Article:

Gooday, G. and Low, M. (1998) Technology transfer and cultural exchange: Western scientists and engineers encounter late Tokugawa and Meiji Japan. Osiris, 13. pp. 99-128.
ISSN: 0369 - 7827

Published paper
Gooday, G. and Low, M. (1998) *Technology transfer and cultural exchange: Western scientists and engineers encounter late Tokugawa and Meiji Japan,* Osiris, Volume 13, 99 - 128.

Technology Transfer and Cultural Exchange

Western Scientists and Engineers Encounter Late Tokugawa and Meiji Japan

By Graeme J. N. Gooday* and Morris F. Low**

DURING THE LAST DECADE of the nineteenth century, the *Engineer* was only one of many British and American publications that took an avid interest in the rapid rise of Japan to the status of a fully industrialized imperial power on a par with major European nations. In December 1897 this journal published a photographic montage of "Pioneers of Modern Engineering Education in Japan" (Figure 1), showing a selection of the Japanese and Western teachers who had worked to bring about this singular transformation.[1] The predominance of Japanese figures in this representation is highly significant: it is an acknowledgment by British observers that the industrialization of Japan—the "Britain of the East"—was not a feat accomplished solely by Western experts who transferred their science and technology to passive Japanese recipients. Yet in focusing primarily on native teachers active in Japan after 1880, this image excludes several of the very foreigners who had trained this indigenous workforce in the preceding decade. Rather than attempting to assess the careers of each of the many international experts involved in Western encounters with Japan before and after the Meiji restoration in 1868, we will focus on disaggregating the highly individualized responses of just some of the English-speaking characters. In documenting their diverse encounters with Japanese people and technologies, we will look at the complex phenomena of cultural exchange in which they participated, not always without chauvinism or resistance.

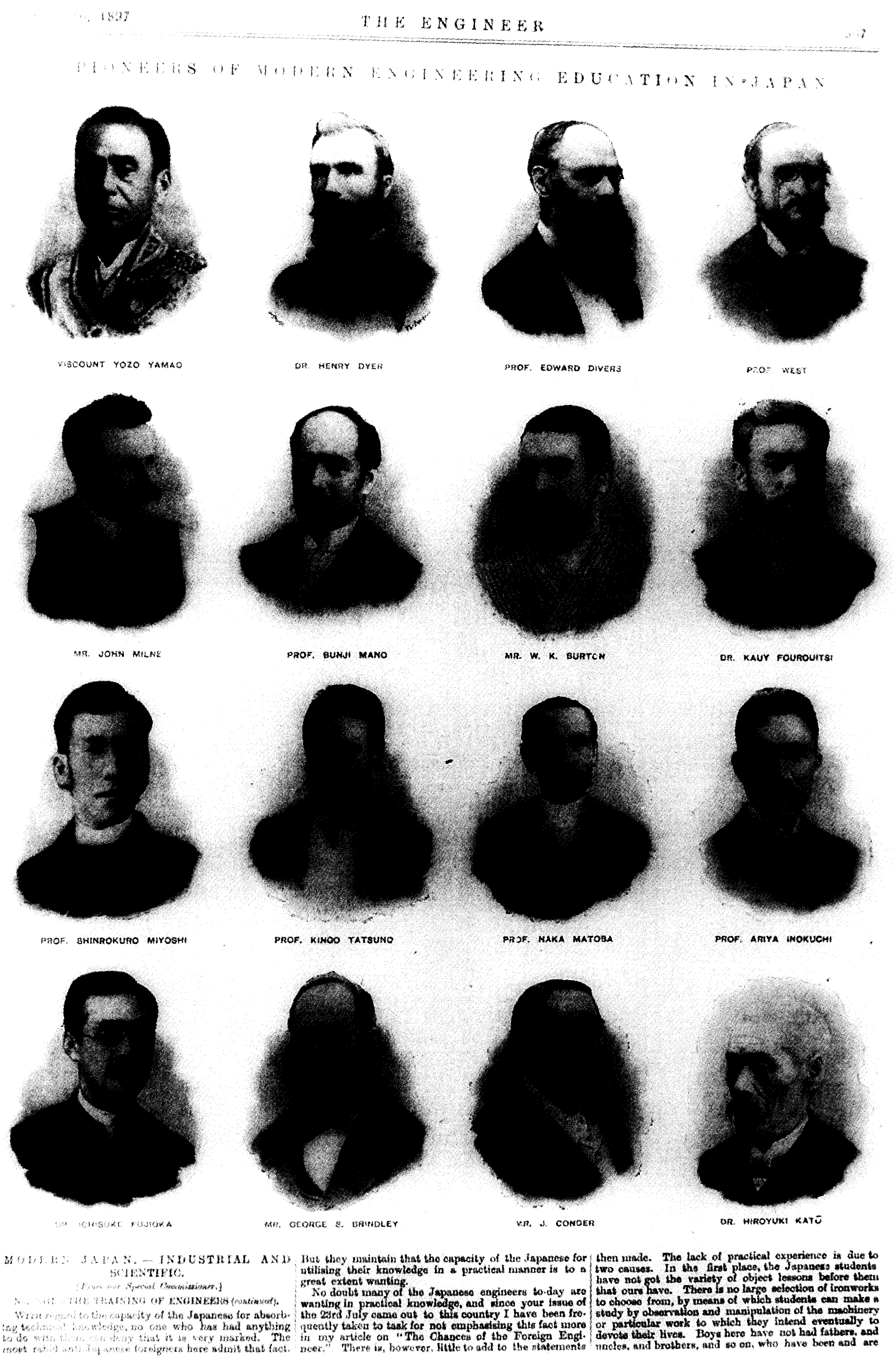
Prevalent in many accounts of Japanese engagement with the West in the nineteenth century is the claim that a cultural "forced entry" by U.S. Navy Commodore Matthew Perry in 1853–1854 opened up Japan to the Western scientists and engineers who showed Japan how to industrialize. This view of things tends, however, to underplay the extent to which powerful elements in Japanese society exercised a significant degree of control over the "technology transfer" involved in this process.

* Division of History and Philosophy of Science, University of Leeds, Leeds LS2 9JT, United Kingdom.

** Department of Asian Languages and Studies, University of Queensland, Brisbane, QLD 4072, Australia.

We wish to thank John Christie, Denise Crook, Richard Francks, Tessa Morris-Suzuki, Nick Wyatt, and two anonymous referees for their helpful advice on earlier drafts of this essay.

[1] "Modern Japan—Industrial and Scientific," *Engineer,* 1897, *84:*567.



1897 THE ENGINEER

PIONEERS OF MODERN ENGINEERING EDUCATION IN JAPAN

VISCOUNT YOZO YAMAO | DR. HENRY DYER | PROF. EDWARD DIVERS | PROF. WEST

MR. JOHN MILNE | PROF. BUNJI MANO | MR. W. K. BURTON | DR. KAUY FOUROUITSI

PROF. SHINROKURO MIYOSHI | PROF. KINGO TATSUNO | PROF. NAKA MATOBA | PROF. ARIYA INOKUCHI

DR. ICHISUKE FUJIOKA | MR. GEORGE S. BRINDLEY | MR. J. CONDER | DR. HIROYUKI KATŌ

MODERN JAPAN.—INDUSTRIAL AND SCIENTIFIC.

(From our Special Commissioner.)

No. [illegible].—THE TRAINING OF ENGINEERS (continued).

With regard to the capacity of the Japanese for absorbing technical knowledge, no one who has had anything to do with them can deny that it is very marked. The most rabid anti-Japanese foreigners here admit that fact. But they maintain that the capacity of the Japanese for utilising their knowledge in a practical manner is to a great extent wanting.

No doubt many of the Japanese engineers to-day are wanting in practical knowledge, and since your issue of the 23rd July came out to this country I have been frequently taken to task for not emphasising this fact more in my article on "The Chances of the Foreign Engineer." There is, however, little to add to the statements then made. The lack of practical experience is due to two causes. In the first place, the Japanese students have not got the variety of object lessons before them that ours have. There is no large selection of ironworks to choose from, by means of which students can make a study by observation and manipulation of the machinery or particular work to which they intend eventually to devote their lives. Boys here have not had fathers, and uncles, and brothers, and so on, who have been and are

Figure 1. *"Pioneers of modern engineering in Japan." From "Modern Japan—Industrial and Scientific,"* Engineer, *1897, 84:567.*

The "industrialization"—or, perhaps, "modernization"—of the nation was by no means simply a process of "Westernization" by uncritically pro-Western forces in Japan.[2] Moreover, such a one-sided approach understates the complex and contrasting ways in which the careers of non-Japanese scientists and engineers were molded or redirected by their participation in Japan's imperial borrowings from other cultures. Far from being immutable sources of Western technocratic wisdom, these imported experts found that their Japanese experiences changed their lives at least as much as their activities helped to change Japan.

In his classic essay on the subject, W. H. Brock has argued in general institutional terms that engineering education in 1880s Britain was considerably altered in "design, pace and execution" by the young teachers who returned there after spending several formative years in Japan. He has argued in particular that Henry Dyer's development of training schemes in Scottish technical colleges, especially in Glasgow, and William Ayrton and John Perry's scheme of teaching in London owed a good deal to the "rehearsal that was held in Japan" in the 1870s.[3] It is not our purpose to challenge these arguments; there is an overwhelming body of evidence in favor of them, and indeed we will develop them further. We will, however, explore issues of cultural conflict that are rather understated in Brock's account, showing that Japanese dealings with foreign scientists and engineers were not always harmonious or even transparent and that Meiji officials by no means readily acquiesced in the plans that foreigners laid down for them. Although technoscientific encounters between Japan and the West from the 1850s to the 1890s did in some instances lead to mutual cross-cultural understanding, we will argue that meetings between the distinct imperialist or neocolonial agendas involved on both sides were rather more often marked by friction or at least opacity.

The primary aim of this essay is to examine the multifaceted significance and aftermath of visits to Japan by the Americans Commodore Perry and William Griffis and the British engineers Henry Dyer, William Ayrton, John Perry, and John Milne. While Commodore Perry intended to dazzle his hosts with up-to-date American technology, he came away unexpectedly impressed by Japanese accomplishments, especially in seacraft; Griffis found his efforts to teach chemistry to Japanese students rather ignominiously curtailed and spent many years back in the United States reflecting on his time in Japan. The science and technology introduced by other foreign employees—specifically Dyer, Ayrton, and John Perry—were part of a

[2] W. H. Brock, "The Japanese Connexion: Engineering in Tokyo, London, and Glasgow at the End of the Nineteenth Century," *British Journal for the History of Science,* 1981, *14:*227–243; the claim is implicit on p. 229. For examples of the view that Perry's "forced entry" led to Japanese industrialization see John K. Fairbank, Donald C. McKay, Douglas S. Paauw, John C. Pelzel, Edwin O. Reischauer, Benjamin I. Schwartz, and **Yang** Lien-sheng, "The Influence of Modern Western Science and Technology on Japan and China," *Explorations in Entrepreneurial History,* 1955, *7*(4):189–204; and **Yuasa** Mitsutomo, "The Growth of Scientific Communities in Japan," *Japanese Studies in the History of Science,* 1970, *9:*137–158. One of the first books to put forth such a claim was W. E. Griffis, *Matthew Calbraith Perry: A Typical American Naval Officer* (Boston: Cupples & Hurd, 1887). Over a hundred years later, some of the rhetoric remains the same: "When . . . Perry's squadron of ships steamed into Edo . . . in July 1853, Japan had been sealed off from the outside world for more than two hundred years. The highly bureaucratic, feudal dictatorship of Japan was thrown into chaos by the brash, self-righteous Americans." This view is in contrast with the actual contents of the book whose back cover these words graced: Peter Booth Wiley with **Korogi** Ichiro, *Yankees in the Land of the Gods: Commodore Perry and the Opening of Japan* (Harmondsworth, Middlesex: Penguin, 1991).

[3] Brock, "Japanese Connexion," pp. 228, 239.

quasi-colonial experiment in a radically new scheme for state-funded technical education and research conducted at the expense of the Japanese government. Only a handful of these foreigners showed much awareness of that government's own imperial and cultural agendas: the two we shall discuss are Henry Dyer and, more particularly, the mining engineer and, later, seismologist John Milne. The singular case of Milne shows that while a foreigner could win the respect and sympathy of the Japanese people by exercising great deference to their culture and social needs, his welcome in the country was still limited in duration and degree.

