Appendix 1: Singapore Education System

Overview of Singapore Education System

All Singapore children go through a compulsory 6-years primary school education, at the age of seven. After the four years of foundation and the final two year orientation stage, the pupils will sit for the Primary School Leaving Examination (PSLE) to assess their abilities for placement in Secondary school, for either a four or five year course depending on capabilities. At the end of the 4-year or 5-year Secondary schooling, the pupils will proceed to take the Singapore-Cambridge General Certificate, (GCE 'O' Level). Upon completion of their GCE 'O' Level, students can proceed to either a pre-university education or a polytechnic education.

A student chooses to go to pre-university education because it is the most direct route to university. The pre-university education offers an advanced curriculum that stresses academic and mental discipline and so prepares a student for university entry. The pre-university education in Singapore consists of a two-year junior college or a three-year centralized institute. Admission is based on a points system computed from the aggregate of the student's GCE 'O' Level result. At the end of the pre-university course, students sit for the Singapore-Cambridge General Certificate of Education 'Advanced' (GCE 'A') Level Examinations. Their eligibility for tertiary education is determined by the results of their GCE 'A' Level Examinations

For those whom have chosen for the polytechnic education route after the GCE 'O' Level, at the end of their course, which can be either a three-year or a four-year course depending on the course programmes, diplomas would be awarded and the majority of the diploma holders would join the workforce after graduation.

University education is provided by three universities. They are the National University of Singapore, the Nanyang University of Singapore and the Singapore Management University. A brief description of the three universities is as follows:

National University of Singapore

The National University of Singapore (NUS) was established in August 1980 with the merger of the University of Singapore (founded in 1962) and Nanyang University (founded in 1956). NUS is a state university established by an Act of Parliament and is under the purview of the Ministry of Education. The University has eight faculties and two faculty-level schools, namely Arts and Social Sciences; business Administration; Dentistry; Engineering; Law; Medicine; Science; the School of Computing and School of Design and Environment. All faculties offer courses leading to first degrees as well as higher degrees. There are also two graduate schools, namely, the graduate School of Medical Studies and the Graduate School of Dental Studies.

NUS' School of Business topped the 1999 ranking of Asia's 25 best Master of Business Administration (MBA) programmes in a survey compiled by *Asia Inc*, a regional business publication. The community at the 150-hectare Kent Ridge campus is a cosmopolitan one with students, teachers and researchers from all corners of the world.

The University has also established specialist research institutes in the fields of engineering, medicine, sciences and information technology. These include the Bioinformatics Centre, Centre for Management of Innovation and Technopreneurship, Chemical and Process Engineering centre, Institute of Engineering Science, Institute for Mathematical Sciences, Medical Informatics Programme, National University Medical Institutes, Singapore Synchrotron Light Source, Temasek Laboratories, The Centre for Financial Engineering, The Logistics Institute- Asia Pacific, tropical Marine Science Institute and the NSTB supported centres.

There are 10 national level research institutes and centres which are affiliated to the University, namely, Centre for Natural Product Research, Data Storage Institute, East Asian Institute, Institute of High Performance Computing, Institute of Molecular Agrobiology, Institute of Molecular and Cell Biology, Institute of Microelectronics, Institute of Materials Research and Engineering and Institute of Systems Science.

Undergraduate enrolment for academic year 1999-2000 was 20,617. As at September 1999, graduate enrolment was 8,712.

Teaching

To produce graduates who are creative, analytical and life-long learners, the university has adopted a holistic approach to education — with cross-boundary learning providing students with intellectual breadth and nimbleness of mind. Multi-disciplinary courses introduced in 1999 included:

- Information and Communications Management — by Faculty of Arts and Social Sciences and School of Computing
- Bachelor of Arts (Industrial Design) — by School of Architecture, Faculties of Engineering and Business Administration; and
- Food Science and Technology — by Faculties of Science and   Medicine

The introduction of a new South Asian Studies Programme strengthened NUS' standing as a centre of Asian studies.

The **Talent Development Programme**[1], a leadership-grooming programme, was made more flexible with students given the option to customize 20 per cent of their course programme according to what and how they want to learn it

A significant development was the growing number of Master's programmes jointly taught with foreign universities, involving overseas study and research stints, such as:

- Master of Science and Master of Engineering/Ph.D. in Advanced Materials and High Performance Computation for Engineered Systems taught jointly with Massachusetts Institute of Technology; and

- Joint Master of Laws in International Commercial Law jointly   taught with University of Nottingham.

IT-enhanced Teaching Environment

In 1999, digital platforms replaced analogue bases and multi-media conferencing replaced video conferencing. At the Faculties of Medicine and Dentistry and the School of Architecture, virtual reality simulation systems were used to train students. The university also enhanced its campus with wireless features

NUS' global classroom came of age with a course taught entirely in real-time by global video-link. Connected by Singapore Internet Next Generation Advanced Research and Education Network (SingAREN) and Internet 2, students from NUS' MBA and Master of Science in Computing programmes learn to work in cross-cultural teams as they interact and attend the same classes as their counterparts in Stanford University and the Swedish Royal Institute of Technology.

Research

The university plays a pivotal role in promoting research and development for the nation's development.

Breakthroughs in 1999:

- A new technology which produces carbon nanotubes with high   hydrogen uptake that is expected to have a significant impact   on the automotive industry; and

- A low-energy laser treatment that offers 98 per cent caries   protection. This is the highest protection rate available in   dental treatment.

NUS continued to work with its affiliated research institutes. A Centre for Advanced Computation in Engineering Science was set up between the Faculty of Engineering and the Institute of High Performance Computing.

In research and development, NUS tied up with Dupont Chemicals to develop new products and processes, and participated in the Asia Mobile Electronics Services Alliance (AMESA) to develop mobile smart card transactions.

NUS' research led to the establishment of two companies, bringing the number under NUS Technology Holdings Pte Ltd to 10. Aromatrix Pte Ltd was set up to commercialize research findings in odour technology. BioMedical Research and Support Services Pte Ltd (BRASS) was established to commercialize technologies for the development of biomaterials.

Links with others

- Overseas applicants for academic year 1999-2000 —   4,61
- International undergraduate students in 1999-2000 —   1,090
- International graduate students in 1999-2000 —   3,312
- Students who went abroad on exchange programmes —   29
- Students from NUS' partner universities who were hosted here — 290

Nanyang Technological University

Nanyang Technological University (NTU) was established by an Act of Parliament on 1 July 1991. It has its origin in the former **Nanyang Technological Institute (NTI)** which was set up in August 1981 with the primary function of providing facilities for tertiary education and research in various branches of engineering and technology.

NTU has seven schools, namely, the Nanyang Business School, the Schools of Civil and Structural engineering, Computer Engineering, Communication Studies, Electrical and Electronic Engineering, Materials Engineering, and Mechanical and Production Engineering. The schools offer undergraduate courses as well as a range of graduate programmes leading to the degrees of Master, Doctor of Philosophy and postgraduate diplomas. NTU's professional education in engineering is internationally recognized. As early as 1985, the Commonwealth Engineering Council commended NTU's engineering curriculum as a model for other engineering institutions to follow.

