Science and the State in Modern China

*By Zuoyue Wang**

ABSTRACT

The question of the role of the state has, in one way or another, dominated historical studies of science and technology in modern China, a field that has experienced rapid growth since the early 1980s both inside and outside of China. While Western scholars have focused their analysis on the state control of science and scientists, Chinese historians and writers, often working under political restrictions, have largely adopted a descriptive approach with an emphasis on biographical, institutional, and disciplinary histories and on the theme of Chinese nationalism. The emergence of an international community of younger historians of science, the easing of access to primary source materials, and new attention to transnational and comparative perspectives promise to make the field an exciting area of scholarship.

WHEN I WAS A GRADUATE STUDENT studying the history of science in the Chinese Academy of Sciences in Beijing in the early 1980s, one particular symposium made a deep impression on me. The speakers were two of my professors, Xu Liangying and Li Peishan, at the Institute for the History of Natural Science (IHNS) and the Graduate School of the academy; they had just returned from an extensive trip to the United States, visiting many of the major institutions in the history of science. Inspired in part by what they saw there, they announced that they believed that it was time for Chinese historians of science to embark on historical studies of science *in China* in *modern* times.

Politically, the study of Chinese science in the ancient period had been safe; indeed, it had been encouraged by the Chinese government both as a response to Joseph Needham's monumental effort in that direction and as a way to inculcate patriotism in the Chinese people. Nearly as safe was the study of science in the West in the modern period, which was justified by the need to promote science and technology for China's modernization drive. In contrast, the study of modern science in China was a risky enterprise, for it would

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My thanks to Grace Shen for organizing this Focus section, to Bernie Lightman for editorial assistance, and to all my fellow contributors in this section for feedback and stimulating discussions that followed the completion of our first drafts. All names of Chinese in China are rendered in *pinyin* with family names first and given names second; *pinyin* spellings are also supplied in parentheses for names of those Chinese who were based in the West or who continued to use the older Wade-Giles spelling of their names.

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inevitably involve evaluation of the social and political context of science under the rule of the Communist Party since 1949, still a highly sensitive issue in this early stage of the post–Mao Zedong reform.[1]

These political concerns did not deter Xu and Li, who would later emerge not only as pioneers in the study of modern Chinese science but also as part of the political dissent in China that advocated for a liberal science policy and the protection of human rights. A former physicist and science administrator turned historian of science and a scholar on Albert Einstein, Xu was especially closely allied with the astrophysicist Fang Lizhi in the fight against political interference in science. Both eventually became leaders of a dissident movement that culminated in the 1989 Tiananmen protest. Indeed, even before that memorable symposium Xu had openly denounced Mao-era attacks on modern scientific theories as a "pernicious influence of feudalism" in his influential "Essay on the Role of Science and Democracy in Society," published in 1981. Science, he maintained, was not only a "productive force" but also a "harbinger of ideological emancipation." Thus he advocated that "in promoting [scientific] exploration, we must not only provide research with the necessary facilities but with an atmosphere of freedom conducive to exploration as well." "Political democracy and academic freedom," he concluded, "are necessary to guarantee the flourishing of science."[2]

Xu's relatively short essay resonated with Chinese intellectuals at the time not so much because of the strength of its historical documentation as because it presented a plausible explanation for the widely recognized failure of Mao's Cultural Revolution (1966–1976), which had just ended. Indeed, had Xu attempted to derive his views from careful studies of modern science in China, he would have found little either in China or, interestingly, abroad. What guided his thinking about science and society was as much his own long and often painful experience as a participant in the politics of science as any specific historical case study.[3] Now, more than a quarter century later, Xu's essay is remembered more as a demonstration of the liberal fervor that prevailed during the early post-Mao years than as a definitive historiographical milestone, but his call for attention to the role of the state in the development of science in modern China has nevertheless remained relevant in the remarkable outpouring of studies on the subject, first in the West and later in China. It is my purpose here to reflect on the evolution of historical studies of science

[1] For a survey of the history of modern science in China in this period see Li Peishan, "History of Modern Science and Technology in the People's Republic of China," *Isis,* 1985, *76:*366–370. One recent study found that of the 977 books on the history of science published in China in 1977–1997, 742 were on ancient Chinese science; see Su Yujuan and Wei Yidong, "1979–2000 nian Zhongguo kexueshi yanjiu zhuangkuang ji quxiang jiliang yanjiu" [A quantitative study of the status and trends of the Chinese studies in the history of science, 1979–2000], *Zhongguo keji zazhi* [Chinese Journal for the History of Science and Technology], 2006, *27*(1):44–53, on p. 49.

