power began in 1978 with the government's approval of the country's first graduate-degree granting programs. Of China's hundreds of universities, some three dozen now have graduate schools, which each year award about 3000 Ph.D.s and 30,000 master's degrees; about 70% of those degrees are in science and technology.

Academic science has also gotten a big boost from the World Bank. Since 1982 the bank has poured money into programs to strengthen the scientific capacities of both comprehensive universities and those affiliated with the various ministries, as well as a third project now winding down to support key labs at 100 academic institutions. Last year, in an attempt to boost morale, the commission announced a program to foster quality at 100 key universities through additional funding for research and greater flexibility to reshuffle departments and form collaborations with other institutions and with the West.

In fact, academic science has improved to the point where education officials feel their institutions can compete evenly with CAS for the best talent. "If you want to do basic research, you should come to a university," says Vice Minister Wei Yu of the State Education Commission. "At a university you are always getting fresh blood as graduate students complete their work and a new generation arrives. At the institutes, people stay and they grow old."

Not surprisingly, CAS officials have a different view. "It's true that we need more young people, but only a third of the staff is fixed," says Wang. "The rest must compete for money to continue their work. In addition, I think the institutes generally have better facilities and a better working environment."

This interagency rivalry is also being played out in the debate over new large scientific facilities. While CAS officials lobby for their top projects (see p. 1139), Wei says that the government's first priority should be improved literacy for all. "I don't think we can afford to expand such large-scale fundamental research," she says. "There's only one bowl of money."

Regardless of the outcome of that debate, most Chinese scientists say the government is doing the right thing in setting priorities, concentrating resources on the highest quality science, and using peer review to help make those decisions. For the Chens of Shanghai's Rui-jin Hospital, it affirms their difficult decision to return home in 1989 after completing their graduate training in Paris. "It was right after Tiananmen," Chen Saijian recalls, "and our friends told us we were crazy what with everything that was going on. But we wanted to help in the modernization of China, and we need to be working here, in this place, to really help our people. And that's what we are trying to do."

–Jeffrey Mervis

STATE KEY LABS

Government Focuses Funds, And Hopes, on Elite Teams

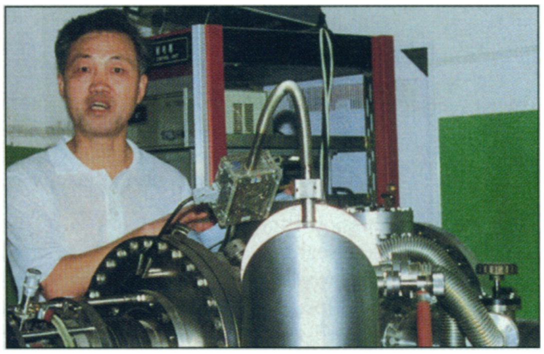
NANJING—Institutions in China customarily shut down for several weeks in the middle of the summer. But not the National Laboratory of Solid State Microstructures (LSSMS). On a muggy morning in late July, associate physics professor Hai Sang is preparing a sliver of cobalt-silver film to test for a phenomenon called giant magnetoresistance. Physicist Wang Guanghou is describing unusual new behavior he has observed in nanoscale clusters of germanium—properties that may have potential uses in optoelectronic devices. In an adjoining lab, two doctoral students from Taiwan are busy setting up an experiment. The hallways of the aging building, darkened to keep both the temperature and the electricity bills down, are plastered with reprints of dozens of articles lab researchers have published in *Physical Review Letters* and other top physics journals.

This buzz of activity is exactly what the Chinese government had in mind when, in 1984, it created a program of state key, or national, laboratories. The Nanjing lab was one of the first to be so designated. The program is intended to help a small number of labs break into the forefront of global science by funding them lavishly—at least by Chinese standards—and turning them into "open" facilities that can be shared by outside researchers.

Key labs receive a large initial grant, typically $1 million or more, to modernize their facilities. (In comparison, an average research grant is about $10,000 over 3 years and does not cover large equipment.) Over time, they are eligible for additional injections of funding to keep up with the latest technology. The labs are distributed unevenly throughout the country, with half in either Beijing or Shanghai, and the research is basic as well as applied, with topics ranging from oncogenes to coal combustion.

A decade into the program, Chinese authorities can cite several successes in the current network of 155 labs. At least a dozen, including LSSMS, are performing at a world level, and many are forging strong links with researchers and institutions overseas. But some Chinese researchers are concerned that the program's funds are being spread too thin, and that what was supposed to be a rigorous scientific review is not being used to weed out weak labs. Others say that many labs have failed to meet the promise of greater openness.