COMMODORE PERRY AND THE "FORCED ENTRY" LITERATURE

The arrival of Americans in Japan in 1853–1854 is often portrayed as the "opening" of Japan and as the beginning of rapid, almost miraculous industrialization during the Meiji period (1868–1912). This ethnocentric emphasis on the agency of Westerners in developing Japanese science and technology overlooks the importance of domestic processes of urbanization, industrial development, and trade during the preceding Tokugawa period (ca. 1600–1868). Thus, rather than taking at face value the purported industrial "modernization" of Japan in the Meiji period, one could argue instead that this was in many ways a strategic reinforcement of the nation's traditional institutions under the diplomatically expedient banner of "Westernization." As Barton Hacker reminds us, Japan was already in the midst of major changes when Perry appeared.[4]

The notion that Japan was totally closed off from the rest of the world, and undergoing a period of feudalistic stagnation, before the Meiji era strongly persists in popular literature today. As Tessa Morris-Suzuki has shown, the Japan that Perry encountered was by no means industrially undeveloped. Although they ruled a country superficially "closed" and peaceful after troublesome aliens were excluded in 1639, the Tokugawa rulers selectively appropriated sources of foreign expertise to meet their own developmental agenda.[5]

The idea that Commodore Perry's arrival heralded the development of modern science and technology in Japan grossly underestimates the developments that had already occurred, for example, in the form of Dutch studies and in agricultural and seagoing technology (Figures 2 and 3). Since Japan had not been closed to the rest of the world during the previous two hundred years, to claim that Perry opened it up is to acquiesce in the self-aggrandizing myth created by Perry and repeated uncritically by his biographers and their readers. A closer inspection of the evidence suggests that Perry was in fact impressed by the Japanese technology he and his squadron observed and, subsequently, recorded with impressive precision in their

[4] Barton C. Hacker, "The Weapons of the West: Military Technology and Modernization in Nineteenth-Century China and Japan," *Technology and Culture,* 1977, *18:*43–55, esp. p. 54. Essays that emphasize Japanese initiatives before Perry include T. C. Smith, "Pre-Modern Economic Growth: Japan and the West," *Past and Present,* 1973, *60:*127–160; and Daniel Lloyd Spencer, "Japan's Pre-Perry Preparation for Economic Growth," *American Journal of Economics and Sociology,* 1958, *17:*195–216.

[5] Tessa Morris-Suzuki, *The Technological Transformation of Japan: From the Seventeenth to the Twenty-first Century* (Cambridge: Cambridge Univ. Press, 1994). For the persistence of the older notion see, e.g., Henry P. Frei, *Japan's Southward Advance and Australia: From the Sixteenth Century to World War II* (Melbourne: Melbourne Univ. Press, 1991), p. 17: "Ostensibly, Meiji history was destined to start at the year zero as far as foreign affairs were concerned." This remark comes from the first section, "Japan in the Western Pacific."

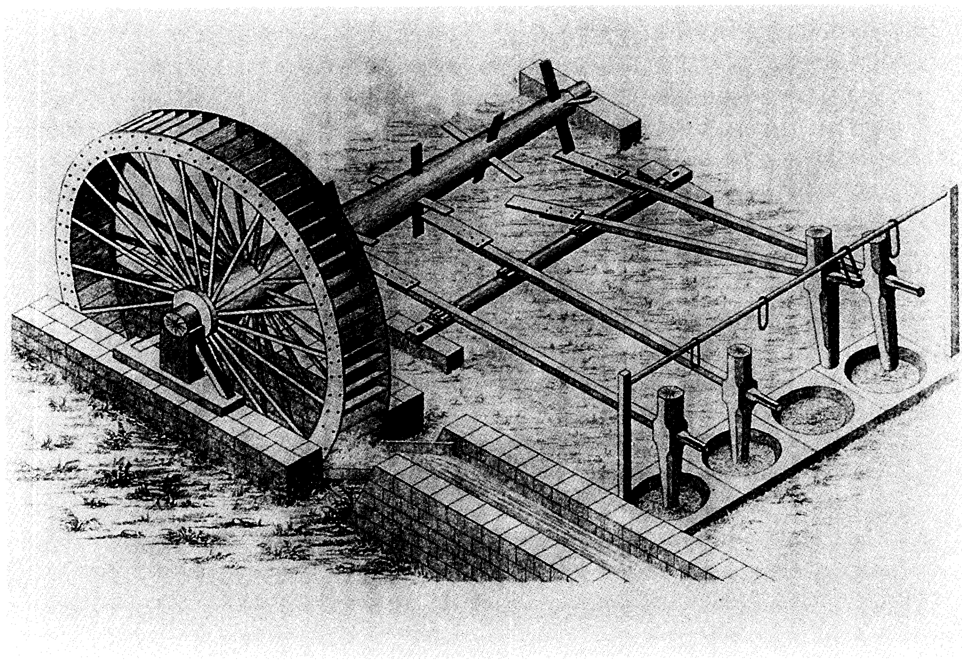


Figure 2. *"Japanese rice mill, at Simoda Nippon," by M. Kellogg. From Francis L. Hawks,* Narrative of the Expedition of an American Squadron to the China Seas and Japan *(Washington, D.C., 1856), page 414. (Courtesy of ANU Library.)*

official report, *Narrative of the Expedition of an American Squadron to the China Seas and Japan* (1856).[6]

Many narratives of Japan's alleged "Westernization" miss the fact that the Japanese were generally discerning and discretionary borrowers who hardly needed all that was available for "transfer" from European or American entrepreneurs. Significantly, Tokugawa envoys sent abroad were by no means always impressed by the marvels of U.S. technology shown to them. On an official visit to San Francisco in 1860, the scholar of Dutch studies and leading proponent of "Westernization," **Fukuzawa** Yukichi, found that "there was nothing really new" and observed that Americans wasted a lot of iron that would have been keenly sought and carefully husbanded in Japan.[7] Individuals such as Fukuzawa were later crucial in helping Japanese science and technology meet the new challenge from external imperialist maneuverings in the late nineteenth century. It cannot be overemphasized that the threat of invasion from alien imperialist forces was at least as much a stimulus to the native development of shipbuilding and newer technologies such as telegraphy as were the efforts of Westerners to communicate their science and technology to

[6] Francis L. Hawks, *Narrative of the Expedition of an American Squadron to the China Seas and Japan* (Washington, D.C., 1856). For an example of a critique of the myth that Perry opened a closed Japan see Ronald P. Toby, *State and Diplomacy in Early Modern Japan: Asia in the Development of the Tokugawa Bakufu* (Princeton, N.J.: Princeton Univ. Press, 1984); on Dutch studies see Morris-Suzuki, *Technological Transformation of Japan,* pp. 23–27, 57–67.

[7] Morris-Suzuki, *Technological Transformation of Japan,* p. 67. On the highly selective nature of many cross-cultural exchanges in technology see Arnold Pacey, *The Culture of Technology* (Oxford: Blackwell, 1983); and Pacey, *Technology in World Civilization* (Oxford: Blackwell, 1990).

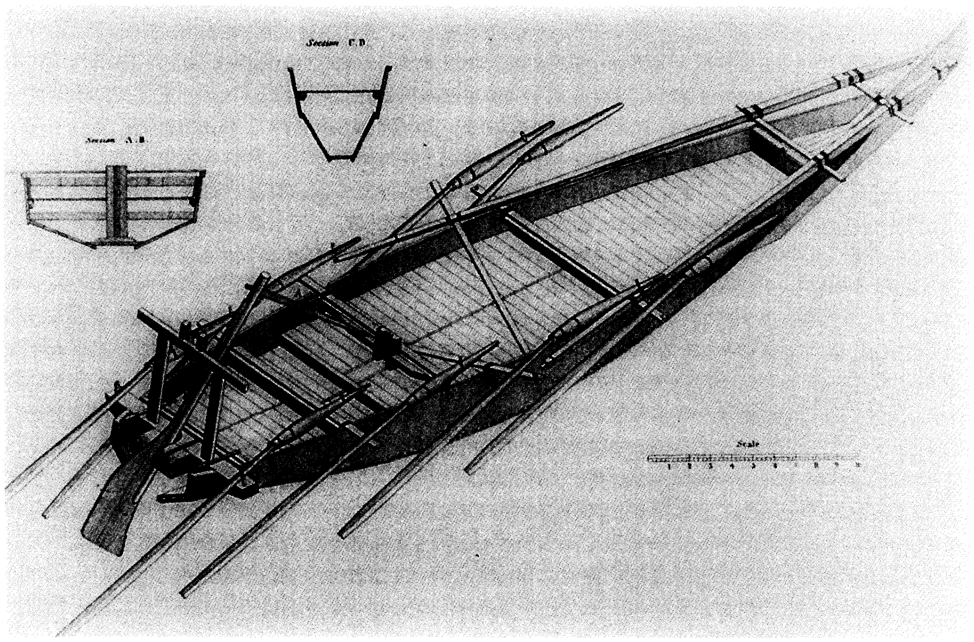


Figure 3. *"Japanese boat," by M. Kellogg. From Francis L. Hawks,* Narrative of the Expedition of an American Squadron to the China Seas and Japan *(Washington, D.C., 1856), page 450. (Courtesy of ANU Library.)*

Japan. Thus any broad account of Japan's industrialization from the 1850s must give at least equal weight to indigenous expertise in response to military imperatives as to short-term help from carefully chosen North American and European specialists.

THE ROLE OF FOREIGN EMPLOYEES

The Meiji bureaucrats employed dozens of foreign advisors from Europe and North America in the late nineteenth century. Hired foreigners were, in many ways, budding imperialists sponsored by their nations and were linked with the unequal treaties and trade agreements. The Meiji government sought to regulate the employment of such foreigners, and thus domains were ordered, as early as August 1868, to seek permission from the foreign office before hiring them. These aliens were known as *oyatoi gaikokujin,* "honorable hired foreigners"—a term sometimes translated more evocatively, if less accurately, as "honorable foreign menials" or "hirelings."[8]

There were many types of hired foreigners in Japan, half of them being Chinese laborers. There were two types of those labeled "professional advisors": general advisors and specialist advisors; in the early Meiji period, the former tended to be more numerous. During the period from 1870 to 1885 the Public Works Ministry

[8] See, e.g., the claims made about the "literal translation" of this term in A. L. Herbert-Gustar and P. A. Nott, *John Milne: Father of Modern Seismology* (Tenterden, Kent: Norbury, 1980), p. 43. The ironic tension between Westerners seeing their roles as imperialist "civilizers" and the Japanese seeing them as hired foreign servants, implicit here, is explored later in this essay. "Domain" was the Tokugawa term for a local feudal administrative region; see Morris-Suzuki, *Technological Transformation of Japan,* p. 27, for further details.

(Kōbushō) accounted for 60 percent of the professional advisors, a considerable number of whom became involved in education.[9] By teaching the Japanese, ironically, these hired foreigners paved the way for a steady reduction in their own numbers. Generally speaking, the Meiji leaders saw the employment of foreigners as a necessary but temporary evil and thus sought to educate Japanese to replace them as quickly as possible. The average length of a service contract for an alien professional advisor was around five years, and contracts were by no means generally renewed. By the turn of the century, native Japanese were in total control of decision making.

In the early years of the Meiji period there were generally around eight thousand hired foreigners in Japan, about half of whom were Chinese day-laborers, and only about three thousand professionals in government service. The peak was in 1874 and 1875: eight hundred new foreign employees arrived in each of these years. Seventy-five percent of professional advisors received salaries appropriate for upper civil service ranks. The majority of the foreigners were between twenty-six and thirty-five years old. Most of the professional foreign employees came from the four countries most significant for Japan's foreign relations at the time: Great Britain, France, the United States, and Germany. The different nationalities developed particular lines of work consistent with their native industrial strength—the formerly cherished expertise of the mercantile and learned Dutch now counted for little in the areas of interest to the Japanese government. The British took over from the French in naval training; German advisors replaced the French in army training; Americans established a foreign mail service at Yokohama, but the most important American project was the technical assistance mission that went to the island of Hokkaido. Their activities included mining, railway construction, agricultural experimentation, and related industries, but in this essay we will be able to look only at a small cross-section of individuals in a limited range of activities.[10]

Among the earliest to arrive were the American biologist William Elliot Griffis (1843–1928), a science educator and graduate of Rutgers University who worked in Japan from 1870 to 1874, and the Scottish civil engineer Henry Dyer (1848–1918), who stayed from 1873 to 1882. The English telegraph engineer William Edward Ayrton (1847–1908) stayed for five years after arriving in the autumn of 1873; his collaborator, the Ulsterman John Perry (1850–1920), stayed for four years from 1875; and in 1876 they were joined by the geologist, mining engineer, and, later, seismologist John Milne (1850–1913), who did not leave until 1895—well after almost all other foreigners. Also important—but not to be discussed in detail here—were the English architect Josiah Conder (1852–1920) and the English chemist Edward Divers (1837–1912).

