PRIORITIES AND FUNDING

“Knowledge Innovation” and the Chinese Academy of Sciences

CAS is working to set the course for scientific and technological development over the next 15 years.

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At China’s 2006 National Science and Technology Conference, President Hu Jintao pledged to make 21st-century China “an innovation-oriented society.” To that end, the conference unveiled a 15-year Medium to Long-Term Science and Technology Development Plan (MLP) (2006–2020) setting national research priorities and providing substantial resources for meeting them. Gross expenditures on R&D (GERD) are expected to rise to 2.5% of the gross domestic product (GDP) at the end of the plan period from its 2005 level of 1.30% (*1*). The plan emphasizes “indigenous innovation,” and “leapfrogging” in research. Science and technology are expected to support and lead future economic growth.

Behind this new plan is a complex story of 20 years of policy development and institutional reform. This is illustrated in the experiences of the Chinese Academy of Sciences (CAS) and its efforts to reinvent itself through the “Knowledge Innovation Program” (KIP) (*2*). A review of CAS can help explain forces driving the scientific infrastructure and challenges in the new long-term plan.

PRIORITY MISSION AREAS FOR CAS
Information technology
Optical electronics, space science, and technology
Advanced energy technologies
Materials science, nanotechnology, advanced manufacturing
Population, health, medical innovation
Advanced industrial biotechnology
Sustainable agriculture
Ecology, environmental protection
Natural resources, ocean technologies
Comprehensive research relying on megascience facilities

Objectives and Achievements

In 1998, when KIP was initiated, CAS supported 120 institutes, many of which had overlapping missions and outdated research agendas. Most institutes were overstaffed with nonresearch personnel and had more than their share of scientists who had passed their peak productivity and lagged behind international research frontiers. Research programs were often derivative of foreign science, physical facilities were typically run down, and the quality of equipment was very uneven. To attack these problems, one of KIP’s main goals is creation of 30 internationally recognized research institutes by 2010, with five recognized as world leaders.

Between 1998 and 2005 the number of institutes was scaled back to 89 as a result of converting some applied research institutes into commercial entities and the reorganization of others to reduce duplication and rationalize missions. At individual institutes, traditional disciplinary orientations and missions have been redefined and more focused.

Revitalization of the human resource base in CAS has been approached by recruitment of talented group and laboratory leaders from “brain drain” scientists working abroad and from young researchers in China. The “100 Talents” Program, for instance, offers high salaries, responsible positions, and generous start-up research support to promising scientists under 45 years old (*3*). Between 1998 and 2004, 899 researchers were recruited using this mechanism, 778 of whom were working overseas (392 of these had doctorates from foreign universities). The academy also expanded its graduate training, with total enrollment as of the end of 2004 reaching some 33,000 at its institutes, its graduate school, and its University of Science and Technology campus. A CAS university center in Beijing is now under construction.

The average age of institute directors and deputy directors in 1991 has dropped from 56 in 1991 to 47 in 2003. Between 1998 and 2003, CAS made 14,409 new appointments, 67.8% of whom were senior scientists under the age of 45 (*4*). New appointments no longer carry promises of lifetime tenure but are subject to evaluation early in the investigator’s career. Salary structures have also changed and now include provisions for merit increases.

In the past 7 years, KIP has provided project support in fundamental research, technologies with strategic significance, and science and technology for managing resources and the environment. The pattern of KIP funding, with 70% going directly to institutes and 30% controlled by CAS headquarters, has given institutes considerably more discretion in research management. Additions of KIP funds to institute budgets have made CAS institutes more competitive vis-à-vis universities and other government research institutes for grants and contracts. CAS research outputs (publications in *Science Citation Index*–catalogued journals, patents granted, and copyrights registered) have increased by more than an order of magnitude.

KIP implementation has been accompanied by the introduction of a demanding evaluation system. It involves administrative reviews to assess the consistency of institute activity with CAS policy and KIP objectives, as well as peer review of professional work by leading Chinese and foreign scientists. There has also been a major investment in upgrading facilities and equipment. CAS manages most of China’s megascience facilities, and substantial investments are shown by the construction of the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) astronomical telescope; the reconstruction of the Beijing Electron Positron Collider (BEPC); the Lanzhou Heavy Ion Accelerator; the Synchrotron Radiation Facility and the Controlled Nuclear Fusion Device, both in Hefei; and construction of the Shanghai Synchrotron Radiation Facility. CAS also continues to play a key role in China’s defense establishment, participating in everything from the space program to supercomputer development.

The Challenges Ahead

During the 2005–2010 period, CAS seeks to respond to emerging national policy priorities, including those identified in the national 11th Five-Year Plan and the new MLP, and secure its place as the “backbone” of the national system of innovation. To these ends, it is establishing a “1+10” strategy, in which activities of its research institutes will be linked to 10 mission objectives (see table, above). A commitment to interdisciplinary basic research in frontier areas will support the effort. This strategy requires administrative reorganization within CAS that will have implications for relations between the institutes and CAS leadership.

