Research » Innovation » Enterprise

2015
SINGAPORE'S FUTURE

Research Innovation and Enterprise Secretariat

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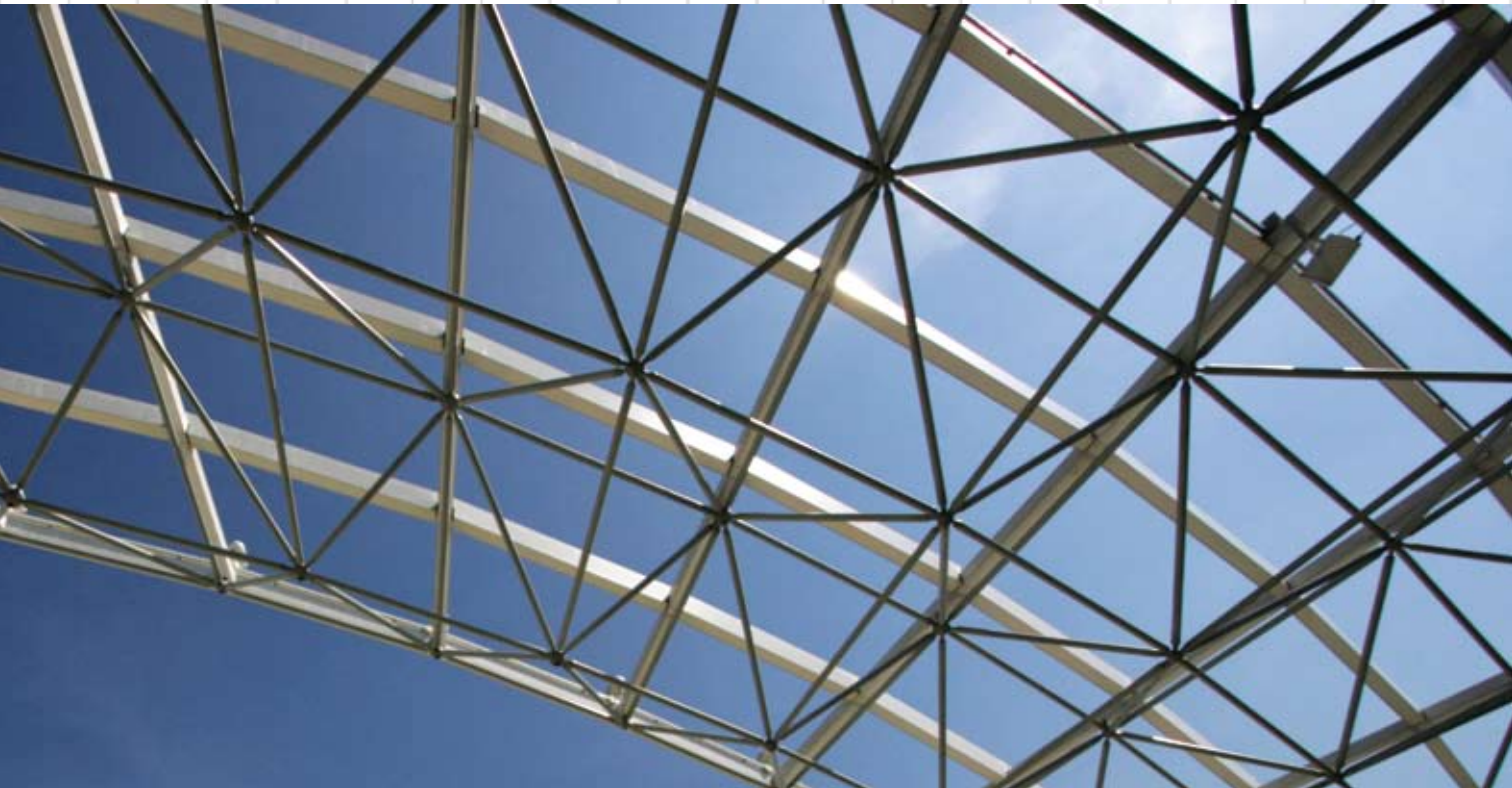


Foreword

R&D is an important part of Singapore's economic strategy. It is a source of innovation and value creation. Singapore has thus been investing heavily in R&D. Since the launch of the first National Technology Plan in 1991, total R&D expenditure has increased about tenfold, from S$760 million in 1991 to S$6,040 million in 2009. As a share of GDP, it grew during this period from 1.0% to 2.3% of GDP.

These investments have helped to build a significant base of R&D capabilities. We have today a spectrum of industry oriented research institutes across engineering and biomedical sciences, covering areas such as data storage, microelectronics, genomics and immunology. Our universities have established peaks of research excellence in areas such as energy, water and biomedical sciences. Two new Academic Medical Centres are now being developed to provide a conducive environment for clinical service, research and education.

Our R&D efforts are beginning to yield results. The number of patents awarded has increased significantly from 20 in 1992 to 747 in 2008. The sales revenue from products of R&D performed in Singapore has doubled from about S$6.4 billion in 1996 to about S$12.3 billion in 2009. R&D has helped to sustain the competitiveness of established sectors such as Marine and Offshore Engineering and Electronics, and seeded new growth sectors such as Biomedical Sciences and CleanTech.

To further boost research, innovation and enterprise (RIE), the Singapore Government will invest S$16.1 billion over 2011-2015 as part of its RIE 2015 plan. This is a 20% increase over 2006-2010. At 1% of the national GDP, it is on par with advanced countries. This demonstrates Singapore's continued commitment to both basic and mission-oriented research in our public sector research institutions.

RIE2015 has six key thrusts. First, there will be continued emphasis on basic science and knowledge as the basis for future innovations. Second, we will continue to focus on talent attraction and development, positioning Singapore as a choice location for researchers. Third, there will be greater emphasis on competitive funding as a means to select the best ideas. This will direct resources to the best research and researchers for further support and development. Fourth, greater synergies between researchers across the public and private sectors will be fostered. Greater funding support will be provided to multidisciplinary, breakthrough science. Fifth, a greater proportion of R&D will be focused on economic outcomes. Sixth, we will strengthen support for commercialisation so as to spur the development of new products and services for economic and societal benefit.

RIE2015 is the culmination of a year-long planning process harnessing the collective effort of all research, economic and funding agencies. It will support Singapore's long term vision to be a research-intensive, innovative and entrepreneurial economy like Sweden, Finland or Israel.

