a theoretical physicist at the Chern Institute of Mathematics, Nankai University, Tianjin, as more high-quality submissions are sent to overseas journals, the quality of submissions to local Chinese journals declines, which lowers the impact of the local Chinese journals. This becomes a vicious circle because the lower the impact, the less likely these local journals are to get high-quality submissions[2].

Setting agendas

Research priorities in developing countries may be very different from those in developed nations, but as science becomes more globalized, so too do priorities. At the national level, developing countries' research priorities increasingly resemble those of the developed nations, partly as a result of international competitive pressures. For example, after the United States announced its National Nanotechnology Initiative (NNI) in 2001, Japan and nations in Europe followed suit, as did South Korea, China, India and Singapore. According to a 2004 report by the European Union[3], public investment in nanotechnology had increased from €400 million (US$630 million) in 1997 to more than €3 billion in 2004.

In their words

Researchers and businesspeople in China, expatriates and 'returnees' give their views of what it will take to make China a research and innovation powerhouse.

CHINA

Ling-An Wu
Professor, Institute of Physics, Chinese Academy of Sciences, Beijing

Fix the gender ratio

When I returned to China in 1962 I was impressed by the equality of men and women in society. Even during the 'Cultural Revolution' there was no prejudice against women, although political discrimination was routine. The reforms of the 1980s opened a new era for science, yet contrary to expectation female scientists have not fared so well. In physics the situation is particularly discouraging. Formerly, 25% of the research staff at our institute were female, but that has dropped to 14%, while the percentage of women full professors has fallen from 17% to 7%. In the physics department of Tsinghua University in Beijing, the percentage of retired female full professors is 19% whereas that of those currently employed is 8%.

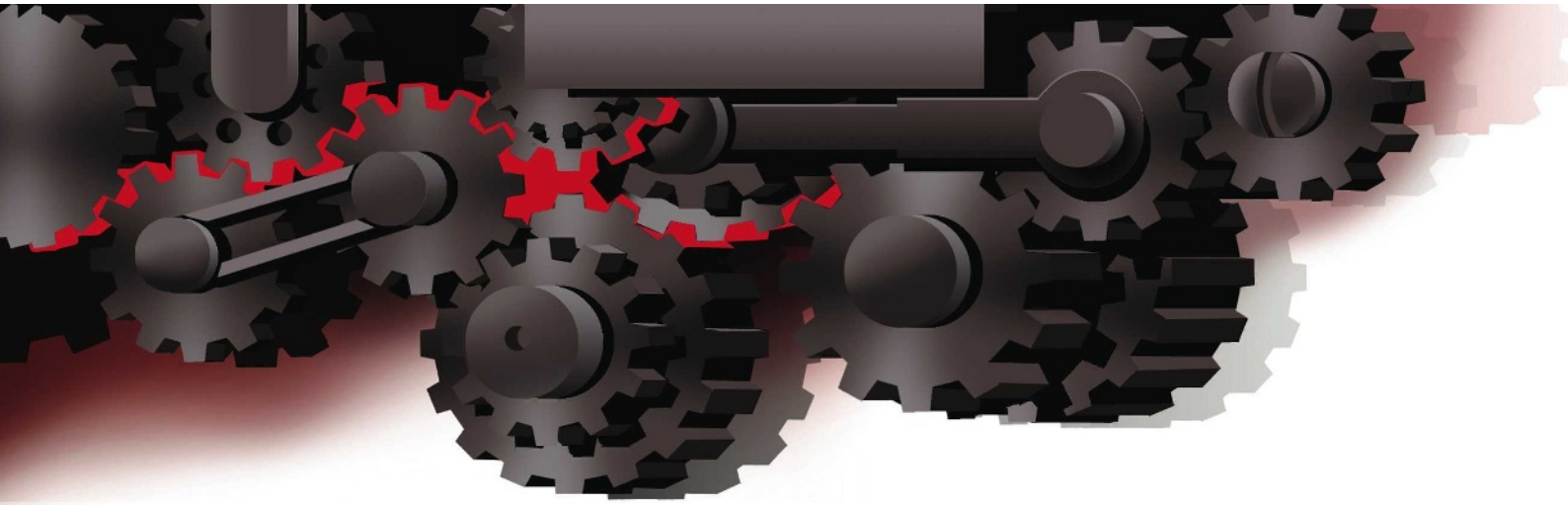
Discrimination now menaces both younger and older women: some employers openly declare that only male applicants need apply, while many institutions force women of associate professor status to retire at age 55; their male counterparts can retire at 60. The current (predominantly male) leadership is not concerned with the statistics. It is true that the number of female postgraduate students has risen, but the chief reason is that job discrimination everywhere is pushing them to seek higher degrees. Will this new generation be able to find their way to the top in China, or will they pursue better opportunities abroad, or just be wasted along the leaky pipeline?

