Science Across the Pacific: American-Japanese Scientific and Cultural Contacts in the Late Nineteenth Century*

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Introduction: the Age of Steam and Electricity

The nineteenth century witnessed a remarkable dissemination of science and technology in the Western world and, from the point of view of history of science and technology, may very well be considered the age of steam and electricity. It was in the nineteenth century that the steam engine, already invented and utilized in the eighteenth century, came fully to exhibit its power in promoting the industrial revolution. It was also in this century that newly invented locomotives and steamships revolutionized means of transportation and spurred oceanic navigation. Thus steam replaced the labor of man and beast and the power of water and wind, served to step up the production of mining and manufacturing, drew distant areas together, and accelerated economic circulation and cultural exchange.

Moreover the cuttings and tunnels required for railway construction revealed a great deal of geological information and furnished new knowledge of the past (particularly of fossils), which led in part to the theory of evolution itself.

The discovery of the electric battery by Alessandro VOLTA in 1799 gave, for the first time, a continuous current of electricity. It facilitated the discoveries of electrolysis, the electric arc, the electro-magnet, the induction coil, the dynamo, and the electric motor. The invention of the electric telegraph and telephone followed. A new era of electricity was thus opened. Effective means of communication by electricity, of transportation by steam and later by electricity, were developed with great rapidity. The consequences were particularly remarkable in America, where both need and effectiveness were so great in developing that vast country's lightly populated land.

After settling the Mexican War and securing California as its territory, America's commercial as well as religious interests extended directly across the Pacific to the Far East. Since Japan lay on the line from San Francisco to Shanghai, the requirement of navigation by steam made it imperative to establish coaling stations somewhere in or near Japan. Thus the second paragraph of Chapter I

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of the *Narrative of Perry's Expedition to Japan* reads:

> Direct trade from our western coast with Asia became, therefore, a familiar thought; the agency of steam was, of course, involved, and fuel for its production was indispensable. Hence arose inquiries for that great mineral agent of civilization, *coal.* Where was it to be obtained on the long route from California to Asia? Another inquiry presented itself: With what far-distant eastern nations should we trade? China was in some measure opened to us; but there was, beside, a *terra incognita* in Japan which, while it stimulated curiosity, held out also temptations which invited commercial enterprise.... By some, indeed, the proposition was boldly avowed that Japan had no right thus to cut herself off from the community of nations; and that what she would not yield to national comity should be wrested from her by force.[1]

Commodore PERRY was, in fact, instructed by the American government to secure from the Japanese government good treatment for distressed American seamen, some facilities for navigation and trade, and particularly a coaling station.

Japan, secluded for many years from the Western world, was far behind the recent progress of science and technology. Therefore when PERRY's fleet steamed into Tokyo Bay in July 1853, Japan found itself entirely helpless before the "black ships," which symbolized the power of the new scientific era. On PERRY's second visit to Japan in the following year, Japan concluded a peace treaty with America and on that occasion, PERRY presented to the Japanese a Lilliputian steam locomotive and an electric telegraph. Both were demonstrated to and greatly admired by the Japanese spectators. Only ten years had elapsed since samuel MORSE telegraphed his first message between Washington, D.C. and Baltimore. As the *Narrative of Perry's Expedition* stated, these gifts appeared in sharp contrast to "the brutal performance of these wrestlers" (*sumō*), which the Japanese commissioners presented; and were "a triumphant revelation, to a partially enlightened people, of the success of science and enterprise."[2]

The age of "Civilization and Enlightenment" was thus opened to Japan. On publishing his book, *Seiyō Jijō* (Things in the West, 1866), FUKUZAWA Yukichi, one of the most potent leaders and eloquent spokesmen of this age, illustrated the title page with electric wires and poles all around the globe, a steamship, a steam locomotive, and a balloon, together with eight Chinese characters. Translated, they meant "steam ferries people, electricity carries messages." Also in his *Minjō Isshin* (Renovation of People's Conditions, 1879) FUKUZAWA emphasized the use of "the steamship and steam locomotive, electric telegraphy, printing, and the postal system," saying that these four inventions of the nineteenth century "constitute

[1] *Narrative of the Expedition of an American Squadron to the China Seas and Japan, performed in the Years 1852, 1853,* and *1854, under the Command of Commodore M. C. Perry, United States Navy, by Order of the Government of the United States* (Washington, 1856), pp. 75–76.

[2] *Ibid.*, p. 372.

the elements of modern civilization."[3]

It was evident to the Japanese eye that these facilities of modern science and technology were exactly what made Western civilization advance and what the Japanese themselves urgently needed. It was no wonder that great enthusiasm for scientific know-how and for Westernization prevailed in Japan for some time in the early Meiji period.

"Knowledge Shall Be Sought Throughout the World"

The year 1543 saw the publication of the two epochal works in the history of Western science. These were COPERNICUS' *De Revolutionibus Orbium Caelestium* and VESALIUS' treatise, *De Humani Corporis Fabrica,* two great scientific achievements which revolutionized traditional ideas concerning the macrocosm and the microcosm respectively. It was coincidentally in the same year that Japan's first contacts with Westerners occurred, with some Portuguese and Franciscan missionaries from Portugal and Spain. The response of the Japanese people to medical art, astronomy, geography, and to such European products as firearms, clocks, and glasses was immediate and enthusiastic. And by the end of the century, a new religion, Christianity, had been rather widely accepted.

Had Japan continued these contacts, the country might have caught up with the development of Western science and technology. In the 1630's, however, the Tokugawa Shogunate, impelled by a strong desire to preserve its own power, adopted the policy of banning Christianity. Thus all Europeans were excluded except the Dutch. For over two hundred years, one closely supervised Dutch outpost and occasional, licensed Chinese traders were to be Japan's only links with the outside world. Due to the stimulus received in the first contacts with Western science, however, astronomy and particularly calendar-making showed remarkable progress during this period of national seclusion. Also during this period, *wasan* (traditional Japanese mathematics) was to flourish.

In 1720, import of foreign books (except those on Christianity) was permitted by the Shogunate and this policy gave rise to the study of Dutch learning among the Japanese people. The publication in 1774 of *Kaitai Shinsho* (a Japanese translation from the Dutch version of a German treatise on anatomy) was a monumental achievement in the history of the introduction of Western science into Japan. This work so distinctly demonstrated the excellence of Western learning that it was followed by the introduction of Dutch versions of European astronomy, physics, chemistry, and botany, with ever-increasing degrees of interest. Marine almanacs and fragments of Aristotelian cosmology were already known in Japan in the seventeenth century. Then the Copernican system and even Newtonian dynamics were introduced through the Dutch, although the interest of the Japanese astronomers was attracted mainly to calendric aspects of astronomy.

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[3] FUKUZAWA Yukichi, *Minjo Isshin* in *Nihon Kagaku-Gijutsu-Shi Taikei* (History of Science and Technology in Japan), ed. by History of Science Society of Japan, Vol. 1, pp. 489–491.

