However, it should be emphasized that the isolation of a DNA sequence is not the end goal. Rather the end goals are to identify its function; locate its role in biological pathways; and understand how it interacts with other molecules. As such, research efforts in the genome sciences requires expertise in multiple disciplines and the ability to integrate information generated from a range of sources into a coherent whole.

Simplistic View of the Genome Sciences and Associated Technologies

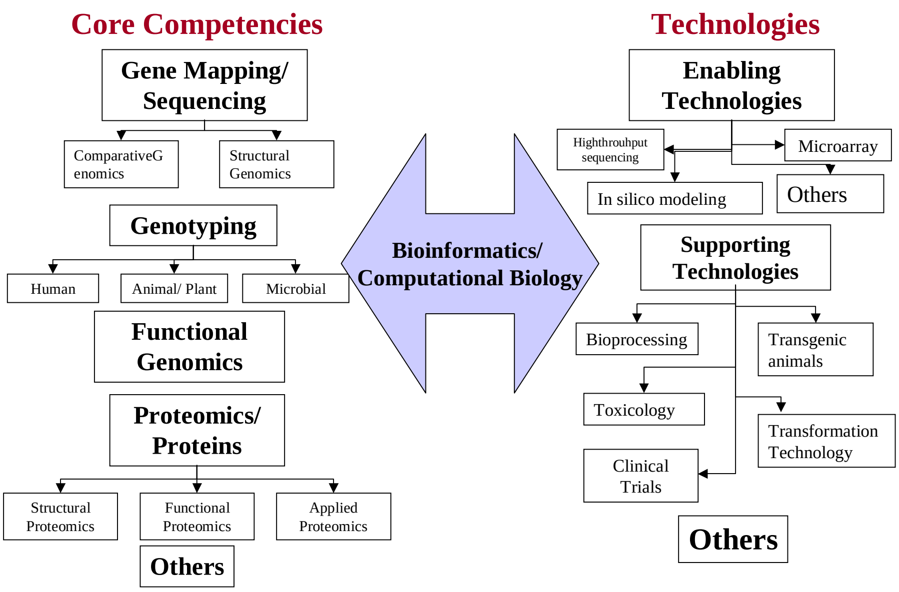


Figure 10: A simplistic view of the genome sciences

Further, the evolution from data generation to data analysis can be seen in the change in emphasis of research investments into genome sciences, with greater funds being invested in functional genomics, bioinformatics and proteomics.

Current Trends and Future Directions

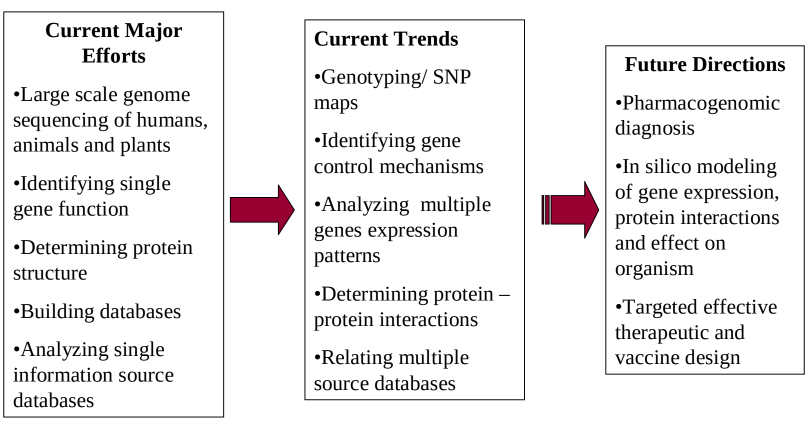


Figure 11: Current trends and future directions in genome sciences

Advances in Gene Therapy[3]

Gene therapy was first conceived in the late 1980s and tested in the early 1990s. Since the early 1990s, nearly 200 gene therapy clinical trials have been organized and submitted to the National Institutes of Health (NIH). While results were often disappointing, recent scientific breakthroughs in genomics and increased understanding of the important role of genes in diseases/conditions have increased interest and activity in the area of gene therapy as the ultimate method of therapeutic delivery. As such, gene therapy has changed from just being a therapy aimed at treating hereditary diseases to a potential treatment for diseases such as cancer, another approach for new vaccine development and a novel tool for biological studies.

With the number of genes with possible clinical applications growing rapidly, research has focused on addressing the limiting factors of a lack of effective gene expression vectors and delivery systems. In particular, efforts are being focused on targeting specific cells and on controlling expression of introduced genes. The approaches developed so far include:

- Novel viral vectors such as :
    - Retroviruses (e.g. HIV-related lentiviruses)
    - Adenoviruses and adeno-associated viruses
    - Herpes simplex viruses to target non-dividing cells
- Non-viral systems
    - Naked DNA conjugated with transferin-polylysine
    - Liposomal gene delivery
- Mechanical delivery means
    - Electroporation
    - Laser technology combined with direct injection of genes

Advances in Cell Culture

The ability to culture cells was a major tool for the advancement of molecular biology and biotechnology. Today, cell culture remains a key research tool and is a crucial stem in the development and production of therapeutics, diagnostics and vaccines. However, having perfected the culture of single cells, the hope of scientists today is to be able to culture whole organs.

Combining molecular biology, biotechnology, engineering and information technology, scientists are attempting to create new tissues/tissue replacements from cells. The approaches generally used include:

- The design and growth of the tissue outside the body for later implantation for repair/replacement of damaged/diseased tissue. This strategy has been in use for the past ten years for the generation of skin grafts.

[3] **Gene therapy** is the introduction of genetic material into cells for therapeutic purposes. This can be done *ex vivo* (i.e. cells are removed from the body before the genes are introduced) or *in vivo* (i.e. genes are introduced directly to the body).

- Implantation of devices stimulating cell growth to replace tissue or promote tissue regeneration. This could include the implantation of a biopolymer matrix to assist in formation of a three dimensional structure.
- The development of external or internal devices containing cells/tissues designed to replace the function of damaged/disease tissue. This may involve isolation of cells from the body, establishing the cells in a structural matrix and implantation of the system into the body. Examples of research being conducted in this area include the in vitro growth of blood vessels and the development of an artificial liver.

Another recent development is the ability to culture embryo stem cells. (Research in this area was hailed by the journal *Science* as the most significant breakthrough of 1999). The potential of human embryonic stem cells to generate all of the cell types present in a fetus holds great therapeutic potential and animal experiments to date have yielded promising results (e.g. regeneration of nerves cells from embryo stem cells induced to develop into immature nerve cells). However, much remains to be done in terms of basic research and in dealing with the ethical issues surrounding this area of work.

3.4 The Impact of Molecular Biology and Biotechnology

It is obvious that molecular biology and biotechnology have countless applications in the fields of medicine and human health, agriculture and food production and environmental protection and remediation. The question, thus, is not if these new technologies can make a major impact, it is where these new technologies can add the most value, in terms of speed, efficacy or cost, in comparison to other technologies.

