The Biopolis story

COMMEMORATING TEN YEARS
OF EXCELLENCE
Singapore’s long-term aim is to be one of the most research-intensive, innovative and entrepreneurial economies in the world in order to create high-value jobs and prosperity for Singaporeans. Research and innovation underpin the competitiveness of our industries, catalyse new growth areas, and transform our economy. Increasingly, intellectual capital will be critical for our next phase of economic development.”

Prime Minister Lee Hsien Loong
Preface
This year marks the 10th anniversary of Biopolis, which was born out of a bold vision in 2000 to establish the Biomedical Sciences (BMS) as a key pillar of Singapore’s economy. This commemorative publication traces the history behind the decade-long national BMS initiative in Singapore; the systematic development of research capabilities and talent spanning basic to translational research; and the establishment of Biopolis in 2003 as the key infrastructure for biomedical research among public and private players.

In the chapter on Success Stories, we take you through a journey of the impactful science that takes place at Biopolis. This includes our response to national crises such as SARS in 2003; the world-class innovations produced by biomedical scientists and engineers; and the close partnerships we have forged with industry partners who are co-located at Biopolis to translate discoveries to benefit society. You will learn more about the many capable and committed scientists, both local and foreign, who are steadfast in pursuing their passions in research to make an impact in science, while creating growth and enhancing lives in Singapore.

Reflections is a chapter on the pioneers, key scientists, advisors and government leaders who have made the BMS initiative possible through their vision, planning, strategies or support in one way or another. They have all contributed to launching what has been an exciting and continuing journey for Singapore, and one that has catapulted Singapore onto the global R&D stage.

Finally, in The Journey Continues chapter, we take a glimpse into the future where Singapore continues to push the frontiers of BMS research through closer collaboration with local and international academic and clinical research communities. With the global biomedical industry looking towards Asia for growth, it behooves the Singapore’s BMS community to work even more closely together to seize the many opportunities to uncover new knowledge and develop impactful innovations for the Asian markets and beyond.

I hope that this publication will give you an appreciation of the thinking behind Singapore’s push into BMS research and what we have achieved so far. More importantly, I hope that you are excited by the journey so far, and will continue to support us in the years to come.

Singapore continues to push the frontiers in BMS research...

Lim Chuan Poh
Chairman
A*STAR
Introduction
...in June 2000, Singapore launched the Biomedical Sciences (BMS) Initiative...

The shift from a manufacturing driven economy to R&D seemed to be the natural progression for Singapore. With Singapore’s manufacturing sector growing steadily and maturing, the Singapore government began to explore other avenues to diversify its growth. After successfully getting Glaxo, a leading British pharmaceutical company to build a plant for the production of a new drug - Zantac in Singapore, EDB and Glaxo went on to collaborate on many projects. It was the beginning of a great partnership in the budding biotechnology industry for Singapore. This strategy proved to be crucial in maintaining Singapore’s competitive edge in the wake of the 1997 financial crisis. It was apparent that focusing on biomedical science was the way to go in order to diversify the economy and propel Singapore up the value chain. Hence, in June 2000, Singapore launched the Biomedical Sciences (BMS) Initiative to focus on developing a full spectrum of capabilities like top scientists and state-of-the art facilities for research in biomedical science. While it seemed like a daunting task for a small country with little or no experience at all, it was necessary in order for Singapore’s survival.

A key factor was the tenacity and pioneering spirit behind those who believed in the biotechnology dream that spurred them on. In year 2000, the Biopolis master plan was conceptualised, leading to the completion of phase 1 of Biopolis in 2003 to house cutting edge research facilities. This sparked the beginning of an ambitious project to position Biopolis as Singapore’s biomedical sciences R&D hub.
Joint Message

Dr Raj Thampuran
MANAGING DIRECTOR
A*STAR

Yeoh Keat Chuan
MANAGING DIRECTOR
EDB

Png Cheong Boon
CHIEF EXECUTIVE OFFICER
JTC CORPORATION
Biopolis – Asia’s Biomedical Sciences R&D Hub. The ‘walking man’ logo that you see embodies the strides that Singapore has taken in the last 10 years to create a hub for Biomedical Sciences research. The name “Biopolis” was coined by Nobel Laureate Prof Sydney Brenner, who in the early 2000s, felt that Singapore needed a “bio-city” to concentrate its biomedical research effort. One-north, a 200-hectare R&D and business park master-planned and developed by JTC, was thus identified to be the home for Biopolis. From the initial seven buildings developed by JTC in 2003, Biopolis has now expanded through 5 phases to 13 buildings with total floor area of more than 3.6 million square feet. This is testament to the success of the masterplan objective of creating a conducive environment for research activities to thrive. More than 2,000 research scientists and engineers from over 60 countries work at Biopolis which houses A*STAR’s research institutes and consortia, corporate labs, as well as local and foreign private research agencies/entities.

This diverse mix of scientific minds at Biopolis makes us unique, and A*STAR, EDB and JTC continue to attract companies to locate research activities here. Starting with pharmaceutical companies such as Novartis and GSK in the early years, the biomedical industry presence has now expanded to include biotech and medical technology companies such as Arkray, Fluidigm, Illumina and Thermo Fisher, as well as an increasing number of nutrition companies such as Abbott and Danone, and personal care companies like L’Oreal and Procter & Gamble. Companies are attracted by the opportunities for collaboration with A*STAR scientists, as well as access to state-of-the-art research equipment and research support services, which enable them to jump-start operations quickly. This close proximity and co-location catalyse collaboration and new ideas to be formed, which translate into medical discoveries and innovations.

As we celebrate the 10th anniversary of Biopolis this year, we acknowledge the pioneers, advisors, key scientists, architects and developers who have made the vision for the Biomedical Sciences initiative and Biopolis possible. We hope that the community at Biopolis will continue to work closely together, leveraging on the synergies of co-location and proximity. We also hope that scientists at Biopolis will continue to reach out to the wider BMS research community in Singapore and vice versa, and take an integrated approach to solving medical challenges, which will take Singapore’s BMS effort to even greater heights in the years ahead.
Contents

Preface 02
Introduction 04
Joint Message 06
Our History 10
Success Stories 24
Reflections 46
The Journey Continues 60
Our History
The year was 1983 when Dr Sydney Brenner first stepped onto Singapore’s shores. He was invited by then Deputy Prime Minister Dr Goh Keng Swee to give a lecture on An Overview of Biotechnology in Industry. It was also at that time that he met former Prime Minister Lee Kuan Yew. During his visit, Dr Brenner was so impressed by the young country’s commitment in breaking into the biotechnology scene that he decided to help Singapore in achieving that dream. The first thing that he did was to propose the establishment of Institute of Molecular and Cell Biology (IMCB). With Dr Goh’s economy building wisdom and Dr Brenner’s authority on biotechnology, IMCB began to attract many top talents and the interest of international pharmaceutical industries. As soon as IMCB was established, a team of top guns were recruited to take IMCB further. One to them was Dr Christopher Y.H. Tan, a professor of medical biology and medical biochemistry at the University of Calgary. Like a man on a mission, Dr Tan then set out to invite researchers to join the IMCB. Dr Brenner, affectionately referred to as the father of biotechnology in Singapore- became the chairman of the advisory board of IMCB while Dr Tan was the founding director. Meanwhile, Mr Philip Yeo, then Chairman of Economic Development Board (EDB) set up the National Biotechnology Committee. "I was genuinely interested in helping a young country motivated to go in the right direction.... This was to be an experiment in developing state-of-the-art biomedical research at a national level in what was a third world country not too many years before. I viewed it as an exciting venture and an exciting opportunity."
Imagine waking up, getting ready for work and reaching your work station in less than half an hour. This is not a far-fetched idea, but a possibility materialised by Biopolis.

Inspired by the success of Boston and San Diego in the United States, Singapore recognises the need for a place where creativity is generated when like-minded people come together and interact with one another.

This sparked the birth of the Biopolis master plan – the name suggested by Dr Brenner, the epitome of Singapore’s commitment to be a biotechnology hub of Asia and a place where people can work, live, play and learn in one location; one-north, a 200-hectare R&D and business park master-planned and developed by JTC, was thus identified to be the home for Biopolis.

By a twist of fate, Dr Louis Lim, another IMCB Advisory Board member who was from the Institute of Neurology in London connected with the Director of EDB’s office in London. Under his encouragement, Dr Lim sent a research proposal on central nervous systems to Glaxo. The proposal was in line with Glaxo’s interest in drugs for the treatment of brain diseases. Glaxo was so impressed with the proposal that it offered a $50 million grant spread over 15 years to finance the researchers from University of London and IMCB. The collaboration between all parties was so successful that IMCB, EDB and Glaxo went on to set up the Centre for Natural Products Research in 1992.

For the new set up, Glaxo contributed $20 million, IMCB offered $10 million in terms of infrastructure and research support, while EDB matched it with another $10 million. This cross disciplinary collaboration between the industry and the research institute became the working model for Biopolis.
The test of a nation lies in its ability to adapt and overcome challenges during a crisis. During the 1997 Asian Financial Crisis, it became apparent that Singapore needs to move away from a solely manufacturing driven economy to a knowledge and innovation driven one in order to stay ahead of competition. Hence, the Biomedical Sciences (BMS) sector was singled out to be one of the key driving forces for economic growth.

In order to understand the complexities in establishing a BMS research infrastructure, a study group which comprised of Dr Tony Tan, then EDB Chairman Philip Yeo and Dr Sydney Brenner was formed in year 2000. The group went on a study tour visiting mainly top biomedical research laboratories in the UK and Europe.

The study tour at the UK Medical Research Council was an enlightening experience. They quickly realised what Singapore needed was more than just a research institute. It needed a biomedical hub that could support medical research effectively. In other words, an infrastructure had to be established; from building state-of-the-art research facilities to attract top-notch researchers and scientists to work here, to implementing corporate R&D activities to create a buzz.

This resulted in the birth of the BMS initiative whose team members included Prof Tan Chorh Chuan, Dr John Wong, Dr Kong Hwai Loong and Philip Yeo.

In June 2000, then Minister for Trade and Industry George Yeo launched the BMS initiative with a budget of $1.48 billion. Perhaps it was a clear signal that Singapore was moving in the right direction. Incidentally, the US and the UK government announced the first draft of the human genome results as part of its 15-year Human Genome Project on that day.

Concurrently, the development of a 200-hectare plot of land in Buona Vista area for a Science Hub was taking place. It was later renamed as one-north which comprised of multi-disciplinary centres of excellence, including Biopolis, Fusionopolis and Mediapolis.

Phase 1 of Biopolis, completed in 2003, comprised seven research buildings, linked by sky bridges to encourage and facilitate multi-disciplinary collaborations. It also promoted the concept of co-location of public-private research institutes and shared facilities as well as to allow companies to leverage on the infrastructure developed for a “plug & play” experience.

By 2005, the Biomedical Research Council (BMRC) had built up a number of biomedical sciences institutes by courting top brains to head the various institutes.

In April 2005, in recognition of Singapore’s rising reputation as a biomedical research hub, The Independent quoted, 

“Globally, it would be hard to find a location with a more new, concentrated pharmaceutical industry investment than of Singapore.”

The Independent
The work on Phase 2 was underway before Phase 1 was completed. The key focus of Phase 2 was to strengthen Translational and Clinical Research (TCR) capabilities. The key difference between the buildings in Phase 1 and 2 was that facilities built in Phase 2 were marketed to the private research institutes while Phase 1 housed mainly the public research agencies. This close proximity of private and public research institutes allowed interaction and collaborations.

From 2006 to 2010, a budget of $648 million was invested to set up programmes related to TCR. Lives were being changed as more TCR institutes and consortia were established to bring more scientific discoveries from the laboratories to the patients in hospitals.

In addition, emerging research areas such as neuroscience and immunology were developed. This was further enhanced by the development of two buildings by Ascendas (Tuas) Pte. Ltd., aptly named Neuros and Immunos, in Phase 2.
Phase 3: Evolution of Biopolis

The buildings and supporting infrastructure are the skeletons and muscles of Biopolis. Without people, Biopolis will just be an empty shell. Hence, no efforts were spared to woo biotech companies from all over the world to bring their innovations to Singapore, thereby spawning new business opportunities. New facilities could be added or refurbished whenever needed. The organic infrastructure allows Biopolis to remain adaptive to changes of a dynamic industry.

Intimate cafes, retail shops and recreational centres are interspersed in various parts of Biopolis to create a lively community. Pockets of open spaces punctuated by occasional art pieces create an element of surprise. Synapse and Amnios, which were part of Phase 3 and completed in 2010, boosted Biopolis’ research space by another 41,000 sqm. These are purpose-built multi-tenanted biomedical research facilities which extend basic research activities into translational and clinical research as well as medical technology research. Chugai Pharmabody Research Pte Ltd and Cerebos Pacific Limited are anchor tenants at Phase 3.

Phase 4 & 5: Future of Biopolis

P&G Singapore Innovation Centre (Phase 4) is expected to be completed in end 2013 and will house Procter & Gamble’s research laboratories as well as pilot plant functions and support offices with total floor area of 32,000 sqm. Moving forward, the fifth phase of Biopolis will add another 46,000 sqm of space and introduce a concept of ready fitted-out laboratories space.
The Structure

In 1998, a 200-hectare land located near National University of Singapore, National University Hospital, Nanyang Technological University and the Science Park was earmarked to develop the Biomedical Hub. It was later renamed as one-north with Biopolis as one of its key centre of excellence, focusing on R&D in biomedical sciences. **PHASE 1:** Phase 1, comprising seven buildings with a total built-up area of 185,000 sq m was completed in 2003. IMCB was the first to move in. Progressively, other A*STAR research institutes moved in, occupying five buildings namely, Centros, Genome, Matrix, Nanos and Proteos. The two other buildings, Chromos and Helios housed private research institutes and critical infrastructure including a district cooling system. **PHASE 2:** Phase 1 was almost full by the time Phase 2 was launched. Two new buildings (Neuros and Immunos) were completed by Ascendas (Tuas) Pte. Ltd. in 2006. The built-up area was 37,000 sq m and housed mainly private research institutes. **PHASE 3:** Phase 3 was completed by Crescendas Bionix Pte. Ltd. with 41,000 sq m of space added to support TCR capabilities.
The Developer – JTC Corporation

JTC has played a critical role in developing industrial land and infrastructure to support Singapore’s economic development in the past 45 years. Its mission is to ensure that there is world-class and competitive industrial infrastructure to meet the needs of industries and enterprises, thereby enabling them to compete effectively in the global market.

As Singapore industrialises, JTC’s role has also evolved, from that of a developer of industrial land (e.g. Jurong Industrial Estate) and standard factories, to one which develops innovative and specialised industrial infrastructure solutions in support of key emerging industries and companies. Such innovative and specialised developments include Jurong Island, Tuas Biomedical Park, Seletar Aerospace Park, Airport Logistics Park, and of course, Biopolis @ one-north.
BUILDING BIOPOLIS
When Singapore decided to build a biomedical hub that not only comprised of state-of-the-art research laboratories and but also a meeting place for researchers, technopreneurs and scientists, they entrusted it to JTC. It was an obvious choice given JTC’s vast experience of building industrial infrastructures, ready-built industrial solutions, business and technopreneur parks.

As the master developer of one-north, JTC faced the daunting task of converting the 200 hectares of land and trees into a vibrant research cluster, in which Biopolis is one of the centres of excellence. Apart from laboratories and research facilities in Biopolis, there are retail shops, entertainment centres and even hotels to support the needs of the future biomedical and life-sciences industry.

