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The United States, China, and the Globalization of Science and Technology

Prepared statement by

Adam Segal

Ira A. Lipman Senior Fellow for Counterterrorism and National Security

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Hearing on Efforts to Transfer America's Leading-Edge Science to China

Chairman Rohrabacher, Ranking Member Carnahan, and members of the committee, thank you for the opportunity to testify on this important subject.

U.S.-China science and technology (S&T) relations are shaped by two paradoxes. First, as many have noted, global problems require global solutions, but while the science that drives these solutions is increasingly collaborative spanning different disciplines, institutions, and geographical locations, it is also an essential component of national power. The results of scientific discovery are public goods, but they can also lead to first-mover advantages and the ability to lock others out of important markets. As a result, China and the United States are collaborators as well as competitors for talent, new ideas, market share, and status and prestige.

Second, science and technology diffusion has and will continue to improve Chinese military capabilities. Shifting research centers to China and developing collaborative business relations with Chinese companies inadvertently involves American institutions in the diffusion process, speeding Beijing's military modernization. But the globalization of science and technology ensures American security at the same time that it creates new security threats for the United States.[1] American universities and private companies, not federal labs, provide much of the technology required by the U.S. military to keep its qualitative lead over potential challengers. Those same universities and private companies need access to talent and markets in developing economies, especially China, to remain competitive. Moreover, the best and the brightest are still coming to the United States, staffing university labs and founding innovative companies.

In order to manage these paradoxes, the United States will have to maintain its scientific strength at home, pressure China on its mercantilist technology policies, and strengthen the ability of the Office of Science and Technology Policy to coordinate and develop S&T relationships with China. Certainly the United States has to ensure that critical science and technologies do not flow to potential adversaries, but at the same time, maintaining ties with emerging science powers is essential to American economic and national security interests.

Rising Powers, Globalizing Science

The United States is still the world leader in science and technology, but others are increasing their capabilities rapidly. A report from the UK Royal Society describes the current situations as an "Increasingly multipolar scientific world, in which the distribution of scientific activity is concentrated in a number of widely dispersed hubs." From 2002 to 2007, for example, developing countries—including China, India, and Brazil—more than doubled their expenditures on R&D, increasing their contribution to world R&D spending from 17 percent to 24 percent.[2]

China's goals in science and technology are particularly noteworthy. The 2006 National Medium- and Long-Term Plan for the Development of Science and Technology (MLP) states China's goal of becoming an "innovative nation" by 2020 and a "global scientific power" by 2050.[3] Investment in R&D has grown by 20 percent a year since 1999 and is expected to top US$153 billion in 2011.[4] R&D spending is now approximately 1.6 percent of GDP and it is supposed to reach 2.5 percent of GDP in 2020. The MLP includes twenty science and engineering megaprojects in such areas as high-end generic chips, manned aerospace and moon exploration, developmental biology, and nanotechnology. China is also turning out huge numbers of science and engineering graduates—2.18 million in 2009.

Chinese analysts and policymakers have expressed disappointment in the qualitative gains in the science and technology system, especially given this massive level of investment (though it should be noted that a recent report in the Chinese press suggests 60 percent of R&D funds have been wasted through embezzlement and misappropriation[5]). Still by most metrics, the results are impressive. In 1996, the United States published more than ten times as many scientific research papers as China. In 2010, China became number two in world paper publication and may overtake the United States in 2013.[6] A 2010 study by Thomson Reuters predicts that China will pass the United States and Japan in new patent applications by the end of this year.[7]

Compounding the sense that China is gaining fast is a fear that the United States has been distracted, neglecting science and underfunding basic research. In 2007, *Rising above the Gathering Storm*, a report produced by the National Academies, warned, "the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength."[8] Today, the United States is hampered by tight budget constraints and future funding is uncertain at best. Capital for high-risk technology development has evaporated. American multinationals have cut R&D spending at home while increasing it in their foreign subsidiaries.
Despite this tendency to characterize R&D investment as a race among countries, the concept of national S&T systems is no longer an accurate description of what is happening in science and technology. Instead, science is interconnected and global. According to the Royal Society, over 35 percent of all articles published in international journals are collaborative, up from 25 percent 15 years ago.[9] The globalization of science and technology is driven by several factors. Cheaper communication technologies and travel make it easier for scientists to develop and maintain projects in several locations at once. Many of the most exciting scientific questions draw on knowledge from several fields, and the equipment needed is so big and expensive that it requires that scientists come to it. Perhaps most important, individual scientists collaborate globally to gain access to funds, data, and other talented scientists.[10]

