Linné and Taxonomy in Japan
‐ On the 300th Anniversary of his Birth ‐

President, dear friends

I am very grateful to the Linnean Society of London for the kind invitation it extended to me to participate in the celebration of the 300th anniversary of the birth of Carl von Linné. When, in 1980, I was elected as a foreign member of the Society, I felt I did not really deserve the honour, but it has given me great encouragement as I have tried to continue my research, finding time between my official duties.

Today, I would like to speak in memory of Carl von Linné, and address the question of how European scholarship has developed in Japan, touching upon the work of people like Carl Peter Thunberg, Linné's disciple who stayed in Japan for a year as a doctor for the Dutch Trading House and later published "Flora Japonica".

Carl von Linné, who was born in Sweden in 1707, published in 1735, when he was 28 years old, the 1st edition of "Systema naturae", in which he outlined a new system of classification. According to this system, the plant kingdom was classified into 24 classes based mainly on the number of stamens, the animal kingdom was classified into six classes—quadrupeds, birds, amphibians, fishes, insects and worms—and the mineral kingdom was classified into three classes—rocks, minerals and mined material. Each class was divided into several orders, and examples of some genera were given for each order.

Linné firmly believed that nature had been created by God in an orderly and systematic manner, and he aimed to discover the order of nature so that he could classify and name all things created by God and thus complete the system of nature.

However, in Linné's system, which classified plants mainly on the basis of the number of stamens, species with different numbers of stamens belonged to different classes, even when their other characteristics were very similar, while species with the same number of stamens belonged to the same class, even when their other characteristics were very different.

This led to the idea that the classification of organisms should be based on a more comprehensive evaluation of all their characteristics. This idea gained increasing support, and Linné's classification system was eventually replaced by systems based on phylogeny.

The binomial nomenclature proposed by Linné, however, became the basis of the scientific names of animals and plants, which are commonly used in the world today, not only by people in academia but also by the general public. In the binomial nomenclature, the scientific name of a species consists of a combination of the generic name and an epithet denoting the species.

Before Linné established the binomial nomenclature, scientific names consisted of the species' generic name and a description of the characteristics of that particular species which differentiated it from the other species in the same genus. Therefore, when there were many species in one genus, the description differentiating one species from the others became highly detailed and very long, making scientific names difficult to use.

To solve this inconvenience, Linné proposed a new nomenclature, excluding the description of characteristics from the scientific name and simplifying it to a combination of a generic name and an epithet only, with the description of the species to be noted separately.

The International Code of Zoological Nomenclature and the International Code of Botanical Nomenclature stipulate that, when more than one scientific name exists for a particular species, the oldest scientific name shall be adopted. It is also stipulated that, for spermatophytes and pteridophytes, the scientific names in the first edition of Linné's "Species plantarum", published in 1753, shall be recognized as the oldest scientific names, and for animals, the scientific names in Clerck's "Aranei Svecici", a monograph on spiders, and those in the 10th edition of Linné's "Systema naturae", both deemed to have been published on 1 January 1758, shall be similarly recognized. The names published before these publications are not recognized as scientific names of the organisms.

In the 1st edition of "Species plantarum" and in his later books, Linné described many Japanese plants and gave them scientific names. *Camellia japonica*, for example, was described in the 1st edition of "Species plantarum", and this scientific name is still used today.

These Japanese plants were illustrated by Engelbert Kaempfer in his book, "Amoenitatum exoticarum", which was published in 1712. Kaempfer was a German doctor who served in the Dutch Trading House in Japan for two years from 1690.

At that time, Japan had isolated itself from the world. Japanese people were not allowed to go abroad, and visits by foreigners to Japan were severely restricted. As the policy of isolation was taken to suppress Christianity, the Dutch, who came for trading purposes only and not to promulgate Christianity, were permitted to come to Japan.

