



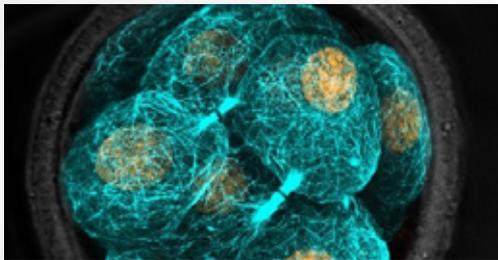
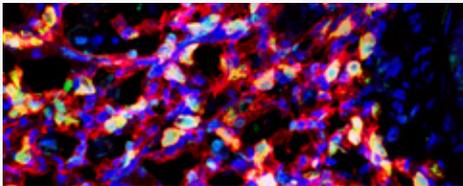
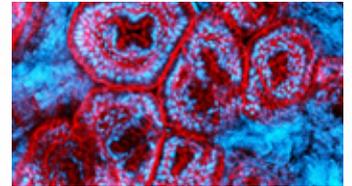
Agency for  
Science, Technology  
and Research

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# ANNUAL REPORT

April 2017 - March 2018

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CREATING GROWTH, ENHANCING LIVES



Agency for  
Science, Technology  
and Research

#### ORGANISATION DETAILS

**Board Secretary:** Ms Emily Liew  
Director, Planning & Policy Department  
Agency for Science, Technology and Research

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Singapore 138632

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# About A\*STAR

# Our Mission and Vision



## OUR MISSION

We advance science and develop innovative technology to further economic growth and improve lives.

The Agency for Science, Technology and Research (A\*STAR) drives mission-oriented research that advances scientific discovery and technological innovation. We play a key role in nurturing and developing talent and leaders for our Research Institutes, the wider research community, and industry.

Our research creates economic growth and jobs for Singapore. As a Science and Technology Organisation, we bridge the gap between academia and industry in terms of research and development. In these

endeavours, we seek to integrate the relevant capabilities of our research institutes and collaborate with the wider research community as well as other public sector agencies towards meaningful and impactful outcomes. Together with the other public sector entities, we develop industry sectors by: integrating our capabilities to create impact with multi-national corporations and globally competitive companies; partnering local enterprises for productivity and gearing them for growth; and nurturing R&D-driven start-ups by seeding for surprises and shaping for success.

Our research, in addition, also contributes to societal benefits such as improving outcomes in healthcare, urban living, and sustainability. These serve to enhance lives in Singapore and beyond.

## OUR VISION

A global leader in science, technology and open innovation.

A\*STAR is a catalyst, enabler and convenor of significant research initiatives among the research community in Singapore and beyond. Through open innovation, we collaborate with our partners in both the public and private sectors, and bring science and technology to benefit the economy and society.

We aspire to be a global leader in Science, Technology and Open Innovation.

## Message from the Chairman

Worldwide, research and innovation has become the main strategy for growth for an increasing number of economies, and not just the advanced ones. Singapore, therefore, has to step up in how we connect our research, innovation and enterprise strategy to stay ahead.

Global rankings place Singapore as a leading innovation nation in the world in 2018 — fifth in Global Innovation Index and third in Bloomberg Innovation Index. Underscoring these rankings is Singapore's sustained and steady commitment to research, innovation and enterprise for future growth, and a focused approach to mission-oriented research that addresses national needs and develops home-grown innovations for the benefits of the economy and society.

Last year, the Committee on the Future Economy (CFE) published its strategies to create an economy that offers ample opportunities for Singaporeans and to build a Singapore of global relevance; a Singapore that can ceaselessly reinvent herself and grasp new opportunities.

Singapore's Research, Innovation and Enterprise (RIE) 2020 Plan is closely aligned to the CFE's strategies and strives to establish Singapore as a Global-Asia hub of technology, innovation and enterprise.

Going into the second year of RIE2020, A\*STAR has sustained the momentum of our R&D efforts. We have relentlessly pursued our mission to advance science and develop innovative technology to further economic growth and improve lives. We worked on over 2,100 industry projects last year and attracted nearly S\$340 million of business R&D investments, a 20% and 50% increase compared to the previous year. At the same time, A\*STAR provides access to ready-to-go technologies and solutions; advanced technologies and facilities; and technology expertise and roadmapping services — initiatives that can help companies at different stages of

their R&D journey, whether they are looking to increase their productivity or to transform themselves for the future.

Local enterprises like Singapore Airlines (SIA) are embarking on projects with A\*STAR to use digital technology to build new capabilities to benefit consumers and the airline itself. SMEs like Feinmetall have developed a longstanding relationship with A\*STAR, tapping on our research talent and Operation and Technology Roadmapping (OTR) expertise. These efforts have helped the company to deepen its capabilities in precision engineering and improve its productivity.

Earlier this year, we also announced a new spin-off from A\*STAR, the Advanced Micro Foundry (AMF), a specialty commercial foundry for integrated optics manufacturing with expertise in silicon photonics technology. AMF has secured



investments and the company is valued at around US\$300 million. It is also in the process of securing additional investments for future capital and operational needs that may raise the valuation to US\$400 million. This achievement is a result of having invested early in fundamental research, and building capabilities for over a decade, and then having the responsiveness to seize the economic opportunities when the time was right.

In manufacturing, we continue to step up our efforts to ensure Singapore maintains a competitive high-value manufacturing industry. Together with fellow economic agencies Economic Development Board (EDB) and Enterprise Singapore (ESG), we work to drive and implement Industry Transformation Maps (ITMs) in the manufacturing cluster. We are developing smart manufacturing capabilities in the aerospace sector, and have also rolled out similar efforts for the pharma sector.

Elsewhere, our investments are also beginning to bear fruit. We are seeing in Singapore a nascent but fast growing and dynamic biotech ecosystem and the sector is possibly at an inflexion point. From 2010 to 2017, over 60 biotechs were incorporated in Singapore, three times that of the preceding decade (2000-2009). These local biotechs are the natural receptacles of public sector drug discovery and development efforts, and add to the drug-innovation ecosystem.

To achieve greater impact with our partners, A\*STAR is proactively transforming to be more agile in harnessing our resources, and making the best use of our entire spectrum of research capabilities.

A more flexibly organised A\*STAR will benefit our industry partners that have ambitions to be at the forefront of global innovation and competitiveness.

Our achievements are the result of the passion and commitment of our talented research scientists and engineers. Internationally, our researchers have been recognised for their achievements and potential.

To highlight a few: Dr Wesley Zheng was named one of the top 10 young innovators under 35 in Asia by MIT Technology Review (TR35). Three researchers, Dr Lena Ho, Dr Ng Shyh Chang and Dr Nicolas Plachta, became the first in Singapore to receive Howard Hughes Medical Institute (HHMI) scholarships, which are awarded to exceptional early career research scientists poised to advance biomedical research internationally.

Joining some of the most capable and committed young scientists in Europe and beyond were Dr Wan Yue and Dr Daniel Messerschmidt, who received Young Investigator Awards from the European Molecular Biology Organisation (EMBO).

As Singapore continues to evolve, A\*STAR remains committed to its goals for RIE2020 and beyond — to advance and translate scientific discovery into innovation to bring about impactful outcomes for the economy and meaningful benefits for society.



