SOUTH KOREA

National Project Aimed at Making It the Leading Tiger

SEOUL—South Korea's pavilion at Taejon Expo '93, part of the host country's contribution to this fall's international science exposition, spotlights a 10-year, $12.5 billion effort to match the major industrial powers in areas ranging from pharmaceuticals to high-definition television. The initiative, called the Highly Advanced National Project, is a symbol of Korea's desire to be the first newly industrialized economy in Asia to join the ranks of the world's advanced nations. The 227-acre expo site is another part of that campaign: After the expo closes next month it will be converted into a permanent science park with companies and research laboratories clustered together in a symbiotic arrangement modeled on the research park at Japan's Tsukuba Science City.

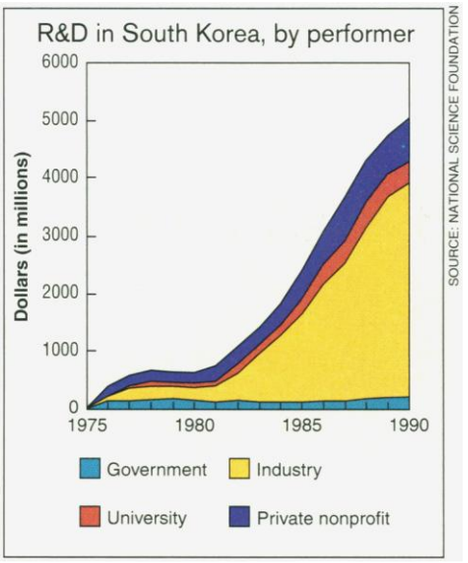
But for all its outward glitter, Korea's ambitious high-tech program rests on shaky scientific underpinnings. Korea's university system is weak, as is academic research (see sidebar). Government and industrial funding for research are concentrated on medium-term projects aimed at boosting the country's economy rather than on long-term basic science. And competition among overly bureaucratic government ministries, companies, and universities for control over specific programs makes it virtually impossible to coordinate R&D efforts across the country. "There's money, but it's not spent in a focused, consistent way," says Myun W. Lee, director of the Research Institute of Engineering Science at Seoul National University (SNU), South Korea's most prestigious university.

Such criticism doesn't diminish Korea's spectacular achievements since the end of World War II. "At the time of our liberation from Japan, we had only 11 science B.A.s in the whole country," says Cho Wan-kyoo, former president of SNU. By 1991, South Korea had amassed 17.6 researchers per 10,000 population, about half the number of the United States, and the country's average per capita spending on that group was $71,700, also about half the U.S. total.

But South Koreans remain acutely aware of how far they must go to achieve their goal of becoming a high-tech economy. The nation of 40 million still has only 16,000 science and engineering Ph.D.s, and their research papers rank 32nd in the world in the average number of citations per paper, according to the Institute for Scientific Information. To beef up science, the government plans by 1998 to almost double the share of its gross national product (GNP) devoted to science and technology; if it succeeds, its 4% share would far surpass what the United States, Japan, and Germany now spend on science (slightly less than 3% of GNP). And, although Korean researchers complain bitterly of bureaucratic obstacles and short time horizons, new institutions that break down some of these barriers are beginning to emerge.

Looking for the right chemistry. Samsung Advanced Institute of Technology.

Scattershot funding. The government is following through so far on one promise: Funding for science is already rising sharply, along with the economy. The total for R&D has gone up from $620 million to $5 billion (in constant 1987 dollars adjusted for purchasing power) between 1980 and 1990 (see chart). Support for basic research is climbing, too, although it remains a small fraction of the total. For example, the budget of the Korean Science and Engineering Foundation (KOSEF), the main source of investigator-initiated grants for basic research, rose from just over $1 million in 1977 to $140 million in 1992, and it is expected to reach $625 million by 2001. Industry has also stepped up its spending; it now accounts for 80% of total research dollars compared with 28% in 1971.



Industry leads the way. Most of the growth in South Korean R&D has been in industrial labs.

Welcome as these increases are, researchers complain that money for basic research is still spread far too thin. The system of distributing research grants aims to preserve a sense of egalitarianism, a quality Korean culture values highly, rather than to foster excellence. As a result, one out of three applicants receives a KOSEF grant, but the sums are too small, around $10,000, to have an impact. "Everyone has to be happy," says Kim Jewan, an SNU physicist. "The U.S. National Science Foundation has program officers in each field [who choose the most worthy proposals]. In KOSEF there are none."

