SPOTLIGHT ON SINGAPORE

Singapore: Asia's Innovation Capital

The Republic of Singapore is one of the most prominent economic and technological success stories in the world. In almost 50 years since its founding as an independent nation, the island has undergone a transformation from a labour and capital-intensive manufacturing centre to a key knowledge and innovation hub of Asia. Underlying this success is a thoughtfully planned R&D strategy underpinned by Singapore's deep capabilities in biomedical sciences, physical sciences and engineering.

With an area of just over 712 square kilometers and a population of about 5 million, Singapore is one of the smallest nations in the world. But its capacity for innovation and growth matches that of countries many times its size. Since its founding in 1965, the country has rapidly developed from a predominantly trading and manufacturing outpost into one of the world's most important and dynamic economies with a strong international profile in banking, electronics and advanced science and technological innovation.

Singapore's dramatic rise as a science and technology powerhouse in recent years can be attributed to a unique partnership model between Singapore's lead agency for scientific research and technology, the Agency for Science, Technology and Research (A*STAR), and the public and private sectors. This partnership links basic and applied research and cuts across traditionally separate disciplines, serving as an engine for economic growth. As A*STAR Chairman Lim Chuan Poh says, "Singapore's value proposition lies in its ability to integrate across multiple disciplines, across value chains and across public sector agencies, research institutes, universities, the clinical community and industry. " As Singapore commemorates 20 years of science and technology planning and development in 2011, it remains strongly committed to sustaining investments in R&D to evolve the country into a knowledge-based, innovation-driven economy. Multinational companies continue not only to bring their manufacturing and services, but also set up their corporate R&D labs in the country. Over the last two decades, Singapore has developed a vibrant R&D ecosystem comprising a plethora of research performers with key capabilities not just in science and engineering, but also in biomedical sciences. The number of researchers has grown more than five-fold to over 26,000 today with almost 60% working in the business sector.

A Planned Future

One major advantage that Singapore has is the ability to galvanise public and private sector agencies together and work seamlessly to catalyse the growth of the entire R&D industry. This 'Whole-of-Singapore' approach that offers industry players the opportunity to work with a range of research performers, each with a spectrum of research capabilities, did not come about by chance.

Singapore's first formal science and technology (S&T) plan was launched in 1991. A*STAR's predecessor, the National Science and Technology Board (NSTB), committed S$2 billion to establish research institutes to develop core R&D capabilities in physical sciences and engineering to transform Singapore's economy. The second five-year S&T plan from 1996 to 2000 saw this investment doubling to S$4 billion. In the next decade, with biomedical sciences identified as a new growth area in Singapore, these investments continued to rise, S$6 billion for 2001 to 2005, and then S$13.9 billion in the S&T plan for 2006 to 2010. These strategic plans and commitment to research

have established Singapore as a world-class R&D hub through the development of human capital, intellectual capital and industrial capital.

Building Up A Spectrum of R&D Capabilities

During the first and second S&T plans, various science and engineering research institutes were set up in Singapore to support specific industry verticals. These institutes have since developed many productive collaborations with businesses, which have spurred companies to set up dedicated R&D facilities here. Mitsui Chemicals set up its first R&D lab outside of Japan at A*STAR's Institute of Chemical and Engineering Sciences (ICES) in 2006, and within two years, announced a breakthrough development of a catalyst that can produce benzene and hydrogen from methane. HP Labs has also set up a S$50m full-scale research lab in Singapore on data centers and cloud computing. In April 2011, Applied Materials announced that it will be setting up a Center of Excellence in Advanced Packaging in Singapore.

Following the Asian financial crisis from 1997 to 2000, biomedical sciences was identified as a key growth pillar of Singapore's economy. The objective was to go beyond biomedical sciences manufacturing and build a strong base in R&D so as to anchor more multinational companies in Singapore.

