ing 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.

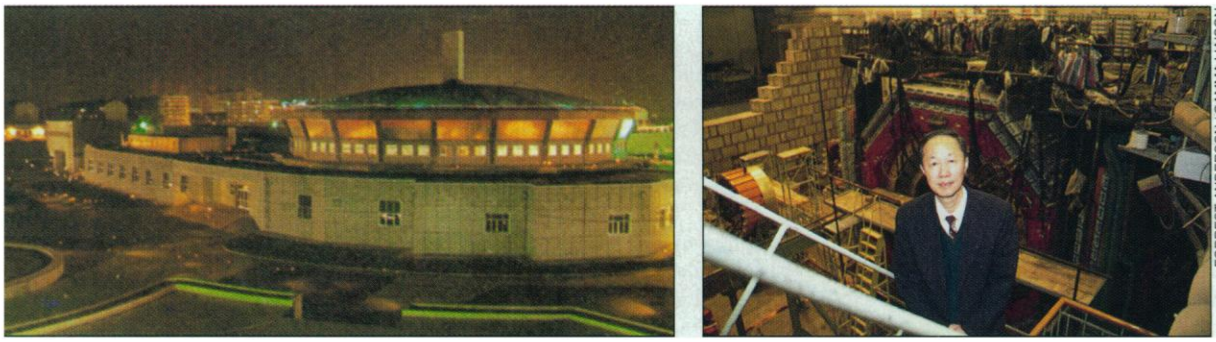
J. D. MERVIS

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 policymakers 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



FORREST ANDERSON / GAMMA LIAISON

Building blocks. Hefei's National Synchrotron Radiation lab *(left)* and Beijing's electron-positron collider, shown with its director, Zheng Zhipeng, are slated for upgrades.

several Japanese institutions put up most of the $2 million cost.

On the other end of the continuum, a proposal for a facility to study tau and charm particles at threshold energies of about 3 GeV is barely out of the starting blocks. A team is studying the feasibility of the proposal, which would involve building a ring adjacent to the Beijing Electron-Positron Collider (BEPC) at the Institute for High-Energy Physics (IHEP). A final decision on the new ring, which is being called BEPC3 to distinguish it from an upgrade already under way, is not expected for a few years.

Two important issues that policy-makers must address are the cost of the facility—estimates range from $120 million to $300 million—and the technical challenge of building such a powerful machine. Weighing in favor of BEPC3 is the fact that China holds a leading position in studying these subatomic particles based on recent work done at BEPC, and government officials are eager to retain that advantage. "The Chinese are the only people in the world doing this type of physics," says the University of Hawaii's Steve Olson, a member of an international team using one of the detectors at the Beijing collider, "and it's natural to build on this prominence to go to this next energy level."

Synchrotron sources. Somewhat further along in the approval process are plans for an advanced synchrotron light source, to be built at the Institute for Nuclear Research outside Shanghai. It is part of a broader plan to give Chinese scientists greater access to synchrotron radiation to conduct both basic and applied research across a range of fields.

China already operates two synchrotrons: a first-generation machine that operates as an ancillary facility to the Beijing collider, and an 800-MeV, second-generation accelerator at the University of Science and Technology of China (USTC) in Hefei. In fact, another project on the CAS list is a $12 million upgrade of the Hefei machine, which was built in the 1980s. The upgrade, already under way, is expected to add eight beamlines to the current roster of five and install superconducting magnets in several beamlines to provide more intense light.

The proposed new machine—called the Shanghai Synchrotron Radiation Facility—would operate at energy levels of from 2 to 2.5 GeV to provide a brighter source of synchrotron light for researchers in fields ranging from advanced materials to virology. Scientists refer to it as a 3.5-generation machine, to distinguish it from a dozen or so similar machines already operating or under construction around the world. Even so, "three machines are not too many for China," says Lee Teng, head of accelerator physics for the Advanced Photon Source at Argonne National Laboratory in Illinois and a member of the committee that will review its conceptual design and construction.

The proposed new light source also has one big advantage over the tau-charm factory: The Shanghai municipal government has agreed to put up at least half of the estimated $100 million to $150 million cost of the facility. "The economic boom has made Shanghai rich," notes Teng. "The city of Beijing, on the other hand, can't afford to help with [the upgrade of] BEPC."