A LEAP OF FAITH
Like the Dandelion structure fronting the building, Biopolis is a place where seeds of ideas burst forth and creativity takes flight. The fact that it is going to host the biomedical and life science industries from all over the world, the place must be vibrant and dynamic to attract the brightest minds in the world. It must cover a full spectrum of research capabilities with a state-of-the-art infrastructure to support it. To bring the plan to reality, JTC engaged Zaha Hadid, a talented architect to masterplan Biopolis. Her artistic interpretation of Biopolis was experimental and bold. Fluid lines weave through the undulating terrain and trees as interesting shapes juxtapose against the backdrop of the old surroundings. The design was futuristic yet timeless in its own way.

That was exactly what JTC was looking for; something that was cutting edge and yet functional. Building Biopolis Phase 1 was not without challenges. Original plans had to be tweaked to accommodate the various regulations. The construction of the buildings was also complicated due to the need to retain as much existing vegetation as possible. This was a conscious effort by JTC to support pro-environmental policies while achieving sustainability in the construction of Biopolis.

Much thought went into making Biopolis a green development. One of the ways was the use of solar panels. In contrast to the conventional way to harness solar energy by installing solar panels on rooftops, solar panels were embedded in glass panels at the Visitor Centre located at Helios building. The solar energy was used to generate power to supply the air-conditioning to the Visitors Centre. The district cooling system also posed a challenge. Unlike other JTC’s developments the chillers and giant chilled water storage tanks had to be assembled on site. The steel parts had to be lowered down to Basement 3, through the second-storey podium roof via access tunnels.

To top it all, the overall timeline to deliver Biopolis Phase 1 was tight – all seven buildings were completed in 30 months! The contractors had to work round the clock with additional manpower and machineries on site. As Mr Kok Poh June, Director of Electronics, Info-comm & Media Cluster of JTC recalled, “It was a tight timeline to develop a biomedical hub that had never been conceived anywhere else, in terms of scale and complexity, to bring 7 public research institutes into one location complete with shared facilities. We also had to do a lot of research and made a lot of field trips within a short span of few months to gear ourselves with good knowledge and understanding of the biomedical research facilities. On top of that, we had to integrate Biopolis with the one-north masterplan mixed use concept and to bring retail, F&B, mature green as well as seamless connectivity, via skybridges from one building to another. Many late nights were spent on site, between JTC, A*STAR, consultants and contractors to make sure high design standards were maintained and tight deadlines were met.”
In order to attract the right mix of tenants, JTC took great care in planning the spaces within Biopolis. Mr Mark Koh, Acting Director of Facilities and Estate Management Division of JTC explained, “By carefully creating public interactive space, we encourage vibrancy and promote interaction of the working community. These spaces not only bring life to the development, but also allow the community to build strong association to the development and call it their own. In community building, having individuals with a collective and common ownership of their spaces is important.”

By the time, Biopolis was officially launched in 2003, it exceeded everyone’s expectations. Mr Mark Koh attributed the success of Biopolis to the involvement of the stakeholders and partners as well, “Economic Development Board (EDB) brings in the varied nature of companies we see today at Biopolis. A*STAR oversees the research initiatives and attracts the research talents. Retailers and F&B operators bind the community together with their amenity offerings. All Government stakeholders, as well as our tenants share the common vision which JTC wanted to build for Biopolis. Without their belief that it is indeed possible to build-up a vibrant biomedical hub from scratch, JTC would not have been able to do it alone, and the vision of Biopolis would not have materialised.”

After the successful launch of Biopolis Phase 1, one would have thought that it would be legitimate to take a break and enjoy the fruit of the labour. It was not so for JTC. Not resting on its laurels. JTC was already working on other expansion phases of Biopolis. As Mr Koh Poh June summed up and gave an overview of the future developments for Biopolis, “The expansion phases build upon the success of Biopolis Phase 1 to attract different biomedical companies into the cluster. As part of the developer partnership programme, we continue to build up our knowledge of biomedical infrastructure, develop awareness of changing laboratory design standards and co-develop these ideas with the private developers in each of the various phases.”

Truly, the best is yet to come and the Biopolis journey has just begun.

The cooling system also posed a challenge. Unlike other JTC’s developments where the buildings could be customised according to needs of the project. In Biopolis, everything was a bit tight and JTC had to work around the limitations. For Helios, the five chillers and two giant chilled water storage tanks had to be assembled on site. The steel parts had to be lowered down to Basement 3, through the second-storey podium roof via access holes.

To top it all, there was a deadline to be met. The contractors worked round the clock, sometimes incurring the unhappiness from the neighbours. It was inevitable as the once peaceful and quiet neighbourhood was disrupted by heavy vehicles moving in and out of the vicinity as well as the noise from the construction site.

Though the noise level was well within legal limits, JTC maintained good neighbourliness by reaching out to the residents around the area and listen to their complaints.

In the midst of all the setbacks, JTC rose above the challenges and managed to push through. JTC worked with Urban Redevelopment Authority (URA), Land Transport Authority (LTA) and National Parks Board to solve the different problems. Open and regular communications between the contractors and authorities were carried out on regular basis in order to ensure that building guidelines were adhered to while ensuring that vision of the master plan was not compromised.

The seemingly impossible deadline was met. Biopolis was officially launched in 2003.
By the time the final product was delivered, Biopolis surpassed everyone’s expectation. The soft outlines with sudden sharp corners of the buildings reflect the unexpected ways that each encounter brings when sparks fly as like-minded individuals connect with one another. The link bridges that flow seamlessly from one building to another facilitate dynamic interaction between the different research sectors. Retail spaces add to the vibrancy of the place and give a sense of community living. Plentiful skylight and strategically placed greenery sections create an atmosphere of expansiveness and calmness. It was the embodiment of modern efficiency and natural beauty.
The Bioinformatics Institute (BII) was founded by Dr. Gunaretnam Rajagopal in 2001 as part of the national initiative to develop and implement efficient computational biology methods to help analyse biological research data. Dr. Frank Eisenhaber became the Director in 2007.

GIS originated from Singapore Genomics Program (SGP) which was set up in 2001. It was then renamed as the Genome Institute of Singapore (GIS) with the objective to integrate technology, genetics and biology and use genomic sciences to improve public health and achieve public prosperity. Led by its founding Executive Director, Dr. Edison Liu from 2001 to 2011, Dr. Ng Huck Hui became the Executive Director in 2012. The key research areas at the GIS include Systems Biology, Stem Cell & Developmental Biology, Cancer Biology & Pharmacology, Human Genomics, Infectious Diseases, Genomic Technologies, and Computational & Mathematical Biology.

In 2003, GIS was awarded the President’s Certificate of Commendation for Overcoming SARS for its contribution in fighting SARS during the 2003 outbreak. GIS worked with Roche to develop a sensitive test for the SARS virus which was made available to hospital and research laboratories. This enabled the speedy and accurate diagnosis of SARS.

Three GIS PIs have won the Chen New Investigator Award presented by the Human Genome Organisation. The award is given to top young scientists in Asia studying human genetics and genomics.

Eight GIS PIs have won the President’s Science Award for groundbreaking work in human genomics or stem cell research.

The Institute of Molecular and Cell Biology (IMCB) is Singapore’s first and oldest biomedical sciences institute. It was started as part of the country’s initial foray into the life sciences and was officially opened by Dr. Tony Tan, then Minister for Education. First led by its founding Director Dr. Chris Tan from 1987 to 2011, IMCB was then led by Prof. Hong Wanjin (Acting Director, 2001-2004). Subsequently, Prof. Sir David Lane became the Executive Director from 2004 to 2007, followed by Prof. Neal Copeland (Executive Director, 2007-2010) and Prof. Stephen Cohen (Acting Executive Director, 2010-2011). Since 2011, it is headed by Prof. Hong Wanjin as Executive Director. IMCB also houses the Molecular Engineering Lab led by Nobel Laureate Prof. Sydney Brenner since 2012.

In 2000, IMCB was conferred the Nikkei 2000 Award in the category of Technology Innovation for its work towards improving the quality of life in Asia through outstanding contribution to biotechnology and IMCB impressive development into the first major centre of research in Asia.

In 2003, IMCB was awarded the President’s Certificate of Commendation for Overcoming SARS for its contribution in fighting SARS during the 2003 outbreak. IMCB assisted in the areas of sample processing and diagnostics development.

Sixteen IMCB Principal Investigators have received the President’s Science and Technology Awards and Medals for their scientific achievements.

In 2000, IMCB was conferred the Nikkei 2000 Award in the category of Technology Innovation for its work towards improving the quality of life in Asia through outstanding contribution to biotechnology and IMCB impressive development into the first major centre of research in Asia.

In 2003, IMCB was awarded the President’s Certificate of Commendation for Overcoming SARS for its contribution in fighting SARS during the 2003 outbreak. IMCB assisted in the areas of sample processing and diagnostics development.

Sixteen IMCB Principal Investigators have received the President’s Science and Technology Awards and Medals for their scientific achievements.

The Bioprocessing Technology Institute (BTI) had its origins from Bioprocessing Technology Unit (BTU) which was formed in 1990. BTU became the Bioprocessing Technology Centre (BTC) in 1995 which was later renamed as Bioprocessing Technology Institute (BTI) in November 2003. BTI’s main aim is to establish a highly qualified labour pool and pioneer technology that will support the bioprocess industry. Headed by its founding Executive Director Professor Miranda Yap from 1990 to 2011, followed by Prof Lam Kong Peng, Executive Director from 2012, BTI helps to bridge the gaps between discovery, process development and commercialisation.

Institute of Bioengineering & Nanotechnology (IBN) is a multidisciplinary research institute with a mission to develop innovations at the cutting-edge of bioengineering and nanotechnology that will have an impact on the commercialisation of technology and its translation to clinical practice. Headed by Prof Jackie Ying, the institute’s research programs focus on Nanobiotechnology, Delivery of Drugs, Proteins and Genes, Tissue Engineering, Artificial Organs and Implants, Medical Devices, as well as Biological and Biomedical Imaging. IBN also plays an active role in linking the research institute and industrial partners to other global institutions.
Under the leadership of its founding Chairman Prof Sir George Radda, the Singapore Bioimaging Consortium (SBIC) gathers existing imaging expertise and capabilities in Singapore and develops them into a focused national platform to support joint research collaborations with biomedical companies. In 2007, A*STAR, through SBIC, and NUS jointly set up the Clinical Imaging Research Centre to serve as a national shared imaging resource for clinical research in humans.

In 2005, a team of Singapore scientists from the Biomedical Imaging Laboratory was awarded the Magna cum Laude (silver award) for their novel 3-D vascular brain atlas, at the American Society of Neuroradiology (ASNR) 43rd Annual Meeting.

In 2010, Prof David Townsend, Head of PET and SPECT Development for the Singapore Bioimaging Consortium (SBIC) and Director of the Clinical Imaging Research Centre, was honoured with the prestigious 2010 IEEE Medal for Innovations in Healthcare Technology for his outstanding contributions to the development and clinical implementation of the PET/CT scanner.

The Institute of Medical Biology (IMB) is headed by Prof Brigitte Lane as Executive Director. It began as a coalescence of research programmes from the Centre for Molecular Medicine and the laboratories of the Singapore Stem Cell Consortium. IMB’s work is geared towards studying the mechanisms of human disease in order to discover new and effective therapeutic strategies that will bring the research from bench to hospital beds. It focuses on 3 key areas of skin biology, human genetics and regenerative medicine. IMB also houses the p53 Lab led by Prof Sir David Lane and the Translational Lab in Genetic Medicine led by Prof Michael Hayden.

In 2009, Dr Alex Ullrich, who heads the Singapore Oncogenome Project in IMB, was awarded the Dr Paul Janssen Award for Biomedical Research for his lifetime accomplishments in cancer research.

In 2012, Dr Bruno Reversade was awarded the EMBO Young Investigator Award for his work on rare genetic diseases.

In 2005, a team of Singapore scientists from the Biomedical Imaging Laboratory was awarded the Magna cum Laude (silver award) for their novel 3-D vascular brain atlas, at the American Society of Neuroradiology (ASNR) 43rd Annual Meeting.

In 2009, Professor Miranda Yap (Executive Director since 2001) was awarded the President’s Science and Technology Medal.

In 2010, Professor Lam Kong Peng, then Scientific Director of BTI, was honoured with the Arthur Kornberg Memorial Award by the Asia Pacific International Molecular Biology Network (A-IMBN), one of Asia’s key organisations for research in molecular biology and biotechnology based in Seoul, Korea.

In 2007, the PET/CT scanner.

In 2010, Prof David Townsend, Head of PET and SPECT Development for the Singapore Bioimaging Consortium (SBIC) and Director of the Clinical Imaging Research Centre, was honoured with the prestigious 2010 IEEE Medal for Innovations in Healthcare Technology for his outstanding contributions to the development and clinical implementation of the PET/CT scanner.

Singapore Institute for Clinical Sciences (SICS) is the result of a key initiative to promote TCR in phase 2 of BMS. Led by founding Executive Director, Professor Judith Swain, SICS focuses on studying Asian-relevant diseases in order to develop new diagnostics and therapeutics. As such work requires collaborative efforts with other scientists and clinicians from around the world, SICS helps to link local investigators with those from overseas and establish effective world class clinical sciences programmes.

In 2005, a team of Singapore scientists from the Biomedical Imaging Laboratory was awarded the Magna cum Laude (silver award) for their novel 3-D vascular brain atlas, at the American Society of Neuroradiology (ASNR) 43rd Annual Meeting.

In 2009, Professor Miranda Yap (Executive Director since 2001) was awarded the President’s Science and Technology Medal.

In 2010, Professor Lam Kong Peng, then Scientific Director of BTI, was honoured with the Arthur Kornberg Memorial Award by the Asia Pacific International Molecular Biology Network (A-IMBN), one of Asia’s key organisations for research in molecular biology and biotechnology based in Seoul, Korea.

In 2007, the PET/CT scanner.

In 2010, Prof David Townsend, Head of PET and SPECT Development for the Singapore Bioimaging Consortium (SBIC) and Director of the Clinical Imaging Research Centre, was honoured with the prestigious 2010 IEEE Medal for Innovations in Healthcare Technology for his outstanding contributions to the development and clinical implementation of the PET/CT scanner.

Singapore Institute for Clinical Sciences (SICS) is the result of a key initiative to promote TCR in phase 2 of BMS. Led by founding Executive Director, Professor Judith Swain, SICS focuses on studying Asian-relevant diseases in order to develop new diagnostics and therapeutics. As such work requires collaborative efforts with other scientists and clinicians from around the world, SICS helps to link local investigators with those from overseas and establish effective world class clinical sciences programmes.

In 2005, a team of Singapore scientists from the Biomedical Imaging Laboratory was awarded the Magna cum Laude (silver award) for their novel 3-D vascular brain atlas, at the American Society of Neuroradiology (ASNR) 43rd Annual Meeting.

In 2009, Professor Miranda Yap (Executive Director since 2001) was awarded the President’s Science and Technology Medal.

In 2010, Professor Lam Kong Peng, then Scientific Director of BTI, was honoured with the Arthur Kornberg Memorial Award by the Asia Pacific International Molecular Biology Network (A-IMBN), one of Asia’s key organisations for research in molecular biology and biotechnology based in Seoul, Korea.

In 2007, the PET/CT scanner.

