11

Displacement of Traditional Chinese Science and Medicine in the Twentieth Century

Despite the relative success of traditional Chinese natural studies and modern Western science in developing together as objects of study by a select number of literati in the late nineteenth century, they and their Protestant informants largely ignored the role of laboratories in modern science to discover and test new findings. For Catholic or Protestant missionaries and literati mathematicians, natural studies were rarely more than translating technical knowledge and memorizing and applying newly available texts. The techno-science practiced in the arsenals was exceptional, but the practical focus there on producing arms and ships precluded cutting-edge research.

Japan quickly replaced England and France as the nation the Qing dynasty should emulate in science and technology. During this period, for example, the Chinese preferred translating Japanese mathematics texts, which proved to be a convenient shortcut to modern mathematics. The conversion to Western mathematics was also aided by the many Chinese students who returned from studies abroad, particularly from Japan after 1895. Over ten thousand Chinese traveled to Japan to study from 1902 to 1907. Some 90 percent of the foreign-trained students who joined the Qing civil service after 1905, for instance, graduated from Japanese schools.[1]

Western Learning Mediated through Japan

Since 1865, literati inside and outside the bureaucracy had distinguished between Chinese learning (*Zhongxue*), which they presented as the whole of native learning, and Western studies (*Xixue*). Neither term was successful as a monolithic designation. Each was politically charged in the 1890s, when they were used by conservatives and radicals in the struggle for or against modernity. When Western learning gained momentum as a model for science and modern institutions, literati displaced mediating terms for science such as investigating things and extending knowledge (*gezhi xue*). They considered educational institutions that used such accommodations old-fashioned.

The ever-increasing numbers of overseas Chinese students in Japan, Europe, and the United States perceived that outside of China the normal language of modern science drew on universal concepts and terms that superseded traditionalist literati notions of Chinese natural studies and was disengaged from classical learning. Nevertheless, continuities remained. For example, Japanese scholars during the early Meiji period, influenced by the rise of industrial Germany, demarcated the new sciences by creating a new term for *Wissenschaft* (= *scientia*) as a broad sense of European science (*kagaku*, lit., "classified learning based on technical training"). They still presented natural studies using traditional terminology such as the exhaustive study of the principles of things (*kyūri, qiongli*).[2] The latter term, long associated with the classical stress on the investigation of things popular in early Tokugawa, was reinterpreted later based on the Dutch Learning tradition of the late eighteenth century, when Japanese scholars interested in Western science still used terms from sinology (*kangaku*) to assimilate European natural studies and medicine.[3]

After 1895, Chinese students and scholars adopted the Japanese bifurcation between technical learning and natural studies. Yan Fu, for instance, rendered the terms "science" or "sciences" using Japanese terminology in his 1900–1902 translation of John Stuart Mill's *System of Logic*, while translating "natural philosophy" as "the investigation of things" (*gewu*). Similarly, when regulations for modern schools were promulgated in 1903, the Chinese term for "science" (*gezhi*) referred collectively to the sciences in general, while the Japanese term (*kagaku*) designated the sciences as individual, technical disciplines. This two-track compromise in terminology lasted through the end of the Qing dynasty and continued after the 1911 revolution. Chinese students who returned from abroad increasingly emphasized a single, modern Japanese term, *kagaku*, for the Western sciences, abandoning the earlier accommodation between traditional Chinese natural studies and modern science.[4]

As traditional accommodational terminology receded from use, so too the multiple identity of science and technology as native and Western disappeared. "Modern science" now simply meant "Western science." When the Qing court launched its New Governance policies in 1901, however, the latter were not called a Westernizing policy. Just as the early Qing court had refused to call the Jesuit calendar Western, so now the late Qing court also called its reform policies new rather than Western.

Although hundreds of Protestant translations printed from 1865 to 1900 had delineated the unique nature of modern science, many conservatives in Qing official circles still asserted the strategic myth that all Western learning could be traced back to ancient China. Late Qing reformers, such as Chen Chi (1855–1900), Zheng Guanying (1842–1923), and Tang Zhen (fl. ca. 1896), also argued that new political institutions and conceptions from the West were rooted in classical sources. In this vein, Kang Youwei could also argue that his recovery of New Text classical learning affirmed that Confucius's political ideals were compatible with modern republics and nation-states.[5]

During the seventeenth and eighteenth centuries, traditionalistic rhetoric was plausible because it legitimated the recovery of early Chinese mathematics and ancient learning. In the late nineteenth century, Wylie's and Fryer's introduction of the calculus to China had shocked many literati mathematicians, such as Li Shanlan and Xu Shou. Until 1895, however, the success of a new development such as the calculus depended on its political packaging as ancient Chinese mathematics. After the Sino-Japanese War, which further ate away at Chinese self-confidence about their native traditions and institutions, such packaging more and more appeared as part of the problem rather than a necessary compromise.[6]

Both Liang Qichao and Zhang Zhidong, for instance, quickly changed the title of their earlier accounts of Western learning (*Xixue*) to new learning (*xinxue*). As in the late Ming, the binary opposition between native and European learning was transformed in favor of the dichotomy between old and new learning. Lacking the notion of Chinese origins, however, this move left the Qing state and its conservative literati bereft of a rationale for encouraging study of ancient learning as a complement for Western learning. Native learning now was simply ancient learning, with no ties to the new learning from the West.[7]

Science and the 1898 Reformers

Westernizing elites who played important roles in the 1898 Reform Movement, such as Kang Youwei, Tan Sitong, and Liang Qichao, enunciated a more-assertive approach to modern science. Chen Chi, a secretary in the Bureau of Revenue and a reform advocate, believed that scientific knowledge was a prerequisite for economic productivity in both industry and agriculture. To anticipate the objections of political and cultural conservatives, Chen still couched his arguments in favor of science and technology within "Chinese origins" rhetoric. Kang Youwei, like Chen Chi, believed that the military successes of Meiji Japan served as a model for China. Expanded education in the sciences and industry was required.[8]

In his 1905 essay on industrialization, for instance, Kang Youwei emphasized that China like Japan needed to master Western forms of mining, industry, and commerce. Because machines had augmented the power of European

states and enhanced the welfare of the people, Kang contended that the Qing dynasty had to change its goals. He advocated educating the people in technology and not just building factories and arsenals based on foreign models. Often, Kang and the reformers misunderstood and demeaned the results achieved when the foreign affairs movement had promoted industrialization from 1865–1895.

