The Translation of Modern Western Science in Nineteenth-Century China, 1840–1895

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ABSTRACT

The translation of Western science texts into Chinese began with the Jesuits in the sixteenth century, but by 1800 their impact had waned. The First Opium War (1839–1842) and the Taiping Rebellion (1850–1864) stimulated renewed interest in Western military technologies and in the sciences that underpinned them, leading to the beginning of systematic translations at government institutions in the late 1860s. At the same time, Western missionaries were making their own science translations, in the belief that science would be an "auxiliary to the spreading of the gospel." Translation techniques are compared to those of the early Buddhist missionaries. Methods for creating new terms and their relative merits are discussed, together with the opinions of those who argued that the whole enterprise was impossible. The relatively small direct influence of the translations is contrasted with their effect as catalysts for intellectual and political changes that would find their full expression only in the next century.

THE TRANSMISSION OF SCIENCE BETWEEN CULTURES has occurred in many different ways—through trade, migrations, direct scholarly contact between individuals, diffusion of techniques and artifacts—but any large-scale, systematic movement of ideas between cultures with no common language has always necessitated the translation of texts.[1] The period with which this essay deals begins with a blow to the Chinese Empire from drug-dealing, seaborne Western barbarians, who forced it to open its ports to foreign

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[1] A. I. Sabra, "Situating Arabic Science: Locality versus Essence," *Isis*, 1996, *87*:654–670, on p. 657.

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trade, and ends with the yet more crushing defeat (over fifty years later) by Japan, which China had always considered its cultural and military inferior.

Between these two humiliations, the first translations of books on modern Western science began to appear. What motivated the Chinese, with their own long and brilliant history of scientific and technical achievement, to translate works on Western science? The shame of defeat led to spurts of translation activity after the First (1839–1842) and Second (1856–1860) Opium Wars, but these efforts were followed by periods of complacency. Only the brutal destruction of the Northern Fleet, the pride of China's "Self-Strengtheners," in the war with Japan in 1894–1895 led to the recognition, at least amongst a substantial section of the educated elite, that modernization—and the concomitant study of the new sciences—could no longer be avoided. From 1895 onward, for the first time in modern history, significant numbers of young Chinese intellectuals came to the study of natural science. The scientific translations of the mid- and late nineteenth century, though largely ignored at the time, were a vital preparation for, and catalyst of, the change of heart that followed naval disaster in the Yellow Sea.

THE PROBLEMS OF TRANSLATION

Although there had been earlier contacts with other civilizations, the first systematic attempt by the Chinese to translate the writings of a foreign culture came with Buddhism, which entered from Central Asia in the first century of the Christian era.[2] The early Central Asian missionaries often possessed only a rudimentary knowledge of the Chinese language, and the first translations of the *sūtras* had to be carried out via bilingual intermediaries. By the time the great missionary-translator Kumarājīva (A.D. 344–413) arrived in the capital Chang'an in A.D. 401, the Buddhist translation enterprise had become highly sophisticated, with a small army of translators, checkers, and revisers. In the translation halls some monks recited the texts in the original languages, while others gave direct oral translations into literary Chinese. Copyists wrote out a first draft, which would then be elaborated and polished. Subsequent drafts were followed by checks and further revisions, which were always referred back to the Dharma-master for his approval. The trouble taken

[2] On the general issues in this essay see Cyrus Peake, "Some Aspects of the Introduction of Modern Science into China," *Isis,* 1934, *22:*173–217; Tsuen-hsuin Tsien, "Western Impact on China through Translation," *Far Eastern Quarterly,* 1954, *13:*305–327; John K. Fairbank, *The Influence of Modern Western Science and Technology on Japan and China* (Rome: X Congresso Internazionale di Scienze Storiche, 1955); R. G. A. Dolby, "The Transmission of Science," *History of Science,* 1977, *15:*1–43; and Ssu-yü Teng and Fairbank, *China's Response to the West: A Documentary Survey, 1839–1923* (Cambridge, Mass.: Harvard Univ. Press, 1979). On intellectual space for science in late imperial China see Jonathan Porter, "The Scientific Community in Early Modern China," *Isis,* 1982, *73:*529–544; Kuo Ting-yee and Liu Kwang-ching, "Self-Strengthening: The Pursuit of Western Technology," in *The Cambridge History of China,* ed. D. C. Twitchett and Fairbank, Vol. 10, pt. 1 (Cambridge: Cambridge Univ. Press, 1978), pp. 491–542; and Ma Zuyi 马祖毅, *Zhongguo fanyi jianshi* 中国翻译简史 [A history of translation in China] (Beijing: Zhongguo duiwai fanyi chuban gongsi, 1984); David C. Reynolds, "Redrawing China's Intellectual Map: Images of Science in Nineteenth-Century China," *Late Imperial China,* 1991, *12*(1):27–61; and Nathan Sivin, "A Biography of Wang Hsi-shan," in *Science in Ancient China: Researches and Reflections* (Aldershot: Variorum, 1995), pp. 1–28. Dealing specifically with the scientific translations of the late Qing are the pioneering work by James Reardon-Anderson, *The Study of Change: Chemistry in China, 1840–1949* (Cambridge: Cambridge Univ. Press, 1991); Li Nanqiu 黎难秋, *Zhongguo kexue wenxian fanyi shigao* 中国科学文献翻译史稿 [A draft history of the translation of scientific texts in China] (Hefei: Zhongguo Kexue Jishu Daxue chubanshe, 1993); and Xiong Yuezhi 熊月之, *Xixue Dongjian yu wan Qing shehui* 西学东渐与晚清社会 [The eastward movement of Western studies and late Qing society] (Shanghai: Shanghai renmin chubanshe, 1994), which is the fullest account of the processes discussed in this essay yet to appear in Chinese or English.

is a measure of the seriousness with which the translation enterprise was viewed: the religious meaning must not be lost through careless transmission.[3]

The most demanding task of the translators was to bridge the gulf between the foreign religion and traditional Chinese ways of thinking. The existing terms of native Chinese philosophy often proved inadequate to "match the meanings" (*geyi* 格義) of the profoundly different Buddhist ideas. Increasingly, terms were transliterated from the source languages, employing strings of characters purely for their phonetic value. An intricate and precise system for transcribing the sounds of Sanskrit was developed, a technique adapted many centuries later to the transcription of Mongolian.[4] Strings of transcriptor characters were inelegant, yet the existence of foreign place- and personal names made some sort of transliteration inevitable. During the Yuan (Mongol) dynasty (A.D. 1279–1368) and again in the Qing (Manchu) dynasty (A.D. 1644–1911), the ethnic heterogeneity of a vast empire meant that immense numbers of non-Han Chinese geographical names had to be transliterated. After the First Opium War, gazetteers of the formerly neglected "ocean regions," from whence the seaborne foreigners came, required the transcription of yet more outlandish place-names. The geographer Xu Jiyu 徐繼畬 (1795–1873) wrote of his frustrations in determining their correct transliteration:

> The place-names of foreign countries are very difficult to distinguish phonetically. If ten people [transliterate] a name, there will be ten different versions of it. Even if *one* person translates a name [he may give] different versions at different times. . . . The foreigners who study Chinese live in Guangdong or Fujian, [regions] where the pronunciation is not standard, [hence their transliterations] cause confusion, or are even unrecognizable. [For example], take "Persia": it is [variously] transcribed as "Baixi," "Baoshe," "Bashe," or even [completely] erroneously written as "Gaoshe." I have tried asking a Westerner to say the word and he said "Baiershe," but [when I] asked [him] to write it down, he wrote "Bierxi"![5]

[3] Walter Fuchs, "Zur technischen Organisation der Übersetzungen Buddhistischer Schriften ins Chinesische," *Asia Major,* 1930, *6*:84–103; E. Zürcher, *The Buddhist Conquest of China* (Leiden: Brill, 1972), p. 31; Tang Yongtong 湯用彤, *Han-Wei-Liang Jin-Nanbeichao Fojiaoshi* 漢魏兩晉南北朝佛教史 [A history of Buddhism under the Han, Wei, Jin, and Northern and Southern dynasties] (Beijing: Zhonghua shuju, 1963), pp. 408–411; Leon Hurwitz, "The Problem of Translating Buddhist Canonical Texts into Chinese," *Babel,* 1963, *9*:48–52, esp. pp. 48–50; and Victor H. Mair, "Buddhism and the Rise of the Written Vernacular in East Asia: The Making of National Languages," *Journal of Asian Studies,* 1994, *53*:707–751, esp. p. 719.

[4] On the problem of rendering Buddhist ideas in Chinese see Zürcher, *Buddhist Conquest of China,* p. 12; and T'ang Yung-t'ung, "On '*ko-yi*,' the Earliest Method by Which Indian Buddhism and Chinese Thought Were Synthesised," in *Radhakrishnan: Comparative Studies in Philosophy,* ed. W. R. Inge (London: Allen & Unwin, 1951), pp. 276–286. On the system for transcribing the sounds of Sanskrit see Stanislaus Julien, *Méthode pour déchiffrer et transcrire les noms sanscrits qui se rencontrent dans les livres chinois* (Paris: Imprimerie Impériale, 1861); Gustave Schlegel, "The Secret of the Chinese Method of Transcribing Foreign Sounds," *T'oung Pao,* 2nd Ser., 1900, *1*:1–32, and Zürcher, *Buddhist Conquest of China,* pp. 39–40. The transcription was so accurate that it has sometimes proved possible to reconstruct the original Sanskrit text where this has been lost. Moreover, awareness of Sanskrit phonology led Chinese scholars to their first detailed analysis of the phonetics of their own language. *The Secret History of the Mongols* was transcribed phonetically from Mongolian into Chinese characters, probably during the late Yuan (Mongol) dynasty (A.D. 1279–1368). See Chen Yuan 陳垣, *Yuan bishi yiyin yongzi kao* 元祕史譯音用字考 [An investigation into the Chinese characters used in the transcription of the *Secret History of the Mongols*] (Beiping: Guoli zhongyang yanjiuyuan lishi yuyan yanjiusuo, 1934). This transcription involved the invention of phonetic subscripts and superscripts to denote sounds not found in Chinese, as well as the creation of some completely new characters.