WILLIAM GRIFFIS: CHEMIST AND COMMENTATOR ON INTERNATIONAL AFFAIRS

As a science graduate of Rutgers University who had already taught some Japanese students in the United States, William Griffis was initially employed to teach at the domain school Meishinkan, which was located in provincial Fukui, not far from the

[9] Ardath W. Burks, "The West's Inreach: The Oyatoi Gaikokujin," in *The Modernizers: Overseas Students, Foreign Employees, and Meiji Japan*, ed. Burks (Boulder, Colo.: Westview, 1985), pp. 187–206, esp. pp. 192–193.

[10] Information about the foreigners comes from *ibid.*, pp. 193–195. See also R. S. Schwantes, "Foreign Employees in the Development of Japan," *ibid.*, pp. 207–217.

Sea of Japan. The employment license for Griffis in the Foreign Ministry Records Bureau in Tokyo, dated 1870, gives his occupation as "science and chemistry instructor" and states that the twenty-seven-year-old had been hired at the request of Fukui province.[11] The Fukui government required a competent science teacher who could establish a laboratory and educate young students. Professor D. T. Reilly, principal of the Rutgers Grammar School, recommended Griffis as a talented person who would be appropriate for the job. Griffis taught four to six hours per day in Fukui. While sixty students attended his chemistry classes, only about twenty worked in the chemistry laboratory, where Griffis used equipment obtained in Yokohama, sent from the United States, or made up specially by local craftsmen.

Griffis was apparently somewhat disconcerted to find that his students were more interested in learning science for military purposes than out of any desire for self-improvement. He related that his audience did not appreciate subtle demonstrations of natural phenomena but preferred spectacle. Thus the Japanese students tended to view the chemical reactions he demonstrated as magical tricks rather than as illustrations of scientific facts. Only when he burned a watch spring in a globe of oxygen, sent up a paper balloon, or showed them how to blow up a hostile warship by electricity were his students "properly impressed."[12]

Griffis's chemical laboratory was one of only four in Japan. Whereas the others had been established by Germans, his was the first "American-style" laboratory. It was equipped with "a large skylight overhead, plenty of windows in the walls, hood, furnace, glass and dark closet, tables, rain-tanks, well and pump, and receptacles for apparatus." The impressive facilities notwithstanding, government measures taken in 1871 to abolish domains and transfer former feudal lords to the capital motivated many of his students to pursue study in Tokyo or overseas. Griffis, too, looked elsewhere for employment. In January 1872, after having taught in Fukui for nine months, he made the trip eastward to Tokyo, where he took up an appointment teaching chemistry and physics at Daigaku Nankō (School for Western Studies), which had been established in 1870. Griffis's teaching methods there were similar to those he employed in Fukui: lectures and demonstrations of experiments, with occasional use of the blackboard. The college where he taught was a forerunner of the Kaisei Gakkō, which in turn would become Tokyo University.[13] Griffis worked in Japan for a total of three and a half years; his frustration with the bureaucratic difficulties

[11] **Motoyama** Yukihiko, "The Education Policy of Fukui and William Elliot Griffis," *ibid.,* pp. 265–300; and Hazel J. Jones, *Live Machines: Hired Foreigners and Meiji Japan* (Vancouver: Univ. British Columbia Press, 1980), App. 3. The domain school's name was Meishinkan. With the abolition of the domains and the establishment of prefectures in 1871 it changed its name to Fukui Middle School.

[12] W. E. Griffis, "Pioneer in Chemistry in Japan," *Industrial and Engineering Chemistry,* 1924, *16:*1195–1196, esp. p. 1195, cited in Shoji **Yamamoto,** "William Elliot Griffis as an Interpreter of the Meiji Society: The First American Envoy of New Japan" (Ph.D. diss., State Univ. New York, Buffalo, 1987), p. 23. See also N. Pedlar, *The Imported Pioneers: Westerners Who Helped Build Modern Japan* (Folkestone, Kent: Japan Library, 1990), pp. 117–121.

[13] W. E. Griffis, "The Rutgers Graduates in Japan," *Targum,* 1871, *3:*2, cited in Yamamoto, "William Elliot Griffis," p. 25 (quotation); Edward R. Beauchamp, "William Elliot Griffis: The Tokyo Years, 1872–1874," in *Foreign Employees in Nineteenth-Century Japan,* ed. Beauchamp and Akira **Iriye** (Boulder, Colo.: Westview, 1990), pp. 34–47 (teaching methods); and Pedlar, *Imported Pioneers,* pp. 117–121 (the college). In the literature, "school" and "college" are used interchangeably to describe the status of the Daigaku Nankō. The institution was considered the equivalent of an American grammar school at the time.

surrounding his employment ultimately resulted in his return to the United States in July 1874.

William Griffis's sister, Margaret (Maggie) Clark Griffis (b. 1838), was active in Japan in women's education. Margaret traveled to Japan in August 1872, partly to provide companionship for her brother and also to secure a teaching position. She stayed for two years, for most of which (sixteen months) she taught English at Tokyo Jogakkō, Japan's first government school for girls, which operated during the years 1872–1877. The school provided training for female teachers and interpreters. There were only eighteen students in 1873, but the number swelled to seventy-eight the next year. Margaret was one of a group of foreign women who were employed by the government but who tend to be forgotten by historians. Unlike her brother, who later wrote prolifically on his experiences in Japan, Margaret wrote almost nothing.[14]

On his return home Griffis, like many other former foreign employees of the Meiji regime, often represented Japanese culture as a potential model for the rest of the world. Griffis was able to draw attention to the mentality of the Japanese through an understanding of their history. With the assistance of Western science, he suggested, the Japanese government had taken advantage of Japanese characteristics for the purpose of national efficiency. This sent the message that Western politicians and bureaucrats, likewise, needed to act to ensure their own nations' socioeconomic progress. While noting that it might be difficult for other nations to replicate the Japanese "spirit," Griffis argued that the Japanese possessed Aryan blood via mixing with the Ainu people of Hokkaido. Their success thus simultaneously offered a worthy model and provided reassuring evidence of the racial superiority of Caucasian people.

Moreover, and equally typically, Griffis attempted to enhance his own prospects by drawing attention to his achievements in Japan. As a science educator and clergyman, Griffis looked to Japan for evidence that race was the key to understanding national evolution and that science could serve as a civilizing influence. Equating race with nation, he pointed to Japanese military and economic successes at the turn of the century to demonstrate Japanese racial superiority. The Sino-Japanese War (1894–1895) and the Russo-Japanese War (1904–1905) were viewed as evolutionary struggles between races; the Japanese victories were understandable, Griffis argued, given that the Japanese were in fact Aryan. While it might be suggested that Griffis contributed most to Japan after he left, by writing extensively and sympathetically about the country's history and his experiences there, his primary goals in doing so were to earn a reputation and to supplement his income. Certainly, in publishing the first biography of Commodore Matthew Perry in 1887, he helped to propagate the highly ethnocentric idea that Perry had brought civilization to a backward Japan that Griffis and others had then helped to evolve into a world power.[15]

In the fifty or so books that he wrote, and in numerous magazine articles, Griffis often inserted himself into his narratives, more in an attempt at self-promotion than through any enlightened desire for critical self-examination. This was part of a

[14] **Usui** Chizuko, "Margaret C. Griffis and the Education of Women in Early Meiji Japan," in *Foreign Employees in Nineteenth-Century Japan,* ed. Beauchamp and Iriye, pp. 213–227.

[15] Griffis, *Matthew Calbraith Perry* (cit. n. 2). For Griffis's views on race and science see Ian Inkster, "The Message and the Massage: The Mythology of Japan's Industrialisation," in *Japan's Impact on the World,* ed. Alan Rix and Ross Mouer (Canberra: Japanese Studies Association of Australia, 1984), pp. 18–29.

strategy to give foreigners formerly employed in Japan a higher profile in American culture—a campaign for recognition that was sometimes criticized. Griffis's book *Verbeck of Japan: A Citizen of No Country* (1900) was chastised by C. Meriwether in the *American Historical Review* shortly after its publication for placing the author rather than the subject of the book in the limelight.[16]

By 1903 Griffis had retired from his ministerial duties to devote himself to writing and giving lectures. *The Japanese Nation in Evolution* (1907) was one of the results. It served further to popularize the notion of a superhuman race that had dedicated itself to the pursuit of national objectives. Coming after Japan's victory in the war with Russia in 1905, it emphasized the benefits of collective discipline, patriotism, and the scientific method. Others had tried, without success, to explain Japan's victory over Russia in material terms; Griffis chose to attribute it to the Japanese "spirit." The book appeared only a few years after Henry Dyer's *Dai Nippon, the Britain of the East* (1904), and no doubt appealed to similar audiences fascinated by the phenomenon of the "modern," rising Japanese state.[17]

HENRY DYER AND THE TOKYO COLLEGE OF ENGINEERING

Henry Dyer was one of a group of young British teachers at the Imperial College of Engineering (Kōbu Daigakkō) run by the Ministry of Public Works. Initially, the role of this college in supplying professional training to young mechanical, civil, telegraphic, and mining engineers contrasted strongly with the much more academic role of Tokyo University, although the two were amalgamated in 1886. **Yamao** Yōzō (1837–1917) was instrumental in the establishment of both the ministry and the college. He had studied at Anderson's College in Glasgow and had then gone on to study engineering and mining in London before returning to Japan in 1870.[18] The college (Kōgakuryō, later known as Kōbu Daigakkō) received its charter in 1871. Yamao was the president, and graduates accordingly looked to him as a father figure.

Invited by the Ministry of Public Works (Kōbushō) to take up an appointment as principal of the college, Henry Dyer arrived in Japan in June 1873. He used this position to project his ambitions onto the nascent industrial Japan. This twenty-five-year-old, who had himself entered Glasgow University only five years before, earned 660 yen per month, a figure that exceeded the salary of **Itō** Hirobumi, the first minister of Industry and Technology, and other *sangi* (Meiji vice-ministers). Dyer took responsibility for engineering education at the college, which formally opened that year.

Dyer was chosen as principal of the new Imperial College of Engineering on the recommendation of W. J. Macquorn Rankine of Glasgow University, under whose tutelage he received his degree in 1872 and a master's degree the following year,

[16] W. E. Griffis, *Verbeck of Japan: A Citizen of No Country* (New York: Revell, 1900). For Meriwether's review see *American Historical Review*, July 1901, *6*:829–830, cited in Edward R. Beauchamp, *An American Teacher in Early Meiji Japan* (Honolulu: Univ. Press Hawaii, 1976), p. 135.

[17] W. E. Griffis, *The Japanese Nation in Evolution: Steps in the Progress of a Great People* (London: Harrap; New York: Crowell, 1907); and Henry Dyer, *Dai Nippon, the Britain of the East: A Study in National Evolution* (London: Blackie, 1904). See also Meirion Harries and Susie Harries, *Soldiers of the Sun: The Rise and Fall of the Imperial Japanese Army* (New York: Random House, 1991), p. 95.

[18] On the activities of British employees see Schwantes, "Foreign Employees in the Development of Japan" (cit. n. 10), pp. 210–211. On Yamao see **Itō** Shuntarō, **Sakamoto** Kenzō, **Yamada** Keiji, and **Murakami** Yōichirō, eds., *Kagaku-shi gijutsu-shi jiten* (Dictionary of the history of science and technology) (Tokyo: Kōbundō, 1983), p. 1058.

graduating within months after Rankine's death. It is not surprising that, as one of Rankine's star students, Dyer drew on his ideas to develop engineering education in Japan and, later, back in Britain.[19] On his way to Japan by ship, he conceived a plan for the Imperial College of Engineering that was largely adopted. It constituted Japan's first institution for engineering education—and young Dyer's first educational experiment.

Before his departure, Dyer carried out a study of engineering education in Europe and the United States. Using Rankine's approach as a model, he tried to develop a program of his own that drew on innovations elsewhere.[20] He found *Systematic Technical Training for the English People* (1869), a book by the eminent naval engineer John Scott Russell, useful for its insights into technical education in Germany and Switzerland. Unlike the botanist and educator William Smith Clark (1826–1886), who attempted to make Sapporo Agricultural College in the image of Massachusetts Agricultural College, Dyer did not try to transfer a specific existing British model of engineering education but sought instead to develop a synthetic model. In so doing he drew heavily, as Brock has shown, not just on the educational proposals of Russell but also on experiences of workshop pupilage in Glasgow and of the professor of engineering at Edinburgh University, Fleeming Jenkin; Graeme Gooday has emphasized the significance of Dyer's own teaching under Rankine at Glasgow, which encouraged the complementary development of classroom work in the winter months and engineering pupilage in the summer.[21]

Continental schools, especially those in France and Germany, tended to inculcate training that was centered on the theory of engineering. In Britain, however, on-the-job training in factories and the workplace tended to be more heavily emphasized. Dyer felt that engineers required both types of training. Notably, the only institution that provided systematic training in all areas of engineering and came close to what the Japanese were contemplating was the Zurich Polytechnic Institute. Dyer's convictions were manifested in the curriculum of the students he educated in Tokyo. Their six years of training were divided into three periods of two years each. The General and Scientific Course involved preparatory, science-based studies. In the middle two years, the Technical Course consisted of alternating periods of more specialized college study and practical experience that enabled the students to use the principles studied in class. Finally, the Practical Course emphasized on-the-job training.[22]

[19] Olive Checkland, *Britain's Encounter with Meiji Japan, 1868–1912* (Houndmills, Basingstoke: Macmillan, 1989), p. 183.