A key lab at the Chinese Academy of Sciences' (CAS's) Institute of Metal Research is widely seen as a success story. Situated in Shenyang, a gritty, northeastern city that is China's second-largest industrial center, the institute has carved out a niche with its key labs for material fatigue and for



J. KINOSHITA

Fine work. Wang Guanghou probes frontiers of atomic clusters with homemade machine.

"quick-solidifying nonequilibrium alloys" used in the aerospace industry. "This lab has few parallels in the U.S. or Japan," says Canadian materials scientist Stewart McIntyre, who reviewed the lab for the World Bank, which has made long-term, low-interest loans to about half of the current roster of key labs. Similarly, the high-performance ceramics and ultramicrostructure state key lab at the Shanghai Institute of Ceramics has won high marks for its work on nanoceramics.

Some first-rate key labs are also fulfilling their mandate to become truly national facilities—open to scientists from less endowed labs. The Institute of Physics in Beijing, for example, with its three internationally recognized key labs in magnetism, high-temperature superconductors, and surface physics, carries out joint projects with some 20 other institutions. The institute's scanning tunneling microscopes, superconducting quantum interference devices, and x-ray diffraction system are in constant use by visiting researchers.

Another key lab that appears to function well as a national lab is one on resources and environment information systems in Beijing. Part of the CAS's Institute of Geography, the lab was chosen in 1985 to serve as a national center to monitor floods, soil erosion, deforestation, and urbanization. The lab integrates data from every province and locality, as well as from LANDSAT, and provides advice on protecting ecosystems and developing flood evacuation plans. "We gave the evacuation plan for the Dongting Lake flood this year, so there was less loss of life than expected," explains director Zhou Chenghu with pride. The lab has also received several million dollars from foreign institutes and companies that commission projects.

Such labs, however, are still the exception. The National Natural Science Foundation of China (NSFC), which reviews the key labs on a 4-year cycle, gave only 11 labs a top rating in the latest round of reviews (see list). "The majority received B's," says NSFC chief Zhang Cunhao, "and a few got C's." But despite a stern warning from the State Planning Commission that "those labs whose research work and cultivation of talent are relatively poor" would have their grants cut and lose their designation as a key lab, not one of the handful of labs given a "C" has been bumped from the list.

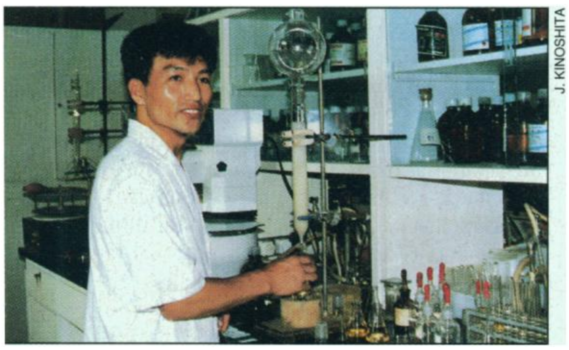
GRADE-A RESEARCH

Parent Institution	Title of laboratory
Nanjing University	Solid state microstructures
Qinghua University	Intelligent technology and systems
Xiamen University	Physical chemistry of solid surfaces
Zhejiang University	Computer-aided design and graphics
Jilin U. & Qinghua U., CAS Institute of Semiconductors, Beijing	Integrated optoelectronics
CAS Institute of Acoustics, Beijing	Acoustics, speech and signal processing
CAS Institute of Atmospheric Physics, Beijing	Numerical modeling for atmospheric sciences and geophysical fluid dynamics
CAS Institute of Biophysics	Biomacromolecules
CAS Institute of Metal Research, Shenyang	Fatigue and fracture of materials
CAS Institute of Technical Physics, Shanghai	Infrared physics
CAS Institute of Virology, Beijing	Molecular virology and genetic engineering

SOURCE: NSFC

Top marks. These 11 state key laboratories received the highest rating in the most recent performance review by the National Natural Science Foundation of China.

Part of the problem stems from the politics behind the proliferation of key labs. The number of labs has grown from 10 to 155, and "the number will certainly increase," says Ping Chang, chief of staff for the State Science and Technology Commission (SSTC). "Perhaps it will reach 200 in 5 years." That growth may be a response to pressure from universities, CAS, and various ministries to get their slice of the program's generous allocations. That pressure has also led to some questionable choices.