Astronomy. The main astronomy project on CAS's list is actually the product of a long process of priority-setting within the astronomical community. Astronomers drew up their own list of 10 projects, later pared to four, before throwing their support behind a new high-tech, 4-meter reflecting Schmidt telescope with one fixed, spherical mirror and a second, adjustable flat mirror. The project, known as LAMOST (Large Sky Area Multi-Objects Fiber Spectroscopic Telescope), would survey a larger portion of the sky in more detail than ever before, collecting spectral information on millions of objects—galaxies, quasars, and so on—of interest to astronomers around the world.

J. KINOSHITA

Home focus. Cui Xiangqun has returned to help build LAMOST telescope.

LAMOST would cost about $12 million, a low price made possible in part by keeping the optical axis of the telescope fixed and by using a cluster of small submirrors rather than one large mirror. Its combination of 4000 optical fibers, 5-degree field of view, and relatively large collecting surface, notes coleader Chu Yaoquan, a USTC astrophysicist, would make it the most powerful instrument in the world for spectroscopic observation, allowing it to see farther, and with greater precision, within a region of 20,000 square degrees. "LAMOST is the next step" after the Sloan Digital Sky Survey, says Princeton University astronomer James Gunn, an investigator in the $30 million telescope project in New Mexico that hopes to see first light next spring and run for 5 years. "It's a much bigger instrument," he adds, "and I suspect we will be collaborating with them."

The telescope would also give China a chance to enter the big leagues of mirror fabrication. Indeed, that opportunity lured Cui Xiangqun home this year to the Nanjing

AN ACADEMY WISH LIST OF BIG-SCIENCE PROJECTS

Project	Location	Description
Tokamak upgrade (HT-7U)	Institute of Plasma Physics, Hefei	Upgrade of Soviet model with superconducting magnets
Optical telescope (LAMOST)	Xinglong Station, Beijing Astro. Observatory	New 4-m Schmidt telescope for large sky survey
Shanghai Synchrotron Radiation Facility	Institute for Nuclear Studies, Shanghai	3.5-generation facility at 2- to 2.5-GeV energy range
Cosmic ray array upgrade	Yangbajing, Tibet	Eightfold increase in collecting area
Tau-charm factory (BEPC3)	Institute for High-Energy Physics, Beijing	Accelerator for quantities of tau-charm particles
National synchrotron radiation lab upgrade	Univ. of S&T of China, Hefei	Upgrade of 800-MeV machine, plus eight new beamlines

Astronomical Instruments Research Center from the European Southern Observatory in Munich, Germany, where she had helped to design the Very Large Telescope now under construction in Chile. "This was exciting enough for me to come back," says Cui. "We hope this instrument will allow China to make a contribution to the world." The new telescope would also require China to train a cadre of engineers, computer scientists, and other professional staff needed to design and operate its active optics system. Such a talent base, say officials, would serve as a magnet for other projects.

Plasma physics. Not every community is as well organized as the astronomers, however. In the area of plasma physics, CAS has endorsed a proposal to upgrade a prototype Soviet-built superconducting tokamak that went into operation last year after being completely retooled by scientists and technicians at the Institute of Plasma Physics in Hefei. But the central government has also received proposals to build tokamaks from institutes not under CAS's jurisdiction, including one from the Southwest Institute of Physics in Chengdu, run by China's National Nuclear Corp.

The Hefei tokamak, known as HT-7, operates at temperatures and pressures well below Western machines. However, the upgrade would allow it to operate at relatively long pulses, measured in minutes. That capacity, says plasma physicist Alan Wooten of the University of Texas, would allow researchers to study long-term phenomena, such as the interaction between the plasma and the material lining the wall of the tokamak, that must be understood before scientists can hope to generate power from a fusion reactor. "It's basic research," says the institute's deputy director, Xie Jikang, "but we think fusion energy is very important to China's future."

Whatever projects are finally approved, it seems clear that scientists are playing a larger role in the decision-making process than in years past, when the only people who mattered were a few senior officials. It's not that the bureaucrats have disappeared: Chu recalls a meeting at which state officials insisted that LAMOST must be built within 5 years so that it could fit within the Ninth 5-Year Plan, despite compelling scientific arguments that it would take at least 7 years. A compromise was reached when the researchers agreed to divide the project into two stages, with the funding distributed over two 5-year plans.

Although scientists are happy to be consulted, their participation does have a downside. "Ten years ago, Deng Xiaoping made the decision to build BEPC," says Zheng Zhipeng, director of IHEP. "But for BEPC3 we have to convince the entire scientific community in China to support us. ... I am spending a lot of my time trying to persuade people."

