• ABSTRACT

*In recent years there has been a vast amount of commentary on the state of Japanese science, little of which has added to our understanding of its social role. This paper explores some of the models which have helped to structure the manner in which the growth of Japanese science has been depicted. While some of the models which are employed may be European by origin, their subsequent use has often been by the Japanese themselves. Models have served to constrain science studies in Japan, and the lack of institutional support has acted to further inhibit activity in the area. It is argued that, despite some exceptions, much of the stimulating work on Japanese science has come from outside the country.*

# The Butterfly and the Frigate: Social Studies of Science in Japan

## Morris Fraser Low

**In recent years, Japanese science** has literally 'taken off'. Paradoxically, social studies of science in Japan have been left far behind. According to Brookman, Japan has produced more historians than any other 'non-Western cultural area'.[1] The History of Science Society of Japan can, furthermore, boast of some 1000 members,[2] and we are told that Japanese scholars tend to stress the social relations of science rather than taking internalist positions.[3] Notwithstanding all of this, social studies of science in Japan today remain in a 'cocoon', or more kindly, in a 'hiatus'.

This paper describes briefly the institutional setting of social studies of science in Japan, and relates this to the approaches historians have adopted and the issues they have examined. Much of the existing literature on Japanese science which has appeared in scientific journals, newspapers, magazines and even history of science publications, draws upon a well-worn range of descriptive models to examine and explain the growth and present-day state of science in Japan. The end result of such

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studies is often a mystification, and the perpetuation of stereotypes which leaves no one much the wiser. Questions such as those posed by a 'colonial science' model are conveniently overlooked by the Japanese, while models emphasizing opposites are employed — nature/organic growth; the 'old' and the 'new'; 'us' and 'them'/East and West; teacher and pupil; copier and copied; and victim and aggressor. All have long been used by scholars of Japan and, of late, Japan itself has become the model. It may be that these models have been instrumental in shaping and structuring images of Japanese science which bear little relation to the practice, past and present, of science in Japan.[4]

## Social Studies of Japanese Science: The Professional Post

The emphasis on science and engineering in the Japanese educational system has not been without cost. The social sciences have for far too long been neglected, and the gap between the 'two cultures' is even more apparent when it comes to funding. Due to the lack of institutional support for the 'history of science' *per se*, social studies of science in Japan remain very much in the domain of 'scientist-historians' who occupy academic positions in fields by other names.

Thus, while Nakayama Shigeru (shortly to retire from the University of Tokyo), Nisio Sigeko (Nihon University), Tsuji Tetsuo (Tōkai University),[5] Watanabe Masao (International Christian University) and Yagi Eri (Tōyō University) continue to be foci for the history of science in Japan, their activities have been augmented by the efforts of such 'scientist-historians' as Konuma Michiji (Keiō University) and his collaborators, Kawabe Rokuo and Laurie Brown.[6] Hayakawa Satio has written many articles from a physicist's point of view,[7] as has Katsuki Atsushi, who has become well known for his painstaking work in the history of solid-state physics.[8] Tamaki Hidehiko and his helpers have continued over the past decade to research Nishina Yoshio.[9] These and other 'scientist-historians', and the academic societies to which they belong, have been particularly active in compiling documentary histories that are thick in pages but lamentably lacking in critical analysis.

The recent rise to prominence of the 'scientist-historian' has created a number of problems — not least of which is the undermining of any claim which the history of science may have as a discipline distinct from, and independent of, the sciences. The appropriation of the title 'scientist-historian' by senior scientists nearing the end of their careers also tends to

work against social studies of science being accorded any separate legitimacy as a field or profession. In a country where seniority is still very much respected, the writings of a renowned scientist have more credibility than those of a humble (and younger) historian. This, combined with the absence of a single dominant figure such as Hirosige Tetu, who died in 1975, has resulted in a hiatus in the history of science in Japan which has lasted over ten years. Although significant books on the social history of science have been written by Itakura Kiyonobu and Nakayama Shigeru,[10] Hirosige's *Kagaku to rekishi* (*Science and History*)[11] and *Kagaku no shakai-shi* (*The Social History of Science*)[12] still remain amongst the most authoritative in the area. A meaningful account of the changes Japanese science has undergone during the last decade has yet to be written.

In the meantime, as for many years in the past, the history of science in Japan is starved of proper academic status and of students. Regularly relegated to the academic periphery, it is slotted into physics departments or colleges of general education. The first Department of History and Philosophy of Science known as such, was established by Tamamushi Bun'ichi in 1951, in the College of Arts and Sciences at the University of Tokyo. In 1970, the Department admitted students to what was then the only formal graduate programme in the field. The Department of Physics at Nagoya University has, however, given doctorates in physics and the history of science to many of the most distinguished Japanese historians of science, including Taketani Mituo,[13] Hirosige Tetu, Nisio Sigeko[14] and Takabayasi Takehiko.[15] This has been to a large extent due to the presence of Sakata Shōichi[16] in the Department of Nagoya.

If we examine the backgrounds of some of Japan's foremost historians of science, common characteristics emerge. Hirosige graduated from Kyoto University in 1952 with, like so many other historians of science, a major in physics. In 1957, he took up a lectureship in the College of Science and Engineering at Nihon University in Tokyo, where he taught the history of science until his death. During this time Hirosige was awarded a doctorate of science by Nagoya University for his work in the history of science, promoted to associate professor in 1967 and made a full professor in 1973. Nisio Sigeko graduated in physics from Ochanomizu Women's University in Tokyo in 1958, worked with Hirosige from 1963 onwards at Nihon University, and took her PhD at Nagoya University in the history of science. As a result of their efforts, a lively group of historians of science still gathers, even today, at Nihon University. From time to time there is some collaboration with Nakayama Shigeru. Nisio is currently vice-editor of *Historia Scientiarum*.

Taketani Mituo was educated at Kyoto University, where he, too, majored in physics. He worked closely with Sakata Shōichi and obtained his PhD in the history of science at Nagoya University. Taketani later taught at Rikkyō University in Tokyo, and for some time has been a freelance writer, mainly publishing through Keisō Shobō. Since Sakata's death in 1970, there has been less emphasis on the history of science at Nagoya University, but still some activity, with the writings of Takabayasi Takehiko, Aramaki Seiya[17] and Hayakawa Satio. In recent years I have begun work on the Sakata archives.

The state of the history of science at Kyoto University, one of Japan's top universities, is rather disappointing, given that the institution is renowned for its liberal education. The Research Institute of Humanistic Sciences at Kyoto has, since 1948, been a major centre in Japan for the history of Chinese astronomy. Yoshida Mitsukuni was, until his recent retirement, based at the Institute and worked mainly in the area of Japanese science and technology of the Meiji period.[18] The establishment of the Yukawa Hall Archival Library at the Research Institute for Fundamental Physics in 1979 attracted great interest from historians and physicists, but Konuma Michiji's move to Keiō University in Tokyo has brought about a sharp decline in the progress being made on the archives.

Much of the activity in the history of science tends to occur in Tokyo. It is no coincidence that the more active historians, such as Nakayama, Watanabe, Yagi[19] and Koizumi,[20] are products of American graduate programmes in the history of science. Despite the presence, in the past, of Watanabe, Itō Shuntarō and Nakayama at the University of Tokyo, differing research interests and personalities have resulted in separate rather than combined activities in Tokyo. While many of the 'younger' historians of science, such as Katsuki (Shinshū University), Yoshioka Hitoshi (Kyūshū University)[21] and Tsuneishi Keiichi (Nagasaki University), have only been able to obtain posts in regional universities, the relative ease of travel means that they and other scholars tend to gravitate towards Tokyo for intellectual stimulation.

Physicist-historians have long dominated the history of science in Japan. Around 1955, nine postgraduate students based in physics departments at the major universities of Tokyo, Kyoto and Nagoya formed a group to study the history of physics: Hirosige Tetu, Tsuji Tetsuo and Tsuneto Toshihiko were based at Kyoto University; Itakura Kiyonobu, Kamikawa Tomoyoshi and Yagi Eri at the University of Tokyo; and Gotō Kunio, Fukuzumi Seiji and Ogawa Tsuyoshi at Nagoya University. The members of this 'group of nine' went on to become major figures in social studies of science and technology in Japan.

Given the rise of the 'scientist-historians', and the strong science backgrounds of the professional science historians, the scientific societies to which the scientists or historians belong have, in turn, each become a hub of activity to rival the History of Science Society. The Physical Society of Japan regularly includes sessions on the history of science in its conference programmes, and has been particularly active in the preservation of archives. Some 'scientist-historians' prefer not to associate with the History of Science Society at all, and are happy to report their research findings to meetings of scientist colleagues. A perceptible tension exists between these 'two cultures', part of which can be attributed to political differences. Nakayama has called for historians of science to work more independently of scientists and their professional societies in order to maintain a critical objectivity about their work. Too close a relationship too often results in triumphal, commemorative essays, or deluxe volumes of collected reminiscences.[22] Yet it is often only by close collaboration with scientists that Japanese historians can obtain access to the archival sources they depend upon, and it is notably the 'scientist-historians' and their collaborators who have been most successful in this regard.