In the post-1895 political environment, reformers could claim they were championing unprecedented policies, when in fact their calls for science and industry built on the efforts of their predecessors. Where Kang Youwei and others did break new ground, however, was in their demand that traditional, subsistence agriculture should be mechanized. A new industrial-commercial society was the goal. In this endeavor, the reformers were as impractical as the self-strengtheners had been a generation earlier. Kang's focus on an educational transformation that would increase the numbers of those trained to industrialize China through science and technology was on target, however. By 1905, the dynasty abrogated the old civil examinations, and most literati now faced a new world of career expectations that drew them away from the classical curriculum that had remained prestigious until 1904.[9]

In particular, Kang was influenced by late Qing translations of Western political economy, such as Joseph Edkins's *Policies for Enriching the Dynasty and Nourishing the People,* which was included in the *Primers for Science Studies* published in Beijing and later reprinted in Shanghai. The missionary Timothy Richard (1845–1919), who unlike Martin and Fryer had confidence in the Qing reforms underway since the Sino-Japanese War, also influenced Kang. In 1895, Richard published the influential essay "New Policies" (*Xin zhengce*) in the *Review of the Times,* which had received as much attention as had Young J. Allen's account of the Chinese defeat by Japan. Richard also prepared a series of forward-looking essays on policy matters, which the reformers published in Shanghai under the title *Tracts for the Times* (*Shishi xinlun,* lit., "New views of contemporary affairs"). Kang Youwei and Liang Qichao consulted with Richard and drew on his essays for inspiration during the 1898 Reforms.[10]

Kang was influenced by the science translations from the Jiangnan Arsenal when he visited Shanghai in 1882. As a result Kang established mathematics as part of the curriculum in his Guangzhou academy, where in the early 1890s he tried to apply its geometrical axioms to the political and philosophical views in his *Complete Book of True Principles and Public Laws* (*Shili gongfa quanshu*). Straying from mathematics, Kang Youwei contended that primal *qi* was the creator of Heaven and earth. He also believed that *qi* was a sort of pervasive ether that lent spiritual form to both electricity and lightning, an interesting trend we will discuss below.

Likewise, Tan Sitong was an amateur mathematician and advocate of science when he established the Liuyang Mathematical Academy in 1895, one of the first such academies, with the help of his teacher Ouyang Zhonggu. A typical reformer, Tan believed that mathematics was the foundation for both science and technology. Tan also read both traditional and Western mathematical works and became interested in geometry and algebra. In his major published work, *Studies of Benevolence* (*Renxue*), for example, Tan relied on mathematics as an authority more than as a tool in his writings to reveal the unity of all learning. Moreover, like Kang Youwei, he regarded ether as the "element of elements."[11]

When Tan traveled to Beijing in 1893, he had his first contact with Westerners. When he saw Fryer in Beijing in 1896, Fryer introduced him to fossils, adding machines, the X-ray, and a device that purported to measure brain waves. Tan was most impressed with Fryer's translation of a work on psychology by Henry Woods (1834–1909) titled *Ideal Suggestion Through Mental Photography* (*Zhixin mianbing fa,* lit., "Method of Avoiding Illness by Controlling the Mind"), which later informed Tan's stress on the dynamics of mental power as an example of the power of benevolence. In *Studies of Benevolence,* Tan declared, "Ether and electricity are simply means whose names are borrowed to explain mental power." At first sight, such pronouncements appear as airy, metaphysical claims out of touch with the tenor of modern science.

Tan's views of the ether were drawn from trends in physics before 1905, when electromagnetic fields were better understood. Before then, physicists explained the motion of electricity and magnetism in terms of mechanical motion within a medium of ether. Both William Thomson (Lord Kelvin, 1824–1907) and James Maxwell (1831–1879), for example, thought that ether was the key to a physical theory that explained electromagnetic phenomena. In addition, literati fiction writers appropriated the translations of modern science to present a technological utopia in late Qing science fiction novels.[12]

Tan Sitong and the Ether

Tan's use of the ether (*yitai*) began in an essay published in 1897, in which he unified the materialistic framework for the chemical elements by making ether the origin of all the elements. Thomson had theorized that ether might turn out to be the universal substratum for all physical phenomena. Drawing on the perennial Chinese notion of *qi* as an undifferentiated, primal stuff from which all things derived, Tan redefined "ether" as an unchanging essence behind all external phenomenal forms, which connected the physical, mental, and spiritual realms through the action of benevolence. Through its principal property of mutuality-interpenetration (*tong*), benevolence operated through mental power (*xinli*). The interpenetration of ether and mental power made benevolence manifest.[13]

Tan Sitong's understanding of Western science drew on notions of the ether and electricity held by eminent Western scientists at the time, which had been presented first in Carl Kreyer's and Zhao Yuanyi's 1876 translation of *Optics* (*Guangxue*) for the Jiangnan Arsenal. Moreover, Tan's use of the concept of ether in his *Studies of Benevolence* maintained the traditional Chinese notion of a continuum between the physical and spiritual realms, which had troubled the Jesuits in China.[14]

Aristotle had complemented the four elements with ether (= *aither, quinta essentia*) as a fifth substance to account for movement and change in the sublunar world. The Stoics had used *pneuma* to account for the coherence of matter and the interaction of all parts of the cosmos. In early modern Europe, Descartes postulated three types of corpuscles, with air or ether as the third, within which the planets swirled through vortices. Newton used the concept of ether to explain the action of gravity at a distance. By 1745, all significant British electricians postulated a special electrical medium analogous to the universal Newtonian ether (aether).[15]

In the nineteenth century, the wave theory of light, the discovery of electromagnetic fields, and the propagation of electromagnetic waves revived theories of the ether to explain theoretical problems in physics. Since 1854, William Thomson and others in Britain were searching for a consistent physical theory of ether and matter that would explain the continuum of matter through space. Earlier the notion that ether was a carrier of waves of light and radiant heat had been developed, but its electrical, magnetic, and thermodynamic characteristics were not understood.

In 1867, Lord Kelvin regarded atoms as vortexes in a plenum-filling ether. Dmitrii Mendeleev (1834–1907) saw ether as a real gas and eventually included it in a revised version of his periodic table as late as 1902. James Maxwell, whose 1860s kinetic theory of gases enabled him to explain thermodynamics, treated the magnetic field as rotating vortex tubes in the ether, which he linked to electricity in his 1873 *Treatise on Electricity and Magnetism.* John Thomson (1856–1940) postulated in 1883 that atoms consisted of interconnected vortex rings in stable structures within an ether continuum, while James Jeans (1877–1946) explained radioactivity in 1905 as a rearrangement of ether structure. The 1880s experiments of Albert Michelson (1852–1931) and Edward Morley using an interferometer had already shown that ether was undetectable scientifically. When Albert Einstein (1879–1955) formulated and completed his ether-free relativity theories between 1905 and 1915, such notions became irrelevant.[16]

Accordingly, Tan's appropriation of the ether paralleled attempts by European physicists to affirm ether as the fundamental unity of spiritual and material phenomena. Balfour Stewart, whose English primers on physics had been translated by Young J. Allen (1875) and Joseph Edkins (1886) into Chinese, had claimed as a coauthor of an 1875 volume titled *The Unseen Universe or Speculations on a Future State* (New York: Macmillan) that the human personality survived after death in a parallel universe. Similarly, Maxwell and his supporters believed that ether was not reducible to any known substance. Moreover, the attractiveness of idealist thought in nineteenth-century Europe among those who sought to redirect the mechanistic physics of atomists toward a spiritually informed world, made it possible for the concept of ether to appeal to both specialists and nonspecialists. In China, as Tan Sitong and Kang Youwei drew on this view of ether as an active medium in the universe and molded its content in light of Chinese natural philosophy.[17]

In addition, Henry Woods's work on psychology suggested that ether, unlike ordinary materials, transmitted not only magnetism, electricity, and heat, but also nervous impulses. From this plausible connection of ether to the transmission of nervous impulses through space, Tan derived his notions of the interpenetration of ether and mental power. This link was enhanced when he read Fryer's translation of Woods's *Ideal Suggestion Through Mental Photography,* which although it did not mention ether, promoted the curative powers of electricity.