In 2010, Prof David Townsend, Head of PET and SPECT Development for the Singapore Bioimaging Consortium (SBIC) and Director of the Clinical Imaging Research Centre, was honoured with the prestigious 2010 IEEE Medal for Innovations in Healthcare Technology for his outstanding contributions to the development and clinical implementation of the PET/CT scanner.

Singapore Institute for Clinical Sciences (SICS) is the result of a key initiative to promote TCR in phase 2 of BMS. Led by founding Executive Director, Professor Judith Swain, SICS focuses on studying Asian-relevant diseases in order to develop new diagnostics and therapeutics. As such work requires collaborative efforts with other scientists and clinicians from around the world, SICS helps to link local investigators with those from overseas and establish effective world class clinical sciences programmes.

In 2005, a team of Singapore scientists from the Biomedical Imaging Laboratory was awarded the Magna cum Laude (silver award) for their novel 3-D vascular brain atlas, at the American Society of Neuroradiology (ASNR) 43rd Annual Meeting.

In 2009, Professor Miranda Yap (Executive Director since 2001) was awarded the President’s Science and Technology Medal.

In 2010, Professor Lam Kong Peng, then Scientific Director of BTI, was honoured with the Arthur Kornberg Memorial Award by the Asia Pacific International Molecular Biology Network (A-IMBN), one of Asia’s key organisations for research in molecular biology and biotechnology based in Seoul, Korea.

In 2007, the PET/CT scanner.

In 2010, Prof David Townsend, Head of PET and SPECT Development for the Singapore Bioimaging Consortium (SBIC) and Director of the Clinical Imaging Research Centre, was honoured with the prestigious 2010 IEEE Medal for Innovations in Healthcare Technology for his outstanding contributions to the development and clinical implementation of the PET/CT scanner.

Singapore Institute for Clinical Sciences (SICS) is the result of a key initiative to promote TCR in phase 2 of BMS. Led by founding Executive Director, Professor Judith Swain, SICS focuses on studying Asian-relevant diseases in order to develop new diagnostics and therapeutics. As such work requires collaborative efforts with other scientists and clinicians from around the world, SICS helps to link local investigators with those from overseas and establish effective world class clinical sciences programmes.

In 2005, a team of Singapore scientists from the Biomedical Imaging Laboratory was awarded the Magna cum Laude (silver award) for their novel 3-D vascular brain atlas, at the American Society of Neuroradiology (ASNR) 43rd Annual Meeting.

In 2009, Professor Miranda Yap (Executive Director since 2001) was awarded the President’s Science and Technology Medal.

In 2010, Professor Lam Kong Peng, then Scientific Director of BTI, was honoured with the Arthur Kornberg Memorial Award by the Asia Pacific International Molecular Biology Network (A-IMBN), one of Asia’s key organisations for research in molecular biology and biotechnology based in Seoul, Korea.

In 2007, the PET/CT scanner.

In 2010, Prof David Townsend, Head of PET and SPECT Development for the Singapore Bioimaging Consortium (SBIC) and Director of the Clinical Imaging Research Centre, was honoured with the prestigious 2010 IEEE Medal for Innovations in Healthcare Technology for his outstanding contributions to the development and clinical implementation of the PET/CT scanner.

Singapore Institute for Clinical Sciences (SICS) is the result of a key initiative to promote TCR in phase 2 of BMS. Led by founding Executive Director, Professor Judith Swain, SICS focuses on studying Asian-relevant diseases in order to develop new diagnostics and therapeutics. As such work requires collaborative efforts with other scientists and clinicians from around the world, SICS helps to link local investigators with those from overseas and establish effective world class clinical sciences programmes.

In 2005, a team of Singapore scientists from the Biomedical Imaging Laboratory was awarded the Magna cum Laude (silver award) for their novel 3-D vascular brain atlas, at the American Society of Neuroradiology (ASNR) 43rd Annual Meeting.

In 2009, Professor Miranda Yap (Executive Director since 2001) was awarded the President’s Science and Technology Medal.

In 2010, Professor Lam Kong Peng, then Scientific Director of BTI, was honoured with the Arthur Kornberg Memorial Award by the Asia Pacific International Molecular Biology Network (A-IMBN), one of Asia’s key organisations for research in molecular biology and biotechnology based in Seoul, Korea.

In 2007, the PET/CT scanner.

In 2010, Prof David Townsend, Head of PET and SPECT Development for the Singapore Bioimaging Consortium (SBIC) and Director of the Clinical Imaging Research Centre, was honoured with the prestigious 2010 IEEE Medal for Innovations in Healthcare Technology for his outstanding contributions to the development and clinical implementation of the PET/CT scanner.

Singapore Institute for Clinical Sciences (SICS) is the result of a key initiative to promote TCR in phase 2 of BMS. Led by founding Executive Director, Professor Judith Swain, SICS focuses on studying Asian-relevant diseases in order to develop new diagnostics and therapeutics. As such work requires collaborative efforts with other scientists and clinicians from around the world, SICS helps to link local investigators with those from overseas and establish effective world class clinical sciences programmes.
Success Stories
The 2003 severe acute respiratory syndrome (SARS) outbreak represented the most severe communicable disease challenge to the Singapore public health system. During this period, a total of 238 people were infected in Singapore, of which 33 of them died.

In response to the crisis, a team of researchers at the A*STAR’s Genome Institute of Singapore (GIS) collaborated with Roche Diagnostics to co-develop a SARS detection kit. The kit used Roche’s Polymerase Chain Reaction (PCR)-based platform technology to rapidly and accurately detect a SARS coronavirus genetic sequence which was sequenced at GIS. The team then tested the kit clinically in the Singapore General Hospital (SGH).

Over at A*STAR’s Institute of Molecular and Cell Biology (IMCB), researchers worked closely with Genelabs Diagnostic Pte Ltd to develop two antibody-based tests for the diagnosis of SARS from just a drop of serum, plasma or blood. The two newly developed tests include a rapid 15-minute quick test and an Enzyme-Linked Immunosorbent Assay (ELISA) test, which can produce results within 1.5 hours. Both tests were based on two recombinant SARS proteins developed at the IMCB that bind to SARS antibodies with the help of antigens.

“This collaboration is an excellent example of how the public and private sectors are working together within a short space of time to...

To date, the FluSurver has been instrumental in the discovery of new influenza strain variants with altered antiviral susceptibility, host specificity, glycosylation and antigenic properties.

The database includes candidate mutations for the recent H7N9 avian flu and the novel reassortant H3N2v swine flu. It also consists of more than 200 mutations extracted from several hundred publications, with information such as the subtype, host, protein, strain and PubMed references.

Collaborators who provided sequences for analysis and helped shape the FluSurver include the Genome Institute of Singapore (GIS), INMEGEN Mexico City, National Public Health Laboratory (NPHL) of the Ministry of Health Singapore, IAL Sao Paulo, the WHO Collaborating Centre for Reference and Research on Influenza, and the Global Initiative for Sharing All Influenza Data (GISAID).
MADE-IN-SINGAPORE H1N1 FLU VACCINE

A team of scientists from A*STAR’s Experimental Therapeutics Centre (ETC) is collaborating with Switzerland’s Cytos Biotechnology on the development of H1N1 vaccine and has already entered into Phase 1 clinical trial. Led by Prof Alex Matter from ETC, this research makes use of Cytos’ proprietary bacteriophage Qbeta virus-like particle (VLP) technology, in which copies of the virus proteins that mimic the structure of the real viruses are produced. These replicates are then injected into humans.

Immunisation is achieved when a small and harmless strain of the target virus is introduced into the body, triggering the body’s defense system. Conventionally, vaccines are produced from natural bacteriophage that is harnessed from chicken eggs. However, this method is time-consuming and the yield is very low, resulting in high production cost. In addition, this method may not be suitable for certain vaccines that contain high toxicity of certain viral strains to birds (e.g. H5N1 bird flu virus). Since the VPL technology does not contain genetic materials that can be replicated, it is generally harmless when injected into humans.

The success of this research will have far-reaching benefits. With faster and cheaper production, more people can have access to the vaccine. It will provide Singapore and the region with an independent supply of vaccine. This is especially crucial in times of outbreaks where scarce or delay in supply from external sources could result in dire consequences.

DENGUE VACCINE BREAKTHROUGH BRINGS HOPE FOR FULL DENGUE PROTECTION

Dengue is the world fastest spreading topical disease with nearly half of the world’s population at risk of dengue infection and an estimated of 100 million people infected a year. The need for a safe and long-lasting vaccine has never been greater. And Singapore might have just found something that can open the door of hope for the world’s first universal vaccine.

Dr Katja Fink and her team of scientists from A*STAR’s Singapore Immunology Network (SIgN) have discovered a new strategy to prevent the dengue virus from escaping the host immune system. This exciting discovery might provide a clue to the development of a vaccine that can give full protection from all four serotypes of the dengue virus.

This new strategy deploys a Trojan horse tactic by introducing a genetic mutation of the MTase, an enzyme found in dengue virus that facilitates chemical modification of its genetic material to escape detection in the host. Once the initial cells are infected by the weakened MTase mutant viruses, the body recognises them as foreign, thereby triggering immunisation responses.

This research was done in collaboration with Singapore’s Novartis Institute of Tropical Diseases (NITD) and Beijing Institute of Microbiology and Epidemiology. It is also supported by Singapore STOP Dengue Translational and Clinical Research (TCR) Programme grant.
As we undergo rapid economic transition, we are very conscious of the growing burden of obesity, diabetes and heart disease. We understand that good reproductive and child health is critical to a healthy passage through life. In 2009, Singapore made a major commitment to assisting research into developmental origins of health and disease when it started the GUSTO study from scratch.

Keeping in mind there is a significant gestational period before data is suitable for analyses, GUSTO has happily met or exceeded its targets in number of researchers trained, and papers published. By creating unifying research and an integrated basic and clinical disciplines platform, GUSTO has attracted considerable partnership with industry without compromising its academic objectives, and energised Singapore’s thrust in nutritional sciences.

We are proud to have contributed to the understanding that led to the United Nations Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases (NCDs) in 2011 - to focus on the developmental dimension (Clause 26), and as our cohort grows up, we look forward to “Living with GUSTO!”

Over a period of 15 months, 1,247 expectant mothers in their 11th – 14th week of pregnancy signed up with GUSTO*. Altogether 1,176 GUSTO babies were safely delivered, with the youngest and last GUSTO baby born, very aptly, on Labour Day, 1 May 2011.

Over the past 4 years, GUSTO has come to establish a state-of-the-art cohort study with detailed protocol and high compliance. It is probably one of the most intensively studied cohorts in Asia of mothers and children, growing in strength in epigenetic analysis, and involves over 100 investigators in Singapore and international collaborators in the United Kingdom, New Zealand and Canada.

GUSTO research has established techniques for performing MRI scans on infants without any need for sedation, shows a much higher incidence of gestational diabetes than previously expected, and informs clinical studies aimed at reducing rates of gestational diabetes, late preterm births, childhood obesity, allergies in children,

GUSTO investigators excited to see some of the first MRI scans coming through clearly, while GUSTO mother patiently sits next to the MRI scanner – watching over her child – just 1 week old, and snugly sleeping through the procedure.

Note:
*The GUSTO study is a collaboration between:
• KKH – KK Women’s and Children’s Hospital
• NUH – National University Hospital
• SICS – Singapore Institute for Clinical Sciences, A*STAR.

Kindly turn to page X for feature on GUSTO investigator, Dr Anne Rifkin-Graboi, Head, Neurocognitive Development Centre, SICS, A*STAR.
GENETIC “SWITCH” FOR WOUND HEALING PROCESS

Wound healing is a process that has not been fully understood and patients with diseases such as diabetes suffer from painful wounds that take a long time to heal, which could even lead to infections and amputations. Dr Prabha Sampath and her team from A*STAR’s Institute of Medical Biology (IMB) recently identified a molecular “switch” which controls the migration of skin cells necessary for wounds to close and heal. This breakthrough may hold the key to developing therapeutics that improve wound healing.

They discovered that a tiny molecule called microRNA-198 (miR-198) which controls several different wound healing processes. In healthy and unwounded skin, miR-198 is present in high levels, which maintains status quo. However, when the skin is wounded, the miR-198 levels drop and the body starts producing follistatin-like 1 (FSTL1) protein instead, which “switches on” the wound healing process. FSTL1 signals cells to move towards the wound to form a barrier. Only miR-198 or FSTL1 can be produced at any one time, not both, hence FSTL1 cannot be found in healthy skin.

However, this switch mechanism does not function the same way in chronic wounds. In the non-healing wounds of diabetics, miR-198 levels do not drop. FSTL1 cannot be expressed and the migration of skin cells is blocked. This defective switch seemed to be the reason why wound healing processes are not activated, resulting in poor wound healing in diabetics.

This discovery is a big step towards better understanding the mechanism of the wound healing process and will open many possibilities for the development of therapies to help patients with chronic wounds which are vulnerable to infections.

LIGHTING THE WAY TO STUDY DISEASE

Fluorescence, which has been used for lighting since the 19th century, is now an indispensable tool for biomedical research and clinical diagnosis. It is especially used in chemical sensing and labelling molecules of interest in living cells and tissues. Fluorescent probes based on small organic molecules (or fluorophores) are the most versatile, and provide dynamic information on molecular events and structures in living cells and tissues.

Conventionally, fluorescent probes are developed by a “hypothesis-driven approach” where a recognition motif is designed based on a known molecular target in the cell, and a fluorophore is then tagged to it. However, the tagging can sometimes affect the property of the recognition motif, making this approach unreliable. To overcome this, the Laboratory of Bioimaging Probe Development led by Prof Chang Young-Tae at the A*STAR’s Singapore Bioimaging Consortium (SBIC), pioneered a new approach known as the Diversity Oriented Fluorescence Library Approach (DOFLA) to explore the diverse chemical space directly around fluorophores using combinatorial chemistry. By using DOFLA in various platforms such as in vitro, cell, tissue and whole organisms, Prof Chang’s laboratory has developed probes which directly interact with molecular targets. In 2010, the laboratory developed the first embryonic stem cell probe, CDy1, which makes it possible to detect and enrich stem cells, and determine the reprogramming of induced pluripotent stem cells. CDy1 was licensed to US-based research tools company Active Motif in 2012.

Prof Chang comments, “Our work in DOFLA is aimed at developing unexplored novel imaging probes. In due course, the work may lead to clinical imaging probes for neurodisease and insulin-secreting pancreatic beta cells. We are also pursuing novel cancer stem cell detecting probes and photodynamic therapy for them.”
GUARDIAN OF THE GENOME: P53 LABORATORY

An estimation of 11 million people live with cancer and forming half of all cases of human cancer, have specific mutations in the p53 gene leading to the production of a faulty p53 protein. Since its discovery by Prof Sir David Lane and others in 1979, this gene has been christened, by Prof. Lane himself, the “Guardian of the Genome”. In addition, cancer patients with an apparently normal p53 gene may have faults in the p53 pathway. As such, the need for the development of anti-p53 treatments has never been greater.

It is with this need in mind that A*STAR established the p53 Laboratory. Headed by Prof Lane, the p53 Laboratory focuses on the development of new therapies, new diagnostics and new discoveries in the p53 pathway. The p53 Laboratory also works closely with many research groups from Singapore and overseas to translate their research findings into clinical benefit. Clinical trials are underway to test the first p53 specific drugs. These drugs are designed to reactivate the wild type p53 in the tumour, where the protein is still present but faulty.

