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THE CHARACTERISTIC FEATURES OF JAPANESE CULTURE IN THE FIELD OF SCIENCE IN THE EIGHTEENTH-NINETEENTH CENTURY

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1. INTRODUCTION

From 1630's on, Japan had closed the door to foreigners. It was in 1853 that America compelled Japan to open the doors. Japan was then such a poor country that she was overwhelmed by only four warships to admit the demands of America. Needless to say, Japan had no armaments and no industries. Starting from such condition, only 40 years after, she gained a victory over China, and ten more years after, in 1905, Japan defeated Russia, one of the biggest countries. Perhaps, few examples in the world history had shown such a striking change in a short period. This fact has often been expressed as "Miracle of Japan". Why was it possible? Without reference to the political causes or results of the wars, I will consider here the circumstances of the modernization of Japan, which brought about the change, only from the cultural point of view. Especially, I will put stress on the examination of the scientific knowledge and thought she had had before the Meiji Restoration.

It goes without saying that every change has its hidden causes. Japan's rapid progress is not an exceptional case. It was her old cultural tradition that could produce such changes.

Roughly speaking, from a historical viewpoint of the Japanese science level, two hundred years of the 18-19th century, could be divided into the following three periods:

(1) 1700-1770: Very few European style science had existed. However, the intellectual atmosphere, which made it possible to accept the European science in the next period, had been gradually formed.

(2) 1770-1860: European natural science had been gradually understood by a few capable intellectuals.

(3) 1860-1900: European science had rapidly and in large quantities flowed into Japan, with the Meiji Restoration as a turning point.

dently of our act of knowing and (2) *The real outer world is not directly knowable* form together the cardinal hinge on which the whole structure of science turns.[28]

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[13]Mach's best known contribution to physics, his study of shock waves was in the continuum tradition. There is no evidence that he used the atomic theory in his work after 1863 (when he was twenty-five), and even before then he had raised doubts about its soundness and necessity. See E. Mach, *Vorträge über Psychophysik*, edited by J. Thiele, Hamburg, 1978, which was originally published in a medical journal in 1863 and Mach's *Compendium der Mediciner*, Vienna, 1863.

[14]Boltzmann, *op. cit.*, pp. 141-157.

[15]See Mach's preface to his *The Principles of Physical Optics*, London, 1926.

[16]Joseph Petzoldt, "Das Verhältnis der Machschen Gedankenwelt zur Relativitätstheorie", Anhang zu: Ernst Mach, *Die Mechanik in ihrer Entwicklung historisch-kritisch dargestellt*, 8th edition, Leipzig, 1921, pp. 490-517.

[17]Or as Planck put it in his scientific autobiography, 1950, pp,. 46-47.
"In the opening paragraph of this autobiographical sketch, I emphasized that I had always looked upon the search for the absolute as the noblest and most worthwhile task of science. The reader might consider this contradictory to my avowed interest in the Theory of Relativity. But it would be fundamentally erroneous to look at it that way. For everything that is relative presupposes the existence of something absolute. The often heard phrase "everything is relative" is both misleading and thoughtless. . . . The Theory of Relativity confers an absolute meaning on a magnitude which in classical theory has only a relative significance: the velocity of light. The velocity of light is to the theory of relativity as the elementary quantum of action is to the quantum theory; it is its absolute core."

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[20]Löwy, *op. cit.*, pp. 302-303.

civilization was introduced in this period. But the accumulation of the little knowledge played an important part later.

Roughly speaking, people could be classified into four classes, that is, warriors (samurai), peasants, artisans and merchants. Peasants were ranked higher than merchants, because Japan at that time was an agricultural country and the merchants ran a small business locally. Among these four classes, the warriors, which occupied only 6% of all population, was the ruling class. While country was divided into about 500 domains, and each of them was governed by high class warriors, called *Daimyo*. The Tokugawas, the biggest of them, were at the same time the virtual governers of whole Japan, exercising extensive powers of control. In fact, the domains of each *Daimyo*, called '*han*', were entrusted to them. Daily administration of each *han* was carried out by the middle and lower classes of warriors. That is, apart from their original duties, the actual work of the class was like those of administrative officers.

Almost all positions and posts of the warriors were succeeded by their sons. They were under the obligation to learn to fulfil their duties. Upper and middle class peasants and merchants were able to learn by various means. Consequently, the educational level of this period was very high. About 70% of Japanese could read and write at the end of the Tokugawa era. In addition, the Japanese had a very simple but efficient calculator called '*soroban*' (a kind of abacus), which is still used commonly in Japan. *Soroban* as a means of daily calculation pervaded all the classes.