Using the scientific terminology he derived from Western translations produced by Fryer at the Jiangnan Arsenal and promoted by the Society for Diffusion of Useful Knowledge, Tan presented scientific terms such as "atom" (*zhidian*) and "element" (*yuanzhi*) in his essays. Tan also used these translations to ground his notion of benevolence metaphysically in the ether. Fryer's notion of the ether came from Woods's work, which he translated in 1896 to describe the space vacuums filled by ether. Fryer associated *qi* with ether to appeal to Chinese literati.[18]

Reformist works appropriated the methods, logic, and nomenclature of science. Tan's *Studies of Benevolence,* for example, opened with a deductive system of twenty-seven definitions of benevolence and other terms, which echoed Kang Youwei's use of axioms to present his political and philosophical views. Both Tan and Kang took modern science seriously as a theoretical enterprise, but they used its concepts and methodology very loosely to reconcile Western science with conventional wisdom and Buddhist notions of production and destruction. In addition, this strategy allowed Tan to affirm the "Chinese origins" theory, while at the same time he advocated the study of modern science to enable China to catch up with the West. Neither Tan

Sitong nor Kang Youwei was well educated in the sciences, however. They were publicists, classical scholars, and sometime officials, never practitioners of science.[19]

From Traditional to Modern Mathematics

Since 1865, Li Shanlan and Hua Hengfang had presented Chinese students with a Sino-Western amalgam of traditional Chinese mathematics and modern mathematics, which in the minds of Chinese administrators at the many arsenal schools represented a hybrid of two traditions. This merging of Chinese and Western mathematics was usually overlooked by Western teachers and translators who—except for Alexander Wylie—looked down on such traditionalistic impulses. Such accommodations are usually mentioned without comment by Western historians of the arsenals and schools.[20]

Mathematicians such as Hua Hengfang quickly rejected the Chinese origins theory when they realized that Western mathematics had evolved independently of traditional methods. Ding Fubao most strongly attacked the claims of Chinese origins. His 1899 annotated catalog of works on traditional mathematics rejected all the claims that had recently appeared. At the same time, however, literati mathematicians tried to explain the convergence of Chinese and Western mathematics despite their separate origins. For this, they used a universalist argument borrowed from classical learning to the effect that "the same mind produces the same principles" (*tongxin tongli*) to explain Western developments.[21]

Other mathematicians such as Zou Zunxian still taught Chinese methods in mathematics until the 1901 civil service examination reforms forced them to use Western mathematics for teaching problem solving. After the reforms added the new fields of foreign arts and sciences, the questions in mathematics presumed knowledge of Western mathematics. Students thus needed training in the new field. Zou's 1904 textbook, *Applying Algebra to Various Types of Problems* (*Fenlei yandai*), was prepared for an accelerated course in mathematics to fill this need, but at the same time he merged Chinese and Western mathematics. Hence, his text presented Chinese solutions first so the students would be aware of traditional methods before using modern algebra to solve traditional problems.

At the same time, however, Zou refrained from insisting on the pedagogical priority of traditional mathematics. By 1905, algebra and the calculus had replaced traditional mathematics. Since the late 1890s, the annual examinations on mathematics held at the Beijing School of Foreign Languages no longer included questions on traditional equations (*kaifang*) or fourunknowns procedures. After 1868, Japanese mathematicians had been forced to teach Western mathematics, but until 1900 Chinese were able to carry out research using traditional Chinese mathematics.[22]

When the Qing government promulgated New Governance policies for an educational system composed of primary, middle, and high schools in 1902, the reformed curriculum prioritized seven fields of learning: politics, literature, science, agriculture, industry, commerce, and medicine. Science was subdivided into six areas: astronomy, geology, arithmetic, chemistry, physics, and zoology-botany. These were fields mostly in name, however. Few teachers were available until later to teach such specialty subjects.[23]

In 1905, when even the civil examinations were eliminated, further regulations put into place a new curriculum and textbooks for the schools that were established. Via the reform of the education system, China after 1905 was fully converted to Western mathematics. The Qing government rearranged curricula according to the four Western school levels for mathematics courses:

1. Junior primary school: four arithmetical operations and decimals
2. Senior primary school: fractions, ratios, areas, and volumes
3. Middle school: algebra, geometry, and trigonometry
4. High school: analytical geometry and calculus

This changeover entailed the westernization of mathematics textbooks and Western formats for numbers (1, 2, 3), known quantities (*a, b, c*), unknown quantities (*x, y, z*), and derivatives (dy/dx) and integrals ($\int ydx$).[24]

Du Yaquan, Ding Wenjiang (1887–1936), Cai Yuanpei (1868–1940) and others, quickly left behind the typical classical education of a literatus. Yan Fu, whose poor prospects in the civil examinations provoked him to enter the School of Navigation of the Fuzhou Shipyard in 1866, associated the power of the West with modern schools where students were trained in modern subjects requiring practical training in the sciences and technology. For Yan Fu and the post-1895 reformers, Western schools and Westernized Japanese education were examples China should emulate. The extension of mass schooling within a standardized classroom system stressing science courses seemed to promise a way out of the quagmire of the imperial education and civil examination regime, whose educational efficiency was suspect in the 1890s. By 1911, middle and high schools were required by the Ministry of Education to evaluate students in ten areas of instruction:

1. Philosophy
2. Chinese Literature
3. World Literature

4. Art and Music
5. History and Government
6. Mathematics and Astronomy
7. Physics and Chemistry
8. Animal and Plant Biology
9. Geography and Geology
10. Sports and Crafts[25]

Overall, until 1923 the new educational system mandated required courses in five areas of specialization:

1. Language
2. Social Sciences
3. Natural Sciences
4. Mathematics
5. Engineering

Among those affected by the educational changes, Ren Hongjun (1886–1961) was one of the founders of the Science Society of China (*Zhongguo kexue she*) in 1914. He had passed the last county civil examinations in 1904, and by 1907 he was a student in Shanghai, where he met the future iconoclast Hu Shi (1891–1962). Ren then traveled to Japan in 1908 and in 1909 entered the Higher Technical College of Tokyo as a student subsidized by the Qing government. The Qing dynasty had reached a fifteen-year agreement with the College to send forty students annually to Tokyo.[26]

While in Tokyo, Ren also joined Sun Yat-sen's early partisans in the Alliance Society (*Tongmeng hui*) and rose to an important position in the Tokyo Sichuan branch. When he returned to China after the 1911 revolution, Ren served in Sun's provisional government. He received a Qinghua University fellowship in 1912 to study chemistry at Cornell. Ren completed his B.A. in chemistry from Cornell, where he studied from 1912 to 1916, and his M.A. in chemistry from Columbia in 1917, during which time he assumed a leading role in forming a Chinese science organization that would replace the old-style literary societies.[27]

Modern Medicine in China

Those trained in modern, Western medicine derided classical Chinese medicine, which was the largest field of the Chinese sciences during the transition from the late Qing to the Republican era, 1895–1911. Traditional physicians were more successful in retaining their prestige than Chinese astronomers, geomancers, and alchemists, who were dismissed by most modern scholars for practicing superstitious forms of knowledge. Since Xu Shou had criticized the traditional concepts used in traditional Chinese medicine in an 1874 article, Chinese scholars increasingly called for a cosmopolitan synthesis of Western experimental procedures with traditional Chinese medicine.

