

- * Solid base of internationallycompetitive research
- * Building peaks of research excellence
- * Growing effective global research links
- * Strong link between research and graduate education



Strategic Research Initiatives

A central pillar of NUS' drive for excellence is the advancement of knowledge and the fostering of innovation through research and its application. By synergising high-quality education, research and entrepreneurship, the University seeks to be a major player in the global knowledge community.

To achieve this, NUS is leveraging, as a comprehensive University, on the wide range of expertise present on campus to establish a solid base of research that is internationally competitive across a broad range of disciplines and in many multidisciplinary areas. The increase in the number and productiveness of NUS' global research links, and the strengthening of the bond between research and graduate education, have also enhanced the depth and quality of research at NUS. In addition, NUS is actively building up a number of peaks of research excellence.



Amongst its numerous new research initiatives, the University has given particular support to a number of strategic programmes that capitalise on existing research talent and strengths in NUS, and which are of high importance nationally and internationally.

Biomedical and Life Sciences is a major research focus at NUS, in line with the Singapore government's objective of developing the biomedical sciences as the next pillar of Singapore's economy. The Biomedical research programme in NUS centres on research in the core areas of Cancer, Hepatology, Vascular Biology, Infectious Diseases and Neurobiology/Ageing, which are built on the platform technologies of Computational Biology, Bioengineering, Tissue Engineering, Experimental Therapeutics, Immunology and Structural Biology. The NUS Office of Life Sciences was established in March 2001 as the key driver for this strategic research initiative, to bring together and to grow existing areas of research strength from within the University's faculties/schools and national research institutes. Internationally renowned researchers and academics have also been appointed to NUS, notably to head key Oncology, Immunology and Cardiovascular research programmes.

Physical Sciences and Engineering form another major domain of technological advancement at NUS. The objective is to exploit NUS' competitive advantages to build up high-quality multidisciplinary research programmes in areas that are strategically important to NUS and Singapore. Vibrant hubs of research have been established in recent years.

The NUS Nanoscience and Nanotechnology Initiative (NUSNNI) is pushing the frontiers of nano space. Set up to develop research human capital and longterm research capabilities in Nanoscience and Nanotechnology, NUSNNI helps accelerate research efforts across departments with research institutes and overseas collaborators. Key collaborative research efforts are being made with the Universities of Cambridge and Oxford and the University of California at Santa Barbara and at Irvine.





Strategic Research Initiatives > 1



The Materials Science and Engineering Initiative (MSEI) is another multidisciplinary driving force to advance strategic integrated Materials Science and Engineering (MSE) research that has impact on discoveries of novel phenomena and fabrication of materials and devices. It aims to develop an infrastructure of international standing in MSE for research and education and to help prioritise strategic research activities in science and engineering of new and advanced materials and related technologies.

The InfoComm and InfoTech Initiative (ICITI) seeks to foster and enhance cooperation in Infocommunication and Infotechnology between NUS and national research institutes, specifically Institute for Infocomm Research (I²R) and Institute of High Performance Computing (IHPC) and national agencies such as Infocomm Development Authority of Singapore. The initiative involves participants from the School of Computing, Faculty of Engineering and Faculty of Science at NUS. Defence-related research also forms a major thrust, with the Ministry of Defence collaborating closely with NUS in areas of strategic importance to national security and safety. Facilities set up to conduct joint work include Temasek Laboratories at NUS (TL@NUS), the Singapore Wind Tunnel and the DSO (Kent Ridge) Building. On the international front, SONDRA – a joint research laboratory, was recently established in Paris, involving NUS and the Defence Science and Technology Agency (DSTA) of Singapore and ONERA (National Institute of Aerospace Research and Studies) and Supelec of France.

Humanities and Social Sciences research puts the spotlight on Asian issues: Asian economies, business and management; Asian legal and policy studies; religion and ethnic relations; population with emphasis on ageing, health and family life; globalisation in Asia with regard to social and urban changes; and nation-building and politics.

The Asia Research Institute (ARI) was set up to engage in interdisciplinary scholarship relating to cultural and social changes in Asia. ARI draws its expertise from scholarship within the humanities and social sciences, with contributions from the business and legal perspectives, in collaboration with the Faculty of Arts and Social Sciences, School of Design and Environment, School of Business and Faculty of Law at NUS.



By leveraging and building upon existing strengths across different disciplines, NUS strives to develop more holistic approaches to address major research questions and problems. This is increasingly important as many of the most exciting research issues extend far beyond the bounds of single, traditionally established disciplines. In this new environment, the ability to bring together excellent minds from within NUS, local and overseas collaborators and industry and government, enhances the likelihood of major breakthroughs and the prospect of significant and mutually beneficial outcomes.





- * Almost 2,000 projects conducted each year
- * Research excellence with high impact
- * Multidisciplinary research in line with worldwide strategic directions
- * Key research areas of strategic importance to the nation



Research Highlights

BIOMEDICAL AND LIFE SCIENCES

Databases for Pharmaceutically Relevant Proteins

The study of protein properties is gaining great interest as scientists strive for better understanding of biological functions. Headed by Assoc Prof Chen Yu Zong from the Department of Computational Science, a multidisciplinary team at the Faculty of Science has developed six bioinformatics databases that detail pharmaceutically relevant proteins. A web-based software is also available for the first time. This software predicts protein functions particularly those of novel proteins.

The research has been published in top ranking bioinformatics and pharmacology journals. A US patent has been filed for the team's method of simulating biological pathways and biomolecules.

Bacteria Boost Immunity to Disease

A protein known as Mycobacterial heat-shock protein 65 (Hsp65) is so highly immunogenic that it is being studied for its ability to strengthen cells in their fight against cancer and infectious disease agents.



Hsp65 from *Mycobacterium bovis* has been observed to be able to modulate or increase the immunogenic response to antigens. Researchers at the Department of Biochemistry are exploring its novel function as an adjuvant, an agent that increases the immunogenicity of antigens, and can stimulate the activity of immune cells to cancer or infectious diseases. The team, led by Dr Gan Yunn Hwen, has shown that Hsp65 can enhance cross-presentation, a process where the antigen presenting cells take up extracellular proteins and present them to CD8 T cells. The significance is that cells do not have to be infected with pathogens for their foreign proteins to be presented to CD8 T cells, which are the cytotoxic T cells. The antigen presenting cells thus alert the immune system of invading pathogens by directly activating both CD4 and CD8 T cells efficiently.

The discovery can be potentially applied to increase the body's defence system to kill tumour cells. The investigators also established that this ability is independent of the action of contaminating lipopolysaccharide from the cell wall of gram-negative bacteria, a problem that has been plaguing the field.

Burkholderia pseudomallei Hsp60 and Hsp70, as well as mammalian Hsp70 are other proteins under study.

Reactive Oxygen Species in Cancer Cell Survival and Death

The Tumor Biology and Apoptosis group led by Assoc Prof Shazib Pervaiz from the Department of Physiology, in collaboration with Dr Marie-Veronique Clement, Department of Biochemistry, have highlighted the critical role of tumour intracellular redox status in the response to drug therapy. Their work has demonstrated that a slight pro-oxidant milieu provides cancer cells with a survival advantage over their normal counterparts by promoting cell proliferation and impeding death execution. Through a series of publications in prestigious journals, the team has successfully demonstrated their model to explain oncogene-induced carcinogenesis and resistance of cancer cells to drug therapy. More importantly, by decreasing the intracellular oxidant levels, cancer cells could be made significantly more responsive to chemotherapy. Their findings could have tremendous implications for the development of novel compounds that favourably alter the intracellular milieu for a significantly improved response to chemotherapy.

Assoc Prof Shazib was awarded the Faculty of Medicine 2002 Outstanding Researcher Award for his work.

Breakthroughs in Proteomics

Proteomics, the study of proteins, is an increasingly important subject. Understanding the interaction between proteins and other molecules can explain the many biological functions in the body, and large-scale study of protein properties provides a general view of disease and cell processes. Research on novel protein functions and interactions is thus an emerging area of great scientific interest.

Dr Yao Shao Qin from the Departments of Biological Sciences and Chemistry and his team at the Faculty of Science have made several breakthroughs in the study of proteins. They developed two new approaches to immobilise specific chains of peptides and proteins such that cell links are extremely stable. They also explored several alternatives that will help identify important enzymatic proteins responsible for important biological processes. The researchers have designed novel approaches, both efficient and cost-effective, that produce large samples of protein arrays for lab work.

Besides publication in internationally prestigious journals, two patents have been filed for the work.

Genetic Links to Leukaemia

Introducing viral DNA into the host genome can be used to tag and hunt down cancer genes. Led by

Prof Yoshiaki Ito, researchers at the Oncology Research Institute, Faculty of Medicine and the Institute of Molecular and Cell Biology are looking at the effect of RUNX1 gene on a mouse model. Families with heterologous mutations in RUNX1 develop acute myeloid leukaemia at high frequency. The BXH2 mouse strain, when integrated with endogenous retrovirus, is susceptible to a spontaneous development of acute myeloid leukaemia in more than 90% of cases in 7-12 months. The mutated RUNX1-introduced mice developed leukaemia about 1.5 months earlier than standard BXH2 mice.

This observation backs the belief that more than one genetic change is needed to cause leukaemia, not solely the chimeric genes generated from chromosomal translocations. Thus, heterogeneous loss-of-function mutation of RUNX1 is not sufficient to induce leukaemia on its own. The researchers also obtained strong evidence that the cause of Down's Syndrome Associated Acute Megakaryoblastic Leukaemia is due to an extra copy of RUNX1.

The two mouse models can be used in humans to investigate the relevant diseases.

Another team headed by Dr Matiullah Khan is applying his newly discovered mechanism of leukaemogenesis, which explained that the inactivation of a co-repressor molecule causes leukaemia, in the investigation of other cancers. Bilineage differentiation from the same mesenchymal stem cell

Osteogenic

Stem Cell Potentials in Tissue Repair

Toluidine Blue stain

Chondrogen

One drawback of current drug and biomaterial screenings on animals is that their effects on human cells can never always be predicted. Human embryonic stem cells (hESCs), on the other hand, offer potential for the development of specialised cells. These can evaluate a drug or biomaterial detoxifying capabilities, and thus provide early warning of patients' adverse reactions to the drug.

Dr Cao Tong at the Faculty of Dentistry is working to stimulate and direct differentiation of hESCs towards somatic cells. He hopes to produce an ideal source of cells for the study of cell/tissue/organ/body development and gene control. These cells would also act as gene/protein deliverers for gene therapy and aid replacement tissue generation to repair defects. Similarly, they can be used to develop safety/ biocompatibility screening tests, as well as cell/tissue/ organ transplantation therapy.



Transplanted Cells to Regenerate Diseased Tooth Supporting Structures

There may be hope for the young and the elderly affected by gum (periodontal) diseases or injuries to chew their way through life with their own teeth instead of relying on artificial ones.

Led by Faculty of Dentistry's Dr Varawan Sae-Lim, the multidisciplinary group is working on regeneration of periodontal structures using one of the most promising tissue engineering techniques to date. The transplanted human osteoblasts and periodontal ligament fibroblasts are introduced into the three-dimensional double scaffold construct in attempts to form bone/tooth connective tissue interface crucial for tooth support. The project has won distinction and clinched three awards at local conferences.

Momentum Picks up in Tissue Engineering

The Cell and Tissue Engineering Programme at the Department of Physiology aims to establish a critical mass of research groups on cell and tissue physiology.

- a: Scanning electron microscopy image of human alveolar osteoblasts (AO) cultured on 3-dimensional PCL scaffolds, showing cells embedded in matrix through the interconnected channel
- b: Light microscopy image of human periodontal ligament fibroblasts (PDLF) cultured on perforated polycaprolactone (PCL) membrane. Cells were observed to bridge perforations
- c: Inmunohistology of PDLF-AO construct consisting of PCL membrane and scaffold, after 4-week implantation in nude mice

Latest research at the Department may create a greater impact on the way medical professionals view regeneration of the liver, the possibility of bioartificial livers and how extracellular microenvironments control cell differentiation. The focus is to understand the structurefunction relationship of liver tissues at cellular resolution and how liver cells and tissues function in engineered

The Institute of Bioengineering and Nanotechnology (IBN) of the Agency for Science, Technology and Research (A*STAR) and Cordlife are co-developing enabling technologies leading to precision engineering of pieces of liver tissues, hepatocyte-based multicellular structures on chip, or microbioreactors for various applications. The fundamental studies done in the Department will support the downstream technology development done through IBN.

constructs to enable tissue repair and regeneration.

The National University Medical Institute's (NUMI) Confocal Microscopy and Flow Cytometry facilities have also been expanded. Together with the NUS Bio-Imaging Initiative and Singapore-Massachusetts Institute of Technology Alliance, greater synergy is expected in the research of liver cell and tissue engineering in NUS.

Study of Inhibitory Molecule in Nerve

A group at the Department of Anatomy, together with multidisciplinary and multicentre colleagues from Europe, Canada, China and Japan, is studying the physiological functions of Nogo-A, an inhibitory molecule in the myelin sheath associated with an axon. The axon carries outgoing action potentials from the cell body towards target cells.

Led by Assoc Prof Xiao Zhi Cheng, an NUS adjunct professor from Singapore General Hospital, the team showed that Nogo-A is a central nervous system (CNS) paranodal component, with a predominant origin of oligodendrocytes, cells that myelinate CNS axons.

The molecule is found to interact with a protein called Caspr and this interaction may play a role in regulating the redistribution of potassium ion (K+) channels along the axon during the early stages of myelination. This knowledge will be important in understanding Nogo-A's role in CNS remyelination and axonal differentiation.

The research has resulted in publications in top scientific journals Cell and The EMBO Journal.

The computer-aided retinal screening system provides early detection of diabetic retinopathy

Screening System Saves Sight in Diabetics

A computer-aided retinal screening system installed at Yishun Polyclinic will help save the sight of many diabetics. Patients will now know of the first onset of diabetic retinopathy, a major cause of blindness.

Jointly developed by Assoc Prof Wynne Hsu and Dr Lee Mong Li from the Department of Computer Science, and doctors from the National Healthcare Group Polyclinics and Tan Tock Seng Hospital, the system adopts three approaches. It offers an electronic retinal medical record to speed up screening, employs image processing techniques to facilitate diagnosis, and uses datamining tools to discover disease trend. Offering 85% accuracy and 100% sensitivity, the system provides early detection, thus timely and appropriate treatment.

A computer-assisted retinal information analysis system is being developed to further enhance the efficiency of the system. Rapid manufacturing machine

Fast Manufacture of Fitting Prosthetics

Design of sockets in prosthetics using computer-aided design and manufacturing (CAD/CAM) systems has seen little significant improvement for a long time. But this may change now, with researchers from multiple disciplines integrating finite element analysis (FEA) and a rapid manufacturing machine (RMM) to create a CAD-FEA-RMM system – one that ensures accuracy, rapid manufacturing and a high chance of successful first fitting.

In a joint project involving the Division of Bioengineering, Department of Mechanical Engineering and Department of Orthopaedic Surgery, the residual limb of a volunteer amputee is scanned into a computer. Rectification can then be made on the computergenerated socket by an experienced prosthetist. The CAD models are automatically meshed into FEA models. After more rectification, the final socket is sent to the RMM and a definitive socket is fabricated in less than four hours. The RMM socket has passed structural tests and characteristics are similar to hand-made ones. This project is led by Assoc Prof Toh Siew Lok, a joint staff from the Division of Bioengineering and the Department of Mechanical Engineering.

Luminescent Biomedical Tags

Nanostructures are characteristically systems of minute size ranging from 1-100nm. They are utilised in fields such as nanobiotechnology and medicine, where biological labels and biomedical tags are best known.

In nanobiotechnology, a number of technological applications make use of semiconductor quantum dots. But possibilities have increased with the successful developments by Dr Han Ming Yong, Department of Materials Science and his team.

Dr Han has successfully synthesised highly luminescent quantum dots that allow varying compositions; quantum dots with different stages of stability; and ternary alloyed quantum dots.

Research results have been featured in journals, magazines and *Technical Review* published by the Netherlands Office of Science and Technology. Patents were filed recently and the team is discussing the possibility of licensing and spinning off the technology.



Composition-tunable optical properties of alloyed ZnxCd1-xSe nanocrystals with high luminescence and stability (J. Am. Chem. Soc. 2003, 125, 8589) Fibre alignment (random orientation, 2D alignment, and 3D alignment)

PHYSICAL SCIENCES AND ENGINEERING

Spinning Strong Nanofibres

Fibres can do more than hold fabrics together. Researchers round the world are working on shrinking the diameter of polymer fibres from micrometre to nanometre using electrospinning. With the extra large surface area, excellent stiffness and tensile strength, the fibre offers revolutionary uses in fields such as orthopaedic medicine and molecular filtration.

On the local front, an NUS bioengineering team from the Faculty of Engineering, headed by Prof Seeram Ramakrishna, has set up a new electrospinning method to produce optimum quality nanofibres. As others ponder on the possibility of attaching antibodies to nanofibre membranes, the researchers have already successfully carried out surface modification with amino groups and other substances. With that, attachment of other specific molecules to produce functionalised nanofibres will be a foreseeable possibility.