NTU's total student population grew by 11 per cent in academic year 1999-2000 to 20,222. There were 5,737 post-graduate and 14,485 under-graduate students.

Campus

NTU has two main campuses: the main 200-hectare Yunnan Garden Campus at Jurong and the Bukit Timah Campus which houses the National Institute of Education (NIE). The latter will relocate to the Yunnan Garden Campus before 2001. NIE, being the only teacher training institute in Singapore, offers training to would-be teachers in arts, science and physical education (see the following section on NIE).

In November 1999, NTU's City Campus opened at 268 Orchard Road. This Executive Centre brings some of NTU's postgraduate and executive training programmes to the heart of the Central Business District. It paves the way for a larger city campus to be built in five years' time.

Flexible academic system

NTU implemented the Academic Unit System in July 1994. This system breaks the academic year into semesters and makes use of academic units for measuring academic achievement. It is a hybrid American-British degree structure incorporating the credit system with a prescribed core of essential subjects.

Under this system, the academic year is divided into two semesters of 16 weeks' duration with a 10-week vacation in between. This system facilitates a broad-based education, where students are encouraged to read general electives outside their main discipline or from other schools within the two campuses. Thus, the modular system maximizes students' learning experience and enables them to progress at an appropriate pace while maintaining high academic standards. It also facilitates students' participation in academic exchange programmes with overseas universities.

R&D and Technopreneurhsip

NTU encourages its staff to undertake R&D work as well as provide consultancy services to industry and business.

To facilitate research and advanced training, various research institutes and centres of excellence have been set up. The growing emphasis on multi-disciplinary research has spawned several high-technology research centres in the past year, including the Satellite Engineering Centre and the Global Positioning Systems Centre. There are now 34 research centres in NTU.

NTU has always focused its R&D efforts on pioneering innovative and reliable homegrown technologies. A company, NTU Ventures Pte Ltd, was set up to commercialize the inventions of its researchers. As of 1999, NTU has more than 10 spin-off companies specializing in e-commerce, IT, electronics and manufacturing processes.

NTU's Innovation Centre, which was set up to encourage local and locally-based enterprises to do their R&D on campus, currently houses more than 20 tenants, a majority of which includes local start-ups and university spin-offs. In January 1999, a Technology Centrium was opened to promote NTU's homegrown technology and transfer it to industry. This is a one-stop centre for interested industrialists and investors to access new technologies by staff and student inventors.

Links with others

NTU encourages international linkages with overseas universities and research organisations. It has expanded its network with overseas universities. It has links with 170 overseas institutions. NTU also has an International Student Exchange Programme that enables students to study at an overseas university for up to two semesters. In academic year 1998-99, 90 NTU students went to 37 overseas institutions under this programme. During the same period, NTU received 110 foreign students from 40 overseas institutions.

Information Technology

The University's Centre for IT Services manages one of the largest campus networks and office automation systems in Southeast Asia. The Campus network, NTUnet, enables the campus community to communicate worldwide via the Internet. Altogether, the University has over 8,000 networked PCs for use by staff and students.

In 1999, the IT infrastructure was extended to all hostel rooms and residential staff quarters to enable students and staff to tap into the campus network easily. More network points were also added to the Library and various reading rooms. This doubles the number of network points on campus to 14,000 in 1999, i.e. roughly two points for every three students. At the same time, the bandwidth was upgraded to enable the transmission of multi-media services, such as live video broadcasts, video on demand, and the Library's new Gateway to Electronic Media Services — a one-stop, 24-hour information gateway.

Online learning is becoming an established fact of campus life with academic staff supplementing traditional classroom teaching with online learning. Video-conferencing also allows staff and students to interact with foreign universities; and "video lectures" have proved to be a useful alternative for some lecturers.

The National Institute of Education (NIE)

NTI was formed in July 1991 by the merging of the former Institute of Education and the College of Physical Education, and became part of NTU. NIE provides professional training for teachers as well as the study of a wide range of academic subjects.

NIE offers the four-year Bachelor of Arts (Education) and Bachelor of Science (Education) Courses as well as the two-year Diploma in Education and Diploma in Physical Education Programmes for holders of GCE 'A' Level and Polytechnic Diploma qualifications. It also offers the Postgraduate Diploma in Education Programme for university graduates. In addition to the initial teacher-training programmes, NIE conducts a variety of in-service training programmes. Facilities are also available at NIE for higher degree studies leading to the degrees of Master and Doctor of Philosophy.

Singapore Management University

Singapore Management University (SMU) was officially incorporated on 12 January 2000. It is Singapore's first private university funded by the government of Singapore. An Act of Parliament empowers SMU to confer its own degrees recognized by the government.

The SMU approach is modeled after the Wharton School of the University of Pennsylvania, America's top business school, SMU's curriculum aims to groom outstanding business leaders and creative entrepreneurs capable of excelling in a rapidly changing and dynamic world.

SMU presently offers the Bachelor of Business Management (BBM) and the Bachelor in Accountancy (BAcc) degrees with several other relevant real-world degrees in the pipeline. Both programmes adopt a flexible, multidisciplinary approach towards managing the increasingly complex demands of modern businesses, notably with an emphasis on computer literacy and technology, company internships, business visits and student exchange programmes. The objective is to develop well-rounded students with the ability to focus on specialized careers. It also offers MSc and PhD programmes by research.

IT is a central feature at SMU. Wireless technology for mobile computing is used, making SMU the first campus in Singapore with full wireless coverage.

Open University

Since 1994, the Singapore Institute of Management has been appointed by the Ministry of Education to run the Open University Degree Programme (OUDP). The undergraduate programmes are accredited and examined to the standards maintained by the Open University in the United Kingdom (UKOU).

The OUDP offers courses leading to Bachelor's degrees majoring in English Language and Literature, Mathematics, Computer Science, Technology (electronics), Psychology, business Studies, Information Technology and Computing, and Chinese Language and Literature. The OUDP also offers courses leading to Certificates and Diplomas under the Programme for Associate Student Studies (PASS) Scheme.