**Mr Lim Chuan Poh**  
Chairman, A\*STAR  
July 2018

## Board Members (as at March 2018)



**Mr Lim Chuan Poh**  
Chairman  
A\*STAR



**Dr Raj. Thampuran**  
Managing Director  
A\*STAR



**Prof Barry Halliwell**  
Chairman, Biomedical  
Research Council, A\*STAR;  
Senior Advisor to the  
President, NUS;  
Tan Chin Tuan Centennial  
Professor



**Prof Sir John O'Reilly**  
Chairman, Science and  
Engineering Research Council,  
A\*STAR;  
Chairman, NICC (Standards) Ltd



**Prof Isaac Ben-Israel**  
Chairman  
Israel Space Agency;  
Chairman  
Israel National Council for  
R&D



**Mr Bruce Brown**  
Retired Chief Technology  
Officer  
Procter & Gamble



**Dr William Chin**  
Bertarelli Professor  
Emeritus of Translational  
Medical Science and  
Professor Emeritus of  
Medicine, Harvard Medical  
School



**Mr Chng Kai Fong**  
Managing Director  
Economic Development  
Board



**Prof Chong Tow Chong**  
President and Acting  
Provost  
Singapore University of  
Technology and Design



**Mr William A. Hawkins III**  
Former Chairman and CEO  
Medtronic; Senior Advisor  
EW Healthcare Partners;  
Corporate Director; NAE  
Member



**Prof Lily Kong**  
Provost  
Singapore Management  
University

## Board Members (as at March 2018) *Continued*



**Dr Josephine Kwa**  
Director  
Barghest Building  
Performance



**Dr Omkaram Nalamasu**  
Senior Vice President and  
Chief Technology Officer,  
Applied Materials;  
President, Applied  
Ventures LLC



**Prof Sir Keith O'Nions**  
Chairman  
Cambridge Enterprise  
Limited



**Mr Quek Gim Pew**  
Chief Defence Scientist  
Ministry of Defence



**Prof Siegfried Russwurm**  
Former Chief Technology  
Officer  
Siemens AG



**Prof Subra Suresh**  
President  
Nanyang Technological  
University



**Prof Tan Eng Chye**  
President  
National University of  
Singapore



**Ms Tan Li San**  
Deputy Secretary (Industry  
& Information)  
Ministry of  
Communications and  
Information



**Dr Tatsumi Yamazaki**  
Distinguished Advisor  
Chugai Pharmaceutical  
Co., Ltd



**Mr Yee Ping Yi**  
Deputy Secretary (Policy)  
Ministry of Finance

## Key Management (as at March 2018)



**Mr Lim Chuan Poh**  
Chairman  
A\*STAR



**Dr Raj. Thampuran**  
Managing Director  
A\*STAR



**Mr Suresh Sachi**  
Deputy Managing Director  
(Corporate & Legal)  
General Counsel  
A\*STAR



**Prof Andrew Wee**  
Deputy Managing Director  
(Research), A\*STAR;  
Vice President (University and  
Global Relations), National  
University of Singapore



**Dr Sydney Brenner**  
Senior Fellow, A\*STAR;  
Senior Fellow, Janelia Farm  
Research Campus, Howard  
Hughes Medical Institute  
(HHMI)



**Prof Barry Halliwell**  
Chairman, Biomedical  
Research Council, A\*STAR;  
Senior Advisor to the  
President, NUS;  
Tan Chin Tuan Centennial  
Professor



**Prof Sir John O'Reilly**  
Chairman, Science and  
Engineering Research  
Council, A\*STAR;  
Chairman  
NICC (Standards) Ltd



**Prof Sir David Lane**  
Chief Scientist;  
Director, p53 Lab  
A\*STAR



**Dr Benjamin Seet**  
Executive Director  
Biomedical Research  
Council  
A\*STAR



**Prof Tan Sze Wee**  
Executive Director  
Science & Engineering  
Research Council  
A\*STAR

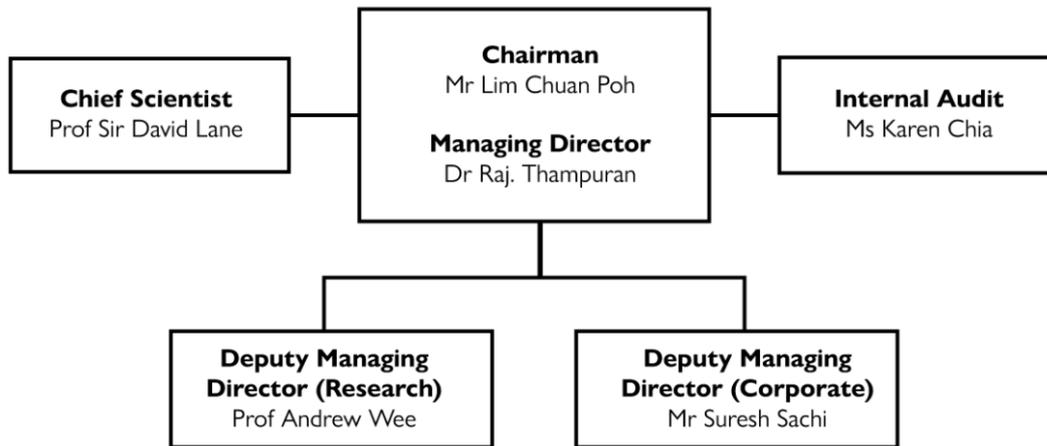


**Mr Philip Lim**  
Chief Executive Officer  
Exploit Technologies Pte Ltd  
A\*STAR



**Prof Ng Huck Hui**  
Executive Director  
A\*STAR Graduate Academy  
Executive Director  
Genome Institute of  
Singapore  
A\*STAR

# Organisation Chart (as at March 2018)



Operations Group			Corporate Group		
<b>Biomedical Research Council</b>	<b>Science &amp; Engineering Research Council</b>	<b>A*STAR Graduate Academy</b>	<b>Administration</b>	<b>Corporate Communications</b>	<b>Finance</b>
<b>Chairman</b> Prof Barry Halliwell	<b>Chairman</b> Prof Sir John O'Reilly	<b>Executive Director</b> Prof Ng Huck Hui	<b>Director</b> Ms Kerin Lim	<b>Group Director</b> Ms Angelina Fernandez	<b>Group Director</b> Ms Goh Mien Zo
<b>Executive Director</b> Dr Benjamin Seet	<b>Executive Director</b> Prof Tan Sze Wee	<b>Deputy Executive Director (Scholarship Management)</b> Ms Ang Ee Luang	<b>Human Resources</b>	<b>Legal</b>	<b>A*STAR Procurement Office</b>
<b>Deputy Executive Director</b> Dr Patrick Tan	<b>Deputy Executive Director</b> Dr Hazel Khoo	<b>Deputy Executive Director (Scholar Engagement and Development)</b> Prof Lisa Ng	<b>Group Director</b> Mr Timothy Sebastian	<b>General Counsel</b> Mr Suresh Sachi	<b>Director</b> Dr Manjeet Singh
<b>Exploit Technologies</b>	<b>Industry Development Group</b>		<b>Information Technology Shared Services</b>	<b>Office of Science Communications &amp; Archives</b>	<b>Infrastructure Planning &amp; Facilities Management</b>
<b>Chairman</b> Dr Raj. Thampuran	<b>Covering Group Director</b> Mr Liau Eng Soon		<b>Chief Information Officer</b> Dr John Kan	<b>Senior Director</b> Ms Choong Ket Che	<b>Director</b> Mr Chang York Boon
<b>Chief Executive Officer</b> Mr Philip Lim			<b>Policy &amp; Planning</b>	<b>Enterprise Risk Management</b>	<b>Organisational Excellence</b>
			<b>Director</b> Ms Emily Liew	<b>Chief Risk Officer</b> Prof Lye Kin Mun	<b>Acting Director</b> Mr Dennis Tan

## Subsidiary Company

**Name of subsidiary company:** Exploit Technologies Pte Ltd

**% shareholdings in company:** 100%

ETPL is the commercialisation arm of the Agency for Science, Technology and Research (A\*STAR), Singapore's lead agency for fostering world-class scientific research and talent.