In 1884, for instance, Tang Zonghai addressed what he considered the dismal state of Chinese medicine in his *Convergence of the Essential Meaning of Chinese and Western Medicine to Explain the Classics* (*Zhongxi huitong yijing jingyi*, Shanghai, 1884, 1892). Later, in about 1890, Yu Yue prepared the first overall attack on Chinese medicine, titled *On Abolishing Chinese Medicine* (*Fei yi lun*), which was perhaps prompted by the deaths of his wife and children due to illness. Using evidential research methods, Yu concluded that the oldest Chinese materia medica was valueless, and he contended that there were no essential differences between popular priests and physicians. Despite his support for Western medicine, however, Yu Yue still critiqued Western science as derivative.[28]

Chinese physicians of traditional medicine, however, remained very large in numbers and very influential despite the inroads of missionary physicians, Western hospitals, and the success of anatomy in mapping the internal venues for bodily illnesses. Coexisting for several decades since 1850, Western-style doctors and Chinese physicians had remarked upon the limitations in each other's theories of illness and therapeutic practices, but for the most part each was practiced in its own institutional matrix of care-giving traditions. Moreover, until anesthesiology was introduced in the early twentieth century and miracle drugs were discovered in the 1940s, the curative power of Western medicine, especially surgery, remained problematic when compared to the noninvasive pharmacopoeia traditions of Chinese physicians.[29]

One aim of the New Governance policies after 1901 was a plan—never realized—to increase Qing state involvement in policing public health. Unlike the Song dynasties, when the government created local medical bureaus to deal with epidemics, state involvement in local health issues since the late Ming markedly diminished. Local elites filled the vacuum by making charitable contributions to deal with health emergencies at a time when literati also took an increased interest in medical knowledge. Late Qing public health policies signified an intention to break with this long-term secular decline of dynastic intervention in local affairs, a devolution that abandoned medical issues to local gentry and Chinese literati-physicians.

Treaty ports such as Shanghai and Tianjin became venues that linked local elite initiatives to the increasing numbers of foreigners who favored sanitation reform and public medicine. By the end of the nineteenth century, the Qing government increasingly saw its role in statist terms. Using Germany as a model, which Meiji Japan had also emulated, the Qing government began,

in the short time left to it, to use quarantine and isolation hospitals to deal with epidemics of infectious disease. During the Ming and Qing, when local physicians had faced southern epidemics they associated with "heat factor" causes, the state was minimally involved.[30]

Qing public health policies accomplished little, however, until an epidemic of plague took some sixty thousand lives from 1910 to 1911 in northeast China. The Qing state turned to Wu Liangde (1879–1960) to bring the epidemic under control. Trained in medicine at Cambridge University, Wu dramatically demonstrated to officials and the public, through substantial immunization and exacting quarantine measures, the superiority of Western medicine. As a result, the slow emergence of the modern Chinese state during the Qing-Republican transition was tied to the extension of Western medicine and the appropriation of Western models for state-run public health systems.[31]

One by-product of government involvement in public health was that Western-style physicians and classical Chinese doctors organized into separate medical associations. They drew the state into the contest for medical legitimacy between them. Hence, the modernizing state was progressively tied to Western medical theories and institutions, while Western-style doctors controlled the new Ministry of Public Health. When the Guomindang-sponsored Health Commission proposed to abolish classical Chinese medicine (*Zhongyi*) in February 1929, however, traditional Chinese doctors immediately responded by calling for a national convention in Shanghai on March 17, 1929, which was supported by a strike of pharmacies and surgeries nationwide. The protest succeeded in having the proposed abolition withdrawn, and the Institute for National Medicine (*Guoyi guan*) was subsequently established. One of its objectives, however, was to reform Chinese medicine along Western lines.[32]

The consequences of increased state involvement in Chinese medical policy after 1901 were significant for both Western and Chinese medicine. After 1929, the government established two parallel institutions, one Western and one Chinese, politically and educationally distinctive. This dichotomy survived both the Guomindang Republic and the Communist People's Republic. The bifurcation also entailed the modernization of traditional Chinese medicine, which Bridie Andrews has called the "reinvention" of classical Chinese medicine in the early decades of the century. Nathan Sivin refers to modern Chinese medicine after 1950 as "Traditional Chinese Medicine" (*Zhongyi*), which the People's Republic endowed with a distinct institutional, educational, and occupational base from Western medicine.[33]

The influence of Western medicine in early Republican China presented a substantial challenge to traditional Chinese doctors. The practice of Western medicine in China was assimilated by individual Chinese doctors in a number of different ways. Some defended traditional Chinese medicine, but they sought to update it with Western findings. Others tried to equate Chinese practices with Western knowledge and equalized their statuses as medical learning. The sinicization of Western pharmacy by Zhang Xichun (1860–1933), for example, was based on the rich tradition of pharmacopoeia in the Chinese medical tradition. Another influential group associated with the Chinese Medical Association, which stressed Western medicine, criticized traditional Chinese medical theories as erroneous because they were not scientifically based.[34]

In this cultural encounter, Chinese practitioners such as Cheng Dan'an (1899–1957) modernized techniques like acupuncture. Cheng's research enabled him to follow Japanese reforms by using Western anatomy to redefine the location of the needle entry points. His redefinitions of acupuncture thus revived what had become from his perspective a moribund field that was rarely practiced in China and, when used, also served as a procedure for bloodletting. Indeed, some have argued that acupuncture may have originally evolved from bloodletting. In this manner, acupuncture survived as an artisanal procedure among the populace.[35]

This Western reform of acupuncture, which included replacing traditional coarse needles with the filiform metal needles in use today (see Figure 11.1), ensured that the body points for inserting needles were no longer placed near major blood vessels. Instead, Cheng Dan'an associated the points with the Western mapping of the nervous system. A new scientific acupuncture sponsored by Chinese research societies emerged alongside traditional acupuncture. The former presented a better map of the human body that would enhance diagnosis of its vital and dynamic aspects.[36]

Similarly, the Chinese assimilated the discourse of nerves and the theory of germ contamination from Western medicine. These new views provided ways for Chinese physicians to discuss older illnesses such as leprosy, depletion disorder, or the wasting sickness. As a description of debilitated nerves, sexual neurasthenia now explained the illness that Chinese physicians associated with the depletion of the body's vital essences of *qi*. Multiple interpretations of germ theory enabled the Chinese to equate the attack of tuberculosis germs as a contingent, external cause, which was brought on by the susceptibility of a weakened body whose natural vitality had wasted away.[37]

Influence of Meiji Japan on Modern Science in China

In the late nineteenth century, an increasing familiarity with Western learning exposed the Chinese to the limits of traditional categories for scientific terminology. Increasingly, the claim that Western learning derived from ancient China was unacceptable. Younger literati perceived in the revival of tradi-

