



## Making an impact

Compared with researchers in the United States, Chinese scientists publish far fewer highly cited papers. Ray Wu believes that this can change.

**D**espite a recent improvement, the number of high-quality research papers published by scientists from mainland China has remained low. I believe that this is because there are few productive scientists in China, and the level of financial support for basic research is inadequate. The system for evaluating research proposals and distributing funds is far from ideal, and does not promote innovative research. In addition, the education system in most universities does not encourage students to think critically and creatively. Many improvements are urgently needed.

The Cultural Revolution, which ended in 1976, severely devastated research in China. At that time, there were probably fewer than 50 internationally recognized biologists in China. Between 1978 and 1989, when Deng Xiaoping served as the country's leader, substantial reforms and progress were made in almost every area of scientific and economic development. In spite of this progress — which has continued under the leadership of Jiang Zemin — a huge gap still exists between the scientific productivity in China and that of the United States. This is because the baseline levels were so very low in 1978. China needs to increase its efforts to accelerate progress on all fronts.

In 2000, the number of biologists, government-funded labs and the total number of publications were similar in China and the United States. But, the number of high-impact papers published by scientists from China was less than 4% that of the United

States. This failing is, I believe, directly proportional to the small number of productive biologists.

### Few productive biologists

The productivity of a biologist can be measured by the number of original research papers published in internationally refereed high-impact journals. An arbitrary and not overly demanding standard would consider a biologist productive if he or she had published at least eight highly cited research papers in the past ten years. I consider such a paper to be one published in a journal with an impact factor of at least two. In addition, among the eight papers, at least one should be published in a journal with an impact factor of five or above.

Using my arbitrary standard, there are now only 500 productive biologists in China<sup>1</sup>. By contrast, in the United States, the number of productive biologists of Chinese descent is over 3,000. And, the total number of productive biologists in the United States, which has only a quarter of the population of China, is over 40,000. (These numbers are my own estimates derived from published statistics.)

China's low-level output is related to the inadequate and short-term nature of its research funding. This encourages scientists to work on projects that are likely to produce quick results. So, in most cases, their research lacks novelty and creativity. Consequently, the vast majority of papers are published in

Chinese journals, which are usually not read by scientists of other countries and thus are seldom cited.

There are two solutions to the low number of productive biologists. One is to educate a larger number of biologists in China to think critically and originally. For this, China would need to improve its higher-education system. Currently, only a small number of universities have adopted teaching methods similar to those in the United States and Britain, where students

are encouraged to think critically and creatively. The majority of the universities and graduate schools in China place more emphasis on memorizing and accepting facts than on thinking innovatively and asking questions. I

hope that the Ministry of Education will encourage all universities to improve their methods for training scientists.

The second solution is to attract a large number of productive Chinese biologists now working abroad back to China. Many Chinese scientists would like to return, but the inadequate level of funding, the poor research environment and the absence of an efficient management system discourage them from doing so.

To be attractive to its expatriate scientists, China needs to invest more in its basic research, establish a fair and transparent system to review research proposals, distribute research funds based on the merits of the proposal and promote reform of the

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infrastructure and administrative systems of the various universities and research institutes. China's annual budget for basic research in biological sciences is approximately two billion yuan (US\$ 242 million), which is about 0.02% of China's gross domestic product (GDP) in 2002. By contrast, the US government spends about \$30 billion on research, or roughly 0.3% of its GDP. In addition, in the United States, another \$30 billion comes from industries and foundations, whereas China has almost no private funding.

China is now an advanced developing country, and its GDP has been increasing by between 6% and 10% every year for the past ten years. There is really no justification for the government to say that China cannot afford to allocate more money to basic research, because we are not talking about absolute amounts but about a percentage of the GDP. The low level of support for basic research reflects a low priority.

I propose that the Chinese government takes immediate action by substantially increasing its annual budget for basic research. I hope that by 2020, the level of funding will be at least 0.1% of GDP, and that the number of biologists who publish high-quality papers will rise to 5,000 — ten times higher than at present.

### Evaluation and selection

The system for evaluating research proposals and distribution of funds in China also needs substantial improvement. There are three large organizations in China that fund the majority of research in the biological sciences: the Chinese Academy of Sciences (CAS), the Ministry of Science and Technology (MOST) and the National Natural Science Foundation of China (NNSFC).

The NNSFC has the strongest system of peer review in China, and it is open to all applicants. It has adopted a review system similar to that of the US National Science Foundation, but because the number of qualified reviewers is very low, it is often difficult to find sufficient reviewers who are familiar enough with the area of research to make a sound judgment. I have also been told by several reliable scientists that the larger grants of the NNSFC (and those of CAS and MOST) are often not peer reviewed. Instead, the funds are allocated by high-level administrators. In other cases, some reviewers

choose to help their friends instead of basing their decision on the merit of the proposals. Therefore, even though the procedures adopted by the NNSFC are good, the process has been spoiled by human factors and influences.

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### Overseas researchers

One way of reducing such problems is to invite qualified reviewers from abroad to serve on the proposal review boards. This would minimize conflicts of interest and lighten the load of the small number of qualified reviewers in China. In doing so, it would make the review process fairer and more transparent.

I am glad that two years ago the NNSFC started inviting highly qualified reviewers from the United States to participate in this process for biological sciences. The review results are without doubt much better than before. I hope that the NNSFC will expand the new process to evaluate proposals in all research areas.

I propose that the government appoints a National Biomedical Science Advisory Committee (NBSAC) to provide guidance for the operation and detailed planning in the procedure of reviewing proposals and in deciding the funding level. At least half of the committee members should be based abroad and should have extensive experience of conducting basic research. The NBSAC would help to establish a National Health Research Board (NHRB) to manage and review research proposals.

In addition, the NBSAC would appoint a special monitoring committee to oversee the activities of the NHRB, the progress of those who receive research funds, and reforms of the infrastructure of the universities or institutes in which the investigators work. After reviewing the progress of the researchers, those who excel should be rewarded: the NHRB could advise universities or institutes which scientists to promote based on performance rather than seniority. Promotion should not include additional administrative responsibilities, and outstanding scientists should be encour-

aged to remain as researchers rather than become administrators.

I also propose that the Chinese government establishes a new type of research project — major programme projects (MPPs). This would allow China to target funds to important research areas. China should establish 80 to 100 major projects within the next ten years. The proposal for one of these projects would need to be jointly submitted by at least three productive biological scientists and target an important area of cutting-edge research.

One important feature of the MPPs is that they should attract outstanding biological scientists from abroad. The budget would be for ten years and would be large enough for each individual MPP to attract up to ten excellent scientists. A long-term commitment by the government to support this would be essential. The initial task of the NHRB would be to review the proposals, and then monitor annual progress.

### A bright future

I am optimistic that substantial improvements will be made soon, because I believe that China's new leaders will pay much more attention to the issues and problems discussed in this article than their predecessors did and that they are keen to solve any problems. I am hopeful that we will soon see a much larger budget for basic research and that a truly fair and transparent system for reviewing research proposals will be established. In addition, I hope that the proposed MPPs and system for managing and monitoring research proposals and productivity will be implemented. If this becomes

a reality, China will be able to train a greater number of productive biologists and attract many scientists of outstanding calibre from abroad. The number of productive biologists can be doubled within five years, and increased tenfold by 2020. ■

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1. Wu, R. in *Chinese Americans in Science and Technology* (C. C.H. Chen, editor), pp. 37-84 (Outer Sky Press, New York, 2003).

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