Although the history of physics continues to attract most Japanese historians of science, scholarly works in other areas (such as the history of chemistry, biology, mathematics and medicine) are certainly being produced.[23] This research activity is, however, not apparent in international journals. There is a marked absence of articles by Japanese historians in such journals, and when they do appear it is often in *Historia Scientiarum*, the English language journal published by the History of Science Society. The highly uneven quality of publication in this journal reflects in many ways the state of the discipline in Japan. The Society's Japanese language journal *Kagaku-shi Kenkyū* (*Research in the History of Science*) is much more representative of the diversity of work being conducted in Japan, while its English language abstracts and list of contents enables ready access to its material. A little known journal entitled *Kagaku-shi Kagaku-tetsugaku* (*History and Philosophy of Science*) has been produced every two years by the University of Tokyo as a type of in-house publication for student work, and for commemorative articles for staff who have left or retired. More frequent publication of this journal would provide a welcome alternative to *Kagaku-shi Kenkyū*.

It is perhaps further testimony to the relative stagnation of the Japanese scene that the encyclopaedic *Nihon kagaku-gijutsu-shi taikei* (*Outline of the History of Science and Technology in Japan*)[24] continues to be the general source of reference. The *Taikei* was published as a series of

source books, and as such contains little in the way of probing analysis. This is arguably typical of much work in the history of science produced in Japan. For those unwilling or unable to consult the huge *Taikei*, Yuasa's two volumes on the history of science and technology in Japan provide a field-by-field alternative.[25] Although published only recently, the books are in fact compilations of a series of articles Yuasa wrote in the late 1950s.

In recent years, the Japanese have been active in setting up archives for the papers of Japanese scientists, and in producing tomes of collected historical documents.[26] A project to update the *Taikei* is currently being coordinated by Nakayama. While such work is necessary, especially given the state of libraries and archives in Japan,[27] scholarly work has for far too long concentrated on documenting the history of Japanese science and avoiding much in the way of analysis. Where analysis occurs, it tends to focus on microscopic detail rather than on the broader, macroscopic issues.

Social studies of Japanese science are located on a periphery within the Japanese academic system and in the field of science studies as a whole. Japanese historians of science have felt the need to study the science of other countries, and a survey of the journals will reveal that there is a considerable body of such literature, symptomatic of scholars on a periphery seeking to legitimate themselves by attempting research topics conducted in the centre, but lacking access to its resources. The language barrier still poses one of Japan's greatest problems: there can be a lag of up to a decade or more before a Western work is translated, published and known widely in the history of science community. While such translations are considered a legitimate research activity for Japanese historians, their time and energy could be diverted to more meaningful original work.

This situation is likely to continue into the foreseeable future. Given the domination of the field by the 'scientist-historian' and his/her access to sources and funds, and given the state of graduate programmes in Japan, it is not surprising that much of the stimulating work in social studies of science should come not from Japanese scholars, but from scholars overseas.

## From the Outside Looking In

Since 1962, the OECD has conducted reviews of national science policy in its member countries. As a part of OECD's 'discovery' of Japan as a

major scientific and economic power, T. Dixon Long produced detailed reports on Japanese science policy and the state of its research and development.[28] These are among a number of studies in which Long explored the relationship between science and government in postwar Japan. In others he has added an historical perspective and located Japanese science policy within the context of Japan's overall modernization since the Meiji period.[29] Papers in *Minerva*[30] and *Science Studies*[31] since the late 1960s looked at the role of scientists and engineers in the political process of policy-making, and several later papers have concentrated on technology policy.[32]

During the last fifteen years, James Bartholomew has been the source of studies of Japanese science which continue to provoke and question the stereotypes which abound in the literature. In his work on Kitasatō Shibasaburō and the Japanese bacteriological community, he argues that factionalism and other so-called 'feudalistic' characteristics of the 'traditional' Japanese university system may actually have worked towards, rather than against, the growth of science.[33] Bacteriology is also used as a case study in Bartholomew's investigation of the development of science in Japan in the absence of certain fundamental 'values' normally deemed necessary in Western nations.[34]

Sharon Traweek has recently added another dimension to studies of Japanese science, with ethnographical descriptions in which she observes Japanese 'doing physics' from the vantage point of a participant-observer.[35] By using the 'laboratory studies' approach,[36] Traweek is able to examine some of the most pertinent issues in the practice of Japanese science. She points out five characteristics of the experimental particle physics community in Japan and the United States which can be extended to much of the wider scientific community: (1) its largely male membership; (2) its self-perception as an intellectual élite working at the forefront of science; (3) its distinctions between insiders and outsiders, core and periphery, groups, laboratories and factions; (4) its patron–client relationships; and (5) the importance of oral communication in scientific research.

In her dissertation, Traweek continues studies of the particle physics community by examining the social construction of space and time within that community, and the impact of conceptions of space and time from 'traditional' culture.[37] While some of the science studies literature has dealt with (or alluded to) the issues which Traweek raises in her writings, her use of anthropological methods enables us to understand why certain characteristics of the Japanese scientific community make sense to the Japanese.

## A Colonial Science Model?

Few historians of Japanese science have attempted to suggest sophisticated models for the introduction of modern science into East Asia. More often than not, accounts tend to show a linear progression towards the introduction of European science, even if it is couched in periods familiar to students of European history.

Sugimoto and Swain have, however, created a framework by which they divide various developments of pre-modern science into 'waves' of Chinese and Western science.[38] Nakayama has looked at the paradigm of Chinese astronomy in Japan,[39] and has more recently extended the 'paradigm' concept to other traditional sciences of the Tokugawa period, including medicine, traditional Chinese natural history and mathematics.[40] Nakayama describes the science of the Meiji period (1868–1912) as 'institution-initiated', in contrast to the 'paradigm-initiated' science of the Tokugawa period, as the Meiji government gave priority to institutional systems within which Western paradigms could be accepted without question.

Twenty years ago, Basalla proposed a model for describing the introduction of Western science into non-European countries which he believed to be valid for Japan.[41] The model consists of three overlapping stages. In the first, the country in question acts as a source for European science through scientific expeditions. The second stage consists in the development of a colonial science which is still based on the institutions and traditions of a scientifically advanced nation. The third and final stage is the development of a national science.

Few Japanese historians of science have sought to develop Basalla's model for, as Blussé has noted,[42] the historiography of expansion in Japan has tended to be strongly nationalistic in flavour, and was used before the war to justify Japan's 'right' to expand overseas in Asia. The unpleasant associations of this expansionism ensured that little has been written on the subject since 1945. Marxist historians have tended to see Japanese expansion as basically a result of prewar Japanese fascism. But Blussé sees a new interest in Japanese imperialism in Asia, arising partly as a result of American research.[43]

An argument can be made that the early Dutch and American expeditions to Japan established Japan as a source for European science, but the second stage of Basalla's model (in which a colonial science develops) may be more difficult to substantiate. Many historians have, of course, noted how the Japanese were taught the need to learn Western science and technology 'at the point of a gun' with the arrival of Commodore Perry

and his 'black-ships' in 1853, but few have considered the scientific aspects of such expeditions. *A Scientist with Perry in Japan*[44] gives an account of an agriculturalist, Dr James Morrow, who accompanied the Perry expedition. Cole, in his introduction, writes:

> The spreading of scientific methods and the benefits derived therefrom were integral in the cultural extroversion of Americans and may be regarded as missionary in nature. The Americans had theories, inventions, machines and techniques which they were anxious to demonstrate to the Japanese and others in exchange for scientific data which would add to various departments of knowledge.[45]

Morrow's task was to collect specimens of plants and seeds which were likely to be of benefit to agriculture and of interest to Western scholars and American museums. Upon their return to the United States, Perry and Morrow made a point of quickly publishing their discovery of many new species from among the 1500 to 2000 varieties of specimens which they had taken back with them.[46] As a further example of early American scientific interest in Japan, Pestana has pointed to the possibility that Americans may have conducted geological studies of Japan from as early as 1862.[47]

MacLean has documented and written extensively on the introduction of Dutch books and scientific instruments to Japan during the period 1712 to 1854, through the Dutch Factory on the island of Deshima near Nagasaki,[48] and the return flow of Japanese ethnographical specimens to the Netherlands.[49] He has also studied the role played by Phillipp Franz von Siebold, in the early nineteenth century, in the growth of interest in natural history in Japan,[50] and the importation of Japanese seeds and plants into Europe.[51] In *Rangaku no jidai*, Akagi has placed Siebold's activities and the botanical garden he created on the island of Deshima within the overall context of such gardens, which had been established throughout the world by the British, French and Dutch during the eighteenth and nineteenth centuries.[52]

Basalla's model may thus be of some use in understanding the early scientific interest in Japan shown by the Dutch and Americans, but it is of limited value in describing Meiji science. The Meiji government did its utmost to establish modern science in Japan without having to enter into a 'colonial-type' dependency relationship with an outside power. But what of Japan's colonial empire? This is where Basalla's three stages may find their most interesting application.