As a one-stop resource, ETPL supports A\*STAR in the arenas of IP management, licensing and entrepreneurship.

For more information, please visit: [www.etpl.sg](http://www.etpl.sg)

## Our Community (as at March 2018)

The A\*STAR community spans across a broad range of research areas from the biomedical sciences to the physical sciences and engineering. The community of scientists and researchers, technical and non-technical staff, and industry development and commercialisation staff was 5,237 strong as at 31 March 2018.

### Biomedical Research Institutes

Bioinformatics Institute (BII)  
 Bioprocessing Technology Institute (BTI)  
 Experimental Therapeutics Centre (ETC)  
 Genome Institute of Singapore (GIS)  
 Institute of Bioengineering and Nanotechnology (IBN)  
 Institute of Medical Biology (IMB)  
 Institute of Molecular and Cell Biology (IMCB)  
 Singapore Bioimaging Consortium (SBIC)  
 Singapore Institute for Clinical Sciences (SICS)  
 Singapore Immunology Network (SigN)  
 Skin Research Institute of Singapore (SRIS)

### Science and Engineering Research Institutes

Advanced Remanufacturing and Technology Centre (ARTC)  
 Data Storage Institute (DSI)  
 Institute of Chemical and Engineering Sciences (ICES)  
 Institute of High Performance Computing (IHPC)  
 Institute for Infocomm Research (I<sup>2</sup>R)  
 Institute of Materials Research and Engineering (IMRE)  
 Institute of Microelectronics (IME)  
 National Metrology Centre (NMC)  
 Singapore Institute of Manufacturing Technology (SIMTech)

### National Platforms

*These are facilities hosted and managed by A\*STAR but funded nationally by multiple public stakeholders and serve specific national capability.*

- Drug Discovery and Development Unit (D3)
- Diagnostics Development Hub (DxD)
- Experimental Biotherapeutics Centre (EBC)
- National Robotics Research and Development Programme Office
- National Supercomputing Centre (NSCC)
- Technology Centre for Offshore and Marine, Singapore Ltd (TCOMS)

# **Key Achievements**

# A\*STAR'S ACHIEVEMENTS FY17

▶ Worked on over **2,100 R&D projects** with companies, a 20% increase from FY16

$\frac{1}{3}$  of the total industry projects remained with **local enterprises** for both years

▶ Seconded over **60 A\*STAR Research Scientists & Engineers** to 56 local enterprises

Help improve products and services in sectors including engineering, infocomms, biotechs, chemicals & electronics

▶ Awarded **101** A\*STAR Scholarships



▶ Achieved around **\$340 million** of R&D spending through industry projects, an increase of over 50% from \$220 million in FY16

More significantly, R&D spending **by local enterprises** outpaced this increase, **growing more than 60%**

▶ More local enterprises **taking up A\*STAR licenses**

$\frac{3}{4}$  of 260 licensing deals were with local enterprises

Compared to about **60% of 235 licenses** that went to local enterprises in FY16

Licenses were deployed to companies in various sectors including digital technology, advanced manufacturing, biotech & medtech

# Advancing Excellent Science and Technology for Innovation

## Pursuing Mission-inspired Knowledge Creation

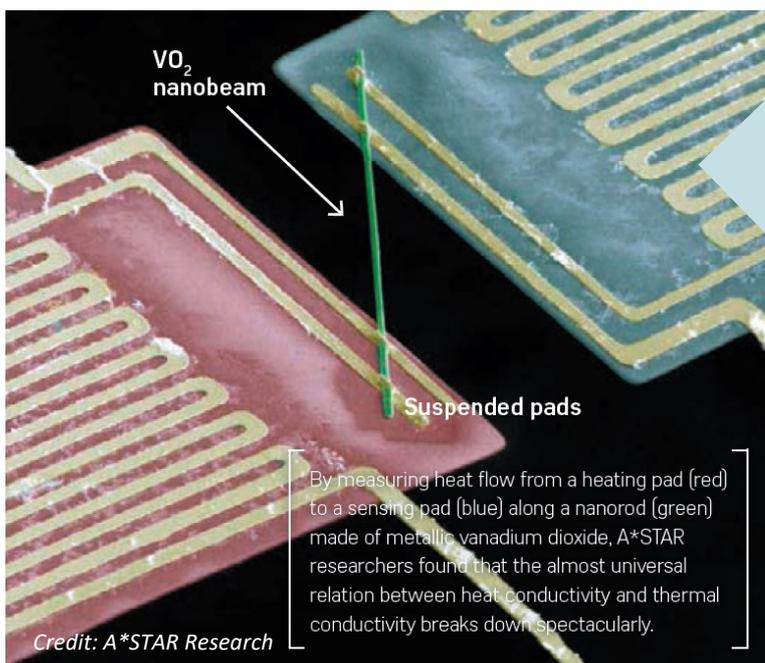


### On the Cover of High Impact Publications:

IHPC’s work on novel transducers for direct electrical-plasmonic signal conversion was featured in the October 2017 issue of Nature Photonics.

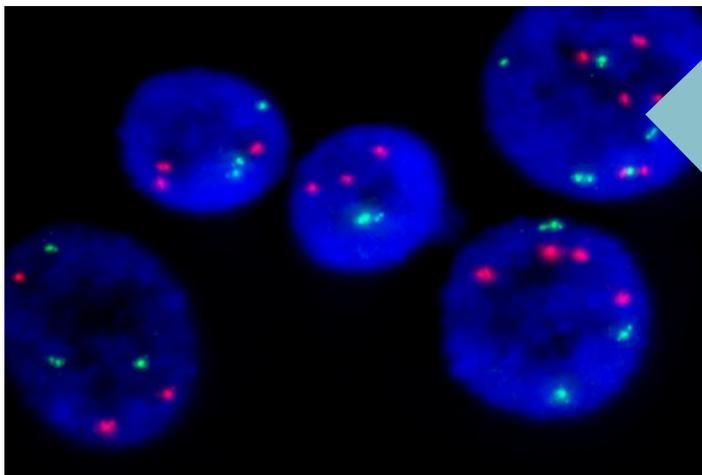
Researchers from IBN have created a DNA technology with two new genetic letters that could better detect infectious diseases, such as dengue and Zika. Their work was published in the September 2017 issue of the journal Angewandte Chemie International Edition.

IMB’s discovery of Lgr5-expressing cells in the stomach was featured in the July 2017 cover of Nature Cell Biology. These cells have been recruited to function as stem cells for epithelial (tissue) renewal following injury.