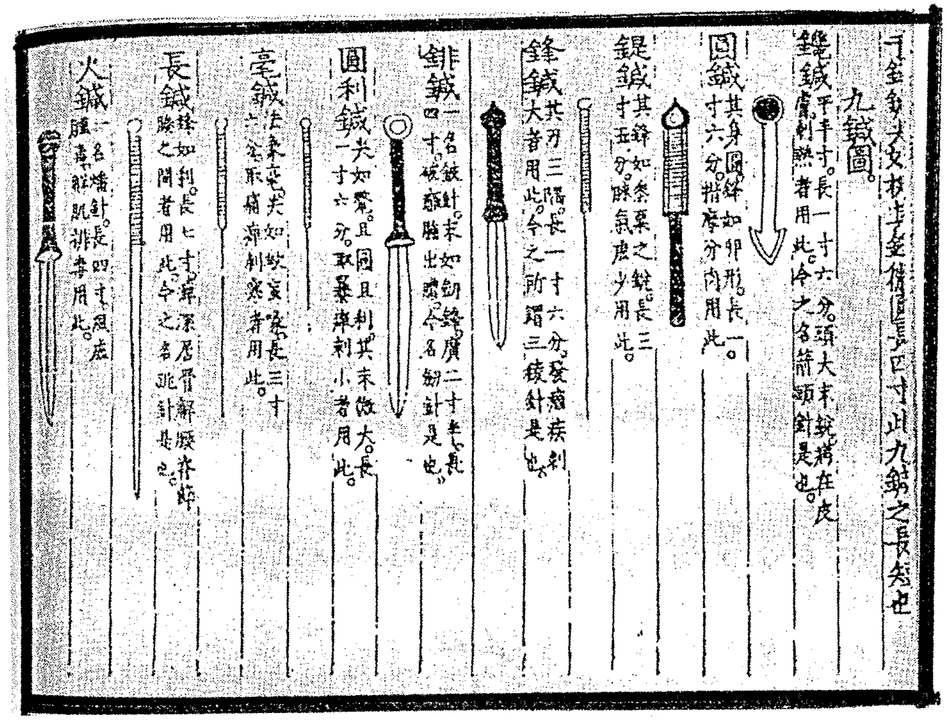

Figure 11.1. Traditional coarse needles and the filiform metal needles used in premodern (on this page) and modern (on next page) acupuncture.
Source: Zhenjiu daquan, 1601.

tional positions after the Sino-Japanese War, which represented the third stage of the Chinese origins argument, a latent conservatism that obstructed the introduction of modern science and technology rather than facilitating it. Hence, those students who studied abroad after 1895 began to question the use of investigating things and extending knowledge (*gezhi*) as a traditional trope of learning to accommodate modern science.

Instead, many turned to Japanese terminology for the modern sciences to make a complete break with the Chinese past. The Japanese neologism *kagaku* (pronounced "*kexue*" in Chinese, lit., "knowledge classified by field"), for example, was perceived as a less loaded term for science than "investigating things," which had so many semantic links to classical learning and the Cheng-Zhu orthodoxy still in place as the curriculum for the civil service examinations until 1905. By 1903, state and private schools increasingly borrowed

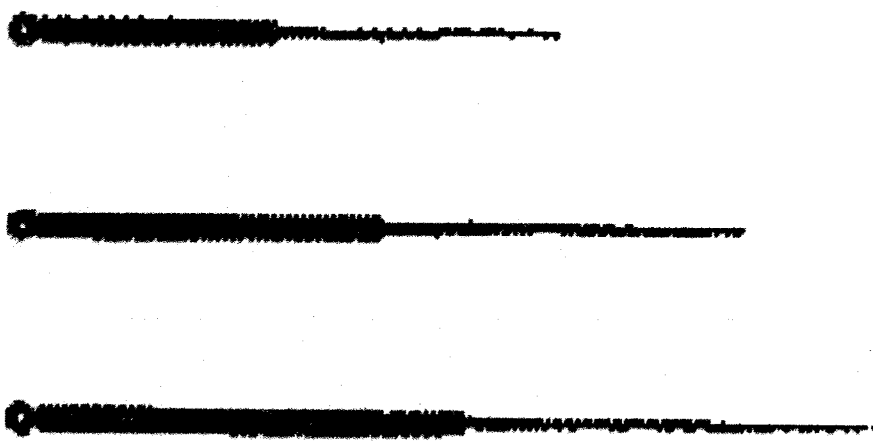

Figure 11.1. The filiform needles are widely used at present in clinics. They are made of gold, silver, alloy, etc., but most of them are made of stainless steel. A filiform needle may be divided into five parts.

from Japanese translations to enunciate the modern classifications of the social sciences (*shehui kexue*), natural sciences (*ziran kexue*), and applied sciences (*yingyong kexue*).[38]

The Impact of Science Translations in Qing China on Japan

Before 1894, Japan had imported many European books on science from Qing China, particularly after 1720 when the shogun Yoshimune relaxed the Tokugawa prohibition of all books related to Christianity. Many had been translated during the Ming and Qing after the Japanese expelled the Jesuits for their meddling in the late sixteenth-century civil wars there. Ricci's mappa mundi, Chinese translations of Euclid's geometry, and Tychonic astronomy, for example, made their way to Tokugawa Japan.[39]

Works from the late Ming collectanea *Works on Mathematical Astronomy of the Chongzhen Reign* and the Kangxi-era *Compendium of Observational and Computational Astronomy* arrived in Japan via the Ningbo-Nagasaki trade after the 1720s. The Japanese also avidly imported eighteenth-century Chinese terminology for Sino-Western mathematics when the second edition of Mei Wending's complete works were imported in 1726 and translated two years

later. Physics, chemistry, and botany books, imported from Europe via the Dutch trading enclave in Nagasaki harbor in the early nineteenth century, were also translated into Japanese from Dutch.[40]

In addition, the translations on science prepared under the auspices of Protestant missionaries such as Macgowen and Hobson in the treaty ports were immediately coveted by the Meiji government. Prominent translations into Chinese of works dealing with symbolic algebra, calculus, Newtonian mechanics, and modern astronomy quickly led to Japanese editions and Japanese translations of these works. Macgowen's 1851 *Philosophical Almanac* and Hobson's 1855 *Treatise of Natural Philosophy* came out in Japan in the late 1850s and early 1860s. Four of Hobson's other medical works from 1851–1858 came out in Japan between 1858 and 1864.[41]

Issues from the 1850s *Shanghae Serial* (*Liuhe congtan*) published by Inkstone Press were also republished in Japan, along with the translations Fryer and others completed in the Jiangnan Arsenal and the publications from the Beijing School of Foreign Languages. The Wylie-Li translations of algebra (1859/1872), calculus (1859/1872), and Martin's *Natural Philosophy* (1867/1869) were all quickly available to scholars and officials in Meiji Japan. Arguably, these works had greater influence in Japan than in China, and today they can still be readily located in Japanese libraries, while they are rare in China.[42]

Many Japanese scholars still preferred Chinese scientific terms in early Meiji times over translations derived from Dutch Learning. The Chinese name for chemistry (*huaxue*), for example, replaced the term *chemie* [*semi* in Japanese] derived from Dutch. Similarly, the impact of Jiangnan Arsenal publications can be seen in the choice of Chinese terminology for metallurgy (*jinshi xue*) used in Japanese publications, which were later changed in Japan and reintroduced to China as a new term for mining (*kuangwu xue*).