Singapore is now home to more than 100 global biomedical sciences companies. These include many of the world's top pharmaceutical manufacturers such as Abbott, Merck Sharp & Dohme, and Novartis. In particular, Abbott's nutrition R&D facility in Singapore is the largest outside the US and the company's third extension in Singapore since 2009. Leading multinational corporations such as Genentech, GlaxoSmithKline and Lonza have invested a total of almost S$2.6 billion since

A*STAR: Beyond Basic Research

As the lead public research agency in Singapore, A*Star's mission is to foster world-class scientific research and talent that will transform the country into a vibrant, knowledge-based economy. It aims to achieve this by investing strategically in human, intellectual and industrial capital to support R&D in both biomedical sciences (BMS) and physical sciences and engineering.

In the last decade, BMS has been an area of focus for A*Star and the agency has played a critical role in developing the robust ecosystem that exists today. Internationally renowned talent was recruited to build and deepen Singapore's BMS capabilities and in 2003, Biopolis, a major biomedical hub, was established to consolidate all BMS research efforts. In the space of 10 years, Singapore has developed research capabilities in a wide spectrum of BMS disciplines, including genomics, bioprocessing technology, bioinformatics and bioengineering, brought together in its seven biomedical science research institutes and six consortia and centres, located in Biopolis and the immediate vicinity.

A*STAR has sought to make the most of its research capabilities by encouraging integration across disciplines, across the R&D spectrum and across public sector agencies, research institutes, universities, the clinical community and industry. This ability to integrate has proven highly successful in attracting industry and forging meaningful public-private partnerships.

> "A*STAR has a mission to drive and sustain world-class scientific research that will be meaningful and impactful for Singapore."
>
> **A*STAR Chairman, Lim Chuan Poh**

In April 2011, A*STAR's Singapore Immunology Network (SIgN) signed a three-year partnership with French pharmaceutical company Servier to isolate human monoclonal antibodies to suppress tumour-initiating cells and develop drugs to restrict the spread of breast cancer - the most common cancer in women. Another A*STAR research institute, the Institute of Medical Biology (IMB), is collaborating with L'Oréal Advanced Research, Paris, to jointly establish an Asian skin cell bank. This library of skin cell samples will enable scientists to gain deeper insights into the unique genetic makeup of Asian skin in order to cater better to the needs of Asian consumers.

Alongside its partnerships with industry, A*STAR has generated commercial successes through its own strategic marketing and commercialisation arm, Exploit Technologies (ETPL). ETPL consolidates under one roof all the intellectual property and knowledge generated by over 2,000 A*STAR researchers. Spin-offs from these efforts in recent years include MerLion Pharmaceuticals (launched from the Institute of Molecular and Cell Biology), VeriStem Technologies (from the Bioprocessing Technology Institute) and bioinstrumentation firm Curiox Biosystems (from the Institute of Bioengineering and Nanotechnology).

2007 to set up biologics manufacturing plants that will create 1,300 high value jobs.

Biomedical sciences have not only diversified the country's economy, but have also been a vital engine for economic growth. In less than a decade, biomedical sciences manufacturing output has more than tripled from S$6.3 billion in 2000 to S$21 billion in 2009, growing from 4% to 10% of total manufacturing output over 2000–2008. It is now the fourth pillar of the manufacturing sector with the other three being electronics, petro-chemicals and engineering.

Such rapid expansion has driven concomitant employment growth, with manufacturing employment in biomedical science-related industries more than doubling to over 13,000 between 2000 and 2009. In addition, research and development in bioengineering and biomedical and related sciences employs more than 5,000 people, of which 40% are PhD graduates. This growth has been fuelled by a manufacturing-friendly environment rich with human capital and a strong research infrastructure, and also by "bench to bedside" breakthroughs from Singapore's laboratories.

One local breakthrough in disease diagnostics technology is the development of the MicroKit - a diagnostic kit capable of detecting the H1N1 virus and other infectious agents within 2 hours, a process which normally takes up to half a day. The team from A*STAR's Institute of Bioengineering and Nanotechnology which developed the MicroKit was recently honoured with a Silver Award at the Asian Innovation Awards 2011 organized by *The Wall Street Journal Asia*.