J. KINOSHITA

Pure learning. Outside funds give Shanghai's Materia Medica modern tools like this purifier.

The National Laboratory of Enzyme Engineering at Jilin University in Changchun, for example, "was not well conceived at the beginning," says a prominent academician who requested anonymity. "The original director was not a good scientist, but had good political connections." Still, the lab's initial poor performance did not pass unnoticed. The Jilin lab was given a warning after receiving a "C" grade in 1991, says Zhang Xuezhong, who was named director of the lab in June. Zhang says the lab was chastised for its "research methods" and "level of research results," and was instructed to narrow its focus and do more applied research.

Despite that unfavorable rating, the lab has kept its designation and its base funding. "The government wanted to give us a chance to improve," Zhang explains. And the new director believes the lab has learned from its mistakes. "We have made a lot of effort over the past several years, and we think we are now at an international level," he says. "I am confident that our next review will result in a B grade."

Some observers worry that such a mild approach could undermine China's efforts to develop world-class science. "Our budget was limited, so we originally decided to focus on labs that can do the best work and give them more money," recalls Kong Deyong, who was director general of the SSTC when the first key labs were launched. "But scientists tell me even that money is no longer enough," says Kong, who is now counselor for science and technology with China's mission to the United Nations. The current expansion, he adds, is a predictable result of the "Chinese character," which requires giving everyone a piece of the pie. "Every ministry wants to be involved," he says. "This always happens in China. At the beginning, it's very nice, but at the end ... oh!" he laughs.

Not only is the pie being cut up into too many pieces, but the pieces are not feeding enough people, some scientists say. Indeed, more than a few national labs visited by *Science* appeared to be underused, the costly equipment gathering dust, with barely any visitors. One reason, says the NSFC's Zhang, is that "each open lab gets only 150,000 yuan [$18,000] per year to support all outside users." The amount is not enough to handle more than a handful of groups. And few regular research grants provide money to visit and work at a state key lab.

But money isn't the only limiting factor. Another barrier is the traditional isolation of Chinese scientists. "Under the old system, every lab was closed," says Xu Zhihong, a vice president of CAS and former director of the national key lab of plant molecular genetics at CAS's Shanghai Institute of Plant Physiology. "And even now, students come to an institute and stay there for their entire career."

That lack of mobility may be starting to change, however. Last fall, for example, Dong Zhiwei, a 56-year-old oncologist, broke with tradition when he left a senior management position at the well-respected, municipally run Beijing Institute for Cancer Research, where he had worked for 20 years, to become director of Beijing's Cancer Institute and Hospital, a part of the Chinese Academy of Medical Sciences and the Ministry of Public Health. "It was an unusual career step," says Dong, "but I wanted to work on a larger stage."

The institute, funded by the Chinese Academy of Medical Sciences, is also home to a national key lab on molecular oncology, and one of Dong's first steps as director was to launch an international search for a successor to Wu Min, age 70 and a member of the CAS. Dong says that he was looking for a "younger, more active scientist trained in the West," and he screened more than 30 candidates. The institute, he says, is close to hiring a Chinese-born researcher with an impressive track record who is now working at the U.S. National Institutes of Health (NIH).

PHOTOS BY J. D. MERVIS

Talent hunt. Dong Zhiwei searched the world for a key lab director.

Dong hopes the prospective new director's modern scientific skills and his U.S. contacts will invigorate the lab's efforts to find the genetic origins of esophageal cancer and to isolate differentiation-inducing genes from human cancer cells. A collaboration with NIH is also in the works. But the key was making room for new blood. "It's not easy to convince an academician to step down," says a colleague of Dong who requested anonymity. "But Dong can be very persuasive, and he knows how to get what he wants."

In addition to greater mobility, scientists at the national labs also need to learn to cooperate better with their Chinese peers. As one Fudan University scientist who requested anonymity admits, "I prefer working with Western scientists because they treat me with more respect."

One key lab struggling with that problem is the Shanghai Institute of Materia Medica's lab on drug research. The group focuses on developing new drugs from traditional herbal medicines to treat cancers, cardiovascular disease, and neurological disorders. Its scientists use large-scale purifiers and Sun workstations to pore over computer-rendered molecules, studying how they bind to target receptors and enzymes. Despite a sophisticated approach to drug chemistry, researchers have fewer than two dozen assays available to screen compounds. And they prefer to collaborate with foreign drug companies rather than to develop new assays with other institutes in the same city.