[20] See Graeme Gooday, "Teaching Telegraphy and Electrotechnics in the Physics Laboratory: William Ayrton and the Creation of an Academic Space for Electrical Engineering in Britain, 1873–1884," *History of Technology,* 1991, *13:*73–111. For further details of Rankine's approach see Ben Marsden, "Engineering Science in Glasgow: Economy, Efficiency, and Measurement as Prime Movers in the Differentiation of an Academic Discipline," *Brit. J. Hist. Sci.,* 1992, *25:*219–246.

[21] See Brock, "Japanese Connexion" (cit. n. 2), pp. 232–233; and Gooday, "Teaching Telegraphy and Electrotechnics in the Physics Laboratory," p. 87. On Clark's work at Sapporo Agricultural College see John M. Maki, "The Japan Helpers," in *Aspects of Meiji Modernization: The Japan Helpers and the Helped,* ed. Clark L. Beck and Ardath W. Burks (New Brunswick, N.J.: Rutgers Univ. Press, 1983), pp. 21–39.

[22] Henry Dyer, "The Engineering College," in "Letters to the Editor," *Japan Weekly Mail,* 25 Sept. 1875, rpt. in Richard Henry Brunton, *Building Japan, 1868–1876* (Folkestone, Kent: Japan Library, 1991), App. 3. See also Olive Checkland, "British Educators, Japanese Engineers: In Lecture Room, Laboratory, and Workshop," in *Educational and Technological Exchange in Nineteenth-Century Asia,* ed. Ian Nish (Discussion Paper no. IS/89/204) (London: Suntory-Toyoto International Centre of

Areas of specialization included civil engineering, mechanical engineering, telegraphy, architecture, practical chemistry, metallurgy and mining, and, later, shipbuilding. For practical training, Dyer made use of national engineering projects undertaken by Kōbushō, the Ministry of Public Works. Students were sent to locations from Hokkaido to Kyushu and were involved in mining, railroads, lighthouses, telegraph work, and civil engineering. As Dyer boasted, "In the College itself mere book-work was made of secondary importance, and by means of drawing offices, laboratories, and practical engineering works the students were taught the relations between theory and practice, and trained in habits of observation and original thought."[23]

One of those who studied mechanical engineering there was **Inokuchi** Ariya (1856–1923), another "pioneer" who later invented the Inokuchi centrifugal pump. Inokuchi graduated from the college in 1882, became a professor of engineering at Tokyo Imperial University in 1896, and received a doctorate in engineering in 1899. He was an expert on hydraulics and the strength of materials. One writer was moved to describe him as "the Doctor Rankine of the Orient." Dyer was proud of Inokuchi and his other students. He noted that the budding imperialists his college had educated "are now to be found not only in all the most important engineering and industrial undertakings in Japan, but a considerable number of them are actively engaged in China and Korea; so that the College has been a most important factor in bringing about the changes in Japan and in influencing conditions in the Far East generally."[24]

A comparison of education at the Imperial College of Engineering to that at Tokyo University reveals how innovative Dyer's program was. Tokyo University was established in 1877 and headed by the Social Darwinist **Katō** Hiroyuki (1836–1916) from 1881. The university inherited the organizational structure of its predecessor, the Tokyo Kaisei Gakkō. Two engineering departments were located in the School of Science, the Department of Engineering and the Department of Mining. The method of education involved preparatory studies, foundation studies, and specialized studies. Instructors from the United States, Britain, Germany, and other countries lectured on specialist subjects. What resulted was a model of education that drew on the expertise of people from many nations but offered students no opportunity to test themselves in the field.

Dyer saw his success as attributable to a number of factors. He believed that it was to his advantage that the minds of his students were like blank pages, without preconceived notions as to what might constitute an appropriate Western-style education in engineering. Another relevant factor was the positive support of the government for his particular scheme of education, which very closely matched what Japa-

---

Economics and Related Disciplines, London School of Economics, 1989), pp. 13–23. On foreign influences more generally see **Shimao** Eikoh, "Some Aspects of Japanese Science, 1868–1945," *Annals of Science,* 1989, *46:*69–91; **Umetani** Noboru, *The Role of Foreign Employees in the Meiji Era in Japan* (Tokyo: Institute of Developing Economies, 1971), pp. 55–58; and David B. Stewart, *The Making of a Modern Japanese Architecture: 1868 to the Present* (New York: Kodansha International, 1987), pp. 33–37.

[23] Dyer, *Dai Nippon* (cit. n. 17), p. 5. See also **Miyoshi** Nobuhiro, *Meiji no enjinia kyōiku: Nihon to Igirisu no chigai* (Engineering education in the Meiji period: Japan and Great Britain compared) (Tokyo: Chūō Kōron Sha, 1983).

[24] Dyer, *Dai Nippon,* p. 6. On Inokuchi see **Demizu** Tsutomu, "Ariya Inokuchi, the Celebrated Pioneer in Mechanical Engineering in Japan" (in Japanese), *Gijutsu to bunmei* (Technology and civilization), 1985, no. 1, pp. 55–76, no. 2, pp. 23–43; and Itō *et al.,* eds., *Kagaku-shi gijutsu-shi jiten* (cit. n. 18), p. 55.

nese technocrats sought from hired foreign assistance. Also very important was the enthusiastic collaborative support of his British instructors at the college: John Perry, William Ayrton, Josiah Conder, Edward Divers, John Milne, and Charles D. West (1847–1908). They were productive: while in Japan, Ayrton, for example, co-authored more than fifty papers that were submitted to journals in London.[25]

Divers stayed in Japan from 1873 until 1899; when he returned to England he was active in a number of academic societies. West had studied mechanical engineering at the University of Dublin and had been engineer in charge of design at a British shipyard. He taught in the naval architecture course at the college from 1882, and then at Tokyo Imperial University, until his death in 1908.[26] These two British scholars were notable for the long-term commitment they made to Japan—and for the relatively long-term commitment that the Japanese authorities made to them, in contrast to many others in their employment.

One of the attractions was the enthusiasm of the students. From the late Tokugawa period, the Japanese recognized the need to nurture engineering personnel in order to facilitate industrialization. Many of the students were from the samurai class; they pursued studies at the college in the hope of finding careers for themselves in the new Meiji Japan, the government of which had greatly reduced their status in the 1870s. Traditionally highly educated, members of the samurai class were quick to take advantage of new opportunities to redefine their identity, and in the process a considerable number became part of Japan's indigenous new engineering elite.

The first student of this cohort graduated in 1879, and eleven of the top students went on to further study in Britain, sponsored by the Japanese government. Dyer himself returned to Britain in June 1882, for reasons that are not entirely clear, after nine years in Japan. In 1886 the college was incorporated into Tokyo University. Its graduates—which numbered more than two hundred—included the chemist **Takamine** Jōkichi (1854–1922), the first graduate of the Department of Applied Chemistry (1879), who later discovered adrenaline and was instrumental in the establishment of the Institute of Physical and Chemical Research in Tokyo in 1917. Another eminent product of Dyer's program of engineering education was **Tanabe** Sakuro (1861–1944), who was in charge of Japan's first hydroelectric power generation project on Lake Biwa and was appointed professor at Tokyo University in 1890.[27]

REPORTING ON JAPAN TO GLASGOW: DYER'S CAREER TRANSFORMED

News of Dyer's work was quickly conveyed back to Britain. In a long proposal sent to the Institution of Civil Engineers in 1880, he wrote of the educational achievements of the college and called for reforms in British technical education and the establishment of technical colleges that would involve half work, half study for the first three years and on-the-job practical training for the remaining three. In 1883 Dyer gave a lecture on reforms in technical education to the Glasgow Philosophical

[25] Miyoshi, *Meiji no enjinia kyōiku* (cit. n. 23).

[26] On Divers see Itō *et al.*, eds., *Kagaku-shi gijutsu-shi jiten* (cit. n. 18), pp. 599–600. On West see **Fukasaku** Yukiko, "Foreign Influence in the Development of Shipbuilding Technology and the Education of Engineers in Japan, 1855–1940," *History and Technology,* 1995, *12:*119–128, esp. p. 123; and *Konsaisu jinmei jiten: Nihon hen* (Concise biographical dictionary: Japan) (Tokyo: Sanseidō, 1976), p. 1270.

[27] On Takamine see Itō *et al.*, eds., *Kagaku-shi gijutsu-shi jiten,* pp. 614–615; on Tanabe see *Konsaisu jinmei jiten,* p. 703.

Society, his first public address since returning home. As a result, in 1886 four educational institutions were amalgamated to form the Glasgow and West of Scotland Technical College, later known as the Glasgow Technical College. In line with Dyer's proposals, the college served as an accreditation organization, issuing three levels of certificates corresponding to three stages of increasingly specialized learning.[28]

Brock has rightly attached much significance to Dyer's revelation, at another talk before the Glasgow Philosophical Society, in 1893, that he introduced the results of his Japanese experiment in engineering education directly at Glasgow Technical College. In 1905 Dyer spoke at the college of other ways in which teaching methods conceived and tested in Japan had been transmitted to Britain. Whereas previously only one professor was allocated for each area, increasing specialization meant that a number of professors, covering various subfields, would be necessary. Also, he saw valuable lessons in the various engineering laboratories that were established, as well as the combination of book learning and practical work. Dyer's experience in Japan reinforced his conviction of the need for British technical colleges along the lines of those he had established in Tokyo. He proposed that students enter such colleges at the age of sixteen, dividing their time in the first three years equally between theoretical study and practical work. The remaining three years would be spent learning on site in the workplace. This scheme was directly inspired by the curriculum in Japan. Brock has claimed that the influence of Dyer's educational experiment also spread to London via Ayrton and Perry, who returned to Britain three years before him.[29]

During his nine years in Japan, Dyer did not just experiment with educational forms at the expense of the Japanese exchequer. He was clearly determined to assist in the country's industrialization and in the training of its engineering personnel. While Japan had initially looked to Britain as a model for industrial development, Britain would, in turn, reimport the innovative, hybrid model of engineering education that Dyer and others developed as expatriates.[30] This two-way technological exchange was facilitated and extended by the good relations engendered by the Anglo-Japan Treaty alliance of 1902. It was around this time that Dyer's book *Dai Nippon, the Britain of the East: A Study in National Evolution* was published, over twenty years after his return.

What retrospective lessons could Britain learn by looking to Japan? In Dyer's period in Japan, 455 (77 percent) of the 588 foreign employees (not including laborers) that had been employed by the Ministry of Public Works had been British. Dyer argued, however, that the nation's industrial revolution was attributable less to its imported education system than to the new technology created by craftsmen who obtained their know-how in the workplace and from guilds. It was perhaps easier for the British to admire the national efficiency of Japan than that of Germany, for the former reflected well on themselves, with their workshop-based methods and their alliance with Japan. Successful Japanese efforts to manage the labor force

[28] Miyoshi, *Meiji no enjinia kyōiku* (cit. n. 23).

[29] Brock, "Japanese Connexion" (cit. n. 2), p. 239. See also Miyoshi, *Meiji no enjinia kyōiku.*

[30] When Dyer returned home in 1882, he was confident that Japan would become the "Britain of the East." See Miyoshi, *Meiji no enjinia kyōiku,* pp. 15–17.

seemed relevant too to Americans, who were fervently promoting national efficiency drawing on models from East Asia.

Dyer saw Japan as the Britain of the East, harking back to the earlier history of industrial development that Japan had sought to emulate. While he saw the comparison as a positive one, Dyer was nonetheless concerned about the potentially negative aspects of Westernization. On returning to Britain he was alarmed by the disparity in people's incomes, the level of unemployment, the monopolistic nature of capitalism, the burgeoning materialism, and the growth in armaments. Given these social problems, Dyer feared that Japan's status as the Britain of the East could ultimately prove a mixed blessing. He hoped that the graduates of the Imperial College of Engineering in Tokyo that he had helped to establish could ameliorate the situation by bringing about social and economic changes that would benefit the Japanese people. They were potential revolutionaries who could combine Western science and technology with the special Japanese characteristics that would galvanize the nation into action.