The success of developing an anti-p53 drug is a huge motivation as millions of lives could be saved. As Prof Lane puts it, “I believe passionately that p53 is a good target. Although I think that the challenge of finding the drug that can kill p53 mutant cells is a big one, the reward is huge because 11 million people could benefit from such a drug. In science you have to try to do very difficult things. That’s where real progress is made. Reach for the stars.”

SPURRING GROWTH OF THE BIOLOGICS SECTOR

Biologics manufacturing, a knowledge intensive and high value-added activity, is a prime example of how Singapore’s efforts to build up biomedical sciences R&D capabilities have successfully attracted large-scale manufacturing investments. For over two decades, A*STAR’s Bioprocessing Technology Institute’s (BTI) unceasing mission to develop manpower capabilities, and spearhead research in bioprocessing, to strengthen linkages between the laboratory and manufacturing activities, has been instrumental in enabling Singapore to gain a foothold in the world’s rapidly growing biologics sector.

In 2003, BTI’s Biopharmaceutical Manufacturing Technology Centre was spun off into A-Bio Pharma, a contract biologics manufacturer. Over the next few years, A-Bio Pharma secured major contracts from GlaxoSmithKline (GSK) and Novo Nordisk, building up a strong track record for itself and for Singapore. To support manpower development for the biologics industry in Singapore, BTI has been running the Bioprocess Internship Programme (BIP) since 2005 to train skilled talent in biologics and process development for industry. To date, BTI has trained 117 people through the BIP, of which almost half went on to join industry. BTI has also spun-off a total of 116 staff to industry since 2003. Having a strong local talent pool enables companies to ramp up their operations quickly and is a key value proposition for companies to invest in Singapore.

Through BTI, Singapore has attracted commercial scale biologics plants from major biologics players – GSK, Lonza, Roche, Abbvie, Baxter Bioscience, Novartis and Amgen – that together employ more than 1,700 people and brought in $2.4 billion dollars in investments since the first biologics manufacturing investment in 2007, thus enhancing Singapore’s status as a global hub for biologics manufacturing.
STEM CELL RESEARCH – DIFFERENTIATING INTO NEW PATHS

Stem cells, which have the potential to develop into many different cell types, tissues or a whole organism, has been a topic of great research interest in Singapore for many years. The beginnings of stem cell research in Singapore can be traced to the work of Prof Ariff Bongso at the National University of Singapore, who was among the first to grow embryonic stem cells from human embryos in 1984, and to grow human embryonic stem cells on human feeder rather than animal cells.

With the launch of the Biomedical Sciences initiative in 2000, the government appointed a national Bioethics Advisory Committee (BAC) whose first task was to develop regulatory guidelines for human embryonic stem cell (hESC) research. Recognising the immense potential from hESC research, the BAC nonetheless carefully considered the ethnic/religious, legal and social concerns. After extensive consultation, the BAC recommended guidelines to support the uncontroversial adult stem cell research, allow hESC research provided that embryos were not used after 14 days, and ban human cloning. These guidelines, seen as a sensible approach internationally, paved the way for stem cell research to take off in Singapore, and attracted international stem cell scientists who were hampered by strict regulations, particularly in the US.

In 2003, Dr Alan Colman who was part of the team that cloned Dolly the Sheep at the Roslin Institute in the UK, was attracted to Singapore to lead ES Cell International (ESI), a regenerative medicine company. In 2007, ESI decided to focus on hESC for in vitro drug testing, and its research programme led by Dr Colman was transferred to IMB. Soon after, Dr Colman became the Executive Director of the Singapore Stem Cell Consortium which provided grants for stem cell research, networking, public education campaigns and relevant infrastructure. With this in place, stem cell research activities in Singapore further flourished.

In A*STAR, stem cell research is conducted across several research institutes, including BTI, GIS, IMB, IMCB and IBN, through different research strategies and approaches. At GIS, Ng Huck Hui, Paul Robson, Larry Stanton, Tara Huber and Bing Lim lead a major effort to understand the molecular basis by which stem cells regulate self-renewal and differentiation. They work with adult, embryonic, and cancer stem cells to unravel the complex networks that control these states and to understand how misregulation can lead to disease. At BTI, Andre Choo and Steve Oh are characterising novel monoclonal antibodies which recognise surface antigens on stem cells and can eliminate undifferentiated stem cells prior to cell therapy. They are also developing new microcarrier technology for the efficient expansion of stem cells. At IBN, Charlotte Hauser and Andrew Wan engineer novel biomaterials to support efficient stem cell expansion and differentiation.

At IMCB, Jonathan Loh conducts research into the epigenetic regulation of stem cell biology. IMB has a major programme on adult stem cells which supports wound healing and skin biology. Basic research is carried out by Leah Vardy, Prabha Sampath and Ray Dunn, while Sai Kiang Lim has been harvesting exosomes (small vesicles released from cells containing protein and RNA) from stem cells in bone tissue, and demonstrated their use in heart disease models. Nick Barker has identified the Wnt target gene Lgr5 as a unique marker of adult stem cell populations in various organs, including the intestine, skin and stomach. This work also led to the discovery that the intestinal Lgr5 stem cells are the cell-of-origin of colon cancer and revealed Lgr5 as a candidate marker of cancer stem cell populations. Simon Cool and Victor Nurcombe’s glycotherapeutics group has been developing heparan sugars which can drive adult stem cell growth and wound-healing, and will soon go into clinical trials. When Alan joined IMB, he turned to induced pluripotent stem cell (iPS) technology, a new approach to create pluripotent stem cells from adult cells rather than embryos, first made possible by Nobel Laureate Prof Shinya Yamanaka in Japan. Insightful human disease models based on iPS technology have since emerged.

So what lies ahead for stem cell research in Singapore? Ng Huck Hui, GIS explains, “The community continues to pursue cutting-edge stem cell research through cross-disciplinary approaches. As iPS cell technology provides unprecedented opportunity to understand human biology, there will be more research in using iPS cells for disease modelling through collaboration with the clinical community. With more researchers joining the stem cell community in Singapore, we will see greater advancements in the areas of somatic stem cells and tissue regeneration. As a whole, our stem cell research will continue with the current trajectory to uncover more striking discoveries and applications.”
CONTRIBUTING TO SINGAPORE’S START-UP CULTURE

The A*STAR’s Institute of Bioengineering and Nanotechnology (IBN) aims to conduct innovative research that will have an impact on the commercialisation of technology and its translation to clinical practice.

Working at the interface of science, engineering and medicine, IBN has created a niche as the first institute to unite the two exciting fields of bioengineering and nanotechnology. Leveraging on nanotechnology, IBN’s multidisciplinary research teams are able to engineer sophisticated biomaterials and devices to tackle challenging problems in nanomedicine, cell and tissue engineering, biodevices and diagnostics, and green chemistry and energy.

IBN has contributed significantly to the development of Singapore’s local entrepreneurial ecosystem over the last ten years through the establishment of seven spinoff companies – Curiox Biosystems, SG Molecular Diagnostics, SG Microlab Devices, HistoIndex, CellSievo, Baldr Biosystems and Invitrocue. Over the next ten years, IBN hopes to contribute further to the next phase of Singapore’s economic development by nurturing a vibrant environment to support local spinoffs and start-ups, and working even more closely with the clinical community to translate new technologies for the benefit of healthcare.

IBN Spinoff Timeline

- **2008:** Curiox Biosystems was founded to commercialise IBN’s DropArray™ technology, a miniaturised bioassay technology platform that revolutionises drug discovery, analytical research and clinical diagnostic testing applications. The company has won Biospectrum Asia’s Emerging Company of the Year Award 2010, A*STAR Scientist-Entrepreneur Award 2010 and the 2010 Asia Pacific Frost & Sullivan Technology Innovation Award in the field of BioAssays for In Vitro Diagnosis.

- **2009:** SG Molecular Diagnostics Pte Ltd (now SG MicroLab Devices Pte Ltd) licensed IBN’s MicroKit technology to develop a range of sample preparation and diagnostic devices. In 2011, SG Microlab Devices rolled out the first product under the MicroKit platform, Lysonator, an automated laboratory tool for tissue dissociation.

- **2010:** HistoIndex was established to commercialise IBN’s liver fibrosis diagnosis platform. It won Biospectrum Asia’s Asia Pacific’s Bioscience Industry Emerging Company of the Year 2012, IBM Global Entrepreneur SmartCamp Asia 2012, A*STAR Scientist-Entrepreneur Award 2013 and Red Herring Top 100 Asia Award 2013.

- **2011:** IBN’s microsieve technology for isolating and detecting circulating tumor cells in patient’s blood was licensed to CellSievo
Pte Ltd. This device can be used to select the appropriate treatment for a cancer patient, and determine success or futility earlier than conventional approaches.

- **2012**: Baldr Biosystems was established to commercialise IBN’s Virtual Reaction Chamber, which provides laboratory quality testing coupled with a novel low-powered thermal management system. Working with a US Health Foundation, the company plans to bring the system to developing regions in Africa and India to facilitate HIV and tuberculosis testing at decentralised locations.

- **2012**: Invitrocue was established to commercialise IBN’s 3D monolayer membrane and digital pathology software. The first platform technology allows high-throughput 3D cell culture that facilitates in vitro toxicity testing, while the second platform technology provides a unique computer/image-based solution for classifying liver fibrosis that may also be adapted for other diseases.

---

**OUTSMARTING CANCER**

Administering the right treatment at the onset of diagnosis can significantly improve the survival chances of cancer patients especially if they are suffering from aggressive forms of cancer. Now, a team of scientists from A*STAR’s Institute of Molecular and Cell Biology (IMCB) has found a way to fight cancer smarter.

The spreading of cancer cells from primary tumour to other parts of the body is one of the leading causes of death in cancer patients. Incidentally, it is found that cancers which have spread contain unusually high levels of a protein called PRL-3.

PRL-3 was first identified by Associate Professor Zeng Qi, from IMCB. Since then, the IMCB team also discovered a strong link between PRL-3 and the epidermal growth factor receptor (EGFR), a cancer-linked protein that is often associated with breast and lung cancers. Their research showed that cancer cells with elevated levels of PRL-3 tend to exhibit high EGFR activity and high dependency on EGFR to thrive.

This synergy between PRL-3 and EGFR reveals a vulnerable spot in aggressive cancers. By identifying patients who are suffering from cancers with abnormally high PRL-3 levels, physician can personalise treatments which targets EGFR. Through the use of EGFR inhibitor drugs to suppress its activity, the cancer cells are more quickly destroyed. The success of anti-EGFR treatments offers hope for patients suffering from aggressive cancers that are often EGFR-driven.
PROF ALEX MATTER, M.D. 01

Chief Executive Officer of Experimental Therapeutics Centre (ETC) and D3 (Drug Discovery & Development), A*STAR

Prof Matter has been the CEO of A*STAR’s Experimental Therapeutics Centre (ETC) since 2009 and also leads the Drug Discovery & Development (D3) programme since its establishment in 2011. Well-known as the “Father of Targeted Cancer Therapies”, Prof Matter is a pioneer in cancer therapy and played an important role in the success of several anti-cancer drugs. In 2013, he was awarded the Eighth Annual Szent-Gyorgyi Prize for Progress in Cancer Research for the development of Glivec, an oral pill to specifically target a molecular lesion in cancer which can turn into chronic myeloid leukaemia. Glivec is the first drug that can treat the life-threatening cancer with nearly 90% long-term survival rate.

Prof Matter received his medical degree from the University of Basel. An elected member of the Swiss Academy of Medical Sciences, he also had fellowships at the Swiss National Science Foundation and the Swiss Academy for Medical Sciences. He is the emeritus Professor of the Medical Faculty of the University Basel and an Honorary Adjunct Professor of the Department of Pharmacology, Yong Loo Lin (YLL) School of Medicine, NUS in Singapore. He is also a member of the American Association for Cancer Research, the National Medical Research Council in Singapore, and the Board of Curiox, a Singapore-based company.

01

02

DR DAVID TOWNSEND

Director of Singapore Bioimaging Consortium (SBIC), A*STAR CIRC Director

Dr David Townsend joined the A*STAR’s Singapore Bioimaging Consortium (SBIC) in 2009. Originally from the University of Tennessee School of Medicine in Knoxville, United States, Dr Townsend was initially the head of Positron Emission Tomography (PET) and Single-photon Emission Computed Tomography (SPECT) development at SBIC. In December 2010, he became the Director of A*STAR’s Clinical Imaging Research Centre (CIRC), a Joint Venture between A*STAR and NUS established in 2008, for research in advanced clinical imaging in human subjects. Considered a leading authority on hybrid imaging systems, and one of the pioneers of the combined PET/CT scanner, Dr Townsend explains his decision to relocate to Singapore, “I moved to Singapore in 2009, because of the opportunity to participate in serious translational research from the pre-clinical at SBIC and NUS to clinical applications at CIRC.”

In 1995, he was the Principal Investigator to design and build the first combined PET/CT scanner. Named “Medical Invention of the Year” by TIME magazine in 2000, the PET/CT scanner enables clinicians to obtain precise information on both anatomy and function in a single imaging examination, facilitating earlier detection of cancer and monitoring treatment responses. In 2010, Dr Townsend and co-inventor Dr Ronald Nutt were honoured with the IEEE Medal for Innovations in Healthcare Technology.

At CIRC, Dr Townsend’s current research interests are in applying advanced imaging techniques such as the use of the hybrid PET and Magnetic Resonance (MR) scanner to stage and monitor therapy responses in both malignant and non-malignant diseases. One of very few such devices in the world, the PET/MR scanner at CIRC has the potential to bring new insights into disease processes.

SITI NURHANA RIDUAN 03

Post-doctoral Fellow, Singapore

Dr Siti Nurhanna Riduan joined the Institute of Bioengineering and Nanotechnology (IBN) in 2005, as a Laboratory Officer. In 2009, she was selected for the Scientific Staff Development Award to pursue her PhD in Chemistry, under the supervision of Dr Yugen Zhang and Prof Jackie Ying. Dr Riduan was part of the IBN team that became the first research group in the world to successfully convert carbon dioxide into methanol via a mild, green process. This groundbreaking research was published in leading international chemistry journal - Angewandte Chemie, in 2009, and was touted as
Dr Andre Choo joined A*STAR's Bioprocessing Technology Institute (BTI) as a research officer in 1994, after obtaining his bachelor degree in Biotechnology from Murdoch University, Australia. Inspired to pursue a career in research, he went on to do a PhD in the molecular engineering of antibody fragments and immunotoxins at the University of Technology, Sydney, Australia.

He returned to BTI to co-lead the Stem Cell Group with Dr Steve Oh in 2001, and subsequently set up his own independent Stem Cell Group in 2007. Dr Choo's work focuses on the discovery of novel monoclonal antibodies (mAbs) and elucidating key signalling pathways regulating stem cell fates.

Working closely with academics, clinicians and industry partners, Dr Choo aims to drive the development of mAbs from bench to clinical applications. His vision is to unlock the potential of mAbs for cell therapy, in vivo imaging, disease diagnostics and/or therapeutics. Dr Choo is also instrumental in the development of an antibody technology to eliminate pluripotent stem cells. This technology later spun-off into a start-up company, VeriStem Technologies which won the Biospectrum Emerging Companies of the Year Award in 2013. Dr Choo shares, “BTI’s ability to train talent was the critical factor that convinced the biologics industry to first invest in Singapore back in the early 2000s. I was extremely excited and inspired by the vision of a collaborative environment to do cutting-edge research when BTI moved into Biopolis in 2003.”

