

BIG Science in a BIG Country

China is a land of scientific opportunity, with energetic young researchers and a government that is delivering on its commitment to research and development funding. Chinese students and scientists with international experience are beginning to feel that the best job opportunities are at home. The research environment is in flux, however, as booming numbers of new Ph.D.s seek training and jobs, and discussions about funding and evaluation raise questions about the quality of Chinese research. In a large country with many voices, the government, the academic community, and grassroots groups all have ideas and advice for young scientists.

By Chris Tachibana



Although their training may be shorter compared to U.S. graduate students, Chinese students are generally less distracted by outside activities and their reputation for being hard workers is well founded.—Chen Deliang



Wang Jun

PHOTO COURTESY OF BGI

Wang Jun is a science rock star. At age 35, he has 100 peer-reviewed papers, with greatest hits that include the panda and pig genome sequences. Even before his 2002 Peking University Ph.D. thesis won a national award from the Ministry of Education, he helped found BGI, a nonprofit genomics services and research organization with more than 3,000 employees, where he is now executive director. Wang is officially a professor at two Danish universities, but his home base is BGI headquarters in Shenzhen, near Hong Kong, where he pursues “creative, collaborative, big science.”

In Beijing, another rising star is setting up her laboratory in the brand-new Medical Science Building at Tsinghua University, which is considered to be one of China’s top academic institutions. **Shen Xiaohua** turned down an attractive tenure-track faculty position at the University of Michigan, accepting instead an offer from **Shi Yigong**, who left Princeton University in 2008 to become dean of life sciences at Tsinghua University. Shen said when she was looking for faculty positions she compared the research programs of her peers in China and the United States. “In the long run, I felt I could do better in China,” she says. “I don’t feel limited by funding, manpower, or brainpower.” Shen has a Ph.D. from the University of Michigan and postdoctoral experience at the Dana-Farber Cancer Institute and Harvard Medical School, but does not see her top

undergraduate students following in her footsteps. Some who had planned to study in the United States are now deciding to stay and train with China’s top scientists at Tsinghua. “Especially for stem cell research,” she says, “the students think they can do more in China because of restrictions in the U.S. And people are coming back,” she adds. One of her technicians has a Master’s degree from the United States and years of project management experience, but returned to China to join the Shen lab.

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OPTIMISM AND CRITICISM

One attraction for returning Chinese scientists like Wang and Shen is the relatively promising financial outlook. After the United States, China has the second largest economy in the world, and the second highest investment in research and development. Science and technology spending has increased every year, even through the recent global economic crisis. In 2006, the government announced a 15-year science and technology development program, with plans to invest 2 percent of gross domestic product in research by 2010 and **continued »**

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2.5 percent by 2020. (It was 0.7 percent in 1998.) **Cong Cao**, associate professor, School of Contemporary Chinese Studies at the University of Nottingham, says that China is slightly behind on the 2010 benchmark, but on track to meet the 2020 goal.

China is transitioning from a labor-based economy to a high-technology and innovation-based economy, and this contributes to a positive scientific environment, says Professor **Paul Kwong Hang Tam**, pro-vice chancellor and vice president of research, University of Hong Kong. Science and technology are national strategies in the

government's recent five-year plan, so Tam says "the overall picture is optimistic for young people who are well trained, motivated, and want a career in science in China."

In fact, in 2011, the Chinese government launched the Young Thousand Talents program, attracting scientists under the age of 40 to China with a high salary and up to \$450,000 in research funding over three years. Both Chinese citizens and non-Chinese are eligible, as long as they have a Ph.D. in natural sciences or engineering from an internationally recognized university, at least three years of research experience, and are willing to work full-time at a Chinese university or research institute. The program extends the Thousand Talents program, which in 2008 began recruiting established scientists under the age of 55 with a \$150,000 signing bonus and generous salaries and startup packages—this is what brought Shi to Tsinghua University.

