SINGAPORE

Topnotch, Targeted Research Propels National University

SINGAPORE—Physicist Bernard Tan remembers the grim situation facing scientists at the University of Singapore when he arrived in 1968 after receiving his degree from the University of Oxford. Research money was scarce, and sometimes the only papers he could get published were how-to articles on, for example, building a carbon dioxide laser "using components costing only a few hundred dollars, including a neon-sign transformer." All departments were in parlous condition, recalls medical researcher Lim Pin: "I had to borrow hospital equipment to measure magnesium levels in tissue."

But those stories, common in a developing country, describe a bygone era. Under the leadership of Lim, who was put in charge in 1981, and Tan, the science dean since 1985, the National University of Singapore (its name was changed in 1980) has experienced a dramatic scientific ascent. Last year NUS spent $70 million on research within its science departments and affiliated institutes. That support has been combined with rigorous standards in hiring and promotion, a concentration on fields that offer economic as well as scientific opportunities, and a government commitment to put science and technology high on the list of national priorities.

So far, the results are impressive. Today NUS is a growing presence on the international scientific landscape. Its citation rates compare favorably with world averages in materials science, mathematics, and chemistry, according to data from the Institute for Scientific Information (ISI) in Philadelphia, and they have climbed sharply in life sciences in the past half decade. At the same time, the number of Singaporean papers in journals monitored by ISI has increased sevenfold since 1981, with 77% having NUS faculty members as authors. "I think they're doing very well," says David Siegmund, a professor of statistics at Stanford University who has served as an external examiner for NUS programs. "Rather than shoot for the stars, they've chosen to follow a steady course."

Lim can see the challenges facing him every time he looks out the windows of his roomy corner office. An armada of offshore refineries and smokestacks juts jaggedly against a pellucid equatorial sky, a constant reminder of his country's fragile environment and its lack of natural resources. And those aren't the only obstacles to success. The economy, being based so heavily on multinational investment, is vulnerable to influences beyond the government's control. And Singapore has significant liabilities, including its small size, remoteness, paternalistic government, and reputation for cultural sterility. The country must also compete for talent and investment dollars against larger, technology-hungry neighbors such as Taiwan and Hong Kong.

Still, Lim says it wasn't hard to know what to do when he became vice chancellor. "We have no choice but to go up the ladder of science and technology," Lim declares. "But our economy is small, so we've got to be very selective" about what to support. That rules out big-ticket items such as particle accelerators and space exploration, he says, as well as highly competitive fields; instead, each department is trying "to come up with niche areas where it can excel at the world level."

Grabbing a niche. Ding Jeak Ling and her lab work on a test for bacterial contaminants from the blood of horseshoe crabs.

One example is research by Ding Jeak Ling and Ho Bow on blood factors from the Asian horseshoe crab. The group has cloned and expressed an enzyme in the crab's blood that is activated by bacterial endotoxin, a discovery that could lead to a multimillion-dollar market as a test for bacterial contamination of biomedical products. The NUS team is now collaborating with Associates of Cape Cod, a company in Falmouth, Massachusetts, that wants to produce the recombinant enzyme. The work is "a significant breakthrough" toward achieving that aim, says the firm's chief executive officer, Tom Novitsky.

Other NUS scientists identify niches by taking advantage of living in what Lim calls "the only tropical country with a well-developed technology base." The West-East Center for Microbial Diversity, for example, has collaborated with the University of British Columbia to sequence DNA from over 100,000 tropical-soil micro-organisms not found in microbial genome databases located in temperate regions. The university hopes companies will want to mine the database for information that could lead to new drugs, enzymes, and other biotech products. In other work with commercial potential, botanist Goh Chong Jin's group is trying to fine-tune the flowering mechanism in orchids (a major cash crop in Singapore) and extend the shelf life of bananas by tinkering with ethylene synthesis.

Yet another strategy is to exploit opportunities at the boundaries of existing disciplines. For example, the university operates one of the world's leading centers for using high-energy protons to study the distribution of trace elements in biological materials. The university converted its old Van de Graaff accelerator into a 2.5-MeV proton microprobe, and 2 years ago it recruited Oxford's Frank Watt, a recognized leader in the field. Watt is excited not only by the state-of-the-art facilities, but also by the open-minded attitude toward such work. At Oxford, he says, "I wasn't accorded the freedom that I have here" to cross conventional disciplinary boundaries.