Nanopattern Paves Way to Nanodevices

Demand is great for compact devices capable of high-



(a) and (b) ZnO nanorods supported on polystyrene microbeads, (c) and (d) ZnO nanorods assembled on carbon nanotubes

density magnetic storage, as information increases and becomes more complex. For Assoc Prof Andrew Wee and his team at the Institute of Engineering Science (IES), their study on nanopattern formation will contribute to the future fabrication of nanodevices capable of complex storage, and help develop new platform technology.

Their attempt to create nanometre-scale structures to form one- and two-dimensional ordered patterns on surfaces has seen good results. There is now an effective way of controlling size dispersion of surface adsorbed nanoclusters. Utilising a reconstructed carbon-rich template with regular periodic porosity, 3nm nanoclusters have grown steadily through the use of electron-beam evaporation.

A computational time-saving solution for quantitative low-energy electron diffraction has been proposed.



8nm x 8nm STM image: blue circles highlight the Co cluster adsorption sites



Edge oriented MoS₂ synthesised by the one-step evaporation of single source precursor. The edge oriented MoS₂ is important in hydrogen desulfurisation catalytic chemistry of gasoline fuels as well as hydrogen storage materials.

New Method Improves Nanoassembly

Light emitting diodes, photodetectors and lasers are some electronic and photonic structures that can be assembled using semiconductor nanowires, a class of nanoscale blocks.

Recently, a group of scientists, led by Dr Loh Kian Ping from the Department of Chemistry, further developed a synthetic method to improve the assembly of nanomaterials on a templated substrate for integration and characterisation of devices. The result was the growth of ZnO nanorods and MoS₂ nanosheets.

The ZnO nanorods are the first demonstration of successful growth and alignment of these nanorods on practically any type of surfaces, regardless of lattice matching conditions between the ZnO and the substrate. The ZnO nanorods are expected to be in demand as they are optically active, have high density and exhibit enhanced photocatalytic effect.

Another first is the growth of crystalline MoS₂ nanosheets by simple evaporation, without the need to use toxic hydrogen sulphide gas. Other advantages include its industrial compatibility, cheap raw material and usability in the hydro-treatment of catalysts. As this type of catalyst accounts for 20% of the world catalytic usage, it has great potential for the market.



Lithography Batch Produces Microcomponents

The Singapore Synchrotron Light Source (SSLS) has used the LIGA process to batch-produce microcomponents at low cost, following the completion of its Lithography for Micro/Nanotechnology facility. LIGA is a German acronym that stands for the main steps of the process, namely deep X-ray lithography, electroforming and plastic moulding.

Using micro/nanofabrication to tailor electromagnetic properties, SSLS has succeeded in producing the first microfabricated potential electromagnetic metamaterial (EM3). It is working in the far infrared or Terahertz spectral range that is currently of great interest to the biomedical field.

The institute also marked another milestone with its X-ray Absorption Fine Structure Spectroscopy that will equip local researchers with an unprecedented tool for chemical analysis and speciation.

Batch Fabrication of Microscopic Tip

Assoc Prof Wu Yihong from the Department of Electrical and Computer Engineering and his team recently made Magnetic Force Microscopy (MFM) more effective with an alternative MFM multilayer tip. Unlike other techniques, the tip is a first that allows for batch fabrication and a resolution close to the theoretical limit of a point-dipole tip.

This is a significant breakthrough as MFM, despite being one of the primary imaging tools for studying magnetic nanostructures, has always been bugged by two issues: tip-sample interaction and moderate (~50nm) spatial resolution. Current solutions, including focused ion beam trimming, electron beam induced deposition, and selective growth of magnetic material on carbon nanotubes, are unable to produce tips in a batch process.

Commercialisation of the new tip is being explored.

Highly Scalable Flash Memories with New-generation Quantum Dots

Flash memory devices are currently based on polysilicon



floating gate memory cells. Quantum dot floating gates made of nanocrystals could offer highly scalable flash memories with high-speed/low-voltage characteristics.

Recently, a new process and device stimulation has even made it possible for quantum dots to be self-assembled, thanks to the collaboration among researchers at NUS, the Institute of High Performance Computing and the Institute of Microelectronics.

Led by Assoc Prof Yoo Won Jong from the Department of Electrical and Computer Engineering, nickel and tungsten metal quantum dots have been developed, along with processes to form semiconductor quantum dots embedded in high-K materials using the chemical vapour deposition and sputtering techniques. The method allows for thinner "equivalent" oxide thickness, lower voltage, higher-speed operation and increased device lifetime. Results have been published in *Applied Physics Letters* and submitted to the 2004 IEEE Electron Device Meeting.



Visualise the Water Filtration Process

How can Singapore ensure a clean supply of water, especially potable water? It has to first solve the problem of the fouling of membrane used in water filtration.

Phase contrast imaging is a good way to do that, researchers from Singapore and Australia discovered. The team made up of Prof Herbert O Moser and Dr Yang Ping, at the Singapore Synchrotron Light Source (SSLS), Mr Adrian Yeo and Dr Tim White at Nanyang Technological University, and Prof Tony Fane of the University of New South Wales, developed a unique approach. The method, enhanced by X-ray absorption spectroscopy, can be used to look into the entire water filtration process particularly inside small pipes or fibres, the walls of which are the nanoporous polymer membranes.

Previously, there were no other ways to visualise the process in such detail, but now, the new technique allows one to understand how the filtration process works, right down to the deposition of the particles in the pores. Phase-contrast image of a polyacrylonitrile pipe used for the water filtration. Pipe axis is vertical, the walls are the darker grey zones delineated by black lines at both edges. The picture is 1mm wide. As water to be filtrated flows radially inwards through the wall, particles will eventually be deposited as can be seen at the left-hand edge.

Optimising Magnetic Performance in Nanostructures

After substantiating a century-old theoretical prediction by Horace Lamb, an English mathematical physicist, investigations by the Brillouin Group led by Assoc Prof Kuok Meng Hau from the Department of Physics have shown new use for the Brillouin light scattering technique. They found that it can be used to determine elasticity of nanoparticles such as phonon, a quantum of acoustic or vibrational energy. This will aid scientists in evaluating the elastic moduli of nanoparticles.

A spin excitation study on arrays of ferromagnetic nickel nanowires revealed the dynamic properties of spins found in nanomagnets of magnetic storage devices. The results will help determine the writing time in magnetic storage devices and contribute to researchers' development of future devices.



Composites for Low Reflectivity

Two types of composites have been studied at Temasek Laboratories at NUS (TL@NUS) for use in reducing reflection of electromagnetic waves.

Researchers have successfully synthesised a new series of barium ferrites, with resonance frequency of 2-16GHz, controllable by doping. A 3mm slab of composite materials containing 50% volume concentration of these ferrites is capable of attenuating the reflected electromagnetic waves by more than 10dB over the frequency range of 3-13GHz.

Fibre-loaded dielectric composites are another class of promising materials. The research team has gained much insight into the interaction of these composites with electromagnetic waves and has derived semiempirical formulae to guide the design of such materials to meet specific requirements.



New Techniques for Purer Reclaimed Water

The most common problem – membrane fouling – in water treatment plants employing reverse osmosis can now be modulated with a general framework.

This development comes after research work jointly undertaken by the Department of Civil Engineering and the Faculty of Medicine, together with Singapore's Ministry of the Environment and Water Resources, the Public Utilities Board and the Defence Medical and Environmental Research Institute.

Led by Prof Ong Say Leong, Centre for Water Research, Department of Civil Engineering, team members have created unique molecular techniques to detect and quantify microbial population in systems that enhance water quality. There are now state-of-the-art protocols to detect emerging contaminants and waterborne pathogens, besides a membrane ultra-compact biofilm reactor for water reclamation. Better systems are also in place for organic and nutrient removal.

The work is expected to help increase the purity of water and make water quality enhancement systems more cost-effective.

Fouling Control in Reverse Osmosis

With the increasing application of reverse osmosis (RO)

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in water treatment plants, an urgent need arises for a solution to a very serious problem – membrane fouling, which significantly increases the cost and shortens the lifetime of the membrane process.

In order to control fouling, a clear understanding of how fouling develops is necessary. A recent model developed by Assoc Prof Song Lianfa at the Centre for Water Research, Department of Civil Engineering, has provided this, making it possible for more costeffective control strategies to be developed.

His model allows the simulation of membrane fouling under various conditions in a full-scale RO process. With controlled simulation, he has shed light on the most sought-after question: how feed-water quality affects the rate of membrane fouling. The model is also the first that can predict when flux declines, an indication of membrane fouling.

The work will aid the choice of optimal pre-treatment method and operating conditions.





Oil washed up on beaches in Singapore results in adverse ecological impact

Environmentally-friendly Way to Clean Oil Spills

Conventional large-scale clean-up techniques may soon be a thing of the past with new biodegradation processes developed by Assoc Prof Jeff Obbard and his colleagues from the Department of Chemical and Biomolecular Engineering.

Cost-effective and efficient, the processes harness the natural capabilities of indigenous microorganisms in beach sediments to biodegrade harmful petroleum hydrocarbons. This is done by the manipulation of the foreshore microenvironment to create optimal conditions for bioremediation of oil-contaminated beach sediments. Using indigenous microbial biomass, even the most recalcitrant hydrocarbons associated with an oil spillage, including polycyclic aromatic hydrocarbons, have been destroyed.

The approach lowers costs dramatically when compared to conventional techniques, reduces economic and ecological impacts, and is definitely an environmentally-friendly alternative.

Spiral-wound reversed osmosis system for water reclamation

Imaging and Processing Data

Modern datasets in their many forms and sizes are presenting challenges for storage, transmission and display. As research continues for development of new technologies for data representation, multidisciplinary studies into imaging science, data processing and their applications are undertaken by a team in the Centre for Wavelets, Approximation and Information Processing and the Department of Mathematics.

To further develop the expertise in NUS, enhance international visibility and extend existing collaborations between the team in NUS and top researchers around the world, the Institute for Mathematical Sciences (IMS) organised a programme on ideal data representations and computational methods in imaging science. The purpose of this programme is to conduct multidisciplinary studies involving mathematical perspectives and foundation of imaging science and data processing. A total of 2 conferences, 4 workshops and 4 tutorials have been organised under the programme. In all, 82 visitors from 20 countries visited the Institute and a total of 268 participants attended the programme activities.

Underwater Acoustic Camera Scores a First

ROMANIS, or the Remotely Operated Mobile Ambient

Noise Imaging System, is the world's first fully digital and broadband underwater two-dimensional Ambient Noise Imaging (ANI) camera.

The device was developed by a team led by Dr Venugopalan Pallayil at the Acoustic Research Laboratory (ARL), Tropical Marine Science Institute (TMSI). The instrument relies on acoustic illumination provided by snapping shrimp to form images of underwater objects. In a further show of the cuttingedge technologies and innovation adopted in the field of underwater acoustics, the "eye" of this camera uses 508 sensors and 54 networked Pentium processors to form a Fibre Channel Arbitrated Loop. Such technology for data management is a first in an underwater acoustic system. Data is relayed at a rate of 1.6 gigabits per second.



ROMANIS has been successfully deployed twice in Singapore waters. ARL plans to use it to study the shallow water wave-breaking phenomenon and to detect buried objects underwater.

Mobile Users Get On-site Information

Electronic gadgets are shrinking in size. Mobile, wireless communication is now more sophisticated. Data is becoming more complex and multidimensional, or what is called spatio-temporal data, creating a problem in a new class of computing, also known as locationbased services (LBS) for mobile users.

LBS applications in surveillance, transportation systems, mobile communications, location-based service provider and geographical information systems (GIS) all require a more effective system to manage and process spatio-temporal data.

Prof Ooi Beng Chin and Dr Huang Zhiyong from the Department of Computer Science, and Dr Huang Bo from the Department of Civil Engineering, are working on SpADE (Spatio-temporal Autonomic Database System for Location-based Services), a system that can support location-based services. Structures to support spatiotemporal data will be developed too.



Counting Trees by Satellite

If you had to count the number of bricks in a wall, you would probably miscount one too many times. Faced with the same dilemma, managers at oil palm plantations could almost never accurately obtain tree count, know their conditions and the physical environment. With the crop's high economic importance in this region, this poses no small problem.

Recently, high-resolution IKONOS images from satellite imagery have allowed accuracy and views of plantations from many angles. This resulted in the development of an optimal procedure and a software prototype by a team headed by Dr Liew Soo Chin at the Centre for Remote Imaging, Sensing and Processing (CRISP). Trees can be located easily and tree intensity profile can be modelled.

The US Department of Agriculture, National Agricultural Statistics Service used the software in a pilot project and was so impressed with the solution's abilities to conduct large-scale inventory, that it ranked the software first among other well-established names. Images of oil palm plantation captured by IKONOS satellite

Close-up of oil palm plantation

Automatic Video Retrieval and Analysis

To address the need for effective tools to model, index and manage multimedia data, especially video, a team at the Department of Computer Science headed by Prof Chua Tat Seng is focusing on using the inherent audiovisual contents and external knowledge sources to perform the analysis and extraction of semantic concepts in video accurately and robustly.

The first project involves the development of automatic or semi-automatic annotators to attach one or more pre-defined concepts or keywords to an image/video. The researchers create a framework to incorporate multimodality and multiple knowledge sources to develop the annotators; they then extend it to automatically acquire and annotate multimedia contents on the web by also using the text data derived from the associated HTML text.

The second project focuses on news video processing, in particular, on the segmentation of news video into story units and retrieval of relevant news based on user's query. For news story segmentation, they employ a multimodality framework to segment news stories using the decision tree and hidden Markov model (HMM). In a public evaluation of news story segmentation at TRECVID 2003 organised by the National Institute of Standards and Technology, US, involving the processing of 120 hours of news video from ABC and CNN, their entry came in top. The team will make use of the audiovisual features, text extracted from automatic speech-to-text and semantic concepts of news video segments to perform the retrieval. Plans for techniques to perform questionanswering of news video are in the pipeline.

Quantum Cryptography Secures Information

Quantum mechanics has found unexpected applications in cryptography. As observations of a quantum system inevitably cause detectable disturbances, it is not possible for one to eavesdrop on a quantum encrypted message without leaving tell-tale signs. Based on this basic characteristic of quantum systems, eavesdropproof cryptographic techniques can be designed.

Prof Berthold George Englert, Assoc Prof Christian Kurtsiefer and colleagues at the Department of Physics are leading a project on quantum cryptography co-funded by Temasek Laboratories at NUS (TL@NUS). Prof Englert has discovered new protocols which improve on the previous standard in security and reliability. His results have been hailed by *New Scientist* as one of the top 10 science news. Assoc Prof Kurtsiefer is leading the effort to develop a system to demonstrate quantum cryptographic communications through air links.



partial differential equations that arise from materials modelling, complementarity problems, semidefinite programming (SDP), stochastic optimisation, generalised singular value problems, numerical linear algebra and computational control theory.

The team has made some significant achievements. Assoc Prof Toh Kim Chuan was awarded the NUS Outstanding Researcher Award in 2003 for developing SDPT3, a general-purpose software used to solve SDP. Assoc Prof Roger Tan Choon Ee and Dr Chu Delin developed an algorithm for computing the special coordinate basis (SCB). SCB is the main technical tool in several important control problems in linear system theory.

The researchers also managed to develop a moving mesh technique that incorporates adaptability and splitting procedures for the efficient handling of the time and space domains separately, so that parallel algorithms can be implemented for an important combustion model.

Cryptosystem Ensures Data Security

Data security is a crucial issue in military and commercial communications. Without sophisticated cryptographic schemes, it would not be possible for modern business, such as banking and e-commerce, to operate.

A team at the Department of Mathematics, comprising Prof Harald Niederreiter, Assoc Prof Ling San, and Assoc Prof Xing Chaoping, is leading the Coding Theory and Cryptography Programme of Temasek Laboratories at NUS (TL@NUS). They have applied deep results in algebra, algebraic curves and number theory to develop new methods, as well as sharpened existing results for data coding and encryption.

The team's work is internationally recognised and has contributed to the basic understanding and knowledge in this field. Some of the findings have already been applied in industrial software.

For their excellent research and outstanding contributions, Prof Niederreiter, Assoc Prof Ling and Assoc Prof Xing were selected winners of the National Science Award 2003.

Reliable Flight Control

One of the key considerations in the design of autopiloted flight vehicles is that the on-board flight control should be able to maintain stable flight after failures of actuators.

Investigators at Temasek Laboratories at NUS (TL@NUS) are working on a design methodology that guarantees stability and performance in different failure modes, without the need to retune in-flight control settings. The proposed methodology is a theoretical extension beyond the current robust control theory and requires development of new solution methods. The researchers have derived different iterative schemes, depending on the type of feedback configuration (full-state or dynamicoutput) at hand, to obtain the optimal closed-loop feedback gains. Work on the full-state feedback approach was presented at the American Control Conference (ACC) 2003 and received a Best Presentation Award.

Optimising Scientific and Mathematical Computing

A group at the Department of Mathematics is delving into numerical solution of partial differential and differentialalgebraic equations, multiscale methods for nonlinear

Study of Symmetries May **Change Future Mathematics**

Symmetry is more than drawing or admiring perfect proportions, as researchers of the subject will tell you. The study of symmetries - otherwise known as Representation Theory of Lie Groups - can bring about a whole new way future generations learn the number theory and mathematical physics. It is an important component in modern mathematics.

A new bioassay method to neasure endocrine disrupting

compounds

In a recent series of tutorials and a workshop organised by the Institute for Mathematical Sciences (IMS), attendees examined recent progress and future directions in three main areas of this study. These included representation of p-adic groups, unitary representation of real reductive groups, and multiplicity-free actions and representations.