As for the quality of learning, it had usually stayed at the stage of daily use in the peasant and merchant classes, but in upper class, the main theme of learning was Confucianism, the contents of which are explained in the next section.

Further, it should be noted that, in addition to learning in narrow sense, the culture in wide sense was widely spread in each class of the society. For example, short type poems were very popular. People not only appreciated, but wrote them and even merchants did. '*Ikebana*' (Flower arrangement), '*Cha-no-Yu*' (Tea Ceremony), etc., which are now well-known to foreigners, were enjoyed by many people.

As a remarkable characteristic of the culture, the mental tendency of the Japanese was to consider these arts as not only amusements, but also a kind of spiritual training. Such a spiritualism was seen widely, and, of course, in the field of learning.

3. The Japanese View of Nature under the Influence of Confucianism

Confucianism is a kind of Chinese philosophical thought, due to Confucius, (the 6th century B.C.), the first systematizer. This thought, as well as Taoism, which originated almost at the same time, exerted a tremendous influence on the Chinese spiritual life. Especially, Confucianism was esteemed by the upper class and was the principle of the society for a long time. It may be safely said that the traditional Chinese thought had been formed on the core of Confucianism. Consequently, it had also exerted great influence on the Chinese cultural area, including that of Japan, Korea, etc.

From very old times, the Chinese society had given priority to politics. It was the fundamental point of view that everything else, including learning and thought, was considered as a supplementary means for politics. Confucianism, at first, according to this tradition, was a mixture of the life and political philosophy for monarchs or governing class. Then, in process of time, it was gradually systematized. At last, in the 12th century, it had grown up into a grand system of thought, namely, Chu-Hsi's Neo-Confucianism. It was this Chu-Hsi's philosophy that gave vast influence on Japan, controlling the framework of thinking of the Japanese intellectuals till Meiji.

The fundamental character of Chu-Hsi's philosophy is the unified understanding of the whole world, from cosmology to building up men's morality by two original concepts, "*Li*" and "*Qi*". Both of these words are difficult ot translate into English. Here, I adopt "Principle" for *Li*, and "Material force" for *Qi*, according to *Encyclopedia Britannica*. It is not the aim of this thesis to explain the details of Chu-Hsi's philosophy. The views of nature and learning contained in this philosophy are needed here.

According to Chu-Hsi, as easily conjectured from the fact mentioned above, natural and human world are not able to separate. That is, they are understood together as, so to speak, a continuum. Consequently, the laws of natural world are, as they are, those of human world. The first aim man should endeavour to attain is to recognize well the principle of things, that is, the principle of nature. If he can accomplish this task, he may also recognize the principle of his own spirit, through which he can grow up to Sage. In other words, the recognition of the principle of external world is connected directly to the moral culture, the latter being led to practical ethics, and finally, to politics.

As mentioned above, this philosophy advocates that every recognition and practice should be understood continuously. In this sense, there is essentially only one learning to exist, admitting no specialization.

Needless to say, European modern natural science is quite different. It completely separates nature from human being, though both are created by God. Man observes nature as 'external object', investigating the laws of nautre, which are quite different from the laws of human world. Comparing these two basic viewpoints, it goes without saying that they are essentially incompatible.

Chu-Hsi's philosophy was introduced into Japan on a full scale at the beginning of the Tokugawa era, and soon became the main stream of Japanese Confucianism. However, there were other schools within Confucianism, and many disputes were held between them. Of course, the points at issue were about Confucianism itself. But, strange to say, from among these disputes, there had risen several opinions, both positive and negative, bearing on the question of the acceptance of European natural science.

One of the most important scholars who appeared in the debate was Ogiu Sorai (1666-1728). On the positive side, by his thinking, the politics was separated from morality, and consequently, official and private standpoints in learning were distinguished from each other, which gave the basis of existence of learning other than Confucianism. From the modern point of view, such an opinion may sound curious. But, considering the character of Chu-Hsi's philosophy, it was a big change in the view of learning.

Next, Ogiu denied "*Li*", that is, principle. Though the heterogeneity of principle of things and of spirits had gradually been recognized by several scholars, the concept was still the kernel of Chu-Hsi's philosophy. Nevertheless, he denied it for the reason that "*Li*" had no definite rule. On one hand, this opinion, which was on the basis of agnosticism, meant the abandonment of pursuit of the laws, closing the road to the study of nature. But, on the other hand, his denial of the concept promoted the tendency to think much of phenomena themselves, refusing the void speculative natural philosophy not based on facts. In this sense, it had both plus and minus side. At any rate, through these debates, a kind of rationalistic thinking, which was of course different from European way of thinking, had grown up in Japan, which was useful for the next generation.