In this light, it is necessary to first identify and define a priority list of the yet unmet needs of humankind and, then to identify means and strategies of meeting these needs from the point of discovery/fundamental and application research.

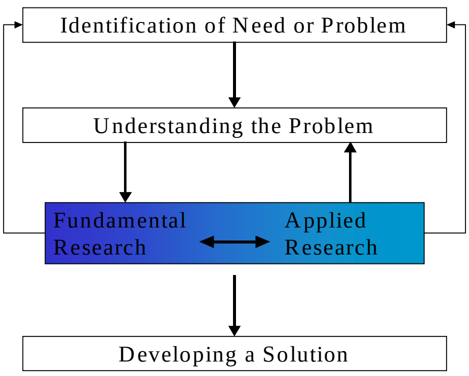


Figure 12: From Discovery to Solution

The following sections examine selected areas as examples to illustrate issues of concern.

3.4.1 Medicine and Human Health

Improvement of human health has always been a key focus of biological research. Today, molecular biology and biotechnology is being used to understand, treat and prevent disease. The major areas of research and development activities and the resultant applications can be roughly classified as:

- Therapeutics
- Development of vaccines
- Development of diagnostics
- Tissue engineering

The challenges here lie not only with the discovery and application of new technologies, but also with the effective implementation and dissemination of these new technologies in the region and the world. This refers, not to commercial large-scale production or manufacturing, but to the development and the proper use of these technologies in existing healthcare systems.

The Needs of the Region

The Asia Pacific region has been characterized in recent times by rapid economic growth and a financial and economic crisis in 1997-98 which was often accompanied by political turmoil. Economic and political realities will impact on health and the World Health Organization is cognisant of the fact that the region continues to be plagued by some important health problems which are going to place significant strains on the region's health infrastructure in the future. This includes the ongoing HIV/AIDS epidemic, the growing problem of TB, the persistence of malaria and dengue fever, the emergence of novel pathogens as well as a changing pattern of disease where chronic disease problems such as cardiovascular disease, mental illness, diabetes and cancer are becoming more important in the more affluent parts of the region. W.H.O. also has a major initiative against tobacco use which is the cause of health problems in several prominent countries of the region. The changing demography of an increasing proportion of aged individuals and continued abuse of the environment are other important concerns.

What are the health challenges for the region ?. An improved system of disease surveillance, better health education, promoting lifestyle and behavioural changes, effective environmental management, stronger commitment to research from national governments, and an increased capacity for medical and health research are some of the key challenges facing the region. Most importantly, these challenges need to be addressed through regional cooperative efforts involving national governments, international agencies, non-governmental organisations and regional scientific and health networks, such as the IMBN.

In order to help meet these challenges, and in line with the Organization's emphasis on the importance of research, the W.H.O. is very keen to develop linkages and partnerships with regional bodies and networks such as the IMBN in the organisation of various initiatives and activities which aim at education and strengthening of research capabilities in the region. The Organization is most interested in discussing with the IMBN the forms of collaboration which will help to achieve these aims.

-Dr Tikki Pang, Director RPC/EIP, World Health Organization

3.4.2 Food and Agriculture

In literature, farming is often described as " a fight against nature". Today, farmers have not only to contend with disease and weather, but also problems such as the loss of cropland to increasing industrialization, environmental damage, the increase in pesticide and herbicide resistant pests, decreasing availability of freshwater and climatic change. Overlying these problems is the pressure to feed an ever-increasing global population. Clearly, there is room and need for improvement in agricultural production.

The agri-industry can be roughly categorized into plant production, animal production and marine production/harvesting (fisheries and aquaculture). While each category has distinctive characteristics, the three areas are interdependent (e.g. the use of grain for animal feed) and linked by similar market demands, environmental concerns and technological gaps.

Molecular Biology and biotechnology can have an impact on:

a) Crop Production:

- Input traits such as pesticide resistance, herbicide resistance, drought resistance, etc.
- Output traits such as improved nutrient profile, higher yields
- Breeding

While molecular biology and biotechnology can and have been applied successfully, the challenges here are not only technical in nature. Scientists and industry will also have to consider long term impact to the environment and human health and the socio-economic impact of modified crops.

b) Livestock production

Improved feeding practices and bloodlines have significantly increased meat production over the last decades. However, the pace of industrialization has resulted in increasing animal production density resulting in higher chances of environmental damage, disease and zoonosis.

Molecular biology and biotechnology can be applied to:

- The prevention, rapid diagnosis and treatment of disease
- The alteration of gut flora/fauna and other microorganisms to reduce waste production and to increase the feed conversion ratio
- The alteration of microorganisms or crops as improved feed
- Breeding and preservation of germ plasm

c)Aquaculture

With declining wild stocks, aquaculture production will have to grow to meet the human food demands and animal feed requirements. While aquaculture has a long history and is a rapidly growing industry, key issues will have to be resolved if aquaculture is to be economically and environmentally sustainable in the long term. Issues include:

- Environmental damage (e.g. soil salinisation due to shrimp culture, reduction of mangrove and other marine ecosystems, pollution by net cage farms waste and antibiotic residues),
- A reliance on fish meal or trash fish in order to produce higher value food fish. This places additional strain on already stretched marine wild stocks
- The lack of detailed knowledge on fish and shellfish nutrition, reproduction, and disease management
- Economic and environmental viability and sustainability of industrial aquaculture.

Molecular Biology and Biotechnology can have an impact on:

- Disease diagnosis, prevention and treatment
- Improved and targeted breeding for desirable traits.

In the area of food processing and production, biotechnological techniques, in various forms and with varying levels of understanding, have a long history of use (e.g. fermentation for alcohol production and soy sauce production, selection of yeast strains for bread production). Today, equipped with better tools and greater understanding, molecular biology and biotechnology are being applied to:

- Yield improvement. For example, yeast strains are being manipulated to allow for greater production of enzymes.
- Production of food ingredients and additives. Engineered microorganisms offer an alternative production system to the traditional chemical synthesis of flavors, additives, etc.
- Development of novel, accurate and rapid diagnostic kits to monitor food safety. This aspect is becoming increasing important with the increased consumption and production of processed foods and with the greater distances over which food is transported.
- Development of novel biosensors to monitor food processing systems so as to minimize contamination and waste and to maximize yield. This could possibly impact the use of chemical additives and preservatives in food

In Asia and the Pacific Rim, it is obvious that molecular biology and biotechnology in farming and food production

3.4.3 Environment

The assault on the environment has not ceased since civilization began. Problems have accumulated and humankind has finally realized that environmental damage has to be stopped, environmental remediation initiated and new technologies developed for future problems. The problem lies in where and how to begin.