As we move into the implementation of RIE2015, the same spirit of collaboration will be kept alive to realise our shared vision.

Teo Chee Hean
Deputy Prime Minister

Singapore: Building up a knowledge-based economy

In the 1990s, Singapore embarked on a major technology drive to transform into a knowledge-driven economy. In 1991, we developed our first 5-year National Technology Plan and established the National Science and Technology Board to catalyse the development of technology.

> "To maintain our competitiveness, Singapore needs to move to an innovation phase of our development and promote activities with more innovative and design content. This means mastering science and technology."
>
> — National Technology Plan, 1991

Thereafter, over a number of successive Science and Technology Plans, R&D has become a cornerstone of Singapore's economic development. Testament to its importance is the high-level attention it receives. The Research, Innovation and Enterprise Council (RIEC), a public and private sector council chaired by Prime Minister Lee Hsien Loong leads Singapore's national drive to promote research and enterprise, and advises the Singapore Cabinet on national research and innovation policies.

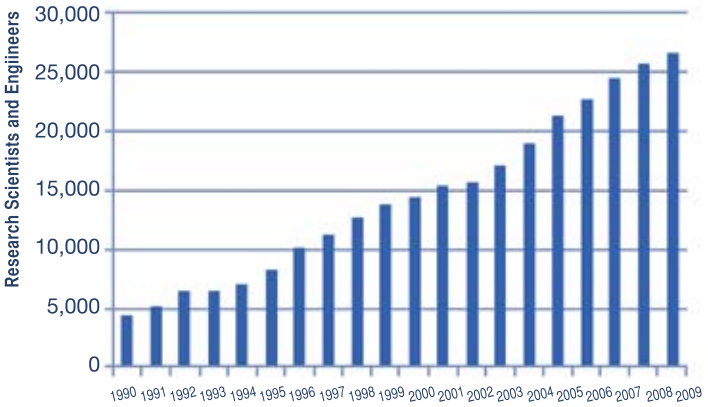
Achievements of the 2006 to 2010 Science and Technology Plan

The S$13.6 billion Science and Technology 2010 plan has helped Singapore distinguish itself as a frontrunner in innovation. It has helped attract talent and private R&D investments. Between 2005 and 2009, the number of research scientists and engineers in Singapore increased markedly from about 21,000 to more than 26,000. Private sector expenditure on R&D increased from about S$3 billion to about S$3.7 billion. R&D also yielded products and processes that generated an average of S$18 billion in annual sales revenue during this period.

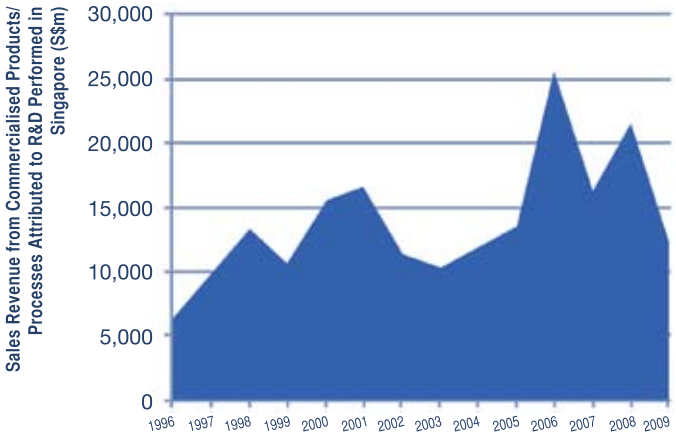
Singapore is a frontrunner in innovation

Country	The Atlantic Century Report by the Information Technology and Innovation Foundation	The Innovation Imperative in Manufacturing by Boston Consulting Group	Global Competitiveness Report 2010-11 by the World Economic Forum (Innovation Pillar)	Global Innovation Index 2009-2010 by INSEAD and India's Confederation Industry
Singapore	**1**	**1**	**9**	**7**
Finland	7	7	3	6
Israel	-	16	6	23
Korea, Rep	5	2	12	20
Sweden	2	10	5	2
Switzerland	-	3	2	4
Taiwan	-	-	7	25

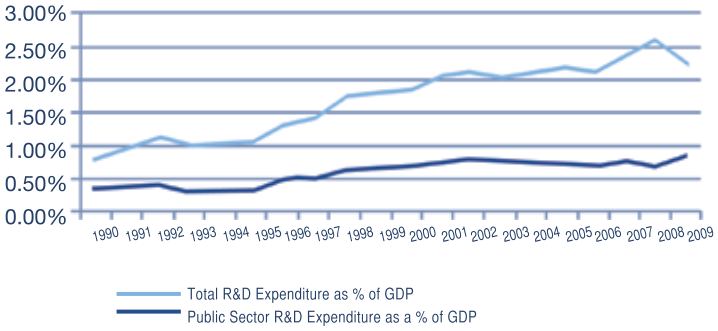
SINGAPORE HAS A WIDE AND GROWING TALENT BASE FOR RESEARCH



SALES REVENUE FROM COMMERCIALISATION HAS DOUBLED FROM S$6 BILLION IN 1996 TO S$12 BILLION IN 2009



A STEADY INCREASE IN GROSS EXPENDITURE ON R&D (GERD) AS A % OF GDP, SUPPORTED BY SUSTAINED PUBLIC SECTOR INVESTMENTS



A S$16.1 BILLION BOOST FOR R&D FROM 2011 TO 2015

On 17 September 2010, the RIEC unveiled a S$16.1 billion national budget for research, innovation and enterprise from 2011 to 2015. This is a 20% increase from the S$13.6 billion allocated from 2006 to 2010, and represents Singapore's steady commitment to R&D. The six key strategies for RIE2015 are to:

- Continue to invest in new knowledge and ideas, to seed the intellectual capital that forms the basis for future innovations. Scientists will receive the support and autonomy to pursue the questions that emerge from their research, and create new knowledge in areas they are passionate about. The Ministry of Education (MOE) has enhanced its **Academic Research Fund** to provide more support for basic, investigator-led research. A new Tier 3 programme has been introduced, to fund

programme-level research projects ranging from S$5 million to S$25 million over 5 years.

» Continue to emphasize the attraction and development of scientific talent to meet the needs of our industry and public sector research institutions. S$735 million will be allocated to scholarships and fellowships for talent training at renowned institutions both locally and overseas.