Prof Ng Huck Hui joined the Genome Institute of Singapore (GIS) in 2003 as a Group Leader. Prior to that, he was a post-doctoral fellow with Harvard Medical School under the prestigious Damon Runyon-Walter Winchell Post-doctoral Fellowship. In 2012, he was appointed Executive Director of GIS, succeeding its founding Executive Director Prof Edison Liu. As the Senior Group Leader in GIS, and an Adjunct Professor with the Departments of Biochemistry and Biological Sciences at the National University of Singapore (NUS) and the School of Biological Sciences at the Nanyang Technological University (NTU), Prof Ng has spent more than a decade studying the intricacies of gene regulation and how they relate to cell biology. Harnessing cutting-edge technologies to dissect the characteristics of stem cells, his research helps scientists to better understand stem cell biology, and inspire many potential applications in disease therapy and healthcare delivery.

Also President of Stem Cell Society of Singapore, Prof Ng has won numerous awards, including the prestigious National Science Award in 2007, the Chen New Investigator Award from Human Genome Organisation in 2010, and the President’s Science Award (PSA) in 2011. A good mentor, Prof Ng takes time to nurture younger scientists and was honoured with a Medal of Commendation in 2010, for his success in stem cell research and being an excellent role model for young scientists. Prof Ng was also one of eight honourees of the Junior Chamber International (JCI), The Outstanding Young Persons (TOYP) Singapore Awards 2009.

Prof Ng explains, “My vision is for GIS to be a research powerhouse that aims to understand human diseases and advance human health through the use of genomics. Working with other A*STAR research institutes, as well as with the universities and hospitals both locally and internationally, I believe that we are well-positioned to deliver impact for the economy, healthcare and society.”
Yang Yi Yan  
**Principal Investigator, People’s Republic of China**

Dr Yi Yan Yang joined the Institute of Bioengineering and Nanotechnology (IBN) in 2003 as the Group Leader of a research group that focuses on developing advanced nanoparticles for co-delivery of drugs and genes, cancer therapy and antimicrobial treatment. Her field of research interests range from drug/gene delivery, cancer therapy, cell grafting and biomaterials. Dr Yang’s research group also worked with International Business Machines Corporation (IBM) Research, Almaden to develop the first biodegradable polymer nanoparticles to combat drug-resistant superbugs, such as methicillin-resistant Staphylococcus aureus (MRSA). These nanoparticles can selectively kill bacteria without destroying the healthy red blood cells, and as they are biodegradable, they can potentially treat infectious diseases in the body as well. This groundbreaking research was published in the journal - Nature Chemistry. It was also named one of 10’s world changing ideas by Scientific American in its Technology Special Report (‘World Changing Ideas – 10 New Technologies That Will Make a Difference’, December 2011). In 2009, Dr Yang received the Great Women of Our Time (Science and Technology) Award given by the Singapore Women's Weekly Magazine.

DR BRUNO REVERSADE  
**Principal Investigator, France**

Dr Bruno Reversade was awarded the inaugural A*STAR Investigatorship in 2008. During that time, he joined A*STAR’s Institute of Medical Biology (IMB) and established a laboratory dedicated to the research of genetic orphan diseases. Together with his team of scientists, Dr Reversade discovered the genetic mechanisms of diseases such as De Bursy syndrome, a congenital premature skin ageing disorder, and Hamamy syndrome which is marked by abnormal facial features, defects in heart, bone, blood and reproductive cells. Dr Reversade has published eight papers, four of which were published in the journal Nature Genetics. Recently, he did two studies; one which identified gene mutations that cause skin hyperproliferation in Punctate Palmoplantar keratoderma, and another study on skin cancer in Ferguson Smith disease. In his quest to understand the common ailments given, Dr Rifkin-Graboi relocated to Singapore in 2009 and heads the SICS’s Neurocognitive Development Centre which focuses on brain and cognitive development, especially in early infancy and childhood. Using non-invasive age appropriate tasks and methodologies including electrophysiology, computerised tasks, eye-tracking, and behavioural observation, Dr Rifkin-Graboi investigates why infants and young children differ in their abilities to remember, learn, and self-regulate. A key part of Dr Rifkin-Graboi’s work is a study called GUSTO - Growing Up in Singapore Towards Healthy Outcomes, which involves over 1200 families, following women during pregnancy, through birth and until their infants are at least three years of age. GUSTO is a collaborative study conducted by SICS with National University of Singapore (NUS), National University Health System (NUHS) and Kandang Kerbau Hospital (KKH). Dr Rifkin-Graboi hopes that the centre becomes a resource for Singaporean researchers and organisations to focus on child development and well-being. As she shares, “My goal is to discover pathways leading to neurocognitive and emotional health in children, in the hopes that this will promote well-being in future generations of children, here in Singapore and abroad.”
that affect the general population, Dr Reversade shares, “No matter what trait one studies, may it be cancer, ageing, sleep or even twin births, there are families with exceptionally rare and extreme phenotypes. These individuals are precious and unique examples of what are the range of possibilities afforded by Nature. We value and study them for they are the most informative cases to understand what we, humans, are made of.”

In 2012, Bruno became the first scientist outside of Europe to be awarded the EMBO Young Investigatorship. The EMBO Young Investigator Programme (YIP) recognises the most outstanding and promising young independent scientists leading their first laboratories in Europe and EMBO cooperation partner countries.

In recognition of her meritorious research and development efforts on Asia’s infectious diseases, A/Prof Ng was voted “Most Inspiring Woman” at the Great Women of Our Time Awards for Science and Technology in 2005 and was conferred the highly prestigious ASEAN “International Young Scientist and Technologist Award” in 2008. More recently, she was confered the Junior Chamber International (JCI) “Ten Outstanding Young Persons of the World” Singapore 2013 Scientific and/or Technological Development Award. A/Prof Ng also believes in encouraging scientific curiosity and she received the A*STAR “Most Inspiring Mentor Award” in March 2013.

“I am driven by the passion to make a difference through the studies I embarked on in virology and immunology. I sincerely hope that my scientific contributions will help to control and prevent infectious diseases with potential devastating global effects.”

In 2011, D Cheok established the IFOM-p53 Joint Research laboratory, a joint collaboration between A*STAR and the FIRC Institute of Molecular Oncology Foundation (IFOM) in Milan. “The IFOM-p53lab/ASTAR Joint Research collaboration has given me the opportunity and the intellectual freedom to grow as an independent scientist with access to precious technology and resources and a high-profile network.

“No matter what trait one studies, may it be cancer, ageing, sleep or even twin births, there are families with exceptionally rare and extreme phenotypes. These individuals are precious and unique examples of what are the range of possibilities afforded by Nature. We value and study them for they are the most informative cases to understand what we, humans, are made of.”

Dr Chit-Fang Cheok heads the IFOM-p53 laboratory, where her team explores various therapeutic strategies that exploit the defects in DNA repair in cancer cells. Her ultimate research aim is to improve cancer treatment and the quality of life for patients. Her journey began when she obtained a BSc (Hons) in Biochemistry at Imperial College London, after which she completed a DPhil at the University of Oxford under the A*STAR National Science Scholarship where she studied Bloom’s Syndrome, a rare genetic chromosomal instability disorder that predisposes the individual to various forms of cancer. Following that, she pursued her post-doctoral research at the A*STAR Institute of Molecular and Cell Biology and p53Lab, studying the role of major tumour suppressor genes such as p53 in regulating genomic stability.

In 2002 after receiving her PhD in molecular biology and virology of coronaviruses. Working closely with colleagues, clinicians and field workers, she made major contributions in the containment, prevention and treatment of epidemic viral infections including SARS (Severe Acute Respiratory Syndrome) in 2003 and avian influenza H5N1 (bird flu) in 2005-2006.

In 2007, she joined A*STAR’s Singapore Immunology Network (SIgN) as a Principal Investigator. Her research focuses on infectious diseases which pose major threats in the tropical region with a strong focus on the Chikungunya virus. Her team has made several key important findings in viral immunity that could help control the rising number of Chikungunya virus infections. Separately, A/Prof Ng also applies her expertise to commercialisation projects and most recently, helped to develop a biochip that can identify 13 different major tropical diseases from a single blood sample to help doctors detect infections reliably and accurately.

In recognition of her meritorious research and development efforts on Asia’s infectious diseases, A/Prof Ng was voted “Most Inspiring Woman” at the Great Women of Our Time Awards for Science and Technology in 2005 and was conferred the highly prestigious ASEAN “International Young Scientist and Technologist Award” in 2008. More recently, she was confered the Junior Chamber International (JCI) “Ten Outstanding Young Persons of the World” Singapore 2013 Scientific and/or Technological Development Award. A/Prof Ng also believes in encouraging scientific curiosity and she received the A*STAR “Most Inspiring Mentor Award” in March 2013.

“I am driven by the passion to make a difference through the studies I embarked on in virology and immunology. I sincerely hope that my scientific contributions will help to control and prevent infectious diseases with potential devastating global effects.”

A/Prof Lisa Ng joined A*STAR’s Genome Institute of Singapore (GIS) in 2002 after receiving her PhD in molecular biology and virology of coronaviruses. Working closely with colleagues, clinicians and field workers, she made major contributions in the containment, prevention and treatment of epidemic viral infections including SARS (Severe Acute Respiratory Syndrome) in 2003 and avian influenza H5N1 (bird flu) in 2005-2006.

In 2007, she joined A*STAR’s Singapore Immunology Network (SIgN) as a Principal Investigator. Her research focuses on infectious diseases which pose major threats in the tropical region with a strong focus on the Chikungunya virus. Her team has made several key important findings in viral immunity that could help control the rising number of Chikungunya virus infections. Separately, A/Prof Ng also applies her expertise to commercialisation projects and most recently, helped to develop a biochip that can identify 13 different major tropical diseases from a single blood sample to help doctors detect infections reliably and accurately.

In recognition of her meritorious research and development efforts on Asia’s infectious diseases, A/Prof Ng was voted “Most Inspiring Woman” at the Great Women of Our Time Awards for Science and Technology in 2005 and was conferred the highly prestigious ASEAN “International Young Scientist and Technologist Award” in 2008. More recently, she was confered the Junior Chamber International (JCI) “Ten Outstanding Young Persons of the World” Singapore 2013 Scientific and/or Technological Development Award. A/Prof Ng also believes in encouraging scientific curiosity and she received the A*STAR “Most Inspiring Mentor Award” in March 2013.

“I am driven by the passion to make a difference through the studies I embarked on in virology and immunology. I sincerely hope that my scientific contributions will help to control and prevent infectious diseases with potential devastating global effects.”
Dr Loh Yuin Han Jonathan

Principal Investigator, Singapore

Dr Loh’s research focuses on understanding the mechanisms that govern the regenerative qualities of the embryonic stem (ES) cells. An extraordinary young talented scientist, Dr Loh’s passion for science led him to rise through the ranks from polytechnic to university. He was awarded the A*STAR Graduate Scholarship (AGS) to do his PhD at the Genome Institute of Singapore (GIS) in 2003, where he pioneered the use of functional genomics to analyse the workings of the master regulators that govern the ES cells. Dr Loh subsequently clinched the A*STAR International Fellowship in 2008 to continue his research at the Children’s Hospital Boston, Harvard Medical School where he became the first in the world to successfully re-programme human blood cells into ES-like induced pluripotent stem (iPS) cells. For his achievements in the field of human embryonic stem cell research, Dr Loh has won many awards, such as the Young Scientist Award in 2009, the Singapore Youth Award in Science & Technology 2010 and most recently, the TR35@Singapore Award in 2012 that recognises young innovators in the Asia-Pacific region under the age of 35 years.

Having benefitted from his mentors, Dr Loh is a firm believer of science education for the next generation. He teaches at the National University of Singapore (NUS) and Singapore Polytechnic (SP) and takes personal interest in mentoring students in scientific projects. In 2011, Dr Loh was awarded the A*STAR Investigatorship Award to start his own lab. He is currently a principal investigator at the Institute of Molecular Cell Biology (IMCB).

“The idea of building a dedicated biomedical research ‘city’ at one-north is nothing short of a bold vision. I’m glad to have helped play a small part in turning this vision into reality. Building on its success, I hope Biopolis will continue to propel Singapore to become the knowledge capital of Asia.”

Dr Chandra Verma

Principal Investigator, India

Dr Chandra Verma joined A*STAR’s Bioinformatics Institute (BII) in 2003, after his stint at the University of York (UK). It was the fact that Biopolis brings researchers together thereby encouraging the long-term commitment of Singapore towards developing the biomedical sciences research sector, that attracted Dr Verma here. As Dr Verma shares, “Bioinformatics is a research field
Dr Valentina Migliori, 29, was awarded the Singapore International Graduate Award (SINGA) and joined A*STAR in August 2008 as a PhD student working with Dr Ernesto Guccione at the Institute of Molecular and Cell Biology (IMCB). An outstanding Italian student from the University of Bologna, Dr Migliori chose to pursue her PhD studies at A*STAR because she found that A*STAR would provide her the opportunity to work alongside leaders in her field of, and that it was an inspiring centre of excellence for junior researchers like herself. Throughout the 4 years of PhD studies at A*STAR, Dr Migliori excelled in her research, publishing several papers in high-impact scientific journals, including a paper entitled “Symmetric dimethylation of H3R2 is a newly identified histone mark that supports euchromatin maintenance” in the Nature Structural & Molecular Biology, which she first-authored.

After completing her PhD in Singapore in 2012, Dr Migliori joined Tony Kouzarides’ laboratory at the prestigious Wellcome Trust/Cancer Research UK Gurdon Institute at University of Cambridge, where she continues to pursue her ambition in conducting research that could contribute to our understanding in cancer biology.

---

Dr Mamai is a Tunisian PhD student from the University of Monasir and is currently working with Dr Bruno Reversade at the Institute of Medical Biology (IMB) under the A*STAR Research Attachment Programme (ARAP). It was through a school project to find a model country in the world that Dr Mamai found out about Singapore. She then decided to do part of her PhD in Singapore because she had heard about the high-quality research that Singapore is known for.

Dr Mamai’s supervisor at the University of Monasir, Professor Ali Saad (University of Monasir), has been collaborating with Prof Birgitte Lane, Executive Director of IMB, and Dr Reversade on the genetics of a typical palmoplantar Multiple Self-Healing Squamous Epithelioma (MSSE). Dr Mamai has been working on this project since starting her attachment in IMB in August 2012, and has already published an article in a prestigious high-impact scientific journal, Nature Genetics, entitled “Haploinsufficiency for AAGAB causes clinically heterogeneous forms of punctate palmoplantar keratoderma”.

---

Dr Verma heads the Biomolecular Modelling and Design Division which utilises computer models to probe and provide insights into fundamental mechanisms in biology. Most recently, he collaborated with Prof Sir David Lane’s pS3 Laboratory and managed to design and develop stapled peptides successfully. Stapled peptides are molecules designed to be able to penetrate cell membranes, bind tightly to diseased target proteins and are resistant to degradation, making them extremely attractive as drugs. Dr Verma has also been working with Prof Roger Beuerman of the Singapore Eye Research Institute, on the development of a portfolio of novel antimicrobials that work against antibiotic-resistant bacteria. This breakthrough is especially timely as bacterial resistance to antibiotics is currently reaching critical levels.
Established in 1987, the Institute of Molecular & Cell Biology (IMCB) is Singapore’s first biomedical sciences institute. Set up as a graduate institute to train life sciences PhDs to support the growth of the biotechnology sector in Singapore, IMCB has, over its 26-year history, produced 230 PhD scientists in areas such as cell and developmental biology, structural biology, as well as the fundamental mechanisms behind cancer, infectious disease and metabolic disease. Its alumni hail from some 40 countries, providing a strong international network and rich diversity of talent.