The Education System
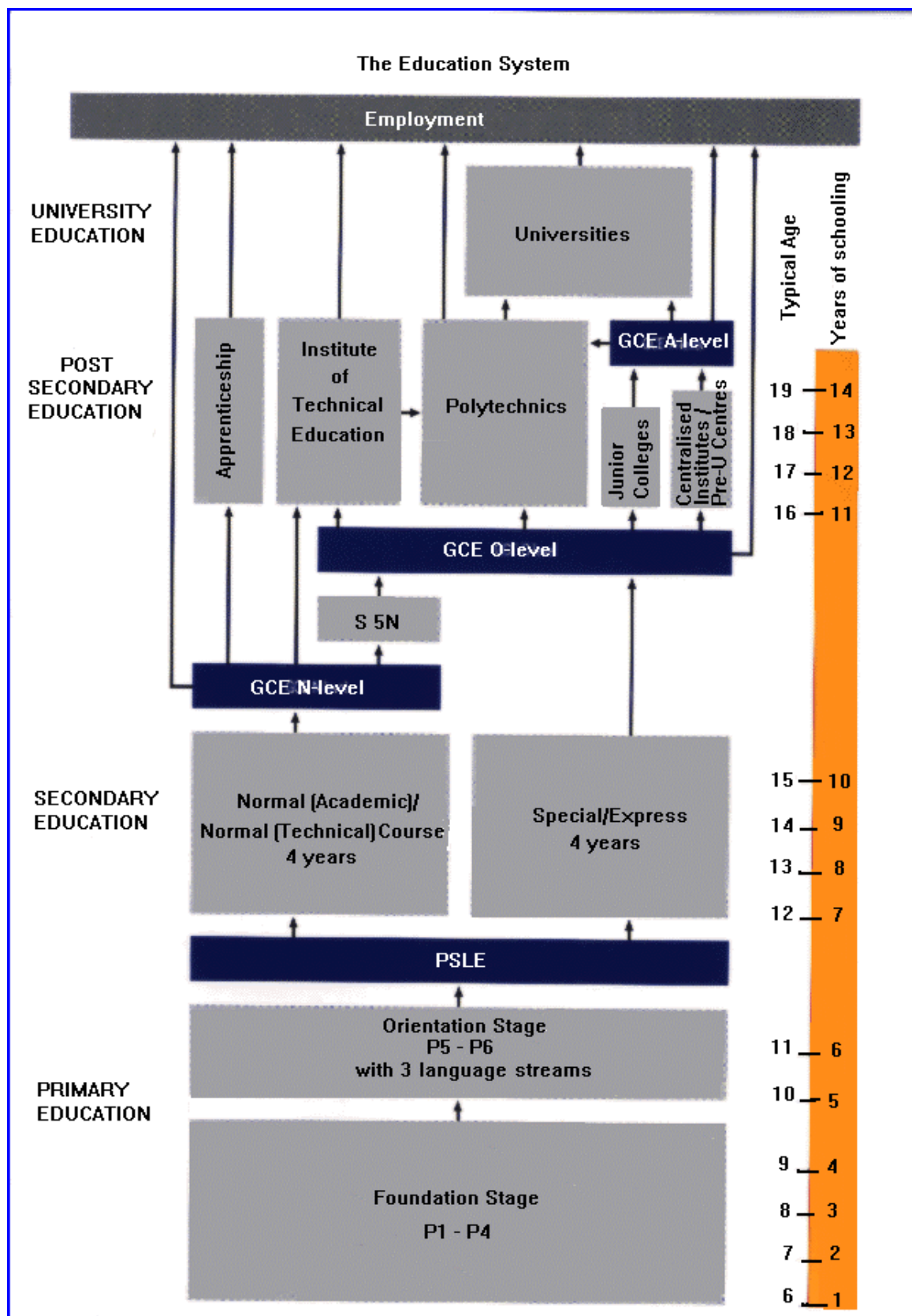
Appendix 2: Historical Development of Singapore Higher Education

As per any of Singapore national development strategy, Singapore's education system is also subservient to the needs of her economy. When the demand for more educated workforce to drive the economy from an entrepôt economy to an export-oriented manufacturing and service center was recognized in the 1960s, Singapore began her plan to structure her education system. The priority of the education system was thus given to generate an indigenous supply of the requisite manpower, particularly in science and technology, complemented by accounting and business management. The projected manpower requirements and the relevance of this manpower to changing needs of the economy therefore determine the basics of the education program, the student recruitment and the output of the universities. Since 1960s, the tertiary education in Singapore is thus an **instrument** under the influence of the political establishment and an **agent** of government policy. Its mission no longer lies in the pursuit of knowledge for its own sake. As early as 1980 the first Vice-Chancellor of NUS emphasized that "*professional and technical studies must take priority over the humanities and arts in university education*".

Governance and Funding

As the tertiary institutions are largely state financed, the Government maintains strong control over their policy direction. As a result, the majority of the academics have very little share in decision-making and hardly any influence in academic policy

Admission Policy and Staff Recruitment

Admission into the universities is merit-based as the system central legitimacy was based on the principle that equal opportunities are open to all individuals who have the talents and motivation to succeed. This is to ensure that quality graduates would be produced and who would be relevant to the work force. Scarce resources would also not be wasted on poor quality graduates.

In addition, in order to have the right mix of high quality, talented graduate output in critical fields, students are streamed into faculties and courses which may not be their first choice for admissions. For example, a number of high achievers who have qualified for entry into a medical program and have indicated the program as their first choice have been channeled to do engineering or law (Low, Toh and Soon, 1991). Through this policy of streaming, the aim is to ensure that the finest minds are not concentrated in one program and that critical fields like law and engineering have a fair share of the brightest students as well (Pang, 1982). Hence a controlled admission policy is necessary to ensure that there is no undue mismatch between the supply and demand of graduates.

When comes to staff recruitment, only staff with high professional and academic standards were engaged. Stringent tenure policy was also enforced to ensure the quality of staff recruited. Due to the lack of local qualified staff, international recruitment was necessary. The expatriate staff receives good salaries and fringe benefits but they were not considered for tenured positions. For staff tenure and promotion, overwhelming weight is given to high quality applied research output and publication in international and regional professional journals rather than to creative teaching.

A2.1   Research and the University-Industry Links

Despite the fact of being state-controlled, supervised and managed, the government has placed strong emphasis on research. Research is seen as vital for enhancing the reputation of the universities and maintaining internationally acceptable standards through publications and dissemination. The universities and their staff are thus expected to be actively involved in research. However, the research choices are prioritized in order to achieve realistic goals and concentrate on incremental technology, beneficial to Singapore's long-term economic development.

And because of the government emphasize on research, the government's R&D policy had encouraged university-industry linkage. This has actively encouraged greater university-industry interaction through consultancy and joint R&D projects. To support research and enhance its quality and productivity, the universities have established their in-house institutes and center to facilitate university-industry R&D co-operation in addition to providing consultancy services. Libraries were improved to keep up with the expanded demanded for material and information. The universities have also forged links with top-ranking overseas universities in the UK, Europe and the US.

To facilitate co-operation between industry and the university, the government has introduced incentives through tax rebates, a Research and Development Assistance Scheme (RDAS) and Product Development Assistance Scheme (PDAS).