» Place greater emphasis on competitive funding, to spur innovation and bring out the best ideas for further support and development. A greater proportion of R&D funding will be available on a competitive basis, while maintaining an appropriate level of assured funding for core capabilities. Competitive funding will help us refresh and renew our R&D portfolio, whilst ensuring that the best capabilities are retained. The National Research Foundation's **Competitive Research Programme** will be expanded significantly from S$350 million to close to S$1 billion.

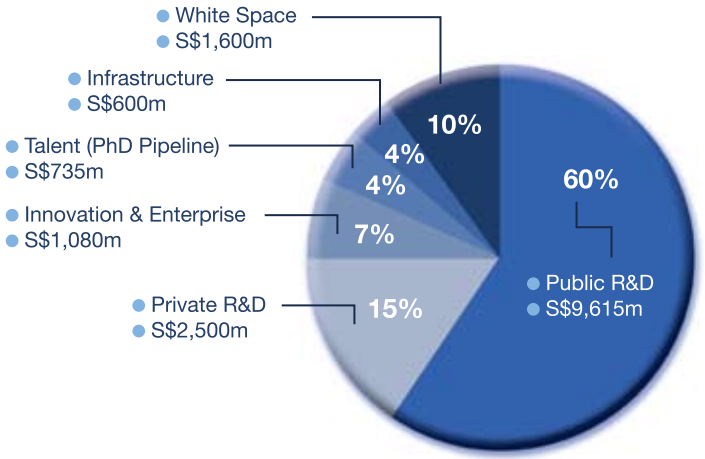
» Strengthen synergies across our various R&D performers in the Agency for Science, Technology and Research (A*STAR) research institutes, universities, hospitals, CREATE (Campus for Research Excellence and Technological Enterprise) centres, and industry. Greater funding priority will be given to such multi-disciplinary and collaborative efforts, including with corporate R&D laboratories. A*STAR's **Joint Council Office**, which supports multidisciplinary research across the physical and biomedical sciences, will receive an expanded budget of S$250 million.

» Focus a greater proportion of R&D on economic outcomes. This means greater support for private sector R&D, closer collaborations between public and private sector R&D, and added emphasis on commercialisation of intellectual properties, leading to new and better products and services. Support for private R&D will be increased from S$2.1 billion to S$2.5 billion. Within public R&D, a new S$1.35 billion **Industry Alignment Fund** will encourage public researchers to work more closely with industry.

» Provide stronger support for our scientists to take their ideas from basic research through to commercialisation. This will strengthen the work of our technology transfer offices, translational and innovation centres, and enterprise incubators and accelerators. The Innovation and Enterprise budget will be doubled to about S$1.08 billion.

RIE2015 will also introduce a new S$1.6 billion **White Space** fund for responding to emerging opportunities in the course of the 5-year period. White Space will be open to proposals from all agencies, and will enable Singapore to respond quickly to unanticipated challenges and opportunities.

RIE2015 PORTFOLIO



Nanyang Technological University

CleanTech Park

NRF Create

Jurong Island

National University Health System & National University of Singapore

Tuas Biomedical Park

A*STAR Fusionopolis & Biopolis

Singapore University of Technology and Design

Mediapolis

Singapore Management University

SingHealth & Duke-NUS Graduate Medical School

Science Park

- **Invest in new knowledge and ideas, to seed the intellectual capital that forms the basis for future innovations**
- **Provide more support for basic, investigator-led research**

RESEARCH-INTENSIVE UNIVERSITIES WITH GLOBAL IMPACT

Our universities engage in a broad range of cutting-edge research - from basic science, to engaging industry in co-developing emerging technology. Five new Research Centres of Excellence (RCEs) have also been established to allow our universities to compete with the world's most advanced laboratories. A 2010 ranking of the most-cited Institutions based on Thomson Reuters-indexed Engineering journals ranked Nanyang Technological University (NTU) and National University of Singapore (NUS) 8th and 9th respectively, ahead of Imperial College and Tokyo University.

In 2009, researchers at the Centre for Quantum Technologies (CQT) RCE successfully achieved Bose-Einstein condensates (BEC). This remarkable achievement has propelled Singapore to the premier league of experimental atomic physics, and will allow researchers to investigate the quantum properties of matter. At the Cancer Science Institute RCE, researchers uncovered that a S$12 anti-fungal drug used to treat everyday infections such as dandruff and athlete's foot could help halve chemotherapy costs for advanced breast cancer patients. Ketoconazole, the anti-fungal drug, complements chemotherapy treatment as it blocks an enzyme in the body from breaking down a drug used to treat cancer. Researchers were able to reduce the concentration level of the chemotherapy by 40% – thereby reducing costs by almost half – yet achieving the desired treatment.

INDUSTRY-ORIENTED RESEARCH INSTITUTES UNDERTAKING A FULL SPECTRUM OF SCIENCE

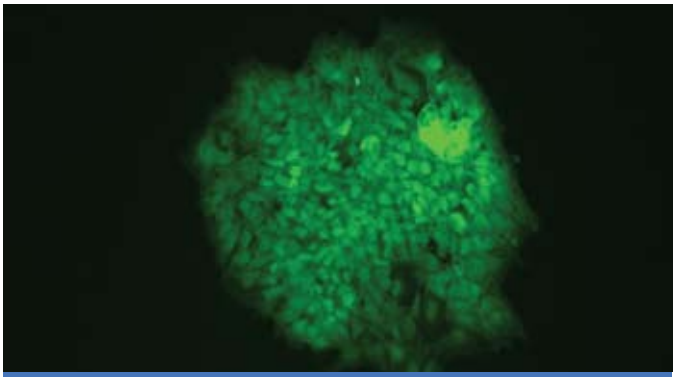
Based on the Nature Asia-Pacific Publishing Rankings 2009, A*STAR was the 7th most prolific agency in the Asia-Pacific region in terms of research papers published in Nature-branded journals. A*STAR was ranked just behind Tohoku University, Japan and ahead of Australian National University.

In 2010, a team of scientists from Singapore led by the Genome Institute of Singapore and the Institute of Molecular and Cell Biology discovered the most important genes in human embryonic stem cells (hESCs). Their research is the first ever genome-wide study of human stem cells on such a massive scale, and its results are crucial in understanding how stem cells may one day be used to treat debilitating conditions such as Parkinson's disease and traumatic spinal injury.