IMCB’s well-trained graduates and alumni are sought after in the academic, industry and education sectors, or have even set up their own biomedical companies. Notable alumni in academia include Prof Yoshiaki Ito (Cancer Science Institute, Singapore), Prof Tuck Wah Soong (Head, Department of Physiology, NUS), Prof Tang Bor Luen (Deputy Executive Director of NUS Graduate School for Integrative Sciences and Engineering), Prof William Chen (NTU), Dr Eyleen Goh (Duke-NUS), Dr Yan Hong (Director, Temasek Life Sciences Lab), Dr. Kah Leong Lim (PI, National Neuroscience Institute), Prof Kong Peng Lam (Executive Director, Bioprocessing Technology Institute), Dr Kanaga Sabapathy (PI and Deputy Head, National Cancer Centre), Dr Kam Man Hui (Head of Lab, National Cancer Centre), Prof Catherine Pallen (University of British Columbia, Canada), Prof Peng Li (Tsinghua University, China), Prof David Murphy (University of Bristol, UK) and A/Prof Nathan Subramaniam (Queensland Institute of Medical Research, Australia).

Many IMCB alumni have also joined industry, holding key positions in pharmaceutical, biotech, medical technology and nutrition companies. They include Dr Emilie Bard (Novartis Institute of Biomedical Research, Switzerland), Dr Hannes Hentze (Senior Scientist, Merck Singapore), Dr Thierry Bogaert (Co-founder and CEO, Devgen, Belgium), Dr Calvin Boon (Senior Manager, R&D, Life Technologies Singapore), Shree Ram Satyavageswaran (Research Scientist, Abbott Nutrition Singapore), Dr Paramjeet Singh (Vice-President, Regional R&D, Cerebos Pacific Limited) and Dr Allan Lim (Group Manager, Nestle R&D Centre, Singapore). In the education sector, IMCB alumni teach life sciences at polytechnics and top junior colleges, and continue to inspire students to consider research as a career. Entrepreneurial alumni who have started their own biomedical companies include Dr Rosemary Tan (CEO, Veredus Labs), Dr Thuan D Bui (CEO, i-DNA Biotechnology) and Dr Ong Siew Hwa (Director, Acumen Research Labs).

Dr Allan Lim, Group Manager, Food Science and Innovation Partnerships, Nestle R&D Centre Singapore joined IMCB in 1989 and did a PhD project in characterisation of a human DNA repair enzyme. He joined industry immediately after his PhD as he realised that his calling was in applied research. However, his links to IMCB and A*STAR have continued, and his molecular biology training proved to be very relevant in modern nutrition research. He explains, “At Nestle, I have started developing partnerships with various A*STAR institutions since 2008. As the only IMCB alumni in the whole of Nestle, I am playing a pivotal role in creating a productive
partnership between the 2 entities. On a personal note, I am proud that my knowledge and passion in molecular biology is beginning to be valuable, thanks to the emergence of nutrigenomics and epigenetics.” Allan maintains contact with friends in IMCB, and fondly remembers the “cowboy spirit” in his days in IMCB, which encouraged him to interact with various groups even if they were working on different subjects.

Dr Paramjeet Singh, Vice President and Head, Regional Scientific Research, Cerebos Pacific Limited, was in IMCB from 1991 to 2010, after completing his PhD in biochemistry at NUS. Wanting to make significant direct impact on society and reasoning that dietary/nutritional interventions would have a strong health protection potential, he sought out organisations where he could participate in the journey from bench research to clinical interventions to consumer outcomes. In 2010, he found the perfect fit in Cerebos Pacific Limited, a leading research-based health supplements enterprise operating across the Asia-Pacific region. Starting as Chief Scientist, he is now Vice President and Head of Regional Scientific Research. He explains, “I found the transition to be quite easy as my experience at IMCB helped me develop a yearning for scientific independence and the confidence to take up completely new areas of research. For this, I am particularly thankful to Prof Hong Wanjin who allowed me free rein to take up a diverse set of research projects.” He believes that opportunity often lies outside the accepted norms of an academic research career, and that one has to be bold and embrace risk in order to make a tangible impact on society.

Dr Rosemary Tan, CEO of Veredus Laboratories, was a Junior Research Fellow in IMCB in 1996. Having learnt a lot about RNA and DNA, as well as hybridisation and cloning techniques in Japan under the EDB-ISK scholarship, Rosemary joined IMCB to try something new – protein work. She comments, “I decided to join Catherine Pallen’s lab to learn about the dephosphorylation of Src. I was introduced to a whole new field of proteomics and I learned from Pallen herself as well as from other lab members many invaluable lessons. I remember discussing my results with her and she spent many hours explaining her rationale about certain experiments. Even though I spent only one year in IMCB, the friendships I made there last a lifetime.” Soon after her PhD programme at NUS and University of Tokyo, Rosemary started her first company, Genecet Biotechnologies, a Life Science education company in 2001. This has since become a market leader in Life Sciences Education in Singapore. In 2004, a year after SARS hit Singapore, she started Veredus Laboratories, a biotech company which is now a global player in the field of Healthcare and Molecular Diagnostics, in partnership with Semiconductor giant STMicroelectronics. Veredus has designed and developed ‘VereChipTM’ a world-class Lab-on-Chip with 5 commercial applications and more applications in the pipeline. The network that she built at IMCB has been valuable, says Rosemary, “Today, a lot of the collaborations I have are based on the people I knew at IMCB or introduced to by them.”
Our Partners
Novartis International AG is a global biopharmaceutical company based in Basel, Switzerland, specialising in pharmaceuticals, vaccines, eye-care, generic pharmaceuticals, consumer health products and diagnostic tools.

In 2002, Novartis and Economic Development Board (EDB) entered into a public-private partnership to set up the Novartis Institute for Tropical Diseases (NITD), a research centre that is dedicated towards finding new medicines to treat neglected, infectious diseases.

NITD moved to Biopolis in 2004 and currently has over 100 researchers and supporting staff from 18 nationalities. NITD uses drug discovery expertise and cutting-edge technologies to develop small molecule drugs to fight threatening tropical diseases such as dengue fever, malaria and drug-resistant tuberculosis. NITD’s mission is to make treatments readily available and without profit in developing countries where these diseases are endemic. The institute also aims to be a centre of training in drug discovery for post-doctoral fellows and graduate students from all over the world.

Chugai Pharmaceutical was established in 1925 and is one of Japan’s leading biopharmaceutical companies particularly in the field of antibody. Chugai’s therapeutic areas are oncology, bone and joint disease, autoimmune disease and central nervous system.

In July 2012, Chugai opened Chugai Pharmabody Research (CPR) in Biopolis with an investment of S$200 million spread over 5 years. CPR will utilise Chugai’s proprietary Recycling and Sweeping Antibody technologies to generate new antibody candidates. Recycling Antibody Technology enables single antibody molecule to repeatedly block the function of the target antigen. Sweeping antibodies are those that can eliminate the target antigen from the plasma.

Conventional antibodies can bind to the antigen only once and cannot eliminate the target antigen from the plasma. This technology will open up possibilities in achieving therapeutic effects in numerous diseases that were previously considered not possible using conventional antibodies.

Chugai chose to set up their R&D centre in Singapore because of the country’s reputation as a leading biomedical hub, state-of-the-art facilities and highly skilled manpower. Chugai also worked with A*STAR to organise the Antibody Symposiums in 2012 and 2013 which gathered all scientists in the field of antibody to foster greater interaction and collaboration.
ARKRAY is a manufacturer of clinical test and in vitro diagnostics devices, with strong focus on diabetic and kidney diseases. Headquartered in Kyoto, Japan, it is ranked no. 13 in the world in the IVD market. It is the market leader for self-monitoring of blood glucose meters used by diabetics in Japan.

In May 2013, ARKRAY set up its first overseas research centre in Biopolis with an investment of about S$8.6 mil, over a five-year period. ARKRAY employs 21 scientists and together with A*STAR’s Institute of Bioengineering and Nanotechnology (IBN), the R&D centre will focus on developing novel detection kits for infectious diseases.

ARKRAY chose Singapore because of Biopolis’ research capabilities and availability of highly-skilled workers. IBN’s niche in the area of biodevices and diagnostics is also one of the reasons why ARKRAY looked to IBN as a partner for the collaboration.

Fluidigm Corporation develops, manufactures and markets microfluidic systems for growth markets in the life science and agricultural biotechnology, or “Ag-Bio industries”. Based in South San Francisco, California, Fluidigm markets its proprietary microfluidic systems consisting of instruments and consumables, including integrated fluidic circuits (IFCs), assays and other reagents to leading academic institutions, diagnostic laboratories, and pharmaceutical, biotechnology and Ag-Bio companies from all over the world. These systems which are for research purposes only, are designed to significantly simplify experimental workflow, increase throughput and reduce costs, while providing the excellent data quality demanded by customers.

In 2013, Fluidigm signed a partnership with the A*STAR’s Genome Institute of Singapore (GIS), to establish the Single-Cell Omics Centre. It is the first research centre in Asia to focus on accelerating the understanding of how individual cells work, and how diagnosis and treatment might be enhanced through insight derived from single cells. GIS’s commitment and clear direction in working with Fluidigm in the research on single-cell genomics is why Fluidigm look to GIS as a partner in enhancing its research capabilities.
Danone is one of the world’s leading nutrition companies. The group holds top positions in healthy food through four businesses: it ranks no. 1 worldwide in fresh dairy products, no. 2 in packaged water and baby nutrition, and is Europe’s no. 1 medical nutrition company. Today, it has more than 160 production plants around the world and aims to bring health through food to as many people as possible.

On 1 April 2011, Danone set up the Nutricia Research (then known as Danone Research Centre for Specialised Nutrition) in Biopolis. This research centre is the company’s first in Asia Pacific to focus fully on child and maternal health, especially the impact of nutrition on gut bacteria, immune system and the overall growth and development of babies and children, to ensure a healthy start in life. Nutricia Research employs more than 20 scientists who work closely with the Danone development experts in Asia Pacific region to support and deliver local innovations. The research centre is also closely connected to Danone’s R&D headquarters in Wageningen, The Netherlands.

Through the synergy between Nutricia Research and Danone, Singapore and the region will benefit from the scientific insights in Asia Pacific and the development of state-of-the-art products.

The Procter & Gamble Company is established in 1837. It is the world’s largest producer of household and personal products by revenue, with its products reaching 4.8 billion people worldwide.

In September 2010, P&G signed a 3-year MRCA with A*STAR which allows P&G access to all 14 A*STAR research institutes and its consortia and centre, providing opportunities for A*STAR researchers to accelerate collaborations with P&G researchers based in Singapore and overseas. The MRCA will also provide P&G with access to research services and facilities at Biopolis. The areas of research will include biotechnology, molecular biology, chemistry, high performance computing and materials to aid new product development for a wide range of product categories in which P&G is active, and in particular consumer care.

In 2011, P&G invested S$250 million to build a mega innovation centre in Biopolis. The second of only two such centres in Asia, the P&G’s Singapore Innovation Center will conduct end-to-end innovation for P&G’s Beauty & Grooming, Home Care, Personal Health Care, and Chemicals businesses. P&G chose to build its Singapore Innovation Center at Biopolis is mainly due to Singapore’s commitment to innovation, world-class infrastructure, business-friendly environment, excellent local talent and the agility to work as partners in progress.
Reflections
The Vision

Singapore had a dream; to build a Biomedical Sciences (BMS) hub and to grow it into an innovator par excellence in science.

There is no dream too big and no dreamer too small. At least this was what these men and women believed in, despite the challenges before them.

One of the believers was Mr George Yeo, then Minister for Trade and Industry who supported Mr Philip Yeo in championing the BMS initiative in 2000. He commented, “We thought that this was a high value-added industry which Singapore could stay competitive in for the long term, principally because it required a high degree of system efficiency and integrity. Singapore has always had a good, trusted healthcare centre which served a much wider region. In the pharmaceutical industry, we were already a natural base, with excellent Intellectual Property (IP) protection. The IMCB was also able to achieve a certain international reputation. From this foundation, we should be able to build up BMS by investing in facilities including research (including clinical research) and research support, and attracting talent. We knew the sector required public investment to attract private investment.”

For one of the pioneers, Mr Philip Yeo, the driving force was the need to move from manufacturing to building intellectual capital. As he shared, “The Economic Development Board (EDB) was starting to promote pharmaceuticals for manufacturing and production, but I was concerned that if we just focused on production, there would be no intellectual capital for this industry in Singapore. Thus, I thought that it was a good timing for us to think of going beyond production, towards research and development, especially in the brand new pharmaceutical industry because the other industries (such as electronics, chemicals, engineering) were already here.”

Responding to the Asian Financial Crisis in the late 90s, the Government wasted no time in chasing the biomedical dream. Once decisions were made, the implementation was very fast. As Dr Sydney Brenner recalled, “I’ve been involved in the many years of committee meetings and discussions (in the UK) but what always impressed me right throughout the years in Singapore is that once the decision is made, then the implementation is incredibly fast, incredibly effective, and very well organised.”

The Government demonstrated its seriousness by investing in the development of the appropriate infrastructure and community at Biopolis. A*STAR started new research institutes to build the research capabilities and jump-start the BMS industry. This was almost unheard of in research hubs elsewhere. This was one of the few things that impressed Prof Jackie Ying, “In the United States and elsewhere, scientists devote

“Whether it’s global challenges, or biomedical sciences research or for that matter almost any research, many of the challenges are very complicated. You must be able to tap into the best contribution from different research hubs and different research communities around the world. As a small country and given our location between the East and West, Singapore can be connected to the wider research community in the world. The more influential we can become, the bigger the problems we can solve as part of bigger wider world community. So we should see Singapore as a bridge to the world as much as we bring the world to Singapore.”

Mr Lim Chuan Poh, A*STAR Chairman
significant time and efforts toward raising funds for research. Here, we have tremendous resources to do the research we want.”

Undergirding any research enterprise is the pool of talent. The search for scientific leadership and the people with the right knowledge and background in different fields who could apply it to Singapore was a major challenge. Singapore needed the people with the right expertise to implement the vision. Recruitment of scientific talent was carried out swiftly and aggressively. Mr Philip Yeo, then Chairman of A*STAR played a major role in recruiting or as he puts it, “kidnapping” the talents. Mr Philip Yeo recalled in a recent interview, “I need to have talent when I build a (research) facility I have to train people - it’s a big gap; it takes 4 years or 5 years of PhD training, and from bachelor to PhD, 9 years. In the short term, we needed to recruit talent - experienced people from abroad to help kick start research here. And if we could get international young scientists too, that’s great as well.”

It was not an easy task, considering that Singapore was just starting its foray into the BMS sector. Undaunted, Mr Philip Yeo started the “whales” programme to recruit senior scientists. “I have to convince them to come here. The word “con” comes from “convince”. I convince them, I say look, this is what I want to do. I think it can be done. Can you help me? Look technically they don’t have to come, so part of the reason they came was because, I convinced them. Otherwise I convinced them here!” quipped Mr Philip Yeo during a recent interview.

