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CHINESE SCIENCE AND THE 'NOBEL PRIZE COMPLEX'

ABSTRACT. China's scientists have so far failed to win a Nobel Prize. Political interference, certain aspects of cultural heritage, and a problematic value system have arguably been major contributing factors. This essay examines the ways in which these factors have operated, and discusses why there is a growing 'Nobel Prize mania' in China today.

INTRODUCTION

During the past five years, the scientific community in mainland China has shown growing interest in the prospect of winning a Nobel Prize.¹ In 1998, several members (*yuanshi*) of the Chinese Academies of Sciences and Engineering (CAS and CAE), who are themselves recipients of China's most prestigious honours in science and technology, made the call: 'Chinese Science: It Is Time for a Nobel Prize!' Later that year, Zhang Cunhao, member of CAS and director of the National Natural Science Foundation of China (NSFC), insisted that 'China make plans for getting a Nobel Prize in the early twenty-first century'. In 1999, CAS President Lu Yongxiang, looking to the country's strength in mathematics, nanoscience, quantum theory, and the life sciences, raised the possibility of China winning a prize sometime between 2010 and 2030. The Chinese-American Nobel Laureate Chen Ning Yang has also predicted that mainland scientists will win a prize within twenty years – even more than one, if the country's economic development continues at its current rate.² The Chinese public is equally optimistic. A popular survey, conducted in 2000, listed a Nobel

¹ The Nobel Prize was set up by the will of Alfred Nobel to reward persons who have conferred benefit on mankind. The prizes for Physics, Chemistry, and Economics are awarded by the Royal Swedish Academy of Sciences; that for Literature, by the Swedish Academy; that for Physiology and Medicine, by the Karolinska Institute in Stockholm; and that for Peace, by a committee appointed by the Parliament of Norway.

² See, for example, *Keji ribao* (*Science and Technology Daily*), 4 August 1998; *Zhongguo kexue bao* • *Dongfang baodao* (*China Science News* • *East China News*), 27 November 1998, 1; *Lianhe zaobao* (*Union Morning News*) (*Singapore*), 22 February 1999; *Qiao bao* • *Zhongguo kexue zhoubao* (*China Press* • *The China Science Weekly*) (New York), 20 August 2000, C2; *Beijing chenbao* (*Beijing Morning News*), 2 November 1999; and *Zhongguo qingnian bao* (*China Youth News*), 15 December 2000.



Prize as among the ‘most likely events in the next ten years in China’ (number 86 of 100 events).³

China’s race to Stockholm reflects a sincere effort to pursue excellence. However, it is questionable whether a Nobel Prize in ‘Science’ should be treated as an objective standard, not least because it has proved as controversial as its counterparts in Literature, Peace, and Economics. For example, the scientific community has long recognized that important disciplines other than physics, chemistry, and physiology and medicine are not mentioned in Nobel’s will. Moreover, even within the accepted categories, many new disciplines have been either passed over, or else rewarded according to the preferences of the Nobel Committees. Given the pace of discovery, it is not surprising that Nobel Committees have been slow to recognize some new scientific frontiers. In any case, simple numbers of laureates do not necessarily reflect a country’s scientific wellbeing. Awarding the Prize to scientists working in India has not appreciably raised the general level of science and technology in that country. Finally, the nomination and evaluation of candidates has always been tinged with controversy. Although winners have, by and large, been gifted, their elevation to this peerless elite, standing qualitatively apart, has not been an altogether objective phenomenon.⁴

In this context, this essay focuses upon the following, related questions: Have Chinese scientists achieved anything that is unequivocally deserving of a Nobel Prize? If so, why have they not won? And why today is there a ‘Nobel Prize mania’ in China? What does it signify, and what will be its likely outcome?

At least one American Nobel Laureate, Paul Greengard, has expressed the belief that China’s scientists will win a Nobel Prize in Science within the next 30 years. See *Beijing qingnian bao (Beijing Youth News)*, 28 May 2002. Jan-Ake Gustafsson, chairman of the Nobel Committee for Physiology or Medicine, suggests that ‘it won’t take too long, perhaps ten years, for Chinese to receive a Nobel Prize’. See <http://peopledaily.com.cn/GB/kejiao/42/152/20021016/843527.html> (accessed 18 October 2002). China is not alone in pursuing the Nobel. Japan, for example, has devised a strategy to win 30 more prizes over the next 50 years. See Howard W. French, ‘Hypothesis: A Scientific Gap. Cause: Japan’s Ways’, *The New York Times*, 7 August 2001, A6.

³ http://www.horizon-china.com/Firsthand/E_Firsthand58.htm (accessed 11 January 2002).

⁴ For further discussion, see Robert Marc Friedman, *The Politics of Excellence: Behind the Nobel Prize in Science* (New York: W.H. Freeman, 2001). See also Elisabeth Crawford, J.L. Heilbron, and Rebecca Ullrich, *The Nobel Population, 1901–1937: A Census of the Nominators and Nominees for the Prize in Physics and Chemistry* (Berkeley: Office for History of Science and Technology, University of California, 1987); Harriet Zuckerman, *Scientific Elite: Nobel Laureates in the United States* (New York: Free Press, 1977); and the special issue of *Minerva*, XXIX (4), (2001), devoted to the centenary of the Nobel Prize.

HAS CHINA MADE NOBEL PRIZE-WORTHY ACHIEVEMENTS?

Several ethnic Chinese scientists have been among the recipients of the Nobel Prize, but all have won their awards for research performed in the United States. In 1957, for example, Chen Ning Yang and Tsung-Dao Lee, while working at the Institute for Advanced Studies in Princeton and at Columbia University, respectively, were awarded the Nobel Prize in Physics for disproving the law of conservation of parity. At that time, both held passports issued by China's Nationalist (Kuomintang) Government, the predecessor of the People's Republic. Since then, four ethnic Chinese scientists have won the Nobel Prize. These include Samuel Chao Chung Ting of the Massachusetts Institute of Technology and the European Centre for Nuclear Research in Geneva (1976); Yuan Tseh Lee of the University of California at Berkeley (1986); Steven Chu of Stanford University (1997); and Daniel C. Tsui of Princeton University (1998) – all working in physics, except for Lee, whose field was physical chemistry.⁵ But all these work in America.