Dutch learning reached its culmination in the early nineteenth century. INŌ Tadataka, for instance, completed a very accurate map of the Japanese islands, a chart which may be regarded as one of the most remarkable and integrated products of Dutch learning in Japan. At clan schools, Chinese classics had constituted the core of the curricula, but from about the end of the eighteenth century, Dutch learning came to be added and by the middle of the nineteenth century, one-third of all courses of instruction consisted of scientific disciplines. At the same time, the number of scholars of Western learning in Japan increased remarkably.[4]

Owing to the efforts of adherents of Dutch learning, not only the superiority of Western science and technology but also economic and military conditions of Western countries in general were made known to some extent. Once the country was opened, therefore, progressive groups of Japanese leaders readily realized that the most urgent matter was expeditiously and extensively to introduce Western systems of knowledge, technique, industry, army and navy, and political administration. With this need in mind, over ninety students were sent abroad by the Shogunate or by the provincial clans. They were scattered into several countries, such as Holland, England, France, Germany, Russia, and the United States of America.[5] Besides the Dutch language, English, German, and French were also then studied in Japan. Naval and army training schools were organized, an institution devoted to foreign matters was created, and a school of Western medicine was founded by the Shogunate.

With the Meiji Restoration in 1867, traditional Chinese learning was replaced by Western learning, and the *Shōheikō* as the central institution for the study of Chinese classics was soon closed. Governmental policy was formulated to accord with the statement in the so-called Charter Oath that "Knowledge shall be sought throughout the world, so that the foundations of the Empire may be firmly established."

Thus education was to play a particularly important role in the whole process of Meiji development. The government sent many Japanese students to study abroad[6] and employed scores of foreigners to help establish modern education and introduce Western science and technology. In the field of natural science, as is shown in the diagram on page 119, the number of foreign teachers in Japan was greatest in the 1870's; it decreased rapidly during the following decade, when most of them were replaced by Japanese trained abroad. The countries to which the Japanese students were sent were primarily America, England, and Germany and those countries from which most of the foreign teachers of natural science came were

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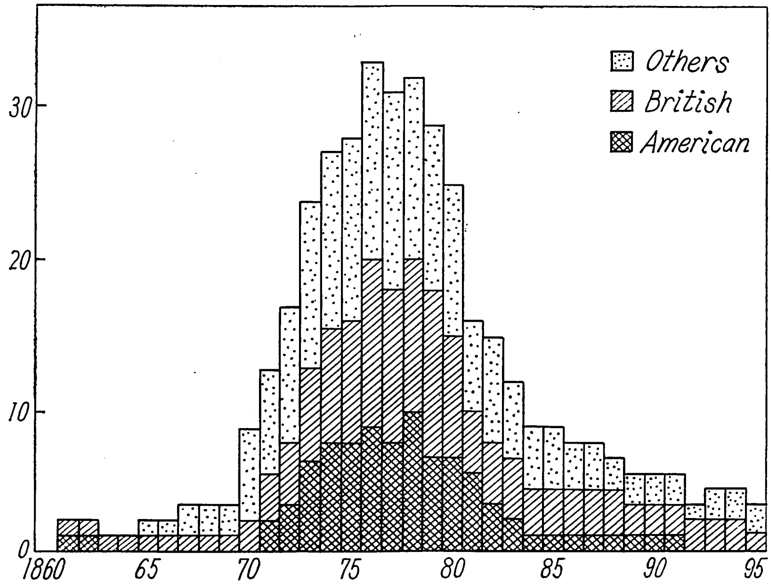
[4] *Nihon Kagaku-Gijutsu-Shi Taikei, ibid.*, pp. 12–16; Vol. 8, p. 27.

[5] YOSHIDA Mitsukuni, *Nihon o kizuita Kagaku* (Science that built Japan) (Tokyo, 1966), pp. 29–30.

[6] The number of Japanese students sent abroad by the Ministry of Education in the entire Meiji period came to 444. Among them, 268 were in the field of science and technology. (*Ibid.*, p. 30.) In addition to these students, there were many others who went abroad privately or were sent by other government departments.

Number of Foreign Teachers in Natural Science at Collegiate or Semi-Collegiate Level in Japan during 1860–1895[7]



	American	British	German	French	Dutch	Total
Mathematics	5 + (2)	4 + (2)	3 + (3)	4 + (2)	——	16 + (9)
Physics, Astronomy, Geophysics	4 + (5)	8	1 + (2)	5 + (1)	(1)	18 + (9)
Chemistry	5 + (1)	3	7	(3)	1 + (1)	16 + (5)
Physical Geography	3 + (1)	1	5	1	——	10 + (1)
Biology	6	1	3	(2)	——	10 + (2)
TOTAL	23 + (9)	17 + (2)	19 + (5)	10 + (8)	1 + (2)	70 + (26)

Number of foreign teachers in various fields of natural science at collegiate or semi-collegiate level who were in Japan sometime during the period 1860–1895. Numbers in parenthesis denote teachers who taught in field indicated in addition to other fields.

America, England, Germany, and France. The table below gives numerical data for the foreign teachers according to their specialities and nationalities.

These facts and statistics for the early years of Meiji Japan may be an indication that the English language itself played an important part in the early transmission of Western science to Japan. In fact, many of the Western books on science translated and published in Japanese in those days were mainly either of American

[7] These statistics, though not complete, are based on the best available sources and may very well show general trends. The author would like to acknowledge his debt to Professor YUASA Mitsutomo for the original form of the statistics.

or of British authorship.

The extensive early American influence on Japan in science was due, first of all, to the leading part which America took in the reopening of Japan. Although England dominated trade at that time, America was more influential in the cultural sphere. Tens of Americans were sent to Japan as missionaries and many of the teachers and technical directors were invited from America. The Dutch-American missionary, Guido H. F. VERBECK (1830–1898), who had been staying in Japan since 1859, and the American educator, David MURRAY (1830–1905), who was called to Japan in 1873 to serve as educational adviser to the Minister of Education, had a particularly profound influence on the whole Japanese educational system and on the selection of foreign teachers to serve in Japan.[8] This may be counted as the second and more direct reason for the extensiveness of American influence on science in early Meiji Japan.

The following will deal with the introduction of science from America, with its influence on various phases of Japanese intellect, and with the ensuing cultural exchange. Although it is rather difficult to single out purely American-Japanese scientific and cultural influx, the author will try to give some representative cases largely pertaining to the activities of individuals, since the influence was exerted and exchange made mostly through a limited number of individuals in those early years. The field of applied science (for example, medicine and engineering), though very important, will not be treated in detail in this paper.

Achievements in Mathematics and Physical Science

Although most of the fields of natural science in Meiji Japan were first developed under the leadership of foreign teachers, mathematics differed somewhat in this respect. Traditional Japanese mathematics had already been quite highly developed and Western mathematics had also been taught by Dutch officers at the Nagasaki Naval Institute since 1855. During the 1870's two Japanese professors, KIKUCHI Dairoku and FUJISAWA Rikitaro,[9] rather than foreign teachers, were most active in the field of mathematics. The Mathematical Society of Tokyo, established in 1877, was also the first among the academic societies inaugurated in Japan. It consisted of three groups of Japanese mathematicians, namely, scholars of Japanese mathematics, scholars of newly introduced Western mathematics, and naval and army mathematicians.