Internationally, governments are beginning to address the problems through policies aimed at areas such as the minimization/elimination of pollutive sources; encouragement of waste material recycling; establishment of wildlife reserves, and establishment of monitoring systems. However, for these policies to be successful, technologies have to be developed to address the diversity of problems around the world. These include the need for :

- Environmental remediation
- Biodegradation
- Biomass as a source of energy
- Examination of the linkages between environmental, human and animal health

Molecular biology and biotechnology could aid the process by :

- Identifying or engineering microorganisms or other organisms (e.g. plants) to either degrade or sequester pollutants in non-toxic forms
- Developing bioreactors to tap on biomass as an efficient energy source
- Conserving biodiversity through assisted reproduction, cloning (in extreme cases) or through genetic sequencing.
- Studying the effects of environmental pollution on human health and developing possible therapies

3.4.4 Impact on National and International Economy

For the large part of civilization, the global economy and national growth has tended to be driven by exploitation of natural resources (i.e. coal, oil, metal). Today, the emphasis has shifted to the exploitation of intellectual property and advanced technologies. From the examples listed in the preceding section, it is evident that molecular biology and biotechnology can have applications in a wide range of high value-added industry sectors from pharmaceutical to agriculture to environmental remediation. Indeed the " biotech" industry that has developed over the last two decades to service these sectors is, in itself, a highly capitalized, high value added industry.

	1998	1997	% Growth
Number of companies	1,283	1,274	1%
Number of employees	153,000	140,000	9%
R & D Expenses	US $9.9 billion	US $8.5 billion	16%
Product Sales	US$13.4 billion	US$ 11.5 billion	17%
Revenues	US $18.6 billion	US $16.1 billion	16%
Market Capitalization	US$ 97 billion	$93 billion	4%
Net Loss	US $5.1 billion	US$ 5.4 billion	5%

Figure 13: 1998 US Biotechnology Industry Statistics (13)

Spurred by the rapid growth and immense economic potential of molecular biology and biotechnology, federal and state governments around the world, have identified molecular biology and biotechnology as a key area for development. Many of these governments have launched a range of initiatives to encourage development of scientific excellence and to attract investments. These include, but are not limited to, research grants, tax incentives, training support, subsidized land and loan guarantees.

In Asia and the Pacific Rim, China, Japan, Korea, Malaysia, and Singapore have already developed "Biotechnology Blueprints" and have invested heavily into molecular biology and biotechnology.. Other economies in the region have also launched a range of initiatives aimed at building up capabilities in the biological sciences, healthcare and agriculture. Comparing these initiatives, it becomes clear that governments are interested not only in attracting investments but also in developing indigenous high tech start-ups.

The reasons behind this are clear. In Asia and the Pacific Rim, the majority of the economies are still in the midst of socio-economic transition and transformation. The short term and long terms needs of a large population has to be addressed, not only in terms of economic growth, but also in terms health, education, food and maintenance/remediation of the environment. Examples of the potential of molecular biology and biotechnology to meet these challenges include:

i. Lowering the cost of healthcare through the development of effective vaccines and novel low cost drugs
ii. Increasing farming productivity and thereby decreasing the need for further deforestation and damage to the environment
iii. Preserving the environment for future generation

On the flip side, it is unclear if the full ramifications of molecular biology and biotechnology on an economy have been considered. For example, what is the impact of an microorganism able to produce palm oil? What would this mean for Malaysia's and Indonesia plantation industry. What does the current controversy over genetically modified crops mean for Asian farmers? While it may ensure food security for present and future generations, would wavering consumer support stop usage of these crops by farmers?

Furthermore, realizing that cultures differ among economies and acknowledging the existence of ethical issues and concerns surrounding research, development and application of molecular biology and biotechnology, there is also a need to consider the social ramifications of these new technologies. The benefits of informed open objective public discussion on such matters should be recognized and acted upon by policy makers, industry and academia. The cost of not addressing these potentially sensitive issues would be high as the public is naturally wary of new technologies, especially those which it does not understand and is not familiar with. This lack of knowledge combined with misinformation and compounded by an unwillingness to discuss and address ethical and social issues poses a real risk in the development of science.

Considerations of this kind also need to be addressed if an economy is to benefit from molecular biology and biotechnology.

The Establishment of Biotech Start-Ups

Germany

Until the late 1990s, the biotech industry in Germany was struggling. However, by April 1999, Germany was host to 225 companies as compared to 270 companies in the United Kingdom and 140 companies in France. This boom has been largely credited to a government program known as BioRegio which funneled government money into selected regions to support biotech companies. An example of the program's success can be seen in Munich where over 30 biotech companies started operations since the establishment of incubator support/management company, BioM, in 1997. Initiatives which catalyzed this growth included:

- A 1+2+2 financial support scheme. In this scheme, if a start-up manages to attract one million from venture capital firms, it is then eligible to attract another 2 million in long term loans from federal or state-linked banks and it can also attract another 2 million in the form of grants.
- A government scheme offering to reimburse 50% of a venture capitalist's investment if a start-up company fails. This was key to attracted venture capital to the region.
- The establishment of incubator facilties
- The ability to rent office and lab space on very short term leases for spin-offs

Australia

In Australia, most biotech start-ups originate from academic investigators. However, in most public and private institutions in Australia, IPR generated by employees belong to the institution and not the individual. Further, all government agencies and most companies do not allow employees to benefit directly from commercial income or to hold equity in spin-off companies although bonus schemes may be in place. In contrast, most non-government research institutions and universities have a royalty distribution scheme to individual inventors in which inventors share about 30% of the commercial proceeds from an invention. Additional rewards often also include a component of the institutional share of income being assigned to the research activities of the inventor. Yet, staff promotion and recognition for commercial activities is highly variable and in academia, these considerations are usually secondary to primary academic publication record. Government support for entrepreneurs include:

- Innovation Investment Fund which provides $2 for every $1 provided by licensed venture capital funds
- Pooled Development Funds Program which support companies investing in Australian start-ups
- R & D Start program (A$700million over 4 years) which funds R D projets of up to 50% costs for companies with <A$50m turnover

However, there are still insufficient technology incubators and integrated biotechnology clusters that would help the rapid growth of start-ups.

Chinese Taipei

In Chinese Taipei, the government owns the patent for intellectual property developed in government funded institutions. Any royalty payment is then shared between the investigator (40%), the institution (10%) and the government. To incentivise the establishment of spin-offs, financial awards are given to investigators who spin-off companies or license products to industry. Furthermore, research projects by entrepreneurs are eligible for R & D support of up to 66-75% of their research budget.