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Human resources. Although CAS has sought to recruit the very best scientific talent, its success has been mixed. Some Chinese scientists working abroad have joint appointments in CAS, but it has been difficult to attract back on a permanent basis those who are most active at the frontiers of international science. Indeed, it is the latter group of scientists that has become more vocal in their criticisms of the Chinese research environment (*5–7*). In addition, CAS is still losing many of its top students to study and research opportunities abroad and to alternative employment opportunities in China, including work in universities and in the growing number of R&D facilities operated by multinational corporations. Within the CAS graduate school system, the steady expansion of enrollment brings to the fore the question of maintaining quality control (*8*).

High-quality Chinese researchers expect a degree of stability and autonomy in the research environment and worry that the new initiatives could be a threat. The evaluation system, especially for new group leaders, generates enormous pressures for productivity. In some cases, this pressure has caused promising scientists to leave CAS for employment elsewhere.

Different types of evaluation standards and processes will need to be developed. CAS aspirations to achieve world-class research status will put a premium on scientific distinction. However, with increased funding, CAS faces new problems of political accountability and government expectations that national needs are being served cost-effectively. This may require evaluation to focus more on consistency with national policy and on the extent to which social needs are met. Imposition of excessive top-down requirements on the research community could discourage creativity and bottom-up innovation. A failure to fine-tune the evaluation system to meet multiple objectives may lead to dissatisfaction from all quarters.

Institutional mission and focus. Few institutions in the world incorporate in one organizational framework so many different activities and goals: basic research; cutting-edge R&D; "public goods" research programs in agriculture, health, energy, and the environment; sponsorship of graduate training; and operation of more than 400 hundred companies, in cooperation with local governments. Finally, its elite "academicians" (*yuanshi*) have important science advisory functions, although publicized abuses have made the system increasingly controversial (*9*). The multiple functions that CAS assumes can threaten maintenance of clear organizational focus. A case might be made for greater specialization and functional differentiation within the organization.

CAS and the National System of Innovation (NIS). As China has moved from a planned to a market economy, there is a growing realization among policy-makers that Chinese industry must become far more innovative. As a result, government policy has recently favored the expanded development of research in business enterprises, with more than 60% of the nation's R&D reportedly now supported by industry (*10*). The importance of building an "enterprise-centered NIS" was reaffirmed in the MLP, and proindustry policy measures will be introduced to make it a reality over the next 15 years.

CAS is faced with the challenge of reconciling its view of itself as the backbone of the nation's innovation system with this "enterprise-centered" model. On the basis of current trends, it is unlikely that many Chinese companies will develop R&D capabilities in support of novel, science-based technologies in the near term. China's more entrepreneurial high-technology companies often lack resources to support their own R&D. Larger state-owned enterprises often find that short-term business objectives are better met by the less risky course of procuring advanced technology from abroad. CAS represents a reservoir of assets for research and innovation. How it makes these assets available to the companies that will actually be marketing products and services is one of the major challenges in making the "innovation-oriented society" a reality.

Although, historically, CAS has been weak in its service to industry, the commercial pressures it has faced over the past 20 years have produced a variety of transfer mechanisms. These include contract research, the licensing of proprietary technologies, the spinning off of new companies from CAS institutes, and the establishment of CAS facilities to serve industry in special high-technology zones established by local governments (*11*). However, problems still remain. There are often mismatches between the relatively advanced technologies being developed by CAS and the willingness and ability of Chinese companies to adopt them. Some CAS researchers are concerned that industrial outreach takes the academy too far downstream (and away from its core strengths) in the innovation process.

Public goods (e.g., public health, agriculture, defense, weather forecasting, and environmental protection) require technology transfer platforms that involve cooperation with other state bureaucratic systems (that have their own research establishments and actually compete for funding with CAS). Relations with local governments may be useful, but they are no substitute for deployment of substantial managerial resources and interagency coordination. Too much involvement with local governments is seen by some in CAS as diverting attention away from its broader, national mission.

Chinese universities had a limited research role in the past, but the value of associating research with graduate education, characteristic of the Western model, has taken root. The role of CAS in relation to universities has become a more pressing issue, especially with regard to sharing of facilities and staff, training and subsequent employment of graduate students, and leadership roles in high priority areas of research.

CAS faces a series of questions as it moves to the next phase of KIP. Do its strategies (including funding and evaluation systems) encourage development of a culture of creativity where risk-taking, initiative, and new ideas are supported and rewarded? Can CAS develop R&D managers with the skills and training for managing interdisciplinary teams in an increasingly international environment? How should CAS set priorities related to its stakeholders, and develop an organizational structure that fits diverse needs? Should it define its mission principally in terms of the supply of public or private goods, and how does it define "success"? How can its educational mission meet its own needs and complement the activities of Chinese universities? In its commitment to serve national needs, can it also be a credible international partner? In its efforts to reinvent itself, CAS still faces formidable problems of internal management and building new relations with the broader national innovation system. Despite these, the trajectory set by KIP helps ensure a central role for CAS in China's emergence as a major player in international research and innovation.

References and Notes

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12. This Policy Forum was based on interviews with senior officials at CAS headquarters and visits to institutes in Beijing, Shanghai, Dalian, and Shenyang in November 2004 and in March and May 2005. Partial support came from U.S. National Science Foundation grant OISE-0440422.

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