[2] Xu Liangying, "Shilun kexue he minzhu de shehui gongneng" [Essay on the role of science and democracy in society], *Journal of Dialectics of Nature,* 1981, *1*(1):3–6; an English translation was published in *Chinese Studies in the History and Philosophy of Science and Technology,* ed. Fan Dainian and Robert S. Cohen (Dordrecht: Kluwer, 1996), pp. 5–11 (the quotations are from pp. 6 and 7, respectively). For a detailed study of Maoist criticism of Albert Einstein's relativity theory during the Cultural Revolution see Danian Hu, *China and Albert Einstein* (Cambridge, Mass.: Harvard Univ. Press, 2005), and Hu's essay in this Focus section.

[3] Initially trained as a physicist, Xu joined the Communist Party during the war against Japan; in the 1950s he became a politically influential editor and philosopher of science in the Chinese Academy of Sciences before being purged in the 1957 Anti-Rightist Campaign. Persecuted again during the Cultural Revolution, he survived a suicide attempt to complete a translation of Albert Einstein's major writings in science, philosophy, and politics with several collaborators in the late 1970s. He has remained an outspoken activist for human rights in China. Xu interview with Zuoyue Wang, 8 July 2004, Beijing. See also Dennis Overbye, "Xu Liangying: Einstein's Man in Beijing," *New York Times,* 22 Aug. 2006, p. F1.

and technology in twentieth-century China, especially those related to science and the Communist party-state under Mao, both in English and in Chinese, to discern the questions that have animated scholarly discourse in this field, to determine how far the connection between science and democracy that Xu articulated has influenced these studies, and, finally, to speculate on new questions that might emerge to guide future developments.

SCIENCE, STATE, AND CONTROL: THE LITERATURE IN ENGLISH

In contrast to the situation in China, the scarcity of Western historical studies of science and technology in modern China derived not so much from political restrictions as from the lack of access to primary source materials. In a way, the two problems were related: international and domestic political considerations, especially in China, made it difficult for Westerners to access materials related to modern Chinese science. For example, in 1973 the Committee on Scholarly Communication with the People's Republic of China (CSCPRC)—a consortium established in 1966 by the U.S. National Academy of Sciences, the American Council of Learned Societies, and the Social Sciences Research Council—proposed to Premier Zhou Enlai a package of exchanges in nine areas of natural sciences and three areas of social sciences, including "science and technology in China's development." Zhou readily approved the former but declined the latter because they required further preparation.[4] (See Figure 1.)

The fact that the history of science made it into the CSCPRC's list, however, indicated that American scientists and the government were keenly interested in that subject both before and after Nixon's dramatic trip to Beijing in 1972. In December 1960, at the height of the Cold War and Sino–American isolation, the American Association for the Advancement of Science, with the support of the National Science Foundation and other organizations, had held a symposium on science in China and later published the proceedings in a massive volume. With the exception of the Canadian geophysicist J. Tuzo Wilson's account of his travels in China in 1958, all of the papers were based on readings of Chinese scientific literature available in the United States (thus a majority of the authors were actually Chinese-American scientists). In contrast, an update two decades later, this time sponsored by the CSCPRC, benefited from the flurry of mutual scientific visits in the 1970s.[5]

What these studies and a few scattered works on science in modern China in the pre-1980s period had in common was the fact that few of them were written by professional historians of science. The 1980 CSCPRC study did include an enlightening essay on Chinese scientific tradition by Nathan Sivin, but it focused on the ancient period. The book also contained an introduction about science policy and organization in the People's Republic by Richard Suttmeier, a political scientist who several years before had published a detailed analysis of the development of the Chinese Academy of Sciences under Mao. Suttmeier's writings provided useful background information and asked intriguing questions to frame the discussion on science in modern China, but they suffered from a lack

[4] Zuoyue Wang, "U.S.–China Scientific Exchange: A Case Study of State-Sponsored Scientific Internationalism during the Cold War and Beyond," *Historical Studies in the Physical and Biological Sciences,* 1999, *30:*249–277, on p. 255.

[5] The two volumes are Sidney H. Gould, ed., *Sciences in Communist China* (Washington, D.C.: American Association for the Advancement of Science, 1961); and Leo A. Orleans, ed., *Science in Contemporary China* (Stanford, Calif.: Stanford Univ. Press, 1980).