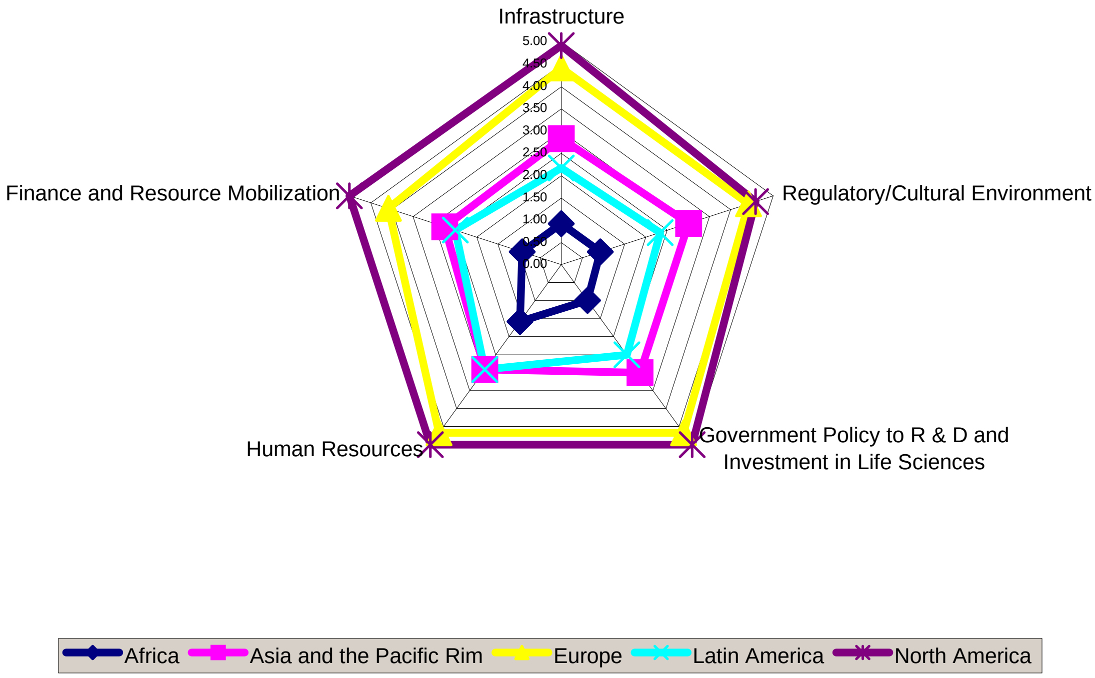
Chapter 4. Understanding the Critical Success Factors for Molecular Biology and Biotechnology Development

The critical success factors for the development of molecular biology and biotechnology can be broadly classified into five categories, namely:

1. Infrastructure Development
2. Regulatory/Cultural Environment
3. Policy Development
4. Human Resource Development
5. Finance and Resource Mobilization

When considering these factors, an integrative view is crucial. The impact of policies, regulations and priorities should be considered at the regional, national and institutional level. Furthermore, given the application of molecular biology and biotechnology in a range of sectors, it is crucial that policies should not be examined or developed solely for the promotion of a particular activity or sector.

Infrastructure for Science in Various Regions of the World



<u>Figure 14. Results of Opinion Survey conducted by Asia-Pacific IMBN Secretariat from August-December 1999.</u>

20 leading experts from around the region were invited to share their perception of scientific development in the region. The results are based on inputs from 12 of these experts. Australia (3), Chinese Taipei (1), Japan (3), Korea (1), Philippines (3), Singapore (1)]

4.2 Issues, Concerns and Opportunities

4.2.1 Building the Region's Infrastructure for Science and Technology

Regional infrastructure for molecular biology and biotechnology can be examined from two angles- physical and scientific.

Physical Infrastructure

A reliable and well-maintained physical infrastructure (power supply, transportation networks, telecommunication networks) is a basic requirement for economic growth, science and technology development and for application of research findings.

In addition to the large-scale public infrastructure, the development and management of industrial parks and incubator facilities by public and private entities are also important factors in increasing the rate of development of excellence in science and the application of scientific discoveries. While clustering high tech activities would help to minimize costs in terms of common facilities and to promote interaction amongst scientists, it is important to remember the basic rules of estate management and market demand so as to avoid the proliferation of "white elephants".

Science Parks in Singapore

The Singapore government has stated and committed to a vision of Singapore as a knowledge-based economy. Further, the life sciences industry has been identified as a future economic growth engine. As such, the government has invested heavily in the establishment of core centers of excellence and science parks. Initiatives include:

- The establishment of a science hub that is formed around the National University of Singapore, key research institutes and two science parks with facilities for high-tech companies.
- The Bioprocessing Technology Center Incubator Unit. This is currently being expanded to encompass pilot bioprocessing facilities and additional incubator units for start-ups.
- A 70ha Pharma Zone for the establishment of pharmaceutical and biotech manufacturing operations. The Zone has common facilities and support such as waste treatment and fire-fighting systems.
- A 10ha Agribiotechnology Park with common facilities (e.g. incineration, diagnostic labs, auditorium) being provided by the Primary Production Department, the key regulatory agency for food and agricultural issues.

Science Parks in South Korea

In 1993, the Korean government initiated an ambitious 14 year-plan to promote biotechnology, the National Biotechnology Development Program (also called "Biotech 2000" Program), which aims to bring Korean scientific and technological capabilities of biotechnology to competitive levels of the world's leading countries, and also to accelerate technological transfer of biotechnology research to commercial applications**.** The total sum of the in vestment for the planned 14 year period is US$ 20 billion.

As part of this plan, the need to establish a nationwide foundation for biotechnological development was identified. As a result, the government initiated the establishment of "BioTechno-Belt" through identifying 5 different regional sectors in Korea with specialized R&D fields. Among these, the Daeduck Science Town (*The largest science park in Korea, it is modeled after the Research Triangle Park of North Carolina and plays host to most of the government and industry research institute.*) was selected to play the key role in the "Bio Techno-Belt", due to its central location in Korea and to the relatively abundant biotechnology-related manpower. Within the park, the Korea Research Institute of Bioscience and Biotechnology(KRIBB) was selected to play the major leading role in organizing the R&D activities of the "Belt". In addition, the Korean government is actively encouraging local governments to establish science parks. For example, the City of Pohang, Pohang Iron and Steel Company and Pohang University of Science and Technology formed a consortium to establish Pohang Science Park.

Scientific Infrastructure

The construction of research buildings is often seen as a key step to developing scientific and technological excellence. While the need for modern buildings still exists, it is becoming increasingly evident that the need for individual research facilities is not as pressing as the need for access to powerful and reliable information and communication networks, and the need to coordinate and maximize utilization of equipment and other research facilities. This holds true at institutional, national and international levels.

In modern biological laboratories, aside from space and basic equipment, central facilities for work such as large-scale sequencing, genomics, bioinformatics, development of transgenic animals, electron microscopy, peptide and oligonucleotide synthesis, mass spectrometry, and x-ray crystallography, are required. Scientists working in areas with possible biomedical applications should have ready access to collaborations with medical facilities. Similarly, access to land for field tests, together with the guidelines for use, should be available. Yet, it is questionable if all such facilities should be established within an institution or even an economy if there usage is low.