KOSEF has recently tried to offset this scattershot approach by focusing some research funding on centers of excellence. Four years ago, it set up 30 research centers at 12 universities covering such key fields as cell differentiation, theoretical physics, thin-film technology, and biomaterials. Yoon Euijoon, a former AT&T Bell Laboratories researcher, says the Semiconductor Research Center located at SNU enabled him to hit the ground running when he arrived there recently as an assistant professor. Most new faculty, in contrast, must build their labs from scratch. While the centers have improved working conditions significantly, some doubt they will give Korea the competitive edge it is seeking. "I think the research centers are a step backward," declares Lee Eun, an SNU chemist. The reason? KOSEF, in his assessment, is throwing money into areas where more advanced nations are already outspending and outperforming South Korea.

Weak links. Even if the government does meet its ambitious targets for funding R&D, Korean researchers and research managers say that some fundamental changes in attitudes, and closer relationships between the country's economic sectors, will be needed to make the best use of home-grown science. One important issue is the uneasy relationship between universities and industry. South Korean conglomerates such as Samsung, Daewoo, and Lucky-GoldStar have recently donated millions of dollars for new buildings on campuses of prestigious universities like SNU. Yet academia and industry still eye each other with suspicion. "I think we should do research for society," says Roe Jung-Hye, an assistant professor in microbiology at SNU. But she fears being "pushed from day to day" if industry sponsors her work, agreeing with her colleagues that such ties mean "losing your freedom." Industry, on

What Ails Seoul National University?

Korea's high school students lead the world in math and science. But the nation's preeminent university, Seoul National, as even its own professors constantly remind visitors, trails its Asian neighbors in the caliber of its scientific output, ranking 32nd internationally in the number of papers published in journals monitored by the Institute for Scientific Information. "Japan has had Nobels, but we don't have any," laments SNU's dean of research affairs, Park Sang Dai. "We don't even have our own science."

SEOUL NATIONAL UNIVERSITY

A barrier? Gateway to Seoul National University.

Why does Korea's most prestigious university, which gets the cream of the nation's high school graduates, the best equipment, and half of the government's research grants (totaling $45 million), rate so low on global scales? One reason is an inefficient funding system. Individual grants typically are for less than $10,000, so professors try to get several of them. But each grant comes from a different source and the money cannot be combined. Worse, lack of money for new equipment forces new faculty to waste precious time and resources figuring out how to set up their labs. Kim Seong Keun, a Harvard-trained specialist in molecular reaction dynamics, recalls arriving at SNU in 1989 and being given $700 to start his lab. "I was really shocked," he says.

There are, moreover, few incentives to do good science. Tenure, for example, doesn't depend on the dreaded publish-or-perish criterion used in the West. "The university never kicks assistant professors out, unless they are politically undesirable," charges Park. Combine inefficient funding and easy promotion with the burden of teaching three courses per semester and it's quite a feat for any SNU researcher to stay current.

Yet there are pockets of good science at SNU. Research facilities have improved dramatically over the past decade, with the completion of the institutes for molecular biology and genetics, advanced materials, and semiconductor research. Slickly styled and bristling with up-to-date instruments, they contrast markedly with the typical campus lab. "Twelve years ago we didn't even have an autoclave," recalls Kim Sunyoung, who returned from Harvard in 1990 to run a lab at the Institute of Molecular Biology and Genetics, which has its own P4 facility. SNU is also home to 10 of the 30 "centers of excellence" established since 1989 by the Korean Science and Engineering Foundation.

Such changes are attracting a higher caliber of young scientists. Sheen Dongwoo, an applied mathematician who arrived in February from Purdue University, says that "now most Korean Ph.D.s abroad want to come back. Pay is not that bad anymore, and I felt I could make more of a contribution here." Their arrival has caused the number of SNU's science publications in international journals to jump from 40 a year in the mid-1980s to more than 100 in 1992. But problems still abound. "If we had something like the [U.S.] presidential young investigator awards, I think we could do better," suggests Yoon Euijoon, a Massachusetts Institute of Technology-trained materials engineer. "Young scientists have so much teaching, they can't keep up their research. Once they fall behind, they're gone."