Figure 1. *Premier Zhou Enlai greeting the American nuclear chemist Glenn T. Seaborg, a member of the Committee on Scholarly Communication with the People's Republic of China, in Beijing in 1973. Courtesy Lawrence Berkeley National Laboratory.*

of access to primary sources other than press reports. The absence of studies by professional historians of science probably derived from multiple factors: the dominant internalist approach, with its focus on significant scientific discoveries, meant that most historical attention was directed to the scientific centers in Europe and the United States rather than to perceived "peripheries" such as China; similarly, in the field of modern Chinese history, science was often relegated to at best secondary importance compared with political and military matters. Indeed, some doubted whether there might not be a fundamental conflict "between the ethos of modern science and the essence of Chinese culture." Finally, the combined linguistic and scientific challenges tended to deter people in either camp from tackling science in modern China. As the China scholar James Reardon-Anderson explained in 1989, "Some people study China, some study science, but few have the stomach for both."[6]

Yet, with the rise of the externalist approach in the history of science, and with a growing recognition of the importance of science and scientists in post-Mao China, research on science in modern China in its broader social and political context has become both possible and worthwhile. China scholars still dominate the field, but, as this Focus section

[6] Richard Baum, "Science and Culture in Contemporary China: The Roots of Retarded Modernization," *Asian Survey,* 1982, *22:*1166–1186, on p. 1182; and James Reardon-Anderson, *The Study of Change: Chemistry in China, 1840–1949* (Cambridge: Cambridge Univ. Press, 1991), p. xviii.

demonstrates, a younger generation with strong ties to the history of science, sometimes with training in both fields, has emerged and promises to introduce innovative analytical frameworks to the study of science in modern China. In many ways, Reardon-Anderson himself pioneered the field when he produced the first major in-depth English-language historical study of science in modern China. With a focus on chemistry in China from 1840 to 1949, *The Study of Change* helped set a pattern for future discourse by placing the relationship of science and the state at the center of the story. According to Reardon-Anderson, "science rose and fell along with the rhythms of change in Chinese state and society." It often suffered from either too little support or too much control by the state—except in the Nanjing Decade (1927–1937), when the balance "was just right."[7]

Thus, what mattered to Reardon-Anderson was not democracy *per se,* in the sense that Xu spoke of, but a stable social and political environment that offered ample financial support for science and a liberal government policy that allowed scientists both to maintain professional autonomy and to contribute to nation-building. Nevertheless, Reardon-Anderson implicitly agreed with Xu that scientists and the state would inevitably come into conflict, as indeed they did under both the Nationalists and the pre-1949 Communists in Yan'an, when political authorities undertook excessive interference with scientific research. My own study of the Science Society of China (SSC) confirmed the centrality of the science–state relationship for scientific development in Republican China, but it also found that the dynamics of the politics of science in that period extended beyond state support and control of science. Motivated by both professionalism and nationalism, scientists, as represented by the SSC leadership, actually took on political roles themselves, seeking to create a prototype civil society and public sphere as well as to build up a centralized national science establishment.[8]

Laurence Schneider, another China scholar, recently took the theme of control to a new height with his masterful survey of the evolving relationship between geneticists and the Chinese state across the 1949 divide. While the book presented nuanced portraits of the biological community, especially during the Republican period, the emphasis is on the state and on its attempts, both under the Nationalists and especially under the Communists, to control nature, science, and scientists. That such attempts were not always successful was perhaps best illustrated by the rise and fall of Lysenkoism in China. In the end, Schneider echoed Xu in concluding that it was not the content of science but, rather, "the self-contained authority of a cosmopolitan science community" that posed a direct threat to Mao's Communist party-state. Similarly, in our study of the Chinese marine biologist C. K. Tseng (Zeng Chengkui in *pinyin*), Peter Neushul and I found that both Tseng's nationalism and the government's modernization drive helped produce China's maricultural success but that the Maoist party-state's attempts at radical political reconstruction of science and nature ultimately resulted in the Great Leap Forward disaster. We also developed a variation on Xu's theme of science and democracy by concluding that specific scientific or technological projects might succeed with adequate support from an authoritarian regime

[7] Reardon-Anderson, *Study of Change,* pp. 1, 10. Reardon-Anderson first published some of his research in "Chemical Industry in China, 1860–1949," *Osiris,* N.S., 1986, *2:*177–224.