–Jeffrey Mervis

ELECTRONIC NETWORKS

Scientists Hope Competition Will Improve Internet Access

Before there was e-mail in China, a problem with the ion accelerator at Fudan University would have meant waiting several months for a technician to come and diagnose the problem. But last July, when their U.S.-built machine suddenly stopped working, physicists sent out an electronic call for help. "The next day, we got 10 replies," recalls Yang Fujia, the university's president, "and we were able to fix the machine ourselves."

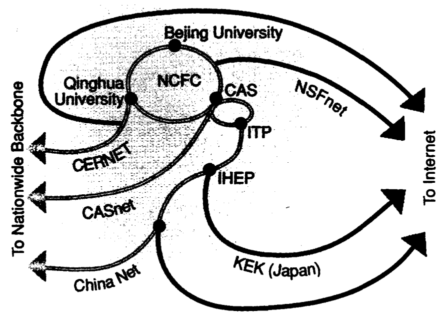
The information age is taking China by storm. "In April 1994, when China got its first direct Internet link, there were about 1000 users in China," says Hao Xin of the Computing Center at the Institute of High-Energy Physics (IHEP). "I think there are more than 10,000 users now." A half-dozen government agencies, plus a fast-growing number of private companies, have plans to set up networks and services for the globe's largest pool of potential users.

These efforts are weaving Chinese science into the global fabric of research. While the garment is certain to grow, some scientists worry that squabbling among government bureaucracies for control of an inherently anarchic institution is holding back development. But others say the intense competition may in fact speed up the pace of network-building and improve service.

As in other countries, particle physicists have been the bushwhackers of the Internet. IHEP in Beijing, site of China's electron-positron collider, set up its own local-area network in 1988 with dial-up links overseas, and last year acquired a direct, 64 kilobit per second (Kbps) fiber-optic link to the high-energy physics lab (KEK) in Tsukuba, Japan. "IHEP users can do most of the things that U.S. Internet users can do," says Hao, including file transfers and Web browsing (**http://www.ihep.ac.cn/ihep1.html**).

Until recently, IHEP provided China's only Internet access. But now options are multiplying fast. CASnet, run by the Chinese Academy of Sciences (CAS), links 30 of its institutes in northwest Beijing with a 64-Kbps connection to the U.S. National Science Foundation's NSFnet, and hopes to connect six of 12 provincial CAS centers by the end of the year (**http://cnc.ac.cn/cas/cas.html**). The Ministry of Post and Telecommunications is fast completing its countrywide ChinaNet that will connect all of mainland China's provinces and regions (**http://www.bta.net.cn/**).

One of the most ambitious projects is the China Education and Research Network (CERNET). Launched last year with funding from the State Education Commission, CERNET has set an ambitious goal for the year 2000 of linking China's 1090 universities, as well as 200,000 primary and secondary schools. Managed by the National Network Center at Beijing's Qinghua University, CERNET is nearing completion of its 128-Kbps backbone joining nodes in Beijing, Shanghai, Guangzhou, Nanjing, Xian, Wuhan,



Net gains. Several institutions are scrambling to connect Chinese researchers.

Chengdu, and Shenyang. It also hopes to link 100 key universities by the end of this year (**http://www.cernet.edu.cn/**).

In practice, however, there remain vast gaps in access. Qinghua University began its campus network 5 years ago and now has nearly 4000 computers on an optical fiber network, and Beijing (**http://www.pku.edu.cn/**) and Fudan universities also have good campus networks. But many key universities are barely out of the starting gate. At Beijing's Capital Normal University, says a visiting U.S. computer expert, "people's notion of a network is connecting their computer to a printer." At Zhongshan University in Guangzhou, southern China's leading university, only the president's office had e-mail access as recently as this August.

Can these lagging universities catch up? The answer, not surprisingly, depends on whether they are willing to spend what it takes. "The State Education Commission provides seed money only," explains Li Xing, a Qinghua professor and member of CERNET's technical board. "Each university has to find its own way to fund its campus network and link [to the regional CERNET node]."

It is also not clear how soon the average bench scientist will have access to the Internet's full power. "We use e-mail, but we don't have enough workstations, so not everyone can use it," says Gao Lian, deputy director of CAS's Institute of Ceramics in Shanghai.