The pivotal institution for the introduction of Western science was Tokyo University, established in 1877 as a result of the merger of separate educational institutions originally belonging to the Shogunate. In 1871, an American teacher, Peter V. VEEDER, was invited by the Japanese government to teach physics. He

[8] It was partly the result of advice of Guido H. F. VERBECK that the Meiji Government decided to learn medicine from Germany.

[9] KIKUCHI Dairoku (1855–1917) studied in England and FUJISAWA Rikitarō (1851–1933) studied in Germany.

continued teaching at Tokyo University until 1878 and published some meteorological observations and other works during his stay in Japan.[10] In 1880, an American astronomer, Henry Martyn PAUL, came to serve as the first professor of astronomy at Tokyo University. In 1883, he returned to the Naval Observatory, Washington, D.C.[11] The groundwork for teaching and research in physics, however, was laid by an American physicist, T. C. MENDENHALL and by two British physicists, J. A. EWING and C. G. KNOTT.

Thomas Corwin MENDENHALL (1841–1924) was largely self-educated and was a professor of physics and mechanics at the newly founded Ohio Agricultural and Mechanical College (later Ohio State University) in 1878, when he was called to the chair of physics at Tokyo University. He remained there for three years and helped establish a physical laboratory. He initiated the measurement of the force of gravity in various parts of Japan and determined the mean density of the earth from the results of his measurements in Tokyo and at the summit of Mount Fuji.[12] The result of his work was the best obtained at that time by the method he employed. Japanese students of physics followed his example and continued the same measurements for other parts of Japan, including Hokkaido and Okinawa.[13]

MENDENHALL was one of the main leaders in the early meteorological observations in Meiji Japan.[14] He served as the director of the newly established meteorological observatory of Tokyo University. In his concluding remarks in the "Report on the Meteorology of Tokio for the Year 1879,"[15] he suggested that the observatory should also be equipped with seismographs. He finished this paper right after a severe earthquake (February 22, 1880) in the Tokyo and Yokohama area and was keenly aware of the need for the scientific study of the earthquake.

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[10] "Some Meteorological Observations in Japan," *Transactions of the Asiatic Society of Japan* (hereafter, *TASJ*), Vol. 5, Part I (Oct. 1876–June 1877), pp. 142–153; "Some Japanese Musical Intervals," *TASJ*, Vol. 7 (1879), pp. 76–85; "Results of Observation of the Visibility of Five of the Principal Mountains Seen from Tokio," *TASJ*, Vol. 7 (1879), pp. 86–89.

[11] Among H. M. PAUL's writings, the following are related to Japan: "Measuring Earthquakes," *Science*, Vol. 4, No. 96 (1884), pp. 516–518; "Seismological Notes," *Science*, Vol. 5, No. 109 (1885), pp. 199–201; "Recent Gravity Determinations in and near Japan," *Science*, Vol. 6, No. 140 (1885), pp. 319–320.

[12] "Measurements of the Force of Gravity at Tokio and on the Summit of Fujinoyama," *Memoirs of the Science Department, University of Tokio* (hereafter, *Mem. Sci.*), No. 5 (1881), pp. 1–17 with preface. MENDENHALL made use of a Borda pendulum for his measurements because, as he wrote, the Kater pendulum which was available gave only an approximate value.

[13] A. TANAKADATE, R. FUJISAWA & S. TANAKA, "Measurement of the Force of Gravity at Sapporo," *An Appendix to Mem. Sci.*, No. 5 (1882), pp. 1–21; *Tōyō Gakugei Zasshi* (Journal of Arts & Sciences), No. 12 (Sept., 1882), p. 298.

[14] Among other leaders of Japanese meteorology were the Englishman, H. B. JOYNER, who inaugurated and supervised meteorological observations at Tokyo Metropolitan Observatory founded in 1875; and the German, Erwin KNIPPING, who was famous for establishing the system of weather forecasting and storm warnings at the same institution.

[15] *Mem. Sci.*, Vol. 3, Part 1 (1880), pp. 1–42, preface, plates.

His meteorological report for the next year[16] included magnetic observations, meteorological observations on Mount Fuji, and the historical survey of the fires in Tokyo. This last survey was done by YAMAGAWA Kenjirō, who had been educated at the Sheffield Scientific School of Yale University and later became the first Japanese professor of physics at Tokyo University.

The Japan Seismological Society was founded in 1880. This was probably the first scientific society in the world for the study of seismology. The frequent earthquakes, particularly the one metntioned above, which terrified the foreign teachers in Japan, gave strong impetus to this outcome. Among the foreign teachers, MENDENHALL and two British professors, John MILNE and James Alfred EWING, were influential in organizing the society. The study of seismology was thus initiated and it made amazing progress in Japan in a relatively short time. MENDENHALL retired in 1901 and died in 1924. His bequest to the Imperial Academy of Japan was made the endowment fund for the Mendenhall Commemoration Prize.[17]

MENDENHALL's principal scientific contributions were in the fields of geophysics (gravity, meteorology, and seismology), geodetic survey, and weights and measures. The breadth of his interest was evidenced by his numerous monographs, reports, and papers which covered a wide field, including articles on the history of science, biographies of scientists and educators, and historical accounts related to the state of Ohio. The Japanese translation of his book *A Century of Electricity* (Boston and New York: 1887) was published in Tokyo in 1893.[18] MENDENHALL is mentioned by D. E. SMITH and J. GINSBURG in their book, *A History of Mathematics in America before 1900*, as one of the most prominent among "American mathematicians who gave particular attention to the subject" of the "mathematical problem of the pendulum."[19] He was also the only American physics teacher who served in Japan during the Meiji period and whose name appears in the list of some 1800 Americans considered by the American Institute of Physics as having made significant

[16] "Report on the Meteorology of Tokio for the Year 1880," *Mem. Sci.*, No. 7 (1881), pp. 1–81, plates.

[17] While in Japan, MENDENHALL published a number of papers, including the following: "An Experimental Solution of a Problem in the Doctrine of Chances," *Proceedings of the American Association for the Advancement of Science*, Vol. 28 (1879), pp. 190–192; "A Japanese Typhoon," *The Popular Science Monthly*, Vol. 18 (1880), pp. 356–361; "On the Determination of the Acceleration due to the Force of Gravity at Tokio," *Transactions of the Seismological Society of Japan*, Vol. 1 (1880), pp. 52–53; "The Wave Length of Some of the Principal Fraunhofer Lines of the Solar Spectrum" *Mem Sci.*, No. 8 (1881), pp. 1–27, plate; while he served as Professor of Electrical Science in the U.S. Signal Corps (1884–1886), MENDENHALL established a systematic collection of data relating to earthquakes. As Superintendent of the U.S. Coast & Geodetic Survey (1889–1894), he was responsible for the development of an improved portable apparatus for the measurement of gravity and according to his plans, a transcontinental series of gravity measurements were made.

[18] *Denki Gakujutsu no Shimpo* (Tokyo, 1893).

[19] D. E. SMITH & J. GINSBURG, *A History of Mathematics in America before 1900* (Chicago, 1934), p. 101.

contributions to physics.