ACADEMIC-MEDICAL CENTRES EXCELLENT IN RESEARCH, EDUCATION AND HEALTHCARE

Two new Academic Medical Centres (AMCs) are being developed to provide a conducive environment for research, education and clinical service. The NUS Yong Loo Lin School of Medicine, Faculty of Dentistry and the National University Hospital have been restructured under one unified management structure, the National University Health System (NUHS). Likewise, Singapore Health Services (which includes Singapore General Hospital) and Duke-NUS Graduate School of Medicine are working towards greater collaboration, including joint governance, in clinical research and education. While relatively young, our AMCs have already achieved ground-breaking research, in their journey to develop better, more cost-effective treatments and diagnoses for patients.

Clinician scientists at NUHS discovered that genetic differences cause Chinese, Malays and Indians to react differently to the blood-thinning drug, Warfarin. The team is developing a formula to calculate the precise dosage a patient needs, depending on genetic makeup. Over in Singapore Health Services, a team led by Professor Donald Tan invented a corneal transplant device called the Tan Endoglide specially designed to cater to Asian eyes, reducing failure rate by tenfold, compared to the original method developed for Western eyes. More of the team's achievements are described on the following page.



A*STAR discovers most important genes in hESCs

PRESIDENT'S SCIENCE AWARD

The President's Science Award is the highest honour presented to research scientists and engineers in Singapore who have made outstanding contributions in basic research leading to the discovery of new knowledge or the pioneering development of scientific or engineering techniques and methods.

PROFESSOR YOSHIAKI ITO

CANCER SCIENCE INSTITUTE OF SINGAPORE

INSTITUTE OF MOLECULAR AND CELL BIOLOGY, A*STAR

"For his breakthrough discovery of the tumor suppressor roles of RUNX3 in gastric and colon cancers"

Prior to his move to Singapore in 2002, Prof Yoshiaki Ito was hailed as one of the famed discoverers of the RUNX "family" of genes in 1993. His team identified RUNX genes as developmental regulator genes deeply involved in carcinogenesis because the malfunction of such genes often induced cancer.

Prof Ito's research on RUNX genes continued to yield fruit in Singapore. Building on his earlier findings, Prof Ito identified RUNX3 as a gatekeeper in colon and gastric cancer, and showed that the disruption of RUNX3 in the gastrointestinal tract could induce a pre-cancerous state in the intestine and stomach.

For this breakthrough discovery, Prof Yoshiaki Ito from the Cancer Science Institute of Singapore and Institute of Molecular and Cell Biology, A*STAR, was awarded the 2010 President's Science Award.

(from left to right)
ASSOCIATE PROFESSOR AUNG TIN

PROFESSOR ROGER BEUERMAN

PROFESSOR DONALD TAN

SINGAPORE EYE RESEARCH INSTITUTE (SERI), SINGAPORE NATIONAL EYE CENTRE

YONG LOO LIN SCHOOL OF MEDICINE, NATIONAL UNIVERSITY OF SINGAPORE

"For their innovative breakthroughs in 'bench-to-bedside' medical research in blinding corneal diseases, leading to major advancements in scientific knowledge and treatment of corneal blindness"

Prof Donald Tan, Prof Roger Beuerman and Associate Prof Aung Tin have solved many mysteries of corneal diseases, and invented treatments which are now adopted world-wide. The trio has spearheaded programmes that span the range of fundamental research to public health interventions. This "bench to bedside to population" approach has reduced corneal blindness, and placed Singapore at the forefront of corneal research.

At the Bench, the team's efforts have led to new insights into corneal and ocular surface stem cell biology and the causes of inherited corneal diseases. At the Bedside, they were the first in the world to perform a series of bioengineered human conjunctival stem cell transplants in patients with chemical and burn injuries, Stevens Johnson syndrome and pterygium. Finally, the group's research at the Population level prevented a major outbreak of blinding corneal infections on a global scale. In 2006, through a nation-wide epidemiological study, the group was the first to identify that a major outbreak of Fusarium Keratitis, a severe fungal corneal infection, was due to contamination of a popular contact lens cleaning solution.

For their outstanding contributions in translational, clinical and epidemiological corneal research, the SERI team made up of Prof Donald Tan, Prof Roger Beuerman and Associate Prof Aung Tin was awarded the 2009 President's Science Award.

- **Emphasize the attraction and development of scientific talent to meet the needs of Singapore's industry and public sector research institutions**

PRO-LOCAL, PRO-FOREIGN APPROACH

Talent is key to knowledge creation and success in R&D. With its small population, Singapore has had to devise a holistic talent strategy to attract and develop world-class scientists, both local and international, at all levels and in all areas of the R&D landscape.

> "Singapore is able to attract the brightest and most committed research talent to carry out breakthrough science."
>
> — Dr Tony Tan, Chairman National Research Foundation

ATTRACTING THE BEST SCIENTISTS FROM ACROSS THE WORLD

Internationally renowned scientists who have moved to Singapore have helped to jump-start the country's biomedical sciences efforts, providing leadership to the research community and mentorship to young local scientists. They include Edward Holmes and Judith Swain from the University of California, San Diego, Edison Liu from the National Cancer Institute, Daniel Tenen from Harvard Medical School, Yoshiaki Ito from the University of Kyoto and Paul Matsudaira from the Massachusetts Institute of Technology.

Clinician scientists are doctors who perform research; they convert laboratory discoveries into new drugs, devices and diagnostics that benefit patients. The Ministry of Health (MOH) has a portfolio of talent development programmes to nurture and support a critical mass of clinician scientists in Singapore. These programmes are designed to build up a pool of home grown talents through scholarships, research training fellowships, and research grant awards. They have also attracted some Singaporean clinician scientists who have built their reputation overseas, to return home to mentor the next generation.

Singapore offers a diverse, cosmopolitan environment for researchers.

The **Singapore National Research Foundation (NRF) Fellowship** Scheme is a key initiative to attract and root young scientific talent to Singapore. The NRF fellowship is open to all areas of science and technology, and scientists of all nationalities are welcomed to apply. NRF Fellows are given complete independence and freedom to pursue their own research directions. They are also free to choose the host organisation which they think is the best environment for their research. Each NRF Fellow will receive a grant of up to S$3 million over 5 years, plus salary pegged to that of an Assistant Professor at a local university.

Prof Kerry Sieh

Director
Earth Observatory of Singapore

In February 2009, Prof Kerry Sieh became the founding Director of NTU's Earth Observatory of Singapore, which aims to conduct basic and applied research related to earthquake, tsunami, volcanic, and climate hazards.

Prof Kerry Sieh initiated the field of paleoseismology (the study of ancient rocks and sediments for evidence of seismic

activity) 35 years ago, with the discovery of how fast California's infamous San Andreas fault slips and how often it generates great earthquakes.