[5] Xu Jiyu, *Yinghuan zhilüe* 瀛環志略 [A brief account of geography] (1848), *fanli* 1.3a–3b. See also Fred W. Drake, *China Charts the World: Hsü Chi-yü and His Geography of 1848* (Cambridge, Mass.: East Asia Research Center, Harvard Univ., 1975), pp. 222–224 n 17. On the difficulties in rendering place-names see Kazuo Enoki *et al., Ch'in-ting Hsi-yü t'ung-wen-chih* 欽定西域同文志 [An imperial translingual gazetteer of the Western regions], Vol. 4 (introduction and index) (Tokyo: Tōyō Bunko, 1964), pp. xvi–xxiii. M. Aurousseau, *The Rendering of Geographical Names* (London: Hutchinson Univ. Library, 1957), gives a valuable summary of the issues.

Transcriptions carried out in Guangzhou, Fuzhou, Shanghai, and Beijing would thus all be marked by the phonetic features of the local dialect. Such problems were inevitable before standardization based on a single regional form of Chinese (Northern Mandarin) was established in the twentieth century. "Chinese" is actually a family of mutually unintelligible languages spoken by the Han Chinese people.[6] Modern Standard Chinese or *putonghua,* based upon the Beijing dialect of Northern Mandarin Chinese, is now the official form and is taught in schools and used in films, radio, and television and for all official purposes.

Chinese characters, like all other developed scripts, represent the sounds of the dialect in which one reads them. What—amongst other things—makes the Chinese script unusual is that each character (with a few minor exceptions) represents a *word* (a unit of meaning) as well as a *syllable.* Thus 馬 stands both for the syllable /ma/ and for the meaning "horse."[7] The first Chinese characters were probably "pictographs" such as *niao* 鳥 ("bird") and *ma* 馬 ("horse"), designations of animals and other natural objects whose pictorial origins are often hard to decipher in the modern form of the character.[8] From the "pictographic" characters were derived "conjoining the sense" characters, more complex entities including two or three components that interact semantically to generate a new meaning—for instance, *ming* 明 ("bright") is made up of *ri* 日 ("sun") and *yue* 月 ("moon"), while *jing* 晶 ("glistening") is a triplet of shining "suns."

There are many tens of thousands of characters in the largest Chinese-Chinese dictionaries, yet only a small proportion fall into the categories I have described. The great majority also carry explicit information about the *sound* they represent and are known as "forming the sound" characters. Such characters are usually built of two components: one, the so-called radical, gives the generic meaning; the other, the phonetic, denotes the pronunciation. For instance, the character *tong* 銅 ("copper") is built of 金, the radical meaning "metal," and the component 同, which, as a freestanding character, has the pronunciation *tong.*[9] A literate native speaker could, in principle, look at 銅 and without knowing its meaning guess that it represents a kind of metal and has a pronunciation something like *tong* 同.[10]

The standard form of the Chinese script, described so briefly here, stabilized during the Han dynasty (206 B.C. to A.D. 220) and was in use up until the 1950s, when the government

[6] On the features of local dialects see Yao Hanming 姚汉铭, "Shilun xin ciyu yu guifanhua" [Essay on neologisms and standardization], *Yuyan jiaoxue yu yanjiu* 语言教学与研究 [Language teaching and linguistic studies], 1995, *1*:82–95. A good demythologizing introduction to the Chinese language and script is John DeFrancis, *The Chinese Language: Fact and Fantasy* (Honolulu: Univ. Hawaii Press, 1984). DeFrancis calls the varieties of Chinese "regionalects" (p. 57). They include Mandarin, Shanghainese, Cantonese, and so on. There are also many languages spoken in China that are not members of the Han Chinese family: some are distantly related to Chinese (e.g., Tibetan), while others belong to completely different language groups (e.g., Mongolian).

[7] Most other scripts have as their basic unit isolated sounds such as /m/ or /a/ (as in the alphabets used for English, Russian, Greek, and Arabic) or isolated syllables such as /wa/ or /ko/ (as in the *hangul* script for Korean or the *hiragana* script for Japanese). Tones are of course an essential feature of the Chinese language, but I am not marking them in this essay.

[8] These are the forms of the characters that became fixed around the time of the Han dynasty, and I have given their modern pronunciations. The pictorial elements have become highly stylized, but one can still see in the characters for "bird" and "horse" four dots, which originally denoted feathers and legs, respectively.

[9] There have been many attempts to show that such "phonetics" have some semantic connection with the characters they are used to form. See William G. Boltz, *The Origin and Early Development of the Chinese Writing System* (New Haven, Conn.: American Oriental Society, 1994), p. 90 ff.

[10] The fact that in some cases such guesses would be wildly wrong is in part a measure of the phonetic evolution of the language in the two or three millennia since the characters were first formed.

of the People's Republic of China introduced a simplified set of characters designed to improve mass literacy.[11] The antiquity of the traditional script means that within the strokes of the most ancient characters are preserved an etymology that may lead back to the earliest period of Chinese history.

The late Qing scholarly communities, based in the Lower Yangzi Valley before the Taiping Rebellion (1850–1864), worked principally on such matters of philology. The Lower Yangzi region was the most prosperous part of China, famous for its natural beauty and for the quality of its artists, calligraphers, poets, and scholars. Within their academies they engaged in collective researches that emphasized the need for cumulative, critical textual study if anything certain were to be known about the distant past, a methodology that became known as *kaozheng* 考證 or "evidential scholarship." For some, the study of ancient phonology was an end in itself, but for others it was a means to discover more about the Way (*Dao* 道). The *Dao* was both the ultimate reality of the cosmos and the moral path that would lead human beings to live in harmony with each other and the natural world. Philology could be a bridge to the purer past, a process of linguistic archaeology through which the layers of accreted, deformed meanings could be peeled away to reveal the true meaning and moral significance of the ancient texts.

As Benjamin Elman and others have shown, these scholars' systematic studies of phonetic changes "established the foundations of modern Chinese linguistics," and their recovery of ancient texts rekindled interest in the native scientific tradition. Although their researches were not primarily concerned with natural science, distinguished work was done on astronomy, mathematical harmonics, and mathematics. Their interest in the reconstruction of the language of the past sometimes led them to study the artifacts of antiquity such as musical instruments.[12] Their skeptical, rationalist, empirical approach to textual research, epitomized by the motto "Seek truth from facts [*shishi qiushi* 實事求是]," was a matrix that supported and nourished the long and continuous Chinese tradition of study of the natural world—and within which the preoccupations and approaches of Western science were not entirely alien.

The Chinese tradition of natural science has an antiquity, scope, and depth that have become evident only in recent decades, through the work of East Asian historians of science and, in the West, the pioneering researches of Joseph Needham and Nathan Sivin. When Western science first became known to Chinese scholars in the sixteenth century as a result of the Jesuit missions, some Chinese scholars opposed it as alien and uncouth, but others believed that it had preserved the vestiges of an older native tradition, "augmented and cultivated" in the West when the chain of transmission within China had been broken.[13]

[11] The "simplified" characters introduced by the Chinese government in the 1950s have replaced the traditional forms for most purposes, but the latter forms are still recognized by most educated readers and seem, if anything, to be more widely used in China today than twenty years ago. People in Taiwan and overseas Chinese communities still retain the traditional script.

[12] Cynthia J. Brokaw, "Tai Chen and Learning in the Confucian Tradition," in *Education and Society in Late Imperial China, 1600–1900*, ed. Benjamin Elman and A. Woodside (Berkeley: Univ. California Press, 1994), pp. 257–291, on p. 270; and Elman, *From Philosophy to Philology: Intellectual and Social Aspects of Change in Late Imperial China* (Cambridge, Mass.: Harvard Univ. Press, 1984), esp. pp. 69, 221. On the study of artifacts see Catherine Jami, "Learning Mathematical Sciences during the Early and Mid-Ch'ing," in *Education and Society in Late Imperial China,* ed. Elman and Woodside, pp. 223–256, esp. p. 228; and Elman, *From Philosophy to Philology,* pp. 180–184.

[13] Joseph Needham's work is best known through his monumental series *Science and Civilisation in China,* 7 vols. (Cambridge: Cambridge Univ. Press, 1954–). An annotated bibliography of the works of Nathan Sivin is given in *Chinese Science,* 1996, *13*:135–142. The "Chinese origin of Western science" theory arose with the first Jesuit mission to China in the late Ming period. During the early Qing dynasty, the Kangxi Emperor

By the mid-nineteenth century the attacks of the Western powers on China had created a much more hostile environment for foreign culture. A group of officials who became known as the "Self-Strengtheners" suggested that knowledge of the sciences that underpinned Western military technology was essential if China were to defend itself against foreign steamships and guns. Their proposal to allow Westerners to teach science in government schools, even in the imperial capital, provoked fierce opposition from conservatives who saw it as shameful to admit that barbarians could ever become teachers of Chinese.[14] Nevertheless, by the late 1860s modern science was taught in government schools, and Chinese and foreign scholars initiated the translation of science texts, albeit at first on a modest scale.

Whereas conservative Chinese scholars had objected on principle to the teaching of Western learning, skeptical foreigners saw no hope of translating what they regarded as the quintessentially Western ideas of modern science into the Chinese language.

THE NECESSITY OF TRANSLATION

The Jesuit translators in the sixteenth and seventeenth centuries had made excellent translations of works on Western mathematics and astronomy. The influence of their translations was of great historical importance, but by the nineteenth century it had waned, and their role in the transmission of contemporary Western science had ceased. By 1840 many of the major discoveries of the previous century in physics and chemistry were still quite unknown in China.[15]

When Westerners came to learn Chinese they were often amazed to discover that it appeared devoid of the structural features their prejudices led them to expect in all well-developed languages. Foreigners disputed whether such a language, contrasting so starkly with modern European languages, let alone Latin and Greek, was even capable of dealing with science.[16] Misgivings about the "vagueness" of the Chinese language were in practice

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commented that the mathematics the Jesuits had brought to China were "all Chinese in origin." See Jonathan D. Spence, *Emperor of China: Self-Portrait of K'ang-hsi* (1974; rpt., London: Peregrine, 1977), p. 74; and Quan Hansheng 全漢昇, "Qingmo de 'Xixue yuanchu Zhongguo' shuo" [The late Qing theory that "Western studies originated in China"], in *Zhongguo jindaishi luncong* 中國近代史論叢 [A collection of essays on modern Chinese history], ed. Li Dingyi 李定一 (Taibei: Zhengzhong shuju, 1956), Vol. 5, pp. 216–258. Westerners were often just as eager to prove that all Chinese science derived from the West; see, e.g., G. E. Moule, "The Obligations of China to Europe in the Matter of Physical Science Acknowledged by Eminent Chinese," *Journal of the North China Branch of the Royal Asiatic Society,* N.S., 1871–1872, *7*:146–164.