Wolfgang Hennig
CAS-MPG Partner Institute for Computational Biology, Shanghai, China and Johannes Gutenberg-University Mainz, Germany

Overhaul education

My first experience of China was in 1985 and since then I've taught in the Chinese Academy of Sciences in Shanghai and elsewhere on behalf of the Max Planck Society, the German Academic Exchange Service and the Chinese Academy of Sciences to improve biological sciences training for Chinese students and to create contacts with European students. So, it's a good time to ask what has changed in China in two decades. The obvious answer is everything — from the thousands of bikes now replaced by air-choking cars to the boost in funding and the focus on science and technology.

Still, what has not changed during the past 20 years is the educational approach in China. It is based on memorizing and reproducing knowledge rather than on developing one's own initiative, critical thinking and originality. Postdocs trained in China rarely show the ability to work independently or demonstrate creativity in the selection of and approach to research subjects. While I had excellent Chinese students in the past, educated in my lab in the Netherlands, today many of the highly qualified students move into commercial fields through business schools and management courses. Making money has become the major attraction in China and this has severe consequences at the university level: basic research is not considered as important and attractive as it had been. Considering the living conditions of most students — dormitories still house four to six students to a room without heating or air conditioning — one can understand this desire.

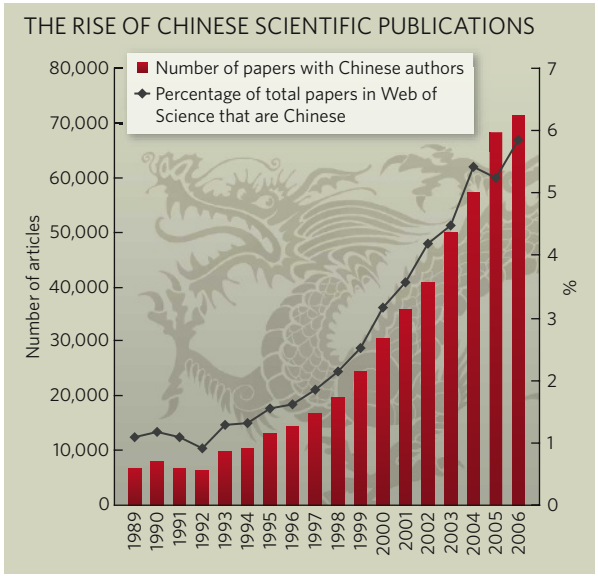


Part of the pressure to jump on the international bandwagon comes from researchers themselves. Scientists in the developing world maintain communications with those elsewhere. It is only natural that they want to share the attention that their colleagues in the developed Western world and Japan are receiving by pursuing the same hot topics. The research is exciting, fast-moving and often easier to publish. At the same time, there are many other crucial challenges to be met in developing countries. For example, public health, water and food security, and environmental protection all beg for attention and resources. If people perceive these research areas as less intellectually challenging and rewarding, the issues will fail to receive the resources, support and recognition they require. Without better agenda-setting practices, the scientific community will continue to face stinging criticism. It can send a satellite to Mars but not solve the most basic problems that threaten millions of lives in the developing world.

The introduction of Western scientific ideals to the developing world can generate an environment that is hostile to the indigenous research that prima facie does not fit those ideals. The confrontation between Western medicine and traditional Chinese medicine dates back to the early days of the twentieth century when Western medicine was first introduced in China. The debate reached a peak last year when a famous actress, Xiaoxu Chen, died from breast cancer. She allegedly insisted on treatment by Chinese traditional medicine, raising the hackles of some who claimed it to be worthless. Many Chinese still support traditional medicine and say that the dominance of Western medicine risks endangering China's scientific and cultural legacy.