Along with the impressive plans and big numbers, however, are concerns expressed by the international and Chinese scientific communities about the funding, evaluation, and training of Chinese researchers. Three major challenges facing young Chinese scientists are a funding system that tends to value connections more than innovation and ideas; a push to generate Ph.D.s and publications that could compromise quality and hurt the reputation of Chinese science; and a desire for training and international experience that does not match opportunities.

In a controversial 2010 editorial in *Science*, Shi and his colleague Rao Yi called for changes in the Chinese research funding system. They said that an investigator's connections with the right bureaucrats matter more than project merit, especially for million-dollar-plus megaprojects. They feel this results in wasteful spending and stifles innovation.

And they are not the only voices. Sciencenet.cn bloggers like Cao have long called for systemic science policy reforms. The Chinese government itself is concerned about getting a good return on the country's research investment as well as being



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PAUL KWONG HANG TAM (LEFT FRONT) WITH COLLEAGUES

able to assure taxpayers that science and technology dollars have been well spent. These pressures might result in reform, for scientists who have patience. In the spring of 2011, both Premier Wen Jiabao and Minister of Science and Technology Wan Gang stated a need for policy changes to make science spending more efficient, including making the competition for grants more open and transparent.

QUANTITY AND QUALITY

Another issue raised by analysts within and outside of China is the rapid growth in all levels of higher education, from Bachelor's degrees to Ph.D.s, prompted by the 15-year plan. China is not the only country that has increased the number of Ph.D.s granted, but Cao says that especially in China, "expansion has affected quality." The top schools have excellent advising, he says, but at second-tier schools, the Ph.D. mentors may not always be qualified to supervise students, and only 20 to 30 percent have a Ph.D. themselves. Also, although Chinese students get a rigorous undergraduate education and most have a Master's degree before starting a Ph.D., Cao feels that the three-year Ph.D. program is too brief for sufficient training.

To raise the quality of advising, graduate programs are beginning to introduce committee-based supervision. Another measure might be to bring in outside examiners from well-regarded universities. In general, however, new Chinese Ph.D. graduates might need more postdoctoral advising than U.S. graduates. "Some are ready to be independent investigators, but many are not," says **Chen Deliang**, associate professor at the Graduate University, Chinese Academy of Sciences (GU-CAS) in Beijing, and a former postdoc at the University of California, Irvine. From his office, Chen has a bird's-eye view of both Chinese **continued »**