Appendix 3: IAAP Profile

Prof William R Brody President	Johns Hopkins University
Prof Jeremy R Knowles Dean of Faculty of Arts and Sciences	Harvard University
Prof Robert A Brown Dean of School of Engineering Massachusetts	Institute of Technology
Prof Joseph Nye Dean of the John F. Kennedy School of Government	Harvard University
Prof Alec Broers Vice-Chancellor	University of Cambridge
Sir Ronald Oxburgh Rector	Imperial College
Prof Hans-Uwe Erichsen President	Conference of Rectors and Presidents of the Tertiary Institutions of Germany (HRK) European Conference of Rectors and Presidents of Tertiary Institutions
Prof Antonio Borges	Dean of the European Institute of Business Administration (INSEAD)
Prof Dr Konrad Osterwalder	Rector and Vice President Swiss Federal Institute of Technology, Zurich Switzerland
Prof T. Kimura President	Tokyo Institute of Technology
Prof Leo Esaki President	University of Tsukuba

Appendix 4: National Research Institutes/ Centers

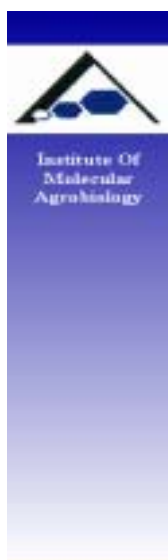| RESEARCH INSTITUTES AND CENTERS		
Institute/Centre	**Core Technology**	**Main Activities**
Biomedical Sciences		
Bioprocessing Technology Centre (BTC) 	The Centre undertakes R&D and develop technological capabilities in strategic areas of bioprocessing relevant to the local biotechnology industry. Specific research focus is in areas such as: • protein and gene expression • fermentation • cell and tissue culture • DNA and peptide technology	Apart from undertaking R&D work in relevant biotechnology areas, the Centre also seeks to collaborate with industry to create novel processes or products of commercial interest. A comprehensive range of bioprocess assistance and custom services is available from BTC as well.
Institute of Molecular and Cell Biology (IMCB)	Its main research emphasis is on cell regulation and functional genomics. Specifically, key areas of R&D work are: • cell regulation • genomics • drug discovery • immunology and virology.	The Institute's mission is to foster a vibrant research culture for biological and biomedical sciences to support the development of biotechnology in Singapore.
Chemicals & Other Sciences		
Environmental Technology Institute (ETI) 	The Institute concentrates on developing new environmental technologies, especially in the following areas: • Water Management • Solid Waste Management • Air Emission Control • Environmental Management Tools • Environmental Services	ETI will collaborate with the private sector in environmental R&D and in the commercialisation of innovative environmental niche technologies and services in a wide range of areas.

Chemicals & Other Sciences

Institute of Materials Research and Engineering (IMRE)	Its focus is on electronic materials, advanced engineering materials, advanced polymers/electrochemistry, biomaterials and nanotechnology.	IMRE plans to develop a comprehensive research programme with commercial aims covering all relevant fields of material science and engineering.
Institute of Molecular Agrobiology (IMA)	The focus of IMA is two-fold: • Basic research that focuses on understanding the cellular mechanisms that regulate the development and physiology of yeast, plants, fish and other animals; and • Applied research programme that addresses both immediate and long term needs in the industry.	The Institute undertakes research with commercial potential, especially in the application of genetic engineering for improved plant and animal protection and production. Its projects are devised through close collaborations with multinational and regional companies.

Electronics and Manufacturing Technology

Centre for Signal Processing (CSP)	The Centre is to spearhead the development of needed digital signal processing (DSP) technologies for the 21st century.	The Centre's main activities includes: • keeping abreast of the latest developments in signal processing, • conducting R&D work in specific areas of DSP technology, and • providing training and consultancy services in DSP-related problems.
Centre for Wireless Communications (CWC)	Wireless technologies for telecommunications.	Digital broadcasting, radio systems, mobile networks and multimedia personal communications.

Electronics and Manufacturing Technology

Data Storage Institute (DSI)	The Institute was set up to lead R&D work in fields related to magnetics and to support data storage systems and consumer electronics. Its focus is on specific technology areas, such as: • magnetic storage (hard disk drives), • magnetic media, • optical storage (CD and DVD drives), and • optical media.	The Institute serves as a critical link between upstream research and downstream development. The Institute actively seeks partnerships with academic organisations and industry.
GINTIC Institute of Manufacturing Technology	Manufacturing related technologies including systems technology, process technology and automation technology.	Aims to advance productivity and competitiveness through R&D, technology transfer and manpower training in its core technologies.
Institute of High Performance Computing # Institute of High Performance Computing *i*HPC	The Institute's strategic direction is to provide and to manage a top-tier supercomputing capability with a range of architectures and capacities.	Its main activity is to enhance Singapore's global competitive position through the effective utilisation of high performance computing in research, manufacturing and services.
Institute of Materials Research and Engineering (IMRE) IMRE	The focus is on electronic materials, advanced engineering materials, advanced polymers/electrochemistry, biomaterials and nanotechnology.	IMRE plans to develop a comprehensive research programme with commercial aims covering all relevant fields of material science and engineering.
Institute of Microelectronics (IME) IME SINGAPORE	The Institute targets R&D work in specialised areas like: • imaging sub-systems, • sensor technologies, • mixed signal designs, • subsystem and component reliability, and • support for advanced packaging development.	The Institute was established to enhance Singapore's technology base in electronics by: • engaging in R&D work over selected strategic microelectronics fields, • supporting and partnering with electronic industries, and • developing skilled R&D personnel.

Information & Communication Technology

Centre for Remote Imaging, Sensing and Processing (CRISP)	Satellite remote sensing and imaging processing as well as interpretation capabilities.	Harnessing advanced capabilities for regional purposes such as forest and water resource development, mapping, civil engineering projects, sea conditions and ship movements.
Centre for Wireless Communications (CWC)	Wireless technologies for telecommunications.	Digital broadcasting, radio systems, mobile networks and multimedia personal communications.
Kent Ridge Digital Labs (KDRL)	Its main focus is spearheading the R&D on information and networking technology in Singapore.	The Institute collaborates actively with industry partners to develop leading edge software technologies. It also help the industry to build useful products and services to improve its business competitiveness.

Appendix 5: Strategic Research Programs

NSTB - Universities collaboration:
Strategic Research Programme

Programmes	Description
NUS	
Synchrotron Light Source Facility	The synchrotron is an electron particle accelerator that emits light and this light is utilized by the SSLS laboratory. The machine is supplied by Oxford Instruments and developed from a similar machine at IBM, East Fishkill, N.Y. The storage ring in the SSLS provides radiation for 20 or more beam lines, each capable of supporting up to three experiments.
Wavelets	In wavelet (mathematical formula) representation, a signal is decomposed into various components from which information in the signal can be analysed and extracted, essential features retained and unimportant ones discarded. Because of these capabilities, wavelets have found applications in many areas of signal processing, such as high-performance audio, image and video compression.
Blue-Green Semiconductor Lasers	N.A.
Computer Security	Security technologies such as data encryption, cryptographic protocols, electronic payment mechanisms and smart card algorithms are essential building blocks of contemporary electronic commerce systems. With a collection of well-designed security technology building blocks, electronic commerce systems can ensure the confidentiality and integrity of business transactions, as well as to enable proper identification of transacting parties.
Datamining and Intelligent Data Analysis	N.A.
Medical Informatics	N.A.
Nuclear Microscopy	Nuclear microscopy is a new technique that utilises million volt nuclear particles (eg, 2MeV protons) from a nuclear accelerator. If the particle beam is focused to a small spot size and scanned across a material, then the particle/material interactions can give a wide variety of unique analytical and structural information.
RF & Microwave Research (with NTU)	To set up an advanced facility for the development of the large signal, nonlinear models of microwave solid state power devices, such as GaAs FETs, Si bipolar transistors, and HBTs.