Although scientists from the mainland have not yet won a Prize, this does not mean that they lack significant achievements. Indeed, Dong Guangbi, a historian of Chinese science and technology at the CAS Institute of the History of Natural Science, has identified ten important Chinese scientific achievements in the twentieth century: the discovery in 1928 of the skull of 'Peking man' by Pei Wenzhong; the experiments on electron-positron annihilation by Zhao Zhongyao in 1930; the publication in 1947 of a treatise on additive prime number theory by Hua Luogeng; the discovery by Wang Ganchang of the anti-sigma hyperon in 1959; the first testing in 1964 of China's atomic bomb; the world's first artificial synthesis in 1965 of bovine insulin; the launch in 1970 of China's first satellite; the trial cultivation in 1976 of the long-grained non-glutinous hybrid rice by Yuan Longping; the discovery in 1985 of Chengjiang fauna in Yunnan; and the discovery in 1995 that the earth's inner core moves faster than the earth mantle.⁶

⁵ These scientists are still working in the institutions where they received the Nobel Prize, except for Yang who has retired, and Yuan Tseh Lee, who is the President of the Academia Sinica in Taiwan.

⁶ 'Chinese Wins of Science Century', *China Daily*, 30 December 1999. Other achievements are even more significant. Richard Haynes, a chemistry professor at the Hong Kong University of Science and Technology, argues that 'there has got to be a Nobel Prize here somewhere', referring to the Chinese discovery of the substance *qinghaosu*, or artemisinin, to treat malaria, still one of the world's major killer diseases. See David Lague, 'Chinese Medicine: Revolutionary Discovery', *Far East Economic Review*, 14 March 2002, 34–37.

The list is impressive, but still the Prize has eluded China. At one level, this can be easily explained by the simple fact that the Prize does not go to paleontology, mathematics, and the earth sciences (except geophysics, on a few occasions). Moreover, atomic bombs and satellites are familiar to scientists everywhere, and China has failed to make a theoretical breakthrough in research on hybrid rice. Of Dong's ten examples, China's achievements in physics and the synthesis of insulin are the only potential Prize contenders. Let us consider them in detail.

In 1930, while using an electroscope to measure the absorption and scattering of gamma-rays from ThC, Zhao Zhongyao (known to the West as Chung Yao Chao), then a graduate student at the California Institute of Technology, first captured the positive-charged electron (positron) through what was later confirmed as the 'electron-positron annihilation', although he did not actually find the positron. At the time, two other physicists worked on similar experiments; however, one failed to reproduce Zhao's results, and the other did not detect the hard-gamma rays that Zhao had observed. These outcomes raised doubts about Zhao's research. (It was later shown that the first attempt obtained irregular findings, and the other lacked instrumentation sufficiently sensitive to make the detection.) Coincidentally, two influential physicists who reviewed Zhao's breakthrough carelessly described the work that failed to replicate Zhao's results as 'Zhao's research', which confused the international community and prevented Zhao from receiving the credit he 'so richly deserved'.⁷

In 1932, Carl D. Anderson, one of Zhao Zhongyao's classmates at Cal Tech, observed the tracks of the positron from a cloud chamber, and four years later, received the Prize. Fifty years afterwards, Anderson acknowledged that Zhao had inspired his discovery. Anderson's office was next to Zhao's, and his research, based on Zhao's experiment, was on the space distribution in various gases of photoelectrons produced by X-rays. He made his discovery by using the same radioactive source that Zhao had used. Realizing that Zhao's results showed the anomalous effects, Anderson adopted a different approach – using a magnet cloud chamber, and observing not only the tracks of electrons, but also those of the anti-electron, an anti-matter with the same mass as an electron but working in the opposite direction.⁸

⁷ Bingan Li and Chen Ning Yang, 'C.Y. Chao, Pair Creation and Pair Annihilation', *International Journal of Modern Physics A*, IV (17), (1989), 4325–4335.

⁸ Carl D. Anderson, with Herbert L. Anderson, 'Unraveling the Particle Content of Cosmic Rays', in Laurie M. Brown and Lillian Hoddeson (eds), *The Birth of Particle Physics* (Cambridge: Cambridge University Press, 1983), 131–154. Anderson also claimed that he found the anti-electron 'by accident'. See Burton Feldman, *The Nobel Prize: A History of Genius, Controversy, and Prestige* (New York: Arcade Publishing, 2000), 123.

In 1959, Wang Ganchang made a discovery when he was at the Joint Institute of Nuclear Research in Dubna, USSR. Using 40,000 pictures, he and a team of physicists from China detected a new hyperon with negative charges – called the ‘anti-sigma hyperon’, the first hyperon of its kind. This discovery enriched the understanding of anti-particles by filling an important gap in the particle-anti-particle table, and underscored the prediction that each particle has an anti-particle.⁹

Wang Ganchang’s work in China, which took place during the early years of the Second World War, was another achievement that came very close to winning a Nobel Prize. In the late 1920s, particle physicists found that when a beta particle is emitted from the nucleus of an atom, a slight amount of energy and momentum is lost. This violates the law of conservation of energy. To explain the phenomenon, in 1933, the Austrian physicist Wolfgang Pauli suggested that an unknown particle, called a neutrino, with little or no mass and no electrical charge, causes energy and momentum to depart from the nucleus. However, Pauli’s conjecture lacked experimental proof. In 1941, Wang Ganchang proposed an experiment to detect the existence of the neutrino by capturing K-electrons in nuclear reactions. He was unable to implement the experiment during the war, because Zhejiang University, where he was a professor, was forced to retreat to the hinterland; but he did write about the experiment, and submitted a paper to the *Acta Physica Sinica*.

Regrettably, the journal had no funds to publish, so Wang submitted his paper – ‘A Suggestion on the Detection of the Neutrino’ – to the *Physical Review*, where it was published in January 1942. Six months later, the American physicist J.S. Allen, adopting Wang’s results, experimentally confirmed the existence of the neutrino.¹⁰ A decade after the war, in 1956, the American physicists Frederick Reines and Clyde Lorrain Cowan, Jr., obtained conclusive proof of the neutrino’s existence by using a powerful nuclear reactor. For this, Reines was awarded the Prize in 1995. By this time, Cowan had died.¹¹ Wang Ganchang is said to have asked: ‘Why

⁹ In 1982, Wang Ganchang and his Chinese collaborators were given the first-class prize of China’s Natural Science Award for the discovery of the anti-sigma hyperon. See Yao Shuping, Luo Wei, Li Peishan, and Zhang Wei, ‘Zhongguo Kexueyuan fazhan shi (A Developmental History of the Chinese Academy of Sciences)’, in Qian Linzhao and Gu Yu (eds.), *Zhongguo Kexueyuan (The Chinese Academy of Sciences)* (Beijing: Dangdai Zhongguo chubanshe, 1994), 3 vols; vol. 1, 1–230, on 195.

¹⁰ Bingan Li and Chen Ning Yang, ‘Mr. Wang Ganchang and the Discovery of Neutrino’, in Zhang Meiman (ed.), *Yang Chen Ning tan kexue fazhan (Chen Ning Yang on the Development of Science)* (1986; River Edge, NJ: Global Publishing, 1992), 301–311.