Prior to his arrival in Singapore, Prof Sieh was a chaired professor in the California Institute of Technology (Caltech)'s Tectonics Observatory that he and others at Caltech created. Over the past two decades he and his colleagues have used coral reefs and GPS measurements to understand the patterns of great earthquakes on the Sunda megathrust, offshore Sumatra. These discoveries have led to useful forecasts of recent and impending large Sumatran earthquakes and tsunamis.

GROOMING SINGAPOREANS FOR CAREERS IN SCIENCE

A*STAR also awards scholarships to capable and committed young Singaporeans to pursue undergraduate and graduate scientific training at top universities local and abroad. The first few batches of scholars have returned to Singapore, and are already showing great promise.

Dr Melissa Fullwood

Lee Kuan Yew Post-Doctoral Fellow, Duke-NUS Graduate Medical School

In 2010, Dr Melissa Fullwood became the first Singaporean to win one of four Regional General Electric (GE) & Science Prizes for Young Life Scientists this year for her original essay, "Genome-Wide Chromatin Loops Regulate Transcription". She ranked amongst 80 promising young scientists in the field of molecular biology worldwide who had received the Prize since it was first awarded in 1995. Dr Fullwood's winning essay, based on her PhD project, addresses the unanswered question of why there are so few genes in the genome. During her PhD, she was instrumental in developing a new technology to study how DNA interactions affect the development of cancer, and findings were published in the top scientific journal Nature.

Singapore's autonomous universities, NUS and NTU have been ranked amongst the top universities in the world. NUS and NTU were ranked 34th and 174th in the Times Higher Education World University Rankings 2010. The two universities host a cosmopolitan student population of over 60,000 from 100 countries.

SINGAPOREAN SCIENTISTS HAVE MADE THEIR MARK INTERNATIONALLY

Dr Lisa Ng

Principal Investigator Singapore Immunology Network (SIgN)

Dr Lisa Ng of the Singapore Immunology Network won the ASEAN Young Scientist and Technologist Award in 2008 for her work in developing diagnostic kits for SARS and H5N1, and preparing infectious disease laboratories in the region for a possible epidemic. She was the first Singaporean and first woman to clinch the honour.

Dr Victor Tong

Research Scientist, Institute of Infocomm Research (I^2R)

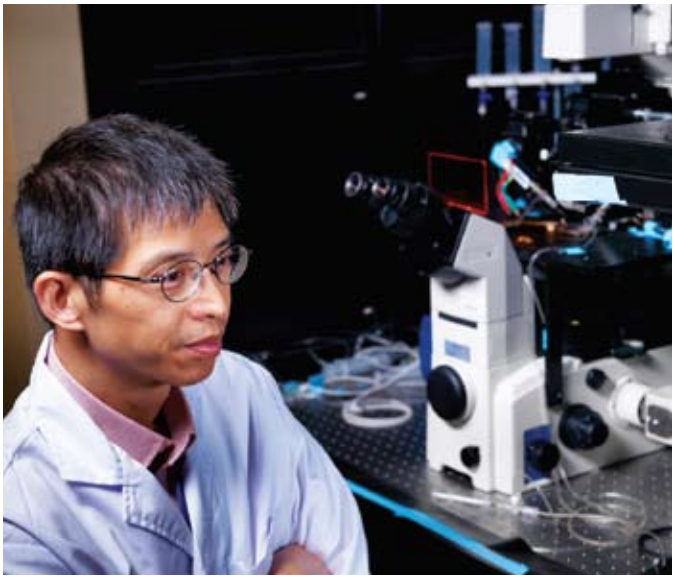
Dr Victor Tong Joo Chuan from the Institute of Infocomm Research, was conferred the "TR35 Award" by MIT's Technology Review magazine for his research on Personalised Vaccine Design. The award honours young inventors under the age of 35 with the most exciting innovations and discoveries each year.

EMPHASIS ON TRAINING FOR INDUSTRY

To support the pipeline of talent for industry, EDB has introduced a new **Industrial Postgraduate Programme**. This will support the training of Masters and PhD students, working on industry projects, and co-supervised by companies and universities. A further 10% of MOE's **Research Scholarship Block** will be channelled to support industry-relevant research training. Such training will not only benefit companies, but more importantly, improve students' employability and help them secure jobs in Singapore. This will encourage locally-trained scientists to stay and contribute to Singapore over the long term.

- **Greater proportion of R&D funding available on a competitive basis to support the best ideas**

Under RIE2015, a greater proportion of R&D funding will be available on a competitive basis, to support the highest quality research leading to the advancement of knowledge for economic and societal benefit.



NATIONAL INNOVATION CHALLENGE

A new **National Innovation Challenge** will harness Singapore's R&D capabilities to tackle large, complex problems facing cities. Half of the world's population now dwell in cities and the number is expected to double from 3.3 billion in 2007 to 6.4 billion by 2050. Developing solutions to such challenges will allow Singapore to fulfil its growth ambitions, and spawn new industries to exploit opportunities abroad.

The Clean Water industry is a good example of how Singapore, in overcoming its own challenges, is able to provide solutions for clean water to itself and the world. Supported by strong R&D capabilities, Singapore now has a thriving water industry cluster comprising more than 50 international and local companies such as Hyflux, Keppel, SembCorp, Marmon Water, Siemens Water, Nitto Denko and Black & Veatch.

COMPETITIVE RESEARCH PROGRAMME

NRF's **Competitive Research Programme (CRP)** is a comprehensive funding scheme that will offer different grant sizes, to support a range of projects in open, thematic or sector-based categories. Under RIE2015, it will be expanded significantly from S$350 million to close to S$1 billion. The CRP is open to all public researchers in Singapore.

The CRP has supported impactful research projects since its inception in April 2007. A project led by Associate Prof Loh Kian Ping from NUS reported the first room-temperature chemical synthesis of carbon nanotubes in liquid, and was the first to demonstrate the use of graphene as optical elements in modulating the power of lasers. The programme's outcome will support the development of novel energy storage materials.

BIOMEDICAL SCIENCES OPEN COLLABORATIVE FUND

As part of the national drive in Biomedical Sciences, S$590 million of competitive funding has been earmarked to support productive collaboration and integration across Singapore's healthcare, academic and research institutions. The **Open Collaborative Fund** will be jointly administered by A*STAR and MOH.