NTU	
Microscale Cooling Technology	Microscale cooling technology deals with the mechanisms of heat, mass and momentum transport in small devices or processes. It has emerged as a critical area for R&D in the past decade largely because of the economic gains associated with miniaturization particularly in semiconductor and optoelectronic devices, sensors and micromachines, biotechnology, and many advanced manufacturing and material processing.
IT and Scientific Techniques using Visualisation, Data Mining, AI and Educational Tools in Internet and Intranet-based Applications	Data mining is a specialised field highly relevamt in today's economy where there is a premium on extracting useful information from the enormous amount of data present for applications in business intelligence for financial and risk management applications.
Interventive Augmented Reality for Medical Applications	N.A.
Control and Signal Processing in the Microlithography Process (with Stanford University)	To construct a working prototype of an integrated bake/chill/develop system for the microlithography process including the implementation of advanced controls and signal processing to improve critical dimensions, uniformity and repeatability.
Studies on Smart Materials and Material Systems for Mechanical Applications	Smart (functional, intelligent) materials such as piezoelectric polymers and ceramics, shape memory alloys, giant magneto-resistive material, etc. are capable of converting one form of physical quantity into another and therefore can perform various functions which traditional materials can not do.
Development of Precision Miniature Mechanism	N.A.
Rapid Design, Prototyping and Tooling	Rapid prototyping (RP) generally begins with modelling the physical part using a computer-aided design (CAD) system. The CAD model is next converted into a RP file format called STL, and transmitted to the intended RP system. There, it is sliced into parallel layers and built layer by layer into a 3D physical model through the solidification of either liquids or particulates.
Ultra-Precision Engineering	The research activities in PESRP are essentially multi-disciplinary and the work of the centre covers a wide spectrum of applications in Nano-metrology, Micro-fabrication and Nanotechnology.
Micro-Systems Mechanics	A distinct trend in engineering nowadays is towards system miniaturization and integration. By studying these fundamentally important issues of mechanics, we seek to develop improved mechanical design methodologies and hence to enhance data density and access speed of future storage devices.

Appendix 6: EDB Vision - Education Hub *(www.sedb.com.sg)*

BACKGROUND

When it comes to education, the role of the Singapore Economic Development Board (EDB) is to beef up academic's links with and collaborations with industry, which are crucial to Singapore's survival in a knowledge-driven global economy. The vision of EDB is to establish Singapore as a world-class education hub, internationally renowned for its intellectual capital and creative energy. The strategic intent is:

▪ To position Singapore as an ideal platform for the establishment of a world-class education hub.

▪ To attract at least 10 world-class institutions to set up either independently or in collaboration with our local tertiary institutions by year 2008.

The selected institutions will represent the best in their respective fields across a spectrum of disciplines, ranging from business management to medicine to engineering to applied sciences. Currently, seven top world-class universities have a strong presence in Singapore: Massachusetts Institute of Technology, Georgia Institute of Technology, Johns Hopkins University, INSEAD, The Wharton School of the University of Pennsylvania, The University of Chicago Graduate School of Business and the Technische Universiteit Eindhoven

These institutions conduct post-graduate education programmes, undertake both academic and applied research, and build strong linkages with industry. The New York Institute of Finance, a world-renowned professional school, also uses Singapore as its primary node in Asia.

The milestones of the last four years from 2000 showcase the commendable achievements of this approach.

MILESTONES

1997   The **New York Institute of Finance** (NYIF) set up its international office in Singapore in 1997. Since then, more than 1,200 senior financial executives and professionals have benefited from NYIF courses, with about 45% coming from outside Singapore.

The first executive learning centre of its kind in Singapore, NYIF fulfils the need for a regional training centre for financial professionals in the Asia-Pacific. NYIF chose Singapore as its international and regional HQ because of Singapore's favorable economic and tax structure and the country's aim to be the region's pre-eminent financial centre and education hub.

1998   **Massachusetts Institute of Technology (MIT)**'s collaboration with Singapore's National University of Singapore (NUS) and Nanyang Technological University (NTU) was announced in Nov 1998. This Singapore-MIT Alliance (SMA) aims to set a new standard for global engineering education and research and will boost the promotion of technopreneurship in Singapore.

SMA will conduct five graduate research and educational programmes advance engineering in Singapore to inculcate in students and staff the intensity, creativity and entrepreneurial spirit that is central to MIT's excellence. It will position Singapore as Asia's hub for high-quality graduate education, and prepare young engineers to be leaders in a technologically advanced economy.

Two of the programmes (Advanced Materials and High Performance Computation for Engineered Systems) have already been launched at NUS in July 1999 and the third programme (Innovation in Manufacturing Systems and Technology) at NTU in July 2000. These programmes have attracted top talents from around the region. Their examination results so far have indicated that the quality of these students is similar to that of students admitted to the programmes at MIT. Singapore will benefit from this influx of talent, as well as the opportunity to work with MIT faculty on world-class Engineering research.   The 4th and 5th programmes (Computer Science and Molecular Engineering of Biological and Chemical Systems) will be launched at NUS in July 2001.

Johns Hopkins has set up Johns Hopkins Singapore (JHS) in July 1998 to focus on collaborative research and medical education, and Johns Hopkins – NUH International Medical Centre in October 2000 to pursue academic medicine. Johns Hopkins will enhance Singapore's efforts to be a vibrant medical hub with the establishment of its flagship Asian facility.

JHS, headed by Prof Paul Lietman, will collaborate with NUS and National University Hospital (NUH) on research focusing on diseases prevalent in the region. Twelve projects have been identified and started, including cancer treatment and diagnosis, complex lipid disorder diagnosis, artificial liver design and medical IT. The R&D centre's deliverables within five years include hiring about 75 researchers and producing scientific advances leading to patents, spin-off companies and international conferences in Singapore.

Johns Hopkins will be offering PhD and Masters programme in clinical research in Singapore. It will also collaborate with NUS to offer other educational initiatives such as medical officer and post-graduate training programmes, continuing medical education courses, nursing and other allied health training programmes.