[8] Zuoyue Wang, "Saving China through Science: The Science Society of China, Scientific Nationalism, and Civil Society in Republican China," *Osiris,* N.S., 2002, *17:*291–322. I turned to science in modern China after completing an M.A. thesis on the discovery of the equivalence of the matrix and wave mechanics under Xu (1985) and a Ph.D. thesis on the U.S. President's Science Advisory Committee at the University of California, Santa Barbara, under Lawrence Badash (1994).

but that, in the long run, the lack of checks and balances or other forms of minimal democratic governance would lead to upheavals like the Cultural Revolution, which devastated both science and society.[9]

Of course, as Schneider acknowledged, the experiences of the geneticists with Lysenkoism were not typical for all scientists; nor was the Communist party-state's policy toward all sciences the same. Like Stalin, for example, Mao gave nuclear physicists considerable leeway in developing the nuclear weapons that he needed for strategic political reasons. (See Figure 2.) As argued first by John W. Lewis and Xue Litai, and more recently by Evan Feigenbaum, the weapons scientists and the party-state leadership forged a powerful consensus, based on a shared drive toward nationalism, that resulted in the remarkable success of the Chinese nuclear weapons program.[10] Feigenbaum further contended that such techno-nationalism not only accounted for the rise of China as a strategic military power during the Cold War but has also guided its post-Mao developmental policy, with both its strengths and weaknesses.

While this picture of a military/civilian scientific dichotomy was generally true, my own case study of physics found that the protective effects of the nuclear weapons projects eventually wore off. This was partly because the sense of urgency lessened after the first successful nuclear test in 1964 and partly because Mao increasingly saw modernization

Figure 2. *Mao Zedong visiting an exhibit at the Chinese Academy of Sciences in Beijing in 1958. Front, left to right: Zhang Jinfu, CAS party leader and vice president; Wu Youxun, physicist and CAS vice president; Mao; and Guo Moruo, CAS president. From Wang Yusheng, ed.,* Fendou yu huihuang: Zhonghua keji bainian tuzhi (1901–2000) *[Struggle and glory: A pictorial record of one hundred years of Chinese science and technology] (Kunming: Yunnan Education Press, 2002), p. 127.*

[9] Laurence Schneider, *Biology and Revolution in Twentieth-Century China* (Lanham, Md.: Rowman & Littlefield, 2003), pp. 271, 281; and Peter Neushul and Zuoyue Wang, "Between the Devil and the Deep Sea: C. K. Tseng, Mariculture, and the Politics of Science in Modern China," *Isis,* 2000, *91:*59–88.

[10] John W. Lewis and Xue Litai, *China Builds the Bomb* (Stanford, Calif.: Stanford Univ. Press, 1988); and Evan A. Feigenbaum, *China's Techno-Warriors: National Security and Strategic Competition from the Nuclear to the Information Age* (Stanford, Calif.: Stanford Univ. Press, 2003).

and revolution not as complementary but as potentially conflicting paradigms for his vision of Chinese nationalism, especially if modernization meant elitist control of national science and the economy. Thus, during the Cultural Revolution, the chaos and terror he unleashed got their start in civilian science and education but later spread to the nuclear weapons program as well, where senior scientists were assailed by Maoist "rebels" and at least one of them, Yao Tongbin, a metallurgist in the missile program, was beaten to death. Even the well-known nuclear physicist Wang Ganchang, a major architect of the Chinese nuclear weapons program and former teacher of Xu Liangying, came under attack during the latter stage of the movement. Finally, Nie Rongzhen, the marshal in charge of the Chinese nuclear and missile programs, had to submit to Mao a "self-criticism" for his failure "to recognize the correct relationship between modernization and revolutionization [*geminghua*]" or "to let revolutionization take command over modernization."[11]

If Xu's theme of linking science and democracy stayed in the background in these studies, it moved to the center in a number of investigations of science and political dissent in post-Mao China. Indeed, Xu himself became the focus in such a study by the China scholar H. Lyman Miller. Echoing the sociologist Robert Merton, Miller argued that liberal Chinese scientists, represented by Fang and Xu, derived "powerful antiauthoritarian norms and rationalist values" from their scientific practice that led them to question the repressive policies of the post-Mao Communist Party led by Deng Xiaoping.[12] While Miller supported his conclusion with a careful examination of the speeches and writings of Fang, Xu, and their supporters, the Mertonian model runs into problems when one seeks to explain the behavior of politically conservative scientists who opposed Fang and Xu. Why did they not derive the same liberal values from their scientific practice? This quandary applies, of course, not only to scientists in China but to those in other national and political contexts as well. Perhaps future comparative analyses, as discussed later in this essay, will help deepen our understanding of the dynamics of the politics of science in the modern era.