RIE2015 COMPETITIVE PUBLIC R&D FUNDING PROGRAMMES

	Public Research Institutes	Universities and University - based Research Centres	Academic Medical Centres and Medical Schools
Fully competitive			
National Innovation Challenge: S$1,000m	√	√	√
Competitive Research Programme: S$960m	√	√	√
BMS Open Collaborative Fund: S$590m	√	√	√
Singapore NRF Fellowships: S$250m	√	√	√
Competitive amongst a subset of research performers			
Joint Council Office Programmes: S$250m	√	-	-
Biomedical Sciences Research Council Industry Alignment Fund: S$600m	√	-	-
Science and Engineering Research Council Industry Alignment Fund: S$600m	√	√	-
Science and Engineering Research Council Public Sector Grants: S$50m	√	√	-
Energy Efficiency Initiatives: S$100m	√	√	-
Academic Research Fund Tier 2: S$240m	-	√	√
Academic Research Fund Tier 3: S$225m	-	√	√
MOH Industry Alignment Fund: S$50m	-	√	√
Clinician Programmes: S$580m	-	-	√

- **Support multi-disciplinary and collaborative efforts**
- **Strengthen synergies across Singapore's various R&D performers to provide greater value to companies and institutions wishing to form partnerships with Singapore**

Science is a global activity, and Singapore aims to collaborate and partner with world-class research universities and institutions to allow top researchers from diverse backgrounds and cultures to interact with local research institutions in collaborative research and innovative projects.

A GLOBAL CAMPUS FOR RESEARCH EXCELLENCE & TECHNOLOGICAL ENTERPRISE

The Campus for Research Excellence And Technological Enterprise (CREATE) is an example of how Singapore has partnered selected elite international research universities and corporate labs to form a complex of world-class research centres which will have intensive research collaboration with Singapore-based universities and research institutions. CREATE offers a multi-national, multi-disciplinary research enterprise unlike anything known till now, strategically located in the heart of Asia, at the nexus of East and West. The Campus as a whole is expected to house some 1,000 young research talent at a steady state, as well as a larger churn of talent coming through Singapore to work with the best minds from all over the world gathered here. Current CREATE partnerships include:

- The Singapore-Massachusetts Institute of Technology Alliance for Research and Technology (SMART) Centre
- The Singapore-Swiss Federal Institute of Technology Centre for Global Sustainability (SEC)
- Research on Regenerative Medicine Initiative in Cardiac Restoration Therapy between Technion-Israel Institute of Technology, NTU and NUS

- Technical University Munich-CREATE Centre on Electromobility in Megacities
- Research on Cellular and Molecular Mechanism of Inflammation between Hebrew University of Jerusalem and NUS
- Berkeley Education Alliance for Research in Singapore (BEARS) between University of California at Berkeley, NTU and NUS
- Research on Nanomaterials for Energy and Water Management between Ben-Gurion University, Hebrew University of Jerusalem and NTU

PARTNERSHIPS IN MEDICAL RESEARCH AND EDUCATION

The establishment of the Duke-NUS Graduate Medical School in 2005 as a graduate-entry medical school has contributed significantly to both Singapore's translational and clinical research initiative and its healthcare landscape. The Duke University School of Medicine, consistently ranked as one of the US's top medical research and education institutions, was chosen to partner NUS to train clinician scientists as well as doctors to serve Singapore's growing medical needs. Key features include its innovative "bench-to-bedside" curriculum giving students exposure to research aimed at improving patient care, and a unique team-based learning methodology developed in Singapore. Duke-NUS GMS currently trains about 50 students per year.

COLLABORATIONS WITH INDUSTRY

Singapore's ability to move discoveries out of the lab and into clinical proof-of-concept and validation studies, as well as its diverse population phenotype for clinical trials is also highly attractive to industry and represents a key competitive advantage. A testimony to this attractiveness is the Roche-Singapore Hub for Translational Medicine that was jointly established by Roche Pharmaceuticals and Singapore in 2010 to collaborate with the A*STAR RIs, hospitals and academic medical centres in Singapore. Roche signed a Master Research Collaboration Agreement with these research entities, and committed a total of S$130 million to be spent over the next five years on R&D projects spanning basic research to clinical studies. A similar project - the Academic Centre of Excellence - is being established by GSK to stimulate and support research collaborations with RIs and hospitals.

PARTNER WITH SINGAPORE

The success that Singapore has enjoyed so far in transforming itself into a knowledge and innovation economy can be attributed in part to the swift and concerted efforts by both the public and private sectors to grow Singapore's science and technology assets.

By taking a Singapore Inc. approach, public agencies, research institutes and centres, hospitals and universities are able to integrate capabilities and resources to provide greater value to companies and institutions wishing form partnerships with Singapore. Singapore's multi-racial, multi-cultural population and connectedness to markets around the world also allows partners to reach out to the rest of the region, offering a conducive environment for creative and knowledge-driven industries.

- **Focus a greater proportion of R&D on economic outcomes**
- **Provide greater support for private sector R&D and closer collaborations between public and private sector R&D**

Research and innovation underpin the transformation of Singapore's economy, by upgrading existing industries and catalysing new growth areas. It ensures the continued competitiveness of our Electronics, Infocomms, Engineering, Chemicals and Biomedical Sciences sectors, as well as creates new growth areas such as Clean Technology, Energy and Medical Technology. Singapore's public research institutions offer a broad range of industry-oriented capabilities.

COLLABORATIONS WITH INDUSTRY

Singapore institutions and universities nurture R&D collaborations with the private sector. These collaborations include large multi-party research consortia which uplift capabilities across whole industry clusters. Such strategic alliances between research institutions, MNCs, and SMEs provide a compelling reason for companies to locate their R&D laboratories and high value-added manufacturing activities in Singapore.

A*CAR Consortium

ATTRACTING CORPORATE R&D

Vestas, the world's leading supplier of wind power systems in Denmark, established a wind R&D centre in Singapore in 2007. This is its largest outside Denmark, and will employ over 200 researchers by 2012. Vestas has collaborations with A*STAR, NUS and NTU. In 2008, Bosch made its second R&D investment in Singapore with the setting up of its Corporate Research and Advance Engineering division's laboratories at NTU. The collaboration with NTU in the area of organic photovoltaics aims to increase the efficiency and service life of solar cells. Other MNCs that have found value in locating an R&D presence in Singapore include GE Water, Hewlett Packard, Nitto Denko, Fujitsu, BASF, Roche, GlaxoSmithKline, Abbott, Merck and Novartis.