An Interdisciplinary Vision

Cross-disciplinary and public-private partnerships in mission-oriented research are a critical component of Singapore's R&D strategy. A*STAR encourages its research institutes to adopt a collaborative approach with private companies to innovate new solutions for increasingly complex problems. DNA sequencing is one area in which the interface between basic and mission-oriented research is most evident. Its inherent complexity requires very specific biomedical research expertise whilst its practical implementation requires technologies ranging from high-resolution image sensing to computational analysis. Collaborative, multidisciplinary efforts between A*STAR's Biomedical Research Council (BMRC) and its Science and Engineering Research Council (SERC) in this area have led to the fabrication of a groundbreaking device that makes the rapid and inexpensive sequencing of DNA a reality.

Two major research complexes in the form of Biopolis and Fusionopolis were purpose-built to facilitate collaboration between biomedical sciences and physical sciences and engineering. The twin hubs located less than half a mile apart are home

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NATIONAL UNIVERSITY OF SINGAPORE

A leading research-intensive university in the heart of Asia

Consistently ranked as one of the top universities in Asia and the world, the National University of Singapore (NUS) offers a supportive environment and state-of-the-art facilities to promote research of the highest caliber.

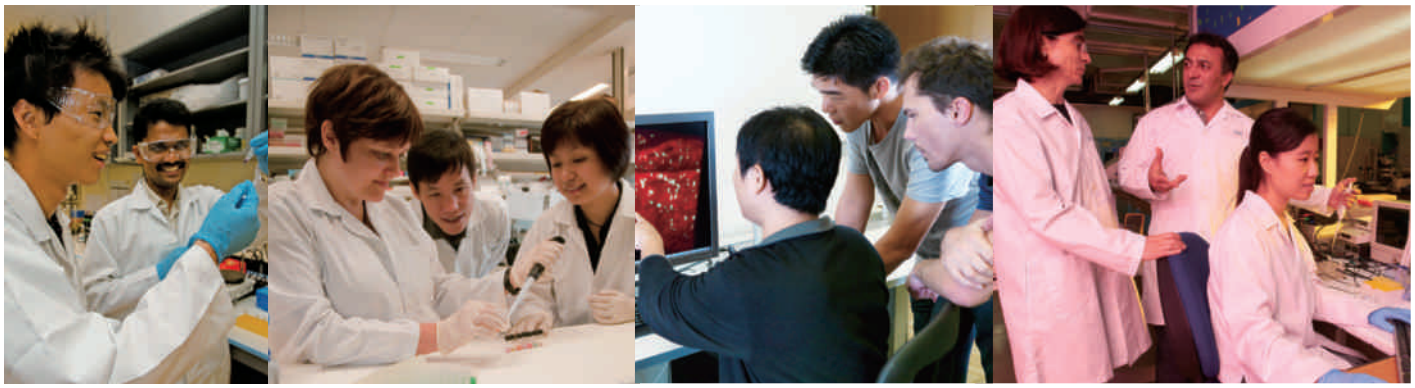
Founded in 1905, NUS is today a widely respected research-intensive university of global standing, known for its high-quality research in science, technology and the humanities – and, increasingly, the interfaces between these areas. Its 21 university-level research institutes and centers focus on critical issues confronting Asia and the world. The overall level of primary research published by NUS has led to its output being recognized by Thomson Reuters as being in the top 1% in 18 out of the 22 field categories surveyed.

