CHARACTERISTICS OF THE HISTORY OF SCIENCE AND TECHNOLOGY OF MODERN JAPAN

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For the history of modern Japan, the half century from 1850's to 1900's, during which she had completed the transition from the feudalistic to the capitalistic society, may be considered to be the period of assimilation of Western science and technology and that of the formation of solid ground for the further development of the said activities to self-standing state. Before the establishment of the new régime (1868), there existed for the history of science a period of several decades spent for elementary studies of natural science, medicine and technology. The author emphasizes that these naïve scientific experiences promoted by eager intellectual interests and emergent necessities of the time were of vital importance for the scientific and technical progress under the new régime after 1868. Further, the author analyses several internal and external conditions which enabled the rapid progress of science and technology under the new régime. Finally it is pointed out that the political and economic order, which Japan had established during the rapid development of her so-called 'modernization', was also obstructively influential upon the scientific and technological activities. Therefore, endeavours of scientists to overcome those difficulties formed also an important factor for the progress of science and technology in modern Japan.

INTRODUCTION

Modern Japan, which started with the conclusion of an unequal treaty of commerce with Western powers in 1858 and decisively with the downfall of the feudal Government in 1867, grew up to an industrialized country by about 1900 equipped with cultural and social order of Western type. The half century from 1850 to 1900 may be considered as the transitional period from the feudal to the modern capitalistic society of this country. During this period, especially during a quarter century after the tenth year of the new régime, namely the year of foundation of one university and one polytechnical college, natural science and technology of this country were laid on a solid

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foundation upon which further development of these activities to a state of self-standing was possible.

It is the object of this short paper to suggest some characteristics of the said development of science and technology in modern Japan.

Characteristics and Problems

The history of science and technology in Japan during the above-mentioned transitional period arouses our interest through its several characteristic features, each of which formulated in the following proposes a question to consider.

1. Natural science and technology of present Japan have been established within a relatively short period of not more than one century. Before Japan entered into a lasting contact with Western culture she had found herself in an extremely isolated state from the world-wide trend of scientific and technical development, notwithstanding her long, highly-refined cultural traditions.

Question I: Did there exist in Japan enough cultural traditions sufficient for acceptance and assimilation of modern science when she had decided to adopt the new social order in 1867 ?

2. Natural science in Japan, starting from an actual null, was laid on a solid foundation during about a quarter century after the establishment of the new government in 1868. On this foundation further development to a self-standing state of scientific activities was made possible.

Question II: What were the causes, external and internal, of the comparatively rapid growth of scientific activities during this period ?

3. The development of science and technology in Japan may be considered, generally speaking, to have stood in mutual interaction with the so-called westernization of her social order and cultural features. However, the social order established during this period had its peculiarities originated not only from the traditional social features, but also by the policies carried out under the new régime. These peculiarities in the social order permitted Japan her rapid accumulation of private capital and the growth of economic and military power of the state. Such social features must have been in some way reflected in the development of science and technology in Japan.

Question III: In what way the development of science and technology in Japan was influenced by the peculiarities of her social order ?

These questions, correlated with each other inseparably, form the object of this article, the time span being limited to about 1850–1900.

Division of Periods of Scientific Development in Japan

The present author assumes the following division of periods for the development of science and technology in Japan :

Period	*Time Span*	*Characteristic*
1st	1837–67	Germination
2nd	1868–76	Transition
3rd	1877–1900	Foundation
4th	1901–*c.* 1930	Self-standing
5th	*c.* 1930–	(Present Time)

The years denoted in the table stand for the following events respectively:

1837: Udagawa Yōan began publishing his systematic treatise on chemistry.

1867: The Information Bureau of Foreign Books of the Shogunate Government reorganized its chemical institute to a modernized form; liquidation of the institute through the collapse of the feudal government.

1868: Foundation of an institute for teaching chemistry and physics in Osaka; similar educational establishment with manufacturing works opened in Kyoto in 1871; the Ministry of Industries organized a Polytechnical School in 1871; each of these was transitional counter-measure taken by the new government.

1877: The Polytechnical School was reorganized to Polytechnical College under the Ministry of Industry; the Ministry of Education established Tokyo University, including the Faculty of Science.

1900: A State Technological Laboratory, first of its kind, was opened in Tokyo.

Some important political events may be added to the above-mentioned chronicle, namely: In 1868 the new government was established; in 1877 the whole country was brought under a single authority after suppression of the revolt of Saigō Takamori, one of the leading statesmen of the new régime; in 1899 the Imperial Constitution was promulgated; in 1894-95 the Sino-Japanese War.