The border between "American" and "Chinese" science is no longer as sharp as international R&D networks and business collaborations expand. China-based scholars, for example, choose to coauthor with U.S. colleagues more frequently with those from other countries; nearly 40 percent of China's science and engineering publications in international journals had U.S.-based coauthors.[11] The information technology sector is particularly interconnected, stretching across the Pacific and involving Chinese, American, and Taiwanese entrepreneurs, designers, managers, and technicians. While outside observers may focus on the reform of the Chinese Academy of Sciences and the shift of R&D funding from government research institutes to enterprises, the most critical developments may be occurring at the nexus between multinational R&D centers and Internet companies in Beijing, or U.S.-based venture capital funds and local chip design companies in Shanghai.[12]

Framework of U.S.-China Relations

The official framework for U.S.-China science and technology relations is the January 1979 Agreement Between the Governments of the People's Republic of China and the United States of America on Cooperation in Science and Technology (hereafter the Agreement). The Agreement now includes more than 25 protocols and 60 annexes and implementation is the responsibility of the Joint Commission on S&T Cooperation (JCM), which is cochaired by the Chinese Minister of Science and Technology and by the President's Science Advisor and meets about every two years.[13] Some of these protocols include a High-Level Biotechnology Working Group that involves the USDA and the Ministries of Agriculture and
Science and Technology (MOST); cooperation between the Department of Energy and MOST on power systems, clean fuels, oil and gas, and energy and environmental control technologies; and a memorandum of understanding between the Department of Health and Human Services and the Ministry of Health for cooperation in prevention activities, treatment, and research of AIDS.

Much of the energy and dynamism of the relationship exists outside of official channels. American universities are expanding the number of formalized relationships they have with their Chinese counterparts. In October 2011, the Bill and Melinda Gates Foundation announced a memorandum of understanding with MOST for joint investment in R&D targeted at global public health and agriculture.

It is also worth noting that the United States government does not provide direct assistance in support of Chinese projects. Instead, Washington has insisted that costs be shared in proportion to the benefits received. Still, U.S. contributions to the reform of China's science and technology have been substantial.[14] Most important has been the support and training of tens of thousands of Chinese graduate students by U.S. universities through research grants to their mentors from U.S. government agencies. Many have returned to China and play leading roles in universities, research institutes, and corporations.[15]
This contribution is likely to continue for at least another decade; China is currently the largest source of foreign students in U.S. science and engineering programs.

While the Agreement has been a source of stability in a relationship that has had its share of ups and downs, much of the original motivation for maintaining and expanding the agreement has changed. Coming out of the chaos and destruction of the Cultural Revolution, China was desperate to gain access to international and American science in particular. Speaking at a 2010 conference on U.S.-China Cooperation on Science, Technology, and Innovation, Yang Xianwu of China's Ministry of Science and Technology said "Cooperation with the U.S. has always been our priority."[16]
For the United States, certainly at the beginning, gaining access to science and technology was probably the least of motivations. Although there was naturally some level of interest, the working assumption for most was that the United States was so far ahead that there was little to be gained from collaboration with China. Instead, the Agreement was part

of a larger relationship designed first to help balance against the Soviets and then to draw China into the international community through a web of commitments and ties.

Changing Assumptions

As China increases its scientific capabilities, the assumption that it has little to offer the United States is gradually changing. In nanotechnology, for example, 5,000 scientists work at 50 Chinese universities, 20 Chinese Academy of Sciences Institutes, and 300 companies, and the National Science Foundation of China funds over 650 projects with nanotechnology in the title, according to the Center for Nanotechnology in Society at the University of California, Santa Barbara.[17]

Moreover, while science and technology were historically an afterthought regarding issues like Taiwan, trade, and human rights, they now play an increasingly important role in economic and national security interests in relations with China. Unhappy being factory to the world and wanting to move from "Made in China" to "Innovated in China," Chinese policymakers have adopted a range of policies designed to create "indigenous innovation" and reduce dependence on the West for advanced technologies, and on the United States and Japan in particular. These policies include government procurement, competing technology standards, and requiring technology transfer from multinational corporations in return for market access. In April 2010, for example, Beijing ordered high-tech companies to turn over the encryption codes to their smart cards, Internet routers, and other technology products in order to be included in the government procurement catalog.[18] In addition, China's failure to protect intellectual property rights leads to massive theft and piracy, and in turn improves the short-term competitiveness of Chinese firms.