At NUS, facilitating the translation of research output to useful applications is a key priority. An example of how the University's research delivers practical benefits to society is the success of scientists of the NUS Nanoscience and Nanotechnology Initiative in developing the world's first energy-storage membrane from organic waste that can power hybrid vehicles and store energy for solar panels. The novel membrane has an energy-storage capability and cost-effectiveness surpassing that of conventional systems, and it can also be recharged up to 6,000 times – approximately 10 times that possible for existing rechargeable batteries. Other innovations NUS researchers have conceived include a portable abdominal simulator that can be used to train medical students in carrying out abdominal examinations. The device proved particularly valuable during the H1N1 influenza outbreak in 2009 which limited physical contact with patients.

NUS is also home to three of Singapore's five Research Centers of Excellence (RCEs) specializing in quantum technologies, cancer, and mechanobiology, and is a partner in a fourth that draws on NUS' strengths in life sciences and sustainability research. These RCEs are headed by world-renowned researchers, with government funding of over US$100 million each. Singapore's Campus for Research Excellence and Technological Enterprise that brings together top researchers from around the world and Singapore is located at NUS

University Town. The Massachusetts Institute of Technology (MIT) has already established a center focusing on infectious diseases, environmental sensing and modeling, and healthcare technologies.

NUS also benefits from its close proximity to many of Singapore's key science and technology hubs, including Biopolis, Fusionopolis, the Singapore Science Parks and the National University Hospital. "The synergistic effect created between NUS and these diverse research and development communities contributes to a fertile environment for innovation and enterprise while promoting and supporting collaboration," says Barry Halliwell, Deputy President (Research and Technology) of NUS.



to A*STAR as well as corporate laboratories and public research institutes. The close proximity of these hubs to each other and to universities and hospitals offers researchers and scientists a conducive environment to develop meaningful collaborations both within and outside of A*STAR.

BMRC Chairman Radda notes that this is part of a larger strategic trend in Singapore. "A culture of collaboration is brewing in Singapore between biomedical scientists and physical scientists and engineers. For instance, the Biomedical Engineering Program launched in 2009 creates opportunities for A*STAR researchers to collaborate with clinicians in hospitals, and a joint council was formed in 2007 to promote and facilitate interdisciplinary research between biomedical sciences scientists, and physical scientists and engineers. "

These efforts are already bearing fruit and are behind such recent developments as Automatic Glaucoma Diagnosis and its Genetic Association Study through Medical Image Informatics (AGLAIA), an automated diagnosis system for glaucoma. This initiative was carried out by A*STAR's Institute for Infocomm Research (I2R) in partnership with the Singapore Eye Research Institute (SERI), and the Centre for Eye Research Australia. Another initiative is advanced rehabilitation therapy for stroke patients based on Brain-Computer Interface (ArtsBCI), a groundbreaking integration of computer-based tools for stroke recovery.

To spur R&D collaborations for future energy and smart grid solutions, the A*STAR Experimental Power Grid Centre (EPGC) was recently opened. The EPGC is one of the world's largest experimental power grid facilities, and has signed a research collaboration agreement with SP PowerGrid, and MOUs with the Housing Development Board (HDB), Meidensha Corporation Japan, and National Instruments. It will conduct cutting-edge research to develop future energy technologies in areas of electrical power networks, energy distribution, and renewable energy resources. This latest public-private partnership builds on existing collaborations forged with Vestas and Rolls Royce, during the centre's groundbreaking ceremony in July 2010. Vestas, the world leader in wind technology, has already completed a project with EPGC to co-develop technologies to enhance the capabilities of wind turbines. Rolls Royce, a global power systems provider, has begun research on marine grid systems with EPGC.

The Singapore Gastric Cancer Consortium (SGCC), comprising a multi-disciplinary group of scientists and clinicians from Duke-NUS Graduate Medical School, the National University Health System, National University Cancer Institute, National Cancer Centre Singapore, Cancer Science Institute of Singapore, A*STAR's Genome Institute of Singapore (GIS), and four public hospitals, succeeded in identifying two new subtypes of gastric cancer, and demonstrated that the classification of these subtypes may be associated with differences in patient survival and responses to standard chemotherapy.

