History of Science in Non-Western Traditions: Japan

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Introduction

One of the first issues that quickly engages the attention of anyone aspiring to understand the history of modern science in Japan is when to date the beginning of the subject. In the strictest sense, we can say that modern Japanese science develops only as professional science, mostly according to the forms which first appeared in Germany and France, though with important influences from Britain and the United States. But even if these developments are to be dated from the Perry expeditions of 1853-54, modern science had an extensive pre-history in Japan tracing back to the earliest contacts with Europe in the late sixteenth century and especially to commercial exchanges with the Netherlands from the mid-seventeenth. Beyond that, there is the question of natural knowledge indigenous to East Asia and its importance for the development of modern science. Mostly through contacts with China and Korea extending over many centuries, the Japanese had considerable expertise in medicine, metallurgy, astronomy, architecture, ceramic technology and mathematics before they began dealing with Europe. During the Tokugawa period (1600-1867) knowledge imported from Europe was introduced to these existing learned specialties, and generally coexisted amicably with them.

There were exceptions. The subject matter encompassed by the domains of physics and chemistry was viewed with suspicion by the Tokugawa Shogunate, and government authorities almost never allowed access to European writings in the physical sciences without restrictions. Medicine was generally much freer and thus developed an extensive clientele base outside official circles. But even medicine could occasionally run afoul of prejudice, suspicion, and even outright antagonism. The so-called Bansha Circle incident of 1839 was one such occasion. Several people were disgraced, driven to suicide, or otherwise punished for their interest in European medicine due to the jealousy and resentment of a well placed official. But this episode was actually atypical of official views, and medicine generally flourished during this period of relative isolation from Europe.

After the change of regime in 1868 (Meiji Restoration), there began a wholesale effort to establish modern science in Japan with respect to infrastructure, recruitment and training of scientists, introduction of important research specialties, preparation of textbooks, founding of journals, and everything else associated with the enterprise of professional science. One can identify various issues associated with these efforts: What sort of people could be attracted to science? How should they be trained? What foreign models were appropriate to Japanese needs in the spectrum of scientific institutions? How many resources should be allocated to particular fields of study? Where should Japanese study abroad? To what extent should "technology" and "science" be separated or linked together? Only, perhaps, in the case of recruitment into science were these questions free of contentious debate; and much of the history of science in the Meiji period (up to World War I) especially is defined by the ebb and flow of controversy over these and related issues.

Discerning readers will notice that only very rarely in Japan did public discussion focus on such issues as the relationship of science to religion, philosophy, traditional morality, or "culture" generally understood. This is because Japan, unlike Europe and also unlike China, did not have an officially endorsed culture or philosophy to whose integrity science was seen as presenting a fundamental challenge. Buddhism, though widespread among the general population and most of the elite, was either irrelevant or indifferent to most of the questions linked to science in other countries. Shinto presented no elaborate philosophical edifice for science to attack, while important spokesmen for Confucianism found science to be both compatible with their own rationalistic outlook and generally acceptable on most other grounds. There were some exceptions: some Buddhists were mildly critical of European cosmology on religious grounds. And some Confucian scholars—especially the Meiji Emperor's official lecturer—believed that European science did pose a significant challenge to Confucian morality. This issue especially arose at an early stage in the career of Japan's great medical researcher, Kitasato Shibasaburo, whose criticism in 1887 of a Japanese mentor's false claims about the medical origin of beriberi aroused the ire of certain Confucian-minded authorities in both the academy and the government. Kitasato's life, in fact, can be viewed in part as a case study in the relationship between the often articulated norms of science (e.g. objectivity) and those of Japanese society (e.g. loyalty between individuals of differing social status).