¹¹ Raymond Davis Jr. and Masatoshi Koshiba were awarded another Nobel Prize in 2002 for their research on the detection of cosmic neutrinos.

wasn't the existence of the neutrino proved first in China?' His answer is not recorded.

Consider another of Dong's examples, the history of bovine insulin. This compound was first synthesized between 1958 and 1965 by Chinese scientists working at the CAS Institute of Biochemistry, Beijing University, and the CAS Institute of Organic Chemistry. This 'world's first' won worldwide recognition, and was reported in *Science* magazine.¹² At the end of 1966, Arne Wilhelm Kaurin Tiselius, President of the Nobel Foundation and Chairman of the Nobel Committee for Chemistry, visited China. Impressed with the work he saw, Tiselius remarked that China might learn from textbooks how to make an atom bomb, but not how to synthesize insulin.¹³ His visit attracted much interest in the possibility that this work would be recommended for a Nobel Prize. However, China was embroiled in the Cultural Revolution, and its intellectuals were under attack. Tiselius' invitation to China to recommend candidates for the Prize was turned down.

In 1972, the Chinese-American Nobel Laureate, Chen Ning Yang, suggested to China's then Premier Zhou Enlai that the insulin work be nominated for a Prize, but was politely refused. In 1978, Yang made the suggestion again. This time China was ready, or at least willing, to consider the possibility. An evaluation meeting was held to decide on the Prize nominees, among the many who had contributed in various capacities to the insulin synthesis. Each of the three participating institutions presented their work, and a vote was cast by an evaluation committee comprising sixteen leading scientists. Four candidates were short-listed. But taking into account that, even if the insulin work were to be rewarded, it would be unlikely to see the prize go to three Chinese, the commission picked just one candidate – Niu Jingyi – and passed supporting materials to Yang for nomination. That year, the biochemist Wang Yinglai, the organizer of the insulin synthesis and a nominator for the Prize, also recommended Niu. But the insulin synthesis was not awarded a Prize.¹⁴

¹² 'Total Synthesis of Insulin in Red China', *Science*, 153 (15 July 1966), 281–283.

¹³ Chen-lu Tsou, 'Chemical Synthesis of Crystalline Bovine Insulin: A Reminiscence', *Trends in Biochemical Sciences*, XX (7), (1995), 289–295.

¹⁴ Ge Nengquan, *Qian Sanqiang Nianpu (A Chronicle of Qian Sanqiang)* (Jinan, China: Shandong youyi chubanshe, 2002), 230–232; telephone interview with Ge (20 May 2003). Wai-Ling Vivian Tsui, 'Revisiting the Insulin Project in China: The Story of the Making of the First Synthetic Protein' (unpublished Bachelor of Arts thesis, Department of Molecular Biology, Princeton University, 1994), 109–111.

The Swedish scientist Tiselius and Chen Ning Yang were said to have independently suggested that Wang Yinglai, the organizer of the insulin synthesis project, be nominated for the Nobel Prize. See L. Ling-chi Wang, 'Obituary: Wang Yinglai (1907–2001)', *Nature*,

Of course, the fact that these achievements were hugely significant does not in itself mean that the scientists involved would win a Prize. Moreover, the Chinese insulin work was not the first successful attempt to synthesize a protein. In 1954, the American biochemist Vincent du Vigneaud obtained the first artificially synthesized protein – oxytocin. In the 1950s, another American biochemist, Christian B. Anfinsen, proposed that the primary structure of a protein determines its higher structures and functions. This hypothesis was implicit in the Chinese attempt to synthesize active insulin, and in fact, one could argue that the Chinese were the first to realize the idea experimentally. That is, once the A and B chains were separately synthesized, they could be put together through a disulfide bond. Then, between 1962 and 1963, the American chemist Robert Bruce Merrifield developed a laboratory method for the automatic synthesis of proteins that cut the time necessary for this process from months to mere days; while the Chinese approach was relatively primitive. The three American scientists – du Vigneaud, Anfinsen, and Merrifield – were awarded the Nobel Prize in Chemistry in 1953, 1972, and 1984, respectively.¹⁵ Therefore, although the Chinese insulin synthesis work was a Prize-level achievement, it was likely to be passed over because similar results obtained at the same time were equally significant and more sophisticated.

WHY HAVE CHINA'S SCIENTISTS NOT WON A PRIZE?

With a population of scientists amongst the largest in the world, why have China's scientists not won a Nobel Prize? Some would say that few achievements are worthy of such an honour at the best of times. Although many ideas are internationally recognized, few are held to be really world class. Of China's two major scientific achievements during the years of the People's Republic, only the synthesis of insulin took place on Chinese soil. China's basic research is said to lack originality, and has not produced discoveries that have led to new intellectual property. The past decade has even seen a decline in the share of basic research in China's overall R&D. On five separate occasions between 1989 and 2002, there were no winners

412 (5 July 2001), 30. But Yang indicated otherwise (personal communication, 22 August 2001). Wang Yinglai refused to become a co-author of the insulin synthesis papers. In 1982, when the achievement was given the first-class prize of China's Natural Science Award, Wang was not included. See Li Hujun, 'Shuaicai kexuejia (A Scientific Commander)', *Nanfang zhoumo (Nanfang Daily Weekend)*, 9 August 2001; Yao Shuping *et al.*, *op. cit.* note 9, on 195.

¹⁵ Chen-lu Tsou describes the research that was conducted during the same period that he and his colleagues were working on the insulin synthesis. See Tsou, *op. cit.* note 13.

of first-class prizes in China's Natural Science Award.¹⁶ And when China presented its State Supreme Science and Technology Award (also known as 'China's Nobel Prize') to five scientists in 2001, 2002, and 2003, only one recipient (Huang Kun) worked in a Nobel Prize field (physics).¹⁷

Furthermore, while there has been a steady increase in the number of international papers published by China's scientists – China ranked eighth in the *Science Citation Index (SCI)* in 2001 (see Table I), and improvement from twenty-sixth place in 1985 – the total number of China's papers in *SCI*-indexed journals in 2000 was only one-quarter of Britain's and Japan's, and one-eighth that of the United States. Although scientists at Beijing University published 1,105 *SCI* papers in 2000, this was less than one-eighth of the number produced by scientists at Harvard.¹⁸ The 'impact factor' associated with journals in which Chinese publish also tends to be lower, and fewer Chinese papers are cited. Indeed, the number of *SCI* citations of Chinese papers is 0.94, while that of papers by Japanese, Taiwanese, and South Korean scientists are 2.99, 1.45, and 1.24, respectively.¹⁹ Papers that Chinese scientists publish in *Science* and *Nature*, and which may well be highly cited, are mainly within the fields of paleontology and geology, and are therefore outside the scope of the Nobel Prize.²⁰

The low level of Nobel Prize-relevant research in China is partly due to a lack of investment. Developments in science have become more and more capital intensive. The purchase of advanced instruments and the recruitment of first-rate scholars, subscriptions to journals, and the use of the Internet all depend on external funding. But because investment in basic research does not bring an immediate return, a short-sighted government can easily find excuses to withhold support. Behind the large share of American Nobel laureates in science lies a long history of support

¹⁶ *Jingji ribao (Economic Daily)*, 2 February 2002.