It also doesn't help that the best doctoral students go overseas to take advantage of better scientific opportunities and more generous tuition support and living stipends. "If the top students could be induced to stay here, it would raise our level," says Park. Better conditions for postdocs would help, too. Postdocs are paid from their advisors' grants and cannot work independently. "My salary is less than what I pay my babysitter," says Choi Kyeong-Sook, a 31-year-old mother.

But the most intractable problem may be what Kim Sunyoung calls a fear of competition. That attitude, Kim believes, explains why "there's no critical mass in any field" and why "peer review is not good." Frank evaluation of colleagues' work, he says, "is not a part of the scientific culture here." Or, as Chung Kwang Ho, an earnest second-year graduate student, put it, "We joke there's no science in Korea, only politics."

Kim Chong-Un, the president of SNU, wants to change that by insisting on stricter evaluations—"including criticism"—of the faculty. "We have to create a competitive environment," declares Park, "but old faculty members resist." Park and others hope the winds of reform stirred up by Korea's first popularly elected president will soon blow their way, too.

–J.K.

the other hand, complains that universities are oblivious to their needs.

One notable effort to bridge this gap is Mogam Biotechnology Research Institute, set up by pharmaceutical maker Korea Green Cross Corp. Funded by proceeds from its parent company's hepatitis-B vaccine, the laboratory is trying to support basic research conducted at universities and to apply it to new products. "Korea has not come up with a biotechnology product we can sell worldwide," says Mogam's president, Moon Hongmo. "My goal is to come up with one within 5 years. Then government and industry will give us more money."

Government-run labs are supposed to act as a bridge between basic research and industry, but—as the United States is finding in its efforts to turn its defense labs into engines of economic growth—knowledge doesn't always transfer readily between sectors. For example, Yoo Sung-eun, a Yale-trained chemist in the science ministry-sponsored Korea Research Institute of Chemical Technology (KRICT), is working on fourth-generation penicillin, but his lab has no interaction with the GoldStar company laboratory working next door on the same medicine. When asked about this, Yoo grins and shrugs, as if to acknowledge the status quo.

That isolation is not supposed to happen. Both KRICT and the Goldstar lab are located in Taedok, the 6680-acre science town established in 1973 to develop home-grown scientific and technological expertise. The town's three universities, 25 government-affiliated and 29 private laboratories were meant to generate some critical mass, but in reality each operates like a lone fortress, hidden away up winding drives and behind thick shrubbery. The design of the new Taejon science town attempts to learn from past mistakes: Here the labs are located on a single campus all within walking distance of one another. But it will still be up to individual researchers to take advantage of that proximity.

Meanwhile, faced with the certainty of mounting global competition, Korean industry is now trying to do more of its own long-term research—and finding it a strug-

gle. In 1987 Samsung created a central research lab, the Samsung Advanced Institute of Technology (SAIT), to focus on key technologies such as semiconductors. Despite a $50 million showcase building with the latest equipment and a staff of 636, SAIT based much of its R&D on reverse engineering technologies from the United States and Japan. Samsung hit a wall in 1990, when skyrocketing local labor rates made its products less competitive, and it is now reworking its R&D strategy to get ahead in high-definition television, 64M bit DRAMs, and other areas.

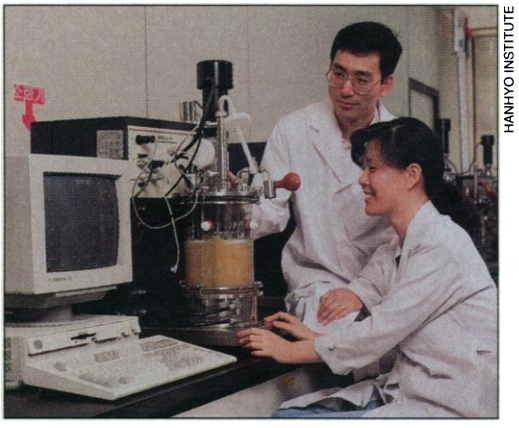
"Though we've reported impressive revenues in our products, they do not contain much impressive technology," says Hur Jeong, head of the technical planning department at SAIT. "Now we must do high technology for ourselves." One managerial innovation the laboratory has introduced is Friday afternoon get-togethers, where SAIT researchers from different divisions can gather.

In Korea's hierarchical, territory-conscious society, such gatherings are rare. Lee El-hang, director of research at the Electronics and Telecommunications Research Institute (ETRI), a Ministry of Communications laboratory started in 1988, sees a difference between ETRI and AT&T Bell Laboratories, where he worked for 6 years. "There is more formality rather than free-flowing communications," he says. "Even Koreans returning from the United States soon begin to behave in the Korean style."