Scientific Activities during Years until 1876

Scientific activities during the period of germination proceeded, according to the present author, in two steps: the first step before 1850 (under stabilized feudalistic order and seclusionism) involved the acceptance of natural science as basic knowledge for medicine and pharmacy; the second step after 1850 (crisis of feudalistic order and emergency of national independence) marked the introduction and application of Western science to confront drastic military and economic necessities and the experience of scientific organization. The two steps will be explained briefly in the following:

(1) *The first half of the germination period (before 1850).*—The time span 1837–67 for the period of germination of scientific activities is rather an arbitrary one. This period begins with publication of books through which

systematic acquirement of scientific knowledge became possible. Following the first monumental work on Western medicine, *Kaitaishinshō* (New Book on Human Anatomy, 1774), there appeared several texts on Western pharmacy, botany, chemistry and physics one after another. Thus by the 1830's it became possible for many intellectuals to acquire elementary knowledge about these branches of science through books written in Japanese.

It must be noted that the enthusiastic movement to introduce Western science, exclusively in the form of the so-called 'Dutch-learning', could be pushed forward effectively only after the feudal central government had partially relieved the order of seclusion and permitted import of non-religious Dutch books (1720). This was because the highest authority had been compelled to appreciate the necessity and utility of Western sciences, particularly those of astronomy and medicine.

However, it would be too one-sided to explain the eager acceptance and introduction of Western science during the feudal age as driven only by practical necessity. It seems rather probable that the scientific activities at that time, as they are revealed in many translations of Dutch books and in constructions of scientific instruments (telescope, astronomical instruments, electrifying machines, etc.), had been spurred also from purely cultural interest. The translators of Dutch books of science were almost always ardent pursuers of experimental practice. The awakening of intellectual affinity, in many cases rather curiosity, for the rationalistic Western science may be attributed to the intellectual tradition going back to the time long before the beginning of the contact with Western cultures. The uniquely-developed plebeian culture of the Edo period and relatively low percentage of illiteracy must have been the important background of the said intellectual tendency.

(2) *The second half of the germination period (after 1850).*—In contrast to the secluded but peaceful first half of the germination period, the second half of this period characterizes itself by an unprecedented emergency of the country, which compelled the Shogunate government and some provincial lords to utilize Western science and techniques to confront the political and military pressure of Western powers.

The Shogunate government established in Edo the Information Bureau for Western Books (Bansho-Shirabesho) in 1855 for the purpose of translation of Western books, chiefly Dutch. Instruction and practice of science and techniques contained in these books were another important task of the Bureau. The central government established also in Nagasaki an institute for medicine and that for chemistry and physics respectively. Some provincial lords founded, in many cases for military and partly for industrial purpose, technological laboratories and manufacturing works under the leadership of scholars versed in 'Dutch learning'. Although these establishments were eventually liquidated after the collapse of the old régime, they

contributed much to the upbringing of intellectuals and specialists who understood rightly what was to be done for the genuine assimilation of modern science and techniques under the new régime. It is also noteworthy that these scientific personnels, mostly born of military family with old-fashioned thoughts, were often reformed into the rationalistic thinkers through their scientific and technical services for their lords. These men, being inspired with more or less progressive and versatile minds, played a leading part for maintaining scientific activities and for establishing or preparing necessary organizations during the first years of the new régime, for example, reorganization of the Information Bureau (later named 'Kaisei-sho') to Kaisei-Gakko (forerunner of the Tokyo University), establishment of Seimi-kyoku (Chemistry Institute) in Osaka and in Kyoto and that of Kōgaku-ryō = Polytechnical School (forerunner of Kobu-Daigakko = Polytechnical College), further the foundation of the learned societies, such as Tokyo Mathematical Society (1877), Chemical Society (1878) and others.

Thus the answer to Question I may be briefly stated as follows: the necessary conditions, mental attitude and organizational experiences for systematic acceptance and assimilation of Western science and technology at the beginning of the new régime had been already provided and accumulated during about a half century of feudalistic social order.

Science and Technology during the Period of Foundation

By the end of the 1880's, not more than 20 years after the establishment of Tokyo University and Polytechnical College, more than 20 journals of scientific and technological societies were publishing a large number of reports written by Japanese researchers including a lot of contributions which are highly evaluated even now. The said achievement formed a solid foundation for further development of science to a state of self-standing in the twentieth century.