Buddhism and science remains a rarely explored but potentially important topic in the historical literature. Yukawa Hideki, Japan's first Nobel laureate (in physics, 1949) was a devout Buddhist and believed that a Buddhist philosophical outlook influenced his research in physics. If so, this remains hard to prove and nearly impossible to document. Yukawa's development of the meson theory of nuclear forces drew heavily on quantum mechanics and his own imposing skills in mathematics and does not, as such, display any obvious connection to Buddhism. What may be more readily shown is the equanimity of the Japanese physicist's acceptance of the underlying view of nature implied by the meson particle theory. Yukawa had none of the agonizing doubt of Einstein with respect to fixed laws of nature ("God does not throw dice!") Rather, in his view natural forces could reasonably be viewed as a somewhat random product of chance or pure contingency in mathematical terms, similar in some measure perhaps to Buddhist notions of karma or constant flux. In any event, Yukawa was the first in a distinguished line of Japanese theoretical physicists sufficiently prominent as a group to warrant description as a "Japanese school" or sometimes as the "Kyoto school."

A third important issue in the history of modern Japanese science is the relationship of science to war. World War I was a major turning point with respect to funding, recognition of the physical sciences' importance, and in regard to Japan's involvement with science in the rest of the world. World War II and the events leading up to it pose issues of morality and science and the conduct of researchers operating under the auspices of an autocratic, militaristic regime. This latter topic has been more intensively discussed in the English (and perhaps even Japanese) historical literature than any other aspect of the history of modern science in Japan. There are both illuminating books and informative articles on both the infamous Unit 731 network of biochemical research facilities in Manchuria and on the atomic bombings of Hiroshima and Nagasaki, as well as some writings on Japan's own abortive efforts to develop an atomic bomb. The roles of personalities as otherwise divergent as Dr. Ishii Shiro, 731's founder, and Dr. Nishina Yoshio, an important figure in one of Japan's atomic bomb projects, can serve as foci for comparative treatment of reprehensible medical experiments under Japanese and Nazi auspices or, in the latter's case, for a comparative discussion of Nishina's efforts with those of the Manhattan Project.

Day 1

Modern Science's Tokugawa Legacy, 1800-1868

Although the dominant intellectual paradigms and most of the infrastructure of modern science were put into place after the change of regime in 1868, several important patterns and underlying attitudes developed during the Tokugawa period (1600-1867). Not all can be dated precisely; nonetheless, all existed by 1800. These include the social class bases of particular fields of study: mathematics was the cultural property of affluent commoners (farmers and merchants), while the study of the physical sciences had come under the control of samurai (about six percent of all Japanese). Medicine had a social class base which straddled all of these groups. This unit explores these patterns and their possible implications.

The unit also discusses the types of schools, formal and informal, which existed and the clienteles they served. By 1800 schooling for samurai was very widespread, and by 1868 nearly all samurai were literate. Educational opportunities for the commoner population were increasing but continued to be less numerous than those for samurai. This situation was a basic factor in samurai (or former samurai) dominance of science not only before 1868 but as late as 1920.

Attention should also be given to the fields of specialization which developed. Except for mathematics where the conditions which developed after 1868 were very different from those which existed earlier, the fields of study which were flourishing before 1868 (under the old regime) were precisely those which predominated between 1868 and 1920. The reference here is to medicine. The physical sciences, by contrast, lagged behind by many different kinds of indicators.

This situation reflected not only the imperatives and influences of Western science from outside Japan; it also reflects the policies and attitudes of the preceding (Tokugawa) government. This unit explores the differing attitudes of Tokugawa officials toward particular fields of study, their implications, and—so far as can be ascertained—their historical origins. This same unit discusses what Tokugawa Japan did (and did not) accomplish in science.

Student Reading

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Extended Reading

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5. Shigeru Nakayama, *A History of Japanese Astronomy* (Cambridge, MA: Harvard University Press, 1969).