The work led to better understanding of research developments, collaborations between local and overseas researchers, as well as the publication of a volume of the Institute for Mathematical Sciences Lecture Notes Series.

Measuring the Ill-effects of Marine Compounds

Many man-made chemicals that contaminate the marine environment such as plasticisers, pesticides A marine EDC bioindicator; green mussel Perna viridis

and flame retardants can become endocrine disrupting compounds (EDCs) that affect marine biota and reproductive health.

Traditional methods can only measure the effect of a single compound, not the combined effects of many. With many different EDCs in the environment, adding up the effects of individual compounds may not be an accurate reflection of certain combined effects.

After studying Singapore's marine environment to find out the level of EDCs in organisms and the water column, the Tropical Marine Science Institute (TMSI), in collaboration with the Department of Chemical and Biomolecular Engineering and Department of Obstetrics and Gynaecology, has developed a new bioassay method. It uses human cells to measure how certain EDCs combine to affect the function of sex hormone receptors at the cellular level found in the reproductive system.

Successful Production of Seahorses for Stock Enhancement

Singapore biologists have successfully developed a hatchery system to ensure sustained production and 2-month-old hatchery-reared juvenile seahorses

survival of juveniles of two local species of seahorses, *Hippocampus comes* and *H. spinosissimus*. The larger numbers of these seahorse juveniles have the potential to be useful environmental indicators in Singapore coastal waters.

8-day-old seahorse embryos

While they have achieved survival rates as high as 70% for *H. comes* and 90% for *H. spinosissimius* up to 2 months old on a regular basis in controlled environment, this may not be true in nature. To identify the suitable areas for restocking and stock enhancement of these creatures in natural surroundings, Dr Konda Reddy, Dr Juan Walford and Dr B Sivaloganathan at the Tropical Marine Science Institute (TMSI) are conducting field trials at Raffles Marina, Republic of Singapore Yacht Club and Pulau Ubin. Results thus far have been encouraging.

The institute is also investigating the use of frozen/ formulated feeds to replace the live food for which the seahorses are rather accustomed to. The development of hatchery technology for local seahorse species makes possible the enhancement of local stocks as well as commercial seahorse production, which is of interest to the traditional Chinese medicine industry.

Since regional differences play a strong role in logistics development, the study divided China into 6 traditional regions. Respondents were asked to report their network operations within each of the regions.

South Western China Eastern China Mid-South China North Eastern China North Western China North Western China

China Logistics Survey

The Logistics Institute - Asia Pacific (TLI-AP), the Georgia Institute of Technology, US, and the China Communications and Transportation Association have come up with comprehensive study reports from the results of two surveys.

Based on 35 leading domestic and multinational logistics service providers, the 2002 China Logistics Providers Survey provided an insider's look into China's logistics industry, its management norms, operations and demand for services in the country. Challenges, opportunities, future growth strategies and how companies deal with competitors were examined.

The following 2003 China Logistics Users Survey compiled feedback from 103 respondents on how they felt about services provided by third party logistics (3PL) providers.

Issues covered included selection criteria and usage of services, business impact, and comparative analyses of factors that influence use of 3PL. Other areas discussed included the expectations, various corporate needs in relation to necessity of 3PL services offered, reasons for non-usage and what would change a company's decision.

Supply Chain Models for Chemicals

The Logistics Institute - Asia Pacific (TLI-AP) is developing supply chain models that can accurately and effectively handle financial considerations such as taxes, duties and trade agreements. These can be impositions by governments or companies.

Recently, researchers at the Institute have developed a model for the capacity expansion of global chemical facilities that takes import duties and corporate taxes into account. Similar models for supply chain planning and operation are being developed to improve production, sourcing, and distribution. Preliminary models have also been developed to deal with the logistics of bulk shipping and container shipping of chemicals.

Optimising Supply Chain

Managers looking to optimise their e-supply chain management will be happy to learn of new methods that will solve multistage stochastic optimisation problems and enable online warehouse contract negotiation.

The School of Business has contributed its first paper by Prof Sun Jie on inventory systems that allow for random demand and discount. It was published in the flagship *Journal of Operations Research*. Two pioneer papers on analytic centre cutting plane methods to address semidefinite feasibility problems were similarly published by first-tier journals.

This research has been presented in seminars and international conferences, with the principal investigator invited as a plenary speaker in two of them. Workshops on semidefinite programming and urban transportation were met with overwhelming response.

HUMANITIES AND SOCIAL SCIENCES

How Labour Migration Impacts the Family in Southeast Asia

In this age of globalisation when work may mean a family member's extended absence overseas, what impact is there on family form and dynamics? This question and related issues such as the concept of an "ideal family", marital satisfaction, and the presence of foreign domestic workers within the Singapore family were explored by a research team, with members from the Departments of Geography and Sociology, the Institute of Policy Studies, and Scalabrini Migration Centre (Manila), led by Assoc Prof Shirlena Huang from the Department of Geography.

Surveys were conducted with women from 1,000 Singapore households followed by some focus group discussions and in-depth interviews with a selected number of respondents. Interviews were also conducted with members of 100 families in the Philippines that had at least one family member who is or has been an international migrant. The research helped shed light on the impact of globalisation, shifts in family roles and the influence of social issues on state policies related to work overseas and family in Singapore and the Philippines.

The findings could prove useful for formulating policies by government and government-related bodies

Negative emotions, stress and a bad social support network increase the chances of coronary heart disease

such as the Ministry of Community Development and Sports, Scenario Planning Office, National Youth Council, and the Feedback Unit of the Family Development Feedback Group.

A Look at Ageing in Asia

At the 2002 World Assembly on Ageing, the Population Division of the United Nations Department of Economic and Social Affairs reported that by 2050, the number of older persons (60 years and over) in the world will exceed the number of young (under 15) for the first time in history.

With the ageing world population, long-term care for the elderly has become a critical social and health issue. A shortage in caregivers, caused by changes in





family living arrangements and more women entering the workforce, has led to government and private sectors being pressured in producing solutions. Long-Term Care in the 21st Century: Perspectives from around the Asia-Pacific Rim and Ageing and Long-Term Care: National Policies in the Asia-Pacific, written by Assoc Prof Kalyani Mehta at the Department of Social Work and Psychology look at local and regional policies surrounding this issue.

Happy Thought, Healthy Heart

Negative emotions, stress and a bad social support network increase the chances of coronary heart disease (CHD) and affect recovery after coronary artery bypass grafting (CABG) surgery, concluded a recent trial done in collaboration with the National Heart Centre of Singapore.

throws focus on Substantiating traditional belief that shock or stress long-term care is bad for the heart, Prof George D Bishop from the

> Department of Social Work and Psychology and his team gathered CABG patients randomly and through workshop intervention, taught them techniques to cope better with difficult life situations. Practical tips helped them develop stronger social relationships.

Results were heartening. Even a good three months after the workshop, depression, trait anger and perceived stress continued to be low. Resting heart rate, blood pressure and the heart's response to stress went down, demonstrating that a workshop was clearly more effective compared to just providing information where patients showed negative or no changes.

Impact of the Internet on Politics

Rethink the assumption that greater penetration of technology naturally produces greater social impact, says Dr Cherian George of the Asia Research Institute (ARI).

His research into the political use of the Internet compares Singapore and Malaysia. He observes that although Singapore has far higher levels of Internet penetration, the medium is not used as creatively and at such advanced levels as in its neighbour.

The independent Malaysian website Malaysiakini, for example, produces daily editions challenging the perspectives of government-controlled news media. The island republic has no equivalent.

He explains this "penetration-participation paradox" further in an *ARI Working Paper* and a forthcoming monograph.

Infocomm Not Bridging Social Gap

Information-communications technologies (ICTs) may be effective in overcoming geographic and time barriers, but do not necessarily make cultural and social differences disappear. To-date, studies on the uses and effects of ICTs in an intercultural context are rare and there is little understanding on their formal impact.

Dr Cho Hichang of the Information and Communications Management Programme aims to examine how technological properties interact with social and cultural factors in social organisations. His research looks at the extent to which computer-mediated communication (CMC) properties mediate group members' efforts to overcome intercultural differences when collaborating on a group project using CMC tools.

> Malaysians are more advanced and creative in their use of the Internet for political purposes, despite Singapore having higher levels of Internet penetration

Study Analyses Law on Patients' Rights

Through the last decade, the area of medical negligence has grown exponentially, and the number of appeals to the highest appeal courts in England, Australia and Singapore has been escalating as well. Patients clearly seek higher autonomy as they become more sophisticated.

As Singapore decides between adopting restrictive medical laws and a more liberal, pro-patient approach, a team of researchers at the Faculty of Law has addressed the need to analyse the scope of a medical practitioner's duty, his or her care, and the standard of care in cases of medical negligence.

Their findings from the first major comparative work done here showed that the local medical and legal professions do not fully recognise the evolving dynamics of doctor-patient relationship.

They also examined patients' rising awareness of their rights, and assessed compatibility of a rightsbased approach with a duty-based approach in the tort of negligence.

The refreshing work that looks beyond the common law jurisdiction will provide theoretical and doctrinal analysis to help shape the law.



Singapore Unearths 14th Century Artifacts

Construction work at the old Parliament House uncovered a new archaeological site, unearthing Singapore's first intact 14th century artifacts. Among the finds were eight intact jars, nine pieces of Chinese stoneware of the type termed "mercury ware", and probably one of the oldest examples of a Malay keris, or stabbing sword. According to Assoc Prof John Miksic of the Southeast Asian Studies Programme at the Faculty of Arts and Social Sciences, the blue and white pattern on fragments of porcelain found suggested that they dated back to the Yuan Dynasty (1279-1368), when techniques for painting cobalt-blue underglaze onto raw porcelain was developed.

Students from Queensway Secondary lending a helping hand in retrieving artifacts



Fragments of a bowl in the form of a compass found at Ford Canning. Early 14th century Chinese characters under the glaze gives names for compass directions.

The quantity and variety of artifacts uncovered by Assoc Prof Miksic and his team on their expeditions in various parts of Singapore have provided further insight into trading ties and patterns of ancient Singapore.

Chinese Architecture Goes Modern

Chinese architecture is reinventing traditions for the modernisation process, reveals Dr Li Shiqiao in his latest research.

The Director at the Centre for Advanced Studies in Architecture, Department of Architecture examines lucid examples in which Chinese architecture was reworked to embody an identity, the circumstances in which this took place and their connections to established intellectual traditions.

Dr Li's papers have been published in international refereed journals such as *Journal of Society of Architectural Historians* and *Journal of Architectural Education*. He has presented papers at the International Conference on Chinese Architecture at the University of Pennsylvania, US, and International Conference on Chinese Architecture. The completed Yunnan Elementary School Expansion and Community Centre

Yunnan Architecture Translated into School

Researchers at the Department of Architecture, led by Assoc Prof Li Xiaodong, have taken their study of native Lijiang architecture in China's Yunnan province a step further.

After investigations spanning folklore, structural engineering, sociology and aesthetics to understanding environment, social and building conservation on the UNESCO World Heritage site, the team interpreted their results into actual construction and completion of a real project – Yuhu Elementary School Expansion and Community Centre.

It broke new ground in the possibilities of curriculumbased hands-on projects. The work also filled a research gap in this important discipline, and offered an alternative framework to sustain native architecture.

Several book citations, publications, an architectural and photographic exhibition, and a fully-funded invitation to present at an international forum are proof of the team's achievements.



- * About 1,000 collaborative projects each year
- * Synergy with international, regional and Singaporean partners
- * Extensive network of alliances complements NUS expertise
- * Strong relationships between academia, industry and government



Research Collaboration

New Way to Treat Malaria

For the two million deaths that happen annually owing to malaria, a solution may soon be available to block cell changes caused by the parasite *Plasmodium falciparum*.

The Division of Bioengineering, Department of Mechanical Engineering as well as the Department of Microbiology of NUS have joined hands with a group of researchers in Massachusetts Institute of Technology (MIT), Ohio State University and the Institut Pasteur to study the way red blood cells (RBCs) were infected, modified, fed on and destroyed. Infected cells became more rigid, causing blood vessels to clog, and subsequently resulting in coma and possibly death.

The research traced various stages of the parasite's development in RBC to understand cellular changes and how soon cells were affected by rigidity. The role of genes in cell modification was also investigated. Blocking the changes with drugs may lead to treatment





The team's achievements included invitations to lecture at Johns Hopkins University and MIT in the US, as well as to talks at international conferences in Japan and the US.

Carcinogens and Anti-oxidants That Affect Colonic Health

Prof Barry Halliwell, Department of Biochemistry, NUS, and Prof Ong Choon Nam, Department of Community, Occupational and Family Medicine, NUS, together with Prof Joseph Rafter of Karolinska Institute, Sweden, have achieved a first with their recent findings.

The researchers have identified potential new colonic carcinogens and anti-oxidants that affect metabolism in the colon. No such data currently exists on the extent to which dietary anti-oxidants reach the colon and how they are metabolised by colonic cells and faecal bacteria.

The researchers also examined the different levels of anti-oxidants in Western and Asian diets, and their subsequent impact on faecal water. This was in line with their objectives to identify toxic agents in faecal water, study the mechanism of toxicity and hyperproliferative response in colon cells.

Big-scale Cohort Study of Chronic Diseases

The Singapore Chinese Health Study is a collaborative research project between the Department of Community, Occupational and Family Medicine, NUS, and the Department of Preventive Medicine, University of Southern California. The two principal investigators are Prof Lee Hin Peng and Prof Mimi Yu from the two universities respectively, with several faculty members from the two departments participating as co-investigators. The study has been supported by grants from the National Cancer Institute, US, since 1993, and thus far, it has been awarded a total of about US\$8 million.

Researchers aim to establish a stable cohort for long-term study of dietary and other environmental determinants of chronic diseases and understand how different classes of food and micronutrients can either play an aetiological effect on these diseases, either independently, or interactively with other factors. So far, 26 scientific reports have been published from this study in leading medical journals.

In 2003, two sub-studies using the same cohort, entitled "Mammographic Density in Chinese Women Participating in the Singapore Cohort Study of Diet and Cancer" and "Dietary and Genetic Factors in Asthma and Chronic Bronchitis in the Singapore Chinese Cohort Study", were awarded research grants by the National Institutes of Health, US, to begin research work in Singapore.

Neuroreceptor Responsible for Fear

Researchers at the Department of Pharmacology, NUS, are working with Prof J Spiess at Max Planck Institute for Experimental Medicine, Goettingen, Germany, to investigate the role of the CCK2 (cholecystokinin) peptide receptor in regulating fear and anxiety.

To study this effect in detail, C57BL/6J mice have been used and work is in progress to delete the CCK2 receptor gene in these animals using transgenic technology. Once this is done, behavioural analysis will focus on changes in these animals related to behaviour and associative learning. The mice will also be examined under different environments of fear conditioning.

Tests with the CCK analogue, CCK4, also showed that the neurotransmitter, corticotropin releasing factor (CRF), mediates part of the action of this peptide. CRF is known to play a critical role in coordinating the overall response of the body to stress. These studies will further our understanding of the involvement of both CCK and CRF systems in fear and anxiety.

A small scaffold with a human hair

and the lot be full

Robotic Microassembling for Tissue Engineering

NUS researchers have developed a novel robotic microassembly technique to fabricate scaffold and cell constructs. The process will allow for better control over biological agents such as proteins and their threedimensional distribution.

Researchers from the Department of Mechanical Engineering, NUS, in collaboration with the Swiss Federal Institute of Technology (EPF-Lausanne), the Centre for Automation Technologies, Rensselaer Polytechnic Institute, US; and Singapore's MicroMachines Centre, Nanyang Technological University, have developed microscopic building blocks and a monolithic shape memory alloy microgripper for the process. The microgripper grasps and moves microparts for precise assembly; the cleaving is seamless due to contact forces.

250 um

Microbuilding block

A large scaffold visible to the naked eye





The Robotics Team and their trophies

Nanoparticles Detect Pathogens

Researchers at the NUS Nanoscience and Nanotechnology Initiative (NUSNNI) have succeeded in using nanoparticles as fluorescence detection reporters in immunological and DNA assays, thanks to their latest invention – a singlechannel weir-type filter chip.

In trials, the chip proved capable of multiplex detection when introduced to two important waterborne parasitic protozoa, namely *Cryptosporidium parvum* and *Giardia lamblia*. Using immunological probes labelled with nanoparticles such as quantum dots, both pathogens were concurrently trapped and detected.

The microfluidic filter chip is an excellent platform compared to existing methods for protozoa detection. In addition to increased efficiency in abilities such as cell trapping and labelling, the chip offers reproducibility, low reagent costs and higher detection sensitivity.

The inventors have produced two research publications and delivered three conference presentations based on the results.

New Materials Developed for Information Storage

The "Information Storage Materials" project, headed by Temasek Professor Charanjit Singh Bhatia, Department of Electrical and Computer Engineering, NUS, studied the physics and developed improved means to fabricate a new generation of materials for information storage. These included magnetic nanostructures and optical memory materials.

The Lab has local collaborations with Data Storage Institute and Institute of High Performance Computing as well as international links with Hitachi Global Storage Technologies, San Jose, and Stanford University.

> Multitarget sputtering machine in ISML Class 100 cleanroom





Humanoid Robot Won World Cup

RoboSapien, the brainchild of a group of engineers, has done its inventors proud.