Japan's Iwakura mission also visited Shanghai in September 1873 at the end of its journey to Europe and the United States and took a tour of the Jiangnan Arsenal on September 4. The report described the shipyard, foundry, school, and translation bureau there in very positive terms. The mission noted how the shipyard was operated by British managers initially. The latter were aided by Chinese who had trained abroad. The account added that "now the entire management of the yard is in the hands of Chinese" and concluded, "This one yard would be capable of carrying out any kind of work, from ship repair to ship construction."[43]

When the diplomat Yanagihara Sakimitsu (1850–1894) visited China, he purchased many of the Chinese scientific translations. On his third visit in 1872, for instance, he bought twelve titles on science and technology in thirty-one volumes from the Jiangnan Arsenal. These included works on chemistry, ship technology, geography, traditional mathematics, mining, and Chinese trigonometry (*gougu*). The Japanese government continued to buy arsenal books until 1877. In 1874, Yanagihara received twenty-one newly translated books from China. Despite the influence of Dutch learning and translations from China, and even though the Japanese began teaching modern Western science on a large scale in the 1870s, the Chinese did not borrow many scientific terms from Japan before the Sino-Japanese War.

Unlike the Chinese translations that were readily transmitted to Japan, Tokugawa authorities kept Dutch Learning translations secret. While much has been made of the contributions of Dutch Learning to Japanese science during the Tokugawa period, we have seen in Chapter 10 that the Yokosuka Dockyard was still dependant on French engineering advisors until the 1880s and British technical aid in the 1890s. There is no evidence that Dutch Learning per se enhanced the Yokosuka enterprise or determined the course of Meiji science and technology. Moreover, the impact of Dutch Learning, while important among samurai elites in the late eighteenth and early nineteenth centuries, was not sufficient to touch off in Tokugawa Japan the sort of technological revolution based on Newtonian mechanics and French analytical mathematics that we have described as the engineer's tool kit in Chapter 4.

Indeed, the concrete advantages that Dutch Learning provided in the rise of modern, industrial science during the Tokugawa-Meiji transition remain undocumented. Japan's overwhelming triumph in the Sino-Japanese War created an environment in which most accounts since 1895 have simply assumed that Dutch Learning gave Tokugawa Japan a scientific head start over the Qing dynasty.[44]

Japanese Science in China after 1895

From 1896 to 1910, the Chinese translated science books that the Japanese no longer worked with foreigners to translate. By 1905, the new Qing Ministry of Education was staunchly in favor of science education and textbooks based on the Japanese scientific system. Instead of the West represented by Protestant missionaries such as Martin and Fryer, Japan now mediated the West for Chinese literati and officials.[45]

After the Sino-Japanese War, reformers encouraged Chinese students to study in Japan. Kang Youwei promoted Meiji Japan scholarship in his *Annotated Bibliography of Japanese Books* (*Riben shumu zhi*) and in his reform memorials to the Guangxu emperor. He recommended 339 works in medicine and 380 works in the sciences (*lixue*), which now replaced the prize essays for the 1894 Shanghai Polytechnic essay competition that listed the best Western books. The Guangxu emperor's (r. 1875–1908) edict of 1898 encouraged study in Japan.[46]

As a publicist while in exile in Japan, Liang translated Japanese materials into Chinese at a fast clip. In addition to his antiquarian interests, Luo Zhenyu (1866–1940), for example, published the *Agricultural Journal* (*Nongxue bao*) from 1897 to 1906 in 315 issues. The articles were mainly drawn from Japanese sources on science and technology. Luo also compiled the *Collectanea of Agricultural Studies* (*Nongxue congshu*) in eighty-eight works, with forty-eight based on Japanese books. Du Yaquan edited journals in 1900 and 1901 that translated science materials from Japanese journals. These were the first science journals edited solely by a Chinese. The massive translation by Fan Diji in Shanghai of a Japanese encyclopedia took several years. When it appeared in 1904, the encyclopedia contained over one hundred works with twenty-eight in the sciences and nineteen in applied science.

Post-Boxer educational reforms of 1902–1904 were also crucial in the transformation of education in favor of Japanese-style science and technology. The last bastion of modern science as Chinese science (*gezhi*) remained in for the civil examinations, where the Chinese-origins approach to Western learning remained obligatory. After the examination system was abolished in 1904, Japanese science texts finally became models for Chinese education at all levels of schooling. In 1886–1901, for instance, Japan officially approved eleven different texts on physics. Eight of those, which were produced after 1897, were translated for Chinese editions. In 1902–1911, twenty-two different physics texts were approved in Japan, and seven were translated into Chinese.

Similarly, in chemistry from 1902 to 1911, seventy-one Japanese texts were translated into Chinese. Most were produced for middle schools and teacher's colleges. Twelve middle school chemistry texts were produced in Japan between 1886 and 1901. Of these, six were translated into Chinese. Eighteen Japanese middle school chemistry texts were produced between 1902 and 1911. Five were translated into Chinese. Japanese scientists were also invited to lecture in China. The Chinese also translated more technical physics and chemistry works from the Japanese. Translators completed Iimori Teizō's (1851–1916) edited volume on *Physics* (*Wulixue, Butsurigaku*) in Chinese at the Jiangnan Arsenal from 1900–1903. They were aided by the Japanese educator Fujita Toyohachi (1870–1929). Iimori's influence on Chinese physics grew out of this project.[47]

The Chinese also compiled updated Sino-Japanese dictionaries such as the 1903 *New Progress Toward Elegance* (*Xin Erya*), which modernized ancient Chinese lexicons. By 1907, when Yan Fu was in charge of the Qing Ministry of Education's committee for science textbooks, he approved the use of Japanese scientific terms. We should not underrate the historical importance of Japanese translations for the development of modern science in China. Japanese translations were much more widely available in China than those produced earlier by the Jiangnan Arsenal had been. In addition, the new Japanese science textbooks contained more up-to-date content than the 1880s arsenal and missionary translations, which were already antiquated by European standards in the 1890s. The introduction of post-1900 science via Japan, which included new developments in chemistry and physics, went well beyond what Fryer and others had provided to the emerging Chinese scientific community.[48]

Chinese presses also published in greater numbers the translations of Japanese texts, which were easier to read because only Chinese compiled them. Moreover, the quality of the translations from works by Japanese scientists improved over the earlier *Science Primers.* Chinese translators themselves could understand the Japanese originals. In addition, the Japanese texts were available to a new and wider audience of students in the new public schools and teacher's colleges that the Qing government established after 1905 as part of its education reforms. The Imperial University in Beijing also invited Japanese professors to join its faculty.[49]

Finally, to make the new translations more easily understood than standard classical translations, Chinese translators helped produce a new literary form for presentation of the sciences, which contributed to the rise of the vernacular for modern Chinese scholarly and public discourse. Among urbanites, especially in Beijing and Shanghai, the first decade of the twentieth century provided the basic education in modern science via Japanese textbooks for the generation that matured during the New Culture Movement of 1915 and the May Fourth era after 1919.[50]

The Delayed Emergence of Physics as a Technical Field in China

When we compare the development of modern physics in Meiji Japan and Qing China, we find that scholars in both countries had started to master Western studies in the early and mid-nineteenth century. The Translation Bureau at the Jiangnan Arsenal and the Dutch Translation Bureau in Tokugawa Japan had produced Chinese books on physics beginning in the 1850s in China and in Japanese from 1811 in Japan. Although the introduction of Dutch Learning in the seventeenth and eighteenth centuries enabled an earlier start in Japan, the materials on physics in the Protestant translations produced in China after 1850—quickly transmitted to Japan—made those earlier studies out of date. Moreover, the *Primer Series* produced in the 1870s and early 1880s in China remained superior overall to their Meiji counterparts until the 1890s.[51]

Despite the range of science translations in Qing China through the 1880s, physics textbooks were not available in China until they were first published in Japan. Much of this had to do with the way the Protestant missionaries such as Martin and Fryer had introduced the physical sciences to literati audiences since 1860. Rather than a unified field of physics, or natural philosophy as it was often called by Euro-American specialists until the 1860s, missionary translators first introduced the disaggregated branches of physics. Accordingly, mechanics (*lixue* or *zhongxue*), optics (*guangxue*), acoustics (*shengxue*), electricity (*dianxue*), and thermodynamics (*rexue*) were presented as independent fields in China. By presenting the subfields of physics independently, the translators made it difficult for the Chinese later to appreciate the unity of physics. Moreover, introducing the branches first made it more complicated later to reach a consensus for a more general term for physics.