¹⁷ Other fields include topology, the mechanization of mathematical proof (WU Wenjun), hybrid rice (Yuan Longping), laser typesetting systems in language and electronic publishing systems (Wang Xuan), and computing technology (Jin Yilian). See *Qiao bao • Zhongguo kexue zhoubao (China Press • The China Science Weekly)*, 25 February 2001, C8. See also http://English.peopledaily.com.cn/200202/02/english20020202_89780.shtml (assessed 14 August 2002).

¹⁸ See http://www.chinainfor.gov.cn/search/show_info.jsp?info_id=25561 (accessed 16 January 2002).

¹⁹ Zou Chenglu, 'Wo de kexue shengya (My Scientific Career [11])', *Kexue sibao (Science Times)*, 11 July 2002.

²⁰ The situation has begun to change. See Yi Rao, 'Zhongguo kexue de fazhan yu tiaozhan: yi shengming kexue zai guoji qikan shang de fabiao wei li (Advances and Challenges in Chinese Science: Chinese Life Scientists' Articles in International Journals)', *Ershiyi shiji (Twenty-First Century)* (Hong Kong), ILXX (February 2002), 83–94.

TABLE I

Publications of Chinese scientists counted in the *Science Citation Index*

Year	Number	Percent	Rank
1985			26
1986			25
1987	4880		24
1988	5590		17
1989	6776		15
1990	7945		15
1991	6630		15
1992	6224	0.92	17
1993	9617	1.28	15
1994	10411	1.32	15
1995	13134	1.54	15
1996	14459	1.62	14
1997	16883	1.62	12
1998	19838	2.13	12
1999	24476	2.51	10
2000	30499	3.15	8
2001	35685		8

Source: National Bureau of Statistics and Ministry of Science and Technology, *China Statistical Yearbook on Science and Technology* (Beijing: China Statistical Press, various years).

by the National Science Foundation, the National Institutes of Health, and other Federal agencies, as well as by private, non-profit foundations. In percentage of gross domestic product (GDP) devoted to research and development (R&D), China (with an expenditure of only 1.1 per cent in 2001) has lagged far behind not only the developed countries of the West, but also behind South Korea (2.65 per cent, 2000), Taiwan (2.05 per cent, 2000), and Singapore (1.88 per cent, 2000) (see Table II).²¹

In 1995, the Chinese Communist Party (CCP) and government proposed to 'revitalize the nation with science, technology, and education (*kejiao xingguo*)', and stipulated that by the end of the century, R&D spending would be increased to 1.5 per cent of GDP. It turns out that, without implementing actual measures to support science and technology,

²¹ Institute for Management Development (IMD), *The IMD World Competitiveness Yearbook 2002* (Lausanne, Switzerland: IMD, 2002), 627.

TABLE II
International comparisons of GERD/GDP (2000)

Country or region	GERD/GDP (%)
Japan	3.12
USA	2.69
South Korea	2.65
Germany	2.46
France	2.14
Taiwan	2.05
Singapore	1.88
UK	1.85
Canada	1.81
Russia	1.08
Italy	1.04
China	1.00
Brazil	0.87
India	0.59

Source: *The IMD World Competitiveness Yearbook 2002* (Lausanne: Institute for Management Development, 2002), 627.

this was merely a gambit.²² According to the *World Competitiveness Yearbook 2002*, issued by the Institute for Management Development, among the forty-nine countries and regions surveyed, China's competitiveness in science and technology dropped from thirteenth in 1998, to twenty-fifth in 1999, and to twenty-eighth in 2000 (but was ranked twenty-fourth in 2001). Low investment in R&D – including lower total expenditure on R&D, a lower percentage of GDP devoted to R&D, and lower total expenditure on R&D per capita – has contributed to the decline of China's competitiveness in science and technology.²³ This, combined with extremely low funding of basic research (which, as part of overall R&D expenditure, decreased from 6.7 per cent in 1993 to some 5 per cent in the late 1990s) (see Table III), continues to constrain China's Nobel Prize prospects for the future.

There are also, however, deeper historical and social factors at work. In discussing why China has not won a Nobel Prize in Literature, the intru-

²² Richard P. Suttmeier and Cong Cao, 'China Faces the New Industrial Revolution: Achievement and Uncertainty in the Search for Research and Innovation Strategies', *Asian Perspective*, XXIII (3), (1999), 153–200.

²³ *The IMD World Competitiveness Yearbook 2002*, *op. cit.* note 21.

TABLE III

International comparison of basic research expenditure as percentage of total R&D expenditure

Country (Year)	Basic research (%)
Switzerland (1998)	27.90
Australia (1998)	26.60
Italy (1998)	22.20
France (1999)	24.40
Czech Rep (2000)	36.60
USA (1997)	18.10
Singapore (1993)	16.10
South Korea (1994)	14.00
Japan (1999)	12.30
China (2000)	5.20

Source: National Bureau of Statistics and Ministry of Science and Technology, comps., *2001 China Statistical Yearbook on Science and Technology* (Beijing: China Statistical Press, 2002), 250–251; and *2002 China Statistical Yearbook on Science and Technology* (Beijing: China Statistical Press, 2002), 438–439.

sions of politics and traditional culture are often mentioned. These factors are no less relevant to the situation confronting the natural sciences.²⁴

THE INTERFERENCE OF POLITICS

Politics plays an undisputed role in Chinese intellectual life. If the Anti-Rightist Campaign in 1957 was a serious blow to intellectuals, the Cultural Revolution between 1966 and 1976 was a far worse nightmare. At the time when world science and technology were making giant strides, Chinese scientists were persecuted. Intellectuals were denounced as 'stinking number nine' (*chou laojiu*), located at the 'bottom of the barrel', and as social outcasts, put somewhere after landlords, rich peasants, counter-revolutionaries, bad elements, rightists, traitors, spies, and

²⁴ Cao Changqing, 'Nuobei'er Wenxue Jiang weihe yu women wuyuan (Why Has the Nobel Prize in Literature Eluded China)', *Shijie zhoukan (World Journal Weekly)* (New York), 21 November 1999, 38–39. In his Nobel Lecture, 'The Case for Literature', Gao Xingjian, a Chinese writer who is now a French citizen, and the 2000 Nobel Laureate for Literature, pointed out that politics have always dictated Chinese literature. See the website of the Nobel Foundation. <http://www.nobel.se/literature/2000> (accessed 13 December 2000).