Nakayama has mentioned how colonial universities and colleges were established in the 1920s in Seoul, Taipei, Lushun and Manchuria.[53] Scientific research was limited to studies deemed 'necessary for local

development', and pure research in science was considered more appropriately confined to the imperial universities on mainland Japan. Furthermore, Japanese students made up the bulk of the students at these colonial universities.

Hirosige has discussed the colonial science conducted by Japan in various parts of Asia, from the time of the Japanese occupation of Manchuria in 1931.[54] In *The Japanese Colonial Empire, 1895–1945*, Peattie mentions the 'scientific colonialism' operating in Taiwan at the turn of the century,[55] but the topic of colonial science is neglected and Manchuria hardly rates a mention. These omissions are especially unfortunate, as Manchuria is one well-documented case in which a 'colony' provided a source of scientific interest for the Japanese. Historians have to date only highlighted the bacteriological experimentation conducted in Manchuria during World War II,[56] and have not made use of the volumes of scientific reports generated by earlier Japanese surveys. Tsuneishi, for example, has looked at the role of social factors in the formation of a biological warfare unit in Manchuria by a Japanese Army surgeon, Lieutenant Ishii Shiro, in the 1930s and 1940s.[57] He sees the activities of Unit 731 as an attempt on the part of medical doctors in the War Ministry to raise their own status, and he examines why the human experimentation which occurred in Manchuria was treated as an open secret in Japanese medical circles. Tsuneishi points out how many of the medical scientists who participated in these activities were, after the war, appointed to influential positions in the medical world and in private enterprise.

While the concept of colonial science is likely to yield interesting work, a more general model such as made popular by discussion of 'centre-periphery', may be useful in extending any study to contemporary Japanese science.[58] Such an approach would help explain Japan's relations with Asia and the rest of the world, for in many ways the 'centre' has now shifted to Japan.

## Butterflies and Frigates: The Search for an Appropriate Model

So far, we have considered some of the institutional factors which have encouraged the domination of social studies of science by scientist-historians often lacking historical training: the propensity of these scholars to mystify their achievements, and their naïveté in analysis. The remainder of this paper will outline the range of models that have become standard

fare in the social analysis of science and, indeed, in much general commentary on Japan. The models appear in various 'guises' but, for the purposes of this paper, will be grouped and discussed in the following way:

1. '*Butterflies and Frigates*' are models which emphasize the concepts of birth, regeneration, organic growth and the 'new' in describing the emergence of modern science in Japan; models which stress the break between 'traditional' Tokugawa science and the 'modern' science which followed Perry's visit to Japan;

2. '*East and West*' is the often-drawn-upon model which promotes the differences between 'us' and 'them' and over-emphasizes the exotic nature of Eastern culture;

3. '*Teacher and Pupil*' models perpetuate the notion of the subordinate, inferior nature of the Japanese and their supposed continued need to learn from the 'West';

4. the '*Unique Imitator*' is an indication of how far this parody has gone.

Finally, 5. '*Japan as Model*' outlines how Japan itself has become an example for the rest of the world, no longer an exotic 'butterfly' but a threatening frigate on the horizon.

## *Butterflies and Frigates*

It is no coincidence that some of the above-mentioned stereotypes can be found in a well-known Puccini opera, for the Japanese have been importing European myths and stereotypes about themselves for many a year. The provenance of the 'butterfly' may be difficult to trace, but Blussé and Toby have shown how Japanese historiography has mistakenly led to the belief that Japan closed itself from the rest of the world in the 1630s.[59] They point out how the term *sakoku* ('national isolation') was not used at the time by the Japanese, but was actually a concept based on the mistranslation of the impressions of a European visitor (the German physician Engelbert Kaempfer) in the 1690s, which were then brought into Japan in the nineteenth century. The Japanese have perpetuated this and other historical inaccuracies ever since.

Said has argued that Westerners have had a highly Eurocentric view of the Orient which is inconsistent with a 'real' Orient,[60] and Wilkinson has examined how the European image of Japan has purveyed inaccurate stereotypes.[61] What both writers have failed to agree is the degree to which Europeans in the Orient, or the Japanese themselves, have been responsible for the continuation of such stereotypes.[62]

Yuasa, in the fashion of many Japanese writers, has likened the growth of scientific communities in Japan to the life of a butterfly.[63] The 'green caterpillar' of ancient times spins a cocoon and slowly undergoes metamorphosis during Japan's so-called period of 'National Isolation'. The pupa reaches its maturation in 1853 with the coming of the American frigates, since when, according to Yuasa, the butterfly has been in flight. Yuasa's butterfly has been used by Ichikawa Kikuga to explain the myth of the lack of Japanese creativity.[64] Research and development in science and technology is likened to a green caterpillar which assumes a form appropriate to the times. It changes slowly with time, and responds creatively to changes in its environment. The gradual process only appears sudden when the pupa becomes a butterfly, and according to Ichikawa, the butterfly is about to fly. Such broad categorizations, while visually and chronologically appealing, tend to do violence to our understanding of Japanese science by favouring a simple, linear, 'natural' picture of growth.

Similarly, it is fashionable to refer constantly to the changes which Japan has undergone, in comparison with developments in the West.[65] In the process, the role of traditional Japanese science has been neglected. In the 1960s, Yuasa attempted to introduce Butterfield's concept of a 'scientific revolution' into Japanese modern history by arguing that science in pre-Meiji Japan bore similarities to science in pre-Renaissance Europe. He likened the 'overthrow' of Buddhism and Confucianism, and the rapid installation of Western science, to a Japanese version of a scientific revolution.[66] Yuasa equated the establishment of modern science with the beginning of modernization,[67] and, in his opinion, Japan's modernization begins with the Meiji Restoration. Such a view has been shared by many Japanese. In 1876, the German physician Erwin Baelz wrote that, when he enquired about Japanese history, he was given the blunt rejoinder: 'We have no history. Our history begins today'.[68]

Although much history of science still deals in terms of conventional Japanese history, some scholars have gone beyond such confines. As Stanley has noted,[69] the periodization of modern Japanese history by 'events' — whether the Meiji Restoration or the reigns by certain Emperors — artificially isolates periods, and highlights discontinuities over continuities. In contrast, Sugimoto and Swain have surveyed the development of science in Japan from AD 600 to 1854.[70] While preserving the conventional periodization of Japanese history, they have superimposed a scheme of 'cultural waves' and 'interims' in order to place science within a wider social and intellectual context. The influence of Chinese culture is depicted as two waves of cultural influx, as is that emanating

from the West. Although the scheme which Sugimoto and Swain propound is not new, it is developed and integrated with historical data in a scholarly manner unusual in the historiography of Japanese science.

Other scholars have questioned chronological divisions, and examined supposed discontinuities in detail. The relationship between *rangaku* ('Dutch studies') in the Tokugawa period (seventeenth to mid-nineteenth centuries) and the intensive modernization which Japan underwent in the subsequent Meiji period, has been particularly at the centre of debate. While the relative importance of *rangaku* may be disputed, a plausible argument can be made that the origins of modern science can be found in the seventeenth century. Itō Shuntarō has long argued that *rankagu* formed the basis for Meiji science.[71] But, as Sleeswyk has also noticed,[72] other Japanese historians such as Watanabe and Yuasa tend to differ, and to view modern science as beginning in 1868. Jansen and Bartholomew have each recently argued for continuity between Tokugawa science and the establishment of Western science in the nineteenth century,[73] in opposition to the findings in the existing literature by scholars such as Dore, Koizumi, Numata, Craig, Goodman and Nakayama.[74]

The Meiji Restoration has provided Japanese historians with a convenient date by which to begin the 'new' and end the 'old'. There have, however, been some notable exceptions, and their work and methods are of great interest. Kanamaru,[75] for example, has looked at the successful introduction of Western science and technology in Japan by examining the *rangaku* and *yōgaku* ('Western learning') communities in the nineteenth century. He has traced the social background, education and activities of 300 scholars, and has analyzed how they were recruited to their particular roles in science and technology. Kanamaru suggests that while there was a possibility of a real science being established, scholars succumbed to devoting themselves to translation (of scientific texts), rather than to observation of natural phenomena. Their translation skills became highly sought after and a means to social elevation, rather than to learning for its own sake.[76]

One of the most significant works to appear in the literature dealing with *rangaku* and *yōgaku*[77] must be Wakabayashi's study of the social and political impact of Western learning in the writings of a Japanese Confucian named Aizawa Seishisai.[78] Wakabayashi points out how Western learning provided the feudal government with a means by which it could resist the West; how the *rangaku* scholar Takahashi Kageyasu proposed the 1825 Expulsion Edict; and how other scholars of Western learning, such as Takano Chōei and Watanabe Kazan, were in favour of excluding Westerners and maintaining national isolation.