Often physics was equated with investigating things (*gewu*). Others preferred calling physics investigating things and extending knowledge (*gezhi*), which frequently overlapped vaguely with the general term for science and created substantial misunderstanding. Edkins's 1886 *Science Primers* associated "investigating the materiality of things" (*gezhi zhixue*) with physics. In 1895, the school of physics in the Beijing Foreign Language School changed its name from the Hall for Investigating Things (*Gewu guan*) to the Hall for Investigating and Extending Knowledge (*Gezhi guan*).

Unlike the Japanese, who developed independent translation techniques, the Chinese remained dependent on their Protestant informants into the 1890s. This dependency placed severe limits on what the Chinese alone could translate. Overall, the Western translations prepared by Macgowen, Hobson, and Martin in China dealt with physics in very general, textbook terms and never produced useful handbooks.[52]

The Qing state also was slower in reforming its educational system. Meiji Japan's new educational system was established in 1868. Qing education reforms were not comparable until 1902. A Japanese Ministry of Education (Mombusho) followed in 1871, while its Qing counterpart was not established until 1905. Similarly, Tokyo University was founded as Japan's key modern teaching institution in 1877, but the Imperial University of Beijing did not exist until 1898. Courses in physics had already started in 1875 in Japan when the Tokyo school that evolved into the university shifted from foreign language lectures by Europeans to lectures in Japanese by students who had studied physics abroad. The first Japanese students trained in Japan graduated in physics in 1883.

Chinese science faculties were not established at the Imperial University of Beijing until 1910, but even then only classes in chemistry and geology were taught. Physics was added in 1912. Of 387 students recruited in the sciences, only 54 received diplomas in 1913. Beijing recruited Japanese science teachers to the University since 1902, but they left in 1908–1909 after their sixyear contracts expired. From 1898 to 1911, only two hundred students were trained in the sciences at the Imperial University, and the initial absence of faculties of mathematics and physics remained a serious problem in training scientists. We have seen above that the science curriculum was formalized in terms of requirements at the high school level beginning in 1911. In Japan, there were few students of physics when compared to the more popular fields of law and medicine. Between 1882 and 1912, however, Tokyo University graduated 186 in physics.[53]

Japan's educational system had a head start in editing and translating physics textbooks. China by comparison lacked textbook materials to teach physics at all levels of the education system. Similar delays occurred in other technical fields, such as chemistry and geology. By 1873, the Japanese taught physics in the new Meiji schools, and Tokyo University had a physics program from 1877. By comparison, the Beijing School of Foreign Languages asked only occasional physics questions on examinations from 1868, which were based on Martin's elementary *Natural Philosophy.* The subfields of physics were taught separately as mechanics, hydraulics, acoustics, pneumatics, heat, optics, and electricity. In addition, the military and arsenal schools also taught some physics, especially its subfields.

Meiji educators produced physics textbooks in the 1870s, but none were available in China until the 1890s. Although the Japanese relied on Protestant translations from China initially, the Mombusho ordered Katayama Junkichi (1837–1887) to compile an official physics textbook when physics (*butsuri, wuli*) became a specialized discipline. Katayama's textbook was added to the Japanese curriculum in 1876 and republished many times. Moreover, Japan invited Western scientists to Japan. K. W. Gratama (1831–1888) served in the Chemistry Bureau from 1869. He was succeeded by H. Ritter (d. 1874). Later, Iimori Teizō completed his edition of *Physics* by consulting the works on physics published by the German J. Müller.

In the late 1890s, the Qing recognized the need to translate physics textbooks. As a result of the 1898 reforms, the government decided to copy the Meiji model for education and create a public school system for science education, rather than simply rely on schooling in the arsenals, navy yards, and factories. Full implementation of this program was not feasible until the civil examination system was scrapped, and the new school system replaced it in 1904–1905. The Sino-Japanese War had taught the Qing government that it was insufficient to rely on arsenals to modernize.[54]

Because there were few science textbooks in China and none that dealt chiefly with physics, the Chinese immediately translated Japanese texts such as Iimori's *Physics.* Direct Chinese translations of the best physics texts by the

most famous Japanese physicists became the most efficient means in the early twentieth century to prepare textbooks for the new Qing school system. This policy also guaranteed that the Chinese would no longer rely on Western informants for specialized translations in important fields such as physics. But China's dependency on Japan was reconsidered after 1915 when Japan's policies toward the Republic of China became increasingly predatory.

Although high-level education in physics began at the Beijing Imperial University in 1912, the best-trained physicists studied in the United States and Japan: Li Fuji (b. 1885) studied in the United States; He Yujie (1882–1939), Xia Yuanli (1884–1944), Li Yuebang (1884–1940?), and Hu Gangfu (1892–1966) in Japan. When Beijing University was reorganized in 1912, it had formal divisions between the humanities and the sciences, with the latter including the three fields of mathematics, chemistry, and physics. An independent physics department was not created until 1917, however. The greater scope of physics texts in the school system after 1905, however, did provide for wider knowledge of the field in China than had been the case before 1900.[55]

Japan also had a lead over China in research in physics, the unification of technical terminology, and research associations by 1900. For instance, Japanese scholars started publishing in physics in 1880s. More than two hundred articles in the various subfields of physics had appeared by the end of Meiji era in 1912. Moreover, several Japanese physicists had emerged who were approaching Western levels of expertise in physics.

The terms for physics were first unified in the 1870s when translators chose the official Meiji designation for physics as (*wuli xue*) in 1872. Terminology in Japanese physics achieved a final unification with the 1888 publication of an official list of technical terms with foreign counterparts. The committee for systematizing the translation of terms for physics, which began in 1885, was led by three of the first Japanese graduates in physics from Tokyo University. Scholars unified terms for a total of 1,700 items from English, French, and German, which they then translated into Japanese and published. Chinese started using the Japanese term for physics in 1900 when a Japanese book by that name was published in China. Before then, the term had usually referred to the principles of things as part of the traditional fields of natural studies.[56]

Academics created the first mathematics society in Tokyo in 1877 with fifty-five members. In 1884, ten of its seventy-five members specialized in physics. When the Tokyo Mathematics-Physics Society was formed in 1884, it started with eighty-two members, twenty-five of whom were physicists. The latter changed its name in 1919 to the Japan Mathematics-Physics Society, which survived as an organization until it separated into two parts in 1948. Smaller specialized groups in physics were also formed in Japan in the 1880s.

