Advancing basic research towards making China a world leader in science and technology

Wei Huang

INTRODUCTION

Basic research is the bedrock of science and technology (S&T) progress and industrial transformation, and the cornerstone to making China a world leader in S&T. In the new round of the technological and industrial revolution, basic research is assuming an increasingly prominent role. Aiming at becoming a world leader in S&T by 2050, China should maintain a clear understanding of its development stage and challenges, consolidate basic research, and enhance its original innovation capability.

UNDERSTANDING OF THE LAWS AND TRENDS OF BASIC RESEARCH

Basic research is characterized by sudden inspiration, free exploration and uncertainty. The results of some basic research endeavours are unpredictable, so it takes time to make breakthroughs and even longer to generate practical applications for novel science. Today, basic research increasingly integrates academic disciplines, and research results are more quickly converted into technologies. Disruptive technologies keep emerging. Basic research has entered the era of ‘big science’. Therefore, when making judgements and making long-term plans for the development of basic research, it is important to thoroughly grasp the laws according to which basic research develops, and properly handle its relationship with applied research.

CHINA’S BASIC RESEARCH HAS ENTERED AN IMPORTANT PERIOD OF DEVELOPMENT

China has attached high importance to basic research and has introduced a number of initiatives and programs, including the National Natural Science Foundation of China and the 973 Program, that act as new driving forces for the rapid development of basic research. China has seen a steady increase of expenditure on basic research, jumping from RMB 5.22 billion in 2001 to RMB 82.29 billion in 2016 [1].

Thanks to increased funding, basic research has made strides. From 2007–17, the citation count of China’s international scientific papers ranked second in the world. It ranked among the top 10 in citation count in 18 academic disciplines, and it ranked third [2] for the number of highly cited papers. In 2016, the number of Chinese scientists on the list of ‘highly cited researchers’ increased to 183 (including Hong Kong, Macao and Taiwan), ranking third in the world [3]. China has made numerous world-leading breakthroughs in basic research, including research on high-temperature superconductivity, multiphoton entanglement, neutrinos, quantum communication and stem cells.

Basic research plays an increasingly visible role in supporting and leading economic and social development. Breakthroughs in key areas of basic and frontier research, such as the theory of tertiary recovery and the theory of millimetre wave communications, have provided important support for
transforming and upgrading China’s traditional industries and fostering emerging industries. A series of major breakthroughs in agriculture, health and environmental science have made important contributions to China’s sustainable development and livelihood improvement, including research on functional genomics in rice and the molecular mechanism of acute promyelocytic leukaemia. Breakthroughs in frontier research areas such as deep-sea, deep-earth, deep-space and polar research have effectively supported China’s major projects regarding national interests and security (e.g. manned spaceflight).

The system of science, technology and innovation (STI) bases has been refined, with state key laboratories as the main pillar of China’s basic research and applied basic research. Currently, China has 495 state key laboratories. China’s major research infrastructures, such as the Five-hundred-meter Aperture Spherical radio Telescope, have strongly supported basic research in key areas.

Shaping of S&T resources lays the foundation for magnifying the role of basic research. There has been a substantial improvement in the sharing of national major research facilities and large-scale research apparatuses. A total of 28 national research resources sharing service platforms have been established; these have aggregated the research resources of nearly 800 universities, research institutes and enterprises.

China has proactively planned its basic research with a global vision, deepening international collaboration in basic and frontier research. Major international projects initiated by Chinese scientists, such as the Daya Bay reactor neutrino experiment, have increased China’s profile in the international scientific community. Chinese scientists have increasingly been involved and played an important role in international big science plans, including the International Thermonuclear Experimental Reactor and the Large Hadron Collider.

**Basic Research in China still faces urgent issues**

The development of China’s modern science started less than 100 years ago and still faces prominent problems. China’s expenditure on basic research is still inadequate, at approximately one-sixth that of the United States. China’s basic research expenditure as a percentage of its gross R&D expenditure has stayed at approximately 5% for many years, versus around 15% for the United States and Japan. Meanwhile the investment in basic research from businesses and society is low. China lacks leading scientists in basic research. The country has not accumulated enough basic research outcomes and technologies leading to major transformations in industrial technology roadmaps, and basic research has not provided strong support for the development of industrial general-purpose technologies.

**Approach and Advice on Strengthening Basic Research to Build China into a World Leader in S&T**

In the coming years, China’s overall plan of basic research is as follows. With the aim of becoming a world leader in S&T, China will push ahead with the Plan for Implementing the National Strategy of Innovation-driven Development and the 13th Five-Year Plan for Science, Technology and Innovation. China will enhance its capabilities in basic research and innovation by strongly supporting major projects, STI base building, cultivation of innovative talent, and sharing of S&T resources.

With respect to research investment, China will:

(i) Continue the increase of central finance expenditure on basic research and guide local governments to increase expenditure on basic research, with emphasis on applied basic research.

(ii) Refine taxation, as well as financial and industrial policies, to stimulate enterprises and society to contribute more to basic research.

With respect to research programs and projects, China will:

(i) Strengthen basic research in frontier areas and conduct research on major scientific subjects, including the structure of matter and the origin of life.

(ii) Deploy major strategic and forward-looking research projects, accurately grasping trends of scientific development and making forward-looking
arrangements for research in key frontier areas.

(iii) Strengthen implementation of Major STI Projects 2030 in frontier areas, including quantum communication and quantum computing, brain science and brain-like intelligence research.

(iv) Continue to advance ongoing key projects under the National Key R&D Program concerning major scientific subjects, including stem cells and nanotechnology.

(v) Promote the launch of key projects in synthetic biology.

With respect to research bases and infrastructure, China will:

(i) Strengthen the development of STI bases and launch new national laboratories in key areas.

(ii) Establish a new operating mechanism for national laboratories to forge strategic national S&T strengths.

(iii) Implement the scheme for refinement and integration of national STI bases.

(iv) Accelerate the construction of major research infrastructures and national field stations.

With respect to S&T resources, China will:

(i) Further improve policies on the sharing of S&T resources, enlarging the scope of research infrastructure and instrument sharing.

(ii) Formulate measures for scientific data management to facilitate the sharing of scientific data derived from fiscally supported research projects.

(iii) Establish a batch of national scientific data centres and experimental biological resource centres.

Finally, with respect to research environment and talent, China will:

(i) Foster an excellent environment for basic research, expand academic autonomy and encourage long-duration and high-risk research.

(ii) Give more incentives for major research achievements.

(iii) Actively participate in and lead international big science programs and projects.

(iv) Attract outstanding overseas talent for collaborative research in frontier areas.

(v) Assess researchers’ performance by evaluating their academic contributions and innovation, instead of counting research papers.

Wei Huang
Ministry of Science and Technology of the People’s Republic of China, China
E-mail: hhhwei2005@most.cn

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