Scientific ability coupled with the pioneer's spirit in this Ohio-born American seemed to have been fully displayed as he managed scientific, educational and administrative matters both in America and in Japan. He was probably best suited for work of this nature, for he was well acquainted with those fields to which physics was to be effectually applied, was proficient in mathematics, and was well experienced in the art of precise measurements. Thus as physicist, educator, and administrator, he rendered distinguished service to his own country as well as to Japan, although in some aspects of teaching physics in Japan he had to be supplemented by other foreign teachers from Europe.[20]

In the field of chemisty, reference should be made to the American teacher William Elliot GRIFFIS (1843–1928) for the uniqueness of the role he played in the cultural contacts between Japan and the United States, although the Dutch chemist, K. W. GRATAMA, and two British chemists, E. DIVERS and R. W. ATKINSON, may be said to have contributed more to the introduction of Western chemistry in Japan.[21]

While a student at Rutgers College, GRIFFIS taught the first Japanese students who were sent there on the advice of VERBECK. Thus, when in 1870 a call came from the Fukui clan in Japan for someone to organize a scientific school on the American principle, GRIFFIS was selected by the Rutgers faculty for that duty. He accepted the appointment and went to Japan. After teaching in Fukui, he was called to Tokyo in 1872 to teach chemistry and physics at the *Nanko*, one of the predecessors of Tokyo University. He remained there till 1874, and returned to America, where he graduated from the Union Theological Seminary in 1877, entered the ministry, and served as pastor of several churches.

GRIFFIS took great pride in the claim that he spent nearly a year "alone in a daimiō's capital far in the interior, away from Western influence, when feudalism was in its full bloom, and the old life in vogue."[22] He devoted much of his life to the work of interpreting Japan to America with voice and pen. His first book, *The Mikado's Empire* (1876) became a mine of information about Japan, including matters scientific and technical. Many other books and articles of his were also concerned with Japan.[23]

While in Japan, GRIFFIS was asked by KATSU Awa to find for the Shizuoka clan "a professional gentleman, regularly educated, not a mechanic or a clerk who has taken to teaching to pick up a living; and, if possible, a graduate of the same school as yourself."[24] Thus, GRIFFIS introduced another Rutgers graduate, Edward Warren

[20] For further information on MENDENHALL's life and activities, see: WATANABE Masao, "Thomas Corwin Mendenhall: Physicist in Japan and America" (in Japanese with English summary), *Kagakusi Kenkyu* (*Journal of History of Science, Japan*), No. 79 (1966), pp. 113–123, including a comprehensive bibliography of MENDENHALL.

[21] Years of stay in Japan as follows: GRATAMA, 1865–1871; DIVERS, 1873–1899; and ATKINSON, 1874–1881.

[22] W. E. GRIFFIS, *The Mikado's Empire* (5th ed.), Preface, p. 9.

[23] GRIFFIS' other writings are too numerous to be listed here.

[24] GRIFFIS, *op. cit.*, p. 527.

CLARK. CLARK taught in Shizuoka and then moved to Tokyo to teach physics and chemistry at *Kaisei Gakko*, one of the predecessors of Tokyo University, during 1873–74. He left two books on Japan, *Life and Adventure in Japan* (1878) and *Katz Awa, the Bismarck of Japan* (1904).[25]

GRIFFIS had a decisive effect on the whole interpretation of history and culture of Japan. In his *Mikado's Empire* he not only presented the history of Japan but also reported his observations on nature and the folklore of Japan. As to some representative aspects of nature in Japan, he wrote:

> The aspects of nature in Japan are such as to influence the minds of its mainly agricultural inhabitants to an extent but faintly realized by one born in the United States. In the first place, the foundations of the land are shaky. There can be no *real* estate in Japan, for one knows not but the whole country may be ingulfed in the waters out of which it once emerged. Earthquakes average over two a month, and a hundred in one revolution of the moon have been known. The national annals tell of many a town and village ingulfed, and of cities and proud castles leveled. Floods of rain, causing dreadful land-slides and inundations, are by no means rare. Even the ocean has, to the coast-dweller, and added terror. Not only do the wind and tempest arise to wreck and drown, but the tidal wave is ever a possible visitor. Once or twice a year the typhoons, sometimes the most dreadful in the dreadful catalogue of destructive agencies, must be looked for. Two-thirds of the entire surface of the empire is covered with mountains—not always superb models of form like Fuji, but often jagged peaks and cloven crests, among which are grim precipices, frightful gulches, and gloomy defiles. With no religion but that of paganism and fetishism, armed without by no weapons of science, strengthened within by no knowledge of the Creator-father, the Japanese peasant is appalled at his own insignificance in the midst of the sublime mysteries and immensities of nature. The creatures of his own imagination, by which he explains the phenomena of nature and soothes his terrors, though seeming frightful to us, are necessities to him, since the awful suspense of uncertainty and ignorance is to him more terrible than the creatures whose existence he imagines. Though modern science will confer an ineffable good upon Japan by enlightening the darkened intellect of its inhabitants, yet the continual liability to the recurrence of destructive natural phenomena will long retard the march of mind, and keep alive superstitions that now block like boulders the path of civilization.[26]

The natural calamities GRIFFIS listed were typical of nature in Japan, especially the earthquake and the typhoon. Thus, once the scientific method of investigation

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[25] Besides these two books, CLARK wrote the following: "International Relations with Japan," *International Review*, Vol. 4, (1877), pp. 51–67.

[26] GRIFFIS, *op. cit.*, pp. 477–478. The quotation is from the second paragraph of the chapter, "The Mythical Zoology of Japan." In following pages, GRIFFIS described the fire dragon, the rain dragon, the wind imp, the thunder-drummer, the earthquake fish, *etc.*

was introduced, seismology and the science of the typhoon were to become two specialities of physical science in Japan.

Concerning seismology in Japan, KIKUCHI Dairoku stated in one of his articles published in 1912:

> It is not strictly proper to speak of seismology as introduced from the West, for it may be said to have originated in Japan with the investigations of Professors Wagner, Milne, Gray, Ewing, Knott, Sekiya, Omori, and others; but its first invertigators came from Europe, and its methods are those of Western science.[27]

MENDENHALL had already in 1900 made a very felicitous remark:

> There is one science which the Japanese have practically made their own. Blessed or cursed (according to how you look at it), by the frequent occurrence of earthquakes, and blessed (certainly) by the presence of a large number of able and enthusiastic students of physical science, Japan has become within twenty years a vast seismological laboratory in which seismic phenomena are being used as they never were before. Indeed, modern seismology had its birth there, and there it has been and is being most carefully nurtured. About twenty years ago there were in Japan a considerable number of foreigners employed as professors of engineering, geology, physics, etc., and of necessity they became interested in the one characteristics natural phenomenon, the unpleasantly frequent manifestations of which none of them will ever forget.[28]

These quotations very adequately describe the growth of a peculiar phase of physical science in Japan as the result of the introduction of the scientific method from the Western world.

Advances in Biological Science

The early influence of American science on Japan was greatest in the field of biological science. Most of the early Japanese leaders in this field had been either educated in American universities or influenced by the American professors who taught in Japan.