1999   **Georgia Institute of Technology** collaborated with the NUS to set up The Logistics Institute – Asia-Pacific (TLI-AP) in Singapore in 1999.   TLI-AP has conducted 5 professional education and training courses in logistics and supply chain management.   An 18-month dual Masters programme in logistics will be offered in July 2001, in which students will obtain two Masters degrees, one from NUS and another from Georgia Tech.

TLI-AP has adopted the highly successful leaders in logistics programme where sponsoring companies provide TLI-AP with financial support and work with TLI-AP on research projects.   Thus far, TLI-AP has managed to attract 9 members including HP, UPS, MSAS, BAX Global and Circle into the programme.

TLI-AP has also implemented a research programme in global logistics, covering areas of particular relevance to the Asia-Pacific such as air and sea cargo transportation, petrochemical manufacturing supply chain and e-logistics. This co-operative effort will enhance local logistics capabilities and further strengthen Singapore's outstanding logistics infrastructure, firming securing the city's position as the gateway to Southeast Asia.

The Wharton School of the University of Pennsylvania has set up the Wharton – SMU Research Centre as part of the overall agreement between Wharton and Singapore Management University (SMU) to collaborate on academic development and research. It will focus on business research related to Singapore and the Asian region, notably technological innovation, entrepreneurship, the management of technology, e-commerce and knowledge transfer within organizations.

Professor Janice Bellace, President of SMU, will be the Center's first Director. Faculty from Wharton working from the Center in Singapore will co-supervise MSc or PhD research. The Centre will develop research expertise that can be utilised by the industry, through avenues such as executive education, publication of research findings targeted at the needs of the industry and providing consultancy services.

2000   **INSEAD** has made the largest investment in Singapore so far. It is Asia's first international business school with a full campus. Its $60 million facility at the Science Hub was inaugurated on 23 October 2000. The 2.9 ha campus will be a centre for world-class teaching and research activities, including MBA programmes, executive programmes and Asia-related research.

The school launched its full-time MBA programme in Singapore in Jan 2000, attracting some of the best executives and students from around the world. These students come from 26 different countries and have GMAT scores comparable to students in some of the top business schools in the U.S. About 1,500 executives from the region are also expected to attend INSEAD's executive education programmes in Singapore this year, helping to anchor Singapore as the regional hub for education. In addition, multinational corporations will also use Singapore as their regional training base for their managers, leveraging on INSEAD's resources.

Eventually, the Singapore campus will increase its annual MBA enrolment to 600. The annual intake for its executive education programme will also grow to 5,000. By then, the Singapore campus will have 80 full-time resident faculty members.

The University of Chicago Graduate School of Business is the first leading US business school to have a permanent campus in Asia with the opening of its new facility in September 2000. The campus, located at the House of Tan Yeok Nee, a 112-year old traditional Chinese residential building in the city, is refurbished at a cost of $12 million.

University of Chicago will offer an International Executive MBA programme, to be taught in 16 one-week modules spread over 19 months. This format allows business executives from the Asia-Pacific to continue working full-time and to travel to Singapore to attend classes for intense periods of group study. The first intake of 85 students started their class in September 2000 and will be taught by the same faculty that teaches at the school's Chicago and Barcelona campuses. This will be the first time a business school will offer a globally integrated executive MBA programme on three continents taught entirely by its regular faculty at permanent campus locations.

2001　**Technische Universiteit Eindhoven (TU/e)**, the Netherlands, has partnered NUS to set up the Design Technology Institute (DTI) to train future leaders in Product Design & Development and to conduct research and education on Design Technology.　DTI aims to train engineers who are able to translate technical concepts into real products efficiently in line with time driven, competitive markets, and to marry form and function across several domains early in the design process.

DTI will offer a Master of Technological Design (MTD) degree, which targets to attract and develop talent in design technology. It will adopt a different approach from the existing MSc and MEng programmes. The joint MTD programmes are modeled after an existing, prestigious MTD programme awarded since 1988 by TU/e and will focus on the three strategic areas - **Rapid Product Development, Mechatronics and Embedded Systems**. The two-year programme comprises one-year coursework and one-year fieldwork in an actual industrial project, jointly supervised by the DTI and industry. The Institute aims to produce 9 Ph.D., 20 M.Eng and 36 MTD each year.

Appendix 7: NUS Milestones – History, Developments & Achievements

- **1823**

  Sir Stamford Raffles proposed the establishment of a College that would provide educational and research facilities.

- **1905**
  History

  Founding of The Straits Settlements and Federated Malay States Government Medical School. The School was renamed King Edward VII Medical School in 1912.

- **1949**

  King Edward VII College of Medicine merged with Raffles College (set up in 1929) to form the University of Malaya.

- **1962**

  The **University of Singapore** was established on 1 January. This followed the decision of the Governments of Singapore and the Federation of Malaya that the Singapore Division and the Kuala Lumpur Division of the University of Malaya should become autonomous national universities in their respective countries.

- **1969**

  A site in Kent Ridge became the new campus ground for the University of Singapore. This site was developed over the next 16 years and the transfer of all the faculties and departments to the new campus were completed in 1986.

- **1980**
  History

  The **National University of Singapore was formed** through a merger between the University of Singapore and Nanyang University on 8 August. President Benjamin Sheares, President of the Republic of Singapore, became the University's first Chancellor, and Dr Tony Tan was appointed the Vice-Chancellor and the Minister for Education concurrently.

- **1981**

  President Devan Nair became the Chancellor after the demise of President Sheares on 12 May. Professor Lim Pin succeeded Dr Tony Tan as Vice-Chancellor on 1 June. The **Institute of Systems Science** was established under a partnership programme between the National University of Singapore and IBM. This signified the strengthening of University-industry collaboration and the beginning of a policy of establishing centres of excellence in selected areas.

- 1982

  A new Coat of Arms was adopted by the University. The design incorporated symbols from the crests of both University of Singapore and Nanyang University. The Department of Obstetrics & Gynecology became one of the few medical centres in Southeast Asia to have an active In-Vitro Fertilization programme which attracted researchers from all over the world.

- 1985
  Development

  Dr Sydney Brenner, an eminent and distinguished geneticist from Cambridge, was appointed as the first Lee Kuan Yew Distinguished Visitor. The LKY Distinguished Visitors' Programme was established with the objective of inviting internationally eminent academics and scholars to Singapore to make high-level contributions to the university. Mr. Wee Kim Wee became the President of the Republic of Singapore and succeeded Mr. Devan Nair as Chancellor of the National University of Singapore.

- 1986
  Achievement

  Two lecturers in the Electrical Engineering Department succeeded in fabricating a semi-conductor laser, widely used in fibre optic communications systems, medical application for bioregulation and in such applications as compact disk players, videodisks and laser printers. They were the first in Singapore, and possibly in Southeast Asia, to do so.