The autonomous humanoid robot won first place in the FIRA Robot World Cup 2003, Humanoid Category, held in Austria. This is the culmination of the efforts and ingenuity of the research team in the Centre for Intelligent Control, Institute of Engineering Science (IES).

The multidisciplinary project makes use of technology from different areas – mechanical design, motor controls, real-time embedded systems, machine vision and artificial intelligence. The robot possesses a wide range of sensors, including vision, force sensors, tilt sensors, magnetic compass and infrared sensors, to perceive and react to the environment. Besides walking, avoiding obstacles and climbing stairs, the robot also plays football; it can seek, dribble and kick a ball into the goal.

Alloy Electroplating Using Synchrotron Radiation

The Singapore Synchrotron Light Source (SSLS), NUS, is collaborating with numerous international groups, among them the team of Prof Monika Saumer who is an expert in electrochemistry and microsystems technology at Kaiserslautern University of Technology in Germany. The collaboration is in alloy electroplating using synchrotron radiation diagnostics from the X-ray diffraction and absorption spectroscopy to the phase contrast imaging (PCI) beamlines, and microfabrication for special experimental set-ups.

There is a also a long-standing cooperation with the group led by Dr Yeukuang Hwu of Academia Sinica,





Prof Saumer discussing phase contrast images of electroplated structures with members of Dr Hwu's team

Taiwan, on various topics of phase contrast imaging. Dr Hwu is a global key player in this technique and was instrumental in the fast set-up of the PCI beamline at SSLS by contributing equipment and manpower.

A phase contrast image of cells of a leaf including stomata. Microradiograph of a hippeastrum leaf taken with broadband (unnonochromatised) X-rays at SSLS's (unnonochromatised) X-rays is 1.5mm x PCI beamline. The image size is 1.5mm x PCI beamline. The image size is 1.5mm x skin membrane. The arrows identify three skin membrane. The arrows identify three of the stoma cells.

Energy-saving Method to Improve Indoor Air Quality

It all started with the "Strategic Partnership towards Excellence in Indoor Environment and Energy" between the Department of Building, NUS, and the Technical University of Denmark.

Now there is a method that greatly enhances ventilation, air quality and thermal comfort in airconditioned buildings. Developed from a project entitled "Evaluation of Energy Efficient Personalised Air Units for Enhanced Ventilation in the Tropics", the energy-saving approach does away with recirculated air that is contaminated with indoor pollutants.

In another project entitled "Productivity and Indoor Environmental Quality (IEQ)", bad air quality was found to affect operators' performance at call centres. A neural-behavioural model gave new insight into humans' responses to indoor air quality. Findings were presented at the International Healthy Buildings 2003 Conference. Illustration of the experimental set-up (with cutaway showing a target) and dolphin during task

Improved Understanding of Dolphin Sonar Could Lead to Better Sonar Systems

Using highly stereotyped echolocation clicks, dolphins are able to recognise shapes and form images of targets ahead. This was proven in trials by the Acoustic Research Laboratory (ARL) at the Tropical Marine Science Institute (TMSI). Researchers observed that as a dolphin approached a target, it could integrate echo returns received over different angles, so gathering a high-resolution representation of the object.

This sonar system, known as the incoherent synthetic aperture sonar, is far more superior to any man-made



Results of the modelling of a diamond shape target using an artificial dolphin-like click signal simulating the use of incoherent synthetic aperture sonar

sonar system, requiring very little energy within a fairly low frequency range.

With this model, the team developed new algorithms that increase beam forming and shape-resolving capabilities of improved biomimetic sonar systems.

Such studies are part of education and conservation efforts of ARL and The Dolphin Institute, a non-profit arm of Kewalo Basin Marine Laboratory in Honolulu, Hawaii.

To achieve a global, trans-climatic model in indoor environment and energy, ongoing research is being conducted, including a joint PhD programme.

Monitoring Organic Pollutants on East Asia's Coasts

The National Project Coordinator of the United Nations University Programme on the East Asian Coastal Hydrosphere has gone from developing a monitoring programme for the coastal environment in East Asia to making it an ongoing one.

Prof Lee Hian Kee at the Department of Chemistry, NUS, is focusing on finding out the extent of damage

A group of trainees undergoing instruction at an instrumental analysis workshop, as part of a capacitybuilding exercise that is also an important component of the United Nations University project



that persistent organic pollutants cause, especially endocrine-disrupting compounds. By constantly watching out for emerging pollutants, he seeks to gather such information through miniaturised extraction techniques that generate virtually no waste. Existing conventional procedures produce up to several litres of waste toxic solvent after each analysis.

The programme is a collaboration with Dr Matahoshi Morira at the National Institute of Environmental Studies (NIES), Tsukuba, and Prof Emeritus Keichiro Fuwa from the University of Tokyo and United Nations University. Other scientists of NIES and the region's national project coordinators are also involved.



Vivaldi antenna array with 50X50 elements: broadside beam (left), scanned beam at 45 degrees (right)

Fast Computational Algorithms for Electromagnetics

Two joint projects with American universities led by Mr Gan Yeow Beng of Temasek Laboratories at NUS (TL@NUS) have yielded good results.

In a joint effort with the Ohio State University, two fast algorithms have been developed for computing electromagnetic wave radiation and scattering. One of these is among the fastest available currently to the international computational electromagnetic community – it can solve a 980-million-unknown vector Helmholtz equation by Galerkin-FEM method with domain decomposition in about 12 hours on a Pentium IV computer with 1.37GB RAM.

Another project with the Naval Postgraduate School has succeeded in defining the design specifications and developing prototypes for new antennas for use in unmanned airborne vehicles.

Improved Aerodynamic Computations and Designs

Dr Tsai Her Mann of Temasek Laboratories at NUS (TL@NUS) is collaborating with Assoc Prof Feng Liu of the University of California, Irvine, on two topics: numerical simulation of aerodynamic flutter at transonic speed and aerodynamic shape optimisation.

Various methods, such as overset grids and meshless numerical methods, have been developed to facilitate the computation of flows around complex, dynamic boundaries. For qualitative investigations, perturbations of the boundary conditions are used to mimic the motion of the surface. This method is found to produce very accurate results with great saving in effort for computing the complex flow-structure interactions.

A comprehensive set of software for optimisation has been developed based on genetic algorithms and other computational intelligence techniques. For refining the solutions at local optima, methods based on the adjoint equations are developed. These methods have been applied to the design of aerodynamic shapes such as turbomachinery blades. Current effort is to extend the software to apply to full threedimensional complex structures.

High-level Design Methods for Embedded Systems

More formal design methods are needed for reactive embedded systems. Prof Thiagarajan from the School of Computing, NUS, is collaborating with Prof Amir Pnueli and Prof David Harel at The Weizmann Institute of Science, Israel, to develop high-level design methods for embedded systems. Their goal is to come up with system description methods based on different scenarios, along with tools to automatically compile them into executable code.

In another joint project, Prof Thiagarajan is developing unified modelling language (UML)-based description methods of embedded systems with Dr Joseph Sifakis, Dr Oded Maler and their groups at Verimag and Centre National De La Recherche Scientifique in France.



The flowchart illustrates how video is directly indexed in the compressed domain making it easier to extract relevant information



Delving into Stein's Method on Randomness

In honour of Charles Stein and his method that delves into fields such as geometric random graphs and random matrices, the Institute for Mathematical Sciences (IMS), NUS, organised a series of talks and lectures, co-chaired by Prof Andrew Barbour from the University of Zurich and Prof Louis Chen of NUS.

Participants looked into various aspects and applications of Stein's method, including its historical developments and the extensive progress since its beginning.

The tutorial and workshop held were attended by about 50 researchers, many of whom started new projects or continued with their collaborations. Nine papers were generated between local and overseas researchers as a result of the joint work.

Smart Video Search

A software system now makes it possible to compile digital image albums by retrieving images using visual keywords. Images are first developed by placing visual keywords in appropriate locations. A neural network that learns these keywords then searches for the images with efficient graph matching. Assoc Prof Mohan Kankanhalli from the NUS Department of Computer Science and colleagues at the Institute of Engineering Science (IES) have also designed a semi-automated indexing scheme for extraction of relevant information from videos so as to put together digital video albums.

For the management of home videos, two sub-systems have been developed. One is specifically for automatic generation of videos while the other speeds up editing process with an intelligent editing interface.

Results of this collaboration with Dr Philippe Mulhem at the French National Centre for Scientific Research (CNRS) have been featured in top multimedia and computer vision conferences.

Economic Relationships through Global Networks

The complex production network of firms in East Asia

and the European Union (EU) have created a nexus of economic relationships among the countries. By looking into the production and distribution links shared by EU, East Asia and Eastern Europe, this project examined the extent of connections between countries and subsequent implications on national and local development.

The three-year project bore fruit with five papers published in internationally-refereed journals/books, one business-related publication, production of eight working papers and discussions with senior political officials from Geneva, Hungary and Malaysia. A book-length monograph and further journal articles are planned.

Researchers involved were Assoc Prof Henry Yeung from the Department of Geography, NUS, Prof Peter Dicken from the University of Manchester and Prof Jeffrey Henderson from the Manchester Business School, UK.

Affective Feelings Influence Brand Perception

How much does a consumer's affective feelings influence personal evaluations on brand extensions? That was an issue examined in a recent collaboration between Dr Catherine Yeung of the Department of Marketing, NUS, and Prof Robert Wyer, Hong Kong University of Science and Technology.

Past research on branding has suggested that what consumers perceive as similarities and product categorisations are in mitigation with affective feelings. But here, researchers drew a line between evaluations based on affective feelings and evaluations after one had drawn parallels between a parent brand and its extension.

They found that affective feelings alone can have a direct impact and be the basis of how one sees and judges a brand extension. Arising spontaneously, these emotions can happen before any comparisons are made with the parent brand, propose the researchers. Thus past perceptions may actually have minimal effect.

The findings represent the first formal study in the field.



Two ways to design the berthing template for 5 vessels. Template B is a better design, compared to template A, as it has additional buffer time capacity deliberately built into the design.

Decision Support for Sea Cargo Industry

Of the many operational and strategic activities in the sea cargo industry, issues on modelling and optimisation abound.

The Logistics Institute - Asia Pacific (TLI-AP), NUS, and the Georgia Institute of Technology, US, have jointly developed the Berth Template Design System and a new revenue management system. Both projects provide leading-edge decision-support tools and operational solutions to the sea cargo industry.

Not settling for flawed berthing plans, the team turned years of unpredictable operation plans, as well as issues such as forecast deviation and consequential added costs to their advantage, when they came up with a more robust design system.

The new management system selects the best cargo mix in a vessel carrier operation. A prototype

optimisation engine is currently under development to cater to multiple cargo types that generate different sources of revenue.

Comparing Laws Against Terrorism

Assoc Prof Michael Hor and Dr Victor Ramraj from the Faculty of Law, NUS, are cooperating with Prof Kent W Roach from the University of Toronto, Canada, to plan and convene a major research symposium in Singapore. Set to bring together experts and leading academics from around the world, the initial electronic interchange will compare and examine anti-terrorism laws and policies in Asia, North America, Europe and Africa.

A subsequent meeting in Singapore will finalise the publication of a volume of approximately 20 essays on "Comparative Terrorism Law and Policy".

The researchers hope that information shared will help introduce a comparative anti-terrorism law and policy component at the Faculty of Law.



- * More than 100 research awards garnered each year
- * International recognition for inportant contributions
- * Accolades evidence of passion in the push for excellence
- * Appointments in prestigious academic bodies that impact society



Research Awards

INTERNATIONAL AWARDS

Fellowship (ad eundem) of the Royal College of Obstetricians and Gynaecologists of United Kingdom/ Asian Innovation Awards

Stem cells can transform themselves into any cell in the human body, depending on instructions from the genes within. Prof Ariff Bongso from the Department of Obstetrics and Gynaecology was the first person in the world to isolate the stem cells from a five-day-old human embryo. He published in the journal *Human Reproduction* that the cells could transform into any

An Excellence Award for Prof Ariff Bongso for his stem cell research



cell in the body. Later, he successfully grew a human embryonic stem cell line without mouse cells. This removed previous risks of pathogens jumping from animal to human cells, and marked the start of safe clinical applications.

For his significant contribution, Prof Bongso was awarded a Fellowship (ad eundem) by the Royal College of Obstetricians and Gynaecologists, and the Excellence for Singapore Award in 2003. He was also the gold winner at the Asian Innovation Awards 2002.

Outstanding Service in Prevention of Blindness Award

For his significant contributions to the prevention of blindness and sight restoration, Dr Wong Tien Yin from the Department of Ophthalmology was presented the Outstanding Service in Prevention of Blindness award in 2003 by the Asia Pacific Academy of Ophthalmology (APAO).

(from left) Dr Allen Yech, Prof Wong Lim Soon, Dr Li Jinyan and Ms Liu Huiging



A multidisciplinary team has developed a groundbreaking diagnostic method that offers 95% accuracy in the detection and diagnosis of childhood acute lymphoblastic leukaemia sub-types. Developed by Dr Allen Yeoh of the Department of Paediatrics and his team-mates from NUS-affiliated Institute for Infocomm Research (I²R), Prof Wong Lim Soon, Dr Li Jinyan and Ms Liu Huiqing, the technology bagged the gold medal in The Asian Innovation Awards in 2003 for its definite impact on the medical community.

Tomizo Yoshida Awards

Prof Yoshiaki Ito, an adjunct professor at the Department of Medicine who is the pioneer for work on RUNX1, RUNX2 and RUNX3 genes, has discovered the molecular mechanisms of these genes in the production of cancerous cells. For his contributions, Prof Ito received the Tomizo Yoshida Award by the Japanese Cancer Association in 2003.

Craniofacial Biology (IADR 1995 Prize) Research Award

The International Association for Dental Research has awarded Assoc Prof Kelvin Foong and his team the Craniofacial Biology (IADR 1995 Prize) Research Award in 2002. The recognition was for the Faculty of Dentistry team's success in determining the "Expression of Nitric Oxide Synthase (NOS) in Palatal Wound Healing". Their findings give useful insights to wound healing in human hard palates.

Richard Spruce Award

Assoc Prof Benito Tan from the Department of Biological Sciences is officially Asia's most outstanding bryologist in moss research. He was chosen by the International Association of Bryologists for the prestigious Richard Spruce Award at the XV World Congress on Bryology in 2004.

Andrew Fraser Prize

Ms Xu Chengyu, a PhD student at the Department of Mechanical Engineering researching under Prof Seeram Ramakrishna, published a paper entitled *Aligned* Biodegradable Nanofibrous Structure: A Potential Scaffold for Blood Vessel Engineering. The work clinched the runner-up prize at the 2003 Andrew Fraser Prize Award, an annual competition in search of the best paper and presentation by postgraduate students.

Humboldt Research Award

In 2003, Prof Colin Sheppard became the first Singapore-based recipient of the Humboldt Research Award. This award is given by the Alexander von Humboldt Foundation to foreign scientists and scholars with internationally recognised academic qualifications. The researcher from the Division of Bioengineering was also given 50,000 Euros for his lifetime accomplishments in research and teaching, particularly his recent collaboration on tight focusing of light.

Best Paper Award, IEEE Transactions on Semiconductor Manufacturing

Assoc Prof Ho Weng Khuen and Ms Lee Lay Lay from the Department of Electrical and Computer Engineering won the IEEE Transactions on Semiconductor Manufacturing Best Paper Award in 2003 for their paper on *Realtime Predictive Control of Photoresist Film Thickness Uniformity.* The project was a collaboration between NUS and Stanford University.



IEEE award presented to Assoc Prof Ho Weng Khuen (centre)


Prof Goh Thong Ngee (right) recognised internationally for his contribution in quality engineering

Best Paper of the Year Award, Computers & Chemical Engineering Journal

Assoc Profs R Srinivasan and I A Karimi and their student Mr N Julka from the Department of Chemical and Biomolecular Engineering won the 2002 Best Paper Award for their paper entitled Agent-based Supply Chain Management, Parts 1 & 2 in the Computers & Chemical Engineering Journal published by Elsevier Science. The paper was cited for providing a unified and comprehensive framework for modelling, monitoring, and managing chemical supply chains.

Fellow of ASQ

For his "continuous outstanding contributions to the quality profession", Prof Goh Thong Ngee from the

Department of Industrial and Systems Engineering has been elected a Fellow of the Society by the American Society for Quality (ASQ) board of directors. He was honoured during the Annual Quality Congress of ASQ in 2002.

MIT *Technology Review's* List of Top 100 Young Innovators

Technology Review, a technology magazine of Massachusetts Institute of Technology (MIT), has put Dr Lee Der-Horng on its TR100 list in 2002 as one of the world's 100 Top Young Innovators. The researcher from the Department of Civil Engineering had applied traffic microsimulation and methodologies to online data that was developed into new decision rules for Intelligent Transportation Systems (ITS).



Dr Adekunle Olusola Adeyeye from the Department of Electrical and Computer Engineering has also won the same recognition for his work on spin electronics. It is one research field of growing importance for its potential impact on ultra-high density data storage media and magnetic random access memory.

NAMS Best Student Paper Awards

Mr Ma Shengwei, a graduate student from the Centre for Water Research (CWR), Institute for Engineering Science (IES), was awarded a Best Student Paper Award in 2003 by the North American Membrane Society (NAMS). The paper Numerical Simulation of the Effects of Spacer on Concentration Polarization in Spiral Wound Reverse Osmosis Modules was co-authored by Assoc Prof Song Lianfa, Prof Ong Say Leong and Prof Ng Wun Jern. This is the second year in a row that a graduate student from CWR has received a Best Student Paper Award from NAMS.