Persuading Watt to come halfway around the world to join NUS was a major coup for Lim, who has waged a determined campaign to raise budgets, weed out mediocrity, and support good science. One of Lim's first moves as NUS president was to lobby the education ministry, which provides most of the university's funding, to put serious money into research. His efforts have paid off: Since 1981, NUS's operating budget has grown nearly fourfold, to $270 million. Out of that, $9 million is parceled out to faculty with the best research proposals, at an average of $100,000 over 3 years. In addition, graduate students receive full financial support, and their numbers have risen fourfold since 1985, to 341 in 1994.

Lim hasn't neglected infrastructure, either. New buildings have sprouted up on the lush hillside campus, replacing cramped, dingy quarters. Staff members are each issued a personal computer hooked up to the Internet, a level of international access denied most Asian scientists.

The university has also adopted a U.S.-style policy on tenure. Junior researchers receive 3-year renewable contracts, and tenure is offered only at the associate professor level. "Excellence in research, as measured by publications in international journals, is a key element in staff advancement and promo-

tion," explains Tan. Promotion to full professorship requires one more step: The individual's record is sent to the Association of Commonwealth Universities in London, which appoints an assessor. In addition, each year Lim, Tan, and their colleagues review staff performance, including the 75 associate and full professors on the science faculty. Raises are based on grants, publications, quality of research, and student evaluations of teaching ability.

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Recruiting coup. Britain's Frank Watt was attracted by the open exchange among disciplines.

All this effort is starting to pay off financially as well as intellectually. Annual support from industry, now just under $10 million, is growing by about 5% a year, with companies such as Asahi Glass, Sony, BP International, Glaxo, and Motorola taking an interest in applying work done by NUS scientists. Three years ago the university established an Industry and Technology Relations Office to promote collaborations. These have led to the development of a heart valve using animal tissue, a method for producing ultrapure water, and new image enhancement technology, says the office's director, S. K. Chou. Singapore's scientific development is also encouraging multinational firms to open research centers on the island. "Our research institutes serve not only as a provider of professional manpower and a trove of knowledge, but as a magnet to draw in other R&D setups," says Teo Ming Kian, chair of the National Science and Technology Board.

The next test for NUS officials is whether the university can attract its share of the next generation of talent. The country is too small to sustain a critical mass of researchers in many fields, and "it is still hard to attract good postdocs and principal investigators," says a young molecular biologist. "We're doing okay, but can we go the next step?"

NUS officials think they can if, in Tan's words, they remain "knowledgeable, prescient, and daring." Having once demonstrated those qualities in building an affordable laser, Tan is now applying them to the job of building a world-class university.

–June Kinoshita

June Kinoshita is a science writer in Boston.

NAS Elects New Members

The National Academy of Sciences last week elected six women and 54 men as new members. The total number of active members is now 1733, of which 93 are women.

Newly elected members and their affiliations at the time of election are:

Kenneth I. Berns, Cornell University Medical College; **Lutz Birnbaumer**, University of California, Los Angeles, School of Medicine; **Jan L. Breslow**, Rockefeller University; **Donald E. Brownlee**, University of Washington, Seattle; **Bob B. Buchanan**, University of California, Berkeley; **Federico Capasso**, AT&T Bell Laboratories, Murray Hill, New Jersey; **David Chandler**, University of California, Berkeley; **Persi Diaconis**, Harvard University; **Adam M. Dziewonski**, Harvard University; **Clara Franzini-Armstrong**, University of Pennsylvania School of Medicine; **Howard Georgi**, Harvard University; **Lawrence M. Gold**, University of Colorado, Boulder; **Corey S. Goodman**, Howard Hughes Medical Institute (HHMI) and University of California, Berkeley; **Melvin M. Grumbach**, University of California, San Francisco; **Lowell P. Hager**, University of Illinois, Urbana; **Clayton H. Heathcock**, University of California, Berkeley; **Clyde A. Hutchison III**, University of North Carolina, Chapel Hill; **Lily Yeh Jan**, HHMI and University of California, San Francisco, School of Medicine; **Judith Kimble**, HHMI and University of Wisconsin, Madison; **Alexander M. Klibanov**, Massachusetts Institute of Technology.