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Day 2

The Meiji Transformation of Japanese Science, 1868-1914
This unit raises a number of issues of central importance for the establishment of modern science in Japan. Foremost among these issues would be the formation of a scientific community, which in turn includes recruitment into science, graduate education, and research training abroad. Another would be the founding of advanced educational and research institutions; important here are the politics and local constraints of selecting particular foreign models. Despite, for example, the support by some Japanese academics and officials for the German pattern of university organization in general and the one-chair rule in particular, Japan chose not to adopt the latter and instead accepted the French system of multiple chairs per discipline at any one institution, based on enrollments or other academic criteria. Similarly, Japanese officials and academics gave remarkably short shrift to lingering contemporary European prejudices against technology or engineering in the academy and decided to include these subjects within the framework of the leading government universities from the very beginning. By similar logic, agriculture also was included from the beginning. In these respects Japan followed American precedents, rather than the practices of European institutions.

The relationship of the science establishment to the government constitutes a third important theme. In the early years of the Meiji regime, many officials hoped that government institutions would become and remain exclusively dominant in every area of natural science and medicine. Financial constraints rendered this impossible, but political pressures were very strong on both sides of this issue. Arguably the matter was only resolved in 1918 when the government finally allowed private institutions to use the title "university" in their names and even began encouraging them to organize courses of study in the natural sciences and in engineering. Relations between scientifically or technically trained civil servants and their legally trained colleagues pose themselves as a variant of this theme of science's relationship to government. From an early pattern of appointing almost exclusively the technically trained to policy making posts in the bureaucracy, the government by stages moved toward the appointment exclusively of the legally trained at this level. This practice angered many engineers and scientists and arguably led to some questionable decisions by government in various public policy arenas.

A fourth set of issues involves the networks of formal, informal, and professional relationships which governed the academic research process in Japan during the early decades of modern professional science. Despite continuing allegations that "unprofessional" behavior was widespread, threatened the research process, and owed its presence mostly to "traditional" patterns of behavior associated with Confucian philosophy, there is more evidence that when the alleged behavior existed, it had much more to do with cyclical trends in the academic job market than it did with "traditional" culture. In this instance, it is instructive to compare Japanese patterns with contemporaneous patterns in German universities where similar phenomena were noted by Zloczower and Ben-David.

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Extended Reading

1. James. R. Bartholomew, "Japanese Culture and the Problem of Modern Science," in *Science and Values: Patterns of Tradition and Change,* Arnold Thackray and Everett Mendelsohn (eds.) (New York: Humanities Press, 1974), pp. 109-155.
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Day 3

World War I and Japanese Science

World War I (1914-1918) was a major turning point for the history of modern science in Japan just as it was in other parts of the world. At least a half dozen major changes are associated with the war. For one, the private sector—big business—begins to support scientific research by Japanese scientists for the first time. Earlier business interest in science had been confined almost entirely to science done in Europe. Secondly, the Japanese government abandons efforts to monopolize scientific education and research outside of medicine; private institutions of higher learning are allowed to call themselves "universities" for the first time in 1918; and several private institutions attempt to develop undergraduate programs in the physical sciences, previously an exclusive domain of government schools. Thirdly, Japanese elites, including government officials, begin to support scientific research in general, not simply a few areas (like bacteriology). Moreover, this support for research is no longer simply ad hoc but becomes systematized with the establishment of the Ministry of Education Science Research Grants Program.

Yet another change of considerable importance for the interwar period is that medicine in Japan loses its relative preeminence, and the physical sciences gain substantially. This change is exemplified by, among other things, the establishment of the Research Institute for Physics and Chemistry, a facility of such quality and material resources for the physical sciences as Japan had not previously possessed. Its importance for the work of Yukawa and especially Tomonaga (see below) was considerable. Finally, Japan becomes much more involved in the international scientific community than had been the case before the war. This involvement included more foreign travel and international liaison work by Japanese scientists (as through the Internation Council of Scientific Unions) and also the first visits to Japan by leading foreign scientists in fields other than medicine. Einstein's famous visit of 1922 was merely the first of a number of such visits. Prior to the war, only Robert Koch had come to Japan, in 1908. This unit would describe these changes and discuss their implications and longer term importance.