The theft can also be more direct. Since January 2010, Google, Nasdaq, DuPont, Johnson & Johnson, General Electric, RSA, and at least a dozen others have had proprietary information stolen by hackers, although how many of these attacks originated from China is uncertain.[19] In the physical world, Chinese nationals have been recently charged in the theft of radiation-hardened microchips and precision navigation devices. In addition, according to a recent report for the U.S.-China Economic and Security Review Commission, the theft of American technology is often conducted through the PRC's science and technology institutes and industrial enterprises.[20] The "key modality is no longer the spy," according to Jim Richberg, former deputy national counterintelligence executive, "but the businessman, student, or academic."[21]

The globalization of S&T also has the potential to improve the technological capabilities of indigenous defense sectors. In China, the shipping and telecommunications sectors have made steady improvements in R&D and production through their engagement with the international economy. The 2011 report from the U.S.-China Economic and Security Review Commission reportedly argues that U.S. aerospace companies may have unknowingly assisted Chinese military modernization.

Policy Response

The most necessary response to the rise of China is to ensure the innovativeness of the American economy. The United States needs to exploit its software, its social and cultural strengths: the ability to conduct cutting-edge, interdisciplinary research; recognize new markets and consumer demands; manage across time, distance, and culture; tolerate risk and support entrepreneurship; and welcome new ideas and talent no matter what their origin.[22]

The government's role in funding basic research has become even more important as business has shifted away from funding "blue sky" projects with uncertain immediate commercial use but with the promise of big breakthroughs.[23] Federal investment in R&D, however, remains hostage to the larger political debate about how to reduce spending and the deficit. No matter the final spending level, it is essential that the money funds high-risk, high-return R&D. Hard times make scientists more conservative, as they seek to secure grants by writing proposals that extend what they already know, not striving toward something new. To counteract the tendency to stay in comfortable territory, more money should be directed to early-career grants and to support well-designed failures—ideas that push the envelope of accepted paradigms.

The United States must continue to confront China on indigenous innovation. Raising it to the top of the agenda at bilateral summits is important, for it signals intent and interest. A strong display of concern from the American side at the January 2011 meeting helped produce a commitment to delink government procurement strategy from innovation policies, though it is too early to know if China will follow through on the promise. Multilateral pressure is especially important; Japan and the European Union are pressing China on the same set of issues and Beijing has in the past been willing to step back when several governments—and governments and the private sector—speak with one voice.

One of China's great strengths has been a laser-like focus on shaping foreign interactions to serve national innovation goals. By comparison, the United States is greatly handicapped as it lacks the ability to gather a comprehensive picture of scientific and technological exchanges with China and to coordinate a whole of society response to Chinese predatory policies. No longer can the United States rely on its more informal, decentralized process; the combination of a rising China and globalizing science and technology make a more strategic approach to interacting with China in science and technology a necessity. Instead of limiting funding for the Office of Science and Technology Policy, the more strategic response would be to expand support for the OSTP.

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[2] "Knowledge, networks and nations: global scientific collaboration in the twenty first century" (Royal Society, London, March 2011) available: http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2011/4294976134.pdf

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[4] Gautam Naik, "China Surpasses Japan in R&D as Powers Shift," *Wall Street Journal*, December 10, 2010.

[5] Wu Xiaojie, "60% of Scientific Research Funds Lost to Corruption and Embezzlement," *Guangming Daily*, September 7, 2011, http://news.sohu.com/20110907/n318651118.shtml

[6] David Shukman, "China 'to overtake US on science' in two years," *BBC News*, March 28, 2011, http://www.bbc.co.uk/news/science-environment-12885271.

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[11] Richard Suttmeier, "From Cold War Science Diplomacy to Partnering in a Networked World: 30 Years of Sino-US Relations in Science and Technology," National Science Foundation, 2009, http://china-us.uoregon.edu/pdf/030409.pdf

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[13] Richard Suttmeier, "From Cold War Science Diplomacy to Partnering in a Networked World: 30 Years of Sino-US Relations in Science and Technology," National Science Foundation, 2009, http://china-us.uoregon.edu/pdf/030409.pdf

[14] ibid

[15] "China's Program for Science and Technology Modernization: Implications for American Competitiveness," Prepared for The U.S.-China Economic and Security Review Commission, January 2011, http://www.uscc.gov/researchpapers/2011/USCC_REPORT_China's_Program_forScience_and_Technology_Modernization.pdf

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[18] Adam Segal, "China's Innovation Wall: Beijing's Push for Homegrown Technology," *Foreign Affairs*, September 28, 2010, http://www.foreignaffairs.com/articles/66753/adam-segal/chinas-innovation-wall

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