[14] Quan Hansheng, "Qingmo fandui Xihua de yanlun" [Arguments against Westernization in the late Qing period], *Lingnan Xuebao* 嶺南學報 [Lingnan journal], 1936, *5*:122–166.

[15] Henri Bernard, *Matteo Ricci's Scientific Contribution to China* (Beiping: Henri Vetch, 1935); Bernard, "Notes on the Introduction of the Natural Sciences into the Chinese Empire," *Yenching Journal of Social Studies,* 1941, *3*:220–241; Pasquale M. D'Elia, *Galileo in China: Relations through the Roman College between Galileo and the Jesuit Scientist-Missionaries (1610–1640)* (Cambridge, Mass.: Harvard Univ. Press, 1960); Zhang Zigao 張子高, *Zhongguo huaxueshi gao* 中国化学史稿 [A draft history of chemistry in China] (Beijing: Kexue chubanshe, 1964), pp. 183–195; Nathan Sivin, "Copernicus in China," in *Colloquia Copernicana II* (Warsaw, 1973), pp. 63–122; Sivin, "Why the Scientific Revolution Did Not Take Place in China—Or Didn't It?" *Chin. Sci.,* 1982, *5*:45–66; and Du Shiran 杜石然 and Han Qi 韓琦, "An Overview of Chinese Science in the Ming-Qing Period," in *East Asian Science: Tradition and Beyond,* ed. Keizo Hashimoto *et al.* (Osaka: Kansai Univ. Press, 1995), pp. 105–110.

[16] "Methods of Imparting Western Knowledge to the Chinese," *Journal of the China Branch of the Royal Asiatic Society,* 1886, *21*:1–21, esp. p. 15. See John Fryer's reply to attacks on the need for translation: Fryer, *Can Western Knowledge Be More Effectually Imparted to the Chinese Nation for the Time Being by Giving Them Translations of Foreign Books, or by Teaching Them to Speak and Read Foreign Languages?* (n.d.), Fryer Papers, Box 1, Carton 1, Bancroft Library, University of California, Berkeley. The Fryer Papers represent a major source for historians of the translation movement in late imperial China.

wholly misguided. During this period, virtually all the textbooks were successfully translated into the literary style, usually in the simplified idiom known to foreigners as "easy *wenli,*" with no significant loss of precision. The problems that arose were largely lexical rather than structural.[17] Other commentators objected to scientific translation on the grounds that Chinese was incapable of having "grafted on to it any such new vocabulary as the terminology and nomenclature of Western sciences require." Yet those who had themselves attempted scientific translation were convinced of its practicality and necessity. The missionary translator and science educator Calvin Mateer (1836–1908) eloquently pointed out that, if Western languages were the sole medium for propagating science, it would be imparted only to the tiny minority who could master a foreign tongue:

> Knowledge is needed, not for the few, but for the many. It finds its true mission not in filling the shelves of the bookworm but in serving the practical ends of life. We not only want men in China who know, but who can also use and teach what they know. So far as influence on the Chinese people is concerned, it is more important to have one man educated in the use of Chinese than ten men educated in the use of English.[18]

Among expatriates the argument continued. As late as October 1889, an editorial in the *North China Herald* held that

> Chinese is good enough as far as the textbooks go, for popular science; but it is impossible that any full knowledge of Western science can be gained in a language which is entirely destitute of a scientific terminology. . . . As a medium of thought English (and indeed any foreign language) is immeasurably superior to Chinese in precision and clearness. The English speaking student has a vast field of collateral thought open to him which does not exist, and never will exist, in Chinese. The English speaking student can keep up with the times, while the one who knows only Chinese must depend on translation. . . . It seems to us as easy for a man born blind to apprehend colours as for a Chinaman who knows none but his own language to reach any proficiency in modern science.[19]

There was some justice in the point that a monoglot Chinese research scientist would be at a serious disadvantage in a world of rapidly developing ideas.[20] The point was moot, however, for in late nineteenth-century China there were no research scientists. Only a tiny minority of the educated elite professed any interest in science, and their only access to such knowledge was via the few translations that had appeared in book form or had been serialized in journals. The pioneer teachers of Western science had no choice but to translate texts themselves.

Typifying the isolation of the early missionary translators in the second half of the nineteenth century was Edward Moncrieffe (d. 1857), who taught at St Paul's College in Hong Kong in 1850. He was among the first Protestant missionaries to teach Western mathematics in Chinese. Finding no suitable textbook, he recounts,

[17] "Easy *wenli*" avoided literary allusions and obscure constructions, keeping to structures and vocabulary that were not too distant from the colloquial language. It was still far removed from the vernacular or *baihua* style. Of the missionaries, only Calvin Mateer dared to write science and mathematics textbooks that were truly colloquial, and he was severely censured by his colleagues for writing in a style that they felt was bound to be rejected by the literati. See W. A. P. Martin, "Dr Mateer's *Geometry*—A Review," *Chinese Recorder,* 1886, *17*:314–316. See also Servus [E. C. Bridgman], "The Bible: Its Adaptation to the Moral Condition of Man: Remarks on the Qualifications of Translators and the Style Proper for a Version of the Scriptures in Chinese," *Chinese Repository,* Nov. 1835, *4*:297–305.

[18] "Methods of Imparting Western Knowledge to the Chinese" (cit. n. 16), pp. 16, 5.

[19] *North China Herald,* 4 Oct. 1889, pp. 405–406.

[20] George Sarton, "The Tower of Babel," *Isis,* 1948, *39*:3–15.

> I adopted the following means to supply the defect: Each day, I wrote out in English a short lesson on one or two of the subjects, which I frequently explained as well as I could in my broken Chinese. One of the boys who understood English rendered this into Chinese as well as he was able, my own teacher then corrected this and wrote it out in a book for us, after which each of the boys copied it out and learned it for the day appointed. In this way we now have in progress a kind of textbooks [*sic*] on Geography, English History, an abridgement of Genesis, & as far as the 8th proposition of the first book of Euclid. The latter was peculiarly difficult, as my teacher had no idea whatever of it, & the greater part of the burden fell upon myself, but I hope I have succeeded in some degree, as a few of the boys appear to have understood the subject.[21]

His translation was—not surprisingly, given the circumstances—far inferior to the scholarly rendering of Euclid's text published by the Jesuit Matteo Ricci (1552–1610) three centuries earlier. Moncrieffe seems to have been quite unaware of his Jesuit predecessor's work, and his *ad hoc* methods—reminiscent of the very earliest days of the Buddhist transmission—could not prevail for long.

Moncrieffe was followed by formidable missionary Sinologists such as Alexander Wylie (1815–1887), Joseph Edkins (1823–1905), and Alexander Williamson (1815–1887), who worked at the Inkstone Press in Shanghai during the 1850s. With the assistance of some extremely talented Chinese co-workers, they and their successors were able to carry out some remarkable translations of works on mathematics, astronomy, physics, and botany. By the 1880s missionary bodies had set up organizations to oversee the translation of a wide range of science texts, and standardization committees worked to harmonize the rival sets of scientific terms that had evolved over the preceding three decades.[22]

Medical missionaries, too, played a role in the early phase of translation: one of the earliest, Daniel Jerome Macgowan (1814–1893), published *Bowu tongshu* 博物通書 [Philosophical almanac] in 1851. Devoted mainly to electricity, it naturally drew the reader's attention to the medical uses of electrotherapy. Slightly later, Benjamin Hobson (1816–1873) in Guangzhou published *Bowu xinbian chuji* 博物新編初集 [A new compilation on natural philosophy: First collection] (1854), while his successor John Glasgow Kerr (1824–1890) and He Liaoran 何瞭然 made the first Chinese translation of a textbook devoted entirely to chemistry in 1870.[23] The illustrations in translated texts were sometimes taken directly from the original source or, more often, redrawn by a Chinese

[21] Edward T. R. Moncrieffe to Henry Venn, 8 June 1850, Church Missionary Society Archives, C CH O/63/3A, p. 4, Special Collections Department, Main Library, University of Birmingham; quoted by permission of the Church Mission Society. Moncrieffe was to leave China in scandalous circumstances in 1852, after the discovery of his liaison with Agnes Gützlaff, the recently widowed wife of the pioneer missionary Karl Gützlaff (1803–1851).

[22] John Fryer, *Catalogue of Educational Books, Works of General Knowledge, Scientific and Technical Treatises, &c., &c., &c., in the Chinese Language* (Shanghai: Presbyterian Mission Press, 1894); and Fryer, *Educational Directory for China* (Shanghai: Educational Association of China, 1895). On the work of the missionary societies in translating science see Pan Jixing 潘吉星, "Qingji de Guangxuehui" [The Society for the Diffusion of Useful Knowledge in the Qing dynasty], *Bulletin of the Institute of Modern History, Taibei,* 1973, *4*:193–227; and Wang Yangzong 王扬宗, "Qingmo Yizhi Shuhui tongyi shuyu gongzuo shuping" [A critical account of the work of the late Qing Educational Association of China in standardizing technical terminology], *Zhongguo keji shiliao* 中国科技史料 [China historical materials of science and technology], 1991, *12*(2):9–19.