SUPPORTING SINGAPORE'S BIOLOGICS INDUSTRY

A*STAR's Bioprocessing Technology Institute (BTI) seeded the capabilities and expertise to create a whole new biologics industry in Singapore. Biologics involves highly complex manufacturing processes dealing with live cell culture. It is the fastest-growing segment of the drug industry today, and has the highest margins. Leading companies such as Baxter, GlaxoSmithKline, Lonza and Roche have invested more than S$2 billion in major biologics projects that will create more than 1,000 jobs.

BTI's Executive Director Dr Miranda Yap

Over the next 5 years, Singapore will continue to encourage R&D that is integrated with industry and economic development strategies. 70% of Singapore's research funding will be set aside for industry-oriented R&D carried out by public agencies (public R&D) and R&D carried out by companies (corporate R&D) over the next 5 years, compared to 65% in the previous 5-year tranche. The public R&D portfolio will be aligned to Singapore's future economic profile and will support R&D intensive sectors earmarked for growth.

A NEW INDUSTRY ALIGNMENT FUND

To foster more active engagement with industry, a new **Industry Alignment Fund (IAF)** has been established to strengthen public-private collaboration, and to pre-position public sector research for future industry needs. The IAF will support R&D consortia, partnerships with the private sector, and cross-disciplinary research programmes and platforms.

A NEW ONE-STOP OFFICE FOR INDUSTRY COLLABORATION IN BIOMEDICAL SCIENCES

A*STAR, EDB and MOH have jointly set up the **Singapore Biomedical Sciences Industry Partnership Office (IPO)** to serve as the one-stop coordinating office between the various research agencies and performers in Singapore with MNCs seeking to establish such multi-party collaborations. The IPO will be responsible for helping the MNC to get its Singapore office set up and facilitating the successful implementation of collaborations.

MORE CO-MATCHING GRANTS FOR PRIVATE SECTOR RESEARCH

EDB's **Research Incentive Scheme for Companies (RISC)** co-funds the establishment of private sector centres of competence in Singapore. These centres develop strategic technologies and capabilities, increase the company's industrial competitiveness in the longer term, and increase hiring and training of researchers. Through RISC, local enterprises can enhance their capabilities to better enable them to compete in the global market.

Singapore's Research Priorities

ELECTRONICS

Singapore has strong capabilities in data storage and semiconductors, which have contributed to the growth and development of the electronics sector.

In **Data Storage**, Singapore has built up expertise in areas such as spintronics, media and interfaces, mechatronics and recording channels, optical materials and systems, and network storage technologies. Singapore will also increase its focus on solid state memory and data centre integrated technologies.

In **Semiconductors**, Singapore has built up strong capabilities in areas such as integrated circuit design and sub-systems, packaging, CMOS (complementary metal-oxide semiconductor) and MEMS (microelectromechanical systems). In the coming years, Singapore research institutes will focus on "More-than-Moore" capabilities - system integration rather than transistor density. This will create new opportunities in diagnostics, memory devices, MEMS, sensors and actuators.

BIOMEDICAL SCIENCES

Singapore has strengths across the entire biomedical sciences spectrum, in areas such as bioprocessing technology, human immunology, eye diseases, stem cell and cancer biology.

Singapore will continue to build up a base of clinician scientists and strengthen core capabilities in **Translational and Clinical Research** to convert laboratory discoveries into new drugs, devices and diagnostics. Key therapeutic areas include cancer, neurosciences, eye diseases, cardiovascular and metabolic disorders and infectious diseases.

Nutrition and **Medical Technology** are new areas of emphasis. The former will focus on obesity and diabetes management, health and high value foods, and food manufacturing processes. The latter will draw on Singapore's clinical and engineering expertise to develop new medical devices, equipment, as well as platforms to improve healthcare.

INFOCOMMS & MEDIA

Singapore has built capabilities in interactive and digital media, IT, computational science, communications and multimedia technologies, cloud computing and security.

Research focus in data analytics will provide organisations with decision-making tools based on data, ranging from the spread of infectious diseases, traffic management to consumer behaviour. Consequently, cloud computing research is poised to be the way the next generation of IT and network services will be delivered to homes and businesses.

In **Interactive and Digital Media**, Singapore will continue to nurture technology enterprises in virtual world and games, mobile media and rich media and publishing.

ENGINEERING

In **Precision Engineering**, Singapore research institutes will advance their strong manufacturing capabilities through research in advanced materials, microfluidics, printed electronics, nano-manufacturing of multi-functional products and sustainable manufacturing.

In **Transport Engineering**, R&D is a key driver for growth in the **Aerospace** and **Marine and Offshore** sectors. The A*STAR Aerospace Consortium engages companies across the entire value chain in pre-competitive research in maintenance repair and overhaul (MRO), engine-related technologies, avionics and composite materials. The Aerospace Consortium includes global players such as Boeing, EADS, Pratt & Whitney and Rolls-Royce. In the Marine and Offshore sector, Singapore supports research in subsea systems, specialised vessel design (including emerging clean tech and engine technology), composite materials, advanced ruggedised electronics, oil and gas equipment manufacturing and reservoir information and data acquisition.

CLEANTECH

Singapore has leading expertise in **Water** and **Solar** research, and will develop capabilities in intelligent energy systems and energy efficiency.

To help companies bring ideas from R&D to the global marketplace, a range of initiatives including world-class R&D centres, competitive programmes, manpower training programmes, and a commercialisation framework have been established.

Large scale test beds such as the Cleantech Park and HDB's Punngol Eco-Town, conceptualised as "living laboratories", allow companies to work with Singapore to co-create, demonstrate and commercialise new-generation solutions.

Spearheading Commercialisation

- **Provide stronger support for scientists to take their ideas from basic research through to commercialisation**
- **Strengthen the work of Singapore's technology transfer offices, translational and innovation centres, and enterprise incubators and accelerators**

Singapore institutes, universities and centres have proactively engaged industry at all stages of the research and commercialisation continuum to convert technologies into new products and services. Industry engagement platforms such as bilateral collaborations, R&D consortia, and Centres of Innovation are complemented by outreach platforms such as the A*STAR-MOE-SPRING GET-Up programme for local enterprises. Entrepreneurial activities are nurtured through gap and seed funding, technology incubators, mentorship and role models.