Rather than looking to racial origins that would enroll the Japanese among the Aryans, as Griffis had done, Dyer focused on other features of Japan's development.[31] Unlike Griffis, Dyer tended not to draw on ancient history. His *Dai Nippon* begins instead with an outline of his own achievements in the Imperial College of Engineering and goes on to discuss, in individual chapters, a host of factors, neglected by Griffis, that Dyer considers important in Japan's success: the fall of feudalism, the Japanese mind and the spirit of the Meiji Restoration, the industrial transformation and Westernization of the Meiji transition, the results of education, the army, and the navy. He then reports on the improved means of communication, industrial development, art industries, commerce, food, colonization and emigration, the establishment of a constitutional government, problems of administration, and the financial conditions of Japan since the Meiji Restoration. This sets the scene for a discussion of international relations and foreign politics—what perhaps prompted Dyer to write the book in the first place. Next, revealingly, he discusses the social results of Japan's modernization and looks to the future—though with an eye to the current political situation, most notably the Russo-Japanese War.

In the final, supplementary chapter, completed in August 1904, Dyer looks to recent events as proof of the significance of *bushidō* ("the way of the samuraï") and the work of the engineer. He concludes that "the chief lesson to be learned from Japan is the need for a truly national spirit for the accomplishment of great ends." He compares Japan to Britain and suggests that his own country has no real national policy. Dyer calls for application of the latest developments in science to the pursuit of national aims, not in a narrow sense but, rather, so as to include "all that is essential to individual and national welfare": "The scientific method must be applied to ethics, sociology, and politics, and above all to the training of men and women, healthy in body, acute in mind, and animated with high ideals of individual, civic, and national duty."[32]

[31] On Griffis's efforts to incorporate the Japanese as Aryans see Morris Low, "The Japanese Nation in Evolution: W. E. Griffis, Hybridity, and the Whiteness of the Japanese Race," *History and Anthropology,* forthcoming.

[32] Dyer, *Dai Nippon* (cit. n. 17), pp. 427, 428, 429.

In 1909 Dyer published *Japan in World Politics: A Study in International Dynamics,* written in the wake of Japan's victory in the Russo-Japanese War. As if taking up where Griffis left off, he writes that the international problems arising from the outcome of the war have provided him with "the opportunity of testing, in a practical way, some of the opinions expressed in my former book [*Dai Nippon*]."[33] The victory amounted almost to scientific proof of the strengths of the Japanese that he had recognized and described.

The books by Griffis and Dyer were published at a time when many throughout the industrial world were attempting to come to terms with what seemed extraordinary military and economic success for an Asian nation. Cumulatively, they show how former Japanese hands attempted to contribute to policymaking by drawing on their experiences. Japan's victory in the Russo-Japanese War generated a literature that is certainly comparable to the flood of writings on the post–World War II Japanese economic "miracle."

Dyer's own experience of teaching the Japanese made him wary of attributing their success exclusively to the wonders of Western science. Rather, echoing his earlier work, he sympathetically suggests that "there must have been intellectual qualities of a high character which prepared them for the reception of Western knowledge." He sees Japan's "Westernization" at the end of the nineteenth century simply as a new direction for the application of these intellectual powers. Familiar with the charge that the Japanese lack originality, he suggests that indeed the feudal system had discouraged originality of every kind. During the recent transitional period, reasonably enough, much intellectual energy was spent assimilating Western know-how. "As conditions develop, the opportunities for originality will increase, but we must remember that what we call originality is only another name for the resultant of the experience and the spirit of the age; genius simply translates that into language which can be understood."[34]

We can now turn to a study of one of Dyer's early associates in Tokyo, William Ayrton, to see how similar convictions about the Japanese capacity for originality were applied with rather different career consequences.

WILLIAM AYRTON AND TELEGRAPHIC EDUCATION: INDIA, TOKYO, AND LONDON

When William and Matilda Ayrton arrived in Japan in September 1873, he was the twenty-six-year-old star of the Indian Telegraph Service and a protégé of the internationally famous Glasgow professor of natural philosophy, Sir William Thomson. She, in contrast, was a refugee from Edinburgh University's expulsion of women medical students, forced to qualify at the Sorbonne and retrain as a midwife in London. While it is certainly the case, as several historians have commented, that they each brought new forms of expertise to Japan, it is also important to note that their encounters with the Japanese people and bureaucracy shaped and redirected their careers in important and lasting ways.[35] Matilda exercised her medical skills in teaching European midwifery techniques (through an interpreter) to Japanese women, but she also took the opportunity to study the physical anthropology of the

[33] Henry Dyer, *Japan in World Politics: A Study in International Dynamics* (London: Blackie, 1909), p. v.

[34] *Ibid.*, pp. 119–120, 120.

[35] Brock, "Japanese Connexion" (cit. n. 2).

Japanese. This work would become the basis of her M.D. thesis at the Sorbonne, "Recherches sur les dimensions générales et sur le dévelopment du corps chez les Japonais." The dedication of her classic popular illustrated storybook, *Child Life in Japan,* shows that she took rather more trouble than her husband to familiarize herself with the Japanese language. From 1874, however, much of Matilda's time was taken up with the Ayrtons' baby daughter, Edith; showing the first symptoms of "consumption," she left Japan with Edith in early 1877 (a year before her husband) in order to continue her medical education in Paris and London.[36]

Although not as fraught with culture shock and ill-health as his wife's experience of Japan, William Ayrton's years as the first professor of natural philosophy and telegraphy at the Imperial College of Engineering in Tokyo likewise transformed the nature and scope of his expertise. His five years there can be summed up as a radical and controversial experiment in a new form of state-sponsored English-language technical education that transformed a young Japanese warrior class elite into a dynamic cadre of indigenous laboratory researchers and telegraph engineers; the formation and frenetic pursuit of what would be an extraordinarily productive fifteen-year research collaboration with John Perry, whom Ayrton met for the first time when he arrived in 1875 to become the college's professor of mechanical and civil engineering; and a somewhat problematic attempt to extend to the Japanese telegraph service the techniques of colonial administration that he had developed in India.

By the time Ayrton returned to Britain in 1878, several major features of his subsequent career had clearly emerged. First, the publication in British journals of many research projects carried out in their Tokyo laboratories transformed his partnership with John Perry into one of international repute. Second, as a technical educator he had a unique opportunity to learn—at the enormous expense of the Japanese government—what unprecedented pedagogical feats could be accomplished with a vastly well-endowed telegraph laboratory. Third, he had been vindicated, contrary to the hostile opinions of his compatriots, in his egalitarian conviction that all students were capable of contributing in some degree to creative researches in an effectively managed laboratory. Then again, although Ayrton left Japan with respect and fascination for its cultural exotica, he remained equivocal about the capacities of the Japanese people to undertake what he had been specifically invited to train them to do: engage in the autonomous practice of European-style telegraphic engineering.

Like Henry Dyer, Ayrton arrived in Japan heavily influenced by his exposure to Glaswegian academic life. He had intensively studied the theoretical and practical aspects of electricity research under William Thomson in 1867–1868 and, indeed, had Thomson's support for his employment in Japan. His education was somewhat wider than Dyer's, however, since he had also studied mathematics (under Augustus De Morgan and T. A. Hirst) and physics (under G. C. Foster) at University College London and had experienced considerable practical training in the "shop" and "field" work of telegraphy in the Post Office scheme administered by William

[36] Matilda Chaplin Ayrton, *Child Life in Japan* (London, 1879). In 1880 Matilda Ayrton was among the first to achieve qualification for clinical practice in Elizabeth Garret Anderson's Medical School for Women (itself the first such school in the United Kingdom to offer full training for women). Her early death from tuberculosis in 1883 not only deprived London of one of its first women doctors; it also cut tragically short the career of Europe's sole female expert on Japanese physiology, medicine, and culture. See "Matilda Chaplin Ayrton, M.D. (1846–83)," *Dictionary of National Biography.*

Preece. Thus he was in principle well qualified to teach under Dyer's scheme that conjoined "theory" with "practice." The restless young Ayrton came to Japan with the apt and multiply connoted term "Energy" embossed on his notepaper, an indication of the dynamism—if not diplomacy—that was the hallmark of his approach to the many challenges faced by the young physicists and engineers who encountered Japan for the first time in the 1870s.[37]

Young, with little teaching experience, and initially given only a cramped one-room laboratory in the Tokyo college, Ayrton faced a cultural challenge of some magnitude in the task of training aristocratic former samurai to become diligent manipulators of electrical equipment. His grandson, Michael Ayrton, later reported that the young professor found the value placed on human life in Japan quite unlike that to which he "had been accustomed" as an undergraduate in London: there were apparently two suicides and one murder among his students in his first term at the Imperial College. Thereafter, Ayrton generally took a large revolver into his classes: whenever ceremonial swords were drawn and violence threatened, he would discharge it noisily into the laboratory ceiling to restore order.[38]

By the time Ayrton moved into his laboratory among the imposing facades of the Imperial College's palatial new buildings in 1877—a facility built to his specifications and at a spectacular cost to the Meiji government—such problems of decorum seem largely to have been overcome.[39] A journalist for the English-language *Japan Weekly Mail* who visited Ayrton's lab in the winter of 1877 was impressed by the work going on: "the general atmosphere of efficiency" would have tempted even the "laziest of men" into using files, hammers, and shellac to build electrical apparatus. It should not perhaps seem ironic that a European needed special methods to discipline the highly self-regimented Japanese aristocrats, since the model of laboratory conduct upon which Ayrton's teaching drew heavily was distinctively British—indeed, specifically Glaswegian, in character. The model in question was William Thomson's liberal enrollment of students in laboratory research, which Ayrton had experienced himself six years earlier. Judging by the later comments of his devoted students, reported by **Takahashi** Yuzo, Ayrton's emphasis on the importance of student autonomy in "original investigations" proved highly inspirational for them: "To help the students in finding the way of scientific thinking, he put many questions that they could not answer readily. He was not a gentle teacher. He often scolded 'stupid' students who would not think [for] themselves. Ayrton's real aim was, how-

[37] On Ayrton's background see **Takahashi** Yuzo, "William Edward Ayrton at the Imperial College of Engineering in Tokyo: The First Professor of Electrical Engineering in the World," *IEEE Transactions on Education,* 1990, *33:*198–205; and Gooday, "Teaching Telegraphy and Electrotechnics in the Physics Laboratory" (cit. n. 20). Ayrton's notepaper is described in John Perry, "Prof. William Edward Ayrton, F.R.S.," *Nature,* 1908, *79:*74–75, on p. 75.

[38] Michael Ayrton, *Fabrications* (London: Secker & Warburg, 1972), p. 98.