The “whales” did arrive. Though they were invited to join the community to build Biopolis, ultimately what attracted them here was the excitement of being part of something bigger and the vibrancy of the place where like-minded people can interact and the diversity of the community which the people bring. As A/Prof John Lim, Chief

“...I think we all know for a fact that, when you go to Boston, the Bay area in the US, or you go to the golden triangle around London, Cambridge, Oxford in the UK with the top institutions, it is by sheer reputation and by the awareness of top talent that scientists assemble in these locations and institutions. The best academics, best scientists, best researchers, the most promising young talent, they all make a beeline to want to be part of this enterprise. (They) want to learn from the best, so we take this lesson on board. If you don’t have the best people, the younger bright people will not want to be part of the action. So you have to attract the best.”

Mr Lim Chuan Poh, A*STAR Chairman
Yeo offered me the position, and when I considered my own advice, the answer was unequivocal that Philip would do everything in his power to make me (and all those he recruited) successful. The vision of he, Tan Chorh Chuan and John Wong to develop a robust clinical and translational research effort in Singapore, together with Philip’s leadership, is what attracted me to Singapore.”

This sentiment was echoed by the former Executive Director of Genome Institute of Singapore (GIS), Prof Edison Liu who remarked “I was impressed with the boldness of the vision, of a country willing to be a competitive player in field of life sciences globally. The scale and the depth of the commitment was stunning. This was confirmed by all the governmental and institutional leaders whom I met.”

For Judith Swain, ED SICS, it was the leadership that impressed her. She wrote in an email interview, “One piece of advice that I have always given (to) young people, is that the most important thing about considering a new position is the person you will work for. You can negotiate for a lot of things, but in the end, you will never fully appreciate what you will need to be successful in a new position. The key is whether the person you will work for is committed to making you successful, and what will he/she give of himself/herself to enable your success. When Philip Yeo offered me the position, and when I considered my own advice, the answer was unequivocal that Philip would do everything in his power to make me (and all those he recruited) successful. The vision of he, Tan Chorh Chuan and John Wong to develop a robust clinical and translational research effort in Singapore, together with Philip’s leadership, is what attracted me to Singapore.”

Recruiting international scientists was part of the plan but it was not a means to an end. One key aspect of the vision was to build up a cadre of younger and established Singaporean scientists, with a clear balance between local and international talent, and leadership who are committed to Singapore. As Mr Lim Chuan Poh shared, “So I think my predecessor Philip Yeo, he did absolutely the right thing; to go to the rest of the world to really draw out the best scientists to Singapore and that’s how we were able to persuade young Singaporeans to come on board, to work with brilliant scientists at the same time (whom we attracted). These scientists themselves brought to Singapore many other younger scientists from around the world, who also want to be part of this interesting endeavour in Singapore. So when it comes to research activity, you want to attract the best talent, and you need the best to attract the best.”

For a small country who is a novice in this field, it was certainly a bold move. What Biopolis had accomplished over the last 10 years was nothing short of remarkable, and getting it to become a campaign for younger Singaporeans to be involved as well such as through the A*STAR scholarships, was even smarter. For Dr Sydney Brenner, it was the rate of growth that impressed him most. “It’s just lightning speed, that’s all I can say. To have grown it from almost nothing as it was when the whole process started…all of the physics and engineering facilities that have grown the biomedical from nothing in 10 years, that’s what I think amazes everybody. And I think also the other thing that hasn’t gone mentioned very much, is that the big ambition is to have Singaporeans participate fully, completely in this and to have most of the people here, not just visitors…but the people with the commitment of the country to be here and to conduct research and practice in the biomedical area and I think it achieved that…That is another great thing that has come true.”
More Than Just Research

“Without strong good science, companies would not be attracted, but we also need to provide expert workforce and both these require attracting talent. Without a good clinical research programme, BMS research loses its endpoint and companies too are looking for this as their “product”, be it a drug, diagnostic agent or a piece of medical technology rely on good clinical applications. We need to keep on working on all of these issues.”

Sir George Radda

When Biopolis first began as the establishment of fundamental biomedical research in Phase 1, the pioneers knew that there must be a greater goal than just acquiring knowledge. As Mr Lim Chuan Poh commented, “In the BMS space, it is not good enough to be able to do wonderful research in the laboratory because we get excellent publications; we discover new knowledge but you cannot close the gap to benefit society, or to create wider benefits for the country.”

Hence, while Phase 1 of Biopolis was being carried out, planning for Phase 2 was underway with the main focus on leveraging the research capabilities built earlier and translating the discovery to clinical use. This spawned the Translational Clinical Research (TCR) initiative.

One major part of the TCR initiative was the setting up of TCR institutes. As former Executive Director of Biomedical Research Council (BMRC), Prof Lee Eng Hin put it, “Having established the basic science institutes, it was a logical step to build institutes that would help to take discoveries from the bench to the bedside. Again after careful planning and consideration and on the advice of the BMS International Advisory Committee, translational research institutes such as SBIC, SigN, IMB and SICS were established. In addition the Singapore Stem Cell Consortium was formed and this gave a real boost to stem cell research.”

Phase 2 of Singapore’s BMS initiative lasted from 2006 to 2010, which culminated with development of institutes that would work closely with clinical companies, and were equipped with capabilities that were ready to receive the industry. Besides enhancing the environment to translate discoveries into useful health outcomes, the TCR Flagship Programmes under the Ministry of Health provided funding concentrated research on areas of strategic importance to Singapore, helping to bring public research, healthcare and academia together.

All these would not have been possible if not for the strong leadership, as Prof Edward Holmes, Deputy Chairman, BMRC, A*STAR remarked, “Ideas would be discussed, a consensus reached as to a course of action such as TCR Flagships in specific areas and then like magic, the program would be instituted. The leadership would make timely decisions with the best information available, and then modify the course of action as relevant information was acquired through the implementation of the program. This resulted in the development of programmes within a very short period of time that were the envy of the international community.”

As Mrs Tan Ching Yee, Permanent Secretary for Health puts it, “The quest for better health for our citizens is an uplifting rallying call to both scientists and clinicians. That the BMS initiative soon came to embrace TCR is an expression of this call. By bringing the fruits of BMS research to impact directly the quality of life of our people, we reinforce the value of such investment. While the effort is still young by international standards, we are proud to see clinician scientists already making impact. Like Dr Ong Sin Tiong from the Duke-NUS Graduate Medical School, who together with collaborators from A*STAR and elsewhere, found a solution to tackle the problem of a gene mutation that decreases the effectiveness of some cancer drugs in lung and blood cancer patients, resulting in better treatment outcomes for these patients. Or Professor Donald Tan and his team from the Singapore National Eye Centre, who found a way to decrease the progression of myopia in children, and even improve the eyesight of some of them, through the use of a type of eyedrop. Better still, we have prevented unnecessary hospitalisation for many dengue patients, and reaped systems-level savings from the work of a team from the Communicable Disease Centre of Tan Tock Seng Hospital, Duke-NUS and the National University Health System.”
Impact of Biopolis

In order to appreciate the impact of Biopolis, one needs to look at the strategies devised to bring the whole thing together, the unwavering faith of the pioneers and the people who walked the BMS journey.

When the idea of Biopolis first came about, many people did not know what to expect of it. The project was ambitious. The concept of integrating public-private research centres with industry players was new. It was never done before in the history of Singapore.

Sir David Lane recalled his initial reaction when Mr Philip Yeo talked to him about Biopolis, “I was in at a conference in London for the Financial Times we were starting a biotech company in Dundee at that time, and Philip was very interested in that kind of link between starting an industry in basic science and we had a very exciting conversation and he painted this picture for me, that seemed completely unbelievable, there would be all these buildings it would be in Singapore, there will be MRT, all these things will happen and it all came true, it was an amazing vision he painted. When I first came out here, I realised people were actually doing it, it was very exciting to see the speed at which things are done and one of the features of Singapore is that once a decision is made, things can happen very fast, so we set up the experimental therapeutics centre here a few years ago, it was just an idea and six months later we were running.”

In the beginning, it was difficult to attract companies to invest in research activities in Biopolis as Singapore did not have a strong track record. One of the first projects embarked on by the EDB was to attract Novartis to set up the Novartis Institute of Tropical Diseases (NITD), the first corporate lab to be established in Biopolis. As Mr Yeoh Keat Chuan, Managing Director of EDB wrote, “To help seed Novartis’ Singapore laboratory, a team of experienced scientists from public research institutions was seconded to Novartis. This paved the way for much fruitful collaboration between Singapore and Novartis. Both have come a long way since then. Biopolis has expanded several times and is home to a growing number of local and international research talents. For Novartis, several exciting products discovered in this lab, including a new class of drugs for treatment of malaria, have entered clinical trials and we hope they will soon be able to benefit patients all over the world.”

Since then, Singapore has built up a critical mass of excellent scientists and had attracted many multinational companies in pharmaceuticals and biotechnology to set up their R&D divisions here. They could capitalise on the knowledge and skills of the local scientists and the spectrum of capabilities, especially the translation capability in collaborative research. This not only added value to the Singapore economy, but enhanced the role that Singapore played in the global biomedical scene.

“I have been to research centres all over Europe, and looked at them. Most research centres are standalone public research centres; there is no industry close to these research centres, and that is not a good way to do things. What I wanted is to have public and private research taking place at the same place, and this is how I envisioned Biopolis, as a public private research complex.

What we have in Biopolis is unique as there is no equivalent to Biopolis in the world”

Mr Philip Yeo, former A*STAR Chairman
Testifying to the attractiveness of Biopolis, Chugai Pharmaceuticals, one of Japan’s leading biopharmaceutical companies particularly in the field of antibody, set up a 70-man research centre in Biopolis with an investment of S$200 million spread over 5-years. It was their second research centre here and the only centres outside of Japan. Mr Koichi Matsubara, Chief Executive Officer of Chugai said, “Chugai set up the first company (Pharmalogicals) 10 years ago and Chugai had 10 years (of) experience in Singapore, and also (being) the first company, it was quite successful here. That’s why Chugai decided to set up another research lab in Singapore because we know we (have) very good and strong support from the Singapore government. Also in Singapore, there are good trained scientists here and if we come here to Biopolis, we have interaction with world famous scientists. That is a very good reason why we come here in Singapore.”

ARKRAY Inc, another Japanese manufacturer of clinical test and in vitro diagnostics devices set up their first overseas R&D centre in Bopolis as well.

Another endorsement of Biopolis, in the area of genome technology, is the collaboration between GIS and US-based Fluidigm Corporation to set up the Single Cell Omics Centre. As Co-founder, President and Chief Executive Officer of Fluidigm, Gajus Worthington commented, “GIS has always demonstrated a commitment and a conviction to work with Fluidigm to help change the world of life science research. When we co-created the Single Cell

“The role of Biopolis in bringing together the major research institutes to create a centre of excellence in BMS and attracting top class scientists from around the world is extremely attractive for the life sciences industry.”

*Sir Richard Sykes, Chairman of International Advisory Council (IAC), Chairman Imperial College Healthcare NHS Trust*
Omics Centre, the leadership team at GIS brought a clear agenda for the single-cell science they wanted to do, and a vision of how we could contribute to the betterment of lives in Singapore, Asia and the world.”

Over the last few years, Biopolis has been diversifying beyond pharmaceuticals, biologics and medical technology to attract multinational corporations from the food and nutrition, as well as the personal care industry. One of them was leading medical nutrition company, Danone which set up the Nutricia Research (then known as Danone Research Centre for Specialised Nutrition) in 2011. Mr. Julian Ho, Assistant Managing Director of EDB shared during the research centre’s opening, “The establishment of the Danone Research Centre for Specialised Nutrition marks a significant milestone in the partnership between Danone and Singapore. Singapore is proud to host Danone’s Asia-Pacific hub for research and innovation – the first in Asia for Danone to focus fully on science for child and maternal health. The new centre at Biopolis would be able to benefit from the synergies between Singapore’s world-class biomedical research capabilities and access scientific insights in the Asia Pacific to contribute to research capacities and public health in the region.”

One of the biggest projects to date, and the biggest multi-national corporate tenant is Procter & Gamble Company (P&G) who invested S$250 million to build a mega innovation centre in Singapore, the second of only two such centres in Asia. Speaking at the ground-breaking ceremony in 2011, P&G’s Chief Technology Officer, Bruce Brown commented, “P&G’s Singapore Innovation Centre is a key component of our multi-year global innovation program to power our “purpose-inspired” growth strategy of ‘touching and improving more consumers’ lives, in more parts of the world, more completely.’ This centre brings even more research activities to where the consumers are in Asia, and allows us to merge P&G’s expertise and scale with Singapore’s positive innovation environment to accelerate and facilitate collaborations with external partners in this region.”

The Biopolis effect was not limited to companies. The Health Science Authority (HSA)’s Health Products Regulation Group (HPRG) also moved their operations to Biopolis. HPRG is Singapore’s national regulator for drugs and devices. A/Prof John Lim explains, “We moved to Biopolis in 2004 because we assessed that it made sense for the regulator to be situated close to the biomedical R&D hub. This enabled our regulatory experts to be apprised of key initiatives in product development, assemble relevant local and overseas regulatory expertise, and be on hand to provide advice on regulatory requirements early in the investigative and product development process.”

Since then, HPRG carried out pilot projects and collaborated with A*STAR institutions and scientific investigators in Biopolis. These include the Singapore Immunology Network (SIgN), the Genome Institute of Singapore (GIS), and the Translational Laboratory in Genetic Medicine.

For EDB, it was the first time that they established a satellite office located in the Biopolis so that their BMS group could work closely with the relevant stakeholders to execute more effectively. The team was based in the Biopolis from the start-up in 2003 up until 2008.
Though the initial motivation for Singapore’s move to develop the BMS sector was economically-driven, it evolved into something much bigger and of greater importance than finances. It contributed to the betterment of mankind, particularly to the Singapore population. Mr Lim Chuan Poh explained, “The efforts that we put in earlier are now seeing real benefits to the patients. For instance the translation in clinical research effort, gastric cancer, this was one disease that is prevalent in East Asia. We supported this research effort, under the Biomedical Sciences Executive Committee. And in Singapore, every year, we have about 4000 patients coming in with gastric cancer. Unfortunately, many of them come in late, stage 3, stage 4. So we put effort in and now we are able to identify some of the markers, so that we can screen and identify patients earlier. And if they can come in at early stage 1, at most stage 2, we actually can treat them, and therefore, save lives. And I think, from these particular TCR efforts, several lives, in fact, have been saved. So this is really direct benefit to the Singaporean population which is really what we want to achieve in Translation Clinical Research effort.”

All in all, Biopolis has cemented a reputation as an excellent place where multinational corporations in the biomedical arena can establish successful collaborations and anchor various aspects of their research operations here. As Dr Tachi Yamada, who has been advising the Singapore government in its Biomedical Sciences initiative since 2006 and member of IAC, summed it up, “The subtle shift in incentives to the science community to make their research relevant to industry has spawned a whole series of collaborations with industry that might not have been there otherwise. I believe we are just scratching the surface of the possibilities to develop strong collaboration with multinational biomedical corporations in the future.”