GET-Up sending-off ceremony

Gearing for Growth

GET-Up is a pro-active integrated approach aimed at boosting the global competitiveness of local technology-intensive enterprises to equip them for the knowledge-based economy. Based on a 2009 survey by the NUS Entrepreneurship Centre, companies on the GET-Up programme projected twice as much revenue and employment growth when compared to companies which had not participated in the GET-Up programme. GET-Up companies also recorded a higher proportion of sales from new and improved products. Since its inception in 2003, over 270 researchers have been attached to some 200 local enterprises.

CEI Contract Manufacturing Ltd, an electronics manufacturing services provider, engaged an A*STAR researcher on a 2-year project through the GET-Up programme. The project was completed successfully with CEI attaining production qualification for its US customer's product. This brought CEI about S$1 million in revenue. The project also helped CEI create a new line of optics and photonics engineering services, and venture into new market segments such as medical instrumentation and semiconductor equipment. CEI was so pleased with the researcher's performance that it recruited him after the GET-Up project, so as to continue his good work for the company.

Seeding for Surprises

Tera-Barrier Films Pte. Ltd, founded by two researchers from the Institute of Materials Research and Engineering (IMRE), was spun off from IMRE in August 2009 after securing a strategic investment from Applied Ventures, LLC, the venture capital arm of Applied Materials, Inc.

The funds have gone into the development and manufacture of a new proprietary, moisture resistant film that can significantly extend the life span of devices such as organic solar cells and flexible displays. The new film protects the easily degraded moisture-sensitive organic materials of plastic devices and targets the burgeoning plastic electronics industry. Applications of the film include the manufacturing of flexible, lightweight and cheap electronics such as disposable or wraparound displays, identification tags, low cost solar cells and chemical and pressure sensitive sensors. The company was incubated by A*STAR for 2 years prior to spin-out.

Over the next 5 years, Singapore will provide stronger support for our scientists to take their ideas from basic research through to commercialisation, and to transfer knowledge to the marketplace.

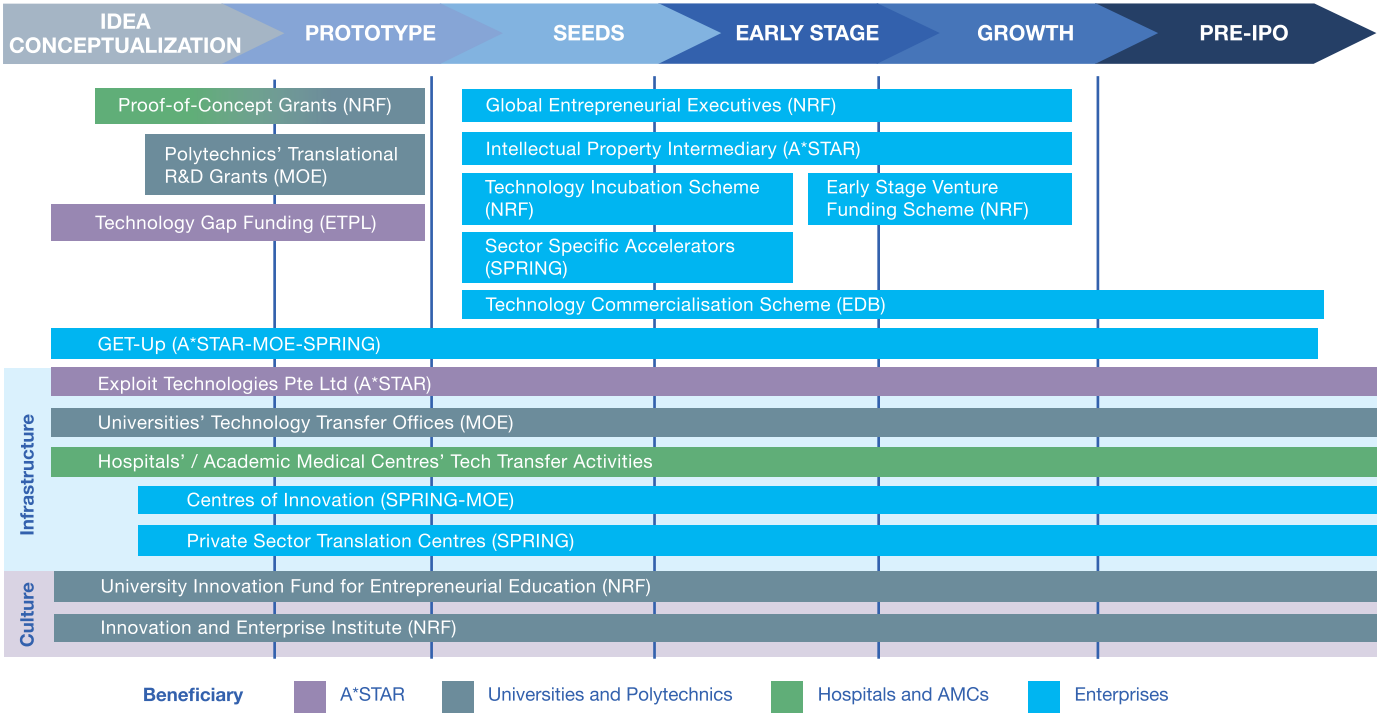
BRINGING INTELLECTUAL PROPERTY (IP) TO THE MARKET

While the current system adequately supports the creation of new IP, more resources are needed to bridge the gap to market. To support innovators, Singapore will ensure adequate support for **Proof-of-Concept (POC)**, **Proof-of-Value (POV)** and translational R&D. Polytechnics will participate more actively in translation of IP. They will partner with both public and private sector to work on translational R&D projects. SMEs can work with the **Centres of Innovation (COI)** at the polytechnics to prototype, test-bed and productise their ideas.

NURTURING TECHNOLOGY ENTERPRISES

A multi-pronged approach will be adopted to nurture and develop technology enterprises. Singapore will continue to provide broad-based support for early-stage companies, especially in nascent sectors. Initiatives include investing and incubating early stage technology start-ups through NRF's **Technology Incubation Scheme** and **Early Stage Venture Funding**. SPRING will also seek to develop **specialised accelerators** in nascent sectors. In addition, **GET-Up** will be extended to the polytechnics to provide another source of expertise for industry. NRF will support academic entrepreneurship through the **University Innovation Fund**. Its new **Innovation and Enterprise Institute** will advance thought leadership. NRF's dedicated fund for **Global Entrepreneurial Executives** will attract serial entrepreneurs to form companies in Singapore.

INNOVATION AND ENTERPRISE LANDSCAPE

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