NATIONALISM INTERRUPTED AND RESUMED: THE LITERATURE IN CHINESE

In contrast to the emphasis in the West on the roles and behaviors of the state in the development of science in modern China, the scholarship on the subject in China has, until recently, focused much more on the experiences of scientists and the evolution of scientific institutions. There are several reasons for this descriptive emphasis. On the one hand, despite Xu and Li's optimism in the early 1980s, political circumstances have made it prudent to refrain from overtly critical inquiries into and evaluations of Communist party-state policy even during the Mao years. The lack of ready access to governmental archives also posed often insurmountable obstacles to any careful examination of the politics of science and science policy. On the other hand, the official policy of modernization based

[11] Zuoyue Wang, "Physics in China in the Context of the Cold War," forthcoming in a collection of essays, edited by Helmuth Trischler and Mark Walker, on physics, funding, and institutions in the twentieth century. On Wang Ganchang see Fan Dainian and Qi Fang, "Wang Ganchang xiansheng zhuanlue" [A biographical sketch of Mr. Wang Ganchang], in *Wang Ganchang he ta de kexue gongxian* [Wang Ganchang and his scientific contributions], ed. Hu Jimin *et al.* (Beijing: Science Press, 1987), pp. 223–268, on pp. 254–255. On Mao and the dialectics of modernization and revolution see also Arif Dirlik, "Reversals, Ironies, Hegemonies: Notes on Contemporary Historiography of Modern China," *Modern China,* 1996, *22:*243–284; and Gardel M. Feurtado, "Mao Tse-Tung and the Politics of Science in Communist China, 1949–1965" (Ph.D. diss., Stanford Univ., 1986).

[12] H. Lyman Miller, *Science and Dissent in Post-Mao China: The Politics of Knowledge* (Seattle: Univ. Washington Press, 1996), p. 4.

on science and technology in the post-Mao era has continued to enhance the political and social status of Chinese science and scientists and therefore has provided the political cover for scholars to write biographies of scientists and histories of scientific institutions. In the name of patriotic education and learning from history, even the government has sometimes sponsored such studies. Both kinds of writings have tended to emphasize scientists' nationalism, and both have acknowledged the damage done by various political movements, especially the Cultural Revolution; but, not surprisingly, those writings directly sponsored by the government accentuated the positive developments. In neither case did the state completely disappear from the scene, but it often took on such an undifferentiated form, without any internal tension or evolution, that it nearly lost its interpretative force. Thus, while the quantity of such work has been impressive, the quality has been highly uneven. As economic reform and social liberalization continue, however, the history of science in China has become increasingly professionalized and internationalized, with promising new scholarship emerging.

Perhaps the most striking example of state-sponsored history of science in modern China was the emergence of the so-called national security "report literature" (*baogao wenxue*), with a focus on the experiences of scientists and engineers in the nuclear weapons complex.[13] Produced mostly by writers who were themselves members of the military and who presumably had access to internal archives, and based on interviews with the subjects, these novelized and often hagiographic biographies (and quite a few television documentaries and docudramas) proved frustrating to serious scholars both in and outside of China: they were often a major source of information on the nuclear weapons projects, but without footnotes or documentation one could never be sure of the reliability of the accounts. Substantively, what emerged from this body of literature is a strong sense of Chinese nationalism as the basis for the successful collaboration between the scientists and the party-state leadership—a finding that, as already noted, has received confirmation in independent research in the West. Yet the extent to which the scientists' nationalism coincided with the strategic and military considerations of the party-state leadership was often left unclear.

In contrast to the patriotic narrative of official histories, works by writers, journalists, and historians outside of the national security system have presented a more nuanced picture of science and scientists under Mao. Nationalism remained a dominant theme, but the state was no longer its chief motivating force or perfect embodiment. A good example in this category is a biography of the pioneering physicist Wu Youxun, who received his Ph.D. for work with Arthur Compton at the University of Chicago in 1925 and who trained many of the first-generation Chinese physicists, including almost all of the future leaders of the bomb projects. In 1949 he declined to move to Taiwan with the Nationalists and was soon appointed vice president of the Chinese Academy of Sciences. Although Wu put his faith in the Communist Party as a vehicle to realize his nationalist dreams, and despite his many contributions, the party never completely trusted him politically during the Mao years. Another recent biography focused on Shu Xingbei, whose career as a brilliant if

[13] See, e.g., Peng Jichao, *Dongfang juxiang: Zhongguo hewuqi shiyan jishi* [A mighty roar in the East: A report on China's nuclear weapons tests] (Beijing: Central Party School Press, 1995), part of the 7-volume Series of Reportages on China's National Security Science and Technology; and Qi Shuying and Wei Genfa, *Jiliang: Zhuming kexuejia Qian Xuesen* [Spine: Famous scientist Qian Xuesen] (Beijing: People's Liberation Army Press, 2001), part of the 9-volume Series of Literary Biographies of Scientists in China's National Defense Science and Technology.