Collaborative work beyond Singapore's borders also holds promise for commercial advances. A*STAR's partnership with the Center for Integration of Medicine & Innovative Technology (CIMIT) – a non-profit consortium of Boston's leading teaching hospitals and universities serving as an entrepreneurial incubator – enables A*STAR to select technologies in CIMIT's portfolio for development and implementation in Singapore that, taken with other innovations, constitute a research and development pipeline that impacts both Singapore's economy and the quality of life worldwide.

Building Human and Intellectual Capital

The fundamental strategy underlying Singapore's R&D successes is nurturing and attracting talented individuals. With a limited population base in Singapore, a holistic strategy is needed to attract and develop world-class scientists, both local and international, for all areas of the R&D landscape. Internationally renowned scientists have been attracted to come to Singapore, its universities, and A*STAR to pursue scientific excellence, and help Singapore develop new capabilities and generate new knowledge, as well as mentor a new generation of young scientists. They include international research talent such as David Lane, who was jointly responsible for discovering the tumor-suppressing gene p53; Jackie Ying, recognised as one of "One Hundred Engineers of the Modern Era" by the American Institute of Chemical Engineers for her groundbreaking work on nanostructured systems, nanoporous materials, and host matrices for quantum dots and wires; Pantelis Alexopoulos who has spent more than 30 years in Maxtor, IBM, Seagate, and Hitachi Global Storage Technologies; and Dim-Lee Kwong, winner of the prestigious IEEE Frederik Philips Award 2011. Kerry Sieh, founding Director of Nanyang Technological University's Earth Observatory of Singapore says of his move to Singapore, "I'm having the time of my life. It's wonderful to be in a place that appreciates you." Sir George Radda, Chairman of A*STAR's BMRC, sums up the reasons why he was attracted to Singapore: "The presence of many outstanding scientists, strong government support and the challenge was too much to turn down. I was also very much attracted by working not just with scientists in the biomedical community, but with colleagues in engineering, physics and chemistry."

Besides attracting eminent international scientists and

researchers, A*STAR plays an active role in identifying and nurturing scientific talent by providing scholarships and research grants, and creating opportunities for young scientists in Singapore to grow and develop. For example, Cheok Chit Fang, one of the first to begin her studies under an A*STAR PhD scholarship, began her post-doctoral training under the tutelage of David Lane (A*STAR's Chief Scientist). She now leads the IFOM-p53 Joint Research Lab, the first international outpost of the Italian FIRC Institute of Molecular Oncology (IFOM).

Another outstanding researcher who has also benefited from A*STAR's scholarship is Joel Yang, who studied for his PhD at MIT. While at MIT, he and his team developed a novel photon detector that can receive information via low-intensity light, which could in theory provide the tools for real-time data transfer to distances as far away as Mars. Currently at the A*STAR's Institute of Materials Research and Engineering (IMRE), Joel has collaborated with the researchers from the National University of Singapore (NUS), and Data Storage Institute (DSI) to develop a process that can increase the data recording density of hard disks to 3.3 Terabit/in^2, six times the recording density of current models. This means that a hard disk drive that holds one terabyte (TB) of data today could in future hold six TB of information without any increase in size.

Another important priority in building human capital is addressed with the provision of post-doctoral fellowships, placement opportunities at A*STAR labs, and industry partnerships as well as collaborative efforts such as the Singapore-Stanford Biodesign Programme (SSB), a joint venture with Stanford University to train young professionals from diverse backgrounds in developing innovative medical devices in Singapore.

In the period between 2000 and 2009, the number of researchers, scientists, and engineers in Singapore rose by over 80% from 14,483 to 26,608, increasing the proportion of the labour force engaged in this sector by almost one-third. Over the last decade, total employment in research and development has grown by more than 75%, with two-thirds of these jobs being in the private sector.