Chen Deliang

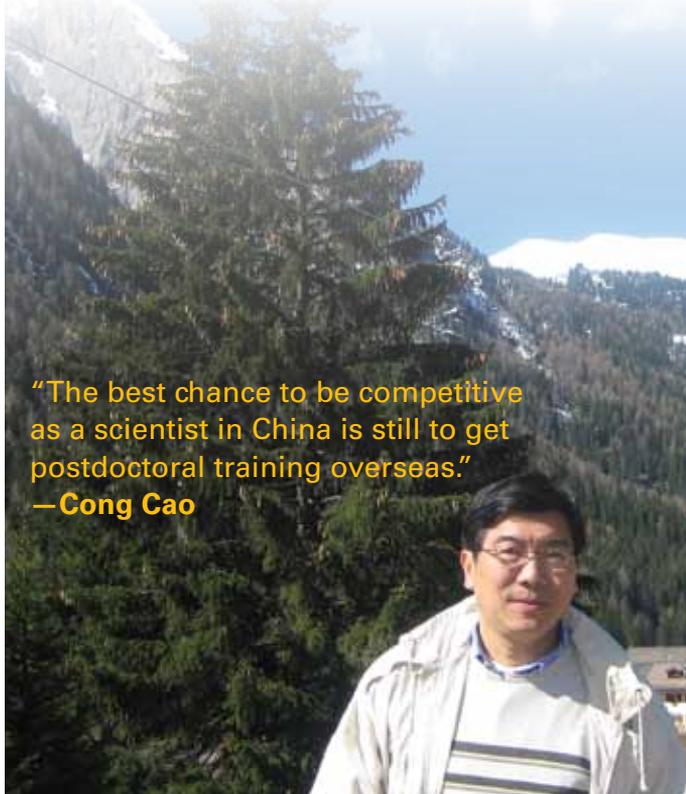


PHOTO PROVIDED BY CONG CAO

“The best chance to be competitive as a scientist in China is still to get postdoctoral training overseas.”
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graduate education and the GUCAS campus, with its winding roads, green lawns, and outdoor table tennis area. Each year, approximately 8,000 science graduate students arrive at GUCAS from all over China for an initial year of training before continuing at another institute or university. In addition to an intensive introduction to their field, the students have a chance to socialize and create a lifelong network of colleagues and collaborators. Although their training may be shorter, Chen says that compared to U.S. graduate students, Chinese students are generally less distracted by outside activities and their reputation for being hard workers is well founded. Says Chen, “The graduate students here are in the lab morning and night.”

HOME AND AWAY

After graduating, new Ph.D.s who stay in China may find that postdoc salaries are low compared to other countries, and housing costs in major cities are high. This makes working abroad attractive for financial reasons, and in addition, international experience is highly valued. Says Cao, “The best chance to be competitive as a scientist in China is still to get postdoctoral training overseas.” This is not always easy, however. In 2008, researchers at Duke University, Harvard University, and the University of California of Berkeley conducted a nonrandom survey of international students in the United States that included 229 from China and Hong Kong (scim.ag/oHphK4). The study found that 61 percent of the Chinese students knew at least three people back home who wanted to study in the United States but couldn’t, mainly for financial reasons. However, although the Chinese students praised their U.S. training and recommended it to their peers, 52 percent still felt the best job opportunities were in China.

Those working abroad might still face difficulties, though, either in their new country, or when they come home. **Qin Hao** did Ph.D. work with BGI’s Wang, which brought her to Denmark in 2005. She has been a postdoctoral fellow at the University of Copenhagen since 2010, but still feels she needs more international experience before seeking a job. “It’s not easy to find a really good job in China after only one postdoc. I need more experience and recommendations to get funding.” Hao is in a bit of a bind, though. She worries that she needs connections to get grants in China, but has a hard time getting funded in Denmark as a foreigner.

Finally, Chinese researchers at home or away face global concerns about their science that are rooted in the country’s evaluation system. As discussed in articles from the *Lancet* to the *New York Times*, promotions and pay rely heavily on the number of publications a researcher has and the impact factors of the journals. China now publishes more papers in international journals than any country except the United States, but this has led to questions about the quantity versus the quality of Chinese publications. Examples of misconduct and plagiarism driven by the push to publish have influenced how the worldwide community views Chinese science. Anecdotes of manuscripts with Chinese author names being automatically subjected to extra review for language or content are not uncommon. “It’s a big problem,” says Cao. “Because of a few cases, people wonder what kind of science is happening in China.”

BOTTOM-UP AND TOP-DOWN SOLUTIONS

China is responding to these challenges to its young scientists. As expected for a country that is big in geography, population, and ideas, the solutions come from many sectors. One organization dedicated to improving, promoting, and popularizing science throughout China is the China Association for Science and Technology (CAST). Founded in 1958, its more than four million members belong to academic and professional societies that are part of CAST. One goal is meeting the needs of Chinese scientists who seek experience, guidance, and networking. “CAST surveys show that scientists in remote regions say it is hard to get opportunities to go to training courses or international meetings,” says **Donghong Cheng**, executive secretary and vice-president, “so CAST encourages community education by our member societies to meet local needs from the bottom up. We facilitate and support training courses by local scholarly societies for new graduates.” China is a big country, she says, so another important function of CAST is fostering interactions between scientists at large, nationally known universities, and researchers working at smaller local institutions.