'capitalist roaders'.²⁵ In the harsh political environment, few scientists, even those not attacked, had enough mental toughness to continue their research. Many lost their lives, never mind the most productive years of their careers.

Neuropharmacologist Zou Gang, then at the CAS Institute of Materia Medica, is a case in point. In the early 1960s, Zou and his mentor, Zhang Shaochang, found that the effective functional sites of morphine analgesia are the third ventricle and central gray substance (substantia nigra) surrounding the cerebral aqueducts. This was considered a milestone in research on the mechanisms of morphinization. Their 1964 paper, published in *Scientia Sinica* (at that time China's only English-language basic science journal), was chosen by the Institute for Scientific Information in 1993 as one of its 'Citation Classics'. Shortly thereafter, Zou made another landmark discovery: Bicuculline is an antagonist of gamma-aminobutyric acid (GABA), the major inhibitory neurotransmitter in the brain. A paper describing the discovery was to be published in the *Chinese Journal of Physiology* in 1966. However, this did not happen, owing to the Cultural Revolution. In fact, Zou was forced to abandon the project. In 1970, when he read in *Nature* that an Australian group had made an almost identical discovery, he was saddened. The failure to publish his work was more than just a tragedy for Zou and Chinese science. According to Australian contemporaries, it imposed a long delay on a whole field of neuropharmacological research.²⁶

An after-shock of the Cultural Revolution was the loss of an entire generation of scientists who might otherwise have led China's research enterprise. China's political system also influenced the direction of scientific research, fostering some fields over others, on ideological rather than scientific grounds.²⁷ Lysenkist biology during the 1950s and 1960s provides a good example.²⁸ But there are many others. China's political situation has in the past caused its scientists to behave irrationally, as in

²⁵ Hsi-sheng Ch'i, *The Politics of Disillusionment: The Chinese Communist Party under Deng Xiaoping, 1978–1989* (Armonk, NY: M.E. Sharpe, 1991), 126–127.

²⁶ Michelle Hoffman, 'Lost in the Cultural Revolution', *American Scientist*, LXXXII (1), (1994), 18–19.

²⁷ Richard P. Suttmeier, 'Science, Technology, and China's Political Future: A Framework for Analysis', in Denis Fred Simon and Merle Goldman (eds.), *Science and Technology in Post-Mao China* (Cambridge, MA: Harvard University Press, 1989), 3–20.

²⁸ Laurence Schneider, 'Editor's Instruction', in Laurence Schneider (ed.), *Lysenkoism in China: Proceedings of the 1956 Qingdao Genetics Symposium* (A Special Issue of *Chinese Law and Government*) (Armonk, NY: M.E. Sharpe, 1986), iii–xxi; 'Learning from Russia: Lysenkoism and the Fate of Genetics in China, 1950–1960', in Simon and Goldman (eds.), *op. cit.* note 27, on 45–65.

the case of the rocket scientist Qian Xuesen. Qian's claim, in 1958, that rice production could be increased more than twenty times over an already inflated 1,000 kilograms per *mu* (or 0.067 hectares), gave the radical 'Great Leap Forward' campaign an absurdly 'scientific' foundation.²⁹

Other scientists redirected their attention to more practical topics as a way of escaping political persecution. Having survived the Anti-Rightist Campaign, for example, the mathematician Hua Luogeng gave up his research on number theory which had brought him international fame, and spent many years popularizing and applying planning methods to factories and the countryside.³⁰ During the same period, the Party and the government set up research priorities, notably focused upon national defence.³¹ Atomic weapons and space satellites were clear priorities. During the People's Republic, scientists followed political instruction, and worked on projects to showcase the political leadership. Individual scientists had little prospect of initiating their own projects. Over the past twenty years, the influence of politics on science has not been as strong, but a top-down approach is still felt in the research community.

THE INFLUENCE OF TRADITIONAL CULTURE

Arguably, the traditional culture of China has been a significant hindrance to the development of modern science. Joseph Needham always argued that the Confucian contribution to science was 'almost wholly negative'; in his view, Confucianism focused on the practical application of technological processes while denying the importance of theoretical investigation.³² As a result, he believed Chinese discoveries were empirically sophisticated but theoretically primitive.³³ Recent work has confirmed Needham's view. There is scarcely any tradition of reasoned discourse between two individuals in order to approach clarity or truth; and whenever there is disagreement between a master and his disciple, the outcome is predeter-

²⁹ *Zhongguo qingnian bao* (*China Youth News*), 16 June 1958, 4.

³⁰ *Renmin ribao* (*People's Daily*), 8 June 1969, 4; Wang Yuan, *Hua Luogeng* (Beijing: Kaiming chubanshe, 1994), 291–306; and Caspar Schweigman and Shuzhong Zhang, 'The Teaching of Hua Loo-Keng: A Challenge Today?' *The Mathematical Intelligencer*, XVI (3), (1994), 36–46, on 41–43.

³¹ Wendy Frieman, 'China's Military R&D System: Reform and Reorientation', in Simon and Goldman (eds.), *op. cit.* note 27, on 252–286.

³² Joseph Needham, *Science and Civilisation in China*, vol. 2: *History of Scientific Thought* (Cambridge: Cambridge University Press, 1956), 1 and 26.

³³ Richard Baum, 'Science and Culture in Contemporary China: The Roots of Retarded Modernization', *Asian Survey*, XXII (12), (1982), 1166–1186.

mined. The master has always had the last, triumphant word, while his disciple was reduced to silence.³⁴

Whatever may be the consequences of Confucianism – and it is dangerous to rely upon stereotypes – it does seem that China's structures do favour age over innovation. Path-breaking scientists are commonly thought to make their most important discoveries between the ages of 25 and 45, peaking at 37. Indeed, 85 per cent of all Nobel Prize winners have been within this age range.³⁵ When the six ethnic Chinese scientists received the prize, Tsung Dao Lee was 31 years old, Yang, 35, and Ting 40, but Yuan Tseh Lee was 50, Chu was 49, and Tsui was 59.