“I had a meeting with Mr Lee Kuan Yew (then Prime Minister) and in my discussion with him, I said what Singapore needs to do is to start PhD training because experience in the rest of the world shows you that you need to have an excess of PhD’s streaming out of academia to become entrepreneurial and start creating, creating the industry. And this is the way it started, with the Institute of Molecular & Cell Biology (IMCB) being a graduate institute as part of the university”

Dr Sydney Brenner, Noble Laureate
“Biopolis has played a key role in positioning Singapore at the nexus of Asia and, as the world looks East, Singapore’s role can only grow. The facilities, people and research outputs have made this a vibrant community pulling in major investment from the life science industries. Success building on success so that the result is a subject of envy for many countries and a good return on investment for the public.”
Dame Sally Davies, Member of IAC

“I think if there’s anything that everyone in Singapore should be proud of Biopolis its actually the constellation of scientist that we have over here. They are truly world class and they are not only world class, it’s a really rich diversity of scientists, we now have very nice local scientists, young Singaporean scientists, some of them have gone onto leadership position, at the same time the rich complement of international scientist usually one that, you know, that allow Singapore to differentiate from the other research hub in Asia.”
Mr Lim Chuan Poh, A*STAR Chairman

“By the first 15 years of IMCB’s establishment, the impact of its research in cell signalling, transport and development was well acknowledged. Today, IMCB alumni and associates have assumed key leadership positions, in Singapore, in China and in the Asia-Pacific. Together, they have provided a network and capability for Singapore to build viable biomedical healthcare industry emanating from Asia.”
Mr Chris Y H Tan, Founding Executive Director of IMCB

“I am most proud of the scientists we developed over those ten years, many who now are Singaporean stars : Hack Hui Ng, Jonathan Loh, Melissa Fullwood, Yijun Ruan, Bing Lim, Wei Chia Lin, JF Liu, Guillaume Bourque, Chris Wong. Their global success could be attributed to the time they spend at the GIS.”
Prof Edison Liu, Former Executive Director of GIS

“Although Biopolis is relatively young, it has already made an international impact. In my travels overseas, the name is well recognized as an internationally competitive Asian centre that pursues excellent biomedical research with many well-known scientists and high impact publications. I am most proud of the fact that we are internationally acknowledged as a credible biomedical research centre on the world stage.”
Prof Lee Eng Hin, Former Executive Director of BMRC

“I am most proud of the young team and the research systems that I had put in place at BMRC, the many young to mid-level researchers whom I had nurtured and trained through the Glaxo-IMCB lab, including Dr Edward Manser and others. In the next 10 years, I hope to see a new generation of research leaders from the talent that Singapore has nurtured, and I am sure that Singapore will continue to shine in the international BM research scene.”
Prof Louis Lim, Founding Executive Director, BMRC

“Biopolis provided the clear nucleus of excellence in all aspects of BMS, especially in structural biology with which we have worked and appreciated its willingness to collaborate and host us (NTU).”
Prof Bertil Andersson, President of the Nanyang Technological University (NTU)

“I see (Biopolis) today as a hub where we have a large critical mass of excellent researchers, well connected within the local environment but also externally, focus on diseases, medical issues, logical problems that are of relevance to Singapore and the region doing highly competitive science, and well respected as a place where extremely good research and very fundamental applications are being thought of, applied and tested. The most important thing is that, I see that many of the ideas, the efforts of researches in Singapore, will result in new diagnosis and treatment which will be beneficial to patients, while also helping to create economic value for Singapore.”
Prof Tan Chorh Chuan, President of NUS

“This was a truly bold initiative to build up an area of activity in Singapore that had little prominence before. The creation of Biopolis was a breathtaking event that attracted global attention to Singapore as an upcoming hub of biomedical research.”
Prof Barry Halliwell, Deputy President (Research and Technology) of the National University of Singapore (NUS)

“I’m most proud of the people that I have in some way influenced. I’m proud of the Singaporeans who have played important roles in the development of biomedical sciences in Singapore, and of the international talent that I have helped to recruit into the biomedical community, and specifically the clinical and translational research community, here in Singapore.”
Prof Judith L. Swain, MD, Executive Director of Singapore Institute for Clinical Sciences (SICS)

“I see what we are proud of, is when (we) put Singapore’s research into the global scientific map and able to attract a lot of international talent to Singapore and at the same time we train the local younger scientists to be the new generation of scientists.”
Prof Hong Wan Jin, Executive Director of IMCB
The Journey Continues...
Today, Singapore is recognised as a leading manufacturing location for pharmaceuticals and biologics as well as various medical technology products ranging from life science tools to medical devices.
Singapore has come a long way in its Biomedical Sciences (BMS) journey over the last decade, making important economic and health contributions to the country, even as the base of basic, translational and clinical research capabilities were being built. Since 2000, employment in the BMS industry has grown 2.5 times, from 6,000 to 15,700 in 2012. BMS manufacturing output has increased by nearly five-fold from $6 billion to $29.4 billion in 2012. By 2012, the value-added of the BMS industry rose to S$15.3 billion, contributing 25.5% of total manufacturing value-added, making BMS the largest by value-added contribution. At the same time, we saw strong growth in BMS R&D, with the number of R&D jobs in the BMS public and private sectors doubling from 2,150 in 2002 to 5,427 in 2012, and the R&D expenditure growing 6-fold from $247m to $1,506m during the same period.

Today, Singapore is recognised as a leading manufacturing location for pharmaceuticals and biologics as well as various medical technology products ranging from life science tools to medical devices. There is also a growing base of research activities as companies look to expand their range of products for Asia. Singapore is also a leading location for commercial operations, with 7 of the top 10 pharmaceutical companies and all top 10 medical technology companies having regional or global commercial operations based in Singapore. Companies continue to be attracted to Singapore to be part of the growing international community, to leverage on our strong IP regime, pro-business environment and to access talent. As for biomedical SMEs and start-ups, the numbers are still modest but a number of young companies such as AIT Biotech, Curiox, HistolIndex, and Veredus Labs have emerged over the years, and have made a mark for innovative medical products and broken into the regional or global markets.

Biopolis, as a unique location for public and private biomedical research, is a recognised icon for Singapore’s bold BMS initiative. With A*STAR’s biomedical research institutes as the anchor, and nearly 40 biomedical or biomedical-related companies present at Biopolis, there is a strong international community of over 2,000 scientists from 50 countries. Close interaction and proximity have led to synergistic collaborations and mobility of talent.

So what lies ahead?
INTEGRATION AND COLLABORATION, AND NEW STRATEGIC RESEARCH THRUSTS

A key focus will be on building on the foundation of basic, translational and clinical research capabilities that has been laid over the years, and having greater integration and collaboration among the whole BMS ecosystem, made up of the A*STAR research institutes, universities, hospitals, specialty centres and companies.

Efforts have already started, with collaborative programmes and grant mechanisms put in place by A*STAR, MOH and NRF. Researchers have seen the benefit of large programmes such as the TCR Flagship in Gastric Cancer which involves a team of scientists and clinicians working across institutions. More collaborations between basic scientists and clinicians leading to translational outcomes have been honed through the Bench-to-Bedside grants. Singapore has also maintained a strong reputation for Phase I and II clinical trials, and we expect more discoveries from local research efforts to reach the clinical trial stage in the coming years. A locally developed H1N1 vaccine from the Experimental Therapeutics Centre and D3 has already gone through Phase I clinical trials, for instance, and there are other promising molecules in the pipeline.

Besides pharmaceuticals and biologics which are the traditional industry clusters that the A*STAR’s Biomedical Research Council (BMRC) has been supporting, there are increasing opportunities in the medical technology, nutrition and personal care industry clusters which are fast-growing in the Asia-Pacific. To this end, BMRC has launched Strategic Research Thrusts to address each of these 5 industry clusters.

Stratified Medicine, for example, has been identified as a niche area for Singapore, given our multi-ethnic population of Chinese, Malays and Indians which is representative of Asia. Many pharmaceutical companies are increasingly viewing Asia as a major growth region, especially since there are a variety of diseases common in Asia that are less prevalent in Western countries, such as gastric and liver cancer, and various infectious diseases. In addition, for common diseases like diabetes and heart disease, the response to treatment may be different due to the subtle genetic differences between populations.

---

STRATEGIC RESEARCH THRUSTS TO SUPPORT KEY INDUSTRY SECTORS

<table>
<thead>
<tr>
<th>Industry</th>
<th>Strategic Research Thrusts</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHARMA</td>
<td>Stratified Medicine</td>
</tr>
<tr>
<td>BIOLOGICS</td>
<td>Antibody Discovery &amp; Development</td>
</tr>
<tr>
<td>MED TECH</td>
<td>Diagnostics</td>
</tr>
<tr>
<td>PERSONAL CARE</td>
<td>Skin Biology</td>
</tr>
<tr>
<td>NUTRITION</td>
<td>Metabolic Diseases &amp; Human Development</td>
</tr>
</tbody>
</table>

Examples of initiatives

1. POLARIS: personalised cancer treatment
2. Singapore Institute for Skin Research
POLARIS or Personalised Omics Lattice for Advanced Research and Improving Stratification aims to identify which therapies are most effective in which patients, and to ensure that these appropriate treatments are administered. Led by Prof Patrick Tan at the Genome Institute of Singapore in partnership with SingHealth, POLARIS will leverage A*STAR’s scientific capabilities to identify and validate new biomarkers and technologies that can predict how patients would respond to medical treatment, as well as how their disease would progress. POLARIS will work with leading Singapore clinicians to personalise clinical care and refine healthcare delivery approaches for cancer, eye disease, and chronic diseases such as diabetes. It will bring cutting-edge science such as genomics and metabolomics beyond a research setting and directly into patient care. This translates to better health outcomes and a more targeted approach for treating individuals afflicted by cancer and chronic disease, based on their genetic and molecular biology profile.

Another strategic research thrust is in Skin Biology, and Prof Birgit Lane at the Institute of Medical Biology (IMB) has been growing research capabilities in basic and translational skin biology, attracting interest from both pharmaceutical and personal care companies. Over the years, there has been a growing demand for prescription dermatological products to address skin diseases, and an increasingly savvy and affluent customer base seeking differentiated and effective innovative products. Recognising this trend, and to concentrate efforts in skin research, IMB is partnering the National Skin Centre and the NTU Lee Kong Chian School of Medicine to jointly set up a new Singapore Institute for Skin Research (SISR) which will conduct high-impact inter-disciplinary research to improve health outcomes and quality of life. SISR will be housed in the upcoming Clinical Sciences building in the Lee Kong Chian School of Medicine in the Novena medical campus in 2015/16, and bring skin researchers and skin research facilities under one roof.

Lim Chuan Poh, Chairman of A*STAR, sums it nicely, “Going forward, I would want to extend beyond Biopolis, because there are some things that take a longer time to permeate, settle in, and really become part of the fabric of the country. We have achieved a lot in a very short period of time through Biopolis and through the wider biomedical sciences research community in Singapore, including the clinical community in the hospitals and the medical schools. But in the longer-term, there must be a shift in how the wider society appreciates knowledge creation and innovation. Singapore is still very new when it comes to appreciating knowledge creation and there is a lot of impatience for quick results. However, we have to realise that when it comes to research, especially biomedical research, it takes a longer time.” So while we continue the pace of our BMS journey in Singapore, there has to be acceptance, both in the government and the wider society, that there will be outcomes, and there will be plenty in due course.
TALENT
To be competitive in the face of other emerging BMS hubs around the world, we must continue to attract and develop world-class scientific talent across the research, innovation and enterprise value chain. In the last 2 years, we see a new generation of local scientific leadership emerging alongside senior scientists recruited earlier from abroad - Prof Ng Huck Hui is Executive Director of GIS, Prof Hong Wanjin is Executive Director of IMCB, and Prof Lam Kong Peng is Executive Director, BTI. Senior scientists provide mentorship for younger scientists as well as post-docs and PhD students. Another distinguishing feature of A*STAR is the opportunities given to younger promising scientists to have early independence if they have a strong scientific record. A number of them were attracted to Singapore through the A*STAR Investigatorship Award such as Bruno Reversade (PI, IMB), Prabha Sampath (PI, IMB) and Jonathan Loh (PI, IMCB), creating new opportunities for promising scientists from around the world.

The A*STAR scholarship programme has trained over 1,200 scholars of which half are in the biomedical sciences. As more of them return, they can look forward to good post-doctoral positions in world class research institutes, and the most competitive ones can gain independent Fellowships or Young Investigator Grants, or even move on to Junior PI positions. Some of the early scholars have also moved on to academic positions at NUS, NTU, Duke-NUS or Yale-NUS, while others have chosen to join the industry, or even take on research support roles such as patenting and IP commercialisation.

OPPORTUNITIES FOR INTER-DISCIPLINARY RESEARCH
Innovation often lies at the interface of different disciplines. Through the A*STAR Joint Council Office (JCO), many initiatives have been started to connect biologists with the chemists, physicists and engineers, so as to leverage on interdisciplinary opportunities and push the frontiers of research. We will continue to provide a supportive environment for such interactions to take place. Already, we see strong inter-disciplinary teams emerging from various JCO grant programmes, and we expect more of these in the years to come.
One example is the Development Programme on silicon biophotonics for cancer biomarker discovery. The team, led by Dr Mi Kyoung Park (Institute of Microelectronics, IME) and Prof Jean-Paul Thierry (IMCB), aims to develop cost-effective and reliable point-of-care diagnostic systems based on silicon biophotonic devices for bladder cancer detection. The team leverages on IME’s advanced silicon micro- and nano-fabrication technologies as well as molecular diagnostic device capability, and IMCB’s expertise in cancer research. Bladder cancer is the 4th most common cancer in men, recurring in 50-70% of patients after surgery, with 45% of patients progressing to invasive cancer within 5 years. Patients require regular, lifelong surveillance for disease progression, and screening methods are now limited to invasive methods which are uncomfortable or non-invasive methods which do not detect the disease well. The team’s goal is to develop a non-invasive and reliable diagnostic method for these patients, and they collaborate with A/Prof Edmund Chiong, Department of Urology, NUHS, and A/Prof Yong Jin Yoon and A/Prof Pei-Chen Su, School of Mechanical & Aerospace Engineering, NTU. The team will soon move on to clinical data to validate the prototype device and hope to license the technology to industry, or even spin-off a company.

Going forward, the scientific community will also be encouraged to respond to national challenges that Singapore faces such as an ageing population, big data and food security, and new innovations through R&D will be needed. If we can gather teams across disciplines and institutions to tackle these big issues in a concerted manner, then Singapore will be an even more exciting research hub in the years ahead.

**WORLD-CLASS INFRASTRUCTURE AND A UNIQUE PUBLIC-PRIVATE ENVIRONMENT – FUTURE PHASES OF BIOPOLIS.**

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam erat volutpat. Ut wisi enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis autem vel eum iriure dolor in hendrerit in vulputate velit esse molestie consequat, vel illum dolore eu feugiat nulla facilisis at vero eros et accumsan et iusto odio dignissim qui blandit praesent luptatum zzril delenit augue duis dolore te.

Taken together, the BMS journey has been a bold and exciting one for Singapore, and has catapulted Singapore onto the global stage as a BMS hub with world-class science, talent and infrastructure, and a trusted location for development and manufacturing of high-value medical products. That public sector agencies such as A*STAR, EDB and JTC, as well as various Government ministries have played such critical roles in the first decade of this journey is testament to the strong and sustained government commitment to this sector. We firmly believe that a supportive funding environment, opportunities for innovation in a vibrant research location, and a desire for impact on the economy, health and society will drive the BMS community to greater heights in the years ahead. So as we commemorate 10 years of Biopolis, we look forward to not just more of Biopolis in the next decade, but towards Singapore as Asia’s innovation capital.