Imposing European intellectual developments such as those conveyed by the 'scientific revolution' on to an Asian setting may have unfortunate results,[79] but Bartholomew has used the concept of scientific revolution to ask why one did not occur in Tokugawa Japan.[80] He suggests that certain features of Japanese social structure in the eighteenth and nineteenth centuries may have provided the full-scale union of theory with observation, and argues that the non-prestigious image of mathematics, and the social class backgrounds of its practitioners, inhibited collaboration with the samurai who had taken an interest in (and control of) the physical sciences. Iwauchi has also found it useful to look at the question of class, to ask how a type of hierarchy was formed by institutions in the formation of various levels of technical manpower in Meiji Japan.[81] Takeda has attempted to describe the transformation which Japanese science underwent during the nineteenth century, and the institutions which helped facilitate it.[82] Ōya Shin'ichi has provided a novel approach to Tokugawa science by producing what can be described as a walking guide to the various remaining monuments and historic sites commemorating the early Japanese scientists of the Edo period.[83]

It is reassuring to see that some scholars have refrained from analytical models based on 'butterflies' and 'frigates', but a more prevalent and fundamental model, 'East and West', has been difficult to abandon.

## *East and West*

Historians of Japanese science, like so many other scholars of Japan, have contributed to an 'Orientalist' discourse which tends to isolate the 'East' from the 'West'. Said sees 'Orientalism' as 'ultimately a political vision of reality whose structure promoted the difference between the familiar (Europe, the West, "us") and the strange (the Orient, the East, "them")'.[84] An order of 'sovereignty' is consequently created,[85] which emphasizes the superiority of the West over the Orient.

Minear has noted that Japan scholars have tended to lump Japan in the same category as China and Korea,[86] and that this East–West division was widespread at least through the 1960s. Nakayama has referred to historians who have projected their picture of the influence of missionaries on Chinese science in the seventeenth century on to that of Japan, by suggesting that the Jesuits systematically introduced the 'superior' Western astronomy to Japan as a means of converting the Japanese to Christianity.[87]

This abstract categorization of 'the East' and 'the West', along with the

periodization of Japanese history, have tended to highlight differences between Chinese and Western science in Japan. But the influence of Chinese science on Western science is still a much-debated question. Bartholomew has found that over half of the Japanese scientists during the Meiji period (1868–1912) had fathers who observed traditional forms of learning, including Chinese medicine, Confucianism, *wasan* mathematics and *rangaku*. As Bartholomew points out, 'these continuities appeared despite intellectual differences between European and Japanese science'.[88] Grant Goodman and others consider that the *rangaku* experience was more important for attitudes towards science and the awareness that it created, rather than for its content and continuity.[89] Yoshida Tadashi speculates that, given time, the Japanese may have made significant achievements within the *rangaku* tradition.[90] The all-out introduction of Western science and technology by the Meiji government put any possibility of this to an end.

The model of two systems of learning — 'Eastern' and 'Western' — is still used to provide a basis for comparative studies. The results and conclusions of such studies are inevitably as artificial as the framework of the questions which are asked. In *When the Twain Meet*, John Bowers portrays Chinese and Western medicine as 'fundamentally divergent' and in conflict with each other.[91] This polarization of the two tends to neglect the interaction between the two systems and their coexistence in a pluralistic system of medical care which still persists in Japan even today. Steslicke[92] suggests that the term 'cosmopolitan medicine', advocated by Charles Leslie,[93] is more appropriate in describing the medical model which has evolved throughout the world from albeit 'Western' beginnings. The concept of 'cosmopolitan' or 'metropolitan' science may indeed offer a better framework within which to consider the science which is operating in Japan, rather than the East–West distinction which has been used so very often in the past.

Today, Nakayama et al., *Science and Society in Modern Japan*,[94] remains the standard English language text on the social history of modern Japanese science and its historiography. Yuasa's period of the butterfly is portrayed in this volume as a time of complex interaction between political, economic, cultural and educational factors acting on developments in science and technology. But, more recently, Nakayama has portrayed the shape and direction of postwar Japanese science and technology as determined by the power relations between four sectors — public, private, civic and academic, and between state-organized science, industrial science, academic and service-oriented sciences.[95]

While some models have thus been able to transcend simplistic notions

of 'Eastern' and 'Western' science, and 'butterflies' and 'frigates', a third category, 'teacher and pupil', combines features of both.

### *Teacher and Pupil*

The 'teacher and pupil' model reinforces the idea that a long-term, one-way traffic in knowledge has occurred from 'West' to 'East'. The resulting pleasant picture of maternal, Western benevolence may be useful in promoting US–Japan relations, but like 'butterflies', tends to limit any meaningful critique.

There is a large amount of literature dealing with the foreign teachers who were hired early in the Meiji period to facilitate the introduction of Western science and technology in Japan. As Gluck has noted,[96] the literature tends to divide into two broad approaches. One tends to highlight and focus on the experiences of the individual, while the other attempts to gauge the effect of the *oyatoi gaikokujin* ('hired foreigners') on Japan's modernization. While the former results in some 'picturesque' biographical accounts of the foreign teachers who ventured to Japan in the nineteenth century, what tends to be neglected is the fact that the Japanese were firmly in control of the situation. As Jones has written, the...

> ...policy of employing foreigners was accepted for its immediate advantage of gaining needed knowledge and technology rapidly but was subordinate in theory if not always in fact to the principal means of modernizing, the training and replacement of foreign employees by Japanese.[97]

The continued emphasis of the role of the *oyatoi* tends to reinforce an inaccurate teacher–pupil model which has been built around Japan's relations with the West, especially the United States. Watanabe Masao is well known for his meticulous work on the introduction of modern science by American teachers. Through numerous case studies, he seeks to reveal the inherent problems associated with the transfer of Western science into the Japanese context. His book, *Die Japaner und die moderne Wissenschaft*,[98] includes a discussion of the contributions of Edward Morse and John Thomas Gulick to the introduction of evolutionary theory in Japan. Shimao Eikoh has also studied Darwinism during the period 1877 to 1927.[99] While such work holds considerable interest, the authors sometimes neglect significant issues. By contrast, Hara has emphasized the importance of the replacement of the *oyatoi* by Japanese students who had returned from abroad.[100] He sees this replacement of foreign teachers by Japanese as 'indirect Westernization'. He contrasts

Japan with other countries in Asia which had undergone long periods as colonies under so-called 'direct Westernization'. It is this point which arguably gives greatest meaning to the story of the *oyatoi*.

### *Japan: The Unique Imitator*

The warm and wholesome picture of a 'teacher and pupil' is often applied to nineteenth-century Japan, but with Japan's subsequent rise in economic power the terms of endearment change. In the twentieth century, Japan becomes the mindless imitator and competitor for markets — on the one hand a 'copier', and on the other 'unique'.

Inkster has pointed to the fallacy of regarding Japan as a slavish imitator, and has emphasized that processes of technological adaptation, as opposed to adoption, were at work in the diffusion of technology.[101] Yet Japanese scholars have enthusiastically taken up the idea of the 'unique imitator', claiming that the Japanese lack creativity and merely borrow from other cultures. Even the Nobel physicist Yukawa Hideki has testified to it, and Nakayama and Watanabe have not been averse to this form of cultural determinism in science.[102] The paradox is that the Japanese see the 'irrationality' of their ways as an indication that they are indeed different from other races and nations. Some speculate that one of the reasons why a 'scientific revolution' never occurred in Japan is because the people lacked a mechanical view of nature.[103] Tsunoda has recently attempted to provide conclusive evidence of the supposedly unique structure of the Japanese brain, which allows the Japanese to have a special affinity with nature and to think less logically than Westerners.[104] He claims to have shown that the two hemispheres of the brain differentiated between the sounds they processed, and, more importantly, that the brains of Japanese and Westerners differed in their auditory dominance patterns. The left hemisphere of the Japanese brain, Tsunoda claims, tends to handle logical processes, emotional functions, and the Japanese affinity with nature, whereas the right hemisphere processes only harmonic and mechanical sounds. This differs from the Western brain in which, supposedly, the left side only processes linguistic and logical functions, and leaves all other functions to the right.

Other Japanese scholars have considered the Japanese language as illogical and an impediment to scientific thinking. Hada has looked at the movement to romanize Japanese during the American Occupation, and has attempted to pinpoint some of the socio-political factors which resulted in its failure.[105] Bartholomew has suggested that the idea of the

Japanese as irrational imitators has downplayed the importance of the universities in social change.[106] Bartholomew claims that Japanese leaders in the late nineteenth and early twentieth centuries in fact saw 'the expansion of scientific knowledge as the principal means of achieving national power',[107] and that the 'political modernization' paradigm in Japanese studies has helped to overlook this. Given that Bartholomew's argument has some credibility, how have the Japanese been able to reconcile a desire for a national identity and their tradition of cultural borrowing?

Some Japanese have responded by arguing for a type of dualism, whereby the Western influence imposed on the Japanese by their modernization has only been 'skin deep'. Under a veneer, there lies the Oriental.[108] Japanese culture is thus seen as a dichotomy between 'East' and 'West', and the Japanese are seen as suffering from long-term schizophrenia.[109]

The excessive amount of literature dealing with the question of Japan's uniqueness has been dubbed '*nihonjin-ron*', as it relates to the national and personal identity of the Japanese people. A type of cultural,[110] and at times 'scientific', nationalism,[111] *nihonjin-ron* writings are an attempt to overcome the sense of inferiority to the West,[112] and their isolation from the rest of the world. Some see the problem behind the Japanese assimilation of Western science as being a result of the 'feudalistic values' of traditional Japanese science rather than the irrationality of the Japanese.[113] Either way, the Japanese nevertheless end up being portrayed as somewhat different or unique. But as Stockwin has written, 'Japan is neither unique (as sometimes asserted), nor merely a copy of the outside world'.[114] The paradox is that the Japanese are now the ones who are copied, and Japan has become the model.