4.2.2 Regulations , Culture and Policy Development

National policies and regulations form the platform and environment for the development of excellence in molecular biology and biotechnology. The approach and aims of the governments and policy makers in developing internal legislation/regulatory systems and in participating in international fora and agreements play a large part in determining if an economy will be able to benefit from these new technologies.

It is essential that all aspects of national policies (e.g. research guidelines, drug regulations, investment and trade guidelines) are developed upon a solid and reliable knowledge of the subject matter and are consistent in encouraging investment in, exploitation of and application of research. Furthermore, as most discoveries would have be of international impact and application, international and regional approaches must also be examined.

On the other hand, given the rate of scientific advancement, regulations should also evolve rapidly to respond to and meet the needs and concerns of public, animal and environmental safety in the near and long term. Today, biosafety, ethics and clinical trial practices are under scrutiny by policy makers eager to ensure public safety, by industry who are eager to secure consumer confidence and larger markets and by consumers who have faced one health/food/ environmental scare too many.

Aside from macro-level legislation, guidelines and policies, scientific policy also refers to the governance and management of research and researchers at institutional and national levels. Science is driven by the knowledge and capabilities of all whom are involved in research from research team leaders to students and technicians.As such, scientific policy must deal with the management and development of human resources at all levels. It includes, but is not limited to, the systems for:

- Allocation of funding
- Development and maintenance of high research standards (e.g. peer review)
- Review and assessment for promotion of scientists
- Scientific career development
- Recruitment and development of scientists and technical staff.

The challenges in developing an efficient, efficacious and responsive scientific infrastructure include:

- The need to balance between ensuring career stability and preventing stagnation
- The need for a transparent, independent and objective research review committee that is able to ensure consistent research standards while being responsive to the varied nature of research proposals
- The need to encourage individual investigator driven research while ensuring coordination and collaboration so as to minimize areas of overlap and/or omission.
- The difficulties in attracting, developing and retaining scientists
- The requirement to forecast and determine research priorities

Thailand's Two Prong Approach to GMOs

Although there is widespread recognition that molecular biology and biotechnology has great potential in improving agricultural output, increasing nutritional content and reducing use of chemicals, the use of genetically modified organisms (GMOs) in agriculture and food production is one of the most contentious issues in the world today. This stems from the potential impact on world trade and increasing consumer sensitivity to food and environmental issues. Industry has already invested heavily in the development and marketing of GMOs and while they have had successes in terms of growing farmer acceptance of GMOs (e.g. 1998 global area of transgenic farms was 27.8 million hectares and global market revenue for transgenic crops was US$1.5 billion), consumers worldwide are growing increasingly wary of GMOs.

In Asia, consumer acceptance is patchy and regulations of GMOs vary across the region. However, events in late 1999 in Thailand, a leading agricultural exporter, are an indication of the need for greater public education and communication, policy development and research.

In late 1999, Thailand announced a series of guidelines and initiatives which meant that transgenic crops would not be allowed to be grown on a commercial scale until there was concrete evidence that the new organisms were safe for human consumption and the environment. With this, Thailand committed itself as an organic/GM-free producer nation. Further, the Thai Department of Medical Sciences embarked on the establishment of a laboratory to test processed foods for GMO-free certification.

At the consumer level, while it was reported that there were low levels of understanding of GMOs and biotechnology, 20 consumer groups formed a confederation opposing the use of GMOs and GMO-derived products. Yet simultaneously, Thailand will continue to invest in GMO research.

Source: (14)

The Balance between Discovery and Strategic Research

Research is the quest for the understanding. Given the complexity of biological processes, it is extremely difficult to determine which areas of discovery research would have the most socio-economic impact. Furthermore, the creativity and diversity of non-directed research has been the source of most discoveries of note in the past. However, given limited financial and human resources and clear human and environmental needs, prioritization has become and is a prerequisite.

Economies will need to decide not only on whether and how much to invest in research, but also on the allocation of funding between discovery and strategic (i.e priority driven/directed) research and on the areas of institutional, national and international need and interest.

The New Approach to Research and Development

Traditionally, R & D activities have been arbitrarily classified as basic research and applied research. Basic research was associated with academic settings and was focused on furthering understanding of the mechanisms of life. In contrast, applied research was associated with industry and was perceived to be focused on development of technology for commercialization. There was often a sharp distinction between the two approaches and research organizations were often deemed to be either basic or applied institutes.

Today, these approaches and distinctions may no longer be valid or appropriate given the greater understanding of the mechanisms of life, a growing need for multi-disciplinary capabilities and the increasing acknowledgement of the enormous potential of molecular biology and biotechnology to contribute to solving key global socio-economic problems. Rather than the differentiation between basic and applied, there is a growing trend towards either a **discovery based approach** or a **strategic approach** to R & D.

The discovery based approach focuses on developing in-depth understanding of the mechanisms of life. There is no particular focus or identification of an end goal. Findings with potential social or commercial application are made by chance rather than deliberate design. In contrast, the strategic approach to R & D requires the pre-identification of an end-goal and the determination of strategies and milestones needed to achieve that goal. It should be emphasized that discovery and priority driven research require both basic and applied research capabilities and technologies. However, the proportion of basic versus applied skills may differ between the two approaches. Specifically, the proportions of basic to applied is usually lower in the strategic approach due to the focus on development of social/economic applications of findings.

Both approaches are equally valid particularly considering that a large proportion of major discoveries have been made by chance. However, in economies where economic growth is of high priority and/or there are pressing social, health, agricultural or environmental problems, a strategic approach to R & D may be more advisable.

Linking Scientists and Institutions- The Advantages of and Mechanisms for Cooperation

As mentioned previously, the problems facing humankind today are multi-factorial in nature. Recognizing this, it is not surprising that multi-disciplinary groups and research teams would be advantageous in the quest to understand the science behind the problems and to translate discoveries into viable applications/solutions.

Taking into consideration the issues raised previously, the formation of linkages between scientists and institutions at the national and international level would facilitate the process of maximizing utilization of physical infrastructure and addressing the need for insightful prioritization of research. Furthermore, the formation of linkages between researchers and research organizations should not be limited to public institutions, the mechanisms of collaboration and cooperation with industry groups should also be explored.

The Economic Impact of Star Scientists

Scientific research revolves around the formulation and testing of theories. In terms of outputs, scientific research contributes to both the sum total of humankind's knowledge and to technological innovation. In any technology based industry, early and easy access to scientific discoveries is key to continual growth and survival of companies. Furthermore, the very nature of new scientific discoveries/applications mean that knowledge or know-how is often embodied in a few key personnel and not easily transferred.