Stanley J. Korsmeyer, HHMI and Washington University School of Medicine, St. Louis; **Anne O. Krueger**, Stanford University; **H. Blaine Lawson Jr.**; State University of New York, Stony Brook; **Stephen R. Leone**, National Institute of Standards and Technology and University of Colorado, Boulder; **John C. Liebeskind**, University of California, Los Angeles; **Edwin N. Lightfoot**, University of Wisconsin, Madison; **David M. Livingston**, Harvard Medical School and Dana-Farber Cancer Institute, Boston; **Gerald D. Mahan**, University of Tennessee, Knoxville; **Donald C. Malins**, Pacific Northwest Research Foundation, Seattle; **Vincent Massey**, University of Michigan, Ann Arbor; **Douglas A. Melton**, HHMI and Harvard University; **Elliot M. Meyerowitz**, California Institute of Technology; **Charles S. Parmenter**, Indiana University, Bloomington; **Charles S. Peskin**, Courant Institute of Mathematical Sciences, New York University; **Gregory A. Petsko**, Brandeis University; **Charles M. Radding**, Yale University School of Medicine; **Calyampudi R. Rao**, Pennsylvania State University; **Anthony C.S. Readhead**, California Institute of Technology; **Austin H. Riesen**, University of California, Riverside; **A. Kimball Romney**, University of California, Irvine.

Stuart L. Schreiber, HHMI and Harvard University; **Ronald R. Sederoff**, North Carolina State University; **Carla J. Shatz**, HHMI and University of California, Berkeley; **Yuen R. Shen**, University of California, Berkeley; **Charles J. Sherr**, HHMI and St. Jude Children's Research Hospital, Memphis, Tennessee; **Richard M. Shiffrin**, Indiana University, Bloomington; **Vernon L. Smith**, University of Arizona, Tucson; **Richard P. Stanley**, Massachusetts Institute of Technology; **Daniel W. Stroock**, Massachusetts Institute of Technology; **John Suppe**, Princeton University; **Steven D. Tanksley**, Cornell University; **David J. Thouless**, University of Washington; **Billie Lee Turner II**, Clark University, Worcester, Masssachusetts; **Alexander Varshavsky**, California Institute of Technology; **Douglas C. Wallace**, Emory University School of Medicine; **Watt W. Webb**, Cornell University; **Carl E. Wieman**, University of Colorado, Boulder; **Bruce D. Winstein**, University of Chicago; **Eric R. Wolf**, City University of New York; **Mary Lou Zoback**, U.S. Geological Survey, Menlo Park, California.

The following were elected as foreign associates:

Michael V. Berry, Bristol University (U.K.); **Jan Bures**, Institute of Physiology, Czech Academy of Sciences, Prague (Czechoslovakia); **Ennio De Giorgi**, Scuola Normale Superiore, Pisa (Italy); **Derek A. Denton**, Howard Florey Institute and University of Melbourne (Australia); **Vitalii I. Goldanskii**, Semenov Institute of Chemical Physics, Moscow (Russia); **Robert Huber**, Max-Planck-Institut Für Biochemie, Munich (Germany); **Holger W. Jannasch**, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts (Germany); **Leonid V. Keldysh**, Moscow State University, Moscow (Russia); **Miguel Leon-Portilla**, National University of Mexico, Mexico City (Mexico); **Xavier T. Le Pichon**, Ecole Normale Superieure, Paris (France); **Paul M. Nurse**, University of Oxford (U.K.); **Leo Sachs**, Weizmann Institute of Science, Rehovot, Israel (Israel); **Jun-Ichi Tomizawa**, National Institute of Genetics, Mishima, Japan (Japan); **Hirofumi Uzawa**, The Japan Development Bank and University of Tokyo (Japan); **Srinivasa S.R. Varadhan**, Courant Institute of Mathematical Sciences, New York University (India).