There are several reasons why Chinese scientists do not display their talents at an earlier age. First, seniority is paramount in Chinese society. The mere presence of young scientists does not ensure that they have an important voice in priority-setting or decision-making. The experience of Chen Zhu, one of the youngest members of CAS, and China's star scientist, who nonetheless hesitated to give his frank opinion on important projects, is a case in point.³⁶ The contrast with science in the West is profound. A conversation between Yuan Tseh Lee and Wu Ta-you (Lee's mentor and President Emeritus of the Academia Sinica in Taiwan until his death in 2000) is typical. Wu claimed, 'If Yuan Tseh Lee had been in Taiwan, he could not have won the Nobel Prize.' Lee agreed. 'I have been in the United States for thirty years, and the most important thing I have learned is that every one is equal.'³⁷ In the West, seniority is seen as a function of skill and experience, and not simply of age.

Second, China's educational system binds students to their mentors. A mentor is an authority figure as formidable as a father, and to challenge him is unacceptable. However, this loyalty discourages criticism of seniors,

³⁴ Derk Bodde, *Chinese Thought Society, and Science: The Intellectual and Social Background of Science and Technology in Pre-modern China* (Honolulu: University of Hawaii Press, 1991), 179. Sivin makes the same point. See Nathan Sivin, 'Comparing Greek and Chinese Philosophy and Science', in his *Medicine, Philosophy and Religion in Ancient China: Researches and Reflections* (Aldershot: Variorum, 1995), 1–11.

³⁵ Paula E. Stephan and Sharon G. Levin, 'Age and the Nobel Prize Revisited', *Scientometrics*, XXVIII (3), (1993), 387–399.

³⁶ Confidential interview with a young life scientist, Beijing, 5 December 1998. Chen Zhu was elected a foreign associate of the US National Academy of Sciences in April 2003.

³⁷ Zhao Hongzhou, 'Women weihe yu Nuobei'er Jiang wuyuan (Why Have the Nobel Prizes Eluded China)', *Xiandaihua (Modernization)*, XVII (1), (1995), 7–8. In a recent talk on Chinese culture and education, Yuan Tseh Lee, now president of the Academia Sinica himself, emphasized the importance of challenging the authority in the progress of science (Hong Kong: New Asian Academy, the Chinese University of Hong Kong, 24 September 1999).

and proves a major handicap.³⁸ The mathematician Su Buqing saw three of his students – Gu Chaohao, Hu Hesheng (Gu and Hu are husband and wife) and Li Daqian – become members of CAS. But whilst proud that his students were honoured, Su warned them not to turn out students who might in turn surpass them.³⁹

A third inhibiting factor arises from the fact that China's scientists have not had enough time to generate a Nobel Prize-winning momentum. As is well known, Nobel laureates reproduce winners.⁴⁰ Earlier generations of Chinese scientists, including some who studied with Nobelists abroad, might well have nurtured a new crop of scientists had they not been burdened by political traumas at home. Only in the past twenty years have Chinese scientists been able to focus their attention upon research. It will take time for them to produce a critical mass. In the meantime, outstanding Chinese scientists are so few in number that they are likely to be deflected from research, by being appointed to administrative positions. Confucian doctrine teaches that 'a good scholar will make an official', and some of the best scientists, knowing that they can in this way secure scarce resources, are willing to leave their labs. The downside comes when they become submerged in administration.⁴¹

THE RESEARCH ENVIRONMENT

Among the six ethnic Chinese who have won the Nobel Prize, two – Chen Ning Yang and Tsung-Dao Lee – attended the Southwest Associated University, an institution formed during the Second World War by an amalgamation of Beijing, Qinghua, and Nankai Universities in Kunming (Yunnan Province). Yang and Lee then went to the United States, where they received doctoral degrees from the University of Chicago. The other three – Samuel Chao Chung Ting, Yuan Tseh Lee, and Daniel C. Tsui –

³⁸ The cultural heritage – Confucian ideas of age grade promotion and piety toward seniors – also explains why Japan, the world's second largest economy, with its significant investment in research, has not performed well in the Nobel Prize competition. See Howard W. French, 'Hypothesis: A Scientific Gap. Conclusion: Japanese Custom' *The New York Times* August 2001; James R. Bartholomew, *The Formation of Science in Japan: Building a Research Tradition* (New Haven: Yale University Press, 1989), 1; and Morris Low, 'From Einstein to Shirakawa: The Nobel Prize in Japan', *Minerva*, 39 (4), (2001), 445–460. Academic inbreeding has also been serious in South Korea. See 'Academic Inbreeding Attached', *Science*, 282 (18 December 1998), 2165.

³⁹ Zhao Hongzhou, *op. cit.* note 37.

⁴⁰ Zuckerman, *op. cit.* note 4, 99–106.

⁴¹ Interviews with young scientists in Beijing and Shanghai in 1998 and 1999.

went to the US after undergraduate degrees in Taiwan or Hong Kong.⁴² Steven Chu was born and grew up in the US. That is to say, all the ethnic Chinese laureates received their college education in China, or were influenced by Chinese culture. But all thereafter established themselves in the United States, where the environment was conducive to research, and where there was greater freedom in choosing projects, a rich academic atmosphere, and advanced experimental facilities. In the absence of these things in China, these future laureates (and many other scientists) actively chose to study abroad.⁴³

On the other hand, China's research environment has discouraged Chinese scientists who, having done well abroad, returned home. The case of Wu Youxun is typical. With Luis Alvarez, Wu was among the best students of the 1927 Nobel Laureate Arthur H. Compton. Alvarez followed his mentor in winning a Nobel Prize in 1968, but Wu – who actually helped Compton prove the Compton Effect experimentally – achieved far less after his return to China. Chen Ning Yang admitted that he probably could have not won the Prize if he had returned to China in the early 1950s, because he would never have known about the debate over the law of conservation of parity.⁴⁴ Similarly, if Tsui had not migrated to Hong Kong in 1953, he almost certainly would not have won the Prize. The circumstances are best described in terms of the ancient adage of an 'orange turning into trifoliate orange'; that is, an adequate environment is crucial to a scientist's performance.⁴⁵

The Chinese environment has yet another limiting condition. The Nobel Prize recognizes originality, and can, of course, be shared.⁴⁶ Several

⁴² Ting was born in Ann Arbor, Michigan, when his parents were visiting professors at the University of Michigan.

⁴³ That is also the case in Japan where the system that has produced relatively few Nobel Prizes is responsible for forcing its best and brightest overseas. See Low, *op. cit.* note 38.

⁴⁴ *Qiao bao • Zhongguo kexue zhoubao (China Press: The China Science Weekly)*, New York, 20 August 2000, C2.