cocky theoretical physicist took a dramatic and tragic turn during the 1957 Anti-Rightist Campaign, when he was purged as an enemy of the people. The book, based on internal government files on Shu and numerous interviews, reconstructed not only Shu's life and experiences during his long, painful persecution but also his gradual, humiliating submission to the power of the party-state.[14]

While such critical accounts of scientists' experiences during the Mao era have been barely tolerated by the government, writings on post-Mao developments, which have focused more on a resurgent Chinese nationalism, have met with a much warmer official reception. They have also benefited from an explosive expansion of the media and the publishing industry. Dozens of books and TV series, for example, have been devoted to the Chinese exploration of Antarctica and the Arctic just since the early 1980s. Such publicity, sometimes encouraged by the government as a way to stimulate patriotism, gave polar exploration and some of the scientists involved the celebrity status usually reserved for Olympic athletes, making the enterprise into an interesting mixture of scientific nationalism and internationalism.[15]

Institutional and disciplinary histories of science have also flourished. Among the earliest and most useful such studies was a history of the Chinese Academy of Sciences that appeared as part of Contemporary China, a series of books on various aspects of PRC history launched by the government in the 1980s. Equally useful have been the works of the historian Dong Guangbi, who has made several valuable attempts at a comprehensive overview of science and technology in modern China. More recently, the IHNS of the Chinese Academy of Sciences has sponsored a valuable series on science and technology in modern and contemporary China, with emphasis on institutional and disciplinary histories. In her excellent study of the development of polymer science in the PRC, based on extensive archival research and interviews, Zhang Li pointed out that polymer chemistry, because of its many applications, both benefited from the generous support of the state and suffered from its rigid control.[16] Once again, the question of science and democracy arises—this time with regard to the state control of science.

It is worth noting that both biographical and institutional studies of science in the recent period have benefited greatly from the open publication or, at least, the restricted circulation of a large number of primary sources, especially sources related to the history of the Chinese Academy of Sciences under the leadership of Fan Hongye.[17] Also of great sig-

[14] Nie Leng, *Wu Youxun zhuan* [A biography of Wu Youxun] (Beijing: China Youth Press, 1998) (like many works in the genre of novelized biographies, this book includes dialogues and apparently authentic internal archival materials but does not always provide specific references to sources); and Liu Haijun, *Shu Xingbei dang'an: yi ge tiancai wulixuejia de mingyun* [The archives on Shu Xingbei: The fate of a genius physicist] (Beijing: Writers' Press, 2005).

[15] See Zuoyue Wang, "China Goes to the Poles: Science, Nationalism, and Internationalism in Chinese Polar Exploration," in *Extremes: Oceanography's Adventures at the Poles,* ed. Keith R. Benson and Helen M. Rozwadowski (New York: Science History Publications, 2007), pp. 269–302.

[16] Yao Shuping *et al., Zhongguo kexueyuan* [Chinese Academy of Sciences], 3 vols. (Beijing: Contemporary China Press, 1994) (Li Peishan was a coauthor of this study); Dong Guangbi, *Zhongguo jinxiandai kexuejishushi lungang* [An outline of science and technology in modern and contemporary China] (Changsha: Hunan Education Press, 1992); Dong, ed., *Zhongguo jinxiandai kexuejishushi* [A history of science and technology in modern and contemporary China] (Changsha: Hunan Education Press, 1997) (a massive compilation of uneven chapters on various aspects of science in modern China that runs to 1,647 pages!); and Zhang Li, *Xin zhongguo yu xin kexue: Gaofenzi kexue zai xiandai zhongguo de jianli* [New science for a new China: Institutionalization of polymer science in the People's Republic of China] (Jinan: Shandong Education Press, 2005).

[17] The latter include two ongoing series—*Zhongguo kexueyuan shishi huiyao* [Key events in the history of the Chinese Academy of Sciences] and *Zhongguo kexueyuan shiliao huibian* [Collection of key documents in

nificance for the study of the history of science in modern China in general has been the publication of the diaries or *nianpu* (detailed chronological summaries of daily activities) of a number of important scientists and science administrators, such as Zhu Kezhen, a meteorologist and longtime vice president of the Chinese Academy of Sciences, Marshal Nie Rongzhen, and Premier Zhou Enlai.[18] Yet another important, but uneven, outlet for primary source materials is the growing number of memoirs, recollections, oral history interviews, Festschrifts, and commemorative volumes produced by scientists and their students, families, colleagues, and institutions.[19] One can only hope that this trend will continue and accelerate, that restrictions will be removed from internal materials, and that more archives will be opened to the international scholarly community.

A TRANSNATIONAL TURN?