[23] Daniel Jerome Macgowan, *Bowu tongshu* [Philosophical almanac] (Ningbo: Aihuatang, 1851); and Benjamin Hobson, *Bowu xinbian* [A new compilation on natural philosophy] (Guangzhou: Huiai yiguan, 1855). The chemistry textbook was *Huaxue chujie* 化學初階 [First steps in chemistry] (Guangzhou: Boji yiju, 1870), a partial translation of David Wells, *Principles and Applications of Chemistry* (1862). He Liaoran had been a student of Benjamin Hobson in Guangzhou.

artist. The quality varies greatly, with a clear tendency in some cases to imitate the style of the diagrams in medieval Chinese alchemy texts.[24]

INSTITUTIONS OF TRANSMISSION: THE TRANSLATION DEPARTMENT OF THE JIANGNAN ARSENAL

Notwithstanding the activities of the missionaries, large-scale, systematic translation of science texts took place mainly within Chinese government institutions.[25] The Beijing Tongwenguan (Interpreters' College) was founded in 1862 and—despite fierce opposition from conservative elements in the Qing court—included science teaching from 1867. Opponents feared that students would be corrupted by the Christian teachings of the foreign lecturers, most of whom were ex-missionaries who tended to see their educational work as part of a wider mission to Christianize the Celestial Empire. Typical of these men was W. A. P. Martin (1827–1916), who taught mathematical physics and occupied the first presidency of the Beijing Tongwenguan. His science compendium *Gewu rumen* 格物入門 [Introduction to natural philosophy] was reprinted several times in China and in Japan. His colleague at the Tongwenguan, the French chemist Anatole Billequin (1837–1894), also made two important chemical translations for his students, although the nomenclature he created verged on the eccentric.[26]

Other modern government schools, in the coastal cities of Shanghai and Guangzhou (Canton), made a lesser contribution to science education. An optimistic early description of the Shanghai Tongwenguan ran:

> [It is] a rather handsome piece of Chinese architecture, enclosing a square, and having verandahs all round, both inside and out. The whole upper storry [*sic*] is to be devoted to the translation department.
>
> The course of instruction to be pursued by the students of the college will have reference to the work carried on in the arsenal, and will be practical as well as theoretical. It is proposed to begin with a course of mathematics, geography, drawing and other elementary subjects; but eventually the students will be divided into classes for mining and metallurgy, the manufacture of firearms, steam-engines, and other machinery, naval architecture, seamanship and navigation, and naval and military tactics.

[24] In his preface to *Huaxue chujie,* John Kerr states that the illustrations are "electrotype plates obtained from Messrs Ivison, Phinney, Blakeman & Co., New York." See also Joseph Needham and Ho Ping-yü, "The Laboratory Equipment of the Early Medieval Chinese Alchemists," *Ambix,* June 1959, *7*:57–115.

[25] See John Fryer, "An Account of the Department for the Translation of Foreign Books at the Kiangnan Arsenal, Shanghai," *North China Herald,* 29 Jan. 1880, pp. 77–81; Fryer, "Science in China," *Nature,* 1881, *24*:9–11, 54–57; Fryer, "Jiangnan Zhizao Zongju Fanyi Xishu shilüe" [An account of the Department for the Translation of Foreign Books at the Jiangnan Arsenal], *Gezhi huibian* 格致彙編 [Chinese scientific and industrial magazine], June 1880, *3*(5):10a–12b, July 1880, *3*(6):9a–11b, Aug. 1880, *3*(7):9a–11b, Sept. 1880, *3*(8):9a–10b; and *Jiangnan zhizaoju yishu tiyao* 江南製造局譯書提要 [A summary of the translations of the Jiangnan Arsenal] (Shanghai: Translation Department, Jiangnan Arsenal, 1909). Secondary sources include Wang Yangzong, "Jiangnan Zhizaoju Fanyiguan shilüe" [A brief account of the history of the Translation Department of the Jiangnan Arsenal], *Zhongguo keji shiliao,* 1988, *9*:65–74; and Wang Yangzong, "Jiangnan Zhizaoju fanyi shumu xinkao" [New investigations into the catalogue of translated books from the Jiangnan Arsenal], *ibid.,* 1995, *15*(2):3–18.

[26] *Gewu rumen* (Beijing: Tongwenguan, 1868). On the Beijing Tongwenguan see Knight Biggerstaff, "The T'ung Wen Kuan," *Chinese Social and Political Science Review,* 1934, *18*:307–340. Regarding conservative opposition see M. J. O'Brien, "The Peking College," *North China Herald,* 25 Jan. 1870, pp. 63–66; and Liu Kwang-ching, "Politics, Intellectual Content, and Reform: The T'ung-wen Kuan Controversy of 1867," in *Reform in Nineteenth-Century China,* ed. Paul A. Cohen and John E. Schrecker (Cambridge, Mass.: East Asian Research Center, Harvard Univ., 1976), pp. 87–100. On science as missionary work see W. A. P. Martin, "Western Science as Auxiliary to the Spread of the Gospel," *Chin. Rec.,* 1897, *29*:111–116. On Billequin see Henri Cordier, "Obituary of A. A. Billequin," *T'oung Pao,* 1st Ser., 1894, *5*:441–442.

A decade later, John Fryer (1839–1928), the head of the Translation Department of the Jiangnan Arsenal, is reported to have said,

> At first an English department was set up, then a French department, but now only a few [students] remain: there are just twenty youths, and it seems akin to a elementary school. In addition, a mining department, a machine department and a navigation department have been set up, all run by foreigners, none of whom can speak Chinese. Since none of the students know foreign languages, they have had to hire interpreters, and [as a result, the students] are more concerned with paying their [interpreters'] salaries than asking [them] about their lessons.[27]

One of the reasons for the low morale at the school was the poor outlook for its graduates in government service—even as interpreters, let alone in the fields of science and technology. In 1870 the translation department of the Shanghai Tongwenguan amalgamated with that of the Jiangnan Arsenal, where for more than thirty years the Department for the Translation of Foreign Books, under the direction of John Fryer (see Figure 1), was to be the most important institution for the translation of scientific books in China.[28]

The Jiangnan Arsenal, which had been founded in 1865, was the paradigm of the "Self-Strengthening" enterprises that had been set up in the 1860s, in the aftermath of the Second Opium War and the Taiping Rebellion. The leader of the "Self-Strengtheners" was Zeng Guofan 曾國藩 (1811–1872), the great scholar-general who, in suppressing the Taiping Rebellion, had seen for himself the peril the dynasty faced without modern steamship and firearms technology.[29] Zeng hoped that the Jiangnan Arsenal would play a leading role in restoring the power of the dynasty. One of the arsenal's central purposes was the translation of books on military matters. Of necessity, this led to the study of the fundamental sciences—mathematics, physics, and chemistry—on which the technologies for building and using modern ships and guns depended.

The translators of the Jiangnan Arsenal employed the Buddhist technique of oral translation (*kouyi* 口譯) by a foreigner who knew enough Chinese to transmit the gist of the meaning, which was then written down by a Chinese "amanuensis" who would transcribe (*bishu* 筆述) the foreigner's Mandarin into literary Chinese:

> The foreign translator, having first mastered his subject, sits down with the Chinese writer and dictates to him sentence by sentence, consulting with him whenever a difficulty arises as to the way the ideas ought to be expressed in Chinese, or explaining to him any point that happens

[27] *North China Herald,* 11 Jan. 1870, p. 22; and Guo Songtao 郭嵩燾, *Lundun yu Bali riji* 伦敦与巴黎日记 [London and Paris diary], in *Zou xiang shijie congshu* 走向世界丛书 [The "Going out into the world" collection], ed. Zhong Shuhe 钟叔河 (Changsha: Yuelu shushe, 1985), pp. 922–923 (quoting Fryer). John Fryer was briefly a missionary in the early 1860s and had a somewhat uneasy relationship with the official church. See A. A. Bennett, *John Fryer: The Introduction of Western Science and Technology in Nineteenth-Century China* (Cambridge, Mass.: Harvard Univ. Press, 1967); Ferdinand Dagenais, "John Fryer's Early Years in China, I: Diary of His Voyage to Hong Kong," *Journal of the Hong Kong Branch of the Royal Asiatic Society,* 1989, *29*:252–301; and Dagenais, "John Fryer's Early Years in China, II: First Impressions of Hong Kong and the Chinese People," *ibid.,* 1990, *30*:146–168. Fryer himself taught French at the Guang Fangyanguan (the former Shanghai Tongwenguan).

[28] The primary source for the Shanghai Tongwenguan, which changed its name in 1870 to Guang Fangyanguan, is "Guang Fangyanguan quan'an" [A complete account of the Shanghai Tongwenguan] (1894), rpt. in *Shanghai tan yu Shanghai ren congshu* 上海滩与上海人 [The Shanghai Bund and Shanghai People collection], ed. Yang Yi 杨毅 (Shanghai guji chubanshe, 1989), pp. 101–163. See also Knight Biggerstaff, *The Earliest Modern Government Schools in China* (Ithaca, N.Y.: Cornell Univ. Press, 1961), pp. 180–181.

[29] See Mary C. Wright, *The Last Stand of Chinese Conservatism: The T'ung-chih Restoration of 1862–1874* (Stanford, Calif.: Stanford Univ. Press, 1957; rpt., London: Atheneum, 1965); and Teng and Fairbank, *China's Response to the West* (cit. n. 2), pp. 64–65.