⁴⁵ According to the Chinese classic *Yanzi chunqiu (The Annals of Yanzi)*, during a banquet entertaining Yanzi (?–550 BC) – who served as an envoy of Qi – the king of Chu deliberately had his soldiers escort a prisoner from Qi near by. The king asked, 'What crime did the prisoner commit?' 'Theft,' he was told. Then the king turned to Yanzi, 'Do citizens in Qi have a habit of stealing?' 'No', Yanzi said, 'An orange is called orange when it is planted in the south of the Huai River, and turns into a trifoliate orange when it migrates to the north of the river. That citizens from Qi committed the crime in Chu was due to the environment of Chu.' Yanzi used this story to show the importance of environment to a person's behaviour.

⁴⁶ Robert K. Merton, 'Priorities in Scientific Discovery', in Robert K. Merton, *The Sociology of Science: Theoretical and Empirical Investigations* (1957); new edition by Norman W. Storer (Chicago: University of Chicago Press, 1973), 286–324.

hundred scientists and technicians worked on Samuel Chao Chung Ting's Nobel-Prize-winning project. The Prize went to Ting only, because he was the person who put forward the new idea, and the outcome was achieved under his guidance.⁴⁷ But an important social issue was involved. China has tried to mobilize its scientific talent across a vast population, and has stressed the value of collective work and egalitarianism.

To make matters worse, China's research system has been dominated by a planning mentality, which has been reluctant to support fundamental research having no immediate economic benefits. For example, Wang Yuzhu, a physicist at the CAS Shanghai Institute of Optics and Precision Instrumentation, was the first – and at least five years ahead of Steve Chu and his fellow Nobel laureates – to propose trapping atoms using the laser cooling technique. But Wang did not pursue the idea, because he had never been educated to be innovative. Moreover, he had to take money from other projects to purchase equipment, and even to devise smaller experiments. As a result, he was over a year behind his competitors when he finally published in 1993.⁴⁸

In recent years, China has been improving its research environment – for example, by setting up the National Natural Science Foundation of China (NSFC), by introducing peer review, by supporting young and promising scientists, and by calling for the 'tolerance of failure'. But the planning mentality is still strong as the 'Nobel Prize mania' shows. Moreover, it will take time for scientists to adapt to the new environment and to nurture the next generation of scientists.

WHY IS CHINA EAGER TO WIN THE NOBEL PRIZE?

Studies suggest that modern countries must be at least thirty years old in order to win a Nobel Prize. The first Soviet scientist was honoured thirty-nine years after the establishment of the Soviet Union in 1917. It took Czechoslovakia forty-one years, and Poland, forty-six, to win a Prize; Pakistan, twenty-nine years, and India, thirty. On average, the time required is thirty-five years. The People's Republic of China was established more than fifty years ago. The Nobel Prize is still beyond reach. China's scientific leadership has come under enormous pressure to win. What can be done?

In 1994, the NSFC launched the National Science Fund for Distinguished Young Scholars, to award each year 100 or so young scientists

⁴⁷ One may well ask whether it is appropriate for laboratory chiefs to receive all the credit when Nobel Prize-winning experiments are carried out by junior colleagues.

⁴⁸ *Wenhui bao* (*Wenhui Daily*), 28 October 2002.

of forty-five years of age and younger substantial funding for research with no restriction on what they pursue.⁴⁹ In 1997, China's Ministry of Science and Technology launched a State Key Basic Research and Development Program, planning to invest RMB2.5 billion (\$300 million) over five years to support some fifty projects in agriculture, energy, information, resources and the environment, population and health, and materials. Although this programme aimed to solve problems associated with China's social, economic, and scientific and technological development, it also stipulated that projects be related to major basic research problems of interdisciplinary significance, the solution of which should help China occupy 'an important seat' (*yi xi zhi di*) in international research. That is to say, the programme encourages participants to achieve breakthroughs in basic research. Beginning in late 1998, CAS launched a 'Knowledge Innovation Program', and the Ministry of Education began a 'Cheung Kong Scholar Program', each targeting scientists with substantial funding.⁵⁰ As China begins to increase its investment, scientific leaders have become optimistic about the possibility of winning a Prize.

However, its quest reflects the motivations of its political, as well as China's scientific leadership. The fact that the six ethnic Chinese laureates were trained before the People's Republic was established, and completed graduate studies in the United States, means that there is nothing in recent experience for which the Chinese Communist Party (CCP) can take credit. Since 1978, when China re-opened its doors to the world, more than 580,000 Chinese students and scholars have gone abroad, of whom only 150,000 have returned.⁵¹ Statistics produced by the US National Science Foundation indicate that between 1986 and 1998, more than 21,600 Chinese earned science and engineering doctorates from American universities, and of these, 17,300 planned to remain in the US.⁵² Those who remain abroad are likely to be among the best. The discovery that the earth's inner core moves faster than the earth mantle was made by Xiaodong Song when he was a post-doctoral fellow at Columbia University. In 1999, Chinese affiliated to American, European, or Japanese institutions published 15 per cent of all the papers in the top five life

⁴⁹ For a discussion of the Fund and its impacts on the rising scientific elite in China, see Cong Cao and Richard P. Suttmeier, 'China's New Scientific Elite: Distinguished Young Scientists, the Research Environment and Hopes for Chinese Science', *The China Quarterly*, 168, (December 2001), 959-983.

⁵⁰ Suttmeier and Cao, 'China Faces the New Industrial Revolution', *op. cit.* note 22.

⁵¹ <http://www.chinanews.com.cn/2001-08-20> (accessed 20 August 2001).

⁵² *Issue Brief: Human Resource Contributions to US Science and Engineering from China* (Arlington: Division of Science Resources Studies, National Science Foundation, 12 January 2001).

science journals.⁵³ Of 300 China-born scientists who are now recognized as leaders in their fields, only five have returned to China – and none of these have been among the top 20 per cent.⁵⁴

Various measures have failed to bring home those who are of the calibre needed to win the Nobel Prize. Yet, unless this happens, it will be a serious blow to China's political leadership. The impact will be even more humiliating than the experience of having Prizes won by Chen Ning Yang, Tsung-Dao Lee, and other ethnic Chinese scientists; the Nobel Prize in Peace, awarded to the Dalai Lama in 1989, and the Nobel Prize in Literature, awarded to Gao Xingjian in 2000. It would be illogical for China's leadership to claim that there was a political motivation to give the Prize to scientists who were born in China, left the country in the past twenty-five years, but made their names abroad, as it did with the two laureates in peace and literature. So to win a 'home-grown' Nobel Prize becomes a face-saving gesture.⁵⁵

This Nobel-driven enthusiasm has also become part of China's resurgent nationalism, as with winning the right to host the Olympics.⁵⁶ Although a 'China Can Say "No"' mentality still exists, the nation is more willing than ever to embrace both the Olympics and the Nobel Prize, and for much the same reason.⁵⁷ It is widely believed that, until now, China has not been given these symbolic awards, because the international community has not fully acknowledged China's place in the world. This is why China unleashed such nationalistic – some would say, patriotic – aspirations among its people after it lost the earlier, 2000 Olympics bid. For the same reason, the Chinese media has reported that it took half a century, once the archives of the Nobel Committee for Physics were opened, to discover the truth about Zhao Zhongyao: that he missed the Prize because of a combination of circumstances outside his control. The press even sensationally declared that 'the world has owed China a Nobel Prize'.⁵⁸ In fact, by contrast with Anderson (who was recommended to

⁵³ *Qiao bao – Zhongguo kexue zhoubao (China Press – The China Science Weekly)* (New York), 8 July 2001, C2.