The development of Hokkaido, the northern island of Japan, was carried out largely under the guidance of American experts during the Meiji era and their influence was so strong that even today the agricultural landscape there bears a startling resemblance to that of American rural areas. The Sapporo Agricultural College in Hokkaido, predecessor of Hokkaido University, was founded at the suggestion of Horace CAPRON, an American adviser to the Colonization Commission (*Kaitakushi*) of the Japanese government. This college was modelled after Massachusetts Agricultural College, now the University of Massachusetts. William

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[27] KIKUCHI Dairoku, "The Introduction of Western Learning into Japan," *The Rice Institute Pamphlet*, Vol. 2 (1915), p. 94.

[28] T. C. MENDENHALL, "Publication of the Earthquake Investigation Committee—in Foreign Languages, Numbers 3 and 4 Tokyo–1900," *Science*, n.s., Vol. 12, No. 305 (1900), p. 678.

Smith CLARK (1826–1886), President and professor of botany and horticulture of Massachusetts Agricultural College, was invited to be the first president of this new college in Hokkaido. CLARK presided there for only a year, yet he exerted such a great and lasting influence on Japanese students in both religious and scientific outlook that his name is still remembered by the Japanese people today. Among the early graduates from this College were MIYABE Kingo and WATASE Shōzaburo, two leading biologists of Japan.

The circumstances differed in Tokyo where Edward Sylvester MORSE (1838–1925) at Tokyo University was influencing Japanese intellectuals. MORSE was born in Maine, showed special interest in collecting and classifying shells and minerals, and happened to win the notice of Louis AGASSIZ, who was about to start the new Museum of Comparative Zoology at Harvard University. Thus MORSE became a student-assistant to AGASSIZ at the Lawrence Scientific School, Harvard University, and specialized for three years in conchology. His study of the brachiopods led him to his undertaking a systematic exploration of the Atlantic Coast from Maine southward and his publication of this research attracted the attention of Charles DARWIN and other European naturalists. The Pacific Ocean brachiopods with their rich varieties lured MORSE to Japan in 1877 and while there he was invited to teach zoology at Tokyo University.

His tenure in this professorship during the years 1877–79 witnessed the introduction among the Japanese of the theory of evolution and modern methods of collecting and classifying objects of natural history. He also "collected books and pamphlets for the University Library to the extent of twenty-five hundred volumes and made the beginning of a good scientific collection."[29] *Memoirs of the Science Department, University of Tokio* was published at his suggestion and the Tokyo Biological Society was established under his strong influence. This society was to grow into the present Zoological Society and Botanical Society of Japan. MORSE's students later became the founders of modern zoology in Japan.

One of the greatest achievements of MORSE in Japan was his discovery of shell mounds at Omori, Tokyo, which he first noticed on a train as it travelled through a railroad pass. His prior experience studying "these deposits along the coast of New England, in company with Prof. Jeffries Wyman"[30] advantageously served him in making this discovery. He examined these shell mounds of Omori, which consisted of kitchen middens with their pre-historic artifacts, and his students and American colleagues, MENDENHALL and JEWETT,[31] cooperated with him. MORSE

[29] E. S. MORSE, *Japan Day by Day* (Boston & New York, 1917), Vol. 1, p. 139.

[30] E. S. MORSE, "Traces of an Early Race in Japan," *The Popular Science Monthly*, Vol. 14 (1879), pp. 257–266 (esp. p. 260).

[31] Frank Fanning JEWETT (1844–1926) was a professor of chemistry at Tokyo University from 1876 to 1880. After his return to America, he became a professor in Oberlin College, where he remained until 1912. Among his students at Obserlin was Charles M. HALL, discoverer of the electrolytic method for separating aluminum from its various compounds. For the shell mound discoveries, see MORSE, *ibid.*

published the results of his investigation in the first issue of *Memoir of the Science Department* and elsewhere. He thus opened the way to the development of archaeology and anthropology in Japan. His example was immediately followed by two of his Japanese students in their excavation of a shell mound at Hitachi, 73 miles distant from Tokyo, and their report was attached to that of MORSE.[32] MORSE sent Charles DARWIN a copy of the proof-sheets for "A Comparison between the Ancient and Modern Molluscan Fauna of Omori," a chapter in his report. DARWIN showed great interest in it and in his reply to MORSE he wrote:

> Of all the wonders of the world, the progress of Japan, in which you have been aiding, seems to me about the most wonderful.[33]

It was mainly MORSE who introduced the theory of evolution to Japan. He came to Japan only eighteen years after the publication of DARWIN's *Origin of Species.* He not only lectured at the University but also expounded the theory at a series of public lectures in Tokyo and did much to popularize it among Japanese intellectuals at the time when this theory was not as yet universally accepted. Darwinism, together with Herbert SPENCER's philosophy, which was also introduced to Japan at the same time, attracted contemporary Japanese leaders.[34] Both biological and sociological implications and applications of the notion of the survival of the fittest were, so to speak, an inspiration to them when their own country had to struggle for existence in new international circumstances.

The lively interest of Japanese intellectuals in Darwinism and Social Darwinism was reflected in academic periodicals of the time, such as *Gakugei Shirin* and *Tōyō Gakugei Zasshi.* In the former were published many articles translated from the originals appearing in *The Popular Science Monthly,* an American journal edited by Edward Livingston YOUMANS (an advocator of SPENCER's thought). The opening article of *Tōyō Gakugei Zasshi,* Volume I (1881), was entitled "How to Apply the Artificial Selection to Obtain Capable Men" and was written by KATŌ Hiroyuki, then President of Tokyo University. Articles of similar sort appeared in the succeeding volumes of the same journal.[35]

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[32] E. S. MORSE, "Shell Mounds of Omori," *Mem. Sci.,* Vol. 1, Part I (1879), pp. 1–36, preface, plates (Japanese translation of the same paper was also published in the same year); "Evidences of Cannibalism in a Nation before the Ainos in Japan," *Tokio Times,* Jan. 19, 1879; and IIJIMA I. & SASAKI C., "Okadaira Shell Mound at Hitachi," *An Appendix to Mem. Sci.,* Vol. 1, Part I (1883), pp. 1–7, preface, plates.

[33] Francis DARWIN & A. C. SEWARD, ed., *More Letters of Charles Darwin,* Vol. 1 (New York, 1903), p. 384.

[34] MORSE's public lectures were translated into Japanese and published in 1883 under the title, *Dōbutsu Shinkaron* (The Evolution of Animals), probably the first book on evolution published in Japan. The following were also influential in spreading the theory of evolution: E. F. FENOLLOSA, American professor of philosophy at Tokyo University; TOYAMA Shōichi, Japanese professor of sociology at Tokyo University, who had studied in England and in America; YATABE Ryōkichi, professor of botany at Tokyo University, who had studied in America.