歷覽英國鐵廠記畧

序○是篇爲本館主人於八年前在英國歷覽製造各種鐵器之廠回華後始編輯者所閱各廠僅爲鐵路便
遇之處又因時日急促不便悉閱且遊
矚之時亦未思及欲記錄之既而華友
相會屢勸撰述又蒙當時製造局內總
辦叮囑故僅於所記憶者草草鋪陳幾
成一册蒙徐翁雪村筆述之潤色之斧
政之遂覺可觀既竣以活字鉛板在製
造局印成若干本分送與各好者今其
書已缺屢有欲閱者函示索購並囑印
諸彙編以便衆人共賞惟自覺是書恐
無大意輒愧貽笑方家而所有雄詞要
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諸壯觀閱者其幸諒之
素在中國有二十年蒙遠近華君過爲
謬愛屢有惠贈詞章獎譽優渥捧讀之
下不勝惶愧略數年前適有銅板草像華友見之屢囑印於彙編使人共識又蒙多君持贈讚言欲書像後惟
自愧庸愚恐貧陋獎故不敢印呈高明以徒增笑口也今因此像仔留已久幾歸無用是以就此一册贅印其
中或閱者視之不厭嫌歟

格致彙編 歷覽記略一 十

Figure 1. *Portrait of John Fryer,* Gezhi huibian, *August 1881,* 4*(7):10a. (Reproduced by kind permission of the British Library, Oriental Collection.)*

to be beyond his comprehension. The manuscript is then revised by the Chinese writer, and any errors in style, &c., are corrected by him. In a few cases the translations have been carefully gone over again with the foreign translator, but in most instances such an amount of trouble has been avoided by the native writers, who, as a rule, are able to detect errors of importance themselves, and who, it must be acknowledged, take great pains to make the style as clear and the information as accurate as possible.[30]

[30] Fryer, "Account of the Department for the Translation of Foreign Books" (cit. n. 25), p. 80. See also Thomas Carter, *The Invention of Printing in China and Its Spread Westwards,* 2nd ed. (New York: Ronald, 1955), p. 34, for a fine description of the preparation of the wood blocks that were used for most Chinese books in the

This description, by John Fryer, grossly devalues the role of the Chinese writer, who did far more than simply transcribe the words "dictated" to him by the foreigner. The foreign translator was speaking in colloquial Chinese (sometimes of doubtful quality), whereas the Chinese amanuensis was in effect retranslating the foreigner's rendering into literary Chinese. This demanded a thorough understanding of the scientific issues as well as a high level of literary skill: it was not at all uncommon for the Chinese scholars to be intellectually more distinguished than their foreign collaborators. Yet the Chinese amanuensis—for we can safely assume his assistance—is often unnamed, ignored, or even, in one of Fryer's more astounding self-justifications, *blamed* for any inadequacies in "his" translations.[31]

The mathematician and translator Hua Hengfang 華蘅芳 (1833–1902) has left us brief accounts of his collaboration with Daniel Jerome Macgowan on translations of J. D. Dana's *Manual of Mineralogy* and Charles Lyell's *Elements of Geology.* The latter collaboration seems to have been particularly frustrating, as Macgowan, who had by then become a private physician, was often called away to attend his patients. Hua noted in his preface that he "just sat and carried on correcting the drafts whilst awaiting [Macgowan's] return." The work almost cost Hua his life: terrible nightmares induced by his study of the cataclysmic geological events described in Lyell's book made him gravely ill. Hua could not read English, and Macgowan had only a limited knowledge of Chinese language and culture. Since Hua knew nothing of geology, it was often only by "looking at [Macgowan's] facial expressions and observing his gestures that the translation could be achieved."[32]

The mental and physical strain of translation under such conditions was enormous, and it is not surprising that many of Hua's colleagues, both Chinese and foreign, stayed at the arsenal only briefly before moving on to more congenial work. Fryer himself called the translation of scientific books

> perhaps about as dull and unthankful a task as any foreigner could engage in especially in such a secluded place as the Kiangnan [Jiangnan] Arsenal, and under the depressing influences of the climate of this part of China. Nothing but a strong sense of duty and a firm belief that this kind of labour is one of the most effective means, under the Divine Guidance, for bringing about the intellectual and moral regeneration of this great country, has sufficed to render endurable the long and weary years of close and continuous application which it has involved.[33]

THE CHINESE TRANSLATORS

The Taiping Rebellion forced many brilliant Chinese scholars to flee from the cities of the Lower Yangzi Valley to the relative safety of Shanghai. There they came in contact with

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nineteenth century. Movable metal type had been used in East Asia for many centuries, but it was too expensive for all but the most prestigious of publications.

[31] "The responsibility for whatever undue haste or carelessness may characterize my work rests rather on my Chinese colleagues than myself": John Fryer, "Scientific Terminology: Present Discrepancies and Means of Securing Uniformity," in *Records of the General Conference of the Protestant Missionaries of China Held at Shanghai, May 7–20, 1890* (Shanghai, 1890), pp. 531–549, on p. 536. This attitude contrasts with the painstaking approach of the Buddhist translators.

[32] Hua Hengfang, preface to *Dixue qianshi* 地學淺釋 [Elements of geology] (Shanghai: Jiangnan Arsenal, 1871), p. 1a. See also Wann-Sheng Horng, "Hua Hengfang (1833–1902) and His Notebook on Learning Mathematics—*Xue suan bi tan*," *Philosophy and the History of Science—A Taiwanese Journal,* Oct. 1993, 2(2):27–76, on p. 39. On Hua's nightmares see Charlotte Furth, *Ting Wen-chiang* (Cambridge, Mass.: Harvard Univ. Press, 1970), p. 37.

[33] Fryer, "Account of the Department for the Translation of Foreign Books" (cit. n. 25), p. 81.

missionaries who had an interest in science, and with the first translations of modern science textbooks. Although the subject matter was unfamiliar, some of these scholars were already equipped with a formidable practical and theoretical understanding of science, a knowledge that John Fryer admitted left him far behind.[34]

The outstanding Chinese translators of this generation were Li Shanlan 李善蘭 (1811–1882), Hua Hengfang, Zhao Yuanyi 趙元益 (1840–1912), He Liaoran, Xu Shou 徐壽 (1818–1884), and his son Xu Jianyin 徐建寅 (1845–1901). Their interest in Western science arose partly out of intellectual curiosity; in some cases it was also perhaps influenced by their failure in the official examinations, which would have given them access to more conventional careers. The most interesting of this group was Xu Shou (see Figure 2), who grew up in the prosperous city of Wuxi on the Grand Canal, in the heart of the Lower Yangzi region. The area was noted for its fine scholars, and Xu Shou's lack of examination success was no doubt due in part to the quota system that limited the number of successful candidates from one locality. Xu was noted for his fiercely skeptical attitude toward many aspects of traditional Chinese belief, such as traditional Chinese medicine, astrology, the Five Phases, and the neo-Confucian concepts of *li* 理 ("principle") and *qi* 氣 ("matter-energy").[35] As a young man he had demonstrated unusual practical skill in building replicas of ancient instruments. During the 1850s, with Hua Hengfang and Xu Jianyin, he performed a number of experiments in acoustics, electricity, thermometry, and optics, some directly inspired by Benjamin Hobson's textbook *Bowu xinbian.*

> It was in this busy little city [Wuxi] that a little *coterie* of intelligent scholars was formed, all deploring the hollow and unsatisfying nature of the ordinary routine of Chinese studies. They determined to push their investigations in a more useful and promising field by endeavouring to become acquainted with the great laws of nature, and to gather as much information as they possibly could respecting the various branches of science and art. Without organizing themselves into a Society these aspirants for intellectual light used to have occasional meetings of an informal kind for mutual improvement, each person explaining any new facts or ideas he had acquired. . . . This book [*Bowu xinbian*], although of a very elementary character, was like the dawn of a new era upon their minds, enabling them to leap at one bound across the two centuries that had elapsed since the Jesuit fathers commenced the task of the intellectual enlightenment of China, and bring[ing] them face to face with the results of some of the great modern discoveries. Apparatus was extemporized at their homes to perform the various experiments described in its pages [see Figure 3], and every new theory or law put to the test as far as their limited means would permit. Frequent papers were written and circulated from one to another, while queries were continually started by individuals asking for more information on difficult subjects. A pile of such manuscripts accumulated in the house of Mr Hsu [Xu Shou], who with his son [Xu Jianyin] formed a sort of centre for this little oasis in the midst of a vast desert of ignorance.[36]

[34] John Fryer to Susy, 11 July 1868, p. 2, Fryer Papers, Box 1.

[35] On Xu Shou see Reardon-Anderson, *Study of Change* (cit. n. 2), Ch. 1; and David Wright, "Careers in Western Science in Nineteenth-Century China: Xu Shou and Xu Jianyin," *Journal of the Royal Asiatic Society,* Apr. 1995, *5*(1):49–90. On Xu's skepticism regarding traditional Chinese medicine see Xu Shou, "Yixue lun" [On medicine], *Gezhi huibian,* Apr. 1876, *1*(3):8a–9b. For a report on his work on acoustics see Xu Shou, "Kaozheng lülü shuo" [Evidential research on mathematical harmonics], *ibid.,* Aug. 1880, *3*(7):14b–15a. Regarding Xu Shou's work on optics see Jiang Shuyuan 蔣 树 源, "Xu Shou de liangfeng qinbi xin" [Two letters by Xu Shou in his own hand], *Zhongguo keji shiliao,* 1984, *5*(4):52–54.

[36] Fryer, "Account of the Department for the Translation of Foreign Books" (cit. n. 25), p. 77. *Bowu xinbian* was a compilation of translations on a range of natural sciences. It contained sections on physics, chemistry, astronomy, geography, and zoology and was influential both in China and in Japan as the earliest widely available text devoted entirely to modern science. The extracts it contained probably derived from a number of sources, including *Bowu tongshu* and an unpublished text by Aurelius Harland (1822–1858). I am grateful to Erasmus Harland for drawing my attention to the latter possibility.

