



Developing Biomedical Research in Singapore

To enhance its capabilities in research and development, sustain the country's economic prosperity, and create a more value-added and knowledge-based economy, Singapore has devoted significant resources during the past decade to build a critical mass in cutting-edge research and development in the biomedical sciences.

The initial project in Singapore's efforts to catalyze biomedical research was the creation of the Institute of Molecular and Cell Biology (IMCB) (www.imcb.a-star.edu.sg/php/main.php) in 1987. Originally a part of the National University of Singapore (NUS; www.nus.edu.sg), IMCB later became an autonomous research institute of the Agency for Science, Technology and Research (A*STAR; www.a-star.edu.sg). Since 2001, the Singapore government and A*STAR have devoted many more resources to strengthening the biomedical research community through the establishment of other research institutes and consortia/centers under the umbrella of the Biomedical Research Council (www.a-star.edu.sg/AboutASTAR/BiomedicalResearchCouncil/tabid/64/Default.aspx). These other research institutes and consortia include the:

- Genome Institute of Singapore
- Institute for Medical Biology
- Institute of Bioengineering and Nanotechnology
- Bioprocessing Technology Institute
- Bioinformatics Institute
- Singapore Institute for Clinical Sciences
- Singapore Immunology Consortium
- Singapore Bioimaging Consortium
- Experimental Therapeutics Center

The majority of these biomedical activities are concentrated in Biopolis (www.one-north.sg/hubs_biopolis.aspx), a biomedical hub that also hosts common shared facilities/resources and other research sites such as the Novartis Institute for Tropical Diseases (www.novartis.com/research/nitd/index.shtml) and GlaxoSmithKline Centre for Cognitive and Neurodegenerative Disorders.

Growing and Funding Research

In addition to biomedical research activities in Biopolis, there has been a major growth of research activity at the NUS, particularly in

the Yong Loo Lin School of Medicine and the Faculty of Science. In addition, a few research centers and institutes have been created and are located in the NUS, such as the:

- Cancer Science Institute of Singapore (www.csi.nus.edu.sg/web/Common/homepage.aspx)
- Mechanobiology Institute (www.dbs.nus.edu.sg/mechano)
- Temasek Life Sciences Laboratory (www.tll.org.sg)

The collaboration between the Singapore government (with participation of A*STAR) and the Duke University Medical School has created the Duke-NUS Graduate Medical School (www.duke-nus.edu.sg/web/index.php), which hosts vibrant basic and clinical research programs to facilitate the training of graduate medical students. The Nanyang Technology University (NTU; www.ntu.edu.sg/Pages/default.aspx) has also created a new School of Biological Sciences (www.sbs.ntu.edu.sg/Pages/Home.aspx) and will soon have a new medical school.

In addition to A*STAR and the universities, there are other research institutes and centers primarily based in hospitals, such as the:

- National Cancer Centre Singapore (www.nccs.com.sg)
- Singapore Eye Research Institute (www.seri.com.sg)
- National Neuroscience Institute (www.nni.com.sg)

The public research programs are primarily supported by intramural and extramural programs of A*STAR, the National Research Foundation (NRF; www.nrf.gov.sg/nrf/default.aspx), the National Medical Research Council (NMRC; www.nmrc.gov.sg/corp/index.aspx) of the Ministry of Health, the Academic Research Fund of the Ministry of Education, and the Temasek Trust (www.temasekholdings.com.sg/media_centre_news_releases_160507.htm).

Contributions by Singaporean Scientists

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advancement of cell biology and related areas.¹ Their contributions cover many areas of cell biology,² and their works have been published in prominent journals. Recently, many prominent scientists have relocated to Singapore.³ Together these scientists form a vibrant and visible community working in cell biology and its associated research fields.

Recruiting Scientists and Students

The current focus to recruit young and promising scientists to Singapore is evidenced by the prominent A*STAR Investigatorship (www.a-star.edu.sg/AwardsScholarships/Investigatorships/tabid/88/Default.aspx) and the Singapore NRF Fellowship (www.nrf.gov.sg/nrf/otherprogrammes.aspx?id=142). Both aim to attract the best young scientists to Singapore to conduct independent research. To facilitate the collaboration between basic scientists and medical doctors and to enhance translational research, A*STAR and NMRC have established several programs. These include the Singapore Translational Research Award and the Clinical Scientist Award programs.