⁵⁴ <http://xinhuanet.com> (accessed 28 January 2003).

⁵⁵ Interview with a young life scientist, Beijing, 5 December 1998.

⁵⁶ For the key issues of nationalism and internationalism as they have concerned the Nobel Prize, see Elisabeth Crawford, *Nationalism and Internationalism in Science, 1880–1939: Four Studies of the Nobel Population* (New York: Cambridge University Press, 1992).

⁵⁷ See Yongnian Zheng, *Discovering Chinese Nationalism in China: Modernization, Identity, and International Relations* (Cambridge: Cambridge University Press, 1999).

⁵⁸ *Zhongguo kexue bao (China Science News)*, 7 October 1998; and *Kexue shibao (Science Times)*, 5 June 2002.

the Nobel Committee in 1934, 1935, and 1936), Zhao never made it into the list of nominees at all.⁵⁹ The Chinese media have also claimed that the scientists who achieved the insulin synthesis could have won a Nobel Prize if there had not been a Cold War.⁶⁰ Now, as China celebrates its successful bid for the 2008 Olympics, national pride looks for a win in the scientific contest. Only in this way will China convince the world that it has moved from the periphery to the centre.

IS WINNING THE PRIZE THE GOAL?

No strategy to win can be scientifically rigorous, because the Nobel Prize cannot be won simply by hard work and planning. Original discoveries cannot be predicted. Together with political, economic, technological, and cultural factors, chance and politics play important roles. With China achieving international prominence in mathematics, paleontology, and environmental studies, the question arises, why does the country allow the pursuit of the Nobel Prize to eclipse its achievements in other areas?

One recent example involves the Chinese earth scientist, Liu Dongsheng, who was awarded the international 2002 Tyler Prize for Environmental Achievement. Liu was recognized for the development of ways to measure global climate change by studying loess, a windblown silt that forms thick deposits in central China and elsewhere.⁶¹ Surely, such an achievement is of great significance, of which China should be deeply proud.

⁵⁹ Crawford, Heilbron, and Ullrich, *op. cit.* note 4, on 136–149. The author is indebted to Professor Gösta Ekspång at the University of Stockholm, former Chairman of the Nobel Committee for Physics, for providing this source, and for clarifying the issue. Personal communication, 24 September 2000.

Professor Robert Marc Friedman of the University of Oslo, who has written extensively on the Nobel Prize phenomenon, does not recall mention of Zhao Zhongyao's case. But Friedman also suggests that unless Zhao was mentioned in Anderson's articles, or was nominated by Robert A. Millikan (the 1923 winner of the Nobel Prize in Physics, then President of the California Institute of Technology), there would be no way in which the Nobel Committee for Physics could have had any special insight into Zhao's work. Friedman's impression is that Millikan was very 'political' in his nominations – he pushed for his closest 'boys', and often ignored others' contributions. Personal communication, 2 July 2002. See also Friedman, *op. cit.* note 4, 176 and 330. Unfortunately, Millikan, normally a 'booster' of candidates in his home institution, did not support Zhao, one of his own students.

⁶⁰ 'Time for Chinese Scientists to Cast off Age-Old Shadow', *China Daily*, 29 December 1999.

⁶¹ See <http://uscnews3.usc.edu/chronicle> (accessed 6 August 2002).

Of course, the goal of winning a Nobel Prize is a good rhetorical device to use when seeking increased funding. The scientific community in China has recently seen an increase in the absolute value of funding for basic research. While this is laudable, there is a danger that less attention will be given to disciplines outside the Nobel Prize categories – especially given the policy of ‘doing what we need and attempting nothing where we do not (*you suo wei, you suo bu wei*)’. Such interests may not help China’s science in the long run.⁶²

Winning a Nobel Prize would certainly be a boost to the Chinese scientific community, and could encourage innovation. To say that now is the time for China’s scientists to win, expresses an eagerness for success. Yet, at the moment, it is hard to envisage anyone making such a ‘great leap forward’. Among the few hopefuls, many will be under pressure to produce quick results. This is contrary to the tradition of scientific research, which requires time and patience.⁶³ Asking scientists for instant pay-offs may work to the detriment of the nation’s prospects, including the production of a Nobelist. A more realistic approach is to create an appropriate environment for Chinese science, including greater autonomy and individualism, multidisciplinary programmes, and a willingness to tolerate failure. As a Chinese proverb says, ‘where water flows, a channel forms’ – that is, only when conditions are ripe, will success come.

In looking towards a Nobel Prize, China’s scientific and political leadership are over-optimistic. Chinese science has achieved astonishing results in building a research system and in training talented researchers. However, there is still a significant gap between China and the West. Moreover, the number of scientists in basic research is only about 79,500 (in 2000), or only 8.6 per cent of China’s total R&D effort. China’s ‘brain drain’ – to foreign countries and multinational corporations, joint ventures, and high-tech start-ups – has not been reversed, and the best and the brightest remain abroad, or else work in Chinese institutions that do not do basic research.

For this reason, the Chinese-American Nobel Laureate Tsung Dao Lee has protested against the national obsession with the Nobel institution. As Lee says,

⁶² The domination by basic research – chemistry, physics, medicine, materials science, and biology – in China’s *SCI*-listed publications is an indication of such bias. See National Bureau of Statistics and Ministry of Science and Technology (comp.), *China Statistical Yearbook on Science and Technology* (Beijing: China Statistical Press, various years). For a discussion of the Japanese case, see Bartholomew, *op. cit.* note 38, on 276–280; and Low, *op. cit.* note 38.

⁶³ ‘China’s Hopes and Hypes’, *Nature*, 410 (1 March 2001), 1.

Basic research should have a certain and stable share in the nation's R&D budget, and attract more young scientists. If few are engaged in basic research, they will have difficulty competing with others. There should be a suitable environment for young scientists to concentrate on their basic research efforts.⁶⁴

He would do well to cite another Chinese proverb, which says, 'a thousand-mile journey is started by taking the first step' – and this first step must be bold.

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⁶⁴ *Shijie ribao* (*World Journal*) (New York), 7 November 1999, A8.