The development of modern industry took place at first under fostering policy of the government. From about 1885 the government-managed factories and mines with up-to-date facilities were released to private enterprises one after another. By about 1900 the 'industrial revolution' was nearly completed. The forerunner was the textile industry. There were, however, belated branches, such as machine tool construction and chemical industry. The development of heavy industry started with the establishment of a state iron work in Yawata (1897).

To what extent could the rapid industrialization be affected by the comparatively rapid growth of scientific activities, and vice versa, is a problem which must be examined by detailed analysis. We may rather consider the conditions which might have been the direct causes of the rapid growth of

scientific activities. As such conditions the author may propose the following points:

(*a*) Systematic organization of research and educational establishments;
(*b*) Generous corresponding measure for upbringing scientific personnels, particularly by employing Western specialists;
(*c*) Development of theoretical researches starting from practical exercises.

The Japanese government, carrying out the policy of industrialization beginning with establishment of government-managed factories, took also an exclusive part in promoting scientific and educational activity. Before two higher government schools, one university under the Ministry of Education and one polytechnical college under the Ministry for Industry, started in 1877, the law of compulsory education for all children had been already promulgated (1872).

The government carried out, from the first moment of its start, quick measures for training officials, professors and scientific-technical personnels. A large number of Western scientists, physicians to technicians and engineers were employed under favourable conditions as teachers and leaders at higher schools and industrial establishments. At the same time, many young students were sent to Europe and America to study at higher schools and factories. According to a survey, the employment of foreigners took place mostly during years between 1871 and 1882. The greater part of these teachers returned home by about 1889, and their places were taken up by young Japanese scholars who had been brought up in Western countries or under foreign teachers in Tokyo. It must be noted that not a few eminent young scientists were sent to this independent country in the Far East which had opened her gate only lately, particularly from United Kingdom, most probably because she had allowed U.S.A. to get the start of diplomatic and commercial relations with Japan. Such men of science were, for example, E. Divers (English chemist), J. A. Ewing (Scottish physicist), T. C. Mendenhall (American physicist), etc. They contributed to the upbringing of Japanese scientists much more through their own vigorous researches than through their lectures.

Scientists of this period produced a large number of reports, which were mostly directed toward problems of practical importance. Their interest and experience in practical problems helped eventually the growth of theoretical researches. For example, in the field of physics, seismological survey, which bore a serious significance in the daily life of Japan, was carried out already in the earlier period and led to extensive studies in geophysics, which in turn developed to scientific researches in magnetism winning a high

appreciation from Western scientists at that time. The famous hypothesis of nuclear atomic structure of Nagaoka belongs to this series of theoretical researches. Analogous circumstances are observed in the field of chemistry.

The chemical literature during the early years of this period almost exclusively dealt with chemical ingredients and analysis of minerals, eatables, herbs, fertilizers, soils, etc. By the end of the period there appeared a number of theoretical studies in organic, inorganic and even physical chemistry. This change of circumstances may be partly attributed to the above-mentioned upbringing of young chemists. However, the chief reason of the growth of theoretical chemical studies must be attributed, according to the present author, to the accumulation of experiences of chemical studies with practical aims. For example, the reason why Nagai Nagayoshi (former student of A. W. Hofmann in Berlin) succeeded in training and organizing a group of organic chemists for pharmaceutical researches, after he had accomplished the isolation of Ephedrin (a narcotic alkaloid) and partial determination of its chemical constitution, may be explained by the fact that these chemists who helped him had already been thoroughly familiar with exercises in extraction and analysis of effective ingredients before they learnt to apply the new scientific method under Prof. Nagai.

Thus the answer to Question II may be stated briefly as follows: The organizational and educational measures adopted by the governmental authority to bring up scientific and technical personnels could be carried out effectively and such an environment encouraged young personnels not only to work on practical problems but also to accomplish theoretical studies.

It must be added that the said growth of scientific and technical activities could not have been possible were it not for the national independence and for the intellectual heritage and experiences, particularly those acquired during the last decades of the feudal age.