In the areas of molecular biology and biotechnology, the link between scientific research and commercial applications/value is strong and the lag-time from scientific discovery to commercialization is decreasing. In studies by Zucker and l Darby on the biotech industry, it was shown that the very best "star" scientists play central roles in the development of the science and its successful commercialization. Furthermore, their findings supported a "geographically localized knowledge spillover" model which suggests that the companies go to the scientists rather than the other way around.

The same study also seem to show the increased productivity of scientists, in terms of paper publications and citation rates, who are involved in commercial collaborations. In a study focused on Japan alone, Zucker and Darby found that collaborations between start scientists and firms increased the average firm's biotech patents by 34%, products in development by 27% and products on the market by 8% as of 1989-1990.

Considering the above and the region's aim of moving towards knowledge-based economies and industries, committing resources into attracting, nurturing and retaining key scientists would be wise investments for the economies of Asia and the Pacific Rim.

Source: (15)

4.2.4 Human Resource Development

The Importance of Education and Capacity-Building

There is insufficient basic education in the concepts of modern biology and implications of this lack should be understood at all levels. The gravity of the situation should be taken seriously, especially when one takes into account the dynamic nature of this field and the speed at which new discoveries and technologies are being discovered around the world. Delays in educating the young pose a serious threat to future development of any society.

The 21st century will certainly be dominated by society which is technology intensive – natural resources will be less dominant – human capital will be critical for any knowledge-based economy . It is important, to reach prosperity, that our economies increase investment in education and that someone should take a leading role in defining the ways in which knowledge-based societies can be fostered.

Investment in education also has major impact in shaping the social profile of societies. It is obvious that developments in science and technology will have a major impact in lives of all people and scientific and technological literacy will be increasingly essential for normal functioning. The future citizen's need for scientific literacy will only increase with time. As such, investment in education is the most cost-effective investment that any society can make. However, there is high heterogeneity amongst economies with regards to national capacity to develop and promote science and technology as subjects in school.

For example, it is important to set ambitious goals in educating students at the undergraduate and graduate levels to become leaders and propagators of biotechnology. As such, academia has a special responsibility for promoting science education. Universities could (and probably should) devote effort into the development of science and technology capabilities in their respective countries. Researchers should also be involved in writing and developing teaching materials.

In addition to the development and promotion of science education, it is also necessary to examine the structure of the curriculum, especially at the tertiary level, to equip students for the move towards multi-disciplinary research and the increasing number of linkages between academia and industry. The understanding of research management, intellectual property management and commercialization processes and issues will equip students not only for an academic career but also for a career in industry and government.

The Israeli Experience in Shaping Education

During the 1960's, leading scientists in physics, biology and mathematics in Israel, in collaboration with the Ministry of Education, established a collaborative framework for the promotion of science education known as the "Center of Science Education". This government- funded organization is involved in a variety of academic and applied activities promoting science education for K-12 graders. These activities include the development and production of teaching materials, participation in and leadership of national curriculum commissions, teaching training (pre-service and in-service), and research activity in science education. The capacity of the "Center for Science Education" to be at the cutting edge of this field was also very instrumental in the introduction of changes in the system, which are essential in this rapidly evolving field.

In 1992, the Ministry of Education appointed a commission, headed by the President of the Weizmann Institute, Prof. Haim Harari, to examine the state of science and technology education, define the future goals, and recommend how these goals can be achieved. The commission made specific recommendations in a variety of topics, including:

i. The strengthening of the mathematical literacy and capabilities of all students, starting with the elementary school level
ii. Joining science and technology education in elementary and junior high school levels (grades 1-9), rather than separating the two disciplines. (This is especially suitable in this period when science and technology are so closely inter-related).
iii. It was emphasized by the committee that it is mandatory not to train just the future scientist or technologist but, also the future citizen whose life will be strongly affected by modern science and technology.

The implementation of these and many more recommendations was approved by the Israeli government in 1993, significantly increasing the budgets allocated for science and technology education and is currently widely applied.

-by Dr Benjamin Geiger, The Weizmann Institute of Sciences, Rehovot, Israel

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4.2.5 Funding Technological Innovation

Research is a long-term capital-intensive activity that should not be subject to the vagaries of changes in government administration. Governments have to recognize and acknowledge the need for stable incremental funding for research. In addition, governments have to develop quality driven, user-friendly, transparent and objective means for fund administration.

The development of funding policies and budgets should also keep in mind:

- The need for balance between fundamental and priority driven research,
- The need to attract, develop and retain scientists,
- The need to encourage application of research findings and
- The socio-economic costs and changes of research findings and applications.

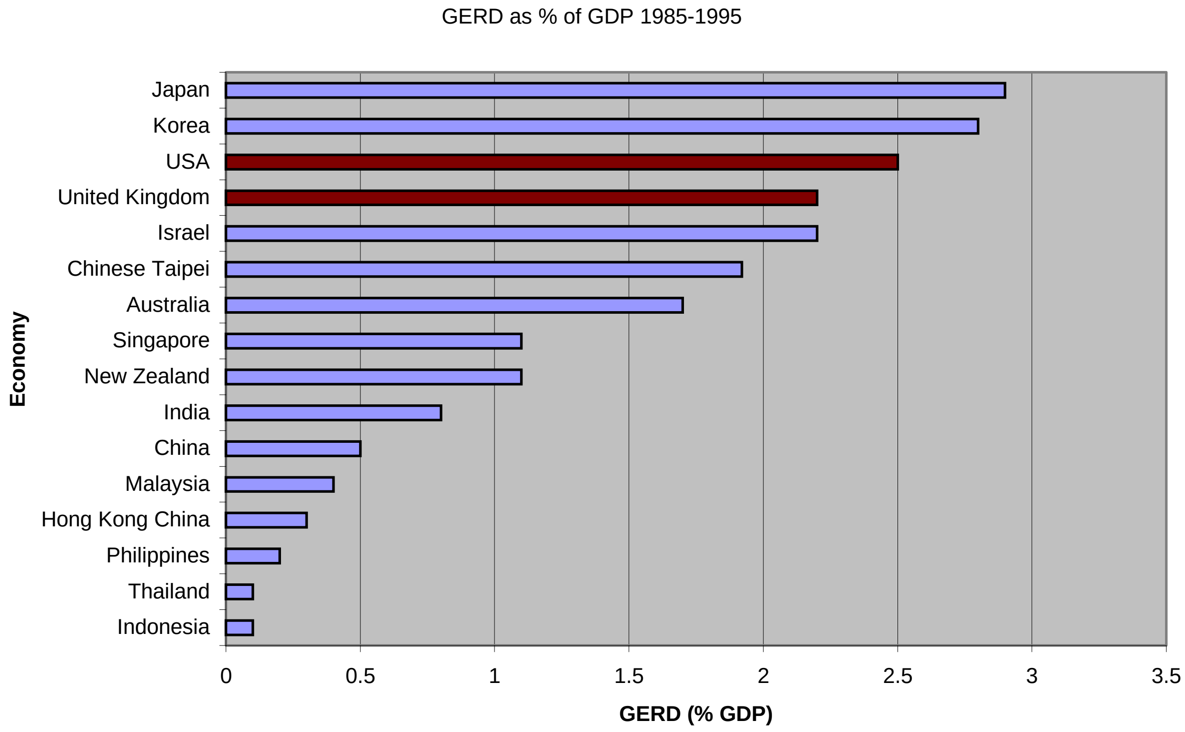

Figure 15: Gross Expenditure on Research and Development as a % of Gross Domestic Product in Economies (16)