### Metal Bucks the Trend:

An IMRE researcher, together with an international team, uncovered an exception to the longstanding rule that effective heat-conducting metals are also good conduits for electricity. This anomaly could eventually be harnessed in thermoelectric devices that convert waste heat from appliances and engines into useful electric power.

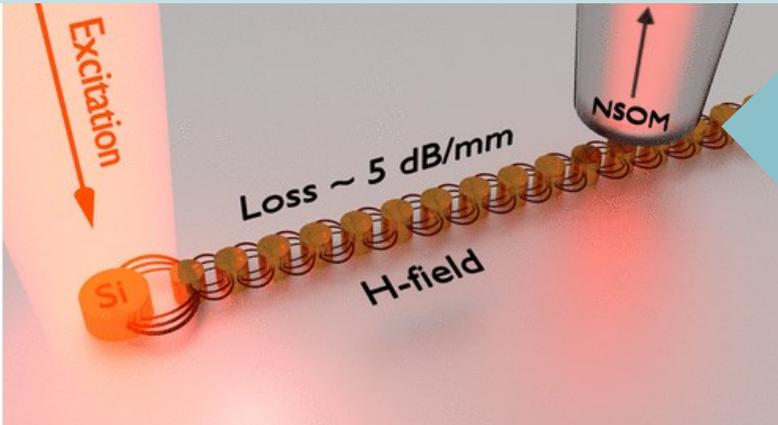
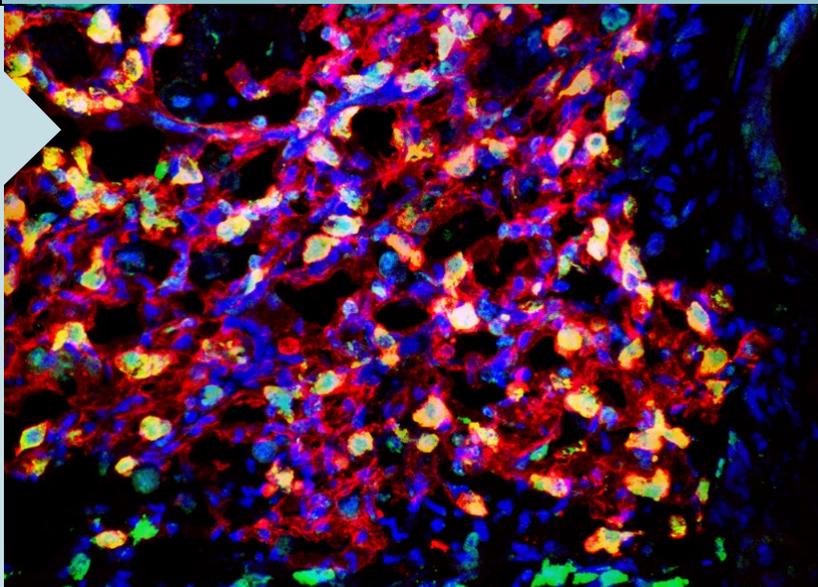


### Biomarkers for Breast Cancer:

GIS, together with Tan Tock Seng Hospital (TTSH) and National University Health System (NUHS) is pioneering a blood test that can detect a biomarker to help treat breast cancer, one of Singapore's most common cancers.

### A Step Forward:

For the first time, researchers have demonstrated that they can grow lung stem cells in large numbers in a petri dish. Upon injection into toxin-injured lungs, these lung stem cells were able to regenerate lung tissue in laboratory mice. The discovery, published in the journal Nature Methods, was made by researchers from GIS, together with US collaborators from Stanford University, the Jackson Laboratory and Clarkson University.



### Guiding Light at the Nanoscale:

A\*STAR researchers have demonstrated a new way to efficiently guide light at tiny scales. Their method, which involves lining up silicon nanoparticles, is promising for applications such as light-based integrated circuits, biosensors and quantum communications.



Read more about A\*STAR's research.

## Translating Technology for Better Outcomes

### Building Strong Digital Capabilities

As digital transformation continues to disrupt business models and jobs, it has created new opportunities for Singapore businesses and the economy. Digital technology can help companies unlock productivity gains, scale up, improve services and generate new streams of revenue.

To complement Singapore's existing digital infrastructure, A\*STAR is building strong digital capabilities such as Industrial Internet-of-Things (IIoT), manufacturing and business data analytics that will support industry and address national needs.

This year, A\*STAR announced the Industrial Internet of Things Initiative (I<sup>3</sup>), with 13 companies signing an MOU with A\*STAR to form a consortium to develop technologies for digital services in the aftermarket customer care sector. It will initially focus on the aerospace, offshore & marine, and transportation sectors, and leverage the capabilities of A\*STAR RIs in close collaboration with industry partners to develop and test-bed solutions on sensors, gateways, industrial data analytics, cybersecurity and integrated systems and solutions to address current industry challenges.

We also started the A\*STAR Artificial Intelligence Initiative (A\*AI), with the aim to position Singapore as the region's leading centre for AI R&D and translation, and to attract significant industry investments, create jobs and other benefits for Singaporeans. A\*AI builds on 20 years of work in areas like deep learning, machine learning, data analytics, natural language processing, image and video analytics. To date, some of the solutions developed under this initiative include an automatic fault detection tool for predictive maintenance and an AI-based diagnostic technology for lung disease with a 97% accuracy rate.



### Singapore Airlines (SIA) Partners A\*STAR for Digital Innovation

SIA announced a collaboration with A\*STAR to use technologies such as virtual reality and data analytics within the airline group. This will enable the airline to develop predictive maintenance solutions to monitor parts that need repair or replacement ahead of failure.



**Such collaborations are very much in line with the partnership spirit of the ITMs and the Research, Innovation and Enterprise 2020 plan - to foster closer public-private collaborations, so that companies can tap on the diverse capabilities of our research institutes and universities to develop and commercialise new solutions.”**

*Mr S. Iswaran, then Minister for Trade and Industry (Industry) at the launch of SIA's Digital Innovation Blueprint*

## Co-innovating for New Products, Services and Spin-offs

SME Tech

The Straits Times, 5 July 2017

### Watch camera with surround view



Credit: Spacemap

Local start-up, **Spacemap** worked with A\*STAR under the Technology for Enterprise Capability Upgrading (T-Up) scheme from October 2015 to April 2016. In 2017, the company unveiled their first product called Beoncam at CES 2017. The innovative product is an “always on” wrist camera which can take 360-degree panoramic shots and this was made possible with the help of A\*STAR’s research engineer who worked with Spacemap for six months on Beoncam’s electronics. A month after the launch, Spacemap started a fundraising campaign on crowdfunding platform indiegogo, where the Beoncam hit twice its original US\$30,000 funding target within two months.

### Innovative Packaging

Empowered with technologies developed by SIMTech, local SME **Honsen Printing Industries** successfully incorporated printed lighting and flexible hybrid electronics in their smart packaging for the launch of a new range of NESCAFÉ products in Thailand. This has opened doors for Honsen to venture into new markets for smart packaging overseas.