Thereafter, as for the view of nature, roughly speaking, Japanese scholars were divided into two groups. One was Chu-Hsi's school. On the firm belief of the continuity of natural and human world, they tried to investigate the laws in the sense of Chu-Hsi. The other supported Ogiu's opinion, taking the agnostic point of view.

It was far after this period when Japanese culture had real contact with European culture. Since almost all Japanese intellectuals learned Confucianism, it is concluded that they were given, before they could touch European learning, the framework of thinking on the nature by either of the two groups. Therefore, to the acceptance of natural science in Japan, the struggle for this framework had essential importance.

4. *Wasan* : Japanese Mathematics

Strange to say, though there had been essentially no natural science in Japan, mathematics had been studied through the period. It was rather high grade mathematics, some results of which were compared with European mathematics. However, its characters as learning was quite different from that of Europe.

Japanese mathematics had originated in China, where it was studied from very old times. In the 1st century B.C., they already had several books of mathematics.

Since then, they produced many remarkable results, though intermittently. The characteristic of Chinese mathematics was the excellency of numerical calculation. In the 5th century, a scholar obtained the value of $\pi = 3.141592$, and in the 13th century, high degree equations were solved by Horner's method. However, the Chinese mathematics worked as a servant of politics, that is, one of the technics for administration, being assigned a very low place in the field of learning. They knew Pythagoras' theorem from very old times. But they gave the theorem, not theoretical, but practical value as a knowledge for surveying.

Such Chinese mathematics was introduced into Japan intermittently. But the direct origin of Japanese mathematics mentioned here—called *Wasan*—was from a kind of instrumental algebra, that is, the method for solving equations with chips. This method was made in the 13th century, but its introduction to Japan was in the end of the 17th century. As soon as the Japanese scholars could understand this method, they tried to find a method using the calculation by figures instead of chips. They succeeded not only in the transformation, but also in the evolution of a kind of notational algebra based on it.

After the invention of this notational algebra, *Wasan* developed rapidly. Seki Takakazu, the greatest *Wasan* scholar who established the foundation of this learning, belonged to the same generation as Isaac Newton's. *Wasan* was extensively studied about 150 years after him, and rapidly declined during the Meiji era, when the Government decided to adopt European mathematics at school. As the result it is only the object of historical study at present. Nevertheless it provides us a good model for investigation of Japanese culture.

Some main results obtained by *Wasan* are as follows.

(1) Seki evolved the theory of determinants earlier and far higher than Leibniz. He expanded 2nd, 3rd, 4th order determinants correctly by the same method just as Sarrus' one. He also obtained Horner's method for solving numerical equations not less than 135 years earlier than he, independently from Chinese achievement.

(2) Takebe Katahiro, one of the most excellent disciples of Seki, expressed the length of an arc of a circle by an infinite series of its diameter and versed since 15 years earlier than Euler.

(3) In the early-19th century, Wada Yasushi made the tables equivalent to integrals $\int_0^1 x^k dx$, $\int_0^1 x^p (1-x)^q$, dx *etc.* Especially, as for the latter, he obtained the general formula, $\int_0^1 x^p (1-x)^q \, dx = \frac{p!\, q!}{(p+q+1)!}$.

These fine results were obtained by some gifted Japanese only, without any aid or influence of Europe.

We cannot miss the spread of '*soroban*' for calculation as one of the fundamental conditions which realized such studies. But then, by what method could Japanese obtain these results? What was their purpose to learn *Wasan*?

I do not explain the details of *Wasan* here, but these problems may be worthwhile examining to inquire into the characteristics of Japanese learning before the full contacts with Europe.

Comparing with European mathematics, *Wasan* had the following characteristics:

Firstly, *Wasan*, as well as Chinese mathematics, entirely lacked the notion of deductive proof and the method for it. *Wasan* scholars developed their theories mainly by an intuitive basis or formal analogies.

Secondly, being related to the first, *Wasan* had little contacts with rational philosophical thought. Lacking the cultural tradition to enjoy the beauty of logic showed itself in such a figure both at philosophy and at mathematics. There was neither a Descartes nor a Pascal in Japan.

Next, *Wasan* was the mathematics which had no, or virtually no relationship with the natural world. This characteristic was a natural consequence of the absence of natural science in Japan. Though Chu-Hsi's philosophy contained a kind of cosmology, it was an entirely speculative one, having no mathematical treatment. Therefore, being different from European mathematics of the same period, *Wasan* did not progress by material or stimulation given by natuıal science.