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1. James R. Bartholomew, *The Formation of Science in Japan: Building a Research Tradition* (New Haven and London: Yale University Press, 1993), Chaps. 7-8.
2. Kiyonobu Itakura and Eri Yagi, "The Japanese Research System and the Establishment of the Institute of Physical and Chemical Research," in *Science and Society in Modern Japan: Selected Historical Sources*, Nakayama Shigeru, David L. Swain and Yagi Eri (eds.) (Tokyo: University of Tokyo Press, 1974), pp. 158-201.

Extended Reading

1. James R. Bartholomew, "Science, Bureaucracy, and Freedom in Meiji and Taisho Japan," in Tetsuo Najita and J. Victor Koschmann (eds.), *Conflict in Modern Japanese History: The Neglected Tradition* (Princeton: Princeton University Press), pp. 295-341.
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Day 4

The Japanese School of Theoretical Physics, 1930-1960

Best known of all Japanese contributions to modern science are those in theoretical physics associated with the work of Yukawa Hideki, Tomonaga Shin'ichiro, Sakata Shoichi, and several of their associates. Theirs is the only field of science in which Japan has received multiple Nobel prizes.

Yukawa received the 1949 Nobel Prize for proposing the meson theory of nuclear forces; Tomonaga shared the 1965 award with Julian Schwin- ger and Richard Feynman for the renormalization theory of quantum electrodynamics. This unit examines the careers and achievements of Yukawa and Tomonaga in particular and seeks to place them appropriately in both a Japanese and an international context. Yukawa's achievements highlight the impressive growth of physics in Japan after World War I; but they did not, of course, occur in an intellectual or social vacuum. They were preceded by the work of Nagaoka Hantaro, who proposed an important atomic model in 1903; by that of Ishiwara Jun, a pupil of Einstein and Arnold Sommerfeld, who first introduced quantum theory to Japan; and by the achievements of Nishina Yoshio, protege of Nils Bohr at Copenhagen, widely known for the Klein-Nishina formula. Yukawa and Tomonaga, additionally, form an interesting duo since they were well acquainted from childhood and studied under the same teachers (especially Tamaki Kajuro) while graduating from the same university (Kyoto Imperial University). Notably also, each was the son of a well known professor at this institution. Yukawa's father taught geology; Tomonaga's father was professor of philosophy.

If one believes that the growth of modern science is primarily to be understood as a process of intellectual and conceptual diffusion from established centers of science, the work of Yukawa and Tomonaga would appear to provide contrary evidence. Yukawa published his most important work on the meson theory four years before ever leaving Japan. Tomonaga's most important work was published in 1944 when Japan was almost entirely cut off from other centers of science. At the same time, it should be emphasized that neither scientist worked in intellectual isolation. In addition to the considerable stimulation afforded by lively Japanese colleagues, including those at the Research Institute for Physics and Chemistry, Yukawa and Tomonaga each had the benefit of meeting and discussing physics with Werner Heisenberg and Paul Dirac in Kyoto in 1929. Moreover, Yukawa was able to meet and discuss physics with Nils Bohr at Kyoto in 1937, while Tomonaga spent two years with Heisenberg in Leipzig in the late 1930s.

Student Reading

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Extended Reading

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9. Mitsuo Taketani, "Methodological Approaches in the Development of the Meson Theory of Yukawa in Japan," in *Science and Society in Modern Japan: Selected Historical Sources,* Mitsuo Nakayama, David L. Swain, and Eri Yagi (eds.) (Tokyo: University of Tokyo Press, 1974), pp. 24-38.
10. Hideki Yukawa, *Creativity and Intuition: A Physicist Looks at East and West*, Trans. John Bester (Tokyo, New York & San Francisco: Kodansha International, 1973).
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Day 5