[39] Some of Perry's obituaries of Ayrton, written thirty-three years after Perry's own arrival in Japan, elided the early laboratory of 1873 with that opened in 1877. Especially misleading is Perry's claim in his untitled eloge for the Institution of Electrical Engineers that "when I arrived in Japan in 1875 I found a marvellous laboratory such as the world had not yet seen elsewhere. At Glasgow, at Cambridge, and at Berlin there were three great personalities; . . . the laboratories of Kelvin and of Maxwell and of Helmholtz, however, were not to be mentioned in comparisons with that of Ayrton. Fine buildings, splendid apparatus well-chosen . . .": John Perry, ["Death of Professor Ayrton"], *Journal of the Institution of Electrical Engineers,* 1909, *42:*3–6, on pp. 3–4. For a similar account in *Nature* see Perry, "Prof. William Edward Ayrton, F.R.S." (cit. n. 37), p. 74.

ever, to cultivate the ability of his students. In the examination, he set them questions that they had not been taught in the lectures."[40]

In Ayrton's many collaborative researches with Perry—another Thomson protégé—the erstwhile samurai students would sometimes be invited to provide practical support in the more arduous repetitive activities—for example, in determining the local gravitational acceleration for Tokyo in 1877—just as Thomson had for decades invited his own students to assist him. However, in trying thereby to train the Japanese to become independent scientific researchers, in accordance with the wishes of the Meiji regime, which sought independence from Western expertise, Ayrton was undertaking what other Westerners deemed to be foolish and absurd. Even the lone journalist who sympathized with Ayrton's unique efforts to make the Japanese into "scientific men themselves" had difficulty accepting the viability of his laboratory project. Though he admired Ayrton's magnificent laboratory as having both greater vitality and more architectural panache than either the Cavendish in Cambridge or the Clarendon in Oxford, this journalist mused chauvinistically that the Tokyo laboratory could produce uniquely important work "if only the men" who would use the equipment "were the same" in caliber as their Oxbridge counterparts. His article explained:

> If we could share Mr Ayrton's belief in the great power shown by some of his students, we might believe that a great school of scientific thought has been founded; and although we venture to doubt the existence of sufficient capacity in the Japanese mind for high original scientific work when unhelped, still our visit to this, the finest physical laboratory which exists perhaps in the world, has impressed us with the notion that these students who we saw working, will yet leave an important impression of their own upon the history of science.[41]

Writing during the winter of 1878, after Ayrton's departure, this journalist tellingly suggested that the future accomplishments of the laboratory would be credited not to any of its Japanese denizens but, rather, to the figure who initially inspired them: "To men of science outside Japan, all future work in Natural Philosophy performed in Japan will be identified with Mr Ayrton's name." It should be noted, however, that following the departure of Thomas Gray, Ayrton's successor, three years later, the laboratory was entirely run by Ayrton's Japanese ex-students. Moreover, as Takahashi notes, the laboratory's director from 1883, **Shida** Rinzaburo, published a number of his own research papers in English—following further study with William Thomson in Glasgow. One of Ayrton's most distinguished students was the electrical engineer **Fujioka** Ichisuke (1857–1918), who would become a professor at the college and go on to become chief engineer of the Tokyo Electric Light Company in 1886 and first president of Tokyo Electric in 1892.[42]

[40] [Anon.], "A Visit to Professor Ayrton's Laboratory," *Japan Weekly Mail*, Oct. 1878, pp. 1129–1131, on p. 1130 (the article explicitly states that this visit was made "last winter"—i.e., probably late 1877); and Takahashi, "Ayrton at the Imperial College of Engineering in Tokyo" (cit. n. 37), p. 202. On Thomson's use of students in the laboratory see William E. Ayrton, "Kelvin in the Sixties," *Popular Science Monthly*, 1908, *27*:259–268; cf. Perry, ["Death of Professor Ayrton"], p. 4.

[41] [Anon.], "Visit to Professor Ayrton's Laboratory," pp. 1130, 1129 (quotation).

[42] *Ibid.*, p. 1131. On the laboratory after Gray's departure see Takahashi, "Ayrton at the Imperial College of Engineering in Tokyo" (cit. n. 37), pp. 203, 205 n 3. On Fujioka see Itō *et al.*, eds., *Kagaku-shi gijutsu-shi jiten* (cit. n. 18), pp. 893–894; and *Konsaisu jinmei jiten* (cit. n. 26), p. 952.

Between 1877 and 1880, observers in Britain came to recognize the names and reputations of Ayrton and Perry through their work at the Tokyo college. This owed much to the fact that over two dozen of their joint papers—several of which were submitted for publication after their return to London—explicitly detailed their research activities in Japan. The intensity of Ayrton's collaborative work with Perry increased considerably in 1877, after Matilda and their daughter returned to Europe; indeed, it was Ayrton, the "never resting, keen-eyed chief," always working at "fever heat," who did most of the experimental observations—and so it continued for over a decade of collaboration thereafter.[43]

The research papers that Ayrton and Perry produced covered a remarkably wide range of subjects, from the earthquakes that seemed to many Europeans Japan's most striking natural phenomenon to the exotic and uniquely Japanese artifacts known as "magic mirrors." The propensity of such a mirror to reveal an image embossed on its metallic rear only when viewed at very specific angles had baffled a number of European scientists for years and was held to pose a considerable challenge to European theories of optics. In his later lectures on the subject back in the United Kingdom, Ayrton interpreted the properties of the mirror as resulting from the subtle craft techniques long maintained among Japanese metalworkers and offered a new theoretical explanation of how they created this unique imaging property.[44]

Most of their work, however, focused on electrical matters and deployed equipment and resources generously furnished by the Japanese authorities. Ayrton and Perry wrote on telegraph tests, the ratio of electrostatic and electromagnetic units, electrolytic polarization, atmospheric electricity, the resistance of galvanometers and the electric arc, the viscosity of dieletrics, and the theory of voltaic action in the electric cell. So strenuous were their efforts to maximize the international visibility of their work that some outside Japan soon noticed what an important research center Tokyo had become. In a response criticizing Ayrton and Perry's claim in an 1878 paper that they had a "good reason" to believe that there was no potential difference between a metal or liquid surface and the air in contact with it, James Clerk Maxwell jested that "a statement like this, coming from men whose scientific energy is threatening to displace the centre of electrical development and to carry it quite out of Europe and America to a point much nearer to Japan, is worthy of all attention, even without an explicit statement of their 'good reason.'"[45]

By the time that this letter to the *Electrician* was published, though, Ayrton had returned to England; Perry was to follow soon afterward. Neither were asked to renew their contracts when they expired, respectively, in 1878 and 1879. A likely reason in Ayrton's case is his tactlessly neocolonialist conduct toward the officials

[43] Perry, ["Death of Professor Ayrton"] (cit. n. 39), p. 4.

[44] William E. Ayrton and John Perry, "On a Neglected Principle that May Be Employed in Earthquake Measurements," *Transactions of the Asiatic Society of Japan,* 1877, *5:*181–202. See discussion of Milne that follows. On the mirrors see William E. Ayrton, "The Mirror of Japan and Its Magic Quality," *Nature,* 1879, *19:*539–542.

[45] James Clerk Maxwell, "Potential" [Letter to the Editor], *Electrician,* 1879, *2:*271–272. Maxwell was reacting to William E. Ayrton and John Perry, "Contact Theory of Voltaic Action," *Proceedings of the Royal Society of London,* 1878, *27:*196–238, 1879, *29:*421–424. For a full discussion see **Hong** Sungook, "Controversy over Voltaic Contact Phenomena," *Archive for History of Exact Sciences,* 1994, *47:*233–289. On the topics treated by Ayrton and Perry see Phillip J. Hartog, "Professor W. E. Ayrton, F.R.S.," *Cassier's Magazine,* 1902, *22:*541–544, on p. 542; and Gooday, "Teaching Telegraphy and Electrotechnics in the Physics Laboratory" (cit. n. 20), pp. 86–90.

of the Japanese telegraph service, whom he treated as though they were as much in need of foreign supervision as had been his subordinates in India in 1868–1872. In India Ayrton had helped develop a precise system of locating faults in landlines, a problem that often severely disrupted imperial communications. He had also implemented a system that allowed greater vigilance in the construction and monitoring of porcelain line insulators, to ensure the consistent operation of telegraph lines in the monsoon season. In a published report on his college teaching to Henry Dyer, dated 1 October 1877, Ayrton was pleased to announce that the Japanese authorities has accepted his advice regarding line insulation. He took this as a clear sign that his courses on telegraphy at the Imperial College had convinced his hosts of the importance of quantitative testing for improving the much-admired Japanese porcelain.[46]

Yet in the same report Ayrton insisted that the secure daily operation of the nation's system of telegraphs required his Japanese students to be under the supervision of foreign experts. Specifically, he held that while his Japanese students were capable of undertaking excellent research within his laboratory, they could not independently apply what they had learned there to the practice of commercial telegraphy. As Gooday has observed elsewhere, Ayrton's specific complaint was that the Japanese were indifferent to his insistence that precision adjustment of telegraphic installations was essential to ensure their reliability. Without the kind of supervision that he proposed, such "trifles" as a gap of 1/100th of an inch in line insulation were liable to be overlooked, with damaging consequences.[47] We do not know how, exactly, the Japanese officials who saw Ayrton's report to Dyer responded, but three months later, in December 1877, Ayrton was already pursuing the prospect of employment back in the United Kingdom.

By the end of 1878 Ayrton had returned to London to earn his living as a telegraphic consultant to Clark & Muirhead. Evidently still seeking an academic position, he avidly publicized his Asian experiences and research to promote his case. In particular, he lectured widely on the mysterious properties of the Japanese "magic mirror." Interest in the subject was strong, for fashionable London and Paris were experiencing a vogue for many Japanese cultural artifacts—as Matilda Ayrton remarked in her introduction to *Child Life in Japan.* When William Ayrton gave his inaugural lecture as professor of the City and Guilds Institute on 1 November 1879, he alluded to the Japanese precedents that Britain might follow; specifically, he urged his countrymen to adopt Japan's generous sponsorship of technical education. Ayrton presented an image of Japanese laboratories as ideal places where all able, motivated students could study without reference to wealth, "position," or qualification—where in fact the young nobleman and the young artisan experimented "side by side." Alluding to the concerns of those who might see laboratory-based technical education as a catalyst for disorder, Ayrton strategically presented the Tokyo college

[46] William E. Ayrton to Henry Dyer, "Report on the Course of Telegraphic Engineering, Imperial College of Engineering, Tokei [*sic*], 1 October 1877," rpt. in [Anon.], "Telegraphic Education," *Electrician,* 1878, *1:*284–286. See also Gooday, "Teaching Telegraphy and Electrotechnics in the Physics Laboratory," p. 87. On Ayrton's work in India see Ayrton, "On Some Points in Connection with the Indian Telegraph," *Journal of the Society of Telegraph Engineers,* 1873, *2:*180–199; and Hartog, "Professor W. E. Ayrton, F.R.S.," pp. 541–542.

[47] Gooday, "Teaching Telegraphy and Electrotechnics in the Physics Laboratory," p. 88. For skepticism about the Japanese students' ability to do independent work see, e.g., Ayrton to Dyer, "Report on the Course of Telegraphic Engineering," pp. 285–286.

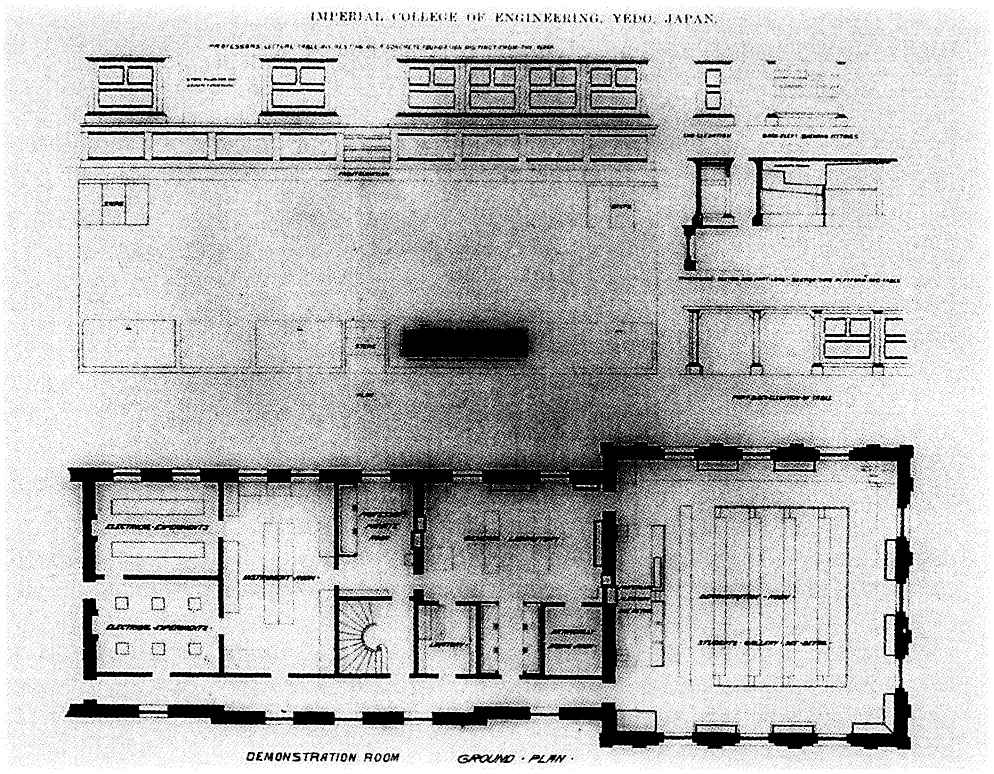


Figure 4. *Ground plan of Ayrton's laboratories at Imperial College of Engineering, circa 1877. From* Builder, *1880,* 38:*449.*

as an example of what positive results might be achieved by juxtaposing distinct social classes in suitably endowed experimental environments.[48]

Reinforcing Ayrton's message that Britain should seek to "emulate" the Japanese was the publicity given his accomplishments in the context of Japanese state-sponsored teaching and research in the following year. The *Builder* published detailed plans of the Imperial College laboratories, calling them the envy of the world, in spring 1880 (see Figure 4). John Perry, newly returned from Japan himself, cited selected passages from the *Japan Weekly Mail* in a lecture to the Society of Arts promoting Ayrton's laboratory as one to be emulated. As they continued to publish research from their Tokyo period, Ayrton and Perry showed not only that Japanese students were manifestly effective as scientific researchers, but that the radical (if resource-hungry) methods they had employed in Japanese laboratory education could work in any cultural setting. Thus in reporting their experiments to determine the local gravitational acceleration for Tokyo, conducted three years before, Ayrton and Perry commented:

[48] Ayrton, "Mirror of Japan and Its Magic Quality" (cit. n. 44); Matilda Chaplin Ayrton, *Child Life in Japan* (cit. n. 36), pp. ix–xiv; and William E. Ayrton, "The Improvements Science Can Effect in Our Trades and in the Condition of Our Workmen," *Telegraphic Journal,* 1879, *7*:366–371, on p. 371.