Finally, *Wasan* scholars ignored or despised sheer utility. For example, trigonometry and logarithmic calculation, which were introduced in the early-18th century via China, were soon understood to use in surveying etc., and they were not able to enter the main stream of *Wasan*. Such practical mathematics as surveying or tax-calculation spread widely. However, they were not the subjects for studies of *Wasan* scholars. Well, what on earth was mathematics for them? At present, it is almost accepted that *Wasan* was a kind of 'jeu d'esprit' in one word.

In its rising period, some excellent scholars, such as Seki and Takebe, seemed to consider their studies as the science which aimed at pursuit of the laws. But, in process of time, this idea was gradually weakened, and in its flourishing period, *Wasan* established itself as 'jeu d'esprit'. In Section 2, I mentioned that poems, tea ceremony, etc. were enjoyed with a kind of spiritualism *Wasan* was learned with a sense very near to them.

The number of *Wasan* scholars was not so few. The social position of them was generally that of lower class warriors, upper class peasants or merchants. Since the character of *Wasan* was mentioned above, there were almost neither hope of elevation of their social positions nor increasing of income by it. They learned and enjoyed mathematics on the permission of this situation.

The existence of such group makes a remarkable contrast with the fact that European natural science was introduced laying stress on the very utility of it.

5. The Process of Acceptance of European Science

As mentioned in Section 2, though in the national isolation, very limited contacts with foreigners had been admitted. That is, only at Nagasaki, a port town situated at the west end of Japan, the Japanese could have relationship with Chinese, Koreans and Dutchmen under severe restrictions.

Through the narrow channel, European civilization flowed into Japan little by little, directly by Dutch, or indirectly via China. Such knowledges accumulated slowly but steadily, and the amount of inflow itself had gradually increased.

From about 1770's on, by the change of political and economic situation, this trend was strengthened. The second period, classified in Section 1, was the one when the European science had been understood step by step by the limited intellectuals. In fact, had it not been for the preparation in this period, Japan might not have been able to understand and digest the Western civilizations in the Meiji era. For this reason, this period was very important for the modernization of Japan.

Roughly speaking, during this period, the Japanese scholars continued to struggle against Chu-Hsi's principle, gradually overcame it, and at last, could understand the concept of 'natural science'.

This process had a characteristic in its order. The Japanese began with gathering the particular areas of knowledge, next recognized the relationships between them, and at last gained the concept of 'natural science' as a whole. That is, this process was reverse in its order, comparing with Europe, where the concept of natural science as the largest framework for the studies of nature had existed firstly. Moreover, it should be noted that this process was completed on the kernel of practical use which is not the essence of science.

In the core of this progress was medicine. The modernization of medicine, paradoxically as it may sound, began with the denial of the existence of laws from a Confucian point of view. Till the early-18th century, in the field of medicine, a void speculative medical thought, based on natural philosophy by Chu-Hsi's school, was dominant. Against this theory, a school of physicians, called *Koiho*, advocated their new healing art on the basis of denying of principle from the agnostic point of view under the influence of Ogiu Sorai (Section 3). They concentrated their attentions on the symptoms of patients as certain phenomena, and treated them by the method which had been consented to be useful from experiences. This theory was, of course, far from modern medical science. However, it was clearly the first step to modernization in the point of their thinking much of actual phenomena instead of speculation.

European medicine was transplanted into Japan where the conditions were mentioned above. The details of the process is not explained here. Roughly speaking, at first, with the object of mere practical use to cure diseases, several groups of Japanese physicians learnt clinical technics without theories. Meanwhile, they began to learn such basic medicine as anatomy, physiology and pathology by Dutch books. At first, the basic medicine was learnt not as pure science but the supplementary knowledge to cure diseases. However, in the basic medicine the Japanese physicians soon discovered new principle, not contained in the healing art of *Koiho*, the basis of which were only experiences. This process may be expressed dialectically that the thought of *Koiho* school arose as the antithesis for the Chu-Hsi's principle, and then it was sublated into new principle with practical use at the moment. It goes without saying that the new principle they found was the concept of European natural science.

It should not be missed that several branches of natural science, for example, physics, chemistry, and botany were derived from medicine in Japan. That is, these branches were introduced and understood in connection with medicine. This was reverse in its order in Europe at that time, where established physics or chemistry influenced medical science. This order was natural in Japan at the time, and moreover, in one sense, might be lucky. For, in the intellectual atmosphere which made much of utility, without the straightforward aim for the sake of medicine, these branches might not have been understood.