Japanese Science and Japanese Militarism, 1930-1945

Here we consider the relations between, and the importance for Japanese science of the years of militarism immediately preceding the takeover by Japan of Manchuria in 1931, continuing until the end of the war in August 1945. Several topics might be included. One would be the dramatically increased funding with which Japanese academic research was favored beginning in 1932 in the aftermath of the Manchurian takeover. In that year the Japan Society for the Promotion of Science (JSPS) was established, primarily to make available research funds on a scale which had not been seen in Japan heretofore. Related to this development also is the substantial growth of the Japanese domestic economy as a function of expanded government spending on armaments and colonial infrastructure. Another important topic is the infamous Unit 731, a military controlled research facility for the biological and chemical sciences located in Manchuria which used captive human subjects for highly inhumane experimental purposes. Apart from the viciously grotesque experiments performed by Unit 731, the phenomenon itself is of historical interest for at least three other reasons. One is that the perpetrators were never punished. The American military authorities which governed Japan during the succeeding years of Occupation (1945-1952) exonerated the Unit 731 researchers in exchange for acquiring all of their data (e.g. on the effects of extreme temperatures on the human body). Most of this data is believed to have been transferred to the U. S. research facility on biological and chemical weapons at Ft. Detrick, Maryland and may well have contributed in various ways to the biochemical weapons research of the United States in the postwar era of the Cold War. Secondly, the phenomenon is historically important because it deeply compromised the entire elite academic medical research establishment, not a mere fringe element thereof. Thirdly, Unit 731 definitely gave certain individuals and certain lines of research (e.g. the development of artificial blood) a leg up for the postwar period. The long term importance and implications of Unit 731 for postwar Japanese science were considerable, though they have yet to be calculated fully.

Japan's experience of becoming the world's first, indeed, only target of an atomic bomb attack was formative in various ways. The *hibakusha* [bomb victims] movement has influenced not only local and national politics in Japan, it has been a defining element of Japan's entire postwar foreign policy. It has influenced the research and defense policy agendas of both the government and the academic science establishment. And it has affected popular attitudes regarding marriage and childbirth so far as the *hibakusha* have been concerned. Superficial impressions to the contrary notwithstanding, there has never been any secret about Japan's own wartime efforts to develop an atomic bomb. There were actually two such efforts, one at the Research Institute for Physics and Chemistry and one at Kyoto University, each coordinated (on paper) with a different branch of the Armed Forces. Neither had come close to building a workable bomb by the time the war ended in August 1945. Nonetheless, some have invoked the existence of these programs as justification for the use of the bombs by the United States at Hiroshima (August 6) and Nagasaki (August 9).

Student Reading

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Extended Reading

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Day 6

Japanese Science of the Past Half-Century, 1945-1997

This most recent half century should be divided into at least two and possibly three distinct periods. The first includes the period of the American Occupation (August 1945 to March 1952), a time when Japanese science—like most aspects of Japanese life—underwent sweeping changes. These changes included an enormous expansion of higher education, the replacement of the prewar Imperial Academy of Science (which actually included all learned disciplines recognized in Japan) by the Japan Science Council, the dismantling of the Research Institute for Physics and Chemistry (since reconstituted), a reorientation of research away from military projects, and a sharpening of political divisions between much of the scientific community on the one hand, government and big business on the other. The Occupation years saw the creation of the leftist League of Democratic Scientists, which received the adherance of many academic scientists, including those best known abroad (as well as within Japan). A second major change comes in 1973-74 as Japan adjusts to the dramatic and quite sudden rise in petroleum prices at the instigation of the Organization of Petroleum Exporting Countries (OPEC). Research budgets begin to rise—at least in the commercial sector, increasingly dominant as a percentage of total Japanese research effort. By 1980 there is an attentuation of hostility between academic scientists, government and business; and during the 1980s one sees important indications of cooperation between and among all three sectors, as with the relatively abortive Fifth Generation Computer Project and the Superconductivity Initiative.