Thus, despite still formidable obstacles, the historical study of science and technology in modern China has made great progress in the last quarter century and promises to take off as one of the most exciting areas of historical investigation in the next generation. As more Chinese primary sources are opened and a younger group of Chinese historians of science matures, we can expect greater sophistication in works on science in modern China produced both in and outside of China. Such development will not only deepen our understanding of the modern Chinese dynamics of science–state interactions but will also allow us to engage in new ways of exploring such interactions in the modern era in general.

One fruitful approach will be transnational comparative studies that examine the differences and commonalities between Chinese experiences and those in other national contexts, such as Russia, Japan, Germany, and the United States. For example, in some recent studise of my own and with~~out~~ others, it has been found that despite the vastly divergent political environments and many other differences, both Chinese and American scientists contended with their governments over their general penchant for basic research versus the governmental preference for applied and practical research.[20] On the question of science and politics, it will be especially illuminating to conduct comparative studies of the development of science in mainland China and in Taiwan after 1949, when the Communist revolution launched the two regions, with their many shared cultural elements, into radi-

the history of the CAS]—as well as a periodical, *Yuanshi ziliao yu yanjiu* [Documents and Studies on CAS History] that publishes documents, recollections, and oral history interviews related to CAS history.

[18] Zhu Kezhen, *Zhu Kezhen riji* [Zhu Kezhen's diary], Vols. 1–2 (covering 1936–1949) (Beijing: People's Press, 1984), Vols. 3–5 (covering 1950–1974) (Beijing: Science Press, 1989–1990). These were excerpts from Zhu's diary. The full version of the diary, along with all his other writings, is being published as *Zhu Kezhen quanji* [Collected works of Zhu Kezhen], 20 vols. projected (Shanghai: Shanghai Scientific and Technological Education Press, 2004–). For the other publications see Zhou Junlun, ed., *Nie Rongzhen nianpu* [Chronicles of Nie Rongzhen], 2 vols. (Beijing: People's Press, 1999); and CCP Documentation Research Office, *Zhou Enlai nianpu 1949–1976* [Chronicles of Zhou Enlai, 1949–1976], 3 vols. (Beijing: Central Documentation Press, 1997).

[19] Some of the best of such materials have been regularly published since 1980 in *Zhongguo keji shiliao* [China Historical Materials of Science and Technology], renamed *Zhongguo kejishi zazhi* [Chinese Journal for the History of Science and Technology] in 2005. It is now regularly indexed in the *Isis* Cumulative Bibliography, along with several other Chinese journals in the field of the history of science and technology.

[20] Michael Gordin, Walter Grunden, Mark Walker, and Zuoyue Wang, "'Ideologically Correct' Science," in *Science and Ideology: A Comparative History,* ed. Walker (London/New York: Routledge, 2002), pp. 35–65; Wang, "Physics in China in the Context of the Cold War" (cit. n. 11); and Wang, *In* Sputnik*'s Shadow: The President's Science Advisory Committee and Cold War America* (New Brunswick, N.J.: Rutgers Univ. Press, forthcoming).

cally divergent political trajectories and isolation from each other until the late twentieth century. Equally valuable will be studies that examine the transnational nature of the scientific and technological enterprise in modern China, which has seen major influences from Europe, Japan, Russia, and the United States. In many ways, Li Peishan's examination of the role of U.S.-trained scientists in modern Chinese science and technology initiated this area of inquiry by historians of science. More recently, Zhang Baichun and colleagues' volume on Soviet technological transfer to China in the 1950s, which appeared in the IHNS series, presented a detailed account of the extent of the Soviet influence on Chinese industrialization together with a balanced analysis of both its benefits and its harmful impact.[21]

A transnational approach also allows us to highlight actors and activities that broke the traditional boundaries of nation-states and state-centered narratives of national sciences. In my own study of Chinese-American scientists I have found that two groups of American-trained Chinese scientists played significant roles in the development of recent science and technology in China: those who returned to China following the revolution in 1949 represented a significant technological transfer at the height of the Cold War, contributing especially to the Chinese nuclear weapons program; while another group, those who chose to stay in the United States after 1949, became active in Sino–American scientific exchange after Nixon's trip in 1972. The latter figures have also played important roles in shaping post-Mao Chinese science policy and China–U.S. relations. (See Figure 3.) It should be noted that the U.S.–China scientific exchange was not a one-way street: as the achievements of the Chinese-American physicists C. N. Yang (Yang Zhenning) and T. D. Lee (Li Zhengdao), both Nobel laureates, and C. S. Wu (Wu Jianxiong), the first female president of the American Physical Society, testify, Chinese Americans have made major contributions to American science as well.[22] Among other effects, their successes also caused Western observers to reevaluate the Chinese potential for *modern* scientific research *in China* before the nuclear test in 1964. "For all we know the country abounds in Lees and Yangs," the prominent American physicist I. I. Rabi declared in 1961.[23]