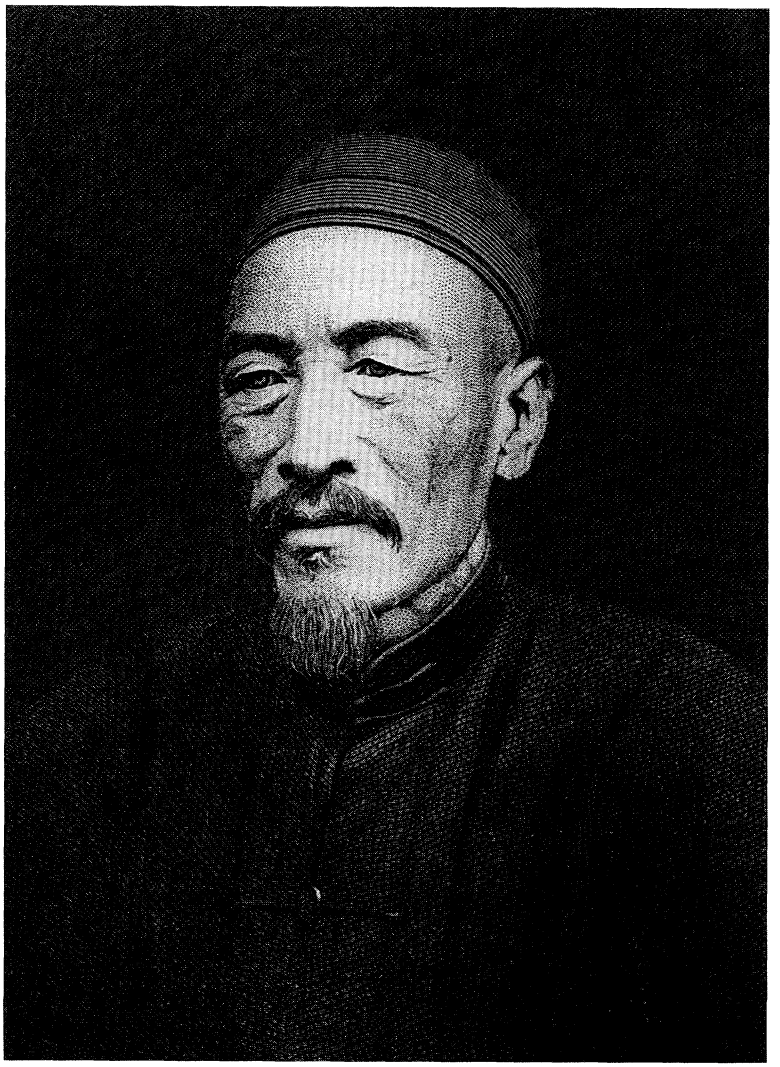

Figure 2. *Portrait of Xu Shou,* Gezhi huibian, *October 1877, 2(9):1a. (Reproduced by kind permission of the British Library, Oriental Collection.)*

This account seems to be describing an embryonic early modern scientific community. When he went to the Translation Department of the Jiangnan Arsenal Xu Shou was thus well prepared, with direct practical experience of many of the scientific concepts in which his translations would be dealing. He is particularly celebrated for his chemical translations, in which he and his collaborator John Fryer established the chemical nomenclature that formed the basis of the modern system.[37]

[37] Yang Gen 杨根, ed., *Xu Shou he Zhongguo jindai huaxueshi* 徐寿和中国近代化学史 [Xu Shou and the history of modern chemistry in China] (Beijing: Kexue jishu wenxian chubanshe, 1986).

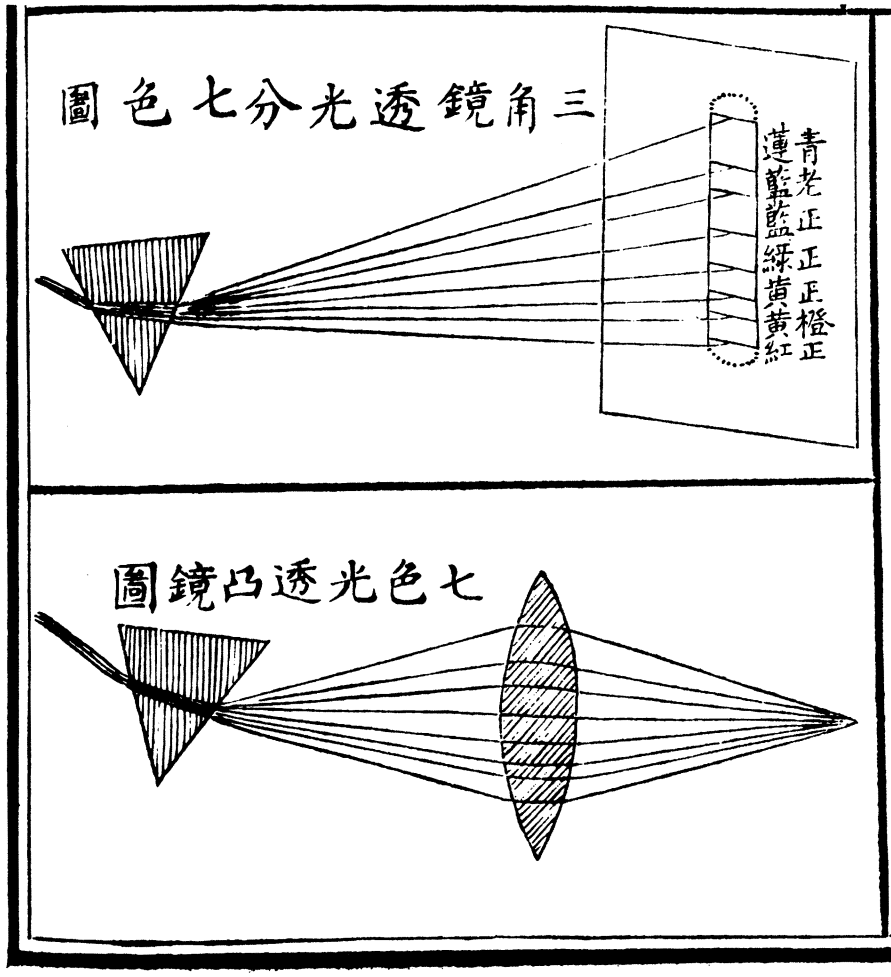

Figure 3.

TECHNIQUES FOR THE TRANSLATION OF SCIENTIFIC TERMS

The translator had a number of options when translating a scientific term.[38]

1. *Not translating the term at all.* Instead, the term would be left as a piece of the foreign language embedded in the matrix of Chinese. While this solution to the problem of translation simplified the translator's task, the foreignness of Western script was likely to increase readers' resistance to the new term.[39] One Chinese writer in the 1890s complained

[38] See Viviane Alleton and Jean-Claude Alleton, *Terminologie de la chimie en chinois moderne* (Paris: Mouton, 1966); and David Wright, "The Great Desideratum," *Chin. Sci.,* 1997, *14*:45–90.

[39] On resistance to foreign scripts see *Gezhi huibian,* Apr. 1877, *2*(2):16a. Transcription is discussed in Zhao Yuanren 趙元任, "Zai lun zhuyin zimu yiyinfa" [The phonetic method of transliterating sounds reconsidered], *Kexue* 科學 [Science], 1923–1924, *8*(9):888–902; and Liu Zexian 劉澤先, "Cong kexue xin mingci de fanyi kan Hanzi de quedian" [Seeing the shortcomings of Chinese characters from the translation of scientific terms], *Zhongguo yuwen* 中國語文 [Chinese language], Aug. 1953, *14*:9–13.

that Western languages "are like the twittering of sparrows and the croaking of frogs, while their scripts resemble the scratchmarks left by tigers' claws." Although some Western mathematical symbols were imported unchanged, translators of chemistry texts usually preferred to translate the Latin symbols of the elements into Chinese characters and to avoid Western script as much as possible.[40]

2. *Transliteration of the sounds into Chinese characters chosen for their phonetic values.* This is the method employed most commonly for foreign place- and personal names, but it was rarely used for terms in scientific translation, with the exception of organic compounds. For the latter there was little choice but to "phoneticise the foreign term, using the sounds of the Mandarin dialect, and always endeavouring to employ the same character for the same sound as far as possible, giving preference to characters most used by previous translators or compilers." Such transliteration was convenient for those whom John Fryer castigated as "lazy and ignorant translators" who did not want the trouble of finding suitable neologisms.[41] As the Buddhists had discovered over a millennium earlier, the great advantage of transliteration is that it *is* alien and therefore does not bring to the reader's mind all kinds of misleading comparisons. Nevertheless, it lacked elegance, and in almost every case the nineteenth-century transliterations have since been replaced by direct translations.

Transliteration was severely hampered by the great linguistic distance between Chinese and the foreign languages the translators were working from: there were virtually no shared lexical elements. This made borrowing far more difficult than it is between, say, French and English or English and German. The "uncouthness" of transliteration, always keenly felt, accounts for its general avoidance. As Xu Jiyu had found with foreign place-names, the varieties of spoken Chinese in Beijing, Shanghai, Guangzhou, and Fuzhou generated a proliferation of different renderings: "benzene" might be *bianxini* 徧西尼 or *biansuen* 徧蘇恩, "chloroform" *geluolufuermi* 格羅路福耳密 or *gelufangmu* 哥路仿姆, and so on.[42]

3. *The use of existing terms.* Although critics of the science translators facetiously called their nomenclature systems "alchemical," the Beijing Tongwenguan translators—W. A. P. Martin and Anatole Billequin—as well as, to a lesser extent, John Kerr in Guangzhou, consciously attempted to revive certain alchemical terms in order to emphasize the continuity of modern chemistry with its Chinese alchemical past, a practice that echoed the *geyi* technique of the early Buddhist translators.[43]

[40] Zhang Binglin 章炳麟, "Yishu Gonghui xu" [An account of the Translation Society] (1897), in *Zhang Taiyan xuanji* 章太炎选集 [Selected works of Zhang Binglin] (Shanghai: Shanghai renmin chubanshe, 1981), pp. 29–37, on p. 30. Even in mathematics there were short-lived attempts to Sinicize the Western notation. See Zhang Dianzhou 张奠宙, "*Dai-wei-ji shiji* de yuan shu he yuan zuozhe" [The source-text and original author of *Dai-wei-ji shiji*], *Zhongguo keji shiliao,* 1992, *13*(2):86–90.

[41] Fryer, "Account of the Department for the Translation of Foreign Books" (cit. n. 25), p. 79; Fryer, "Scientific Terminology" (cit n. 31), p. 534; and Liu Zexian, *Kexue mingci he wenzi gaige* 科學名詞和文字改革 [Scientific terms and language reform] (Beijing: Wenzi gaige chubanshe, 1958), p. 29. For later views on the question of loanwords see Zhou Youguang 周有光, "Wailaici pinyinfa wenti" [The problem of romanizing foreign loanwords], *Zhongguo yuwen,* 1959, *3*:106–113; and Zdenka Novtná, "Linguistic Factors of the Low Adaptability of Loan-words to the Lexical System of Modern Chinese," *Monumenta Serica,* 1967, *29*:103–118.

[42] For renderings of "benzene" and "chloroform" see Xu Shou and John Fryer, comps., *Huaxue cailiao Zhong-Xi mingmingbiao* 化學材料中西命名表 [A Chinese-English vocabulary of the names of chemical substances] (Shanghai: Jiangnan Arsenal, 1885), pp. 5, 10; and *Huaxue yuhui* 化學語彙 [Chemical glossary] (Shanghai: Commercial Press, 1908), pp. 4, 7. On borrowing more generally see Jean Aitchison, *Language Change: Progress or Decay?* (London: Fontana, 1981), pp. 120–121.