Breaking the mold. In a society filled with pressure to turn profits, spread money equally, and work within the confines of a rigid bureaucracy, independence is a rarity. But some research institutions have begun to throw off the shackles that are holding back much of Korean science. For example, the Hanhyo Institutes of Technology, a 40-person research lab with an annual budget of $7 million from synthetic fiber-maker Hanil, is under no obligation to produce a commercial product. Its long-range objective, however, is to gain a foothold in biopharmaceuticals.

"We can conduct research for 7 years before the company expects a payback," says Hanhyo President Kang Sung-zong. He recruits excellent young scientists from abroad by offering top-of-the-line facilities and freedom from both corporate or academic pressures. The institutes' strategy is to target leading-edge areas, such as basic research on angiogenesis, where it faces relatively little worldwide competition and has a chance of developing innovative products. This stands in contrast to most Korean biotech efforts, which join such crowded fields as the search for hepatitis B vaccines.

In education, too, several universities created outside the bureaucratic control of the education ministry have enjoyed considerable success. The country's best graduate university, KAIST, for example, was set up in 1971 by the Ministry of Science and Technology despite opposition from the Ministry of Education (MOE). Using an American-style system of academic promotions, KAIST has assembled a first-rate, 327-member faculty. Last year, the U.S.-based Accreditation Board for Engineering and Technology concluded "KAIST has the potential to become one of the top institutions in the world."



HANHYO INSTITUTE

Research model? Scientists at the Hanhyo Institutes of Technology, which focus on long-range R&D.

Another non-MOE venture is POSTECH, a well-funded and modern university set up by the Pohang Iron & Steel Co. to foster an academic climate in the city of Pohang. POSCO was diversifying into information technologies and thought that a university would help recruitment. Like Hanhyo's Kang, POSTECH President Kim Hogil lured the bulk of his staff from elite U.S. universities. To shore up the educational system, POSTECH offers a student-teacher ratio of 8:1 compared with an average of 35:1 at the national universities. The university will soon boast Korea's first synchrotron, a 2-GeV, $181 million machine scheduled to open in 1995.

Although progress remains slow, these innovative new arrangements may point the way to South Korea's high-tech future. And if the past 45 years have proved anything about South Korea, it is that one should not underestimate the nation's capacity to challenge the economic superpowers.

–Lori Valigra

Lori Valigra is a science writer based in Cambridge, Massachusetts.

Home-Grown Talent

PROFILE

SEOUL—Unlike his friends, Shin Jae-min did not grow up dreaming of becoming a businessman. He wanted to be a scientist, and his role models were physicists like Einstein and Newton.

Today, at 32, he is living that dream as a senior research scientist at the Hanhyo Institutes of Technology (HIT), a privately funded institution committed to supporting basic research. Although he is a member of an elite corps of home-grown scientists, his life is far from idyllic. Shin and his colleagues face pressure from the Korean government to contribute to its economic growth. He must also cope with doubts about his ability from the top echelon of Korean scientists who, trained mostly overseas, believe their country's educational system is not up to snuff. Their feelings persist even though Shin graduated from a well-regarded school, Yonsei University, and received his master's and Ph.D. degrees in physical chemistry from the Korea Advanced Institute of Science and Technology, the nation's finest graduate university. "I am somewhat limited in mobility because I did not study overseas, and I would welcome an opportunity to go abroad," he says.

Shin joined HIT after working on polymers and monomers at Samsung Petrochemical Co. Like most of his colleagues, he switched jobs because of the chance to pursue basic science, despite a cut in pay. "Good working conditions are more important than salary for scientists," he says.

Shin's work is a key component in supporting other HIT laboratories. He spends his days browsing through a protein database software program, looking for structures of chemicals similar to those in the human body. The database software can display protein structures in three dimensions, making it easier to synthesize new molecules by computer simulation. His research is very useful to colleagues developing new chemicals and biopharmaceuticals.

Part of a generation that would like to prove South Korea can train scientists at the cutting edge in their fields, Shin is philosophical when he's reminded that government and corporate bureaucrats expect to see immediate economic results from his work. And he is not sure that he can reconcile those opposing forces. "Society is practical and wants profits, but scientists want to do research," he says.

–L.V.