[35] *Gakugei Shirin* was first published in 1877 and *Tōyō Gakugei Zasshi* in 1881. Japanese

On leaving Fukui for Tokyo and travelling in heavy snow on January 23, 1872, GRIFFIS could write and joke:

> We resume our march.... The tracks of boar, bear, foxes, and monkeys are numerous. It is the hunter's harvest-time. Dressed carcasses are on sale in every village. I wonder how a Darwinian steak would taste. "No, thank you; no monkey for me!" is my response to an invitation to taste my ancestors. Good people, you need "science" to teach you what cannibals you are.[36]

At the time, many of the missionaries and Christian teachers in Japan were uneasy in seeing evolution popularized there, since it was, they decided, entirely contrary to the Biblical account of creation. Thus they started a strong campaign of apologetics in Japan.[37]

As for the Japanese, however, they saw practically nothing in the theory of evolution which contradicted their own philosophy of life, nor were they furnished with any other systems of scientific knowledge according to which they might criticize this new theory. At the time when ill feeling toward Christianity was still existent, Darwinism, presented antagonistically to this Western religion, must have appealed to the Japanese mind. It was ready to accept the newest outcome of Western science and technology but clung mostly to traditional value systems. Moreover evolution might have provided justification for modernization and enlightenment and, as Dr. SCHWANTES pointed out, it "offered a solution to the problem of the new *versus* the old: if the future, present, and past were continuous, one developing inevitably out of the other, then respect for ancestors and national heroes was perfectly compatible with modernization and progress."[38] Under these circumstances, evolutionary thought, sometimes in its most simplified form but still armed with the term "scientific," swept over the Japanese mind. It was to lead critiques on social affairs and was to be invoked to justify powerful armament.

MORSE was responsible for the early introduction of the theory of evolution to Japan and, to a considerable degree, for the above situation as well. He did not introduce the elaborate theory of DARWIN but rather presented his own interpretation,

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students in America had also been exposed to Spencer's philosophy. Even YAMAGAWA Kenjirō, for example, while a student at Sheffield Scientific School of Yale University, argued that promotion of natural science was indispensable for the furtherance of national strength and thus he decided to major in physics. As he related in his recollections, the whole argument was deduced by a Spencerian mode of thinking as was presented by YOUMANS in his *Popular Science Monthly*, started in 1872, when YAMAGAWA entered the Sheffield Scientific School. See WATANABE Masao, "Kenjirō Yamagawa: a *Samurai* Scientist at Yale University" (in Japanese with English summary), *Bunkashi ni okeru Kindai Kagaku* (Science in the History of Modern Culture) (Tokyo, 1963).

[36] GRIFFIS, *op. cit.*, p. 542.

[37] Robert SCHWANTES, "Christianity *versus* Science: A Conflict of Ideas in Meiji Japan," *The Far Eastern Quarterly*, Vol. 12, No. 2 (1953), pp. 126–127.

[38] *Ibid.*, p. 125.

which was much simpler. He sometimes did not bring transitional stages under careful consideration but related results too hastily to the supposed causes of evolution. Nor was he adequately cautious when he compared examples in plants and animals with the cases of mankind. Often he interpreted plant or animal phenomena in terms of human affairs and conversely applied the patterns of the former too rashly to the latter. As he was originally a student of AGASSIZ, who was strongly opposed to Darwinism, MORSE was not thoroughly trained in theory of evolution. He also saw evolution as conflicting with Christianity and presented it, in fact, as something quite antagonistic. In doing so, he might have intended to set the Japanese people's mind free from superstitution. He had been brought up under austere religious instruction but did not realize the role of Christianity was to play in Japan in modernizing people's thought. Therefore the effects of his endeavors were probably contrary to his original intentions.[39]

MORSE recommended Thomas Henry HUXLEY as his successor but because of his failing health, HUXLEY could not come. Had he come, the whole story of evolution in Japan might have been somewhat different. Since MORSE thus remained the major figure who introduced evolution to Japan, its effects were limited.

Another American evolutionist in Japan, John Thomas GULICK (1832–1923), although he did not teach at any university, made original contributions to the theory of evolution by his study of shells. He was a son of an American missionary to Hawaii and he himself became a missionary to China and Japan. He was at the same time a specialist in Hawaiian snails. He not only substantiated DARWIN's theory but also took a further important step in post-Darwinian development of the theory of evolution. He made a careful study of the relation between the geographical distribution and the variation of the species of *Achatinellidae* and applied the theory of evolution to account for observed facts. While DARWIN regarded selection by outside environmental forces as the dominant factor in evolution, GULICK showed that there were other factors working as causes of change or evolution. This was the new evidence discovered by GULICK through his study of *Achatinellidae*. As he observed, the power of migration of this particular species was limited to a very extraordinary degree in that they scarcely moved from one tree to another. Nevertheless, there were noticeable differences between this family of snails in one valley and the next and even on one tree and the next. Thus he argued that even in the absence of differences of selection there must be an inherent tendency in check. Therefore he emphasized isolation, or the prevention of mingling, and also many factors that were of internal origin.

While the majority of contemporary Christian leaders and laymen were hesitant in accepting the consequences of the theory of evolution and even in Japan there was controvarsy among missionaries and visting Western teachers as to the validity

[39] For an evaluation of MORSE's presentation of the theory of evolution in Japan, the author is indebted to Mr. TSUKUBA Hisaharu, in *Nihon Kagaku-Gijutsu-Shi Taikei*, *op. cit.*, Vol. 15, pp. 168–169.

of what was implied by the Darwinian theory, GULICK saw both science and religion in harmony. He maintained a theory of evolution that emphasized a non-fatalistic self-determination. He felt that future advancement of the race would be determined by the conscious choices by man himself and that the work of the missionary was to spread the influence that leads men to make the best choices. In connection with these thoughts was the ethical incentive to discover and to make known the scientific laws that set the conditions for achieving a better racial and cultural evolution, according to GULICK.

J. T. GULICK lived mainly in Kōbe and Ōsaka. Japanese land snails constituted an additional conchological interest for GULICK. He could observe the similar but more intricate relations of the varieties and localities than those of the Hawaiian Islands he had observed. He lectured on evolution several times at Dōshisha, a Christian school in Kyoto, and on "Evolution in the Organic World" at the Protestant Missionary Conference in the 1880's. His scientific work has come to be reevaluated today, but, in his lifetime, he seems to have exerted relatively little influence on science and thought in Japan. Several reasons for this fact may be cited.

Lack of impact by GULICK was due first, to his modest and quiet personality and second, to his unpretentious scientific attitude. Third, he was stationed in the Kansai area, far removed from Tokyo, the center of modern education as well as of politics. Fourth, he was sent to Japan as a missionary and not as a science teacher. Fifth, Christian educational institutions in Japan did not lay stress on science education, while governmental institutions accentuated the scientific and technological aspects of education. Sixth, the Japanese people in general were eager to learn Western science and technology but were less favorably inclined toward Christianity, as has already been pointed out. Thus E. S. MORSE was quite enthusiastically accepted, but for GULICK, there existed little room to bring his scientific expertness into full play, although his activities in Japan as a missionary bore significance of immeasurable degree.[40]

In the fields of anthropology and archaeology in Japan, again MORSE took the lead. Under his influence, the Tokyo Anthropological Society was organized in 1884, and the teaching of anthropology and paleontology was started at Tokyo University. MORSE not only excavated shell mounds, as mentioned above, but also investigated prehistoric caves and ancient tombs in Japan. One of his books, *Japan Day by Day*, was an excellent record of his travels and observations. It gave the reader vivid descriptions, made by a friendly foreigner, of life in Japan when the country was "little influenced by the modes and manners of foreign