- 1987
  Achievement

  The University established linkage to international academic networks via a computer network called **BITNET** in January. Singapore, through the University, was one of the first countries in Asia to be on this network. The **Institute of Molecular and Cell Biology** was officially opened on 2 October. Its establishment served to strengthen the infrastructure for basic biomedical and biotechnological research, and to enhance the University's research capability in selected areas of particular importance and relevance to Singapore.

- 1988

  The **Hon Sui Sen Memorial Library** was officially opened by the first Deputy Prime Minister, Mr. Goh Chok Tong, in January.

  Achievement
  The world's first successful microinjection pregnancy was carried out by the Department of Obstetrics & Gynecology using a technique called Micro-Insemination Sperm Transfer (Mist). This technique allowed men with extremely low sperm count to father their own children.

- 1989
  Development

  The University became linked to one of only two super computers in Singapore located at the Singapore Science Park. This enhanced the University's role in advancing the frontier of research and the globalization of computing technology and skills.

- 1990
  Development

  The **Bioprocessing Technology Unit** (BTU) was established to serve the twin objectives of providing project-based manpower training and a central facility for multi-disciplinary research and development in bioprocessing. It was the first project to be funded under the $20 million Biotechnology Competence Enhancement Programme administered by the Economic Development Board.

  The **Institute of Microelectronics** was set up in September to spearhead strategic research and development in microelectronics engineering, the first of its kind in Singapore.

- 1991
  Development

  The University's campus-wide optical fibre network, **NUSNET**, was officially launched on 11 April. Equipped with the largest state-of-the-art campus network in the Asia Pacific region and plugged into a world network of about 3,000 academic and research institutions through INTERNET, the system greatly enhanced the University's research productivity. The NUS Library took a historic step into the future on 1 October when its online public access catalogue known as **LINC** (Library Integrated Catalogue) was made available to the University community 24 hours a day via NUSNET, the campus network.

  The **Universities Endowment Fund** was launched to institutions public and alumni support for university education in Singapore. The secretariat was based at the University with the Director of the Alumni Affairs and Development Office serving as campaign director.

- 1992
  Development

  The University was the first among the tertiary institutions in the region to conduct a remote lecture from the University of Minnesota in US, using the latest video-conferencing technology - a two-way video and audio communication network.

  The **Magnetics Technology Centre**, funded by National Science & Technology Board and hosted by NUS Faculty of Engineering, was launched on 10 July. The Centre was tasked to undertake industry-driven, applied R&D projects in relevant areas of magnetic recording technology. The centre was later upgraded to a national institute in 1996 and renamed the Data Storage Institute.

Achievement

The NUS Campus Concerts won the prestigious Commonwealth Youth Award for 1992.

▪ 1993
Development

President Ong Teng Cheong became the new Chancellor of the University. The semester-based **modular system** <u>was introduced</u>, beginning with the Faculty of Business Administration. The new system incorporated the rigour and depth of the British system, including retaining the features of small group teaching and External Examiners, and the flexibility and breadth of the American credit system. The modular system was later extended to the Faculties of Arts & Social Sciences, Engineering, Science and the School of Building & Estate Management. The National Supercomputing Research Centre was set up to promote the use of advanced computational technology to enhance Singapore's industrial and commercial competitiveness.

The NUS Centre for the Arts (CFA) was established in March to give greater focus to the development of cultural activities on campus. The new centre incorporated the existing cultural agencies on campus, viz. the Centre of Musical Activities, Campus Concerts, NUS Theatre, NUS Dance Ensemble and the Forum for the creative Arts and Literature.

▪ 1994
Development

NUS and the National Science and Technology Board jointly established an <u>Adjunct Research Appointment scheme</u> in NUS. The *aim was to enable NUS to appoint senior industry researchers and managers to undertake part-time R & D work in NUS, particularly in the Faculties of Engineering and Science.*

The Institute of Systems Science was made a partner of the Japan-based Real World Computing group, a highly visible and prestigious organisation sponsored by Japan's Ministry of International Trade and Industry, whose areas of research focus included neural networks. It was the only research body in Asia to be given this recognition, and was awarded grants of US$50,000 for research into neural logic networks and multimedia archival systems.

The **National University Medical Institutes** was established in September 1994 with the primary objectives of boosting medical research and developing facilities and expertise for top-level research into the 21st century.

▪ 1995
Development

The **Institute of Molecular Agrobiology** (IMA) was set up on 18 April to carry out world-class agrobiological research and to provide a strong knowledge infrastructure that would support the growth in high-tech agro-industry in Singapore. A technology holding company, IMAGEN Holdings Pte Ltd, which would handle all investment matters of IMA, was incorporated in July.

In December, NUS set up the **Centre for Biomedical Materials Applications and Technology** (BIOMAT) to promote multi-disciplinary research and development in biomedical materials in Singapore and the Asia-Pacific region.

The NUS Library in May became the first academic library in the region to launch the full-text electronic document management and retrieval system. Called **Library InfoGate**, the system was the first step towards the vision of a borderless library, and would ultimately provide library users desktop access to bibliographic data, full-text and full-image of selected library collections via Internet.

The **Materials Technology Enterprise** (MTE) was set up in October to help manufacturing industries identify and develop core research capabilities in materials technology.

Achievement

The Education Division of the Institute of Systems Science became the first department in NUS to receive the ISO 9001 certification for its short courses, postgraduate programmes and joint projects. At the Institute of Systems Science, the Apple-ISS Research Centre developed a Chinese speech-recognition software for use in personal computing which won the "Best Software Product" and the "Best of Best Product" awards at Comdex Asia in October.

- 1996
  Development

  The NUS introduced a new programme called the "**Talent Development Programme**" in July to fully develop the potential of top students and groom them for leadership roles. The objective of this programme was to produce well-rounded graduates with a broad intellectual outlook.

  The establishment of the NUS Cybercast Station, an on-line station on the internet, made it possible for significant events in Singapore to be transmitted live to Singaporeans living abroad. The launch of ChiLINC (Chinese Library's online public access catalogue on 6 May placed the NUS Library at the forefront of providing computerized Chinese language bibliographic data in Singapore. NUS Library and Informit (the commercial arm of the Royal Melbourne Institute of Technology) launched the "SMC Ondisc", the first bibliographic CD-ROM produced by a Singapore tertiary institution library.

- 1997
  Development

  NUS held its first staff awards ceremony to honor outstanding staff who had excelled in teaching, research and service. The awards were given out under three categories: Teaching Excellence Awards, Outstanding Researcher.

Awards and Staff Achievement Awards

The Bioinformatics Centre was set up to spearhead the development of state-of-the-art bioinformatic tools and provide bioinformatics services to the biotech industry in Singapore. The East Asian Institute was set up as the University's first non-natural science research institute. The institute was established to study developments in East Asia and succeeded the Institute of East Asian Political Economy (IEAPE).

NUS Library took the lead amongst local libraries to install **INNOPAC**, a library automated system with the ability to handle Chinese, Japanese and Korean characters. The new system enabled users to search for books using Chinese characters, making its online catalogue (LINC) available in English and Chinese.

