

# How to Push Forward Science and Technology in China

## —About Research, Development, and Technological Innovation

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It is out of question that China has achieved considerable advancements in science and technology. The worldwide spread of “Made in China” that gets on the western countries’ nerves is a good illustration. However, although comparatively better than some other developing countries, we have to face the situation that science and technology in such a great nation as China is still seriously lagged behind, lacking great breakthroughs and top-ranking masters and leaders. That’s why we feel uneasy in front of international colleagues.

Why hasn’t China achieved a generally high scientific and technological level, although many domestic researchers have great potential? That is because scientific and technological study is a kind of creative process, which requires researchers to have wide basic knowledge and rich research experience, as well as to be good at creation and expression. What’s more, only when there is no any interference can they be possible to give full play to their curiosity and imagination to create novel scientific knowledge, thus to push forward science and technology. Scientific and technological researches require complete freedom to solve given or optional questions. The only thing to lead and direct science should be science itself, not political commands and orders, which means that the specific scientific research should keep the initiative in its own hands. It is so called Academic Freedom internationally, which is already a universal law.

The guideline for advancing arts and sciences in China is “let a hundred flowers bloom and a hundred schools of thought contend”, that is, to allow a great variety of opinions. This is the conclusion in view of China’s history of thousands of years, and has the same meaning as academic freedom. However, currently the primary problems of science and technology development in China are the conservative ideas and the research environment. That’s why President Hu Jintao has indicated that deepening the system reform and enhancing the talent management are indeed the key points to the development of science and

technology. I am confident that, with the improvement of academic freedom and research environment, our researchers surely will and are definitely able to play at the leading edge of international science and technology.

### Scientific and technological research

Thanks to China’s substantial education foundations that inspire people to enjoy learning, the scientific and technological researchers in China generally know their fields of study fairly well. Most senior researchers and professors, especially academicians (of both the Chinese Academy of Sciences and the Chinese Academy of Engineering), can keep abreast of the latest development and be aware of the changes in their fields, hence providing them the solid foundations for creative research. Their future researches will be inestimable in an open environment with the overcome of conservative ideas.

However, quite a lot of problems can be found in the industrial system. For the past fifty years, the scientific study of the industrial system were mainly subject to copying or imitating, and technicians had only to follow instructions. At the beginning of reform and opening up, industry leaders were even unable to find out any scientific and technological problems during the production but requested scientists to do so. Unfortunately, scientists had been seldom contacted with the industrial production and thus were incapable to act on such requests. Although much progress has been made in the last two decades with the “Made in China” spreading all over the world, the management in general enterprises except those with foreign capital is still subject to the aforesaid influence, while the technology power is still weak and there are few academicians. Therefore, the most critical task of our country is to establish an advanced scientific and technological research system in enterprises expeditiously, with the aim of improving our giant industrial system to the modernization of both management and technology. The measures and requirements for various researches are as follows:

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### ***Basic research***

Basic research, or research for short, is the means that deals with natural phenomena systematically and creatively to seek novel scientific knowledge, which refers to the theories, regulations, techniques, methods and so on, that have not yet existed in the literature. The research problems should be new ones that have no solutions in the literature by now or previous ones with possible new solutions. Problems could be big or small, but must be original, which cannot be worked out simply by induction from the result of an experiment, because any induction does not produce new theories, only by creative thoughts can problems be solved. Therefore, this is the highest level of research work, namely the original research, which should be the responsibility of the researchers of the highest level, especially academicians and senior scientists, among which academicians should be the main force.

The achievement of basic research is discovery; once published, the discovery is open worldwide so that repeated work will lose its significance. It is also important to publish the result in time to avoid the forfeiture of the intellectual property right in case that some other researchers might publish the same result ahead. Many such lessons existed in the past.

### ***Development***

China needs more development. The study method of development is completely the same as that of basic research, while its purpose is to transform the scientific knowledge into real things, such as new instruments or equipment, products, and design methods. Invention is the important result of development, which also has to be new and apply for a patent, otherwise the work will be in vain if others have obtained the patent first. In fact, the effects of basic research normally will not be seen immediately, but may be in the next five, ten, or even fifty years (for example, the application of atomic energy), while the effects of development are in sight. Comparatively, the United States is reputed for its attention to development. There is a case that most inventions initially made in Britain have been realized in the US, which greatly promoted the economy of the latter. However, the industrial system of China falls far behind in development. The economy will catch up really fast if it is improved. Meanwhile, the industrial system also needs to pay attention to basic research, which is the

backup force and foundation of the sustainable development of economy and should never be neglected.