### *Japan as Model*

In the 1970s and 1980s, the world has looked to Japan as a possible developmental model. A number of monographs have been written on Japanese science policy, such as McGaffigan and Langer's *Science and Technology in Japan*,[115] and Alun Anderson's comprehensive guide to Japanese science and technology.[116] Although the 'copy Japan' movement has developed beyond sensible limits, some writers have gone to the opposite extreme and used the uniqueness argument to argue that the reception of science in Japan represents a special case which is not repeated elsewhere.[117] The Japanese are increasingly seen as a type of

Asian superman — held in awe by the rest of the world — which acts as one to conspire against other nations.[118] Behind the facade of a democratic nation lurks 'Japan Incorporated'. Closely linked with this idea is the perception of Japan as a consensus society, one of many images drawn upon by Westerners coming to terms with Japanese science.

Hoddesdon has suggested that Japan's so-called 'tradition' of decision-making by common consensus was a major factor behind the long delays in the construction of the KEK National Laboratory for High Energy Physics.[119] The 'democratic' decision-making structure brought about by the Science Council of Japan, and the lack of confidence of the Japanese scientific community in their first major foray into 'big science', are consequently neglected in favour of supposed national traits.

The language of war is, as Dower has pointed out,[120] often used to describe the activities of the Japanese, and when this is insufficient, 'expert commentators' feel no qualms about drawing on models which help to mystify what they do not understand. For example, Marvin J. Wolf views Japanese science and technology as part of a massive conspiracy aimed at world domination. He sees the United States as victim of Japanese aggression.[121] Not surprisingly, the Japanese, too, have long considered themselves a 'victim' of technology, but in their case, just made in the United States. Charles Lummis writes that Japan stubbornly adheres to the notion that it was defeated by American 'know-how' during World War II, rather than by an alliance of forces that included Asians. He points out that to think otherwise would mean drawing a very different set of lessons from the war.[122] The Japanese are reluctant to consider themselves as aggressors, for they are a people 'wronged' by the atomic bomb. This is not unrelated to the disinclination of Japan scholars to explore the subject of Japanese colonial science in Asia. It is, however, inevitable that historians must one day explore the imperialistic undertones of the spread of Japanese science and technology throughout the world. Naturalistic models and representation are no longer sufficient. The 'butterfly' has flown.

## Conclusion: Looking to the Future

Since the late nineteenth century, the Japanese have felt the need to liken Japan's modernization to the historical development of Western nations. The pre-World War II generation of science historians, such as Taketani, perceived in the Marxist approach to the history of science a universal theme of scientific development. Hirosige and other postwar historians

were sceptical of this, and instead attempted to construct a social history of Japanese science which focused on the new factors affecting science after the war. With the loss of Hirosige in the mid-1970s, social studies of Japanese science lost direction, and entered a period of stagnation from which they have still yet to recover.

In the late 1970s and early 1980s, concerted moves to preserve the papers and archives of scientists by scientific societies in the US, UK and Japan saw the rise to influence of scientist-historians. The emergence of Japan as a 'superpower' in the same period encouraged a rash of Japan commentaries which attempted to explain the economic miracle in terms of the models which this paper has described.

The Japanese, too, have been looking for answers in an attempt to come to terms with their own scientific and technological progress. Their choices, as we have seen, have been limited to concepts which, while seeming to describe and explain, tend to reinforce the idea of the cultural autonomy of the Japanese, stressing dichotomies, couched in opposites. The recent shift of Japan to centre stage, as a world economic power, calls for new methods of understanding. Japanese histories of science have been slow to respond to the new situation. With or without the help of 'outsiders', social studies of science remain in a chrysalis, waiting to be awakened.

## • NOTES

Throughout this paper, Japanese proper names are given in the traditional manner of 'family name' first and 'given name' last. However, in the Notes, the names of Japanese authors are given in the Western fashion. I would like to thank Shigeru Nakayama, Sigeko Nisio, Masao Watanabe and Eri Yagi for their careful readings of this essay, and Roy MacLeod for his editorial advice throughout. Responsibility for the comments and opinions expressed in this paper rests solely with the author.

1. F. H. Brookman, 'The History of Science in the Non-Western World: An Inventarisation of Some Important Works During the 20th Century', *Historia Scientiarum*, No. 25 (September 1983), 93–100.

2. History of Science Society of Japan, *Nihon Kagaku-shi Gakkai kaiin meibo* (*List of Members of the History of Science Society of Japan*) (Tokyo, 1985).

3. S. Nakayama, 'The History of Science: A Subject for the Frustrated', in Nakayama, D. L. Swain and E. Yagi (eds), *Science and Society in Modern Japan: Selected Historical Sources* (Tokyo: University of Tokyo Press, 1974), 3–16.

4. To date, little attempt has been made to survey the field apart from J. R. Bartholomew,

'An Annotated Bibliography of English Language Works on the Social History of Modern Japanese Science', in Nakayama, Swain & Yagi (eds), op. cit. note 3, 312–25.

5. Apart from Taketani's Marxist writings on the philosophy and methodology of science, there is little literature available on the philosophy of Japanese science. The following volume by Tsuji presents an historical outline and discussion of the philosophy of science in Japan: T. Tsuji, *Nihon no kagaku shisō* (*Japanese Scientific Thought*) (Tokyo: Chūō-kōron-sha, 1973).

6. All three are well known for their research on Yukawa Hideki. For example, see: R. Kawabe and M. Konuma (eds), *Source Materials of Hideki Yukawa on Meson Theory* (Kyoto: Organizing Committee for Kyoto International Symposium: Jubilee of the Meson Theory, Research Institute for Fundamental Physics, Kyoto University, 1985); L. M. Brown, 'Hideki Yukawa and the Meson Theory', *Physics Today* (December 1986), 55–62. They are currently working on a history of elementary particle theory in Japan.

7. See, for example, S. Hayakawa, 'The Development of Meson Physics in Japan', in L. M. Brown and L. Hoddeson (eds), *The Birth of Particle Physics* (Cambridge: Cambridge University Press, 1983), 82–107.

8. A. Katsuki, 'KS jishaku-kō no hatsumei katei' ('On the Process of the Invention of K.S. Magnet Steel by Honda and Takagi'), *Kagaku-shi Kenkyū*, Series 2, Vol. 23, No. 150 (Summer 1984), 96–109; No. 151 (Autumn 1984), 150–61.

9. The group has recently published some of Nishina's correspondence. For example, see Y. Nishina, *Y. Nishina's Letters to N. Bohr, G. Hevesy and Others* (Tokyo: Nishina Memorial Foundation, 1985); H. Tamaki, 'Wareware no Nishina Yoshio kenkyū' ('Our Research on Yoshio Nishina'), *Kagaku-shi Kenkyū*, Series 2, Vol. 26, No. 163 (Autumn 1987), 184–86.

10. K. Itakura, *Kagaku to shakai* (*Science and Society*) (Tokyo: Kisetsu-sha, 1971); S. Nakayama, *Kagaku to shakai no gendai-shi* (*A Modern History of Science and Society*) (Tokyo: Iwanami Shoten, 1981).

11. T. Hirosige, *Kagaku to rekishi* (*Science and History*) (Tokyo: Misuzu Shobō, 1965, 1970).

12. T. Hirosige, *Kagaku no shakai-shi: Kindai Nihon no kagaku taisei* (*The Social History of Science: The Organization of Modern Japanese Science*) (Tokyo: Chūō-kōron-sha, 1973). Hirosige was the first Japanese science historian to bring an international standard of scholarship to the social history of Japanese science. His series of ten articles on postwar Japanese science movements which appeared in the science magazine *Shizen* (*Nature*) from May 1959 to June 1960, and later published as T. Hirosige, *Sengo Nihon no kagaku undō* (*Science Movements in Postwar Japan*) (Tokyo: Chūō-kōron-sha, 1960), are considered to be his first major contributions to social history. Like many Japanese historians, Hirosige sought to come to terms with the gap between internal and external histories of science, but he was never able successfully to reconcile the two in his own work. His articles on the history of atomic theory tend to be written in an internalist fashion, while other studies are decidedly less so. See T. Hirosige (ed. S. Nisio), *Hirosige Tetu kagaku-shi ronbunshū, 2: Genshi-kōzō-ron-shi* (*Collected Papers of Tetu Hirosige on the History of Science, Volume 2: The History of Theories of the Atomic Structure*) (Tokyo: Misuzu Shobō, 1981). This fluctuation between approaches is typical of much of the work of Japanese historians. It is due, in part, to the heavily science-oriented background of most Japanese historians of science, on the one hand, and their feelings of social responsibility for science, on the other.