[40] For information on John Thomas GULICK and his work, see: Addison GULICK, *Evolutionist and Missionary: John Thomas Gulick* (Chicago, 1932); WATANABE Masao, "John Thomas Gulick: American Evolutionist and Missionary in Japan" (in Japanese with English summary), *Kagakusi Kenkyu* (*Journal of History of Science, Japan*), No. 77 (1966), pp. 1–15 and "John Thomas Gulick: American Evolutionist and Missionary in Japan" (in English), *Japanese Studies in the History of Science*, No. 5 (1966), pp. 140–149.

countries,"[41] and it contained nearly eight hundred drawings beautifully done by the author. What made him decide to have his material published sooner was, according to his preface, the following argument by William Sturgis BIGELOW in a letter addressed to him:

> The only thing I don't like in your letter is the confession that you are still frittering away your valuable time on the lower forms of animal life, which anybody can attend to, instead of devoting it to the highest, about the manner and customs of which no one is so well qualified to speak as you. Honestly, now, is'nt a Japanese a higher organism than a worm? Drop your damned Brachiopods. They'll always be there and will inevitably be taken care of by somebody or other as the years go by, and remember that the Japanese organisms which you and I knew familiarly forty years ago are vanishing types, many of which have already disappeared completely from the face of the earth, and that men of our age are literally the last people who have seen these organisms alive. For the next generation the Japanese we knew will be as extinct as Belemnites.[42]

MORSE also became well-informed on Japanese pottery and houses, as well as other ethnological aspects of Japanese life. No other collection of Japanese pottery could surpass the one made by E. S. MORSE and deposited in the Boston Museum of Fine Arts. A chance discovery at a china shop in Tokyo, of a saucer resembling a shell, first turned MORSE's attention to Japanese pottery. He looked for and found other examples modelled on shells. He was told by a Japanese friend, however, that these were not famous potteries. Thus "Morse became aware that there was a cult of pottery in Japan and that good pottery was to be recognized by an incised potter's mark."[43] Soon he had a Japanese expert[44] as his tutor of ceramics, with every Sunday afternoon devoted to lessons. Although MORSE had had no aesthetic training, he had a special talent for accurate observation and for skillful drawing.

> . . . Morse's camera eye, his uncanny ability to carry an image in his mind with complete fidelity of detail, enabled him to recognize at a glance the unfamiliar hieroglyphs of the various potters' marks. He could not read the Japanese written language, but he could carry in his memory and identify unerringly hundreds of potters' signatures in Japanese characters.
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> The third factor that made a ceramics connoisseur of Edward Morse was his passion for collecting. All his life he had a compulsion to collect, catalogue, and classify objects, beginning with the Maine land shells of his boyhood, and this natural impulse had been disciplined and encouraged by the great

[41] A letter from John G. MORSE, son of E. S. MORSE, to ISHIKAWA Kin-ichi, Japanese translator of *Japan Day by Day*.

[42] William Sturgis BIGELOW (1850–1926), physician, orientalist, and collector of Japanese art. For the quotation, see *Japan Day by Day*, *op. cit.*, Vol. 1, preface, pp. ix–x.

[43] Dorothy G. WAYMAN, *Edward Sylvester Morse: A Biography* (Cambridge, Massachusetts, 1942), p. 259.

[44] NINAGAWA Noritane.

collector, Agassiz.[45]

Another MORSE book, *Japanese Homes and Their Surroundings* (1885), was republished very recently in America in a paperback edition. MORSE's careful observations of Japanese houses, made three-quarters of a century ago and presented in this book with abundant illustrations of his own, seem to remain so important and reliable a source of information that it must have been worth republication today, when Japanese architectural influence on the modern American home is becoming more evident than ever before.

After returning to America, MORSE took up his lifework as director of the Peabody Museum in Salem, Massachusetts. There he also did a great deal to introduce Japan and Japanese art to the American people. The things he brought back from Japan and deposited in the Peabody Museum make one of the world's finest collections of Japanese ethnological objects. MORSE died in 1925. Since his mentality was encyclopedic and, on occasions, he drew brilliantly using both his hands, the Director of the Wister Institute of Anatomy became interested in the function of his brain. Thus MORSE proposed to contribute it to the Institute "when I am done with it"[46] and there his brain was studied[47] and is still preserved in alcohol.

MORSE recommended competent American teachers to Tokyo University, men like MENDENHALL, Ernest FENOLLOSA, and Charles Otis WHITMAN (1842–1910), who succeeded him at Tokyo University. WHITMAN was another pupil of AGASSIZ and had done his graduate work in Germany.[48] He remained in Japan for a period of two years (1879–1881) and taught embryology, introducing the latest method of microscopic study. His own scientific work in Japan was on the study of leeches.

While his predecessor was a man of gay and expansive personality and was a naturalist (or *hakubutsu-gakusha*) in the broadest sense of the word, WHITMAN was a grave scholar of the more analytical type. He had only four students in Japan, namely, SASAKI Chūjiro, IWAKAWA Tomotarō, IIJIMA Isao, and ISHIKAWA Chiyomatsu, but they all became leaders in the field of biology in Japan. After returning to America, he successively assumed the chairs of Director of Allis Lake Laboratory at Milwaukee, Professor and Head of the Department of Zoology, University of Chicago, and Director of the Marine Biological Laboratory at Woods Hole. His main scientific contributions were in embryology, comparative anatomy, taxonomy,

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[45] WAYMAN, *op. cit.,* pp. 259–260. And thus an American biologist became the supreme authority on Japanese pottery, consultant to the British Museum, the Royal Museum in Desden, the Freer Art Gallery, the Boston Museum of Fine Arts. Japanese pottery, for the first time systematically collected, classified, and catalogued according to the scientific fashion of natural history. His acquisitions were listed and published in *Catalogue of the Morse Collection of Japanese Pottery* (1901).

[46] MORSE's letter to ISHIKAWA Chiyomatsu.

[47] Henry H. DONALDSON & Myrtelle M. CANAVAN, "A Study of the Brains of Three Scholars, Granville Stanley Hall, Sir Wiliam Osler, Edward Sylvester Morse," *The Journal of Comparative Neurology*, Vol. 46, No. 1 (1928), pp. 1–95.

[48] Under Karl G. F. R. LEUCHART at the University of Leipzig.

evolution, heredity, and animal behavior. To him belongs the credit for introducing scientific zoology to America. Among the science teachers in Meiji Japan, WHITMAN may justly be counted as one of the most eminent scientists and investigators.

Both MORSE and WHITMAN were pupils of AGASSIZ and at least three early Japanese professors of zoology at Tokyo University, namely MITSUKURI Kakichi, who succeeded WHITMAN, WATASE Shōzaburō, and GOTŌ Seitarō, were trained at the Johns Hopkins University under William Keith BROOKS, another pupil of AGASSIZ. Thus it is true that "during the latter part of the last century there was hardly an active naturalist in America and Japan who had not either studied under Agassiz or been a pupil of one of his students."[49]

Both YATABE Ryōkichi, who was already professor of botany at Tokyo University when MORSE came to Japan, and MIYABE Kingo, who became a professor of botany at Hokkaido University, had studied under Asa GRAY, another great naturalist in America. GRAY was a pioneer and master in the field of plant geography and of his contributions to this department the most famous was the monograph on the botany of Japan and its relations to that of North America and other parts of the north temperate zone.[50] The collections of plants of Japan and of other Asian regions necessary for his study, GRAY was able to obtain through the scientists who joined PERRY's and other expeditions to the East.