Chemistry and botany seemed to be understood easily because they treated actual things. On the contrary, physics seemed to be difficult to understand. One reason of this was that its object was not things, but laws at nature, around which there was confusion or misunderstanding of concepts in connection to Chu-Hsi's principle. In fact, the words used as the translation of physics were the terms of Chu-Hsi's philosophy, which had the means of 'investigation of principle', but had not the means of 'study of nature'. By the way, the Japanese physicians at the time learnt only the outline of elementary physics in the Dutch books, which explained physics not using mathematics. It was during the third period that the European mathematics flowed into Japan.

Medicine played a very important part in the Japanese Scientific Revolution as shown above. On the contrary, as for astronomy, which had played brilliant part as a spearhead in Europe, the essence worthwhile its name, at least, in the official institution at the time, could not be understood. The duties of it were the making of calendar, which had great importance for agricultural nations, and the previous announcements of such extraordinary phenomena as solar and lunar eclipses. Since these duties were one of the national projects, they were done simply from force of habit, and since the posts of the official scholars were hereditary, they usually had not spirits of mental adventures. Though the Copernican theory was introduced at the early-19th century, the theory had no practical use for the calendar making. In short, they had no necessity to think seriously of the impact given by the Western science.

There were some exceptional non-official scholars, who studied Newtonian mechanics only from their intellectual curiosities. Though they were able to understand to some extent, there were some obstacles. It was so high that they could not go forward beyond it, because of the absence of two fundamental concepts which had been the very basis of the Scientific Revolution. One was mathematics as the means for representation of nature, and the other was the mechanism based on Cartesianism. The situations around this problem are easily understood, I think, from what I have already explained.

6. Japanese Mentality

In the last section of my thesis, I will discuss an aspect of Japanese mentality or Japanese intellectual curiosity which naturally realized a type of modernization viewed above from various angles.

The Japanese had their own intense intellectual curiosity, the growth of which had been fostered by the geographical and historical setting of Japan. From the time Japan belonged only to the Chinese cultural region, her geographical setting caused the Japanese to have always burning thirst, a centripetal tendency, for various informations from higher civilization. When the Japanese came into contact with Europeans and learnt about the greater world, they felt more ardent thirst. The Japanese general intellectual curiosity, it could be said, came from this thirst.

In spite of the geographically and politically unfavourable situation, the Japanese gained marvellously great amount of knowledge in the 2nd period. In 1830's the Linnean classification of plants and the Lavoisier's combustion theory were somewhat popular, and some people knew the Encyclopaedists' science classification and even a small history of Western philosophy.

One could be surprised at their way to assimilate knowledge. The Japanese at the time gained almost all their knowledge only through books. Very few foreigners visited Japan due to her geographical setting. The Japanese were, therefore, obliged to read Chinese or European books by themselves without any Chinese or European teachers. They could not choose their books nor could have them imported. They could get their books only by chance. We are all the more surprised again at these facts.

Generally speaking, the Japanese did not carry a positive curiousity. They naturally acquired a habit to rely on others' knowledge without seeking positively for the solution of their problem.

From another point of view, their thirst was an aspect of the reverse side of inferiority complex. They inevitably thought highly of new knowledge before they learnt its true nature. Their sense of inferiority appeared in a form of China worship in the earlier times and of the cult of Europe since the 19th century, and led to the destruction of the traditional culture, which we could say, was a national loss. But it could be also said that haunted by the very sense of inferiority the Japanese was able to learn new knowledge with intellectual humility. Mathematics would be a good example where both of the two faces of the inferiority complex appeared. Though the Japanese had their excellent mathematics like *Wasan* mentioned at the 4th section, they put it away without hesitation in the surge of the European civilization. But the complete adaptation of the European mathematics in place of *Wasan* made it possible to introduce new scientific technique smoothly. The European mathematics was also introduced into China almost in the same age. On the contrary to Japan, their traditional thought prevented the complete adaptation and made them go as far as to create their own unique figures. Their assimilation of the European science was all the slower for such an incomplete adaptation.

There was no comment on the 3rd period. The circumstance in this period was rather different from those of the previous periods. The air of crisis was everywhere in Japan at the possible invasion by advanced nations. Reinforcement of armaments as an urgent countermeasure was a supreme order. So, the Government took the leadership and tried chiefly to increase the import of technique in a narrow sense. The state of things in this period can be explained in this context, but will be discussed in detail in another chance.

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