The cultivation of the next generation of scientific talent extends beyond A*STAR to institutes of higher learning which are part of Singapore's vibrant R&D ecosystem. The NUS is the largest university in Singapore and one of the most prestigious seats of learning in the world. Providing a transformative education that includes a broad-based curriculum underscored by multi-disciplinary courses and cross-faculty enrichment, NUS has over 36,000 students from more than 100 countries. Nanyang Technological University (NTU) is among the fastest

PROFILE

Duke-NUS Graduate Medical School Singapore

Shaping the future of Singapore's healthcare

Duke-NUS Graduate Medical School Singapore (Duke-NUS), a joint venture launched in 2005 between Duke University School of Medicine in North Carolina, USA and the National University of Singapore (NUS), is the country's first graduate-entry medical school. The mission of the institution is the training of new physicians to meet Singapore's long-term healthcare needs and grooming the next generation of top-flight medical and scientific leaders who will drive the government's biomedical sciences agenda.

The Duke-NUS strategic collaboration traces its roots to the Biomedical Sciences Initiative (BMI), a multi-billion dollar governmental project announced in 2000 aimed at turning Singapore into a regional biomedical hub and boosting the research and healthcare delivery capabilities of the country. Evaluation of the plan identified the need for a graduate medical school and the Duke University School of Medicine was chosen as the international partner. The school operates a US-style graduate admissions model and offers three programmes of study, of which the main is a four-year Doctor of Medicine course, leading to a joint MD degree from the NUS and Duke University. The first student cohort was enrolled in 2007, and graduated in 2011, subsequently entering a structured residency programme with Singapore Health Services and a consortium of healthcare institutions in Singapore. In addition to the MD programme, the school runs a seven-year MD/PhD programme combining clinical practice with biomedical research and a PhD Programme in Integrated Biology and Medicine. Approximately 240 individuals are enrolled in the three programmes at any one time.

Duke-NUS has also formulated five cutting-edge Signature Research Programmes (SRPs) covering a range of contemporary biomedical research themes. The aim of the SRPs is "to provide a seamless link between the research activities carried out by Duke University in the U.S. and Duke-NUS, while taking advantage of diseases that tend to be more prevalent in Asia," according to Patrick Casey, senior vice dean of research at Duke-NUS. Initiatives within the SRPs have been supported by more than S$200 million in research funding and resulted in the publication of over 400 papers in international peer-reviewed journals.

Phase two of the Duke-NUS project commences in 2012. The school will work

closely with SingHealth on research in the context of medical practice. "The partnership is envisioned as an integrated working enterprise that guides and promotes the future of medicine, tapping into and combining the collective strengths of SingHealth's clinical expertise and Duke-NUS' biomedical sciences research and medical education capabilities," says Ranga Krishnan, dean of Duke-NUS. A key concept in this context, termed Academic Medicine, seeks to integrate three functions of medicine – clinical care, education and the development of new medicine – to close the gaps between research and academic discovery and target improved patient experience and healthcare outcomes, according to John Rush, vice dean of clinical sciences at Duke-NUS.




growing, most research-intensive universities in the world and is also one of the seven founding members of the Global Alliance of Technological Universities, a network of the world's top technological universities that seeks to address global issues through leading-edge science and technology. NTU boasts over 33,000 students enrolled in science, medical and engineering disciplines. DUKE-NUS Graduate Medical School Singapore was established in 2005 as a strategic collaboration between the Duke University School of Medicine in North Carolina, and the NUS. Based on the unique Duke model of education, its 4-year medical training programme includes a dedicated year of research and study on basic and clinical sciences. Another initiative is the Campus for Research Excellence And Technological Enterprise (CREATE) which is currently under development by Singapore's National Research Foundation. This multidisciplinary campus of research centres will feature partnerships with major universities and corporate labs worldwide; for example, the Singapore-MIT Alliance on Research and Technology (SMART) opened in 2007 and represents MIT's first and largest research centre outside the US.