### ***Technological innovation***

Research and development can also be called innovations (original innovations), since all the theories and results generated are new, but generally, innovations refer to small improvements and upgrades of the existing technologies, while many a little makes a mickle. Take the development of the semiconductor for example. It is the germanium transistor that was first invented, then the more stable silicon transistor, and next the planar transistor that was easier to be produced. Later more and more transistors were integrated in the integrated circuit (IC), the large-scale IC, and the super large-scale IC, until now millions of or even tens of millions of transistors are integrated on a chip less than one square inch. This great development has been gradually accumulated by tens and hundreds of small innovations in a long time. Therefore, most work at current development level includes large amounts of technological innovations, each of which is a new step forward.

Generally speaking, technological innovation does not require researchers of the highest level, whereas it is necessary to have the university education background and rich professional knowledge. "Made in China" is the achievement of our country in technological innovation, yet further development is still needed. Discovery offers primary principles, development provides samples and prototypes, while technological innovation can make the product more applicable and useful, which is the key to application. Therefore, a great number of technological innovations are essential for the development of China.

### **Features of different research work**

There are two types of basic research, one is pure basic research, which does not consider application, and the other is applied basic research, which considers application in specific fields. Obviously, China should pay more attention to applied basic research, but high level pure basic research will help to raise the national culture level. It has been mentioned above that research and development need academicians to handle. As a matter of fact, any research work, including technological innovation, should be people-oriented with individual responsibility. As what we said in the

past, oriented to “one professor with students (who are technical assistants, not collective workers)”, it keeps so nowadays. Most discoveries and inventions in the past centuries can all be attributed to individuals, for example, radioactivity, cathode ray tube, X-ray, radium, color photography, radio telegraphy, electron tube, quantum, atomic structure, Brown movement, quantum mechanics, nuclear fission, computer, camera tube, accelerator, laser, optical fiber communication, microprocessor, and so on. Only the investigation of the parity conservation by Chen Ning Yang and Tsung-Dao Lee, both won the Nobel Prize in Physics (1957), was their collective work. Three scientists (William Bradford Shockley, John Bardeen, and Walter Houser Brattain) were awarded the Nobel Prize in Physics (1956) for their researches on semiconductors, but they each had independent contributions for which the award was given.

It is completely misleading to say that the time of individual scientific research has gone and now comes the collective research, in the name of big science. Big science is actually engineering but not science. The discovery of particles is still the individual contributions of Samuel Chao Chung Ting, Ganchang Wang, and others. Individual research should be people-oriented and meets the researcher’s expertise. Assistants may be needed, but this is different from collective research.

Different types of research work have different requirements of researchers and facilities. Research and development need senior researchers and academicians, while technological innovation needs researchers with at least university education background and rich professional knowledge. Basic research needs no complicated equipment, sometimes only a desktop computer can be very helpful; devel-

opment needs experiments, which could be somewhat complex at times; technological innovation normally needs simple experiments. In general, research work does not require magnitude equipment.

### **Academicians should take the lead of basic research**

Academicians are the most honorable and lifetime academic titles awarded by the country to the first-class researchers in science and technology. Shouldn’t they take the lead to the highest level of original research? Actually, research ought to be original and focus on new problems, otherwise how could science and technology progress? It is known that the post-graduates abroad will be given new problems for exploration. However, possibly due to the result of “learning from the Soviet Union” at the beginning, researchers in China seldom had the concept of original research but thought that handling with existing scientific issues was “research”. That’s why most researchers are at a loss when dealing with problems requiring creation and innovation in recent years. Therefore, it is quite necessary for academicians and senior researchers to lead basic research, discuss new issues, consider deeply, and conceive audaciously, in order to obtain new achievements of science and technology. Furthermore, they need free minds with curiosity, creativity, and imagination, unbound by existing theories, tendencies, and experiences, while should not totally listen to the seniors and authorities as well as be brave to practice. Assignments may be given, but the specific work of researchers should not be interfered in the respect of academic freedom.

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