13. For a comprehensive list of books written by Taketani, see M. Taketani, *Shisō o oru* (*The Interweaving of Ideas*) (Tokyo: Asashi Shinbun-sha, 1985), 203–06. In the

immediate postwar period, the Marxist-inspired writings of the physicist Taketani had a major impact on Japanese intellectuals. Taketani's philosophical and historical accounts of Japanese science, as well as his writings on the social problems facing postwar Japan and the role of science in solving them have earned him a considerable following in that country. Two scholars who have been profoundly influenced by him are Yoshirō Hoshino (social studies of technology) and Takeshi Kawakami (history and social commentary on the state of medical care in Japan). Kawakami, a medical practitioner, deserves to be much better known, but because he is outside the academic mainstream, and his 'non-scientific' research area, he tends to be only accorded limited recognition within the physics-dominated history of science community in Japan. In terms of the significance of his work he could perhaps be labelled the 'Foucault of Japan'. Kawakami has published extensively through the progressive publishing house Keisō Shobō. In many of his works, Kawakami looks at the problems of contemporary medical care in Japan from an historical perspective. He views the history of medicine in Japan as the negation of Chinese medicine and the institutionalization of Western medicine. Despite the breakdown of the feudal hierarchy in the medical world which existed during the Tokugawa period, Kawakami contends that forms of prejudice remain, and that these were manifested in the form of medical education which was created. See, for example, T. Kawakami, *Iryō no fukken no tame ni: Kaigyō-i, chiimu iryō, iryō-shi* (*A Call for the Rehabilitation of the Medical System: Physicians, Team Medical Treatment and the History of Medical Care*) (Tokyo: Keisō Shobō, 1975); Kawakami, *Gendai Nihon byōnin-shi: Byōnin shogū no hensen* (*A History of the Sick in Modern Japan: Transition in the Treatment of the Ill*) (Tokyo: Keisō Shobō, 1982).

The molecular biologist Atuhiro Shibatani has long called for changes in the Japanese scientific world. His writings on science and science criticism over a twenty-year period are contained in A. Sibatani, *Kagaku-sha wa kawatta ka* (*Have Scientists Changed?*) (Tokyo: Asahi Shuppan-sha, 1981); and his well-known book *Han-kagaku-ron* (*Anti-scientism*) (Tokyo: Misuzi Shobō, 1973) calls for a more intuitive and humane approach to knowledge. Hitoshi Yoshioka, the most promising young scholar working in the area of science studies in Japan today, surveys science criticism in his important book *Kagaku-sha wa kawaru ka: Kagaku to shakai no shisō-shi* (*Will Scientists Change?: The History of Ideas of Science and Society*) (Tokyo: Shakai-shisō-sha, 1984), esp. 108–25. See also H. Yoshioka, *Kagaku shakai-gaku no kōsō: hai-saiensu hihan* (*The Construction of a Sociology of Science: A Criticism of High Science*) (Tokyo: Riburopōto, 1986); and Yoshioka, *Kagaku kakumei no seiji-gaku: Kagaku kara mita gendai-shi* (*The Politics of the Modern-Day Scientific Revolution: Contemporary History from the Perspective of Science*) (Tokyo: Chūō-kōron-sha, 1987).

There is a large amount of descriptive literature dealing with scientist movements, the bombing of Hiroshima and Nagasaki, and the anti-nuclear movement which relates to this area of science studies. Recent works include: Committee for the Compilation of Materials on Damage Caused by the Atomic Bombs in Hiroshima and Nagasaki (trans. E. Ishikawa and D. L. Swain), *The Impact of the A-Bomb: Hiroshima and Nagasaki, 1945–85* (Tokyo: Iwanami Shoten, 1985); S. Iijima, T. Toyoda and Z. Maki, *Kaku haizetsu wa kanō ka* (*Is Abolition of Nuclear Armaments Possible?*) (Tokyo: Iwanami Shoten, 1984). Few works, however, have the insight of G. D. Hook, 'The Nuclearization of Language: Nuclear Allergy as Political Metaphor', *Journal of Peace Research*, Vol. 21, No. 3 (1984), 259–75. Hook looks at how the metaphor of nuclear allergy was used in the late 1960s as a means of branding those opposed to Japan's nuclearization as 'abnormal'.

The anti-nuclear power movement has recently gained more momentum in Japan, with the popular writings of Takashi Hirose having a major impact on the general public. See,

for example, T. Hirose, *Tōkyō ni genbatsu o! (An Atomic Power Plant in Tokyo!)* (Tokyo: Shūeisha, 1986); Hirose, *Jon Wein wa naze shinda ka? (Why did John Wayne die?)* (Tokyo: Bungei Shunjū, 1986).

14. For recent work see, for example, S. Nisio, 'The Transmission of Einstein's Work to Japan', *Japanese Studies in the History of Science*, No. 18 (1979), 1–18. Nisio is currently working on a history of nuclear fusion in Japan.

15. See, for example, T. Takabayasi, 'Some Characteristic Aspects of Early Elementary Particle Theory in Japan', in Brown & Hoddeson (eds), op. cit. note 7, 294–303; Takabayasi, *Soryūshi-ron no kaitaku (The Development of Elementary Particle Theory)* (Tokyo: Misuzu Shobō, 1987).

16. See S. Sakata, *Butsuri-gaku to hōhō: Ronshū 1 (Physics and Method: Collected Papers, Volume 1)* (Tokyo: Iwanami Shoten, 1972); Sakata, *Kagaku-sha to shakai: Ronshū 2 (Scientists and Society: Collected Papers, Volume 2)* (Tokyo: Iwanami Shoten, 1972).

17. See, for example, S. Aramaki, 'Formation of the Renormalization Theory in Quantum Electrodynamics', *Historia Scientiarum*, No. 32 (1987), 35–42.

18. See, for example, M. Yoshida, *Oyatoi gaikokujin: Sangyō (Hired Foreigners: Industry)* (Tokyo: Nihon Hōsō Shuppan Kyōkai, 1970); Yoshida, *Kikai (Machines)* (Tokyo: Hōsei Daigaku Shuppan-kyoku, 1974); Yoshida, *Gijutsu to Nihon kindaika (Technology and Japan's Modernization)* (Tokyo: Nihon Hōsō Shuppan Kyōkai, 1977); Yoshida (ed.), *Jūku seiki Nihon no jōhō to shakai hendō (Information and Social Change in Nineteenth-Century Japan)* (Kyoto: Research Institute of Humanistic Science, Kyoto University, 1985); Yoshida (ed.), *Bankoku hakuran-kai no kenkyū (Studies on International Exhibitions)* (Kyoto: Shibunkaku, 1986); Yoshida, *Nihon kagaku-shi (A History of Japanese Science)* (Tokyo: Kōdansha, revised edition 1987).

19. See especially K. Itakura, T. Kimura and E. Yagi, *Nagaoka Hantarō den (Biography of Nagaoka Hantarō)* (Tokyo: Asahi Shinbunsha, 1973); Nakayama, Swain & Yagi, op. cit. note 3.

20. See K. Koizumi, *The Development of Physics in Meiji Japan: 1868–1912* (unpublished PhD dissertation, University of Pennsylvania, 1973); Koizumi, 'The Emergence of Japan's First Physicists: 1868–1900', *Historical Studies in the Physical Sciences*, Vol. 6 (1975), 33–108.

21. Yoshioka, op. cit. note 13.

22. S. Nakayama, 'Tenbō: Sengo kagaku-gijutsu-shi' ('A Survey of the History of Postwar Science and Technology'), *Kagaku-shi Kenkyū*, Series 2, Vol. 23, No. 150 (Summer 1984), 67–72.

23. For chemistry, see M. Ōnuma and T. Dōke, 'Recent Studies in Japan on the History of Chemistry', *Japanese Studies in the History of Science*, No. 12 (1973), 5–14. Recent studies include K. Hirota, *Meiji no kagaku-sha: Sono kōsō to kujū (Chemists of the Meiji Period: Disputes and Bitter Experiences)* (Tokyo: Tokyo Kagaku Dōnin, 1988); Chemical Society of Japan (ed.), *Nihon no kagaku hyaku-nen-shi: kagaku to kagaku kōgyō no ayumi (The 100 Year History of Chemistry in Japan: The Story of Chemistry and Chemical Engineering)* (Tokyo: Tokyo Kagaku Dōnin, 1978).

For biology, see Z. Suzuki, 'Recent Studies in the History of Biology by Japanese Historians', *Japanese Studies in the History of Science*, No. 11 (1972), 11–21. Teiri Nakamura has been one of the most active scholars in the social history of biology in Japan. See, for example, T. Nakamura, 'Seibutsu kagaku kenkyū ni okeru kokka to kigyō no yakuwari' ('The Role of the State and Industry in Research in the Biological Sciences'), *Kagaku-shi Kenkyū*, Series 2, Vol. 1, Part 4, No. 64 (October–December 1962), 145–50. See also M. Watanabe (ed.), *Daawin to shinka-ron (Darwin and the Theory of Evolution)*

(Tokyo: Kyōritsu, 1984). Publishing houses such as Kōsakusha have, in recent years, attempted to woo young Japanese readers to science studies by attractive book design. See T. Okada (ed.), *Ōganizumu no kansō* (*The Physiognomy of the Organism*) (Tokyo: Kōsakusha, 1980); H. Aramata, *Medama to nō no dai-bōken: Hakubutsu-gaku-sha-tachi no jidai* (*The Great Adventure of the Eye-Ball and the Brain: The Age of the Natural Historians*) (Tokyo: Chikuma Shobō, 1987). For zoology, see M. Ueno, *Nihon dōbutsu-gaku-shi* (*A History of Japanese Zoology*) (Tokyo: Yasaka Shobō, 1987).