Dr Lee Der-Horng (left) and Dr Adekunle Olusola Adeyeye (right) are top young innovators

ACM SIGMIS Best Doctoral Dissertation Award

Dr Atreyi Kankanhalli from the Department of Information Systems won the Association for Computing Machinery Special Interest Group on Management Information Systems (ACM SIGMIS) Best Doctoral Dissertation Award in 2003 for her PhD thesis Understanding Contribution and Seeking Behaviour in Electronic Knowledge Repositories. This honour is given only to the best doctoral dissertation worldwide in the field of information systems.

President of Institute of Mathematical Statistics

Prof Louis Chen from the NUS Institute for Mathematical Sciences (IMS), has been elected President of the Institute of Mathematical Statistics in

Prof Louis Chen elected President of the Institute of Mathematical Statistics in 2003



2003, which is the US-based society in probability and statistics. In the Institute's 65-year history, there was never a Singaporean or ethnic Chinese who had served as the president. Prof Chen was also the first Asian to become the President of Bernoulli Society for Mathematical Statistics and Probability based in Europe.

SIOP Distinguished Early Career Contributions Award

Assoc Prof David Chan was the first non-American to receive the Distinguished Early Career Contributions Award. Presented by the Society of Industrial and Organisational Psychology (SIOP), the researcher from the Department of Social Work and Psychology was also the only recipient of the award in 2003.

SIOP, the world's largest psychological association, gave the award in recognition of Assoc Prof Chan's important contributions in areas such as personnel selection, longitudinal modelling, multilevel issues and work adaptation in industrial organisational psychology.



(from left) Mr David Anderson, Public Affairs Officer, US Embassy Singapore and Assoc Prof Victor Savage, President, Fulbright Association of Singapore presenting Assoc Prof Henry Yeung with the Fulbright Foreign Research Award

Fulbright Foreign Research Award by the Bureau of Educational and Cultural Affairs of the US Department of State

The Fulbright Foreign Research Award was established by the US Government as part of a flagship education exchange programme of international standards. Grants allow university faculties and professionals to better their academic and professional expertise through collaborations with American colleagues.

One person who benefited from the award in 2003 was Assoc Prof Henry Yeung who completed his book project entitled *Reshaping Chinese Capitalism in a Globalising Era* in the four-month grant period. A member of the Department of Geography, his book was published by Routledge (London) as *Chinese Capitalism in a Global Era*.

Australian National University Humanities Research Centre Award

A Fellowship awarded and funded by the Humanities Research Centre, Australian National University (ANU) for 2003, paved the way for an eight-week attachment to the ANU for Prof Lily Kong. The then Dean of the Faculty of Arts and Social Sciences was to find out how secular spaces contributed to religious identity, life, and the community in contemporary urban society, or perhaps challenged the maintenance of them all. Spaces studied were public museums, schools, domestic spaces and technological spaces.

Academic Prize at the 13th & 14th Fukuoka Asian Culture Prizes

The Academic Prize presented at the Fukuoka Asian Culture Prizes is given to individuals or groups who have made outstanding achievements in work that contributes to the value, awareness and promotion of Asian culture around the world.

In 2002, Prof Anthony Reid, Director at the Asia Research Institute, received the Academic Prize for his impactful historical research, which resulted in the creation of a different historical viewpoint of the region.

In 2003, Prof Reynaldo Ileto, Coordinator of the Southeast Asian Studies Programme, Faculty of Arts and Social Sciences, received this recognition for his fresh perspectives on social and political movements, particularly on grassroots masses and marginalised people of society.

Suzhou Graduate Campus City International Competition

Prof Heng Chye Kiang walked away with the best conceptual design and presentation of a 9.8km² Graduate Campus City to house a comprehensive university and up to ten graduate schools. As a consultant of Singapore's Public Works Department responsible for the scheme, the Head of the Department of Architecture led his team to beat strong international competitors. The 2002 design competition was organised by the Suzhou Industrial Park Education Development and Investment Company.





Assoc Prof Joseph Lim's winning treehouse

Kenneth F Brown Asia Pacific Architecture Award, Honourable Mention

It was a humble treehouse that earned Assoc Prof Joseph Lim Ee Man from the Department of Architecture honourable mention at the 2002 Kenneth F Brown Asia Pacific Architecture Award. Lee Treehouse stood out among 120 projects submitted by more than 15 countries for the competition organised by Architects Regional Council Asia and University of Hawaii School of Architecture. The refreshing project provides a demonstration of the harmonious co-existence of an old tree in Singapore and a modern steel-framed, multilevelled, timber-slatted treehouse.

For his sustained efforts and contributions to defence R4D, Prof Lim Hock was awarded the 2003 Defence Technology Prize



OISTAT International Theatre Competition

A team at the Department of Architecture, led by Ms Belinda Ho and Assoc Prof Li Shiqiao, clinched second prize at the OISTAT International Theatre Competition in 2003. OISTAT, the International Organization of Scenographers Theatre Architects and Technicians, chose the Singapore design of a 400-seat theatre out of 250 entries from 38 countries.

SINGAPORE AWARDS

Tan Kah Kee Young Inventors Award

Ms Renuga Gopal, a postgraduate student at the Division of Bioengineering, has found that composite technology can be used to develop aesthetic yet flexible archwires in orthodontic fixed appliances, compared to the conventional pultrusion process. A patent is pending for this work that won her the Tan Kah Kee Foundation Young Inventors Award in 2003. The project was supervised by Prof Seeram Ramakrishna and Dr Loh Poey Ling.

Innovator Award

A year of conceptualising and interaction with teachers and students resulted in a product for Internet-based mathematics learning. It also earned Dr Soh Pek Hooi from the School of Business, NUS, and a team of engineers from the industry the 2002 Innovator Award. The award by the Prime Minister's Office in Singapore recognises individuals or teams as The Enterprise Challenge innovators.

Defence Technology Prize (Individual)

Prof Lim Hock, Director of Temasek Laboratories at NUS (TL@NUS), received the Defence Technology Prize 2003 in the R&D Individual category from the Ministry of Defence.

Prof Lim set up the Laboratory for Image and Signal Processing at NUS in 1987. From 1992 to 2000, he was the founding director of the Centre for Remote Imaging, Sensing and Processing (CRISP), a research facility established and operated with funding by A*STAR. In 1999, CRISP received the Excellence for Singapore Award for its contributions to the regional effort in monitoring ocean pollution and forest fires. Since September 2000, Prof Lim has been assigned the duty of establishing TL@NUS with funding from the Defence Science and Technology Agency. TL@NUS' mission is to conduct basic research on topics identified to be critical to Singapore's defence and security. Within about three years, TL@NUS has grown to a staff strength of nearly 90, and is active in research on topics ranging from electromagnetics and aerodynamics, to nonlinear dynamics.

Temasek Young Investigator Awards

Assoc Prof Ben M Chen from the Department of Electrical and Computer Engineering was the Temasek Young Investigator in 2003 for his development of intelligent control of autonomous vehicles. Assoc Prof Li Baowen from the Department of Physics won the Temasek Young Investigator Award in 2004 for research on controlling heat flow at a microscopic level through nonlinear dynamics.

The award by the Defence Science and Technology Agency aims to build up a pool of high-quality researchers in NUS to undertake leading-edge research in defence and security.

National Science & Technology Awards (NSTA)

The National Science and Technology Awards are given by the Agency for Science, Technology and Research (A*STAR) for outstanding research in Singapore.

Prof Ariff Bongso from the Department of Obstetrics and Gynaecology was presented the 2002 National Science Award for his significant contributions and pioneering work in reproductive techniques and stem cell research.

Assoc Prof Zhang Dong Hui from the Department of Computational Science and Prof Lee Soo Ying from the Department of Chemistry won the National Science Award in 2003 for their research in first principles study of elementary chemical reaction dynamics that can lead to a better understanding of catalysis, combustion and atmospheric processes. Prof Harald Niederreiter, Assoc Prof Ling San and Assoc Prof Xing Chaoping from the Department of Mathematics received the National Science Award 2003 for creating groundbreaking mathematical tools useful in algebra, algebraic curves and number theory, which are applied to coding, cryptography and low-discrepancy sequences.

Prof Andrew Nee and team at the Department of Mechanical Engineering were presented the 2002 National Technology Award for their outstanding research and engineering in the development of a knowledge-based tooling design system.

Dr Sim Wee Sun from the Department of Chemistry won the Singapore National Academy of Science/A*STAR Young Scientist Award 2002 for his research using sophisticated ultra-high vacuum surface science techniques, which have applications towards a fundamental understanding of industrially important processes in nanotechnology, molecular electronics and catalysis.

For his achievements in combining virtual reality with the real world in a new medium called mixed reality, Dr Adrian David Cheok from the Department of Electrical and Computer Engineering bagged a 2003 Young Scientist Award. Dr Low Boon Chuan from the Department of Biological Sciences also won the 2003 Young Scientist Award for his research in identifying parts of proteins that play an important role in controlling human cell functions.

Special Recognition Award

The Singapore Ministry of Information, Communication and the Arts has presented Assoc Prof John Miksic with the Special Recognition Award in 2002 for his extensive archaeological work. The researcher from the Southeast Asian Studies Programme and his team has discovered over a hundred thousand ancient artifacts in Singapore.

Late 13th century Chinese figurine depicting an Arab or central Asian man found on Fort Canning, Singapore



UNIVERSITY AWARDS

Outstanding Researcher Awards

Assoc Prof Toh Kim Chuan's excellent achievements in semidefinite programming in the Department of Mathematics define him as one of the brightest young numerical analysts of this generation and won him an Outstanding Researcher Award in 2003.

Recipient of Outstanding Researcher Award 2004 for his work on how Singapore's biodiversity was affected by deforestation was Assoc Prof Navjot S Sodhi from the Department of Biological Sciences. Dr Wong Tien Yin from the Department of Ophthalmology was another recipient of the 2004 award for his outstanding clinical and epidemiological research in ophthalmology.

Young Researcher Awards

The Young Researcher Award 2003 was presented to Assoc Prof Wu Yihong from the Department of Electrical and Computer Engineering in recognition of the potential impact of his discoveries, particularly in electronics and data storage. Another Young Researcher Award winner was Assoc Prof Li Baowen from the Department of Physics whose finding proved a long-held view that chaos is not a necessary condition for Fourier's Law of heat conduction, and that microscopic chaos has no direct connection with irreversible behaviour.

Assoc Prof Thio Li-ann from the Faculty of Law was awarded the Young Researcher Award 2004 for her dedication and outstanding research on important fields of international law, human rights and constitutional and administrative law. Dr Adekunle Olusola Adeyeye from the Department of Electrical and Computer Engineering was another 2004 winner for his role as a pioneer and developer who expands the area of spin electronics. The next-generation Semantic Web is being verified using new techniques for checking and reasoning, and Dr Dong Jin Song from the Department of Computer Science has been named Young Researcher 2004 for his work in this area. Assoc Prof Chan Heng Huat from Department of Mathematics, who is in the list of top young researchers in pure mathematics and an established figure in Number Theory, has also won the accolade.

Recipients of the Outstanding and Young Researcher Awards for 2004. (from left) Dr Dong Jin Song, Assoc Prof Thio Li-ann, Dr Wong Tien Yin, Dr Adekunle Olusola Adeyeye, Assoc Prof Chan Heng Huat and Assoc Prof Navjot S Sodhi.





- * About 100 patent applications per year
- * Marketed breakthroughs indicate relevance of research
- * Novel technologies licensed for commercialisation
- * Spin-offs underscore enterprising spirit



Patents, Commercialisation & Spin-offs

PATENTS

New Uses of Polypeptides in Treating Inflammation

Researchers at NUS have found that polypeptides and their synthetic analogues and polypeptide variants have other potential uses besides alleviating inflammation. The team from the Department of Anatomy comprising Assoc Prof P Gopalakrishnakone, Dr Thwin Maung Maung and Dr A Armugam, together with Prof K Jeyaseelan from Department of Biochemistry, proved that these polypeptides can also be used in the study, diagnosis, prevention and treatment of Phospholipase A2-related human inflammatory diseases. A US patent was granted in 2002 for the discovery entitled Novel Therapeutic and Prophylactic Agents and Methods of Using Same.

Researchers received a Ministerial Citation for their outstanding research in the discovery of a new class of anti-toxic and anti-inflamatory drug





Horseshoe Crab Enzyme Helps Toxin Detection

The blood of the horseshoe crab, an endangered species, is used for the detection of endotoxin produced by bacteria. Prof Ding Jeak Ling from the Department of Biological Sciences and Assoc Prof Ho Bow from the Department of Microbiology have successfully developed A Novel Generation of Cloned Horseshoe Crab recombinant Factor C (rFC) for Detection and Removal of Endotoxin. With the rFC, pharmaceutical companies can develop tests for endotoxins, for quality assurance of injectable pharmaceuticals, and develop new antibiotics.

Several US patents have been issued for this intellectual property. American biotech company Cambrex-BioWhittaker has licensed the technology for use in its detection kit, which is commercialised as PyroGene.

Agent to Treat and Prevent Heart Disease

Heart disease is on the rise, and it is expected that every person has a one-in-five lifetime risk of developing heart failure. Thus, the discovery of the peptide des-aspartate-angiotensin 1 by Assoc Prof Sim Meng Kwoon from the Department of Pharmacology could change practices in cardiology. In animal models of cardiac infarction, the patented peptide decreases the size of the infarct scar (dead heart tissue). Although the exact mechanism of the cardioprotection action of the peptide is not known, it is believed to work through the release of prostaglandins, which are long-chain lipid molecules with roles in inflammation.

Prostaglandins are made up of different kinds of long-chain fatty acids and some are involved in inflammation while others could prevent

inflammation. Research is ongoing to know more about the actions of the prostaglandins.

The Use of Angiotensin 1 Derivatives as an Agent for the Treatment and Prevention of Infarctionrelated Cardiac Injuries and Disorders was granted a US patent in 2003.

Assoc Prof Sim Meng Kwoon's discovery could change practices in cardiology



Stronger, Better Composite Membrane

Put two immiscible polymers together, rearrange the molecular structure of the materials, and the product is a transparent, flexible composite membrane with mechanical strength and thermal properties far superior than its parent polymers.

This new Transparent Composite Membrane that got a US patent in 2003 was invented by Prof Teoh Swee Hin, Dr Tang Zheng Gui and Prof Seeram Ramakrishna from the Department of Mechanical Engineering. One of the polymers used is a porous polymeric membrane made of a fibrous network with interconnecting pores, while the other is an elastomer with a refractive index similar to the first. The elastomer is dissolved in a solvent to form a diluted elastomeric solution, and used to impregnate the polymeric membrane, thus forming a wet composite membrane. Subsequent drying and heat treatment forms the interpenetrated membrane.



Ref: SH Teoh, ZG Tang and S Ramakrishna, "Development of thin composite membranes for biomedical applications," Journal of Materials Science: Materials in Medicine, 10 (1999): 343-352

New Method to Fixing Tissues

Medical implant devices made from biological tissue and fixed with glutaraldehyde often fail because of calcification, a process where calcium salt deposits harden.

Assoc Prof Eugene Khor from the Department of Chemistry, Mr Loke Weng Keong, a student at the Faculty of Medicine, Assoc Prof Teoh Swee Hin, from the Department of Mechanical Engineering, and Assoc Prof Chian Kerm Sin from the Nanyang Technological University, have found that simply treating devices with dimethylsulfoxide delays the onset of in vivo calcification cost-effectively. Durability tests have showed no reduction in mechanical properties of the treated biological tissue. There were no harmful effects and calcium levels saw a 20-fold decrease compared to untreated controls. The new Method of Fixing Biological Tissue was granted a Singapore patent in 2002.

Thermal Cycler Tests Multiple DNA Samples

Large numbers of DNA experiments can now be conducted simultaneously in a short time. The invention that enables this feat is a Miniaturised Thermal Cycler, which allows multiple samples to be treated simultaneously in independent thermal protocols. The chamber is thermally isolated from its



surroundings, such that heat flowing in and out of the unit is limited to one or two specific heat transfer areas. All heating elements are located within these transfer areas and at least one temperature sensor is positioned close by.

Chambers within may be manufactured as integrated arrays to form units where each cycler chamber has independent temperature and fluid flow control. The thermal cycler was developed by a team that comprised Assoc Prof Lim Tit Meng and Mr Yan Tie from the Department of Biological Sciences; Dr Zou Quanbo, Dr Sridhar Uppili and Dr Chen Yu, formerly from the Institute of Microelectronics (IME); and Dr Emmanuel S Zachariah who had a joint position at IME and Department of Chemistry. The invention received three US patents in 2002 and 2003.

Peptide to Treat and Prevent Kidney Disease

Renal failure and proteinuria, a condition where an abnormal amount of protein is present in the urine, may finally be treatable, even prevented.

Assoc Prof Sim Meng Kwoon from the Department of Pharmacology and Prof Tan Chorh Chuan from the Department of Medicine have discovered that a peptide, known as des-aspartate-angiotensin 1, improves the proteinuria in a rat model of glomeruloscleorosis that leads to end-stage renal failure. So far, the peptide has shown great promise as no secondary or adverse effects were observed.