A similar row erupted around earthquake prediction. In the 1960s and 1970s, China set up a network of popular earthquake-prediction stations, using simple instruments and local knowledge. For the most part, the network was decommissioned as China built the modern earthquake-monitoring system run by the China Earthquake Administration. When the system failed to predict the recent Sichuan earthquake, several people claimed that non-mainstream approaches had predicted its imminence. Scientists in the agency have tended to brush off such unofficial and individual predictions. To many this seems arrogant and bureaucratic.

It would be foolish and impossible to stop the globalization of science. There are tremendous benefits to science enterprises in different countries being integrated into a global whole. One should never think of turning back the clock. At the same time, it is possible to take some practical steps to minimize the harmful effects of this trend on local innovation.



Prioritizing for the people

First of all, there is a need to re-examine the governance of global science in recognition of the changing international geography of science. Many international norms and standards should be more open and accommodating to the changing environment in developing countries. For example, there is a need to re-evaluate the SCI and SSCI list of journals to include quality journals in the developing countries. In the long run, the relevant scientific community could also think about establishing an international panel to make decisions on the selection of journals for these indices, given their important influence. The recent move by Thomson Reuters, the parent company of ISI, to expand its coverage of the SCI list by adding 700 regional academic journals, is a step in the right direction[4].

English has become the de facto global language of science. Developing countries should invest in public institutions to provide translation services so that global scientific progress can be disseminated quickly. Developing countries can learn from Japan, a world leader in collecting scientific information and making it available to the public in the local language. At the same time, there should also be international institutions to provide similar services to the global

science community so that "results and the knowledge generated through research should be freely accessible to all", as advocated by Nobel Laureates John Sulston and Joseph Stiglitz[5].

When setting agendas, governments in developing countries must be careful in allocating their resources for science to achieve a balance between following the science frontier globally and addressing crucial domestic needs. A balance should also be struck between generating knowledge and disseminating and using knowledge. In addition, the global science community has a responsibility to help those developing countries that do not have adequate resources to solve problems themselves.

Finally, special efforts should be made to differentiate between pseudoscience and genuine scientific research. For the latter, one should tolerate or even encourage such indigenous research efforts in developing countries even if they do not fit the recognized international science paradigm. After all, the real advantage of a globalized scienctific enterprise is not just doing the same research at a global scale, but doing new and exciting research in an enriched fashion. ■

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See Editorial, page 367, and News Feature, page 382.
To comment on this article and others in our innovation series, visit http://tinyurl.com/5uolx2.

Li Gong

Chief executive, Mozilla Online, Beijing

Liberate funding

Research funding in China has increased manyfold in the past two decades. The National Natural Science Foundation awards alone went from 80 million renminbi (US$12 million) in 1986 to 4.33 billion renminbi in 2007. These programmes have succeeded in nurturing researchers and yielding research papers, books and patents. However, regulations governing how research funds can be spent, established in part to prevent misuse and abuse, are handicapping researchers and institutions, distorting research activities, and resulting in significant waste.

Chinese research programmes operate much like those in the rest of the industrial world, with a major difference that China has strict national guidelines on project spending. The most flawed rule dictates that researchers are already paid salaries and thus only a small portion of funding (usually 10–20%, sometimes less) can be spent on personnel. In reality, academic research salaries are uncompetitive. The average overall income per faculty member at top computer science departments is comparable to a fresh graduate's starting salary at IBM or Microsoft. These government guidelines make it much more profitable to stay outside the academic institutions, and drive researchers towards more commercial projects to earn more income. The rules can also result in spending on equipment that is unnecessary and in the worst cases resold, and in wasteful conferences and trips, meals and entertaining, and other excesses. The spending regulations are a significant drag on research performance, fund efficiency, and personal advancement, and need urgent reform.

Cong Cao

Sociologist, Neil D. Levin Graduate Institute of International Relations and Commerce, State University of New York

Encourage returnees

Of the some 1.2 million Chinese who have gone abroad as students and scholars, only a quarter have returned, thereby constituting an unequivocal 'brain drain' for China. Indeed, non-returnees, especially academics, are most likely to be the best and the brightest, who are most needed in China's innovation push.

Besides taking several years to set up a laboratory, form a team, recruit students, apply and get grants, and start the research, returned academics have to adapt and adjust to a 'different' research environment and be involved in various activities unimaginable to those abroad. They risk not being able to survive because they do not know the rules of the game played in China, and without *guanxi* — personalized networks of influence — and social and political connections, they have no one to turn to for help.