> We have to thank several of our late [i.e., former] students, and especially Messrs. Honda, Kikkawa, A. Kasai, J. Nakabara, and H. Nobechi for assistance rendered us during this investigation. And it may here be mentioned that this investigation, like the many others we have been enabled to carry out during the last few years, has resulted from the plan we have followed of teaching the laboratory students not, as is customary in Colleges, to repeat well-known experiments, but to endeavour in their investigations to advance, in some small degree at any rate, the bounds of existing knowledge. And this system of enlisting the assistance of even quite young students in original research we have found to create an enthusiasm in experimental work otherwise unproducible.[49]

As Gooday has noted elsewhere, the problems Ayrton faced in establishing a credible and effective system of technical education at Finsbury Technical College, London, were vastly different from those he had experienced in Japan.[50] Ayrton's Japanese experiences are nonetheless palpable in the details of the palatial plans that he helped Alfred Waterhouse draw up for the City and Guilds Central Institution between 1881 and 1882. Indeed, the similarities between the two colleges were reinforced by E. C. Robins (Finsbury's architect) in an informed discussion of both the "Central" and the "Tokyo" laboratories in his magisterial *Technical School and College Building* of 1887. Ayrton's final link with his Japanese period came at the Central: among the many visitors who came from around the world to view this spectacular enhancement of the Tokyo facilities were several students from Japan who wanted to study with Ayrton and his colleagues.[51] Indeed, the Central become part of Britain's very own "Imperial College" in 1907, the year before Ayrton died.

JOHN MILNE IN TOKYO: CREATING THE SOCIAL AND MATERIAL TECHNIQUES OF SEISMOLOGY

> Among the first desires which seize a visitor in an earthquake country, is to experience a shaking. Should he leave the country without the fulfilment of his wish he expresses regret. On the other hand, if he becomes resident in such a country, after the first tremblings he will often express pleasure at the sensation he has experienced, and it is seldom that alarm is created. These expressions, however, are not permanent . . . finally he comes to the conclusion of those who have had more experience than himself, that the oftener you feel earthquakes the less they are to be disregarded.[52]

[49] "The Imperial College of Engineering," *Builder,* 1880; John Perry, "The Teaching of Technical Physics," *Journal of the Society of Arts,* 1880, *28:*167–174 (the discussion of Ayrton's laboratory is on pp. 171–174); and William E. Ayrton and Perry, "Determination of the Acceleration of Gravity for Tokio [*sic*], Japan," *Proceedings of the Physical Society of London,* 1880, *3:*265–276, on p. 276.

[50] Gooday, "Teaching Telegraphy and Electrotechnics in the Physics Laboratory" (cit. n. 20), pp. 99–104. Contrast Brock's view that Ayrton and Perry's shared experience of Japan was a "necessary condition for the success of the Finsbury venture": Brock, "Japanese Connexion" (cit. n. 2), p. 239.

[51] See Sophie Forgan and Graeme Gooday, "'A Fungoid Assemblage of Buildings': Diversity and Adversity in the Development of College Architecture and Scientific Education in Nineteenth Century South Kensington," *History of Universities,* 1994, *8:*153–192; and Edward C. Robins, *Technical School and College Building* (London, 1887). The Imperial College archives list the following Japanese students who were formally registered to work with Ayrton in the Department of Electrical Engineering: M. Hayashi (1901–1905) and J. K. Tanaka (1903–1905). There were probably other Japanese workers who did not register as students. After Ayrton's death the following students worked under his successor and former assistant, Thomas Mather: S. Aoki (1914–1915), S. Kotō (1914–1915), H. Mukoyama (1918–1919), and Y. Asami (1923–1924). My thanks to Anne Barrett for this information.

[52] John Milne, "Earthquake Effects, Emotional and Moral," *Transactions of the Seismological Society of Japan,* 1887, *11:*91–113, on p. 91.

While Ayrton and Perry had self-indulgently spent their spare time pursuing their own research in Japanese government–funded laboratories—and thereby established their reputations throughout Europe—John Milne's public services in seismology brought him to a somewhat closer understanding with the people of Japan, especially its Ministry of Works and its Telegraph Service, that lasted throughout his twenty-year stay in that country.

Arriving in Tokyo in March 1876 to take up his post as professor of geology and mining at the Imperial College of Engineering, John Milne was primed for his encounter with Meiji Japan by a much wider range of cultural experiences than either Ayrton or Perry had undergone. Educated at King's College London, and then trained as a mining engineer at the Royal School of Mines in the late 1860s, the newly graduated Milne gained practical experience of mining techniques in Cornwall and Lancashire. He then undertook further training in mineralogy in Freiberg and traveled to mines in various parts of Germany and central Europe. At the request of the U.S. telegraph entrepreneur Cyrus Field, Milne spent 1872–1874 exploring the mineral resources of Newfoundland and Labrador, following that with a trip to the Middle East with a party from the Royal Geographical Society in 1874. Upon learning of his appointment to a three-year contract at the Tokyo college in 1875, he chose not to take the direct passage to Japan, as he was prone to seasickness. Milne instead followed the arduous overland route via Scandinavia, Russia, Siberia, Mongolia, and China, making geological and social observations throughout his eight-month journey.[53]

Although, as has been widely noted, Milne did experience a minor earthquake on his very first night in Japan, it was not quite the case, as his biographers A. L. Herbert-Gustar and P. A. Nott have claimed, that this experience was "eventually to determine the course of his life." Certainly, like many visiting Europeans, he was struck by the frequency of such occurrences; and he often debated the causes of earth tremors and quakes with fellow Britons, who apparently had "earthquakes for breakfast, dinner, and supper and to sleep on." Up to 1880, however, these visitors produced only occasional research and brief papers on the subject; as Robert Muir Wood has pointed out, these were largely a nationalistic response, on behalf of the British-run Asiatic Society, to the work of German scientists, who had presented many papers on earthquakes at their Deutsche Gesellschafte für Natur und Volkerkunde Ostasiens.[54]

During his first three years as a professor, Milne spent most of his time meeting contractual obligations to the Meiji government rather than engaging in extramural studies of seismology. He undertook the teaching of over a hundred students at the Imperial College, specializing in giving instruction to Japan's aspirant mining engineers. Milne also lectured to these and other students in architecture, chemistry, and metallurgy on mining-related sciences such as crystallography, his lectures on which

[53] On Milne's early career see John Perry, "John Milne, 1850–1913," *Proc. Roy. Soc. Lond.,* 1913–1914, *91A:*xxii–xxv; and John W. Judd, "Prof. John Milne, F.R.S.," *Nature,* 1913, *91:*587–588. On his journey to Japan see Herbert-Gustar and Nott, *John Milne* (cit. n. 8), pp. 20–42. On his propensity to seasickness see Robert Muir Wood, "Robert Mallet and John Milne—Earthquakes Incorporated in Victorian Britain," *Earthquake Engineering and Structural Dynamics,* 1988, *17:*107–142, on p. 121.

[54] Herbert-Gustar and Nott, *John Milne,* p. 70; Mrs. Lou Henry Hoover, "John Milne, Seismologist," *Bulletin of the Seismological Society of America,* 1912, *2:*2–7, on p. 2 (also cited in Herbert-Gustar and Nott, *John Milne,* p. 71); and Wood, "Robert Mallet and John Milne," p. 120.

soon furnished the material for his own textbook.[55] Although he shared with his mining students his considerable expertise in geology and vulcanology, it does not seem that the teaching of seismology ever became more than a marginal part of his formal duties at the college. When not teaching Milne traveled widely—with government chaperones—to map the geological formations of Japanese islands in pursuit of mineral deposits. He also studied the ominous activities of indigenous volcanoes and advised on improvements to the country's hazard-prone mining installations. His evidently diplomatic and efficient fulfillment of such duties led to the renewal of his contract in 1879.

The intensive development of seismology in Japan commenced only after a severe earthquake struck Yokohama on 22 February 1880. Learning of the large-scale destruction of buildings and human life, Milne and his colleagues Thomas Gray and W. S. Chaplin thenceforth devoted themselves to analyzing the endemic seismic threats. On 26 April 1880, in cooperation with a number of Japanese enthusiasts, the college professors launched the Seismological Society of Japan—the first permanent learned society of its kind in the world (although the ad hoc Swiss Seismological Commission preceded it by two years and there were earlier short-term collective studies by Italians). As the Japanese government showed no inclination to fund Milne's work beyond his official college duties in training engineers, he moved immediately to gain funds from the Earthquake Committee of the British Association for the Advancement of Science, winning £25 despite his lack of any track record in seismology. Such funding was vital for Milne's new activities in this area of research, since he was now competing at the forefront of seismology not only with Alfred Ewing at the nearby but rather more intellectually oriented University of Tokyo but also with Teutonic rivals at the Deutsche Gesellschafte.[56]

Tactful as ever, Milne refused the presidency of the new society and insisted that this position should be filled by a Japanese official instead. After the Minister of Works, His Excellency **Yamao** Yōzō, declined on grounds of pressure of work, the presidency was filled by **Hattori** Ichizō, who in 1878 had published an important paper on earthquakes in the *Transactions of the Asiatic Society of Japan,* pointing out the distinct chronological clustering of severe quakes. The other positions in the society were taken by Milne (vice president) and Chaplin (secretary)—although in 1882 the personnel was changed so that General **Yamada** Akiyoshi, Minister of the Interior, became president, Ewing vice president, and Milne foreign secretary. This last appointment reflects the extent to which Milne was in regular correspondence with the British Association's subcommittee "for the purpose of investigating the earthquake phenomena of Japan," whose financial grants he used in his Japanese work in developing highly accurate forms of seismometry and whose journal published his reports of seismic science in Japan.[57]

[55] John Milne, *Crystallography and Crystallo-Physics* (London: Trübner, 1879); see also Herbert-Gustar and Nott, *John Milne,* pp. 45–47.

[56] On the founding of the Seismological Society of Japan see Charles Davison, *The Founders of Seismology* (Cambridge: Cambridge Univ. Press, 1927), pp. 138–140. For a brief account of Ewing's teaching at Tokyo University see Alfred W. Ewing, *The Man of Room 40: The Life of Sir Alfred Ewing* (London: Hutchinson, 1939), pp. 48–51. On work at the Deutsche Gesellschafte see Wood, "Robert Mallet and John Milne" (cit. n. 53), pp. 124–129.

[57] Davison, *Founders of Seismology,* pp. 179–180; and Herbert-Gustar and Nott, *John Milne* (cit. n. 8), pp. 75–83, 87, 190–191. For Hattori's 1878 paper see Ichizō Hattori, "Destructive Earthquakes in Japan," *Trans. Asiatic Soc. Japan,* 1878, *6:*249–275.