The Use of Angiotensin 1 Derivative as an Agent for the Treatment and Prevention of Glomerulosclerosis and Renal Failure was granted a 2003 US patent.

Producing Sintered Electroceramic Materials

A research team, comprising Assoc Prof John Wang and Dr Xue Jun Min from the Department of Materials Science, and their colleagues from the Departments of Physics, Chemistry and Mechanical Engineering, has invented a method to fabricate electroceramic materials of high sintered density at much lowered temperatures.



This means that materials such as lead zirconate titanate and barium strontium titanate of high sintered density can be produced from co-precipitated hydroxides and oxalates without sintering aids or additives.

The direct processing technique, which eliminates old intermediate processing steps such as the calcination and subsequent milling of precursor powders, also minimises contamination. The method (Method for Producing Sintered Electroceramic Materials from Hydroxide and Oxalate Precursors) received a US patent in 2003.

Improved Method to Recover Metal

There is now an improved process to recover metal from solutions in an industrial environment. Developed by Assoc Prof Nikolai Kocherginsky from the Department of Chemical and Biomolecular Engineering, the new Method for Metal Recovery from Aqueous Solution does not require pressure or voltage and produces no secondary waste.

For example, this improved process using supported liquid membrane (SLM) recovers copper from aqueous solutions. Besides adjusting the pH to 6-9 before the SLM process, a weak base such as ammonia is also added to form complexes with copper. Recovery of copper as copper sulfate becomes more complete, without the need to adjust feed solution composition later in the process.

This new method is more attractive than reverse osmosis or electro-dialysis in the treatment of wastewater and spent etchant, and can be applied

European and US patents have been granted for this breakthrough in 2003. Industrial tests have been successful and an NUS spin-off company Biomimetico was formed to commercialise this and other processes developed.

for the microelectronics industry, for example after

printed circuit board production.



Onsite data

reduction to

get k-value

Preparing NUS k-tester for use





Portable Device Measures Road Drainage

A team from the the Department of Civil Engineering comprising Assoc Prof Tan Siew Ann, Prof Fwa Tien Fang and Dr Chuai Chip Tiong have invented a portable field device that measures the permeability of roads or road drainage bases. The instrument provides Drainage Testing of Porous Asphalt Pavement/Road Mixes.

For ease of use, high repeatability and measurement accuracy, the apparatus was granted a US patent in 2002.



The prototype of the INERT has been fabricated and tested

(hest treated)

In-situ Performance Assessment of Sealants

Currently, many sealants in local high-rise buildings and civil structures are reaching their life span. However, there has been no non-destructive scientific method of assessing the quality and performance of sealants.

Assoc Prof Michael Chew from the Department of Building has developed an In-situ Non-destructive Elastic Recovery Tester (INERT) that may overcome this problem. The portable instrument takes insitu measurements of the sealants' elastic recovery property based on relaxation and compressibility. Data collected is subsequently related to performance using the data bank already present. The tester is sensitive, non-destructive, portable and able to measure vertical and horizontal joints with ease. The invention received a US patent in 2003.

Synthesis of Micro-hard Aluminium-Titanium Formulations

As the number of high performance devices and their range of applications increase with advanced technology, the search intensifies for new materials that can withstand relatively high temperature and stress conditions. To address this need, Assoc Prof Manoj Gupta at the Department of Mechanical Engineering has developed a disintegrated melt deposition technique of synthesising Metastable Aluminium-Titanium Materials. The aluminiumtitanium materials exhibited low porosity and high micro-hardness. It can be potentially applied in near-net-shape synthesis, structural applications, and materials that are heat-resistant, corrosion-resistant and probably biocompatible. The method, which has been granted US and Singapore patents in 2003, overcomes the disadvantages of current process. It avoids the need for more expensive and specialised equipment to melt the aluminiumtitanium mix. As this technique limits the time titanium is added in molten aluminium, titanium is retained in its elemental form.

Near-field Scanning Raman Microscopy

An apparatus that provides nanometre spatial resolution complete with chemical and structural specific information has been developed by Assoc Prof Shen Ze Xiang and Mr Sun Wanxin from the Department of Physics. The device received a US patent in 2003.

Known as an Apertureless Near-field Scanning Raman Microscopy Using Reflection Scattering Geometry, it combines scanning probe microscopy and nearfield Raman spectroscopy to benefit a wide range of applications such as the study of nanodevices, quantum dots, and even single molecules of biological samples. With a short integration time, the technique has proved







its effectiveness for imaging purposes. The metal tips in the set-up can be used to make simultaneous atomic force microscopy and electrical mappings such as resistance and capacitance, both critical parameters for device applications.

Self-tuning Control Apparatus Expands Process Control

Though not the most effective in meeting requirements of increasingly elaborate control systems, control engineers remain stuck on conventional fixed-gains Proportional-Integral (PI) control, a method that has been around for more than 50 years. On the other hand, the benefits of using more advanced control methods that are more elaborate in structure have not been clear in actual applications.

AFM image of a Si device recorded with the near-field scanning Raman microscope. A near-field Raman image is constructed using spectra collected at each point of the AFM image

> Conventional tuning of a PI controller uses a set of fixed control gains gathered from characteristics of a particular process. But as specifications on control performance become tighter, convention is no longer adequate for systems such as time-delay systems, unstable processes and those with timevarying parameters.

A Novel Predictive and Self-tuning PI Control Apparatus for Expanded Process Control Application developed by Assoc Prof Tan Kok Kiong, Prof Lee Tong Heng, Dr Huang Sunan, and Assoc Prof Wang Qingguo from the Department of Electrical and Computer Engineering, brings together the best of both worlds as research advances. It retains conventional control, yet with a Generalised Predictive Control approach, is able to predict and self-tune according to different classes of processes. It thus improves performance beyond fixedgains PI control.

Industries related to control engineering such as food processing, petrochemical, aerospace and factory automation are expected to benefit from the invention, which received a Singapore patent in 2002.

Constructing Triangular Surface Mesh

Mesh construction is an important stage in the acquisition of 3D object models. But to work with unorganised 3D points on object surfaces, Assoc Prof Leow Wee Kheng from the Department of Computer Science has developed a method that allows a triangular surface mesh to be constructed. The new approach on Frontier Advancing Polygonization was granted a US patent in 2003.

Construction is done by advancing mesh frontiers from smooth surfaces to surface discontinuities. At flat surfaces, the algorithm constructs Delaunay triangulation of 3D points for optimal results. At surface discontinuities, it advances the mesh frontiers from all directions to enable reconstruction of surface discontinuities such as edges and corners without human intervention.

Optimum Cache Sizing for Directory

An enterprise's computer network often relies on a directory service that provides information about users, machines and usage (e.g. when a user logs in or looks for a printer). Such a service may handle hundreds of queries per second, and millions of objects that contain the queried information. If the directory server's cache memory is too small to contain all the objects, then they must be shuffled between disk and memory, thus slowing down performance.

Together with Microsoft Corp, Prof Tay Yong Chiang from the <u>Departments of Mathematics and Computer</u> <u>Science</u> has developed a technique to estimate the cache size necessary to ensure good performance for the directory server. It earned a US patent (Cache Sizing for a Directory Service) in 2002.

COMMERCIALISATION

US Firm to Commercialise Local Drug

A US biotechnology company will be commercialising a drug developed in Singapore to help maintain open blood vessels in patients with stents. A wire-mesh tube that keeps arteries open, a stent is normally coated with drugs to prevent blood and vessel cells from growing over it and cause renarrowing of the vessel.

Assoc Prof Sim Meng Kwoon from the <u>Department</u> of Pharmacology discovered the drug des-aspartate



angiotension 1 (DAA-1) that stimulates the production of chemicals with anti-inflammation and anti-clotting properties in vessels. Medlogics has bought the worldwide rights to commercialise the drug. It plans to integrate DAA-1 into stents and conduct clinical trials in two years.

Chinese Hamster Ovary Cellderived Vaccine Boosts Immunity in Bone Marrow Transplants

A vaccine from a hamster may be able to help patients who have undergone bone marrow transplants or people who have weak immune system.

Prof Chan Soh Ha from the Department of Microbiology found that hepatitis B virus (HBV) vaccine produced in Chinese hamster ovary cells stimulates the production of T and B cells involved in an immune response. The HBV is effective in non-responders of the yeast-based vaccine. Ongoing studies include use of the vaccine in HBV carriers, immunocompromised patients and bone marrow transplants.

Following clinical trials for SciGen Pte Ltd in Southeast Asia, the product has been registered for clinical use in Israel, Singapore, Hong Kong, Vietnam and the Philippines. Assoc Prof Gong Zhiyuan's pioneering work on transgenic fish

World's First Genetically Engineered Pet

The world's first genetically engineered pet – GloFish – is making waves.

Besides lighting up with a fluorescent red under ultraviolet light, the genetically modified zebra fish also doubles up as a pollution bioindicator.

Assoc Prof Gong Zhiyuan from the Department of Biological Sciences who created the fish has patented the discovery. US and Taiwanese biotechnology firms have bought exclusive trade rights to produce GloFish for the aquarium trade. High demand continues as fish farms cultivate them to meet orders expected to surge into the millions.



Asthma diagnostic kit

Diagnostic Kit Tailors Asthma Therapy

A component-resolved diagnostic (CRD) kit can now tailor immunotherapy. The Department of Paediatrics, NUS, and the Bioprocessing Technology Centre (now Bioprocessing Technology Institute) jointly developed the kit from technology and intellectual property generated from their collaborative research.

The product allows specific diagnosis and immunotherapy, thereby the effective treatment of children with asthma and rhinitis. These diseases related to mite allergy are significant health problems in Singapore and around the world.

Spin-off company ImmunoBiocare Pte Ltd, started by Assoc Prof Chua Kaw Yan, Adjunct Assoc Prof Lee Bee Wah and Dr Cheong Nge from the Department of Paediatrics, will continue with research arising from the technology to produce recombinant dust mite allergens for more diagnostic applications.

Soya-based Ice Cream Offers Fat-free Goodness

A soya-based ice cream now offers the rich, creamy satisfaction without the sinful calories. Created by Dr Leong Lai Peng from the Department of Chemistry, this new dessert has only one-third the fat of a dairy ice cream. Besides tasting like the real thing, it is a good alternative for people who are lactose-intolerant.

Phytoestrogens in soya such as isoflavones inhibit cancer growth and help relieve menopausal symptoms. Soya also has very high anti-oxidant properties that delay the onset of ageing and degenerative diseases through the elimination of free radicals. Saponins, lecithin and phytosterols are some components that lower blood cholesterol.



Air-water interface viewed under high vacuum of soya-based frozen dessert



Singapore Software Schedules Mars Mission

You are a scientist capable of filling up to five different roles on a space mission. With 200 others on the Mars Exploration Rovers' Science team, you are able to perform several of the 22 different operational roles allocated by the duty planner, based on a complex schedule that is created to minimise personnel fatigue.

All these were real issues that start-up company FriarTuck Pte Ltd dealt with when the National Aeronautics and Space Administration (NASA) approached the company to do the complex scheduling. Founders, Dr Martin Henz, Department of Computer Science and Mr Sevugan Alagappan, an NUS Computer Engineering graduate, successfully used their software product FTStaffRosterer to handle the two Mars Rover missions, taking into account that the Mars time is 40 minutes longer than an Earth day.

FTStaffRosterer, an online application designed to handle most complex scheduling requirements and preferences, has a specially designed engine that generates high-quality schedules within minutes, using the client's machine to provide an intuitive, graphical and media-rich environment.

Natural Interface for SMS

Users of SMS, or short messaging services, can now access a more natural interface that is interactive and user-friendly.

NUS spin-off MultiTREX Pte Ltd, founded by Prof Chua Tat Seng, Department of Computer Science, has developed a suite of products called Smart TExt Processing Software (STEP*) to provide natural language interactions and analysis tools that support a wide range of interactive applications. One product, stepTALK, is deployed in Green Dot Internet Services for overseas trips through short natural language interfaces. Managed service providers (MSPS) have also implemented stepTALK to enable the public to book cinema and concert tickets through natural language interfaces.

PurpleACE Mobile Product Gets Siemens' Nod

PurpleACE will be commercialising its first product called Ripple Premium with funding and support from Siemens Mobile Acceleration. The spin-off was founded by Assoc Prof Hari Garg and his student Mr Kartik Prabhakara from the Department of Electrical and Computer Engineering, and Mr Brojo Pillai, a graduate from the Department of Computer Science.

Ripple Premium is a platform that lets subscribers share applications and contents such as images, games, music and video clips with other users. This increases the profit margins from content sales, as the distribution reach is significantly enhanced. In addition, Ripple Premium offers a personalised buying experience to each subscriber, recommending content that the subscriber will like.

The solution targets mobile operators and service providers.

SPIN-OFFS

OsteoPore International

Five months after a group of surgeons and researchers from NUS and the National University

Hospital invented the world's first biodegradable bone scaffold from titanium mesh, OsteoPore International was set up to make and market the product across Asia.

Team members and founders of the company are Dr Dietmar Hutmacher and Prof Teoh Swee Hin from the Division of Bioengineering, NUS. Dr Hutmacher explains that the Burr Plug made

> Implantation of scaffolds with cells

from polycaprolactone, or biodegradable plastic, is cheaper, can be custom-made, does not cause infections, and completely fuses with skull tissues after two years. The product has been so successful in repairing the punctured skulls of 10 patients that the team is exploring its use to regenerate bones in the spine, knees and eye socket.



QuantaGen

The market for nucleic-acid testing is valued at US\$1.2 billion. Presently, a speedy, accurate yet portable and sensitive detection system is not available. To tap this pent-up demand, QuantaGen has come up with a quantitative analysis of genes using a novel label-free detection technology. The start-up is founded by Dr Casey Chan from the Department of Orthopaedics.

To further exploit the DNA-based application in fields such as research, healthcare and biodefence testing, the firm is working on commercialising an integrated label-free portable detection system. Its patented technologies can potentially help create such portable devices and reagents for rapid, ultra-sensitive DNA testing at the point of care.

Chiral Sciences and Technologies

Chiral Sciences and Technologies currently owns the licence to a new technology that develops durable chiral stationary phases (CSP) from facile synthetic methodologies.

CSPs are used in enantioseparations of a wide range of racemic drugs and other high-value chemicals such as biochemicals, flavours and fragrance compounds. They can be applied for analytical, preparative and commercial scales.

Chiral Sciences and Technologies was founded by Prof Ching Chi Bun and Ms Chen Lei from the Chemical and Process Engineering Centre, together with Assoc Prof Ng Siu Choon from the Department of Chemistry. The company is currently developing the technology with several international companies in North America. It has plans to work with the Shanghai Institute of Organic Chemistry in China for the use and evaluation of chiral columns.



Atsuma Technology

Atsuma means aggregate in Japanese, which is what this company intends to do with unused computer power. It harnesses idle processor cycles into a single system for independent resource sharing through its grid technology.

Atsuma Technology, founded by Assoc Prof Teo Yong-Meng, Department of Computer Science, enjoys strategic alliances with manufacturers and systems integrators such as Dell Computer Asia and SCS Enterprise Systems. As such, its team, comprising one entrepreneurial NUS computer scientist, information technology industry practitioners and academia, are able to stay at the forefront of new technological advances. The firm continues developing technologies that will lower the unit cost of computing power.

Directors of Chiral Sciences and Technologies, Prof Ching Chi Bun (left) and Assoc Prof Ng Siu Choon



to pick up and move virtual musicians. When speech command Play is given, the band begins to play.

DBD Visualising speech with Brooklyn-media's interactive software



Brooklyn-media provides tangible interaction with its mixed-reality system



The world's first integrated multiprocess micromachining tool

MultiTREX

A product suite named Smart TExt Processing Software (STEP*) that provides natural language interactions and analysis tools for interactive applications has helped propel an Institute of Engineering Science spin-off company to success.

Started by Prof Chua Tat Seng from the Department of Computer Science, MultiTREX is now a premier solution provider of interactive information management and services used in mobile commerce, customer relation management and business intelligence applications.

Brooklyn-media

Brooklyn-media focuses on creating mixed-reality content and human-computer interaction products.

With its server and software infrastructures that house and distribute content to users, companies can share complex information - even real-time 3D visualisation via various reception modes of different parties. Display options will extend beyond head-mounted displays, camera-enabled handheld devices and mobile phones.

Brooklyn-media is working with a Korean mobile games company to develop unique mobile entertainment for Asia Pacific. It is also partnering with the Singapore Economic Development Board to develop a different 3D game interface.

Co-founded by Dr Adrian David Cheok from the Department of Electrical and Computer Engineering, the spin-off also provides digital education and entertainment consultation.

Mikrotools

Mikrotools has developed the world's first integrated multiprocess micromachining tool. The NUS spin-off, founded by Prof M Rahman and his team from the Department of Mechanical Engineering, develops and manufactures advanced precision micromachining tools to help companies develop new products and capabilities.

Using its patent-pending technology, multiple micromachining processes can now be integrated into this single machine, rather than the old way of using different machines to fabricate a piece of work. Electrodes used in electrical discharge machining (EDM) processes to fabricate features on a piece of work no longer need to be fabricated by another machine. When used together with an on-machine measurement device, a high level of accuracy is achieved. This unique multiprocess tool has dedicated controllers that are able to process network channel codes according to different operation types.