In due course we may well recognize 1990 as another turning point because the Keidanren (Federation of Economic Organizations), an influential group of big business leaders, formally called that year for the expenditure of $100 billion in new money on behalf of academic science whose infrastructure and research budgets were universally deemed to be quite inadequate. Due to national economic difficulties, only modest steps have been taken to date to fulfill this commitment; but there are interesting signs of change, including significant efforts to attract both foreign graduate students and foreign senior and junior researchers to Japanese laboratories on a long term basis. To that end, the government removed in 1987 legal barriers to the tenuring of non-Japanese nationals in Japan's government universities.

By some indications the post 1945 era has been the most successful period in the entire history of modern Japanese science with Nobel prizes in science being awarded to Japanese in 1949 (Yukawa Hideki), 1965 (Tomonaga Shin'ichiro), 1973 (Esaki Reona), 1981 (Fukui Ken'ichi), and 1987 (Tonegawa Susumu). However, the first two belong substantively to the pre-1945 era, while the 1987 prize was awarded for work done in Switzerland by a Japanese molecular biologist who has made nearly all of his career outside Japan. Only the Esaki and Fukui awards reflect postwar work, and in both cases the work was done in the 1950s, four decades ago. It needs to be emphasized that the patterns in postwar Japanese science are in some very important respects not those of the pre-1945 era, a point especially highlighted in the Nishizawa essay cited below.

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Extended Reading

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Possible Topics For Student Research

1. Some physicians, medical researchers, and historians (e.g. Norman Howard-Jones) have argued that only Alexander Yersin should be recognized as the discoverer of the plague bacillus (1894). Others credit Kitasato Shibasaburo equally. Which view betters accords with the scientific evidence available?
2. What factors explain the Japanese decision to establish the Tsukuba Science City and Tsukuba University in the early 1970s? What objectives were envisioned for these institutions at the time? What indications are there that the objectives are being achieved?
3. SONY remains the only Japanese company to have produced Nobel prize-winning research (Esaki Reona / Leo Esaki in physics, 1973). What did Dr. Esaki do? How did the particular environment of SONY, including its corporate culture, facilitate his success?
4. "Internationalization" has become a widely acclaimed aspect of Japan's scientific research establishment in the past decade or so. What are the origins of the concerns this term expresses? What have been its major manifestations? What would one mean by "success" in these endeavors? And how should one assess the prospects for success in the "internationalization" of Japanese science?
5. Japanese elites, including many scientists, regularly decry the perceived differences between the strengths of academic science in the United States and the weaknesses (real or perceived) of academic science in Japan. What are these strengths and weaknesses? How have they influenced the scientific achievements of academic researchers in Japan?

6. How should one evaluate the influence of the U. S. Occupation on modern Japanese science? Has this influence been exaggerated? Has it been insufficiently recognized?
7. By many indications, Japanese researchers in chemistry were slower to achieve international recognition for their work than were colleagues in medicine, physics, engineering, or agriculture during the first half of the twentieth century. Is this because there were fewer such contributions, or were evaluations of them unreasonably low? How should we evaluate Japanese contributions to chemistry in this period?
8. Despite the lack of any lengthy or very impressive "pre-history" for the field, theoretical physics became the first specialty in which Japan received a Nobel prize (in 1949). What was the context for Dr. Yukawa's achievement? How does one explain this apparently sudden, rapid emergence of Japanese theoretical physics?
9. Mathematics is probably the technical discipline in which Japan's reputation has been strongest since World War II. In what special branches of mathematics is Japan especially well regarded? What accounts for the particularly high standing of Japanese matheticians and their work?
10. By many indications, academic scientists frequently felt politically estranged from government and business elites after 1945. Why? What manifestations did this estrangement take? Did it have any significant impact on Japanese science or the work of Japanese scientists?

Note: The topics listed here can all be investigated solely by the use of English language sources.