China was also later than Japan in training physicists and organizing associations. The Chinese had to study physics abroad, and the research institutes for physics at the Academia Sinica, the Beijing Institute, and the Qinghua Institute were not formed until 1928–1929. Although Chinese terms for physics were unified in 1905, they were not finally settled until the 1920s. Moreover, the Chinese Science Society and its journal were not founded until 1915, and that took place abroad in the United States at Cornell University. Physicists did not form the Chinese Physics Society until 1932.[57]

The belief that Western science represented a universal application of objective methods and knowledge was increasingly articulated in the journals associated with the New Culture Movement after 1915. The journal *Science* (*Kexue*), which the newly founded Science Society of China created in 1914, assumed that an educational system based on modern science was the panacea for all of China's ills because of its universal knowledge system. Meiji Japan served as the model for that panacea until 1915, when Japanese imperialism, like its European predecessor, forced Chinese officials, warlords, and intellectuals to reconsider the benefits of copying Japan.[58]

Despite the late Qing curriculum changes described above, which had prioritized science and engineering in the new public schools since 1902 and in private universities such as Qinghua, many Chinese university and overseas students were by 1910 increasingly radical in their political and cultural views, which carried over to their convictions about science. Traditional natural studies became part of the failed history of traditional China to become modern, and this view now asserted that the Chinese had never produced any science. How premodern Chinese had demarcated the natural and the anomalous vanished, when both modernists and socialists in China accepted the West as the universal starting place of all science.[59]

After 1911, many radicals such as Ren Hongjun linked the necessity for Chinese political revolution to the claim that a scientific revolution was also mandatory. Those Chinese who thought a revolution in knowledge required Western learning not only challenged classical learning, or what they now called Confucianism (*Kongjiao*), but they also unstitched the patterns of traditional Chinese natural studies and medicine long accepted as components of imperial orthodoxy.[60]

As Chinese elites turned to Western studies and modern science, fewer remained to continue the traditions of classical learning (Han Learning) or Cheng-Zhu moral philosophy (increasingly called Neo-Confucianism in the twentieth century) that had been the basis for imperial orthodoxy and literati status before 1900. Those who still focused on traditional learning, such as Gu Jiegang (1893–1980) in Beijing and others elsewhere, often did so by reconceptualizing ancient learning in light of "doubting antiquity" and applying new, objective procedures for historiography that they derived from the sciences. Thereafter, the traditional Chinese sciences, classical studies, and Confucianism survived as vestigial native learning in the public schools established by the Ministry of Education after 1905. They have endured as contested scholarly fields taught in the vernacular in universities since 1911.[61]

The Great War from 1914 to 1919 acted as a profound intellectual boundary between those modernists who still saw in science a universal model for the future and the "New Confucian" (*Xinru*) traditionalists, such as Zhang Junmai (Carson Chang, 1886–1969), who showed renewed sympathy for distinctly Chinese moral teachings after the devastation visited on Europe. The former reformer and now scholar-publicist Liang Qichao, who was then in Europe leading an unofficial group of Chinese observers at the 1919 Paris Peace Conference, visited a number of European capitals. They witnessed the war's deadly technological impact on Europe. They also met with leading European intellectuals, such as the German philosopher Rudolf Christoph Eucken (1846–1926), Zhang Junmai's teacher, and the French philosopher Henri Bergson (1859–1941), to discuss the moral lessons of the war.[62]

In his influential *Condensed Record of Travel Impressions While in Europe* (*Ouyou xinying lu jielu*), Liang Qichao related how the Europeans they met regarded World War I as a sign of the bankruptcy of the West and the end of the "dream of the omnipotence of modern science." Liang found that Europeans now sympathized with what they considered the more spiritual and peaceful "Eastern civilization" and bemoaned the legacy in Europe of an untrammeled material and scientific social order that had fueled the world war. Liang's account of the spiritual decadence in post-war Europe indicted the materialism and the mechanistic assumptions underlying modern science and technology. A turning point had been reached, and the dark side of "Mr. Science" had been exposed. Behind it lay the colossal ruins produced by Western materialism.[63]

In the early twenty-first century, we tend to forget the degree of skepticism that Joseph Needham's remarkable collectanea, *Science and Civilization in China*, initially provoked five decades ago. The consensus when Needham's first volume appeared in 1954 drew on heroic accounts of the rise of Western science to demonstrate that premodern China had no science. Some accused him of doctrinaire Marxism. Others dismissed the embryologist's foray into the history of Chinese science as a dead end, a project they felt revealed Needham's wishful thinking about premodern China. For some, the Needham project simply reiterated the Chinese origins of Western learning approach.[64]

Many twentieth-century scholars were convinced that premodern China had no industrial revolution and had never produced capitalism. Therefore, they contended, the Chinese could never have produced modern science on their own. While Needham granted that China lacked the capitalist catalyst required for modern science, he did not stop there. Few besides Needham, his collaborators, and Nathan Sivin stopped to consider what the rich archives in Taiwan, China, and Japan might yield if someone bothered to go through them. As the evidence of a rich tradition of natural studies and medicine accrued in volume after unrelenting volume of the *Science and Civilisation in China* project from 1954 to 2000, it became harder and harder to gainsay it all as superstition, irrationality, or inductive luck.

The largest archive of premodern records for the study of nature remains in China. By better understanding the history of imperial Chinese natural studies, technology, and medicine, and the cultural mystifications that undergirded them, we can be more perceptive about ourselves and the mystifications that undergird our contemporary versions of modern science. "Chinese science" has grown in respectability among academics. The romanticized story of European science, whether capitalist or socialist in genre, has slowly unraveled under the onslaught of fifty years of nonpositivist research. Younger scholars now probe the surface of self-satisfied rhetoric about science as fundamentally Western and go beyond simplistic appeals to the Greek deductive logic by armchair philosophers of Western science.[65]

In this volume I have reconsidered the scholarly consensus about the alleged failed history of science in China and the alleged victorious history of science in Europe and Japan. Both histories are pieces of a larger, yet unwritten global narrative of science on the planet.[66] With the exception of a modernized version of traditional Chinese medicine that is now flourishing as one version of holistic medicine, the traditional fields of natural studies in imperial China did not survive the impact of modern science between 1850 and 1920. We have tried to show that earlier accounts of the historical construction of Western science, technology, and medicine in Republican China depended on specious claims that the Chinese sciences failed during the Ming and Qing dynasties.

The Chinese construction of modern science, medicine, and technology on their own terms is a remarkable achievement, even if they did not initiate the internal and external revolutions that provoked that construction. Early modern Europe, after all, borrowed much from Asia and Islam before its own scientific revolutions. To be sure, China's plans to send space expeditions to the moon and Mars in the twenty-first century are in part a response to the

Ming navy that allegedly—and anachronistically—failed to take advantage of its commercial and military opportunities in the early fifteenth century. Withdrawing from the Indian Ocean after 1450 and unintentionally leaving the Pacific to become a site for the rise of Spanish, Portuguese, Dutch, and English naval power certainly is a lesson that contemporary Chinese will not soon forget. The shock of Western and Japanese imperialism in China remains a tragedy for the Chinese, but their accruing triumphs in contemporary science, medicine, and technology should not be placed in a time frame that overlooks the era before 1900. In this century, modern science in China will hopefully work more benevolently than did Euro-American techno-science.