A Planned Trajectory for Growth

Over the next five years, Singapore will focus on the continued development of an environment for world-class collaborative science, with the government pledging S$16.1 billion in research and development for the period 2011–2015 This represents a substantial 20% increase over the previous five years. The target that Singapore has set for gross expenditure on research and development is 3.5% of GDP by 2015.

In the future, this investment will support a continued focus on translational and clinical and multidisciplinary research under the auspices of A*STAR's SERC, BMRC and the National Medical Research Council . For example, the Translational Clinical and Research (TCR) Flagship Programme is now supporting the translation of research into clinical applications, funding projects in areas such as gastric cancer, ocular surgery, and the treatment of dengue fever. The budget will go into industry-oriented research and technology designed to create value and yield economic returns, thus enabling scientists to have the means to continue with their research.

A recent deal concluded among the Experimental Therapeutics Centre (ETC) and Singapore Immunology Network (SIgN) and the Swiss company, Cytos Biotechnology, is one such example. The partnership is expected to lead to a new generation of influenza vaccines specific to the needs of Asia, whilst giving scientists sufficient investment to engage in foundational research to explore and capture new opportunities in science. SIgN Chairman Philippe Kourilsky describes agreements such as these as part of a broader trend. "The decision to focus on human rather than mouse immunology was strategic, as was the establishment of a broad clinical network and powerful platforms supporting both basic research and industrial and clinical projects. This is how we could successfully link up with industry, whilst dedicating just a few per cent of our resources."

As a result of increased funding, partnerships with industry and research performers from both public and private sectors have increased. The number of industry collaborations initiated between 2006 and 2008 has almost doubled the combined total of the period 2000–2005. The launch of three notable major initiatives in one year alone (2010) is destined to impact the long-term future of research and development in Singapore. The Roche Translational Medicine Hub focuses on expanding the knowledge of disease biology to create new, personalised treatment modalities, whilst the Academic Centre of Excellence (ACE) established by international pharmaceutical giant GlaxoSmithKline is a virtual research network that works with academics to target the development of new medicines. The ACE initiative places emphasis on projects that will impact health in Asia including early initiatives on stem cell research and new biomarkers for dementia. A Master Research Collaboration Agreement (RCA) has also been signed with Proctor & Gamble focusing on Transformative Platform Technologies (TPT), exploring areas ranging from process development to high performance computational modelling for consumer products.

A Future Global Innovation Hub

The substantial and sustained increase in research and development funding promises to create a new paradigm for the biological sciences and science and engineering in Singapore, based on a multi-disciplined, multi-pronged network of collaborations – within A*STAR, with clinicians, and with industry. This underscores the very real possibility that Singapore will become a global model for commercially viable research in the near future.

With the shift of markets to Asia, Singapore is well-placed to become Asia's Innovation Capital – set to attract both global companies seeking to develop solutions targeted at Asian markets, and Asian companies that need a launch pad to globalise their products and services. With sustained funding and strategic planning from the government, Singapore is on the way to becoming a global research and development powerhouse to rival other major international centres. ■

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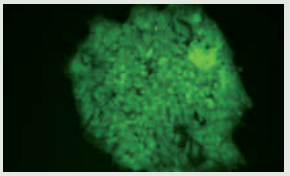
INNOVATIONS & BREAKTHROUGHS

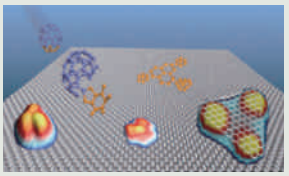


A*STAR
First large scale Genome-Wide Study of Human Stem Cells

A team of scientists led by A*STAR's Genome Institute of Singapore (GIS) and the Institute of Molecular and Cell Biology (IMCB) have uncovered the genes which regulate the capacity of human embryonic stem cells (hESCs) to transform into any type of cell in the human body. To achieve this breakthrough in understanding, the scientists studied all 21,000 genes in the human genome in the first ever genome-wide study of its kind. Their results, published in *Nature*, provide important clues to how stem cells may be used to treat Parkinson's disease and traumatic spinal injury.