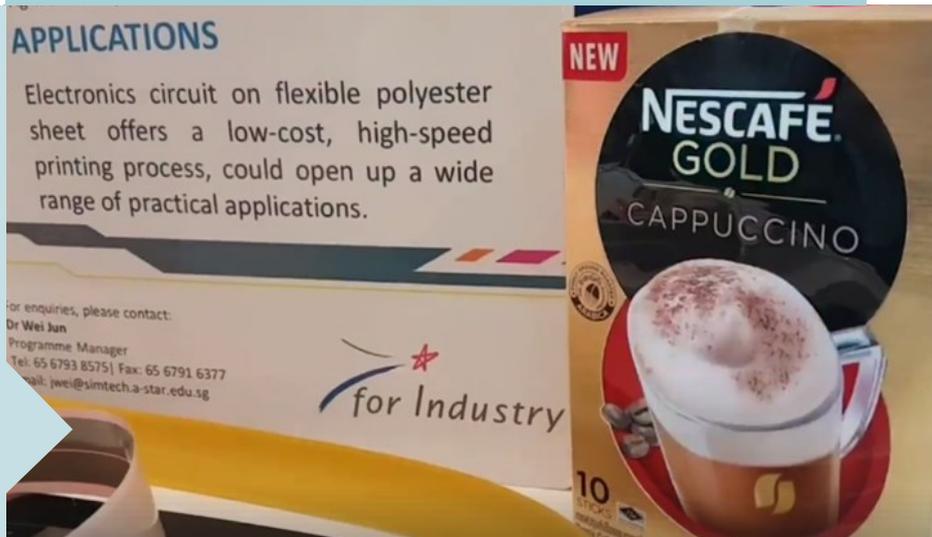
The successful development of smart packaging for fast moving consumer goods was the outcome of an Operation and Technology Roadmapping ideation session between SIMTech and Nestlé.

### APPLICATIONS

Electronics circuit on flexible polyester sheet offers a low-cost, high-speed printing process, could open up a wide range of practical applications.

for enquiries, please contact:  
Dr Wei Jun  
Programme Manager  
Tel: 65 6793 8575 | Fax: 65 6791 6377  
Email: wj@simtech.a-star.edu.sg

for Industry



**“ In partnering with SIMTech, we are able to tap the use of Printed Lightning and Flexible Hybrid Electronics Technologies in smart packaging. This capability opens doors in new market for us.”**

Mr Garry Ng, Director of Honsen Printing Industries Pte Ltd



## Creating New Services through R&D Collaboration

**Admaterials Technologies**, a building and construction materials-testing company, started collaborating with A\*STAR in 2011 to diversify its business and capture new revenue streams.

Through T-Up, A\*STAR helped to set up two laboratories that have enabled the company to conduct environmental and microbiological testing of construction materials and water for harmful compounds in-house. These new services now contribute to 20% of Admaterials' total revenue and it no longer needs to outsource these services. A\*STAR also created an automated cube testing system for structural testing of concrete slabs, which helped the company to improve labour productivity. Admaterials' revenue has quadrupled in the last five years, reaching about S\$12 million last year.

**The creation of AMF marks a major milestone for A\*STAR and Singapore. It is a testament to A\*STAR's commitment to develop differentiated capabilities and nurture talent, enabling the capture of valuable economic outcomes for Singapore.**

## Game Changing Spin-off, Next-Gen Technology

The **Advanced Micro Foundry**, an A\*STAR spin-off, was incorporated in July 2017. The AMF is a specialty commercial foundry for integrated optics manufacturing with expertise in silicon photonics technology. It is the world's first commercial micro foundry capable of high-mix low-volume manufacturing.

In this digital age, the increasing need for high-speed data communications is driving demand for silicon photonics devices that enable unprecedented performance, functionality, and economies of scale compared to traditional optic devices. AMF's Foundry services enable its customers to develop and manufacture integrated photonics chips for a broad range of applications – cloud computing, cloud security, 5G communications, autonomous vehicles and diagnostic chips.

In the early 2000s, A\*STAR decided to invest in research in silicon photonics, a technology platform that is now a game changer for future computing systems and advanced data centres. Since then, A\*STAR has developed market leading capabilities that enabled the support of nearly 70% of the integrated photonics industry in silicon wafer fabrication, bringing the technology to production and commercialisation.



# Supporting Enterprise and Industry for the Future Economy



## Helping Companies Scale Up

A\*STAR's Growing Enterprises through Technology Upgrade (GET-Up) initiative helps companies improve their innovation capacity and respond to market demands and challenges through the expertise of seconded Research Scientists and Engineers (RSEs) and OTR.

Since the inception of GET-Up in 2003, 680 companies have participated in GET-Up, and over 760 A\*STAR RSEs have been seconded to over 600 companies.

Additionally, over 300 companies have benefitted from OTR, which helps SMEs to develop customised technology roadmaps aligned to their business strategies and goals. A\*STAR is scaling up these efforts to better grow whole sectors of the industry, with Senior Minister of State for Trade & Industry, Dr Koh Poh Koon, announcing the launch of OTR for consortia at this year's Committee of Supply debates. This enhanced initiative allows more companies to leverage shared resources and further customise solutions for their needs.



**If we only spend on research and innovation without enterprise, we will not get very far. And our enterprises need to make use of all the research and innovation outcomes to grow their enterprises so that we have more resources to put back into further research, further innovation, further enterprise, and the loop must continue.”**

*Mr Chan Chun Sing, Minister for Trade and Industry at the SME Technology and Innovation Day 2018*



## Working together for Value Capture

To drive the growth of high value-added industry sectors and to help our local companies better catalyse innovation, A\*STAR works closely with fellow economic agencies to shape and implement the ITMs. These efforts will uplift the capabilities of our local companies and help them move up the value chain to capture greater value from both local and overseas markets through the use of research and technology.

With EDB, we are working together under a Joint Industry Sector Planning (JISP) initiative to strategise development plans and execute R&D plans specific to each industry sector.

To align efforts in developing local industries and enterprises through technology and innovation, we are working with ESG on a National Industry Sector Planning (NISIP) framework.

Our initiatives align with the goals of the ITMs by encouraging innovation, and building up technical capabilities in sectors such as food manufacturing, electronics and aerospace, so they can remain competitive.

### Growth of Specialty Chemicals

A\*STAR and EDB have embarked on a joint technology road mapping exercise to identify scientific and technological needs and gaps of companies, and then invest in developing them so as to support and foster companies' innovation.

We target 20 new or expanded application development centres by 2025, with an increase of S\$55 million in Business Expenditure on Research and Development (BERD). One such application development centre has already been set up by Evonik, a German specialty chemicals company focusing on technologies for additive manufacturing and functional surfaces.

## Manufacturing - A Key Pillar for Singapore's Economy

A key recommendation of the CFE was to maintain manufacturing at 20% of Singapore's Gross Domestic Product (GDP) in the medium term. To raise the competitiveness of the manufacturing sector and drive companies towards higher value-added activities, A\*STAR helps industry to develop deeper innovation and digital capabilities as well as adopt Future of Manufacturing (FoM) methods and technologies.

Through initiatives such as OTR, T-Up, and the public-private partnership (PPP) platforms of Tech Access, Model Factory, and Tech Depot, companies can tap into the latest manufacturing technologies, test-bed innovative solutions and eventually adopt them.

Also working closely with industry to develop advanced manufacturing and remanufacturing capabilities is ARTC. The centre is a public-private collaboration between A\*STAR, NTU and over 60 industry players from MNCs and SMEs to help bridge technological gaps in the adoption of advanced manufacturing and remanufacturing processes. To develop the skills base needed for the sector to make a seamless transition to FOM, leading companies like McKinsey have also been working with ARTC to conduct joint training sessions on emerging technologies in Industry 4.0 to benefit industry users, technology providers, which include local SMEs.