The Dutch people were made to live on an artificial island, Dejima, built in the sea off Nagasaki and connected to land by a bridge, and could not leave the island without permission. The head of the Trading House, however, was to visit the shogun at Edo, present-day Tokyo, once a year, accompanied by his delegation including the doctor. Kaempfer thus visited Edo twice during his stay, taking more than 80 days for the trip each time.

It was during his stay in Japan that Kaempfer sketched the plants, which were later published in "Amoenitatum exoticarum" in 1712. His 256 sketches are now kept in the Natural History Museum.

In 1775, 83 years after Kaempfer left Japan, a Swedish doctor, Carl Peter Thunberg, arrived at the Dutch Trading House. Thunberg was Linné's disciple and later became a full professor at Uppsala University in both botany and medicine.

Kaempfer and Thunberg were both doctors who worked in the Dutch Trading House during Japan's period of isolation. But unlike Kaempfer's days, Japanese doctors had a deeper recognition of European medicine when Thunberg came to Japan.

This change occurred because in 1720, Shogun Tokugawa Yoshimune relaxed the prohibition on importing books, which had been put in place to prevent Christian ideas from coming into Japan, and allowed the import of books on European science published in China, which were unrelated to Christianity. This development stimulated research on European science and people came to focus their attention on medical books written in Dutch.

Yamawaki Toyo, who had studied classical Chinese medicine introduced into Japan, noted the great difference between what he had learned and the illustrations in the imported Dutch medical books. To find out which was true, he performed a dissection of a human body in 1754, with permission from the government, and published the results as "An Account of the Observation of Viscera". From that time onward, dissections were often performed.

In 1774, a year before Thunberg arrived in Japan, "A New Book of Anatomy" was published. It had been translated from Dutch into Japanese by Sugita Genpaku and other doctors of Edo. They decided to start the translation when they actually saw a dissection and were convinced of the accuracy of the Dutch book on anatomy.

Some of the people who came together knew the Dutch language, but the leader of the translation project, Sugita Genpaku, did not even know the alphabet. Translation proved to be an extremely difficult task, but thanks to the zeal of Genpaku, who wanted to publish the book in Japanese as soon as possible and contribute to medicine, "A New Book of Anatomy" was completed for publication after only three years.

In Kaempfer's posthumous book, "The History of Japan", he writes that, during his two visits to Edo, only one Japanese doctor visited him just once to ask for medical advice on some disease. In Thunberg's book, "Travels in

Europe, Asia and Africa Made During the Years 1770—1779”, however, he writes that immediately upon arrival in Edo, he received visits from five doctors and two astronomers, and that thereafter, Katsuragawa Hoshu, a doctor for the shogun, and his friend Nakagawa Jun-an visited Thunberg almost every day and sometimes stayed till very late into the night to learn from him about various scientific matters. These two doctors had both participated in the translation of “A New Book of Anatomy”. In the book, their names appear after Sugita Genpaku, the translator, as Nakagawa Jun-an, the editor, and Katsuragawa Hoshu, the supervisor. Both of them, Nakagawa Jun-an in particular, could speak Dutch quite well. Thunberg writes that he asked them the Japanese names of the fresh plants which they brought and taught them the Latin names and the Dutch names of the plants.

Exchanges between Thunberg and the two Japanese doctors continued even after Thunberg’s return to Sweden. The letters the two doctors wrote to Thunberg are kept in Uppsala University. I saw those letters with Their Majesties the King and Queen of Sweden during our visit to Uppsala University in 1985, as Crown Prince and Crown Princess, and it left a deep impression on both of us.

We do not know exactly when the **sc**ientific names under the binomial nomenclature, originated by Linné, were introduced to Japan. As I mentioned earlier, Thunberg writes in his book that he taught Katsuragawa Hoshu and Nakagawa Jun-an the Latin names of plants. It is my view, however, that some doubts remain to conclude, from what Thunberg writes in this book, that the scientific names were first introduced to Japan at that time.