[43] W. A. P. Martin, "Alchemy in China: The Source of Chemistry," in *The Lore of Cathay* (Edinburgh: Oliphant, Anderson & Ferrier, 1901), pp. 44–71; and *Gewu rumen* (cit. n. 26), 6.77a–79b. In the latter work,

4. *The formation of a new term by juxtaposing two or more existing characters.* This was by far the most common way in which scientific and technical terms were translated into Chinese. For instance, Benjamin Hobson's term for "oxygen," *yangqi* 養氣, derived from *yang* 養 ("nourish") and *qi* 氣 ("vapor," "gas") because oxygen is a gas that "nourishes" or supports combustion; "hydrogen" was *qingqi* 輕氣 ("light gas"); and so on (see Figure 4). The majority of scientific terms were thus translated without the coining of new characters, for, as W. A. P. Martin wrote,

> no language, not even the German or the Greek, lends itself with more facility than the Chinese to the composition of technical terms. Its elements being devoid of inflection form compounds by mere juxtaposition—each component reflecting on the other a tinge of its own colour. It is not therefore an achromatic medium such as we require for the purposes of philosophy, but its residuary tints in most cases offer aid rather than hindrance to the apprehension and the memory.[44]

5. *The resuscitation of an archaic character.* The translators of the Jiangnan Arsenal made strenuous efforts to avoid creating new characters, combing the pages of one of the most authoritative dictionaries, the *Kangxi zidian* 康熙字典 [Kangxi dictionary], which had been compiled and published in 1716 on the orders of the Kangxi Emperor (reigned A.D. 1662–1722). Although imperfect as a work of philology, the *Kangxi zidian* included over forty-seven thousand characters. Within this vast lexicon it often proved possible to find characters that fit the new purposes. Thus, for instance, the character eventually chosen for the element "vanadium," *fan* 釩, possessed roughly the right sound, /fan/ (for the syllable /van/), and also included the "metal" radical 金 on the left of the character. Another technique was to find an obsolete character that could be regarded as having a mnemonic value for the term in question: for instance, the character *lu* 鑥, built of the "metal" radical 金 and *lu* 鹵 ("natural salt"), proved a convenient term for "sodium."[45]

6. *The creation of a new Chinese character.* If all of these methods failed, a new character might be created. John Fryer stated that these should be such that "the sound . . . can easily be known from the phonetic portion."[46] A completely new "forming the sound" character, *mei* 鎂, was created for "magnesium." The lefthand component is the "metal" radical, the righthand side 美 gives the sound *mei*. (The original meaning of *mei* 美 ["beautiful"] was irrelevant.) Unfortunately, different translators often chose different phonetics for the same term, generating much acrimony as rivals argued for the superiority of their own creations. His background in the *kaozheng* preoccupation with phonology must partly explain the subtle skill with which Xu Shou revived archaic characters and created novel phonetics.[47]

Untutored in such philological niceties, Billequin at the Beijing Tongwenguan created elaborate "conjoining the sense" characters to serve as chemical mnemonics. One such was 鎘 for cadmium, a composite built of the "metal" radical 金, *shuang* 霜 ("frost")—

Martin says that "chemistry and [Chinese] alchemy are "*tong ben er yi ming, zi mu xiang shu* [of different names but the same origin, mutually related as child is to mother]": *ibid.,* 6.77a. For a critical description of the nomenclature as "alchemical" see Gustave Schlegel, "Scientific Confectionery," *T'oung Pao,* 1894, *5*:147–151.

[44] "Methods of Imparting Western Knowledge to the Chinese" (cit. n. 16), p. 3. Note that *qi,* as well as denoting "gas" or "vapor," may in other contexts have meanings that are far more metaphysical, such as "matter-energy."

[45] *Kangxi zidian* 康熙字典 [Kangxi dictionary] (1716; rpt., Hong Kong: Zhonghua shuju, 1977), pp. 1224, 1246.

[46] Fryer, "Account of the Department for the Translation of Foreign Books" (cit. n. 25), p. 79.

[47] On the creation of new characters see Fryer, "Scientific Terminology" (cit. n. 31), p. 542. On the significance of phonetics in *kaozheng* scholarship see Elman, *From Philosophy to Philology* (cit. n. 12), p. 218 ff.

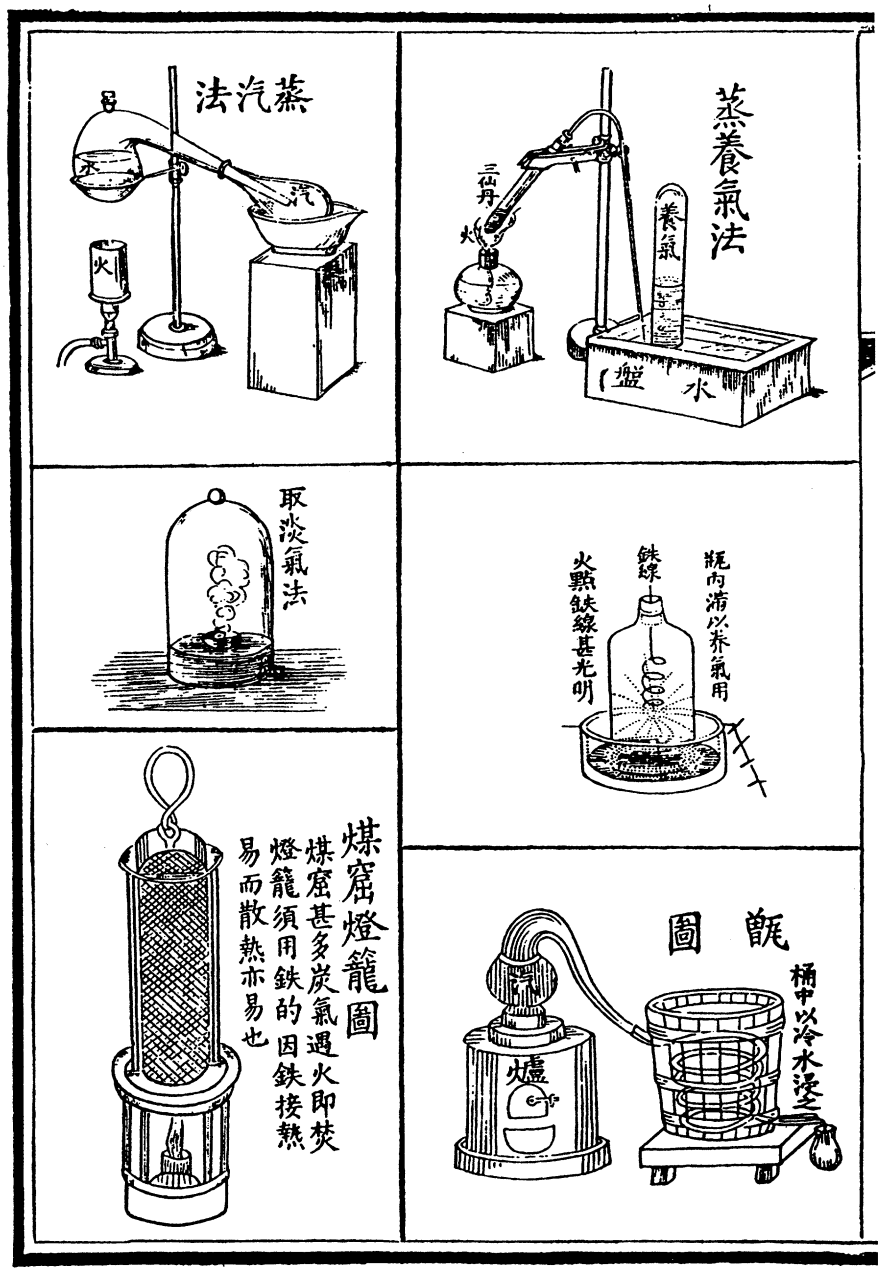

Figure 4. Bowu xinbian *(1855): illustrations of experiments showing the use of the terms* danqi 淡氣 *for "nitrogen" and* yangqi 養氣 *for "oxygen."*

an alchemical term for "precipitate"—and *huang* 黃 ("yellow"); together these components recalled the bright yellow precipitate of cadmium sulfide. Billequin intended such graphs to have *no* pronunciation, a basic misunderstanding of the nature of Chinese characters, which were never purely "ideographic" in the sense of being divorced from the spoken language.[48] For this and other—aesthetic—reasons, his complex creations were received with almost universal distaste.

7. *Japanese loanwords.* The Japanese had begun officially teaching Western science on a large scale in the 1870s, but the Chinese borrowed surprisingly few scientific terms from them before 1900. It was only after China's crushing defeat in the war of 1894–1895, as Chinese students went by the thousands to study science and medicine in Japanese institutions, that Japanese scientific neologisms began to enter the Chinese language in large numbers.[49]

THE POPULAR RESPONSE TO TRANSLATED SCIENCE

John Fryer's schooling in science was, as he admitted, often inadequate to the task. As a result, some of the obsolescent texts he chose for translation remained influential in China long after they and their systems of terminology had been superseded in the West. Moreover, the Western source texts often assumed knowledge Chinese readers lacked. The small number of translated texts and the conflicting terminologies they used meant that earnest students looking to clarify matters had little hope of finding accessible information in another book.

Despite these obstacles, popular interest in science grew steadily as the century progressed. As early as the 1860s the photographer John Thomson (1837–1921) reported meeting a wealthy Beijing merchant with a fine collection of chemical equipment. Stores in Shanghai in the 1870s are known to have sold several thousand dollars' worth of science equipment per year. By the late 1890s there was a brisk market in pirated science textbooks, an indication that their illicit publication was becoming profitable. A gradual sea change in attitudes was under way.[50]

This was not perhaps entirely due to a love of learning. The analysis of bags of mineral ores sent in by readers proved one of the most popular services offered by John Fryer's *Gezhi huibian* 格致彙編 [Chinese scientific and industrial magazine]; some of the readers certainly seem motivated by the commercial possibilities of exploiting ores of silver and antimony. *Gezhi huibian* consisted largely of translated articles on science and technology. In the "Readers' Inquiries" column of this journal we find several reports by writers who carried out their own experiments under the guidance of translated textbooks. Mr. Zhou of Wuchang spoke with the authentic voice of the frustrated lone experimenter,

[48] DeFrancis, *Chinese Language* (cit. n. 6), p. 72 and Ch. 8.