As the infamous security case of the Chinese-American nuclear scientist Wen Ho Lee demonstrated, states—both Chinese and American—have remained key players in shaping the broader geopolitical environment for Chinese-American scientists and their efforts to promote Sino–American scientific exchange. But the growth of Chinese-American scientists as both a subnational and a transnational community, absorbing members not only

[21] Li Peishan, "The Introduction of American Science and Technology to China before 1949 and Its Impact," in *United States and the Asia-Pacific Region in the Twentieth Century,* ed. Shi Xian-rong and Mei Ren-yi (Beijing: Modern Press, 1993), pp. 603–618; and Zhang Baichun *et al., Sulian jishu xiang Zhongguo de zhuanyi, 1949–1966* [Technology transfer from the Soviet Union to the People's Republic of China, 1949–1966] (Jinan: Shandong Education Press, 2004).

[22] Zuoyue Wang, "Chinese American Scientists and U.S.–China Scientific Relations: From Richard Nixon to Wen Ho Lee," in *The Expanding Roles of Chinese Americans in U.S.–China Relations: Transnational Networks and Trans-Pacific Interactions,* ed. Peter H. Koehn and Xiao-huang Yin (New York: Sharpe, 2002), pp. 207–334; and Wang, "Physics in China in the Context of the Cold War" (cit. n. 11). On the remarkable story of the migration of several thousands of Chinese refugee intellectuals, many of whom were scientists and engineers, from China to the United States following the Chinese revolution of 1949 see Benjamin Zulueta, *Forging the Model Minority: Chinese Immigrants, American Science, and the Cold War* (Honolulu: Univ. Hawaii Press, forthcoming).

[23] I. I. Rabi to Aage Bohr, 19 Apr. 1961, Rabi Papers, box 1, folder "Bohr, Aage, 1948–1985, n.d.," Library of Congress Manuscript Division, Washington, D.C. Adding that "on the other hand, they may be quite provincial and stimulus from the outside may be important for their scientific development," Rabi tried to encourage Bohr, a Danish physicist and the son of Niels Bohr, to accept an invitation to visit China; and indeed he did so in 1962.

Figure 3. *The Chinese-American physicist T. D. Lee (left) receives thanks from Deng Xiaoping in Beijing in 1984 for his role in launching the Beijing Electron Positron Collider. From Liu Huaizu, ed.,* Beijing Electron Positron Collider *(Beijing: Science Press, 1994), p. 67.*

from the United States but also from places around the Pacific Rim with strong Chinese cultural connections, has created possibilities and influences that cannot always be controlled by any one nation-state. By the turn of the twenty-first century, the scientific migratory pattern can best be described as "intellectual circulation," as large numbers of a younger generation of Chinese-American scientists moved with ease among institutions in the United States, mainland China, Taiwan, Hong Kong, and Singapore, playing, at times, a political role in trying to mediate tensions both between the United States and China and between Taiwan and the mainland.[24]

In sum, this review of historical scholarship on modern Chinese science and the state in the last generation indicates that, in many ways, the field has expanded beyond Xu's (and Merton's) theme of the interdependence of science and democracy—even as we continue to grapple with the complexity that surrounds it. Yet, as China experiences rapid economic growth and becomes increasingly incorporated into the global community in the early twenty-first century, one can hope that Xu's dream of seeing science and democracy

[24] Wang, "Chinese American Scientists and U.S.–China Scientific Relations" (cit. n. 22).

flourishing together in China will be shared by more of his fellow citizens and may come closer to realization. The fact that Wang Ganchang signed several petitions, drafted by Xu and calling for political reform, in the 1980s and 1990s seems to signify that at least some of the former bomb makers recognized that a strong and prosperous China could not be built on techno-nationalism alone.[25]

By all indications, despite encouraging advances, there is still a long road ahead before China reaches its full potential in science or enacts a fully functional democratic political system with guarantees of human rights for all of its citizens. For historians of science, progress in this direction will be measured by the openness with which research can be conducted and by the extent to which historical issues, even of a sensitive political nature, can be publicly debated. After all, what is at stake is not only a better understanding of the development of science in modern China but, potentially, the intellectual vitality and political stability of a leading economy in an integrated world.

[25] See Miller, *Science and Dissent in Post-Mao China* (cit. n. 12), p. 15.