The literature on the history of mathematics is described in K. Honda, 'A Survey of Japanese Mathematics during the Last Centenary', *Japanese Studies in the History of Science*, No. 16 (1977), 1–15. As in physics and chemistry, there is also the deluxe set of volumes commemorating 100 years of mathematics: see Editorial Committee, *Nihon no sūgaku 100-nen-shi* (*The 100 Year History of Mathematics in Japan*), 2 Vols (Tokyo: Iwanami Shoten, 1983).

For the history of medicine, see the bibliography of J. Z. Bowers, *When the Twain Meet: The Rise of Western Medicine in Japan* (Baltimore, MD: Johns Hopkins University Press, 1980), 161–68. Thanks to the writings of Kawakami, social studies of medicine in Japan arguably offer some of the most stimulating literature available in science studies. See, for example, E. Namihira, *Byōki to chiryō no bunka jinrui-gaku* (*The Cultural Anthropology of Illness and Medical Care*) (Tokyo: Kaimeisha, 1984). For a more traditional approach, see S. Yamamoto, *Nihon korera-shi* (*A History of Cholera in Japan*) (Tokyo: University of Tokyo Press, 1982); S. Sakai, *Nihon no iryō-shi* (*A History of Medical Care in Japan*) (Tokyo: Tokyo Shoseki, 1982).

Also highly useful are the annual Japanese language bibliographies compiled by Hiroshi Ishiyama and others. For an example, see H. Ishiyama, K. Ōmori and Y. Tamagawa, 'Kagaku-gijutsu-shi kankei nenji bunken mokuroku (1985-nen 1–12 gatsu)' ('Annual Bibliography on the History of Science and Technology for 1985'), *Kagaku-shi Kenkyū*, Series 2, Vol. 25, No. 159 (Autumn 1986), 165–223. For a very general guide to research tools in the history of Japanese science, see S. Nakayama and H. Ishiyama, *Kagaku-shi kenkyū nyūmon* (*Introduction to Studies in the History of Science*) (Tokyo: University of Tokyo Press, 1987).

24. History of Science Society of Japan, *Nihon kagaku-gijutsu-shi taikei* (*Outline of the History of Science and Technology in Japan*), 25 Vols (Tokyo: Dai-ichi Hōki, 1964–70). For a description of the contents in English, see M. Yuasa, 'History of Science and Technology in Japan', *Japanese Studies in the History of Science*, No. 10 (1971), 1–16.

25. M. Yuasa, *Nihon no kagaku-gijutsu-100-nen-shi* (*A 100 Year History of Japanese Science and Technology*), 2 Vols (Tokyo: Chūō-kōron-sha, 1980, 1984).

26. For example, see Physical Society of Japan, *Nihon no butsuri-gaku-shi* (*The History of Physics in Japan*), 2 Vols (Tokyo: Tōkai University Press, 1978).

27. See Borsa's impressions of the state of archives in Japan, in 'Archives in Japan', *Journal of the Society of Archivists*, Vol. 7, No. 5 (1984), 287–94.

28. For example, OECD (T. Dixon Long rapporteur), *Reviews of National Science Policy: Japan* (Paris: OECD, 1967); Long, 'Science Policy in Japan', *OECD Observer*, No. 28 (June 1967), 32–37.

29. T. D. Long, 'Development of Modern Science Policy in Japan', in A. W. Cordier (ed.), *Columbia Essays in International Affairs: The Dean's Papers, 1965* (New York: Columbia University Press, 1966), 205–25; Long, 'Science and Government in Japan', *Sartryck Ur Svensk Naturvetenskap 1967* (Stockholm, 1967), 296–315; Long, *Science Policy in Postwar Japan: Its Background, Development, and Role in Public Policy and Administration* (unpublished PhD dissertation, Columbia University, 1968).

30. T. D. Long, 'Policy and Politics in Japanese Science: The Persistence of a Tradition', *Minerva*, Vol. 7, No. 3 (1969), 426–53.

31. T. D. Long, 'The Government of Science: A Comparative Approach', *Science Studies*, Vol. 1 (1971), 263–86.

32. T. D. Long, 'Japanese Technology Policy: Achievements and Perspectives', *Research Policy*, Vol. 4 (1975), 2–26; Long, 'Technology and Power: Japan Catches Up', in L. Austin (ed.), *Japan: The Paradox of Progress* (London: Yale University Press, 1976), 141–64.

33. See J. R. Bartholomew, *The Acculturation of Science in Japan: Kitasatō Shibasaburō and the Japanese Bacteriological Community, 1885–1920* (unpublished PhD dissertation, Stanford University, 1972); Bartholomew, 'Science, Bureaucracy and Freedom in Meiji and Taisho Japan', in T. Najita and J. V. Koschmann (eds), *Conflict in Modern History: The Neglected Tradition* (Princeton, NJ: Princeton University Press, 1982), 295–341; Bartholomew, 'The "Feudalistic" Legacy of Japanese Science', *Knowledge: Creation, Diffusion, Utilization*, Vol. 6, No. 4 (June 1985), 350–76.

34. J. R. Bartholomew, 'Japanese Culture and the Problem of Modern Science', in A. Thackray and E. Mendelsohn (eds), *Science and Values: Patterns of Tradition and Change* (New York: Humanities Press, 1974), 109–55.

35. S. Traweek, 'Tradition in the Training of Novice Physicists in Japan and the United States', *Journal of Asian Affairs*, Vol. 5, No. 2 (Fall 1980), 135–48.

36. See S. Woolgar, 'Laboratory Studies: A Comment on the State of the Art', *Social Studies of Science*, Vol. 12, No. 4 (November 1982), 481–98; K. D. Knorr-Cetina, 'New Developments in Science Studies: The Ethnographic Challenge', *The Canadian Journal of Sociology*, Vol. 8, No. 2 (1983), 153–77.

37. S. J. Traweek, *Uptime, Downtime, Spacetime, and Power: An Ethnography of the Particle Physics Community in Japan and the United States* (unpublished PhD dissertation, University of California, Santa Cruz, 1982); and Traweek, *Beamtimes and Lifetimes: The World of High Energy Physicists* (Cambridge, MA: Harvard University Press, 1988). The Japanese history of science community has strongly resisted the notion of a 'women's history/feminist history of science'. As a consequence, the existing literature rarely goes beyond documenting the lives of women scientists. See, for example, S. Miyata, *Kagaku-sha no josei-shi* (*A History of Women Scientists*) (Tokyo: Sōchisha, 1985); A. Yamashita, *Kindai Nihon josei-shi: Kagaku* (*A Women's History of Modern Japan: Science*) (Tokyo: Kajima Shuppan-kai, 1983).

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39. S. Nakayama, *A History of Japanese Astronomy: Chinese Background and Western Impact* (Cambridge, MA: Harvard University Press, 1969).

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41. G. Basalla, 'The Spread of Western Science', *Science*, Vol. 156 (5 May 1967), 611–22.

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44. A. B. Cole (ed.), *A Scientist with Perry in Japan: The Journal of Dr James Morrow* (Chapel Hill, NC: The University of North Carolina Press, 1947).

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48. J. MacLean, 'The Introduction of Books and Scientific Instruments into Japan, 1712–1854', *Japanese Studies in the History of Science*, No. 13 (1974), 9–68.

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52. A. Akagi, *Rangaku no jidai* (*The Age of Dutch Studies*) (Tokyo: Chūō-kōron-sha, 1980).

53. S. Nakayama, 'The Role Played by Universities in Scientific and Technological Development in Japan', *Cahiers d'Histoire Mondiale*, Vol. 9, No. 2 (1965), 340–62, esp. 355. See also Nakayama, op. cit. note 40, 220–24, for a discussion of what Nakayama calls 'local science'.

54. Hirosige (1973) op. cit. note 12, 144–47.

55. M. R. Peattie, 'Japanese Attitudes Toward Colonialism, 1895–1945', in R. H. Myers and Peattie (eds), *The Japanese Colonial Empire, 1895–1945* (Princeton, NJ: Princeton University Press, 1984), 80–127, esp. 85.

56. See, for example, the work of popular writer Seiichi Morimura: *Akuma no hōshoku* (*Feast of the Devils*), 3 Vols (Tokyo: Kakukawa Shoten, 1983, 1983, 1985).