Influences of Social Conditions

The last-mentioned point does not mean that there existed a satisfactory correlation of theory and practice in the study of natural science. Natural science in Japan during this period could not enjoy the favourable connection with industries. It was World War I which compelled the leading part of Japanese industrialists, eventually under strong influences of scientists, to feel the necessity of establishing research institutes appropriately organized to combine purely scientific studies with industrial researches. Before World War I serious efforts of industrialists were not directed to, except in a few cases, utilizing and applying the latest achievements of natural science. To accomplish necessary technical improvements by import of ready-made products, machines and processes from Western countries was the common

practice of average industrialists at that time. This circumstance of commerce and industry checked co-ordinated progress of science and technology, as will be seen from the following example:

By the 1880's several researches on synthesis of artificial dye-stuffs and their intermediate products were published, as Takamatsu's 'On the synthetic indigo' (1882) and Ikuta's 'New reactions of nitrosamine' (1887). Ikuta, a graduate from the Polytechnical College (Kōbu Daigakkō) and a pupil of O. Fischer (German dye-stuff chemist), published many other reports and articles on dye-stuff synthesis based on new chemical theory. In one of his popular lectures (1890) he proposed to set up the aniline-dye industry by utilizing domestic coal. In spite of these experimental researches and technical proposals, even the first steps toward manufacturing of synthetic dye-stuff were not taken until the outbreak of World War I. Until then few scientific reports on dye-stuff synthesis were published. As a result of rapid growth of the textile industry import of aniline-dyes from Europe (large portion from Germany) amounted to 178 tons already in 1889. This predominant amount of imported products of higher quality prevented the domestic production in the same line and thus checked the development of synthetic researches on these chemical products.

We have already seen how the growth of science and technology was related to the social background during the years up to 1900. The social conditions must have been partly in common with the world-wide trend of modern countries and partly peculiar to this developing country in the Far East. The above-mentioned example shows that science at that time remained under the obstructive influences of economic conditions, as overwhelming predominance of imported Western industrial products, unbalanced development of domestic industries and short-sighted policies of industrialists having no positive interest in developing basic techniques by themselves. Such conditions are considered to reflect themselves in the peculiarities of Japanese society at that time. It is a remarkable fact that the rapid modernization of Japan could be accomplished through enforced accumulation of capital, establishment of parliamentary but non-republican form of government, organization of strong military power and other countermeasures. One of the most possible consequences of this social structure was the lower level of working and living conditions of common people in comparison with the national prosperity. Marked ideological restriction was also another direct result. These peculiar social conditions could not deny their influences upon scientific activities and technical progress.

The answer to Question III may be stated rather in a proposition as follows: Peculiar social order of Japan, formed as a result of her rapid modernization, might have played a promoting, but at the same time an obstructive,

rôle in the progress of natural science and technology. Studies on this problem, including detailed examination of the said peculiarities and their influences on scientific and cultural activities, will afford a valuable key for understanding the modern history of science and technology in Japan.

Response of Scientists

It is to be noted that scientists and technologists did not always behave passively under the above-mentioned unfavourable conditions. Not a few of them, alone or united, tried to establish effective means and conditions for their own activities. Their struggles or resistance, in their broad meaning, should be evaluated as one of the important factors of the scientific and technological progress during this period.

Fit examples may be seen in organizational actions of scientists. On the occasion of the foundation of the Society for Chemical Technology a leading staff member said in his opening address: 'It is to be regretted that not a few chemical factories are working furnished with qualified chemists. Lack of technologists is also seen in the government officials. The direct result is the lack of legislative and administrative measures for the progress of chemical industry. We, chemists, must unite to a Society so as to let the industrialists realize the utility of chemical technology and to make them propose necessary measures to the government.'

Another example: In 1907 leading members of the Japan Society for Physics and Mathematics opened a series of popular lectures to propagandize the significance of natural science. Tanakadate, a geophysicist, made an appealing talk on the indispensability of the state physical laboratory. He stated, pointing out the lack of glass manufacturing for scientific purposes in Japan, as follows: 'One of the up-to-date characteristics of physics is the shortening of time lag between basic research and its technical application. Scientific researches as seed of practical utilization have become vital for industrialists. The forerunning Western countries are now competing with each other for establishing state laboratories.'

Between scientists as Tanakadate and leading statesmen there existed often wide divergence of understanding about the situation of science and technology in Japan. Commemorating the turning of the century, Ōkuma Shigenobu, former Prime Minister and one of the most influential statesmen, said proudly that modern Japan, only in three decades after her start, has acquired an ability of producing almost all sorts of industrial products. This self-conceit was not a rare exception. To overcome such mental circumstances it required further struggle of scientists and eventually a basic change of economic conditions through the outbreak of World War I.

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