NTU
Quick and Scar-less robotic stomach surgery

Nanyang Technological University (NTU) pioneered a ground-breaking biomedical technology that removes stomach tumours without scars, reducing surgery time from a few hours to just minutes. A flexible endoscope with two robotic hands that removed tumours in the stomach was successfully used on patients in India by Dr R. Pradeep at the Asian Institute of Gastroenterology. The surgical robot, built entirely by NTU, was developed by NTU's Associate Professor Louis Phee with Professor Lawrence Ho of National University Hospital.



NUS
Unraveling Carbon Magic

A team led by Kian-Ping Loh from NUS' Department of Chemistry in the Faculty of Science has conceived a novel assembly approach using C_{60} fullerene as a precursor to generate graphene. With ruthenium as a catalyst and employing scanning tunneling microscopy, Loh's team conceived a controllable pathway to generate geometrically well-defined graphene quantum dots from C_{60} fullerene. Their breakthrough sheds new light on the diffusion and thermal dynamics of carbon clusters on metal surfaces, as well as boosts graphene's promise as a next-generation semiconductor.

DUKE-NUS
Ceramides in Obesity and Metabolic Disease

Experimental reduction of ceramides, which are toxic byproducts of metabolism of saturated fats, ameliorates features of diabetes and cardiovascular disease in rodents. Scientists at Duke-NUS and UT-Southwestern collaboratively discovered that the induction of ceramide levels is essential for inflammation-induced insulin resistance, while ceramide degradation accounts for the cardioprotective and anti-diabetic actions of the hormone adiponectin. These studies, which were published in 2011 in the Journal of Clinical Investigation and *Nature Medicine*, respectively, suggest new therapeutic strategies for warding off complications of obesity.

A*STAR

Agency for Science, Technology and Research
SINGAPORE

www.a-star.edu.sg

The Agency for Science, Technology and Research (A*STAR) is the lead agency for fostering world-class scientific research and talent for a vibrant knowledge-based and innovation-driven Singapore. A*STAR oversees 14 biomedical sciences and physical sciences and engineering research institutes, and six consortia & centres, located in Biopolis and Fusionopolis as well as their immediate vicinity. A*STAR supports Singapore's key economic clusters by providing intellectual, human and industrial capital to its partners in industry. It also supports extramural research in the universities, and with other local and international partners.

Nanyang Technological University, Singapore

NANYANG TECHNOLOGICAL UNIVERSITY

www.ntu.edu.sg

Nanyang Technological University, a major science and technology university in Singapore, offers Engineering, Business, Science, and Humanities, Arts & Social Sciences and from 2013, Medicine, with Imperial College London. Research-intensive and interdisciplinary, NTU also has four world-class autonomous institutes – S Rajaratnam School of International Studies, National Institute of Education, Earth Observatory of Singapore and Singapore Centre on Environmental Life Sciences Engineering.

National University of Singapore

NUS National University of Singapore

www.nus.edu.sg

A leading research-intensive university in Asia, the National University of Singapore (NUS) is Singapore's flagship university offering a global approach to education and research. Its 16 Faculties and Schools offer diverse undergraduate and graduate programmes. Its 21 university-level research institutes and centers as well as three Research Centers of Excellence engage in cutting-edge research on issues confronting Asia and the world.

DUKE-NUS

DUKE NUS GRADUATE MEDICAL SCHOOL SINGAPORE

www.duke-nus.edu.sg

The Duke-NUS Graduate Medical School Singapore is a strategic collaboration between Duke University School of Medicine, USA, and the National University of Singapore. It offers three programmes, leading to Doctor of Medicine (M.D), M.D/PhD and PhD degrees. Duke-NUS also runs five Signature Research Programmes in Cancer, Neuroscience, Emerging Infectious Diseases, Cardiovascular & Metabolic Disorders, and Health Services and Systems Research.