Supporting Science and Technology in USA

USA is well recognized as a global leader in science and technology. US science and technology (S & T) policymaking and support of research and development (R & D) is characterized by pluralism in priority-setting, funding and conduct of R & D. While the federal government supports about 40% of the nations R & D activities and provides direct and indirect S & T direction, there is not central funding department. Another unique feature of the US federal funding for R & D is that almost 76% of federally funded R & D is not performed in government laboratories or facilities but extramurally via grants and contracts. This is one of the key operating principles-that the government is able to "buy" the best performer for its R & D funds and infrastructure development funds.

With regards to molecular biology and biotechnology, in addition to a large receptive venture capital market, there are specific initiatives to support R & D, commercialization and application at the federal and state level. At the state level, almost every state has molecular biology and biotechnology specific incentives in an effort to attract high-tech jobs. Examples include:

- *California*
  - **Sales Tax Savings**: California has a 6% sales tax (local sales tax can add up to 2.5% more) but exempts biotechnology and other qualified companies from this tax.
  - **Local programs**: Vacaville and Solano Country: -Local municipalities will abate property taxes for new biotechnology construction and may offer construction fee waivers and subsidies on land use tax.
- *Maryland*
  - **Employee Training:** Partnership for Workforce Quality provides 50/50 matching grants for companies involved in biotechnology manufacturing for reimbursement of employee training costs. The University of Maryland's School of Engineering offers up to one week of no-cost consulting service to assist in solving bioprocessing and other manufacturing problems
  - **Favorable utility pricing**: Maryland life science firms are eligible to received 5% discount on their gas and electric bills

Source: 17)

4.2.6 Dealing with the Ramifications of Scientific Endeavor

Socio-economic impact

The unknown or misunderstood is usually feared. Today's public is bombarded with information from television, newspapers, and the internet. When it comes to science, conflicting reports, sometimes within days of each other, generate confusion and mistrust for new ideas and technologies. Compounded with the under-studied socio-economic impact of new technologies, the public is understandably reluctant to accept new technologies and products.

Scientific research is still largely funded by the public in the belief of the worthiness of the pursuit of knowledge and in the hope of future benefits to humankind. It is essential that scientists recognize and assume the responsibility of communicating the implications, significance and benefits of research to the community at all levels.

While potentially time-consuming, this activity benefits all parties-scientists, industry, government and the lay public. The effort spent communicating objective and accurate information about scientific research would

Conclusion

The 21st century promises to be the best ever for humankind as new advances in technology, and growing awareness and understanding of nature will enable us to harness it for sustainable growth and development.

If the Asia-Pacific region is to be a significant player in future developments in the field, it needs to start working today to build the science and technology information base and the infrastructure which will fuel the revolution.

Chapter Five: The Vision for Asia Pacific IMBN

Growth will not come from one or another area of focus or study, but from the novel and exciting use of new skills, capabilities and technologies in new and exciting ways. The future belongs to those who have the vision and the courage to peer across the artificial boundaries of different disciplines to find ways to work with colleagues in all fields of endeavor to find solutions to the problems which exist.

There is much that has been achieved – but we have only begun to glimpse the potential of developments in science and technology to contribute to human and ecological well-being around the world. Asia-Pacific IMBN can play a critical and important role in making this happen.

5.1 Vision of Asia Pacific IMBN's Role

Despite the fact that science is largely an international endeavor and that industry is often driven by multinational companies, development of science and technology is still promoted largely by national and regional frameworks such as the National Institutes of Health (NIH), National Science Foundation (NSF), and Centre National de la Researche Scientifique (CNRS). In Europe, in an effort to enhance scientific capabilities and to establish a critical mass of scientists, organizations such as the European Molecular Biology Organization (EMBO) and the European Science Foundation (ESF) were established.

Similar to Europe, where a greater coordination between economies in the development of science and technology had discernable impact, Asia and the Pacific Rim could also benefit from cooperation between the various economies.

The vision is that Asia Pacific IMBN will act as a change leader, a catalyst and a facilitator. It will identify and act on the levers of power to effect change necessary to the development of molecular biology and biotechnology in Asia and the Pacific Region. At the same time, the Network will promote science as an international integrated endeavour, paving the road for laboratories and institutions in the region to the international scientific and biotechnological arena.

In view of the central role of science and technology in society, it would be imperative that modern biology will be attentive to the needs of society and that the Network will communicate with policy-makers at various levels, including the leading scientists, the relevant government officials, the leaders of international scientific organizations, the general public, various funding sources, industry and so on. The regional potential and needs include future governmental support to Asia-Pacific IMBN, special attention to the unique potential and weakness of science and technology in the region and understanding of the special needs of the economies in Asia and the Pacific Rim.

Asia-Pacific IMBN should be exclusive in terms of identifying only the best to be its members, while being inclusive in its targets and activites and in encouraging all who wish to be involved in the development of molecular biology and biotechnology to be proactive in working with Asia-Pacific IMBN.

Individuals who wish to contribute to the development of molecular biology and biotechnology in the region will be welcome to participate actively in the work of Asia-Pacific IMBN regardless of their national origin or level of scientific achievement. The promotion of professional training and education is one of the central goals and everybody is invited to participate in instruction and learning. The Asia-Pacific IMBN welcomes the active participation of all individuals in its various programs.

5.2 Action Plan for Achieving the Vision

Realizing the vision of Asia-Pacific IMBN will require concerted effort on the part of Asia-Pacific IMBN and its strategic partners in academia, industry and government who are committed to working with Asia-Pacific IMBN to realize its goals and objectives.

This section will carry the process of translating Asia-Pacific IMBN's consensus vision forward by defining specific goals and objectives for strengthening and developing areas of interest and concern, identifying the action steps that will need to be undertaken to ensure that the necessary infrastructure, core competencies and capabilities are built up, and then identifying the specific actions or tasks which will need to be undertake.

The action plan will, of course, define clear timelines and identify milestones in the realization of Asia-Pacific IMBN's mission, as well as characterize the expected outcomes and measures of performance which will need to be built into Asia-Pacific IMBN's programs and activities to ensure that they are consistently effective and of high impact and responsiveness to the changing priorities, concerns and needs for molecular biology and biotechnology development in the various participating economies of Asia-Pacific IMBN.