### Model Factory

Through the Model Factory initiative, A\*STAR bridges technological gaps in the private sector, helping businesses across sectors and the value chain to re-invent themselves through effective technology adoption.

The Model Factory at SIMTech, which launched in October 2017, is targeted at local companies that are on their first mile of advanced manufacturing technology adoption. It provides a real-life production environment and low-cost, digital learning factory platform. Local SMEs such as Feinmetall, CKE Manufacturing, and JEP Precision Engineering have adopted and implemented FoM technologies on their shopfloors.

The Model Factory at ARTC targets companies that are more advanced in their digitalisation journey, providing a platform to develop and validate various convergence of Information Technology and Operational Technology (IT/OT) architectures, technologies and process models required for a smart factory concept.





**Feinmetall decided to invest in R&D because we wanted to stay competitive with the market.”**

*Mr Sam Chee Wah, General Manager of Feinmetall Singapore*



**Feinmetall**, a local precision engineering SME, has been partnering A\*STAR since 2008 to deepen its expertise and grow its business through technology development. In 2017, the company launched its S\$6 million digital manufacturing facility that is enabled by digital manufacturing technologies developed by A\*STAR’s Model Factory@SIMTech. Feinmetall’s digital manufacturing facility is set to more than double revenue for Feinmetall in the next four years.



*The DroneScanner (above) is a drone solution that taps on SIMTech's technology to enable RFID scanning capabilities in warehouses.*

**Tech Depot** was established by A\*STAR, the Info-communications Media Development Authority of Singapore (IMDA) and ESG to improve local enterprises' access to technology and digital solutions. Since its launch in FY2017, there have been 265 adoptions of A\*STAR’s Ready-to-Go packages.



*The Industrial Additive Manufacturing Facility (IAMF) is one of the facilities under Tech Access. SMEs can leverage additive manufacturing technologies to improve the performance of their products, and to integrate these technologies into their existing operations.*

**Tech Access** provides access to A\*STAR’s installed base of advanced manufacturing equipment and facilities, user training and consultancy. SMEs can learn, experiment and prototype with the advanced tools, thereby mitigating the high upfront cost of investment. To date, 30 companies have accessed A\*STAR’s equipment and facilities.





## Supporting Aerospace Manufacturing

A\*STAR established a strong headstart in industry collaboration through our Aerospace Programme.

Over the last decade, the programme has brought together leading aerospace companies to collaborate in more than 120 aerospace research projects. It has also helped Singapore build a suite of aerospace-related R&D capabilities in areas such as advanced materials, non-destructive inspection techniques, process automation, avionics and wireless communications.

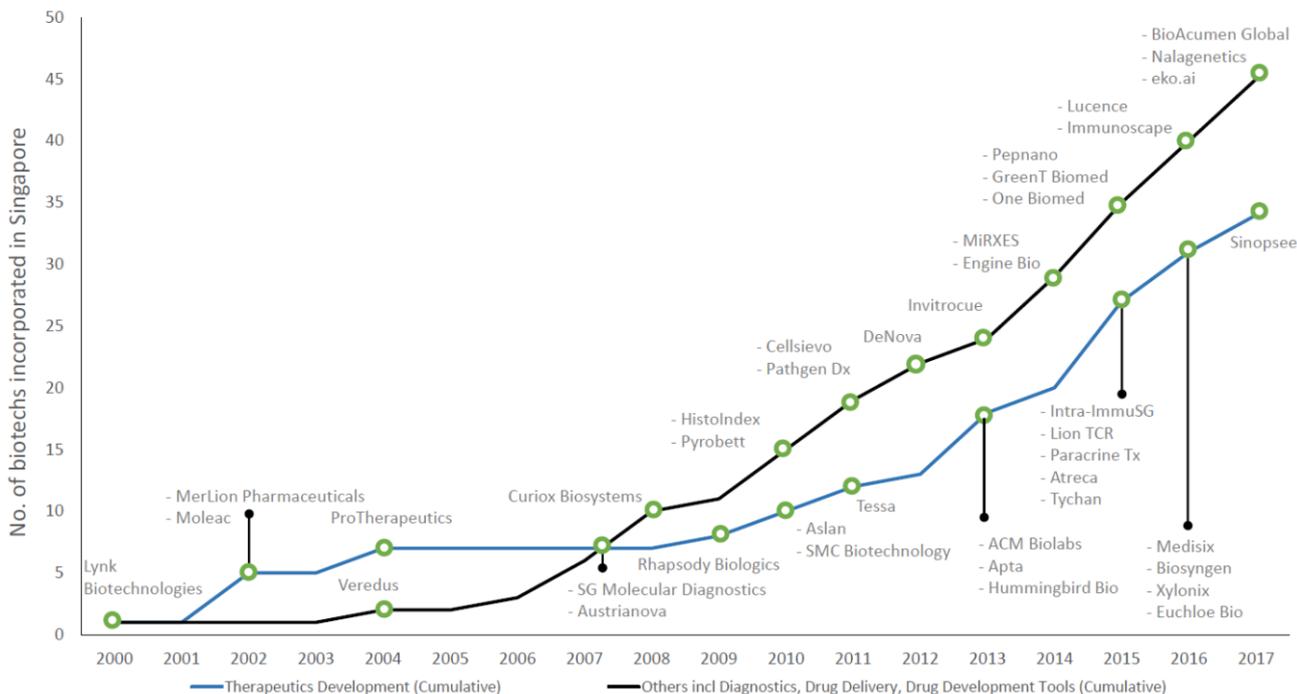
By bringing together a suite of capabilities across our research institutes, A\*STAR has been able to offer a differentiated value proposition that has proven critical to partnerships with companies such as Rolls-Royce, Singapore Aero Engine Services Pte Ltd (SAESL) and ST Aerospace.

*In September 2017, A\*STAR established a smart manufacturing joint lab with Rolls-Royce and SAESL, a five-year programme worth S\$60 million, that will allow both parties to speed up the development of innovative technologies. These technologies will be adopted on-site at Rolls-Royce and SAESL's facilities to improve productivity, save costs and enhance competitiveness.*

**“ This agreement is further evidence of our special relationship with Singapore that began over 50 years ago. This continues to flourish as we make ground-breaking technological advances, together. Singapore, as demonstrated by its Future of Manufacturing initiative, is continually transforming, able and inventive. That is why Singapore is a compelling partner to work with.”**

*Mr Ian Davis, Chairman of Rolls-Royce*

## Catalysing a vibrant local biotech ecosystem in Singapore



A\*STAR has continued to nurture Singapore’s growing biotech ecosystem. As of 2017, there were 79 operational biotechs that were incorporated in Singapore, a quarter of which are A\*STAR spin-offs, and about half of which have collaborations, IP licenses, joint labs, or were incubated with A\* STAR.

From 2010 to 2017, at least 60 of these biotechs were incorporated in Singapore, three times that of the preceding decade from 2000 to 2009.

From 2011 to 2016, local biotechs’ contribution to R&D expenditure increased by nearly nine-fold, from S\$21 million to S\$186 million.

