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."

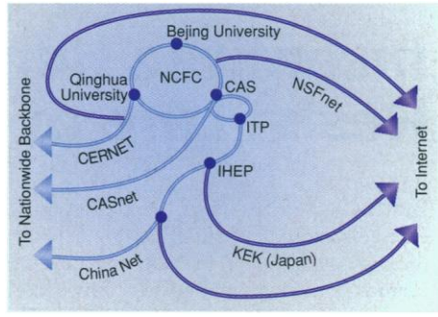
The information age is taking China by storm. "In April 1994, when China got its first direct Internet link, there were about 1000 users in China," says Hao Xin of the Computing Center at the Institute of High-Energy Physics (IHEP). "I think there are more than 10,000 users now." A half-dozen government 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.

"Also we can't use it to transfer data files." Another impediment is the narrow bandwidth of the existing network backbones and international links. At IHEP, users can do almost everything except read Usenet news—not because of censorship, says Hao, but because "that would put too much load on the 64-Kbps link."

Some policy-makers blame the problem on the inefficient use of resources. "We have too many networks," complains a senior official. "One would be enough. The problem is to raise the capacity. If the speed is slow, what is the good of having all these networks?"

But the case of the National Computing and Networking Facility of China suggests that competition can also lead to progress. The CAS narrowly outbid Qinghua University for the project, an $8.4 million, World Bank–supported effort to finance China's portion of the global Internet. Poor management, according to a former employee, has stalled the purchase of a supercomputer needed to do the job, and its national backbone now exists only as a triangle in northwestern Beijing that links CASnet and Beijing and Qinghua universities. But with competitors such as CERNET and ChinaNet racing to complete their nationwide backbones, CASnet is now rushing to extend links to other cities as well. "Before, CASnet had no intention to connect anybody," says the former employee. "Competition has surely changed them."

The Internet craze is also causing people to make end runs around rules restricting global connections to a few national agencies and "landing points" to Beijing and Shanghai (with Guangzhou under consideration). Several regional networks have already sprouted, using leased telephone lines.

With Internet access becoming a part of everyday life for scientists, any attempts to limit access seem doomed to fail. "The official story is that the government wants control," says Chin-Tu Chen, a medical physicist at the University of Chicago who swaps data with colleagues in Beijing. "But technology-wise, that's no longer easy. Everyone I know can use the Internet freely."

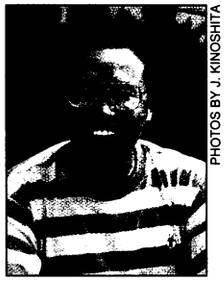
–June Kinoshita

YOUNG SCIENTISTS

Incentives Help Researchers Resist Lure of Commerce

BEIJING—Perhaps it's no accident that the emerald-colored mirrored glass that sheaths the soaring office tower in the south China economic boom town of Shenzhen shines like a precious jewel. It's the most prominent feature in the region, which embodies the get-rich-quick philosophy that has drawn thousands of scientists unwilling to pursue a long, arduous, and financially unrewarding path to glory. "I wanted him to go to America to study, but he says that doing research is too hard," recalls Qian Yitai, a chemistry professor at the University of Science and Technology of China (USTC) in Hefei, about one promising student. "Now he manages a McDonald's restaurant in Shenzhen, and he's made enough money to go to America three times as a tourist."

But for every tale of talent lost to mammon, there's a countervailing story of a promising researcher returning home. This past July, for example, nearly 1000 young Chinese scientists—many from elite institutions in the West—gathered at Qinghua University in Beijing. For 4 days they networked, discussed their research, and explored the exciting opportunities offered by the fast-evolving world of science in China.



PHOTOS BY J. KINOSHITA

Rising stars. Chemist Zhao Xinsheng, *(top)* and paleontologist Sun Weiguo are on the fast track.

These changes are pressing on a generation of Chinese scientists in their 30s and early 40s. In every discipline, economic forces are separating wheat from chaff, directing talents to where the money is. Top students flock to computer science, which feeds China's sizzling software industry, while funding for basic research is restricted to the most gifted and enterprising scientists. It's a sharp break with the past, when the state parceled out tiny amounts to everyone. But it feels right to Zhang Cunhao, president of the National Natural Science Foundation of China (NSFC). "The market economy is really working," he declares with a broad smile.

One of the most important forces for change is a demographic shift in Chinese science. There's a yawning void in the ranks of middle-aged scientists left by the Cultural Revolution, which disrupted most learning from 1966 to 1976. And the looming retirement of thousands of senior scientists as they reach the age of 60 is expected to clear the way for younger scientists. For example, an informal survey of institutes belonging to the Chinese Academy of Sciences (CAS), in fields ranging from paleontology to plasma physics, found that 50% to 90% of senior professors will retire by the year 2000. Although only half as many young people will be hired to replace retirees (in order to shrink the overall size of institutes), they will enjoy a larger share of research funds.

The nagging question is whether younger scientists, many of whom now work in the West, will throng to the newly available jobs. The answer varies. China's top institutions, for example, still seem to have their pick of talent. "Last year, we had 74 graduates who went abroad and 48 who came back," says Yang Fujia, a physicist and president of Fudan University in Shanghai, one of China's leading universities. "My first Ph.D. student says Fudan gives him better opportunities than any other place." At the Beijing Electron-Positron Collider, one third of the 40 postdocs are returnees who found the climate for particle physics better in China than overseas.

Location is another important factor. Just being in an out-of-the-way place can be enough to tip the scales against a top-flight institution. "In the past 2 years we have lost eight professors in a 25-person department," says mathematician Feng Keqin, vice president for research at the USTC, about 400 kilometers west of Shanghai. "They want to go to the big cities."

And jobs go begging in fields such as the life sciences, where China still lags. "Work conditions and living conditions are not attractive," says Mang Keqiang of the CAS Institute of Microbiology in Beijing. "Only 2% of my students have come back [from abroad]. It will take us 10 to 20 years to get a critical mass." Virtually every other director of a life sciences institute interviewed by *Science* echoed Mang's lament.

Prospects look particularly bleak for those just starting their careers. Li Guoxiang, a doctoral candidate at the CAS Institute of Geology and Paleontology in Nanjing, tells a typical story. "I entered university in 1984, at a time when there was little difference in salary from job to job," he says. "But when I graduated, I found I had made a big mistake!" Wages in China's growing commercial sector were rising fast, while academic salaries remained frozen. While Li ekes out a living on $30 to $40 a month, a 21-year-old taxi driver flagged down by the front gate of the institute says her monthly take is $750.

A talent bounty. Government officials are concerned about the plight of budding scientists, but their ability to correct the situation is extremely limited. Two years ago,