Training the next generation of scientists is another important aspect in Singapore's biomedical efforts. The A*STAR Graduate Academy (A*GA; www.a-star.edu.sg/AboutASTAR/ASTARGraduateAcademy/tabid/74/Default.aspx) has recruited over 1,000 Singaporean scholars who are at various stages of pursuing doctoral studies in major research universities in the U.S., UK, and locally in A*STAR research institutes, NUS, and NTU. Some scholars have already returned to Singapore to contribute ongoing research in A*STAR. Working with NUS and NTU, A*STAR has established an attractive PhD program called the Singapore International Graduate Award (www.singa.a-star.edu.sg). The program aims to recruit international students to pursue PhD training in A*STAR research institutes, NUS, and NTU. A prominent and high-profile graduate program called the NUS Graduate School for Integrative Sciences and Engineering (www.nus.edu.sg/ngs) was established at the university level to attract the very best PhD students both locally and internationally. Similarly, various PhD fellowship programs are also available at NTU (<http://admissions.ntu.edu.sg/graduate/scholarships/Pages/ResearchScholarship.aspx>).

The collective efforts of A*STAR, NUS, and NTU will have a huge impact in training future scientists and nurturing future leaders to sustain the momentum in biomedical research and future clinical and translational research.

Collaborating Internationally

A*STAR, NRF, NUS, and NTU have established several successful collaborations with overseas institutes such as the Massachusetts Institute of Technology (MIT), resulting in the creation of the Singapore-MIT Alliance for Research and Technology (SMART) Centre (<http://web.mit.edu/smart>). A*GA's ongoing overseas PhD scholarship program has teamed up with several overseas universities, such as Imperial College London, University of Cambridge, University of Oxford, University of Dundee, Karolinska Institutet, Carnegie Mellon University, and University of Illinois at Urbana-Champaign. Other international partnerships such as joint grant calls have also been established (www.a-star.edu.sg/Partnerships/ASTARCollaborations/tabid/172/Default.aspx). ■

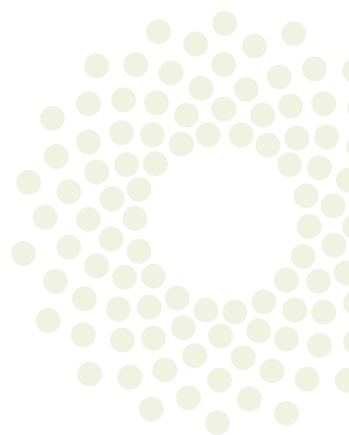
—Wanjin Hong, *Institute of Molecular and Cell Biology, Singapore*

Notes

¹Singaporean scientists who have contributed significantly to cell biology and related fields include Mohan Balasubramania, Xinmin Cao, William Chia, Graeme Guy, Barry Halliwell, Wanjin Hong, Walter Hunziker, Kong Peng Lam, Thomas Leung, Ding Jeak Ling, Edison Liu, Edward Manser, Alirio J. Melendez, Huck Hui Ng, Shazib Pervaiz, Yijun Ruan, Kanaga Sabapathy, Haiwei Song, Tuck Wah Soong, Uttam Surana, Patrick Tan, Bor Luen Tang, Byrappa Venkatesh, Yu Wang, Markus Wenk, Xiaohang Yang, Henry Yu, Qiang Yu, Qi Zeng, and Lian Hua Zhang.

²Singaporean scientists have made major contributions to areas that include PAK protein kinases and their regulatory pathways in Rho GTPase signaling, cell polarity of mammalian cells and model organisms, identification and functional characterization of SNAREs and other molecules in protein secretion and endocytosis in mammalian cells, structural biology of translational control and mRNA decay, cell signaling pathways, PRL-3 phosphatase in cancer metastasis, protein complexes in asymmetric cell division of the fly, molecular machineries and mechanisms of cell cycle in the yeasts *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*, comparative genomics, microbial quorum sensing mechanism, cancer and stem cell genomics, epigenetic regulation of stem and cancer cells, molecular and cellular immunity, lipidomics, and free radicals and antioxidants in biological systems.

³Prominent scientists who have relocated to Singapore include George J. Augustine, Brian Burke, Patrick J. Casey, Stephen Cohen, Alan Colman, Neal Copeland, Frank Eisenhaber, Xin-Yuan Fu, Philip Ingham, Yoshiaki Ito, Nancy Jenkins, Michael Kemeny, Barbara Knowles, Birgit Lane, David Lane, Alex Law, Bing Lim, Edison Liu, Paul Matsudaira, Pernille Rorth, Michael Sheetz, Shirish Shenolikar, Davor Solter, Colin Stewart, James Tam, Yoichi Taya, Daniel Tenen, Jean Paul Thiery, David Virshup, and Jackie Ying.



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