A\*STAR aims to sustain the growth of the biotech industry, and provides support through incubators, and access to its research capabilities through joint projects and laboratories.



**There are many reasons to be optimistic that Singapore's biotech ecosystem is poised to deliver even more, as our biotechs break new ground in drug discovery and development."**

*Mr Lim Chuan Poh, Chairman A\*STAR, in his article "Biotech Sector Poised to Deliver More Health and Wealth" for The Straits Times, 29 July 2017.*

Read more:





## Licensees

**Lion TCR** is a clinical-stage T cell immunotherapy company that specialises in producing T cell products to treat viral-related cancers such as hepatocellular carcinoma (HCC), which are widespread in Asia.

Lion TCR's technology, licensed from A\*STAR, was developed based on research led by Prof Antonio Bertoletti, Lion TCR's Scientific Founder and Research Director at A\*STAR's SICS. In August 2017, the US Food and Drug Administration (FDA) granted two orphan drug designations (ODD) for two of Lion-TCR's T cell therapy products, which will enable the company to accelerate their product development and commercialisation to both US and Asian markets.

**Intra-ImmuSG Pte Ltd**, is a spin-off company from A\*STAR that licensed the intellectual property portfolio behind PRL3-zumab, a first-in-class humanized antibody for cancer therapy.

**Paracrine Therapeutics**, a local biopharmaceutical company focusses on development of stem exosome for regenerative medicine and has exclusive license to an extensive patent portfolio that covers the production, composition and use of exosomes from A\*STAR.



## Joint Laboratories

**Invitrocue Pte Ltd** and GIS set up a joint laboratory to advance personalised therapy in cancer, with a focus on developing patient-derived 3D organ models for high throughput screening of cancer drugs. The collaboration leverages the company's 3D cell-based scaffolding technology for organoids as well as GIS's expertise in cancer biology, quantitative image analysis. Invitrocue is also A\*STAR's first publicly listed spin-off.

**Tessa Therapeutics**, a clinical stage biopharmaceutical company, collaborates with IMCB, through a joint laboratory to build on Tessa's virus-specific T cell platform, to create the next generation of immunotherapies that treat solid cancer tumours. Tessa is also collaborating with SigN and the National Cancer Centre Singapore, to investigate viruses that cause cancers. In 2017, Tessa acquired Euchloe Bio, a spin-off from A\*STAR that develops novel therapeutic antibodies for cancer treatment and therapy.



## Spin-offs

**Lucence Diagnostics** is an A\*STAR spin-off founded by Dr Tan Min-Han, a principal research scientist at IBN. Lucence runs cancer-detection tests using liquid biopsies offers a range of diagnostic tests, including its flagship liquid biopsy tests used in cancer diagnostics. These tests have a turnaround time of less than 48 hours to speed up treatment selection for patients.

**Watch the story of how Invitrocue leveraged A\*STAR R&D efforts to create ground-breaking three-dimensional cell-based models that better mimic the human liver.**



## Fuelling Singapore's Food, Nutrition and Consumer Care Industry

Singapore's Food, Nutrition and Consumer Care (FNCC) cluster continues to grow, boosted by long-term investments in Biomedical Sciences R&D. BERD for the sector grew at a Compound Annual Growth Rate (CAGR) of 18% from S\$47 million in 2002 to S\$494 million in 2016, while the number of R&D jobs grew from about 340 to close to 1,970 within the same period.

To step up the focus on Asian growth, companies like Roquette have opened a regional headquarters and innovation centre in Singapore at Biopolis. The French plant-based ingredients maker also works with BTI and the Clinical Nutrition Research Centre (CNRC) to examine critical issues such as how different Asian populations react to certain dietary ingredients.

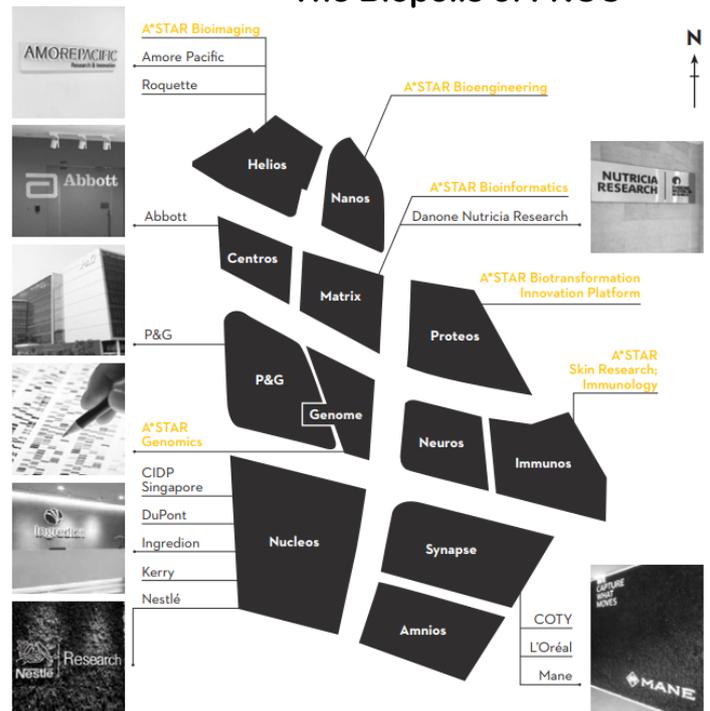
## Innovation Platform for Food and Consumer Care Sectors

Other global industry brands like Mondelez are tapping on A\*STAR's Biotransformation Innovation Platform (BioTrans) and CNRC to develop product innovations.

The BioTrans platform uses microbial fermentation-based processes to impart flavours and functional benefits to food, produce high-value compounds sustainably, and convert food industry side streams into value-added products. With BioTrans, A\*STAR is well positioned to contribute to this emerging market opportunity for Singapore to establish manufacturing standards, attract greenfield manufacturing investments, and be recognised as a global hub for production of new therapeutic modalities and bioingredients.

Since the beginning of the strategic partnership between Nestlé and A\*STAR in 2014, scientists from both parties have since worked together to improve nutrient yields obtained from raw materials such as barley, during Nestlé's malt extraction process. This has enabled the company to advance operational efficiency and environmental sustainability. As of 2018, Singapore is one of Nestlé's top destinations<sup>^</sup> for public science and research partnerships.

## The Biopolis of FNCC



## Investing in Excellent Skin Research

Singapore's excellence in skin research has been instrumental in anchoring global industry leaders like P&G and L'Oreal. These MNCs have established skin and hair research labs in Biopolis, which have contributed to the growth of innovation partners, driving the robust and organic expansion of the Consumer Care sector.

To further boost the sector's innovation capacity, SRIS is building R&D capabilities to address common medical conditions like eczema, diabetic skin ulcers and tumours. These capabilities also have the potential to yield economic benefits.

SRIS is also developing novel therapeutics for high-burden conditions like atopic dermatitis and acne, and therapies to manage hard-to-heal wounds. For example, the institute is developing customised 3D-printed bandages for wound management such as those for diabetic wounds.

# Celebrating World-Class Talent

As our economic strategy becomes increasingly dependent on promoting innovation and enterprise, a solid local R&D talent base, complemented by rich and diverse international talent, is key to securing Singapore’s future.

