
A*STAR




# Singapore surges upwards

Part laboratory, part resort and part architectural gem, Fusionopolis is Singapore's newest mega-science facility. Visitors who walk through its theatre, shops and cafes, up past the gym and the bar to the 24th-floor swimming pool, may not realize that this is the biggest piston of Singapore's roaring science-based economic engine. It is a futuristic, twin-towered laboratory cluster for communications, materials and electronics research, and it's opening this month. Fusionopolis looks down on Singapore's flagship biological sciences conglomerate, Biopolis, just 600 metres away (see *Nature* **425,** 746–747; 2003), as well as the National University of Singapore (NUS) and the National University Hospital. The area is becoming a city unto itself, a commune of scientists and engineers. "By 2010, there will be 10,000 here," says Chuan Poh Lim, chairman of A*STAR, Singapore's central agency for encouraging science and technology.

Launched in February 2003, Fusionopolis is the physical-sciences sequel to Biopolis. Housing six institutes and some 3,000 PhDs, it will capitalize on the city-state's strengths in microelectronics, materials, communications and computing research. The buildings are meant to spur interdisciplinary research not only among its own institutes but also with those of Biopolis. Industry initiatives will occupy 60% of the space, and collaborations between the private and public sector are a major aim.

Fusionopolis, like Biopolis, reflects Singapore's focus on building science infrastructure and talent in the hope of generating products, patents and royalties. Lim explains that, as China, India and other regional competitors move into generic drugs and low-cost electronics, Singapore has fewer lucrative alternatives. "In terms of 'cheaper and faster', we will lose out," says Lim. "We need a framework for innovation."

It is a sentiment common at many a research hub. But nowhere else are such plans so generously funded on a per capita basis or so quickly executed. Singapore's science budget more than doubled to S$13.5 billion (US$880 million) in the current five-year plan compared with the previous one.

The city-state's achievements are already impressive. Thanks to researchers at A*STAR institutes, some university labs and other standouts such as the Temasek Life Sciences Laboratory, Singapore's scientific output (in terms of the number of published papers) increased 79% between 2000 and 2006 to 6,226 papers. That figure is only 0.6% of the world's total, but it places Singapore at the top per capita. Their impact, however, is low; in 2006, Singaporean papers were cited only 80% as often as the world average.

By 2010, Singapore plans to increase scientific funding from an already impressive 2.6% of gross domestic product in 2007 to 3%, which would put it ahead of most of the big players, including Britain and the United States. But as Singapore continues its scientific spending spree, observers are asking what economic gains these high-profile projects will achieve.

The Fusionopolis towers are the latest signs of Singapore's determination to build its future on science. But can the city-state meet the expectations it has raised? **David Cyranoski** reports.

## University overhaul

A key government objective is to improve not only the country's institutes but also its universities. Despite their standing as two of the top universities in Asia, Nanyang Technological University (NTU) and the NUS have long

been considered teaching rather than research institutions. When Philip Yeo, the former A*STAR head mainly responsible for Biopolis, sought to train the next generation of Singaporean scientists, he sent the most promising students abroad on full scholarships for their university studies. He also hired from overseas. With a few exceptions, Singapore's universities did not have the infrastructure to support top-class research.

This is changing rapidly, thanks in large part to a new funding scheme — the National Research Foundation (NRF). For the 2006–10 period, Singapore's research budget is slated to rise from S$6 billion in the previous period to S$13.55 billion — although slow economic times could have an effect. So far, S$5 billion has been used to establish the NRF, which has helped to revitalize the universities with high-powered recruitment.

Like A*STAR's institutes, the first three NRF-supported 'research centres of excellence' all have foreign directors: Artur Ekert, a professor of quantum physics at the University of Oxford, UK, for the NUS Centre for Quantum Technologies; Daniel Tenen, who will keep his laboratory at Harvard, at the NUS Cancer Research Centre of Excellence; and Kerry Sieh, of the California Institute of Technology, for NTU's Earth Observatory of Singapore.

Funded with S$150 million each over 5 years, all aim to become world leaders. The cancer institute will carve out five cancer-related areas, including cancer stem cells, led by Tenen, and cancer biology. Ekert, who started last December, says his centre already has good interdisciplinary teams in theory and experimental quantum optics. The goal, he writes, is "to boldly go where no man has gone before, into the quantum world (or worlds)".