The costs of working in China are high. Some productive scientists have expressed the wish to return permanently and demonstrate that it is possible to do first-rate science in China. But this depends on whether China can provide the kind of research environment that will help them thrive.

Jianguo Liu

Director, Center for Systems Integration and Sustainability, Michigan State University, East Lansing; guest professor, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences (CAS)

Integrate disciplines

China's unprecedented economic boom and societal changes have created unexpected environmental challenges. Divorce, for example, usually splitting one household into two smaller ones, is increasingly common in China and traditional multi-generation families are also fragmenting. More households require more land and construction material for housing. Smaller households are often inefficient and produce relatively more wastes and pollutants. To tackle environmental problems, there is an urgent need to integrate natural sciences with socioeconomics, demography, human behavior and policy, addressing seemingly unrelated trends. Enhancing international partnerships for systems integration is a win-win strategy for China and other nations.

Ming-Wei Wang
Director, the National Center for Drug Screening, Shanghai, Professor of Pharmacology, Shanghai Institute of Materia Medica, CAS

Build bridges
China's drive to transform its pharmaceutical industry from imitation to innovation has reaped its first fruit: consistent elevation of research standards, rapid growth of a talent pool, and massive build-up of essential technology platforms.

Apart from common technical difficulties and social hurdles shared with Western peers, Chinese pharmaceutical scientists are facing some unique challenges. First, discovery activities are largely conducted at academic institutions. Chinese drug companies are much less interested in early lead compounds than their Western counterparts. Second, the current regulatory system is not optimized for innovation — it is far more difficult and takes much longer to file an investigational new drug application in China than in the United States. Third, public tolerance for failure is not a major part of the culture. High expectation and pressure to produce short-term returns often force scientists to abandon long-term and more difficult projects. Working as a fast follower or contract service provider is thus a convenient strategy.

International collaboration, especially with reputable industrial partners, could shorten the time for learning and reduce trial errors thereby strengthening China's drug-discovery capabilities. With more transnational pharmaceutical giants setting up R&D mechanisms in China, innovation-oriented cooperations are expected to increase.

Duanqing Pei
Professor and deputy director, Guangzhou Institute of Biomedicine and Health, CAS

Arm the troops better
Researchers are like an army fighting a tough war with imported, somewhat unreliable, weapons. Most reagents and equipment must be shipped from abroad, and thus are only available in leading research centres in major cities. Perishable supplies are handled by careless local suppliers. Domestic companies have sprouted up, but they need time to learn how to serve the biosciences sector.

Xiang Yu
Professor, Institute of Neuroscience, CAS

Be patient
As a young scientist returning to China after nearly 20 years of studying and working abroad, the task of building a research group is daunting and exciting. The usual challenges of starting to run a laboratory without prior experience are compounded by attempting the task in a country where the education and research systems are themselves undergoing a merger between East and West, traditional and modern.

Many students were attracted to biology during college because it was a popular choice and are choosing graduate school because of the tight job market. Breaking habits is difficult as these students are the first generation from 'one child families', each growing up with two parents and four grandparents attending only to them. Why should they bother listening to me, the only 'parent' in the lab, airing Western ideas and making things up as I go along? Well, it's an experiment. It is exciting to witness history in the making and be part of it. As to how my experiment is going, please check back in 20 years.

Zhangjie Shi
Associate professor, College of Chemistry, Peking University, Beijing

Foster collaboration
Historically it has been hard for researchers to establish interdisciplinary collaborations. Pure synthetic chemistry has grown fast, but fields such as chemical biology face major challenges because of gaps between chemical and biological research. Few scientists in China can really bridge chemistry and biology, in contrast to those in the United States. Fortunately, many people are working to change this. The rapid pace of reform and change makes me believe that these problems will be solved or partially solved by efforts from government and scientific communities in China in the future.

Liping Wei
Professor, Center of Bioinformatics, College of Life Sciences, Peking University

Tolerate risks
In this time of fast economic growth, it is easy to discount innovations in basic sciences that do not necessarily have clear and immediate practical value. Funding agencies must tolerate higher risks and longer research cycles.

"A closed society is less likely to produce internationally recognized scientific achievements, and this is particularly true for a developing country such as China that had long been isolated from the rest of the world."
— Xing Xu, palaeontologist, Institute of Vertebrate Paleontology and Paleonanthropology, Chinese Academy of Sciences