In collaboration with the Glaswegian physicist Gray—and in competition with the Edinburgh-trained engineer Ewing—Milne undertook the practical business of creating new sorts of instruments for quantitative seismology. Hitherto only "seismoscopes" had existed in Japan for the qualitative registration of passing earth tremors; in Britain, seismometers had first been used in the 1840s by David Milne Home (no relation) to measure the magnitude of earth vibration by the ingenious use of an inverted pendulum. What Gray, Milne, and Ewing produced in Japan between 1880 and 1883 were not only more sensitive seismometers but also the first seismographs: devices, modeled to some extent on William Thomson's syphon recorder for receiving telegraph messages, that made continuous recordings of seismic disturbances on squared paper. With this new technology, more comprehensive surveillance of Japanese seismological activity could be undertaken; Milne explained how this could be done in the opening address to the Seismological Society in spring 1880. After giving a detailed and deferential account of his many predecessors in the field through the previous two centuries, and emphasizing the central pragmatic issue for contemporary seismologists of learning to predict *when* and *where* earthquakes would occur, he proposed a new kind of project that might lead to a clearer regional understanding of earthquake behavior:

> Through the interest taken in seismological science by Mr Yamao Yozo, the Minister of Public Works, fifteen seismometers of the pendulum type as designed by Mr Gray are now being constructed for distribution over the plain of Musahu. Through the kindness of the Director of the Telegraph Department, these instruments are to be placed in the telegraph offices, where by means of clocks which are every day regulated by Tokyo time, not only will the earthquake movement be recorded, but the time at which the shocks are felt will also be noted.[58]

Now able to ascertain the relative movements of the earth at different places at a given time, Milne raised the prospect that Japan could join the seismological "first rank" of the world's earthquake-shaken countries. Since volumes of the Seismological Society's *Transactions* were distributed internationally, this aim was soon achieved, thanks especially to the extraordinary amount of research published by Milne from data gathered by sympathetic sources around Japan. For example, the second part of the first volume of the *Transactions* was taken up almost entirely with a monumental (116-page) account of the quake of 22 February 1880, compiling information supplied by European readers responding to Milne's letter requesting assistance in the *Japan Gazette* and other English-language papers and from private communications with Japanese observers that were almost certainly undertaken by Milne's assistant **Nakano** Toshio. From the vast piles of data he accrued Milne was able to establish with unprecedented accuracy both the source of the earthquake on the eastern side of Tokyo Bay and its probable cause in the formation of a fissure parallel to the hills dividing Kazusa and Awa; he also plotted the dynamics of its destructive movement across the countryside.[59]

[58] John Milne, "Seismic Science in Japan," *Trans. Seismol. Soc. Japan,* 1880, *1*:3–37, on pp. 28–29. On the equipment see Davison, *Founders of Seismology,* pp. 42–43; J. Alfred Ewing, "A New Form of Pendulum Seismograph," *Trans. Seismol. Soc. Japan,* 1880, *1*(1):38–53; and Thomas Gray, "On a Seismometer and a Torsion Pendulum Seismograph," *ibid.,* pp. 44–51.

[59] Milne, "Seismic Science in Japan," pp. 28–29; and John Milne, "The Earthquake in Japan of February 22nd, 1880," *Trans. Seismol. Soc. Japan,* 1880, *1*(2):1–116, esp. pp. 3–15, 41–52, 110–116.

Not all of his attempts to recruit laypersons to take distant recordings worked to Milne's satisfaction. Yet he seems to have been rather more tactful than Ayrton had been in dealing with the Telegraph Department, replacing seismometers with self-recording Gray-Milne seismographs wherever possible to eliminate the problems of human reliability. Owing to his warm advocacy of these instruments and his negotiations with interested parties, over the next ten years "Earthquake Milne" was able to enlist the support of civilians who sent him postcards detailing the time and impact of quakes in their vicinity. He also used his charm to achieve cooperation from the Japanese Ministry of the Interior, the Meteorological Office, the Imperial Telegraph Company, and the Naval and War Departments for a fully national survey of earthquakes based on seismometer and seismograph recordings. Moreover, Milne arranged for the seismographs to be manufactured for global usage by Whites of Glasgow (William Thomson's instrument maker)—perhaps one of the earliest cases of technological transfer from Japan to the West.[60]

Working almost exclusively with Japanese associates and students after Gray left in 1881, and free of the rivalry with Ewing after his departure in 1883 (despite offers of a new contract), Milne produced catalogues containing a wealth of temporally correlated tremors, foreshocks, and aftershocks that enabled him to deduce much about the patterns and relative locations of seismic upheavals. The historian of seismology Charles Davison suggests that the period from 1880 to 1895, when Milne was active in Japan, saw the most rapid development of the science in all of the nineteenth century. Among the many papers published in the *Transactions of the Seismological Society* between 1880 and 1892 were some of the most important analyses of the epicenters of earthquakes, the mechanisms of transmission, and the artificial induction of earth tremors, along with predictions of future quakes and suggestions for the construction of earthquake-proof buildings. The Japanese government's sympathy—if not direct financial support—for Milne's cooperative seismological research is palpable in the persistent renewals of his contract at the Imperial College. In 1888 he was decorated by Emperor Meiji with the Order of Merit with the Cordon of the Sacred Treasure, and soon afterward he was elevated to the status of Chokunin, despite the fact that the emperor himself had not been greatly impressed by Milne's demonstration of a simulated earthquake at court.[61]

Milne's labors proved to be of some value in limiting the damage caused by the unusually devastating earthquake that hit central Japan on 28 October 1891, and subsequently he was very active in interpreting the form of the quake from seismographic data that his instruments had recorded. Yet the loss of 9,960 lives and 128,750 houses in this disaster brought new government initiatives that would, ironically, eclipse Milne's activities. When the Imperial Earthquake Investigation Committee was set up by the emperor in the immediate wake of this tragedy—an unprecedented indication of governmental interest in seismology—Milne was the only foreigner invited to join. But the sheer force of this committee's activities soon led

[60] See John Milne, "Experiments in Observational Seismology," *Trans. Seismol. Soc. Japan,* 1881, *3:*12–63, on p. 62 (attempts to recruit recorders); and Herbert-Gustar and Nott, *John Milne* (cit. n. 8), p. 84.

[61] Davison, *Founders of Seismology* (cit. n. 56), pp. 177–202 (esp. pp. 177, 201–202, for the claim about the importance of Milne's work to nineteenth-century seismology); and Herbert-Gustar and Nott, *John Milne,* pp. 91, 186–187. "Chokunin" was an imperial appointment; thus Milne became a professor directly appointed by the emperor.

to the atrophy and then the disbanding of its Milnean predecessor, the Seismological Society of Japan, in 1892. Although for several years Milne produced his own *Seismological Journal of Japan,* he departed for England in 1895 upon finding that the work of his former students had rendered his expertise superfluous—and after watching his house and library burn down at a time of increasing Japanese hostility toward foreigners. On resigning from his university post, Milne was awarded the Order of the Rising Sun, Third Grade, by the emperor (a rare distinction, especially for a foreigner), and a life pension of 1,000 yen, with which he supported his continuing researches back in England.[62]

In the summer of 1895 Milne and his Japanese wife, Tone (daughter of an eminent Buddhist abbot whom he had married in 1881), settled on the Isle of Wight, in an area of unusual geological formations at Shide. With his assistant **Hirota** Shinobu (known as "Snow"), Milne launched into even more ambitious projects. Toward the end of his time in Japan he had speculated—as had the late young German seismologist Ernst von Rebeur-Paschwitz—on the global transmissibility of seismic vibration.[63] Milne now used his Japanese-won authority as the most eminent seismologist in both Europe and the British Empire to set up what was effectively an imperial network of earthquake detection and measurement bureaus. From the data sent to him from colonial stations, he compiled an international catalogue, mostly at his own expense, demonstrating that it was indeed possible to detect the effects of any earthquake anywhere on the planet and that these effects were transmitted both through the earth and around its surface. Milne himself never forgot how important his time in Japan had been for crafting a career that brought him to such heights of fame and accomplishment. But others—at least outside of Japan—soon lost sight of this fact. By the time of his death, in 1913, the direction of the debt had largely been reversed: Milne was seen as having saved the Japanese from their plague of earthquakes. Others simply attributed his achievements to his character and intellect. With the notable exception of John Perry, himself an employee in Japan from 1875 to 1879, most of those writing on Milne's career after his return to Britain refer to Japan only as a passive "background" canvas for his life's work.[64]

A valuable perspective on the significance of Milne's work in Japan can be found, however, in an American review of results published by the Japanese "Earthquake Investigation Committee" in 1900. Writing for the journal *Science* in 1900, the U.S. scientist T. C. Mendenhall evoked Milne's zeal and untiring patience in the context of explaining how the Japanese had made seismology a science that was practically "their own." According to Mendenhall, during the preceding twenty years Japan had become a "vast seismological laboratory" in which, with the aid of foreigners such

[62] Herbert-Gustar and Nott, *John Milne,* pp. 18–21; and Judd, "Prof. John Milne, F.R.S." (cit. n. 53).

[63] Davison, *Founders of Seismology* (cit. n. 56), p. 194. Ernst von Rebeur-Paschwitz (1861–1895) was awarded his Ph.D. in physics from the University of Berlin in 1883. In the following year he developed a form of horizontal pendulum that was highly sensitive to the vibrations of distant earthquakes. He subsequently used this device to make extensive reports of global seismological activity, and in the year before he died he proposed a plan to deploy it in an international system for monitoring earthquake activity. See his obituary in *Nature,* 1895, *52:*599–600; see also Davison, *Founders of Seismology,* pp. 194–195.

[64] See Perry, "John Milne" (cit. n. 53), pp. xxii–xxv. For the view of Milne as having saved Japan see, e.g., Mrs. Hoover, "John Milne, Seismologist" (cit. n. 54), pp. 2–3. For an example of the "de-Japanization" of Milne's career see H. W. Woodward, "Eminent Living Geologists: John Milne," *Geological Magazine,* N.S., 1912, *9:*337–346, on p. 337.

as Milne, seismic phenomena had been studied as "they never were before"; now, he wrote, in entirely Japanese hands, the discipline of seismology was being "most carefully nurtured."[65]

CONCLUSION: THE "TRANSFER" OF SCIENCE AND TECHNOLOGY RECONSIDERED

While one result of the events we have described was the embedding of some British and North American expertise and hardware in Japan between the 1850s and 1890s, this essay has shown that the outcome of Japan's encounter with other industrial cultures was far more complicated and more interesting than a mere "transfer" of science and technology. As Ian Inkster has pointed out, such transfers have generally been much more complex than a one-way injection of intellectual and material resources into an industrial "latecomer" nation. Inkster himself emphasizes the commercial importance of bipartisan trading in Japan, and we would add to his "complexifying" analysis of transfer processes by drawing attention to the active managerial role played by the indigenous authorities.[66] We have shown that Japanese officials exercised selective control over the emerging features of the country's technical development by their strategic financial and contractual management of hired foreign aides. The Japanese understood science and technology in terms of their utility for the nation's industrial development—but also as something they could graft onto "traditional" values that remained largely intact despite Western incursions; in particular, the Meiji looked to science and technology to further their aim of defending Japan against future invasions from other imperial powers.

In offering a more detailed microanalysis than Inkster, we have shown the contingency of Japanese perceptions of the utility of foreign know-how—perceptions that changed with the political climate and, more specifically, with the rapidly developing self-sufficiency, made possible by (foreigner-trained) Japanese practitioners. A major consequence of this contingency for North American and British employees in Japan was that their experiences were far from uniform, a point that has been rather understated by previous historians. While a few American and British employees had arrived at some mutual understanding with Japanese officials by the late 1870s, others lamented that the Japanese did not "truly" understand the science and technology being transferred—nor were they capable of sharing the practices that many Westerners held to be necessary in sustaining it.

Hence, although the Japanese superficially adopted the trappings of alien technoscience, contemporaries noted that they did so without taking on the various messages of Western superiority that several of the foreign experts had attempted to inculcate.[67] It is thus telling that once the imported "hirelings" had performed their tasks for the Meiji government, many—but, significantly, not all—of them were forced to return home in the late 1870s or early 1880s by the nonrenewal of their contracts. Any interpretation of the nineteenth-century transfer of science and

[65] T. C. Mendenhall, "Scientific Books: Publications of the Earthquake Investigation Committee—in Foreign Languages, Numbers 3 and 4, Tokyo—1900," *Science*, N.S., 1900, *12*:678–681, on p. 678.

[66] Ian Inkster, *Science and Technology in History: An Approach to Industrial Development* (Basingstoke: Macmillan, 1991), pp. 21, 197–204; on the managerial role of indigenous authorities see, e.g., pp. 194–204.

[67] See Jonathan Spence, *To Change China: Western Advisers in China, 1620–1960* (Boston: Little, Brown, 1969), p. 290.

technology to Japan must accept the highly perspectival basis and fluctuating character of judgments about its goals—as well as persistent and profound ambiguities about who had the upper hand in its management.

Our final criticism of the conventional transfer concept as a historiographical device to capture the nature of the encounter between Japan and the West in the second half of the nineteenth century concerns the assumption of an inherent asymmetry in the process. Many Eurocentric and American-centered accounts, including Inkster's, focus on what Japan gained from the West, without reflecting fully on reciprocal currents of cultural exchange. We would argue, rather, that Japan's encounter with the West was a complex, multileveled cultural experience to which both sides contributed resources and agendas and from which institutions and individuals on both sides took away prized material benefits and newly invigorated rhetorics of their own international invincibility. Disaggregating the experiences of individual Britons and Americans enables us to see how these experiences of Japan—and, later, public accounts of them—served many purposes in the participants' own lives.

By the turn of the twentieth century, Japanese science and technology meant many things to and served many purposes for Europeans and Americans. Historians of late Victorian science and technology might thus learn much from the formative contingencies of neocolonial encounters with Japan in its period as the unconquered "Britain of the East."