But it isn't just those with centres of excellence that are benefiting. "It was the best thing that ever happened to me as a scientist," says Wun Jern Ng, director of the Nanyang Environment and Water Resources Institute, about the NRF funding. The money enabled Ng to pull together the NTU's water-related research into a new institute. Membrane technology, water reclamation, desalination and biofilms — all of which are already Singaporean strong points — are among its projects. The institute is recruiting 50 to 100 people, and Ng hopes to link up with a proposed 'clean tech hub' next door. The NTU's Swedish provost Bertil Andersson calls it the "Greenopolis" and says it will lure companies developing water, photovoltaics and wind technologies.

The NRF also offers grants for fledgling researchers. Its Competitive Research Programme gives S$10 million over 3–5 years for projects expected to benefit Singapore's economy. Young Singaporean researchers can apply for NRF research fellowships, which provide US$1.5 million on top of salary for three years.

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## Facing criticism

A central focus of Singapore's latest round of spending is to expand its pharmaceutical and biotechnology industry. Facing criticism from its advisory council over the lack of clinical applications likely to come from its basic-research investment in Biopolis, A*STAR teamed up with the NRF and the health ministry and put together a S$1.55-billion 5-year 'integrated biomedical sciences initiative'. They quickly funded, among others, a translational clinical research flagship programme (S$125 million, the first S$25 million of which will go to the Singapore Gastric Cancer Consortium), the Singapore Institute for Clinical Sciences (S$116 million) and the Experimental Therapeutics Centre (S$100 million), an incubator for Biopolis technologies. Biopolis, which has assembled seven biological-science institutes since it opened in 2003, is adding two new buildings dedicated to translational and industry research.

A promising sign for future biomedical success is the Duke–NUS Graduate Medical School. Established in 2005 with staff from Duke University in Durham, North Carolina, and the promise of hundreds of millions of dollars from the Singapore government, the school offers a joint MD and PhD. New buildings with 24,000 square metres of space will be ready in late 2009. The school already has 108 faculty members, mostly from the United States.

Good quality-control and patent protection have lured industry, for both research and manufacturing. In less than two years, Genentech, GlaxoSmithKline, Lonza and Novartis all decided to build biologics manufacturing facilities in Singapore. In 2007, GlaxoSmithKline added a US$13-million laboratory to its Singapore facility to develop therapies for Alzheimer's disease and schizophrenia. At about the same time, Eli Lilly decided to triple the number of researchers at its Singapore base with a US$150-million boost over 5 years to focus on cancer and type 2 diabetes therapies. Just this August, AstraZeneca teamed up with the National Cancer Centre Singapore and the National University Hospital to carry out research on liver-cancer drugs.

## Fuelled by Fusionopolis

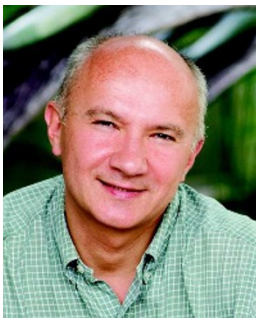
Given the difficulties facing the global pharmaceutical industry, Singapore's hopes of making money are likely to be fulfilled sooner by Fusionopolis. This month, some 500 researchers will arrive from the Institute for High Performance Computing, the Institute for Infocomm Research and the Data Storage Institute. In 2010, another 1,000 will come from the Institute of Microelectronics (IME), the Institute of Materials Research and Engineering (IMRE) and the Singapore Institute of Manufacturing Technology (SIMTech).

The IME's director, Dim-Lee Kwong, says it was partly "R&D for the sake of commercialization" that enticed him from the University of Texas three years ago. "In the United States, that is not explicit," says Kwong, whose institute's work on silicon nanowires — aiming to keep semiconductors improving their capacity — won the 2007 George E. Smith technology award.

The IME already has 26 projects with industry, from which it receives 25% of its operating budget. In 2007, the institutes that will comprise Fusionopolis had 202 R&D projects with 339 companies. Industrial spin-offs have made some wealthy: researchers from the IMRE, for example, sold the company owning its magnetic fingerprint-tagging technology for S$19.6 million.

Its cutting-edge facilities could arouse further industry interest. Fusionopolis will have an anechoic chamber and supercomputing, nanofabrication, characterization and test-bedding facilities. Fourteen corporate labs, including wind-turbine maker Vestas and Second Life creator Linden Lab, have signed up for Fusionopolis.