[49] On Japanese loanwords see Wang Lida 王立達, "Xiandai Hanyu zhong cong Riyu jielai de cihui" [Japanese loanwords in modern Chinese vocabulary], *Zhongguo yuwen,* 1958, *2*:90–94; and Lydia Liu, *Translingual Practice* (Stanford, Calif.: Stanford Univ. Press, 1995), p. 32 ff. On the introduction of Western science to Japan see Eikoh Shimao, "The Reception of Lavoisier's Chemistry in Japan," *Isis,* 1972, *63*:309–320; James R. Bartholomew, *The Formation of Science in Japan* (New Haven, Conn.: Yale Univ. Press, 1989); and Togo Tsukahara, *Affinity and* Shinwa Ryoku: *Introduction of Western Chemical Concepts in Early Nineteenth-Century Japan* (Amsterdam: Grieben, 1993). On Chinese students studying in Japan see Immanuel C. Y. Hsü, *The Rise of Modern China,* 2nd ed. (New York/London: Oxford Univ. Press, 1975), pp. 414–421.

[50] On equipment and instruments see John Thomson, *Thomson's China* (Hong Kong: Oxford Univ. Press, 1993), p. 209; *Second Report of the Chinese Polytechnic and Reading Rooms, Shanghai* (Shanghai: North China Herald Office, 1878), p. 8; and *Gezhi huibian,* Spring 1890, *5*(1):1b. On the market in pirated textbooks see *Chin. Rec.,* Aug. 1897, *28*:388–389, Sept. 1897, *28*:444.

struggling with intractable apparatus and obscure instructions: "I love science, and have bought several science books and many types of apparatus. I have tried out all the techniques contained therein, but they have not worked. I do not know whether there are mistakes in the books, the equipment is faulty, or whether I am not following the instructions properly during my experimentation."[51]

One of the rare institutions where Zhou might have found enlightenment was the Shanghai Polytechnic, founded in 1876 by John Fryer and Xu Shou with the purpose of bringing "public science" to a lay Chinese audience. Its sad history of official neglect and public apathy epitomizes the great difficulties of promoting such foreign ideas even in the most cosmopolitan of the coastal cities.[52]

CONCLUSION

Only once before, with the coming of Buddhism, had the Chinese respected a foreign culture enough to translate its books on a massive scale. Even then, it had taken several centuries for the religion to be fully assimilated. Translation of the artifacts of another culture implies some degree of humility before and a felt need of the alien artifact. Despite China's technological backwardness, the defeats of the two Opium Wars did not convince most literati that a scientific translation program was necessary or desirable. For the few Chinese actively involved in the development of modern industries, dependence on foreign-language textbooks was not a practical option; nonetheless, even in the 1890s the translation of foreign books was still regarded with suspicion by many of the ruling elite. One eminent scientific translator complained in 1897 that "there is deep dread of the exposure of the masses to translated books."[53]

The students who followed courses of instruction at the Tongwenguans and the Fuzhou Shipyard Schools came to grips with the ideas of modern science, although the teaching by expatriates was very uneven in quality. Translation offered partial liberation from reliance on foreign pedagogy. Zhang Zhidong 張之洞 (1837–1909), a relatively progressive provincial governor, complained at the close of the century that "Westerners have a habit of teaching very slowly in order to prolong their stay, some even taking a whole year just to teach addition and subtraction." He went on to recommend that there should be large-scale translations, so that "the book would be the teacher."[54]

The transmission of science via translations between 1840 and 1895 was a failure. This was partly a matter of cultural affinity: Chinese culture valued the *Dao,* and the *Dao* could be approached only through study of the Chinese classics. Yet the translated texts were

[51] *Gezhi huibian,* June 1877, *2*(4):12a. On the "Readers' Inquiries" columns see Li San-po, "Letters to the Editor in John Fryer's Chinese Scientific Magazine, 1876–1892: An Analysis," *Bull. Inst. Mod. Hist., Taibei,* 1974, *4*:729–777.

[52] Knight Biggerstaff, "Shanghai Polytechnic Institution and Reading Room: An Attempt to Introduce Western Science and Technology to the Chinese," *Pacific Historical Review,* May 1956, *25*(2):127–149; Wang Ermin 王爾敏, *Shanghai Gezhi Shuyuan zhilüe* 上海格致书院志略 [A brief account of the Shanghai Polytechnic] (Hong Kong: Chinese Univ. Press, 1980); and David Wright, "Making Space for Science in China: John Fryer and the Shanghai Polytechnic," *British Journal for the History of Science,* 1996, *29*:1–16.

[53] Xu Jianyin to Wang Kangnian, in *Wang Kangnian shiyou shuzha* 汪康年師友書札 [Correspondence of the teachers and friends of Wang Kangnian] (Shanghai: Shanghai guji chubanshe, 1986), Vol. 2, p. 1510.

[54] Zhang Zhidong 張之洞, *Zhang Wenxianggong quanji* 張文襄公全集 [The collected works of Zhang Zhidong] (Shanghai: Commercial Press, 1937), pp. 203.14a, 203.16a. See also Su Jing 蘇精, *Qingji tongwenguan ji qi shi-sheng* 清季同文館及其師生 [The Qing dynasty Tongwenguans, their students and teachers] (Taibei: Su Jing, 1985); and Xu Zhenya 徐振亞, "Jingshi Tongwenguan zhong de huaxue jiaoyu" [Chemical education at the Beijing Tongwenguan], *Zhongguo keji shiliao,* 1987, *8*(5):28–36.

probably not read, let alone used, even by the artisans building ships and guns at the Jiangnan Arsenal. In referring to his own work in the Translation Department of the Jiangnan Arsenal, Fryer commented despairingly on the neighboring Guang Fangyanguan school:

> Strange to say, there are schools which have existed for several years in the Kiangnan [Jiangnan] Arsenal where these books are published . . . without making any use of these translations. They are taught by foreigners who neither speak nor write Chinese, to scholars who had to begin with no knowledge of foreign languages. The fact that such classes are carried on in close proximity to this Department would seem to furnish strong proof of the uselessness of the whole work of translation. Like many other things in China, it is difficult to account for.[55]

Translating books does not guarantee that anyone will use them. The translations of the nineteenth century directly influenced only a few of the educated elite. They were hard to understand without a teacher, even for the exceptionally brilliant. Highly motivated students found working through one of the Jiangnan Arsenal texts as unrewarding as "chewing wax."[56]

However, in the longer term, these translations were to feed a slowly accelerating interest in natural science. Although by the 1890s the Fuzhou Shipyard Schools and the coastal Tongwenguans were all in decline, some private academies were beginning to teach Western science, and science curricula were developed in the new government schools established in Tianjin, Nanjing, and Wuchang. The intellectual ferment following the defeat of 1895 generated a remarkable number of societies devoted wholly or in part to the study of Western science, with a correspondingly healthy rise in the circulation of journals carrying articles on popular science.[57] Chinese graduates in natural sciences began making their own translations of Japanese texts, which would gradually supersede those of the Jiangnan Arsenal. The influence of foreign missionaries on the course of transmission, and on the development of modern Chinese scientific terminology, began to wane.

The terminology created by the late Qing translators, particularly by Xu Shou and others at the Jiangnan Arsenal, became the foundation of modern Chinese scientific nomenclature. Their translations prepared the way for the rapid advance of science and scientific ideas in twentieth-century China. In the decades that followed the defeat by Japan, natural science came to be seen not only as the foundation of military technologies but also, for some, as the basis of a new, radically materialistic worldview.[58]

[55] Fryer, "Account of the Department for the Translation of Foreign Books" (cit. n. 25), p. 81. For contemporary Chinese assessments of the translations see Che Shancheng 車善呈, "Taixi gezhi zhi xue yu jin ke fanyi zhu shu xiang lüe de-shi he zhe wei zui yao lun" [On the study of Western science and whether the successes or failures of the recent translations are the more important], in *Gezhi keyi huibian* 格致課藝彙編 [Essays on scientific themes], ed. Wang Tao 王韜, Vol. 4 (1889–1890), pp. 28a–32b; and Liang Qichao 梁啓超, "Lun yishu" [On translation], in *Yinbingshi heji* 飲冰室合集 [Collected works from the ice-sipper's studio], 40 vols. (Shanghai: Zhonghua shuju, 1932), Vol. 1, pp. 64–76.

[56] Luan Xueqian 欒學謙, "Gezhi Shuyuan jiaoyan huaxue ji" [A memoir of teaching chemistry at the Shanghai Polytechnic], part of "Sanshi nian qian wuguo kexue jiaoyu zhi yi ban" [A science education class in China thirty years ago], *Kexue,* 1924, *8*(4):430–432, partially translated in Reardon-Anderson, *Study of Change* (cit. n. 2), p. 49.

[57] On the decline of the Fuzhou Shipyard Schools see Steven A. Leibo, *Transferring Technology to China: Prosper Giquel and the Self-Strengthening Movement* (Berkeley: Inst. East Asian Studies, 1985); Fang Aiji 方靄吉, "Wo guo zuizao de zaochuan zhuanke xuexiao—Fuzhou chuanzhengju qianxuetang" [China's earliest specialist shipbuilding school—the Fuzhou Shipyard School], *Zhongguo keji shiliao,* 1985, *6*(5):57–62; and Fryer, *Educational Directory for China* (cit. n. 22), p. 82. On the growth of scientific societies see Pan Junxiang 潘君祥, "Wuxu shiqi de woguo ziran kexue xuehui" [Natural science societies during the Hundred Days' Reform Period in China], *Zhongguo keji shiliao,* 1983, *1*:28–30.

[58] D. Kwok, *Scientism in Chinese Thought* (New Haven, Conn.: Yale Univ. Press, 1965).