Our most valuable asset has always been, and will continue to be, our people. The A\*STAR scholarship is an example of the continuous effort in developing a steady pipeline of highly skilled scientific talent by providing students the opportunity to pursue scientific training at local and international universities. Since the inception of the A\*STAR scholarship programme in 2001, over 800 A\*STAR scholars have completed their PhD or post-doctoral education and are contributing to Singapore’s R&D ecosystem in various ways.

Every year, A\*STAR’s talent is recognised for their achievements and contributions to their fields of research. Our scientists placed A\*STAR on the map through their prestigious awards in 2017.

## Dr Sherry Aw

Independent Fellow, Institute of Molecular and Cell Biology

The **L’Oréal Singapore for Women in Science National Fellowship** is awarded to women who have demonstrated scientific excellence in their career. The Fellowship also identifies exceptional female scientist as role models for younger generations.

Dr Aw was recognised for her use of genetics, molecular and imaging techniques to understand the underlying causes of the pathological tremor that comes with neurodegenerative diseases.



## Dr Wesley Zheng

Scientist, Institute of Materials Research and Engineering

Dr Wesley Zheng was named as one of the **top 10 young Innovators under the age of 35 in Asia** by MIT Technology Review (TR35) for his pioneering work in developing high energy density lithium batteries for automotive, aerial, and renewable storage applications.

This award recognises the development of new technology or the creative application of existing technologies to solve global problems in industries such as energy, materials, biomedicine, computing, communications, web and transportation.





### Dr Wan Yue

Senior Research Scientist,  
Genome Institute of Singapore

### Dr Daniel Messerschmidt

Principal Investigator,  
Institute of Molecular and Cell Biology



The **EMBO Young Investigator Award** recognises young, promising researchers less than 40 years of age, who are in the early stages of setting up an independent lab in Europe or the EMBO cooperation partner countries. Dr Wan studies functional RNA elements in transcriptomes through genome-wide detection of RNA structures, and Dr Messerschmidt focuses on epigenetic reprogramming and its implications in development and disease.

### Dr Ng Shyh Chang

Senior Research Scientist,  
Genome Institute of Singapore

### Dr Lena Ho

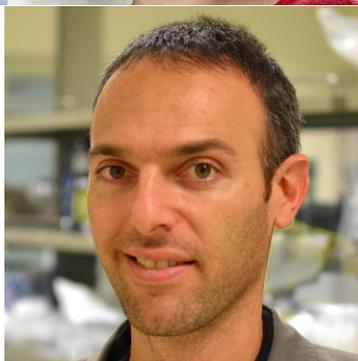
Assistant Professor, Duke-NUS and  
Joint Principal Investigator,  
Institute of Medical Biology

### Dr Nicolas Plachta

Senior Principal Investigator,  
Institute of Molecular and Cell  
Biology



These three A\*STAR researchers are the first in Singapore to receive **Howard Hughes Medical Institute (HHMI) scholarships**, which are awarded to exceptional early-career scientists poised to advance biomedical research across the globe.



## Dr Justin CW Song

Scientist, Institute of High Performance Computing

## Dr Li Jingmei

Senior Research Scientist, Genome Institute of Singapore

Dr Justin Song received the **Young Scientist Award (YSA)** for his research on quantum electronics, as his work has revealed a host of unconventional properties native to quantum materials.

Dr Li Jingmei was awarded the YSA for her research on mammographic density and its impact on women's health.

The YSA recognises young researchers aged 35 and below who have shown great potential to be world-class researchers in their fields of expertise.



## Prof Edward Holmes

Senior Fellow, A\*STAR

## Prof Sir David Lane

Chief Scientist, A\*STAR

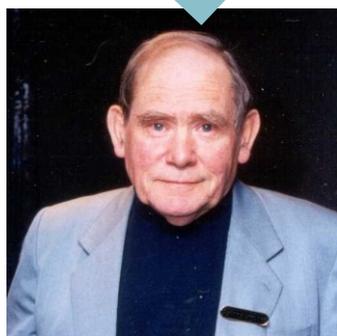
Senior Fellow A\*STAR, Prof Edward Holmes, and Chief Scientist A\*STAR, Prof Sir David Lane, were awarded the **President's Science and Technology Medal (PSTM)**.

Prof Holmes was recognised for his pioneering work in developing the human capital, programme and infrastructure that galvanised translational and clinical research in Singapore's health and biomedical sciences ecosystem. Prof Lane was honoured for his important role in the strategic development of Singapore's biomedical sciences and distinguished contributions to cancer therapeutics and research.

## Dr Sydney Brenner

Nobel Laureate and A\*STAR Senior Fellow

Prof Sydney Brenner received the Japanese Government's **Grand Cordon of the Order of the Rising Sun award**, the second-highest accolade Japan gives to foreigners, for his contributions in developing education and research in the field of science and technology in Japan. The award was presented by the Japanese Ambassador to Singapore, Mr Kenji Shinoda, on behalf of Emperor Akihito.



## Prof Jackie Y. Ying

A\*STAR Senior Fellow, NanoBio Lab  
Executive Director, Institute of  
Bioengineering and Nanotechnology  
(2003-2017)

Prof Jackie Y. Ying was elected as a **Fellow of the U.S. National Academy of Inventors**. This is the highest professional accolade bestowed upon academic inventors who have demonstrated a prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on quality of life, economic development, and welfare of society. She is the first researcher based in Singapore to receive this recognition.



## Assoc Prof Chong Yap Seng

Executive Director, Singapore Institute for Clinical Sciences and  
Senior Consultant, National University Health System

Assoc Prof Chong Yap Seng was awarded the **2017 National Outstanding Clinician Scientist Award** for his outstanding contributions towards improving population health in Singapore through the study of health and disease in early life, and its potential impact in later life. The prestigious accolade is presented by the Ministry of Health (MOH) to recognise contributions from health professionals for innovations in healthcare, patient safety, clinical quality, biomedical research as well as training and education of clinicians.



## SIMTech

SIMTech researchers received the **2017 IES Prestigious Engineering Achievement Award** in the Applied Research and Development category.

The SIMTech team received the award for their project on high power mid-infrared fibre lasers, a complex equipment that is used in manufacturing for greater precision and better performance, allowing for greener and sustainable processes. This is the third time that SIMTech has won an IES Prestigious Engineering Award since 2004.

# Outreach to the Community



one-north Festival



one-north Run



X-periment!





Science Outreach to Schools



A\*STAR Talent Search



Science Talks and Publications



SERIOUSLY SCIENCE

Talks by A\*STAR Scientists



HQASTAR



A\*STAR and Industry



ASTARSingapore



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# Annex

## Key Performance Indicators

S/N	RIE2020 KPIs	FY2017 Achievement Cumulative (% achieved)	RIE2020 Target
1	Industry R&D Projects	4,000 (121%)	3,315
2	Industry R&D Spending (S\$ mil)	570.5 (48%)	1,200
3	Licenses	498 (111%)	450
4	Spin-offs	31 (60%)	52
5	Industry Cash Funding Received (S\$ mil) <i>(as a subset of indicator no. 2)</i>	210 (67%)	313
6	Licensing Revenue (S\$ mil)	14.4 (96%)	15
7	RSEs from RIs seconded to Industry	127 (46%)	275
8	PhD Postgraduates trained or being trained	261 (45%)	585

In addition to the indicators above, A\*STAR's research was also published in 2,432 high impact publications.