Cheng feels the solution to the boom in Ph.D.-level scientists is not to limit the degrees granted, but to improve education and training. “The Chinese culture has a high respect for education, **continued** »



Donghong Cheng

PHOTO COURTESY DONGHONG CHENG

and families want their child to have a Ph.D., and will invest almost every coin they have in their child's education, so we can't say that we won't provide that opportunity. Instead, we need to improve the quality of higher education to meet and guide the demands of society for high-quality human resources and help graduates find jobs." To encourage young researchers, CAST gives an award every other year for talented young scientists, and five years ago, started an annual award for young women scientists, funded by L'Oréal (China) as an extension of the L'Oréal-UNESCO Women in Science Partnership. Although awards for young scientists usually have an under-40 age requirement, the age for the L'Oréal award was recently raised to 45. "We did this to encourage women to return to their science career after maternity leave," says Cheng.

Other new opportunities for young scientists are coming from corporations and nonprofits, which are not currently major funders of research and training. BGI has a joint undergraduate program to educate students in multidisciplinary genomics work. **Huang Xiaojuan**, director of Educational Cooperation and Exchanges at the BGI Education and Training Department, explains that the program started in 2009 with the Southern China University of Technology as the first academic partner. The approximately 100 students in the program now come from more than six universities. Participants are considered students at their home university, but live at BGI employee dormitories in Shenzhen while they are trained in bioinformatics and genomics and gain general research and development experience. BGI is now setting up graduate programs with international partners such as the University of Copenhagen and the Chinese University of Hong Kong. Huang and her husband both trained in the United States, but a sense of opportunity and potential brought them back to China.

Young scientists might look to Hong Kong for opportunities. "Hong Kong is a small place but we provide an international perspective," says University of Hong Kong's Tam. "We're transforming from a three-year to a four-year undergraduate curriculum, so the university is recruiting an additional 20 to 25 percent academic staff." Hong Kong researchers are now eligible to apply for some Chinese state grants, says Tam, which should result in more opportunities for exchange and collaboration between Hong Kong and mainland China.

FAMILIAR ADVICE IN TIMES OF FLUX

The Chinese scientific landscape has both promising heights and problematic low points but reassuringly, experienced

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	The University of Nottingham www.nottingham.ac.uk

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scientists all point young researchers in the same direction. Says Tam, "the most important thing is to follow one's passion but be prepared for changes. Some people may take the academic pathway and some may choose industry, business, or administration, but just enjoy your work, and take opportunities as they come along. It's a great moment to be in science and we need more young scientists."

CAST Vice-President Cheng also advises students that first and foremost, they must be committed to science. Then, she says, "there's no right or wrong way to start your career. Different people have different opportunities, skills, and starting points." Science is without borders, she says, but Chinese scientists have a unique potential for worldwide impact. "We have the biggest population in the world, so Chinese development contributes to global development. It's all one mission: not two sides of a coin, but only one."

The young science stars Wang and Shen, as you might expect, have an even more universal perspective. At BGI, where a bold attitude is valued and the idea of Chinese scientists as followers instead of leaders is considered outdated, Wang advises learning to work in English, and aiming high. "Pick the best and most high-impact projects, select the best team, and be collaborative and creative. Dare to say and do what you think is most important. Students should not be shy."

At Tsinghua University, Shen looks back on her first year back in Beijing and remains bullish on Chinese science. So far, she has found the system to be more fair and honest than she expected from media descriptions. She still encourages students to go abroad at some point, though, just to have the experience. Her advice to young researchers—"Don't stay in one place"—could just as easily be given to her international colleagues, who are increasingly being invited to follow the rising star of Chinese science. At GUCAS, Chen encourages visitors to come to China, not just to exchange scientific ideas, but also for the cultural opportunities and personal experience. He says, "Just as we go to the U.S. and other countries, we want researchers and students from all over the world to come here."

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