Conferences & Symposiums Organised

6

- * Some 200 symposiums \$ conferences hosted/organised by NUS each year
- * NUS leadership contributes to world's academic community
- * Over 1,700 conference papers delivered
- * Platforms for interchange of ideas and knowledge



Conferences & Symposiums Organised

The Future of Neurobiology, NUS (3-4 Feb 2004)

Neuroscientists at the NUS Office of Life Sciences and five international experts gathered at a Scientific Advisory Board Meeting early 2004 to showcase their work and develop integrated research themes. The efforts and collaborations by over 200 professionals contributed to The Future of Neurobiology.

Speakers at the event included Prof Allan Butterfield from the University of Kentucky in Lexington, US; Prof Jason Morrow from Vanderbilt University School of Medicine in Nashville, US; Prof Claudio Stern, University College London, UK; Prof Aryeh Routtenberg, Northwestern University, US; and Dr Michael Chee from Singapore General Hospital.

IARC-NUS-ISI International Course in Molecular Epidemiology (21–26 Sep 2003)

The International Agency for Research on Cancer (IARC), NUS and the Institute for Scientific Interchange Foundation (ISI) came together to conduct a course that introduces basic molecular epidemiology knowledge and encourages scientific exchange. The course, organised annually by IARC in France, has been getting enthusiastic response.

Held for the first time in Singapore, the IARC-NUS-ISI International Course in Molecular Epidemiology was a success as it brought together renowned speakers in molecular epidemiology and was attended by 35 international participants.

First SERI-ARVO Meeting on Research in Vision and Ophthalmology (6-9 Feb 2003)

The Singapore Eye Research Institute (SERI), an affiliation of <u>NUS Department of Ophthalmology</u>, has hosted the first combined meeting of the Association for Research in Vision and Ophthalmology (ARVO) outside the US. ARVO is the leading ophthalmic research body in the world.

An important goal of the First SERI-ARVO Meeting on Research in Vision and Ophthalmology is to encourage young investigators to present their works. To motivate them further, awards were given for research excellence.



Deputy Prime Minister Dr Tony Tan and Assoc Prof Donald Tan at a poster session at the SERI-ARVO Meeting

Over 800 delegates from 36 countries attended various research symposia and keynote lectures on cuttingedge advances in eye research, complemented by a series of workshops on the design and conduct of eye research. Topics at the meeting covered a broad range of ophthalmic work with an emphasis on translational research that bridges disciplines of basic science and clinical ophthalmology.



Prof Shih Choon Fong, President, NUS (front row, 2nd from right), the Guest-of-Honour at the Second International Conference on Structural Biology and Functional Genomics

The Second International Conference on Structural Biology and Functional Genomics (2–4 Dec 2002)

So overwhelming was the response for the Second International Conference on Structural Biology and Functional Genomics in 2002 that it had to be conference-cast to alternative venues in real-time.

Second of a series held every two years, the conference, a joint effort of the Department of Biological Sciences, Institute of Molecular and Cell Biology and Genome Institute of Singapore, featured internationally renowned scientists in the field such as Sir Tom Blundell of the University of Cambridge, UK; Prof Michael James of the University of Alberta, Canada; Dr Ruedi Aebersold of Institute for Systems Biology, US; and Dr Peter R Jungblut of Max Planck Institute for Infection Biology, Germany.

First Asian Musculoskeletal Ultrasound Course, Organised by NUH and NUS (9–10 Nov 2002)

Musculoskeletal ultrasound is a relatively new clinical imaging technique that offers wide applications to diagnose a variety of clinical orthopaedic and rheumatologic conditions. While cheaper than magnetic resonance imaging (MRI), it requires professionals to undergo intensive hands-on training to gather experience so as to ensure reliability and proficiency.

To address this need, the National University Hospital (NUH) Department of Diagnostic Imaging and the <u>NUS Faculty of Medicine</u> organised the First Asian Musculoskeletal Ultrasound Course 2002 for radiographers and radiologists to provide them with the theory, practice and application of musculoskeletal ultrasound.

The first by an Asian institution, the two-day course emphasised small-group training for various parts of the body and was as successful as an earlier one run by the Musculoskeletal Ultrasound Society in Singapore in 2000. Delegates from countries as far away as Russia appreciated the rare opportunity to be taught and supervised by experts.

The course will be conducted as a regular biennial programme.



Guest-of-Honour, then Acting Minister for Education, Mr Tharman Shanmugaratnam officially opening the 4th Sino-Singapore Conference

3rd Sino-Singapore Symposium, Xiamen, China (27–30 Sep 2002)/ 4th Sino-Singapore Conference (11–13 Nov 2003)

The Department of Biological Sciences (DBS) remains extremely involved in the research and academic exchange programme with Tsinghua University and Xiamen University of China.

Examples include a 20-hour course on protein science for third-year Xiamen University students in July 2002. In October, members of DBS attended the 3rd Sino-Singapore Symposium in Xiamen, China.

Another milestone was marked in 2003 when the 4th Sino-Singapore Conference attracted seven top universities in China. Besides the existing two partners, Fudan University, Peking University, Sun Yat-Sen University, Nankai University and Wuhan University attended the event.

Intellectual Property & Biological Resources: Law and Policy (1–3 Dec 2003)

Judges, legal practitioners, academics and policy-makers face many challenges in their attempts to bridge the gap between environmental and intellectual property law.

To address the myriad of complex issues related to protection of biodiversity and ownership of such knowledge, Intellectual Property and Biological Resources: Law and Policy was organised to bring together experts from around the world.

The event was organised by the Asia-Pacific Centre for Environmental Law (APCEL) of <u>NUS Faculty of Law</u> with the Singapore Academy of Law (SAL), Intellectual Property Office of Singapore (IPOS) and the Intellectual Property Academy. Partner institutions included the IUCN (World Conservation Union) Commission on Environmental Law, the IUCN Academy of Environmental Law, the Macquarie University Centre for Environmental Law and the Japan Bioindustry Association.

Participants expressed views and concerns for legal and ethical controversies that arose from the global biotechnology revolution, in particular to



the compatibility of intellectual property rights with biological wealth present in flora and fauna of developing countries.

NUS Prof George Wei Sze Shun gave a powerful presentation on the spectrum of issues arising from biological inventions entering the present international intellectual property framework.

6th International Symposium on Fibre-reinforced Polymer Reinforcement for Concrete Structures (FRPRCS-6) (8–10 Jul 2003)

The International Symposium on Fibre-Reinforced Polymer Reinforcement for Concrete Structures (FRPRCS), a biennial event, was organised in 2003 by the Department of Civil Engineering, NUS, and the Fibre-Reinforced Polymer Society, Singapore. Marking the 10th anniversary of the FRPRCS Symposia Series, FRPRCS-6 ushered in an era of Fibre-Reinforced Polymer (FRP) reinforcement – the use of these reinforcements and structural shapes, along with added interest in masonry and steel structures.

Some 180 attendees from 30 countries heard keynote lectures by distinguished experts. Prof A E Naaman from University of Michigan gave an assessment of progresses and prospects when applying FRP reinforcing bars in structural concrete. Prof T Uomoto from the University of Tokyo provided a much-needed approach for the durability design of GFRP rods. Prof T Ueda from Hokkaido University shared valuable insights into the development of flexible continuous fibre reinforcement to provide structural ductility.

International Conference on Materials for Advanced Technologies (ICMAT) (7-12 Dec 2003)

The International Conference on Materials for Advanced Technologies (ICMAT) held in 2003 saw more than 1,400 delegates converging in Singapore from around the globe. The biennial event was organised by Materials Research Society Singapore, <u>NUS</u> and Institute of Materials Research and Engineering.

Nobel laureates Sir Harold Kroto and Prof Klaus von Klitzing delivered keynote addresses and public lectures, attracting a capacity audience from the research and educational communities.

Scientists, engineers and biomedical researchers gathered at 16 symposiums to foster interdisciplinary exchanges and extend ideas. Subjects covered ranged from biomaterials and polymers to nanomaterials.

The International Conference in Asia (ICA) 2003 Symposium hosted by the Institute of Engineering Science (IES) focused on some rapidly developing areas, namely surface and nanoscale science. Prominent speakers came from key institutions such as Princeton University, US; University of Birmingham, UK; and Centre National de la Recherche Scientifique, France.

Other symposiums delved further into the science and technology of nanomaterials. Oral and poster contributions ranged from basic science of nanoscale physics and chemistry to applications in nanodevices, synthesis and characterisation of nanomaterials, nanomaterial modelling and simulation, quantum engineering and quantum computing. Researchers from NUS Nanoscience and Nanotechnology Initiative (NUSNNI), Faculty of Engineering and Faculty of Science actively participated in the symposiums, presenting their latest achievements and sharing their knowledge in the exciting field.

The Department of Mechanical Engineering organised the **iMEMS 2003 Symposium on Microelectro-Mechanical Systems (MEMS) and Nanoelectro-Mechanical Systems (NEMS)**. The Symposium looked into advanced materials for general applications; characterisation and numerical modelling; and microfabrication technologies and processes. Both systems are revolutionary technologies for manufacturing in the 21st century.

> Nobel laureates Sir Harold Kroto (right) and Prof Klaus von Klitzing at ICMAT 2003

The **Symposium on Electromagnetic (EM) Materials** organised by Temasek Laboratories at NUS (TL@NUS) was well-received for its expansion on materials of interest such as dielectric and magnetic composites with inclusions, meta-materials, thin films, smart materials and structures, and materials with periodic structures. EM materials are getting considerable attention for their impact on civilian and defence sectors.

The latest developments in synchrotron radiation were covered in the **Symposium on Synchrotron Radiation for Advanced Materials Analysis and Processing** organised by the Singapore Synchrotron Light Source (SSLS). Proceedings of the event will appear in a special issue of *Journal of Physics: Condensed Matter*.



Singapore International Chemical Conference 3 (SICC3) (15–17 Dec 2003)

The Department of Chemistry and the Singapore National Institute of Chemistry held the biennial Singapore International Chemical Conference (SICC3) in 2003.

Prof Richard Zare from Stanford University, US, delivered a public lecture on "Chemical Fizzics". Prof Peter W Atkins from Oxford University, UK, presented the Ang Kok Peng Memorial lecture. Over 400 chemists from 24 countries bore testament to the conference's aim of establishing lasting collaborations with international academic bodies.

As part of the theme of "Frontiers in Physical and Analytical Chemistry", past achievements in chemical sciences were reviewed, with discussion of ideas and emerging trends. A chemical education workshop for local science educationists was a platform to promote chemistry among young Singaporeans.

The 3rd Overseas Chinese Physics Association (OCPA) International Accelerator School (25 Jul–3 Aug 2002)

Some 80 years after particle accelerators were invented



OCPA International Accelerator School 2002 participants. First row: (third from left) Prof Herbert O Moser, NUS; (centre) Prof Alex Chao, (Chairman), Stanford University; and, (fourth from right) Prof Oh Choo Hiap, NUS.

to generate the first artificial nuclear reactions, the 3rd Overseas Chinese Physics Association (OCPA) International Accelerator School was held to teach students about modern accelerators.

Organised in a collaborative effort by NUS Singapore Synchrotron Light Source (SSLS) and Department of Physics, with the South East Asia Theoretical Physics Association (SEATPA) and Overseas Chinese Physics Association's Division of Beam Physics, the school satisfied a demand that is growing as accelerators have become increasingly important for research at synchrotron radiation facilities and in medicine. Not just limited to advanced cancer therapy and radio surgery, accelerators now have more applications that extend to transmutation of nuclear waste that produces electrical power at the same time, generation of neutrons for materials science, customs inspection, as well as sterilisation of medical supplies and foodstuff.

Following excellent attendance, selected lectures have been published in a book entitled *Accelerator Physics*, *Technology*, and *Applications*.

4th Asian Control Conference (25–27 Sep 2002)

The Asian Control Conference (ASCC) is the main control event regularly organised and held in Asia. It provides excellent opportunities for researchers, engineers and professionals worldwide to interact and exchange their findings and views.

For the first time in the history of ASCC, a web-based submission and information system was introduced that proved very useful for conference organisers and participants.

Organised by the Centre for Intelligent Control, ASCC 2002 received over 600 submissions, of which about 400 were presented at the conference. Prof Vladimir Kucera, president of International Federation of Automatic Control, graced the occasion, as did past presidents, the president-elect and the general co-chair of the European Control Conference 2003.

Speakers and organisers of the 7th Workshop on Ocean Models for the APEC Region. Prof Chan Eng Soon, TMSI Director, is standing at far left of the group.

2nd International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS 2003) (15–18 Dec 2003)

The 2nd International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS) was held in 2003 to provide a common platform to disseminate knowledge among field researchers.

This event was organised by the Centre for Intelligent Control, Institute of Engineering Science, NUS. Through the meeting, the Centre showcased the Department of Electrical and Computer Engineering's strengths in robotics and autonomous systems.

The Centre plans to continue the CIRAS series of conferences as it is a good interaction venue for the research community at large, and particularly beneficial to research students.



7th Workshop on Ocean Models for the APEC Region (30 Sep-2 Oct 2002)

The 7th Workshop on Ocean Models for the APEC Region was held in Singapore at the Tropical Marine Science Institute (TMSI). There were 15 speakers from APEC member countries. The objective of this workshop is to share experiences of APEC member countries in the development and application of computer models for hydrodynamics, water quality and ecological simulation in coastal and ocean development.

> Prof Larry Hall (left) from the University of South Florida, one of the three keynote speakers at CIRAS 2003. Next to him are Honorary Chair, Prof Lee Tong Heng (centre) and General Chair, Dr Prahlad Vadakkepat.

UN ESCAP Workshop participants



United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) Workshop on the Use of Space Technology for Disaster Management in Southeast Asia (27–30 Jan 2004)

CRISP, the Centre for Remote Imaging, Sensing and Processing, aims to develop a demonstration project that will use satellite remote sensing technology to monitor and manage regional natural disasters such as severe floods.

But to achieve that goal, CRISP needs to play a pivotal role in promoting regional cooperation. And it did with the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) Workshop on the Use of Space Technology for Disaster Management in Southeast Asia when it brought together European technology providers and regional users.

Participating bodies included Ministry of Water Resources and Meteorology in Cambodia, Mission for International Relations and the Centre National d'Etudes Spatiales in France, Japan Aerospace Exploration Agency in Japan, Singapore's National Environment Agency, United Nations Affairs Office for Outer Space in Vienna, and the European Space Agency in Paris. Also present were speakers from Australia, China, India, Myanmar, the Philippines and Vietnam.

International Symposium on Knowledge Construction (22–24 Oct 2003)

What challenges does the knowledge-based economy pose to the construction industry? How can these demands be met through appropriate national programmes and corporate strategies? Solutions to these and more were presented by world-renowned researchers at the International Symposium on Knowledge Construction.

One of the largest gatherings to be co-organised by the Department of Building, NUS, and International Council for Research and Innovation in Building and Construction (CIB), the symposium of the three CIB Working Commissions – W55 (Building Economics), W65 (Organisation and Management of Construction) and W107 (Construction in Developing Countries) – was held in October 2003. It attracted 166 participants from 27 countries. University researchers, government officials

Guest-of-Honour, Her Excellency Ms Stella Sigcau, Minister of Public Works of the Republic of South Africa, and Mr Fanus Schoeman, High Commissioner of South Africa in Singapore



as well as consultants from institutes and professional institutions shared their views at the conference.

Sponsored by the Singapore Tourism Board, this event received support from Singapore organisations such as JTC Corporation, Building and Construction Authority, Housing and Development Board, Real Estate Developers' Association of Singapore, Singapore Institute of Arbitrators, Singapore Institute of Building Limited, the Society of Project Managers and Singapore Institute of Surveyors and Valuers.

Workshop on MOBile, WIreless and SEnsoR Networks: Technology and Future Directions (5-6 Mar 2004)

The Workshop on MOBile, WIreless and SEnsoR Networks: Technology and Future Directions was an international academic conference sponsored by IBM, CISCO Systems, BSI Group, Institute of Electrical and Electronics Engineers (IEEE) Singapore Communications Chapter, Pearson Publishers and NUS.

Organised by the School of Computing, the event served as a venue to bring together leading researchers from both academia and industries to present their research and practice in the area. Some prominent speakers included Dr Pravin Bhagwat, Chief Technical Officer of Wibhu Technologies, India; and US researchers such as Mr Craig Fellenstein, executive consultant and senior architect/strategist at IBM, Prof Jim Kurose from University of Massachusetts in Amherst, Prof Nitin Vaidya from University of Illinois at Urbana-Champaign and Dr Archan Misra from IBM T J Watson Research Centre, New York.

Symposium on Stochastics and Applications (SSA) (15–17 Aug 2002)

Through the study of stochastics, important topics have emerged such as Probability Approximations, Random Matrices, Gaussian Random Fields, Markov Chain Monte Carlo and Financial Mathematics.

The last holds such potential that a day was dedicated for its updates and discussions of methods at the Symposium on Stochastics and Applications (SSA). SSA was one of the satellite conferences of the International Congress of Mathematicians 2002.

Jointly organised and sponsored by NUS Institute for Mathematical Sciences (IMS), Department of Statistics and Applied Probability, and Department of Mathematics, along with Singapore Mathematical Society, SSA saw 100 participants from 17 countries.

Prominent plenary speakers hailed from University of Zurich, Switzerland; Humboldt-Universität zu Berlin and Bielefeld University, Germany; University of Warwick, UK; and Chinese Academy of Sciences, Beijing.