57. K. Tsuneishi, *Kieta saiken-sen butai: Kantō gun dai-731 butai* (*The Germ Warfare Unit that Disappeared: Unit 731 of the Kwantung Army*) (Tokyo: Kaimeisha, 1981); Tsuneishi and T. Asano, *Saiken-sen butai to jiketsu shita futari no igaku-sha* (*The Germ Warfare Unit and the Two Doctors Who Killed Themselves*) (Tokyo: Shinchōsha, 1982); Tsuneishi, *Hyōteki, Ishii: 731 butai to Bei-gun chōhō katsudō* (*Target, Ishii: Unit 731 and US Army Intelligence Activities*) (Tokyo: Ōtsuki Shoten, 1984).

58. Edward Shils has argued that there is a 'centre'/'metropolis' in every social system, from which a type of authority emanates which acts as a source of social cohesion and defines relationships between individuals, groups and societies. The centre–periphery/metropolis–province relationship becomes explicit when any society expands or attempts to expand beyond its own boundaries. Ben-David has commented on how today, the 'authority' has become science. See E. Shils, *The Intellectuals and the Powers, and Other Essays* (Chicago, IL: The University of Chicago Press, 1972); J. Ben-David and T. N. Clark (eds), *Culture and Its Creators: Essays in Honor of Edward Shils* (Chicago, IL: The University of Chicago Press, 1977).

59. Blussé, op. cit. note 42; R. P. Toby, 'Reopening the Question of *Sakoku*: Diplomacy in the Legitimation of the Tokugawa Bakufu', *Journal of Japanese Studies*, Vol. 3, No. 2 (1977), 323–63; Toby, *State and Diplomacy in Early Modern Japan: Asia in the Development of the Tokugawa Bakufu* (Princeton, NJ: Princeton University Press, 1984), 11–22.

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61. E. Wilkinson, *Japan versus Europe: A History of Misunderstanding* (Harmondsworth, Middx: Penguin Books, 1983), 17.

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*Japanese Society: A Study in the Structure of Social Reality* (London: Kegan Paul International, 1986).

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65. K. B. Pyle, *The New Generation in Meiji Japan: Problems of Cultural Identity, 1885–1895* (Stanford, CA: Stanford University Press, 1969), 21.

66. M. Yuasa, 'Scientific Revolution in Nineteenth Century Japan', *Japanese Studies in the History of Science*, No. 2 (1963), 119–22.

67. M. Yuasa, 'The Scientific Revolution and the Age of Technology', *Cahiers d'Histoire Mondiale*, Vol. 9, No. 2 (1965), 187–207, esp. 206; Yuasa, op. cit note 24, esp. 1.

68. E. Baelz (ed. T. Baelz), *Awakening Japan: The Diary of a German Doctor* (New York: Viking Press, 1932; reprinted Bloomington, IN: Indiana University Press, 1974), 17.

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71. S. Ito, 'Science in Japan before the Meiji Revolution (1868)', *Proceedings of the Tenth International Congress of the History of Science* (26 August–2 September 1962, Ithaca, NY) (Paris: Hermann, 1964), 291–94.

72. A. W. Sleeswyk, 'Masao Watanabe: Die Japaner und die moderne Wissenschaft', book review, *Archives Internationales d'Histoire des Sciences*, Vol. 33, No. 111 (December 1983), 356–57. For a different opinion of the book, see O. T. Benfey, book review, *Annals of Science*, Vol. 44 (1987), 528–29.

73. M. B. Jansen, '*Rangaku* and Westernization', *Modern Asian Studies*, Vol. 18, No. 4 (1984), 541–53, esp. 541; J. R. Bartholomew, 'The Japanese Scientific Community in Formation, 1870–1920 [1]', *Journal of Asian Affairs*, Vol. 5, No. 1 (1980), 62–84, esp. 71. Also more recently, see Jansen, 'Japan: The Dutch Experience', book review, *Journal of Japanese Studies*, Vol. 13, No. 2 (Summer 1987), 464–69.

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92. W. E. Steslicke, 'Bowers, *When the Twain Meet*: The Rise of Western Medicine in Japan', book review, *Journal of Asian Studies*, Vol. 41, No. 4 (August 1982), 839–41.

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95. S. Nakayama (ed.), *Nihon no gijutsu-ryoku: sengo-shi to tenbō* (*Japan's Technological Power: A Postwar History and Survey*) (Tokyo: Asahi Shinbun-sha, 1986).

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Teachers by Japanese Who Studied Abroad', *The Developing Economies*, Vol. 15 (1977), 440–61. Also see J. T. Conte, *Overseas Study in the Meiji Period: Japanese Students in America, 1867–1902* (unpublished PhD dissertation, Princeton University, 1977). Conte has found that Japanese students who had studied overseas early in the Meiji period were able to take up influential positions in government and education upon their return to Japan, whereas by the 1890s such study was sometimes considered inferior to one obtained in Japan.

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102. H. Yukawa (trans. J. Bester), *Creativity and Intuition: A Physicist Looks at East and West* (Tokyo: Kōdansha International, 1973); C. A. Moore (ed.), *The Japanese Mind: Essentials of Japanese Philosophy and Culture* (Honolulu: East West Center Press and the University of Hawaii Press, 1967); Nakayama, op. cit. note 74; M. Watanabe, 'The Conception of Nature in Japanese Culture', *Science*, Vol. 183 (25 January 1974), 279–82.

103. Bartholomew, op. cit. note 80.

104. For an English language work, see T. Tsunoda (trans. Y. Oiwa), *The Japanese Brain: Uniqueness and Universality* (Tokyo: Taishūkan, 1985).

105. J. J. Hada, *The* Rōmaji *Movement During the Allied Occupation of Japan (1945–52)* (unpublished D Ed dissertation, University of San Francisco, 1981). Also see M. E. Hardesty, *Language, Culture and* Rōmaji *Reform: A Communications Policy Failure of the Allied Occupation of Japan* (unpublished PhD dissertation, University of Minnesota, 1986). Hardesty looks at the *rōmaji* reform movement as an attempt by Americans to 'democratize' the Japanese through their language. She suggests that a distorted, ethnographic view of Japanese culture and language, as well as administrative constraints, contributed to the failure of the movement.

106. J. R. Bartholomew, 'Japanese Modernization and the Imperial Universities, 1876–1920', *Journal of Asian Studies*, Vol. 37, No. 2 (February 1978), 251–71.

107. Ibid., 266.

108. Wilkinson, op. cit. note 61, 63.

109. Ibid., 80–81.

110. See 'Introduction' of Dale, op. cit. note 62.

111. S. Crawcour, 'Alternative Models of Japanese Society: An Overview', in Y. Sugimoto and R. Mouer (eds), *Japanese Society: Reappraisals and New Directions*, special issue of *Social Analysis*, Nos 5–6 (December 1980), 184–87, esp. 184.

112. Dale, op. cit. note 62, 176; R. J. Smith, *Japanese Society: Tradition, Self, and the Social Order* (Cambridge: Cambridge University Press, 1983), 111.

113. Bartholomew (1985), op. cit. note 33, 350–51, 361.

114. J. A. A. Stockwin, 'General Editor's Preface', in Dale, op. cit. note 62.

115. E. McGaffigan and P. Langer, *Science and Technology in Japan: A Brief Analytic Survey* (Santa Monica, CA: Rand, 1975).

116. A. M. Anderson, *Science and Technology in Japan* (Harlow, Essex: Longman, 1984). For other examples, see R. J. Fifield (ed.), *Guide to World Science, Vol. 13: Japan* (Guernsey: Francis Hodgson, 1969); OECD, op. cit. note 28; A. Gerstenfeld (ed.), *Science Policy Perspectives: USA–Japan* (New York: Academic Press, 1982). Gerstenfeld examines the relationship between basic and applied science, and the ties between science, industry and government. Shigeru Nakayama has looked at Japanese science and technology policy very much in terms of its historical development, and has recently considered the influence of the American Occupation on the Science Council of Japan in S. Nakayama, 'The American Occupation and the Science Council of Japan', in E. Mendelsohn (ed.), *Transformation and Tradition in the Sciences: Essays in Honor of I. Bernard Cohen* (Cambridge: Cambridge

University Press, 1984), 353–69. Rodney Huff has looked at the role of Japanese scientists as political actors in relation to Japan's civilian atomic energy programme in Huff, *Political Decisionmaking in the Japanese Civilian Atomic Energy Program* (unpublished PhD dissertation, George Washington University, 1973).

117. Sometimes it is a substitute for further analysis: see, for example, Koizumi, op. cit. note 74.

118. J. Dower, *War without Mercy: Race and Power in the Pacific* (London: Faber & Faber, 1986), 312.

119. L. Hoddeson, 'Establishing KEK in Japan and Fermilab in the US: Internationalism, Nationalism and High Energy Accelerators', *Social Studies of Science*, Vol. 13 (1983), 1–48, esp. 35–36.

120. Dower, op. cit. note 118, 313–14.

121. M. J. Wolf, *The Japanese Conspiracy* (Sevenoaks, Kent: New English Library, 1984).

122. C. D. Lummis, 'Introduction. Japanese Critiques of Technological Society', *Canadian Journal of Political and Social Theory*, Vol. 8, No. 3 (Fall 1984), 9–14.

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