All of the above examples illustrate the deep and extensive influence of American scientists on Japan, particularly in the field of natural history during the early Meiji Period.

Conclusion

From the time of reopening of the country, Japan had made great efforts to catch up with Western countries and in a relatively short time seemed successfully to have introduced modern science and technology. Already in 1874, GRIFFIS could write of the revolt in Saga:

> The days of Old Japan were passed. The era of steam, electricity, and breech-loaders had come. From the national capital darted the telegraphic lightnings. On the wings of steam, the imperial battalions swooped on Saga, as if by magic. The rebellion was annihilated in ten days.[51]

By about 1890, the educational system had been established; academic societies had been founded; scientific terminology had been formulated; academic periodicals were being published; and original works by Japanese scientists which won international reputations had already appeared. For example, there were the theory of typhoon by KITAO Jirō, a physicist trained in Germany, and the study of magneto-

[49] "Agassiz, Jean Louis Rodolphe," *Dictionary of American Biography*, Vol. 1, pp. 114–122, particularly p. 121.

[50] *Memoirs of the American Academy of Arts and Sciences*, Vol. 6 (1859).

[51] GRIFFIS, *op. cit.*, p. 575.

striction by NAGAOKA Hantarō, a young Tokyo University graduate who later went to Germany for further study.

The tradition of Dutch learning in Japan paved the way and enabled Japanese to make rapid strides in assimilating Western science. Moreover, unlike other Asian countries, there existed a lingual unity in Japan. This made it possible for Japanese to translate the body of Western science efficiently into their own language and to teach and to conduct research. Third, science and technology in the nineteenth century could be explored by individuals. Only a few Western teachers in Japan and Japanese students abroad were able to fulfill the initial task of quickly transmitting modern science into Japan. A century later, such an endeavor would certainly require groups of researchers and technicians working together in factory-like laboratories, with gigantic amounts of research funds.

The influence of American scientists was particularly notable in the fields of natural history and geophysics. These Americans at the same time proceeded even to unknown corners of the country and made observations not only on scientific matters but also on Japanese life in general. Thus they contributed to the introduction of Japanese culture into the Western world, as well as to the introduction of Western science into Japan.

In the late 1880's however, Japanese leaders, impressed by the rise of Germany, switched over from America to Germany to look for their models and tried to follow German examples in almost every aspect of education as well as in constitutional and military affairs. Consequently American influence in natural science declined, to be revived about a quarter of a century ago.

Remarkably rapid as it was, the introduction of Western science into Japan could not be effected without leaving various strains and deformities. Since the modernization of the state was the pressing question, the promotion of national industry and military forces took priority. Scientific activities were commenced primarily at governmental institutions under centralized national authority. Unlike the situation in Western countries, these activities were not necessarily initiated voluntarily by individuals interested in scientific inquiries, but were promoted as parts of national projects spurred on by immediate national needs.

Already before the opening of the country, scholars of Western learning in Japan were well aware of the effectiveness of modern science. Even after direct contact with Western countries was made possible, however, the Japanese people did not fully realize how deeply these disciplines were rooted in Western culture. Consequently, although they were eager to introduce the latest scientific findings, they did not pay much attention to how these could be made to fit their own cultural environment. The frequently used phrase, *wakon-yōsai* (Japanese spirit with Western learning) might well represent the basic attitude of the Japanese intellectuals of the time. Most of the Western teachers, who so much appreciated traditional Japanese culture, did not seem to have thoroughly perceived this shortcoming either.

In this respect, Erwin BAELZ's observation was exceptionally adequate and penetrating. He had been invited from Germany and taught at the Medical School of Tokyo University for as long as twenty-five years, beginning in 1876. "As a true and warm friend of the Japanese people" he set forth the following criticism, on the occasion celebrating his twenty-fifth year of service in Japan:

> ... So far as I see, a mistaken notion seems to be frequently prevalent in Japan concerning the origin and nature of western science. The Japanese people regard science as a kind of machine which yearly performs a prescribed amount of work and can easily be transferred to any place to have it kept working there. This is a mistake. The western scientific world is not a machine at all, but it is an organism, for the growth of which a certain climate and atmosphere are necessary as is true with the case of all other organisms....
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> ... The western countries sent many teachers to you, and with zeal did these teacher endeavor to transplant this spirit [of the West] in Japan and to make it adopted by the Japanese people. However, their mission was often misunderstood. They were looked upon as traders of scientific fruits who sell those fruits by the piece, although they were to be and they themselves intended to be the cultivators of the trees of science.... The Japanese people are content only with receiving the most recent developments and do not care to learn the basic spirit which has yielded these results.[52]

As was rightly pointed out, the Japanese people did not quite learn how to be creative in scientific investigations, although they became ever alert to import the newest products of technology. They did not seem fully to have acquired the scientific mind, but retained some conventional modes of mental attitude, such as secretiveness and sectarianism, which hampered exercising open and free discussions among researchers, a means vital to the advancement of scientific knowledge.

Only as most effective tools for the modernization of the country were Western science and technology introduced into Japan, independent from their intrinsic cultural environment and value system. As a result, in Japan there has been an almost complete isolation between the scientific-technological aspect and the cultural-religious aspect of life. The Japanese people did not try to see the newly introduced science in relation to its cultural foundations in the West, nor did they feel it necessary to correlate it adequately to their own traditional culture. Thus it is doubtful whether the Japanese people operated modern science and technology with modern consciousness and modern humanitarianism.

Christianity and science are the two distinguishing features of the Western cultural heritage. It is, however, the result of recent scholarship in the history of scientific thought that the fact was brought to light that Christianity played an important role in the growth of modern science. In the late nineteenth century, this fact was not yet established and, with the rise of Darwinism, science became regarded generally as conflicting with Christianity. Some Western teachers in

[52] Translation by the present author from Japanese edition, *Baelz no Nikki* (Tokyo: Iwanami Bunko), Part 1(2), pp. 51–52.

Japan therefore taught science regardless of their religious concepts, while others upheld their beliefs and disregarded the theory of evolution. For the most part, the former type of presentation appealed more to the Japanese intellectual leaders, and less religiously motivated Western teachers soon became prevalent, particularly at Tokyo University, although this was not the case with the Sapporo Agricultural College where the inspiration of W. S. CLARK was predominant.

In this peculiar period of intellectual history, science was consequently introduced into Japan all the more independently of the humanities and the religious aspect of the Western culture. Moreover, science was taught only in the scientific departments at governmental institutions. On the other hand, Christian institutions in Japan inaugurated by missionaries (mostly from America) concentrated upon the teaching of humanistic phases of Western learning and did not include science as a major field. Consequently, the gap between scientific discipline and humanistic scholarship was there from the beginning, inherent to the Japanese academic world, and is now part of the more serious gap of the "two cultures" of today.[53] How to close the gap and integrate the divided cultures and specialized frontiers of academic attainments has become the task not only of the Japanese but also of all peoples of the world.

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[53] C. P. SNOW, *Two Cultures and Scientific Revolution* (Cambridge, 1959).