Collaborations between Fusionopolis and Biopolis could reap rewards as well. An 'e-health' initiative, for instance, will draw expertise from both to provide remote diagnoses based on urine or stool samples,



**Artur Ekert (top) and Dim-Lee Kwong are both heading for Fusionopolis.**

TAN NGIAP HENG, THE POND PHOTOGRAPHY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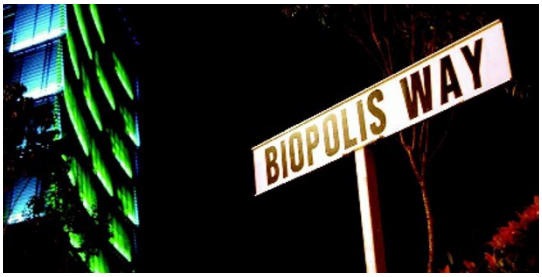


**Biopolis is expanding, and will also feature in crossover projects with Fusionopolis.**

wound image analysis, diabetic retinal imaging and delivery of drugs. And A*STAR is offering grants to encourage such links. Photochemist Jonathan Hobley of the IMRE, for example, is leading a project with scientists at A*STAR's Institute of Molecular and Cell Biology (IMCB) to use the reflectivity and emission of light at interfaces to assess what surface properties guide axonal growth. "There's something the cell does or doesn't like about a surface, and that guides it along. It's really a surface chemistry problem," he says. The project will get S$750,000 for 3 years for postdocs and equipment.

Edison Liu, head of the Biopolis's Genome Institute of Singapore, is leading two crossover projects. One, with the IME and SIMTech, aims to develop a DNA preparation device to sequence the human genome for less than US$10,000 and claim the US$10-million Archon X Prize. "Many people talk about doing interdisciplinary research, but here we're doing it," says Liu.

## Research challenges

Despite ample investment and impressive progress, Singapore's science programme does face stumbling blocks. Controls meant to stem corruption make the day-to-day use of funds a tedious affair. "There are too many well-meaning bureaucrats," says Tenen. "They question every little purchase, without understanding the science or the way science works. You buy a paper clip and they want to know why." Stem-cell biologist Davor Solter, who recently joined the A*STAR Institute of Medical Biology from the Max Planck Institute of Immunobiology in Freiburg, Germany, says he had to get the rubber stamps of some 16 people to get a computer. "It can take a month or more," he says.

Some worry about Singapore's reputation for heavy-handed government. In 2005, the University of Warwick, UK, dropped plans to open a Singapore campus for fear that academic freedom would not be protected. That, and the closure within 6 months of opening of the University of New South Wales's Singapore campus last year for financial reasons, set back efforts to internationalize university education.

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Concerns about how Singapore's government deals with recruited international scientists were raised by a case involving UK neuroscientist Simon Shorvon. Brought in to run the National Neuroscience Institute in 2000, Shorvon, an authority on epilepsy, was ousted in 2003 after being accused of failing to secure proper informed consent from study patients. Shorvon denied any impropriety. He returned to Britain, where the General Medical Council cleared him of any wrongdoing. But in an unprecedented move, Singapore officials challenged that decision in London. The UK High Court subsequently dismissed this claim. Adding to the controversy, Shorvon's initial critic was Lee Wei Ling, daughter of Singapore's long-time ruler Lee Kuan Yew (see *Nature* doi:10.1038/news061218-15; 2006).

"It takes time to explain to some of our colleagues and potential hires that one can speak English here, that one can jaywalk and chew gum without being caned on the spot," says Ekert. Still, the combination of funding and research freedom will probably continue to be a draw as budgets get slashed elsewhere.

But as expectations rise, some fear that research independence might get curtailed. Government officials are "feeling insecure as to whether it is useful for the economy", says Jean Paul Thiery of the IMCB, who also heads the Experimental Therapeutics Centre. "Will the pharmaceutical companies stay? It is a very fragile structure," he says.

Questions of researcher priorities and independence will take centre stage as Singapore prepares its next five-year plan, in 2010. Failure to secure patents and technology transfer could cost funding. "When we first started at the high-growth phase, the runway was big and you couldn't see the guy next to you," says Lim. "In the next two years when we have full recruitment, we have to move into the high-productivity phase. There will be more competition for resources — and that's a good thing." ■

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