While working towards the goal of promoting the development of molecular biology and biotechnology in Asia and the Pacific Rim, the Network will hold to its aims, guiding principles and functions, as stated in Chapter One, Section 1.4.

5.2.1 The Network's Activities

In fulfilling the aforementioned aims and functions, in the spirit of the guiding principles, the Network shall engage in a range of activities including:

- holding meetings and arranging lectures, training courses, workshops, seminars, symposia and conferences;
- undertaking studies and other projects on behalf of or in collaboration with other organizations and institutions;
- publishing and disseminating books, periodicals, reports and research and working papers through print and electronic media;
- establishing and maintaining contact with individuals and institutions with expertise in relevant fields through collaborative research, seminars, exchange visits, sabbatical attachments and likewise;

- maintaining offices, laboratories, information resources, and other facilities as may be necessary for its proper functioning; and
- taking such other actions as may further the aims and objectives of the Network.

The Network's programs and plans shall be reviewed and approved by its Governing Council taking into account the needs of developing and developed economies and the Network's capacities in meeting these needs.

5.2.2 The Way Forward

The Action Plan will be based on the completion and release of the reports of both the Asia-Pacific IMBN Strategic Vision Commission and the Priority Needs Commission. These commissions will aid in the identification of strengths of economies at the national and institutional level and will advise on areas which require enhancement and modification. The findings of these commissions, especially that of the Priority Needs Commission, will be the foundation for future activities. It should be noted that the work of the two Commissions are considered to be complete upon publication of the final reports. New Commissions/ Taskforces will be required to implement the recommendations of the Commissions.

Consideration of the Action Plan will be in line with the analytical framework to be used in the Priority Needs Commission analysis and used in surveys conducted by Asia-Pacific IMBN. This Conceptual framework considers challenges, issues and opportunities in molecular biology and biotechnology in terms of:

- Infrastructure and Institutions
- Policy and Regulatory Environment
- Human Resource Development Considerations
- Finance and Resource Mobilization Considerations

5.2.3.i Infrastructure and Institutions

Objective:

- To enable Asia-Pacific economies to recognize the prerequisites for success in the life sciences, and to encourage investment in the development and strengthening of the basic physical infrastructure, technical resources and facilities, academic and education institutions, centers, science parks and industrial organizations which would facilitate molecular biology and biotechnology development in the region

Activities

- Upon identification of strengths and weaknesses at national and institutional level, the formation of national taskforces would be recommended. These groups would interact with policy makers and industry to encourage investment in the necessary infrastructure and institutions.

- On a regional level, these groups would interact to coordinate access and sharing of existing facilities around the region; identify the need for central facilities for the region; encourage policy makers at a regional level to invest in such facilities so as to facilitate molecular biology and biotechnology in the region. The existing working group on the establishment of Asia-Pacific IMBN Laboratories, interacting with the Program Committee, can take the lead in this. Specific activities would include:
    - Development of systems and guidelines for sharing of existing facilities
    - Development of regional professional training programs to facilitate establishment of institutions at the national and regional level
    - Development of guidelines for the establishment of Asia-Pacific IMBN Laboratories (a central facility and/or a network of centers)
        - Terms of reference for host institutions/economies
        - Guidelines for selection of priority research facilities and/or areas
        - Terms of reference for scientists in such facilities

5.2.3.ii Policy, Regulatory and Cultural Environment

Objective:

- To encourage the development of forward looking governmental and industry policies aimed at ensuring an intellectually stimulating environment in support of research and development in the life sciences.

Activities:

- Asia-Pacific IMBN and its members at the national and regional level, should actively engage policy-makers in government and industry in a dialogue aimed at facilitating the development of national policies and guidelines, etc. A regularly updated report on national and regional policies affecting molecular biology and biotechnology development should be developed along with a directory of key policy makers in the region.

Objectives:

- To encourage the establishment of regulatory and cultural environments in the Asia-Pacific region which facilitate responsible molecular biology and biotechnology development

Activities

- In line with growing global awareness and understanding of the need for more sophisticated tools and approaches to minimizing risks to human and ecological health and well-being, Asia-Pacific IMBN should take a more active role in helping to safeguard the interests and concerns of the public and in ensuring that every effort is taken by policy-makers and regulators in the interest of biosafety.

Specifically, a Asia-Pacific IMBN Commission may be established to benchmark the best practices in the region and around the world.

- A directory of Asia-Pacific IMBN members who are knowledgeable in this area and who are interested to serve as advisors to regional consumer groups, policy makers, and research organizations should be compiled and disseminated. This group of experts would also be national and regional spokespersons for Asia-Pacific IMBN on matters related to biosafety, ethical issues and regulatory guidelines via publication of opinion papers, and participation at regional and international for a.

Objective

- Encouragement of Support for Innovation and Entrepreneurship in the Development of Molecular Biology and Biotechnology

Activity:

- Asia-Pacific IMBN should continue to provide regular forums for interaction between academia and industry, and continue to support industry-academia research and development collaborations.

- Asia-Pacific IMBN should develop programs aimed at supporting scientific entrepreneurship through initiatives such as the attachment of young scientists to biotech start-up companies; the establishment of workshops aimed at providing basic business skills, the award of a cash prize to outstanding individuals in the region with a strong business plan so as to seed their ventures, etc.

5.2.3.iii Human Resource Development

Objective:

- Asia-Pacific IMBN and its membership should play an active role in education and training of the next generation of leaders in life science and technology at all levels.

Activities

- Education and professional training is a key focus of Asia-Pacific IMBN. A variety of innovative programs and initiatives should be launched under the aegis of a special Asia-Pacific IMBN Commission on Education in order for the Network to be proactively involved in the development of education and training resources for schools and the general public. Activities may include:
    - Training workshops on cutting edge technologies for students and scientists throughout the region.
    - The development of educational material for the young.
    - The development of media training programs aimed at providing colleagues working in media organizations with the opportunity to obtain a good understanding of the opportunities and challenges confronting scientists, policy-makers and industry throughout the region.

5.2.4.iv Financing and Resource Mobilization

Objectives:

- To encourage greater investment in molecular biology and biotechnology development

Activities:

- Establishment of an Asia-Pacific IMBN Commission focused specifically on financing and resource mobilization considerations in life science research and development in the region. The Commission will work closely with colleagues in government, industry and the private sector to catalogue available resources and facilities available at the national and regional levels to support research and development, as well as the establishment of new ventures aimed at capitalizing on new developments in science and technology
- Working with national authorities and with industry groups, to work to encourage greater investment and support through grants and investment in activities aimed at developing molecular biology and biotechnology
- Identifying specific opportunities for research and development and investment partnerships for research institutions, industry and government.

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