NUS took up the call made by Prime Minister, Mr. Goh Chok Tong, to make Singapore the "Boston of the East" by working towards becoming a world-class university. <u>A need-blind admission policy was introduced in the new academic year to attract more quality students from both Singapore and the region.</u> In line with this policy, NUS scholarships were established for outstanding undergraduates. An **International Academic Advisory Panel (IAAP)** comprising 11 eminent academic administrators from top American, European and Japanese universities was set up to help the University chart the directions and research strategies which would help it to develop into a world-class university.

Achievement

NUS was voted one of the top ten universities in the Asia Pacific region. It ranked fourth in a survey of 50 top universities in Asia and Australia. In ratings by academic reputation, NUS was placed second by its academic peers in Asia and Australia. The survey was conducted by Asia Week, a regional news magazine. NUS received the Top IT User Award '97 from Computerworld, Singapore. The award recognized NUS' pioneering usage of leading-edge technologies such as Intranet, ATM networking and supercomputing.

- 1998
  Development

Two new research institutes, the **Tropical Marine Science Institute** (TMSI) and the **Institute of Engineering Science**, were established. TMSI spearheaded research in areas like underwater acoustics, coral reef ranching and marine biotechnology. The Institute of Engineering Science was a virtual centre to oversee a number of multi-disciplinary research centres in areas of strategic importance in engineering and the sciences. A Pilot Preparation Programme was launched to prepare NUS students for exchange attachments in non-English speaking European countries. For a start, the Programme involved students in the ASEAN-European Engineering Exchange (ASE3) Programme and helped them adapt to the culture of their host countries as well as learn the language.

Major initiatives under the NUS IT Strategic Plan were implemented. They included the **Notebook Ownership Programme** to equip every student with a personal notebook; the launch of the **Secure Plug & Play Environment** with a network of 12,000 plug-in points; and introduction of secure smart cards with stored cash values for transactions at the University.

NUSCast, the University's campus radio channel and network TV service, was launched, hosted by Computer Centre, Centre for the Development of Teaching and Learning (CDTL) and the NUS Students' Union.

A double-degree programme was initiated with two prestigious French institutions -- Ecole Central and Ecole Polytechnic, allowing top NUS undergraduates to spend two years at NUS, followed by another two years at one of the two foreign institutions. Postgraduate degree would be completed upon their return to Singapore. NUS and the French Centre National de la Recherche Scientifique (CNRS) established a joint laboratory, the Image Processing and Application Laboratory, as part of their efforts at R&D collaborations. Based at NUS, Laboratory's main areas of research include indexing and retrieval of video data and 3D images for medical applications. The University's Talent Development Programme, established to groom students with intellectual and academic potential, produced its first batch of 16 graduates.

The Institute of Logistics -- Asia was established at NUS in collaboration with the US top ranking Georgia Institute of Technology, offering multi-disciplinary programmes with the aim of providing total and integrated solutions to the manufacturing industry. The research arm of the Institute of Systems Science merged with the Information Technology Institute (ITI) to form Kent Ridge Digital Labs (KRDL), providing companies with technology-based solutions targeted at new global markets. ISS's educational arm continued to operate as an autonomous department within the University.

Achievement

The research team from the Institute of High Performance Computing received the Defense Technology Prize for their software involving virtual reality that helped to analyze the after-effects of naval vessels subjected to close-range shock. The project was a collaboration with Mindef's Naval Logistics Department and Defence Science Organisation.

Academics and researchers from NUS swept all categories of the 1998 National Science and Technology Awards including the National Science Award, the National Technology Award, the National Science and Technology Medal and the Young Scientist Award.

- 1999
  Development

NUS introduced an online course for gifted JC students. The collaboration with Stanford University offered a range of Mathematics and Physics courses, and allowed participants to earn credits for advance placements at NUS or other top American universities.

The **Core Curriculum** was implemented in July starting with selected students from the Faculties of Arts and Social Sciences, Science and the School of Computing. The **Singapore-Massachusetts Institute Alliance (SMA)** started its first full-time graduate courses and research programmes in July for degrees including Master of Science in Advanced Materials, Master of Science in High Performance Computation for Engineered Systems (HPCES), Master of Engineering and Doctor of Philosophy. The School of Computing launched a first-ever master course conducted completely through video-conferencing in conjunction with Faculty of Business Administration. Called Global Project Coordination, the course was conducted with the Stanford University and the Swedish Royal Institute of Technology.

President SR Nathan succeeded Mr. Ong Teng Cheong as the new Chancellor.

Achievement

The NUS Symphonic Band was the only Asian band to be featured at the 3rd International Youth Music Festival, Zurich, in July. The Festival is held once every seven years. NUS Centre for Remote Imaging, Sensing and Processing (CRISP) received the Excellence for Singapore award in recognition for its contribution as an international center in the field. NUS School of Building and Real Estate emerged the top contributor to Construction Management and Economics, an international refereed journal which received the highest international ranking among construction management journals. The Computer Centre gained the distinction as the first NUS administrative department to qualify for the ISO 9001 certification.

- 2000
  Development

  An MOU between the Institute of Molecular Agrobiology (IMA), Monsanto, SpaceHab Inc and the Donald Danforth Plant Science Centre marked Singapore's first foray into outer space research. The collaboration involved IMA participating in protein crystal experiments on board a US space shuttle to be launched in 2001. Professor Shih Choon Fong succeeded Professor Lim Pin as NUS' new Vice-Chancellor. NUS celebrated the year's graduation at the University Cultural Centre as Commencement, which symbolized the start of the graduate's new relationship with the University as alumni. WAP (Wireless Application Protocol)-enabled technology was introduced on campus, with 24-hour alerting and web-based services.

  Achievement

  The Institute of Microelectronics (IME) achieved a breakthrough in short-range wireless communication through the development of 2.45 GHz Bluetooth RFIC chip for telecommunication applications.

- 2001
  Development

  <u>The NUS bioinformatics collaboration with Stanford University and Sweden's Karolinska Institute and Uppsala University expanded to a five-country tie-up, together with South Africa's University of Western Cape and Australia's University of Sydney</u>. With the new additions, the collaboration was renamed as the **Singapore-Stanford-South Africa-Sweden-Sydney S* Life Science Information Alliance**.

  Design Technology Institute was established by The National University of Singapore (NUS) and the **Technische Universiteit Eindhoven** (TU/e), the Netherlands. The Institute was set up to train future leaders in Product Design & Development and conduct research and education in the discipline of Design Technology. The Vice-Chancellor gave his first State-Of-The-University Address, highlighting his vision for NUS as a world-class Knowledge Enterprise. The University unveiled its new corporate identity that carried a stylized branding to symbolize a forward-looking organisation.

  Achievement

  Faculty of Law became the first law school in the world to win the prestigious Philip C. Jessup International Law Moot Court Competition four times.