International Conference on "Numerical Methods in Imaging Science and Information Processing" (15–19 Dec 2003)

Fostering exchanges and collaborations between researchers in Singapore and experts around the world – this is one of the aims of the Institute for Mathematical Sciences (IMS), and a key reason for the International Conference on Numerical Methods in Imaging Science and Information Processing in 2003.

Held as part of the programme on "Mathematics and Computation in Imaging Science and Information Processing", the Institute also wanted to promote research interest in mathematical modelling and computational methods in imaging science and information processing for mathematicians and engineers.

The conference focused on several mathematical and computational areas for solving image and information processing problems such as Ill-posed Inverse Problems, Partial Differential Equations, Numerical Optimisation, Numerical Linear Algebra, Sparse Grid Approximation and Applications.

The conference was attended by 60 participants, with many from leading mathematical institutions around the world.

5th International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing (MCQMC 2002) (25–28 Nov 2002)

The 5th International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing (MCQMC 2002) was a joint forum for specialists to present their results and exchange views in theory and application of both methods.

Used to solve a variety of complex problems on a number of topics, both methods have seen rapid development and fast convergence as research continues to span many disciplines. With Monte Carlo simulations consequently being applied to more problems in derivatives pricing and risk management, the conference at NUS in 2002 had dedicated a day to "Computational Finance in Banking".

The event, attended by 121 participants from 19 countries, featured speakers from reputable institutes such as University of Southern California, University of Kentucky, Universite de Montreal and WIAS Berlin. Delegates of the 5th International Conference on Monte Carlo and Quasi-Monte Carlo Methods in Scientific Computing (MCQMC 2002) in Singapore

The conference was sponsored by the Centre for Financial Engineering, <u>NUS Department of Mathematics</u>, DBS Bank and Lee Foundation.

Third International Conference for e-Business (13–19 Dec 2003)

The Centre for e-Business and Department for Decision Sciences, NUS School of Business, organised the Third International Conference for e-Business in 2003. Some 150 academics and researchers gathered to present papers based on the theme "E-Business Paradigms: Strategic Transformation and Partnership".

Areas covered included e-business, e-learning and innovations, Internet marketing and advertising, collaborative commerce, e-finance, business infrastructure, organisational behaviour, management of information systems, and quantitative methods.

The conference was a success with over 200 papers received from authors in 20 countries across four continents.



Logistics 20/20: Managing the Asia Challenges (6 Nov 2003)

Industry analysts foresee tremendous growth potential in the Asia-Pacific logistics industry. And for the 250 attendees who turned up for Logistics 20/20: Managing the Asia Challenges in 2003, it was their turn to talk about the latest trends and look into future challenges of logistics practices in Asia, particularly China.

The conference dealt with pressing issues that professionals face in the logistics industry in a bid to help companies keep up with world-class practices. It was steered by The Logistics Institute - Asia Pacific (TLI-AP) and Exel, both thought leaders in supply chain management. The two are constantly looking to newer technologies and innovations to help companies transform their supply chain, increase efficiency and remain competitive in tough times.



250 participants attended the conference held in Singapore

Speakers and commentators at ARI's inaugural Asia Trends Conference

The Third International Convention of Asia Scholars (ICAS3) (19–22 Aug 2003)

The Faculty of Arts and Social Sciences and the Asia Research Institute (ARI) secured the honour of bringing the renowned Third International Convention of Asia Scholars (ICAS3) to Asia for the first time.

ICAS3 is one of the largest regular gatherings of scholars whose research centres on humanities and social sciences in Asia. The event has encouraged cross-disciplinary and interregional dialogues in Asian studies.

Refreshingly without a theme to encourage crossboundary work, the conference attracted over 1,000 scholars from 50 countries who presented some 940 papers over three-and-a-half days. The wide spectrum of topics ranged from technology, archaeology and politics to philosophy. Some multidisciplinary areas covered included social networks, sexuality, ageing and popular culture.

The event received support from the Association for Asian Studies, the International Institute for Asian Studies and the Asian Studies Association of Australia.

Asia Trends Conference – "Babel or Behemoth: Language Trends in Asia" (4 July 2003)

"Babel or Behemoth: Language Trends in Asia" kicked



off the inaugural Asia Trends public conference organised by the Asia Research Institute (ARI) where renowned scholars gathered to address fundamental issues on language in Asia.

The debate on mother tongue continued as Prof Wang Gungwu, Director of NUS East Asian Institute, drew from his experience to highlight issues that emerge when language is lost in the face of dominant "Father Languages". He also discussed transformative teaching in education policies, as well as the performance power and orality of mother tongues.

From India to Thailand and Malaysia, scholars spoke on the multilingual situation and the impact of language on political territory, language policies and education.

Speakers also introduced performance and non-print media for further insights. In a bid to tackle dilemmas faced by practitioners who attempt to preserve integrity for language-based performances in a globalising world, participants discussed exploitation of multilingualism and how language aesthetics from Chinese opera to Thai Khon might be conveyed.

Human Communities and Contexts of Nature, University of Tokyo (UT) Forum 2002 (27–28 Nov 2002)

Initiated by The University of Tokyo (UT), Japan, the UT Forum 2002 was organised with the assistance of the NUS Faculty of Arts and Social Sciences.

The theme "Human Communities and Contexts of Nature" explored possibilities that would deal with pressing social and environmental Asian issues through the application of interdisciplinary research in the areas of human and social sciences, natural sciences and engineering.

It provided a platform for UT to disseminate research results, thus increasing international exchange across all levels. Prof Reynaldo Ileto from the Southeast Asian Studies Programme and Assoc Prof Victor Savage from the Department of Geography presented their papers at the event held in Singapore.

NUS also signed a new Memorandum of Understanding with the College of Arts and Social Sciences, UT for student exchange.

Reflections and Re-Presentations: Writings and Images of Malaysia and Singapore, 9th Malaysia-Singapore Forum (28–30 Oct 2002)

The 9th Malaysia-Singapore Forum served as the venue for 28 academics from the respective Faculties of Arts and Social Sciences at NUS and the University of Malaya to present papers and exchange ideas. The 2002 theme was "Reflections and Re-Presentations: Writings and Images of Malaysia and Singapore". Dr Donna Brunero from the Department of History delivered a paper entitled *Heritage*



and Nationalism: A Critique of 'Reflections at Bukit Chandu' A World War II Interpretative Centre.

Leisure activities such as dinner under the stars and museum tours took place over the three days.

The Second Generation of Environmental Laws 2003 (11 Nov 2002)

The Asia-Pacific Centre for Environmental Law (APCEL) of NUS Faculty of Law was involved in the organisation of the Second Generation of Environmental Laws 2003, under the auspices of the IUCN (World Conservation Union) Commission on Environmental Law.

It is clear that environmental laws are changing as Prof Koh Kheng Lian, Faculty of Law, stated in her papers entitled *The 'First Generation' of Environmental Laws in Asia* and *Regional Biodiversity Collaboration – The ASEAN Approach*. These and other papers presented at the symposium have been compiled into a book entitled *Towards a 'Second Generation' in Environmental Laws in the Asian and Pacific Region – Select Trends, Proceedings* of an IUCN/IGES/ADB Symposium (2003).

Papers presented at the Second Generation of Environmental Laws 2003 symposium compiled into a book





- * Vibrant hubs of research in strategic areas that cut across disciplines
- * Multidisciplinary research in areas recognised as internationally important
- * Advanced infrastructure serves as platform for collaboration



University Research Institutes & Centres

Asia Research Institute (ARI)

Officially launched in 2001, the Asia Research Institute (ARI) engages in social sciences broadly defined, and in particular, pursues interdisciplinary frontiers between and beyond disciplines.

In the bid to provide world-class focus and research resources on and for the Asian region, ARI works closely with the Faculty of Arts and Social Sciences, Faculty of Law, Business School, and School of Design and Environment at NUS to support research, conferences, lectures and graduate study at the highest level.

Its six core areas of research are: Changing Family – where low fertility and late marriages transform family composition, the subject has become an increasingly important field when examined together with labour market realities, changing gender relations and structures in Asian societies; Religion and Globalisation – which focuses on the changing patterns in religious practices, beliefs and identities particularly in Southeast Asia, China and South Asia; Migration – which is a major policy concern to many nations as it affects the mobility of professional, managerial and unskilled labour; Cultural Studies in Asia – looking at the consequent changes in contemporary cultures with increased human mobility across national boundaries; Southeast Asia China Interactions – understanding the changing linkages with



RADM (NS) Teo Chee Hean (right) officiating the launch of ARI. To his right, Prof Anthony Reid, Director, ARI and Prof Shih Choon Fong, President, NUS.

growing interdependencies and alliances; Southeast Asian Archaeology – looks at early historic sites on issues ranging from trade to architecture and sculpture.

Centre for Remote Imaging, Sensing and Processing (CRISP)

The Centre for Remote Imaging, Sensing and Processing (CRISP) was established in late 1992. The mission of CRISP is to develop an advanced capability in remote sensing such that most of Singapore's scientific, operational and business requirements can be met. In the last few years, the Centre has gained recognition as a major international remote sensing centre. CRISP's work on ocean pollution and forest fire monitoring has attracted worldwide attention. Its researchers have also participated in several projects by the National Aeronautics and Space Administration (NASA), Japan Aerospace Exploration Agency (JAXA), and the European Space Agency (ESA). The Centre's current research focus is on the processing and application of very high resolution, hyperspectral and microwave remote sensing.



The IKONOS satellite that captures highresolution images of the Earth surface A multimode atomic force microscope (AFM) in NUSNNI, used mainly for topographical imaging of samples up to micron resolution

Institute of Engineering Science (IES)

The Institute of Engineering Science (IES) seeks to foster interdisciplinary research, with members from NUS' Faculties of Engineering and Science, and School of Computing. It comprises seven research centres: the Centre for Information Mining and Data Extraction (CHIME), Centre for Intelligent Control (CIC), Centre for Superconducting and Magnetic Materials (CSMM), Centre for Wavelets, Approximation and Information Processing (CWAIP), Centre for Water Research (CWR), Surface Science Laboratory (SSL) and Centre for Advanced Computations in Engineering Science (ACES).

Institute for Mathematical Sciences (IMS)

Through thematic programmes, workshops, tutorials and other specialised activities, the Institute for Mathematical Sciences (IMS) brings to the research community state-of-the-art mathematical ideas and their applications to other fields of human knowldege, thus supporting and promoting multidisciplinary research in the mathematical sciences.

IMS also provides opportunities for local scientists to exchange ideas, interact and carry out research

collaboration with foreign experts and researchers. It publishes a Lecture Notes Series as a contribution to scholarship and knowledge made by invited lecturers and a regular newsletter as a platform for maintaining links with the scientific community. In its efforts to promote awareness and interest in mathematics, it organises talks to the public, schools and junior colleges by distinguished visitors, and conducts "math camps" for students to learn about mathematical research from active researchers.

In recognition of the high calibre of its professional activities, the Institute was invited to be a member of the International Mathematical Sciences Institutes (IMSI), an international consortium of research institutions, in August 2002.

NUS Nanoscience and Nanotechnology Initiative (NUSNNI)

Nanoscience and nanotechnology research has the potential to influence applications in biotechnology, medicine, infocomm technology, engineering and the sciences. But the NUS Nanoscience and Nanotechnology Initiative (NUSNNI) has taken a step further to identify seven focus areas.

These are nanobioengineering, nanoelectronics, nanophotonics, nanomagnetics, molecular functionalisation, self-assembly and devices, as well as nanostructures and nanomaterials and nano/micro fabrication. Thus far, a number of research grants have been secured and selected chairs will now galvanise and coordinate strategic research programmes. What adds to the impetus is the recent launch of a multidisciplinary research scholarship to develop research human capital.

NUSNNI has previously participated in nano-related conferences such as the International Conference on Materials for Advanced Technologies (ICMAT) and Towards Innovation in Nanotechnology (TINY) in 2003. It continues to hold seminars to update staff on the latest advancements in the field.
Singapore Synchrotron Light Source (SSLS)

What's glowing right now in the laboratories is the near possibility of developing key concepts for 4th generation synchrotron light sources. At the Singapore Synchrotron Light Source (SSLS), researchers are developing the superconducting miniundulator and the Linac Undulator Light Installation (LIULI).

The centre will soon be able to study free radicals, carbon clusters, fullerides, biologically significant molecules and nonlinear optical materials when a facility for infrared spectro/microscopy (ISMI) is completed.

Such advances will expand the present portfolio of experimental methods such as X-ray lithography, X-ray diffraction and absorption spectroscopy, phase contrast imaging, photoemission spectroscopy, and magnetic circular dichroism, as well as confirm the mission of SSLS to provide synchrotron radiation as a tool for scientific and technological applications.



SSLS is training manpower in science and technology fields related to synchrotron radiation. In addition, it is empowering industries to conduct advanced research and manufacturing in Singapore.

Temasek Laboratories at NUS (TL@NUS)

Temasek Laboratories at NUS (TL@NUS) was established in September 2000 with funding from the Defence Science and Technology Agency. Its mission is to conduct basic, upstream research in areas of science and technology critical to Singapore's defence and security. A researcher at SSLS uses the optical profiler to measure the height and surface roughness of microstructures by optical interferometry

Currently, it has taken up research in the following areas:

- Electromagnetics: antenna design, propagation and scattering of electromagnetic waves, electromagnetic materials, computational electromagnetics;
- Aeronautics: aerodynamics, flow/vortex control, flight control, computational fluid dynamics, multidisciplinary design optimisation;
- Information Security: coding theory and cryptography, system security, quantum cryptography;
- Signal Processing: wavelet techniques, radar data processing;
- Meteorology: meso-scale numerical weather prediction for the Southeast Asian region; and,
- Nonlinear Dynamics: basic research in nonlinear dynamics, with applications to communications, control, and fluid dynamics.

The Logistics Institute - Asia Pacific (TLI-AP)

As it strives to be the premier institute in Asia Pacific to further logistics research and education, The Logistics Institute - Asia Pacific (TLI-AP) has not let up on its goal of conducting leading-edge research, developing logistics engineering, and providing excellent postgraduate education.

A collaborative effort between NUS and the Georgia Institute of Technology in the US, TLI-AP has been the organiser and brains behind many events aimed to help logistics service providers and the manufacturing industry. The institute also provides training programmes so companies can upgrade human resources and achieve their growth potential through innovative logistics solutions.

For the strong relevance of its programmes to the industry, TLI-AP received the accolade of "Best Education Provider" at the Asian Freight and Supply Chain Awards in 2003.

Tropical Marine Science Institute (TMSI)

The Tropical Marine Science Institute (TMSI) concentrates on research in marine environment monitoring, assessment and enhancement; physical oceanography and underwater acoustics; as well as food safety and hatchery technologies relevant to marine aquaculture.

Key achievements made over the past few years include successful development of an imaging system using ambient noise, enhanced capabilities in assessing and predicting marine environmental impact, detecting and quantifying parameters in the marine environment from physical to biological, and a feed delivery system successfully developed for fish larvae.

The Maritime and Port Authority of Singapore, Agro-Food and Veterinary Agency, and National Environment Agency

Brig-Gen (NS) George Yeo, then Minister for Trade and Industry, examining some of the marine biodiversity in Singapore at the official opening of TMSI's research facilities on St John's Island in Nov 2002



are just some of the local agencies that are strategic partners of the Institute. In the US, collaborators include the Scripps Institute of Oceanography at the University of California, San Diego; Massachusetts Institute of Technology; Duke University; and Cornell University.





- * Main parameters indicate growth of NUS research base
- * Strong funding on competitive basis from external sources
- * Talented research manpower successfully recruited and retained
- * Research publications rising in quantity and quality



Research Data & Statistics

RESEARCH FUNDING



RESEARCH FUNDING



Research Funding – By Faculties & Schools (FY 2003)

- Figures exclude funding for RICs and Research Programmes
- Ministry of Education figures are based on approved budgets for approved projects

FY 2000 - FY 2003

- Ministry of Education figures are based on actual expenditure



Research Funding – Profile (FY 1997 – FY 2003)



RESEARCH PROJECTS



Foundations, Industries and other sources.

funded by Academic Research Fund (ARF), grants from Ministries, Statutory Boards,

Number of Research Projects Funded – By Faculties/Schools/RICs (FY 2003)

Number of Research Projects Funded – Profile (FY 1997 – FY 2003)



RESEARCH MANPOWER



Undergraduate Student figure as at 30 Sep 2003

RESEARCH MANPOWER



* University RICs and 3 NUS-affiliated RICs (Institute of Materials Research & Engineering, Institute of Molecular & Cell Biology, Institute for Infocomm Research)

Research Graduate Students Enrolled – Profile (FY 1997 - FY 2003)



Note:

Includes students who have withdrawn/terminated/graduated during the specific period. The enrolment trend of Masters and PhD students has shifted in recent years, with more students enrolling into PhD studies.

RESEARCH MANPOWER



Research Graduate Students Graduated

* Includes 3 NUS-affiliated RICs (Institute of Materials Research & Engineering, Institute of Molecular & Cell Biology, Institute for Infocomm Research)

Graduate Research Students Graduated – Profile (FY 1997 – FY 2003)



Note:

The number of graduates has declined in recent years because more students enrolled or upgraded to PhD studies.

RESEARCH PUBLICATIONS



Research Publications – Type (CY 2002)

Research Publications – Profile (CY 1996 – CY 2002)



PATENTS



Patents Filed & Granted – Profile (FY 1997 – FY 2003)



Financial Year