Overseas firms have state-of-the-art technology and capital to invest, of course. But relying on them limits the development of science in China. "Most of the state key labs in our academy work quite well," says CAS's Xu. "But they focus on very narrow fields, and we need scientists from different fields to work together."

Because the key labs program has not broken down the interdisciplinary barriers in Chinese science, Xu and others in Shanghai recently organized a new type of laboratory, under the auspices of CAS, that would attract young scientists committed to multidisciplinary research. This lab, called the Shanghai Research Center for Life Science and known as the "Academy Center," is the nucleus for a larger network of state key labs and other life science labs known as the "Shanghai Center" (see p. 1147).

So far, the Shanghai Center has funded three joint projects, but one researcher admitted that the participating labs continue to work in isolation from one another. "Chinese labs seal off everything from other labs," he says. "They don't even like to add a word of acknowledgment of their collaborators. That's why I would rather collaborate with Western labs."

Although the Shanghai Center is still feeling its way, some hope it will serve as a model for other multidisciplinary research centers now being considered by SSTC officials. These would include a new center for condensed matter physics in Beijing, says Yang Guozhen, director of the Institute of Physics. "The state key labs are too narrow," he says, echoing Xu's complaint. "This center would combine several labs, mostly from our institute but also from other CAS institutes." Yang expects to get money from the CAS, SSTC, and the State Planning Commission.

Although Xu would like to see more such multidisciplinary efforts, he hopes that government leaders will apply lessons learned from the state key lab experience. "This time, the government needs to limit the number," he says. "The research centers should be more open than the state key labs, and they should focus on basic research." That philosophy, he says, is the best way to break down the Great Wall that has kept Chinese researchers apart for the past 50 years.

–June Kinoshita

BIG-SCIENCE PROJECTS

Reading the Tea Leaves in a List of Major Priorities

BEIJING—"Big science" presents a big problem for a country with grand scientific ambitions and limited resources. Large, cutting-edge scientific facilities are an essential requirement for some disciplines, but they can soak up pools of money that might be better spent on a larger number of projects with more direct impact on national problems. And choosing between competing big-science projects also pits different scientific factions against each other.

In China, these kinds of choices tend to be made behind closed doors by the central government. So last year, when the powerful Chinese Academy of Sciences (CAS) unveiled a list of big-science projects that it hopes to support before the end of the decade, researchers took it seriously. The result of months of deliberation, the list also provides a blueprint of sorts for the country's scientific future.

The list itself is a bit preliminary: The original, brief announcement of 10 projects actually mentioned only nine, and since then Chinese officials have said that at least one may be dropped and others may be combined. Still, the information obtained by *Science* about several of the projects points to bold intentions on several fronts.


J. D. MERVIS

Homegrown tokamak. Xie Jikang helped turn a Soviet model into a working fusion machine.

The catalog of big-science projects, including a new optical telescope, a new synchrotron facility and improvements to an existing machine, a new collider, and an upgrade of a tokamak fusion reactor, is weighted heavily toward the physical sciences. It also reflects what one Western scientist calls "the need to show one's virility" by building what other countries want or already have. At the same time, the list features facilities capable of making a unique contribution to global science, along with ones that will serve a growing base of users. And it represents a continued commitment to basic science at a time when most of the country's resources are devoted to applied research. In addition, the list assumes significant funding from sources outside the central government and envisions a major role for an international community of scientists to advise policy-makers on the merits of each proposal.

Although the projects are part of the country's new 5-year economic plan for 1996–2000, few details have been announced publicly. Each project appears to be following its own track through the Chinese bureaucracy, and there are conflicting accounts by scientists close to the process about the status of several of them. Officially, however, the list is still preliminary. "We have proposed them," says one CAS official, "but the state planning commission has not approved any of them. Until it is approved, it is not reality."

Elementary particles. Despite those words of caution, some projects are already moving ahead. Indeed, one item on the list, an eightfold expansion of a gamma ray detector built in 1990 at an altitude of 4300 meters in the Himalaya Mountains northwest of Lhasa, was actually completed this summer. The altitude of the array allows scientists to measure showers of particles, created when gamma rays hit the upper atmosphere, in an energy range—about 10 TeV—not currently well monitored by other arrays around the world. The government's decision to back the project was made easier by the fact that