Linné’s nomenclature started to be used in Japan after a German doctor, Philipp Franz von Siebold, arrived at the Dutch Trading House in 1823. By the time Siebold came to Japan, there were many Japanese who could speak Dutch. Siebold established a school of medicine and a clinic for treating patients in the suburbs of Nagasaki. He could also leave the island of Dejima to visit patients at their homes or to collect medicinal herbs.

It was under such circumstances that in 1829, Ito Keisuke wrote a book in which Linné’s nomenclature was used for the first time in Japan. Keisuke took the scientific names of plants in Thunberg’s “Flora Japonica”, which Siebold had brought to Japan, put them in alphabetical order, and added their Japanese names. In the supplement, he introduced Linné’s classification system as “Explanation of the 24 Classes.”

Keisuke studied under Siebold for six months in Nagasaki, and when he was about to return to his home in Nagoya, he was given Thunberg’s book as a gift. Keisuke sent the manuscript of his book, “A Translation of Thunberg’s Flora Japonica”, to Siebold in Nagasaki, and Siebold checked it.

In 1854, Japan and the United States signed the Treaty of Peace and Amity as the arrival of the American naval fleet brought to an end Japan’s policy of isolation, which had lasted for more than 200 years. After that, Japan started establishing diplomatic relations with many countries. The last shogun, Tokugawa Yoshinobu, resigned from his post in 1867, and a new government was formed under Emperor Meiji. The Meiji government sent students overseas and invited foreign teachers to Japan, and the Japanese people made a great effort to acquire Western knowledge. The foreign teachers who were invited to Japan at this time made a great contribution to Japan, and the students who went to study overseas also contributed in various ways to the subsequent development of Japan.

One of the academic achievements made by Japanese scientists in the 19th century was the discovery of ginkgo sperm by Hirase Sakugoro in 1896. Hirase Sakugoro, who worked as an illustrator in the botanical laboratory of the University of Tokyo and later became a research associate, observed the swimming of ginkgo sperm, and published his paper on this discovery in a botanical journal.

A month later, Ikeno Sei-ichiro, an associate professor in the agricultural department of the University of Tokyo who collaborated with Hirase Sakugoro in his studies, found cycad sperm, and also reported it in a botanical journal. It was known at the time that ferns have sperm, but this was the first time in the world that a gymnosperm was found to have sperm.

This discovery was not believed at first, but it became accepted after zamia sperm, from the same cycad family, was discovered in the United States the following year in 1897. For this achievement these two researchers were awarded the Imperial Award of the Japan Academy in 1912.

The ginkgo is a gymnosperm unique in its phylogeny because it is a single-order, single-family, single-genus, single-species plant. It flourished in the Mesozoic Jurassic age but survived only in China, and was brought from China to Japan in ancient times. It was given a scientific name by Linné, on the basis of Kaempfer’s illustration.

The ginkgo tree that Hirase Sakugoro used for his research is still standing in the Koishikawa Botanical Gardens of the University of Tokyo. I visited the botanical gardens with the Empress last year and looked at the ginkgo tree, thinking of the research that was done a long time ago.

In the 20th century, as Japanese taxonomy made progress, more and more new species began to be reported. Before that, Japanese animals and plants were given scientific names by European scientists, and as a matter of course, the type specimens used for naming them were kept in European museums. Therefore, when Japanese researchers wanted to describe a Japanese animal or plant as a new species, they had to check the type specimens in foreign countries one by one, and the difficulties they encountered were far from trifling.

Thanks to the efforts made by many people, all Japanese spermatophytes, pteridophytes and vertebrates excluding fishes now have scientific names. However, there are still many unnamed fishes, and, in particular, there are many gobioids which must be given scientific names.

When I started my research, I frequently referred to a book titled “Fish Morphology and Hierarchy” by Dr. Matsubara Kiyomatsu, published in 1955. The book covered all Japanese fishes with keys to the species, and it listed 134 gobioids including subspecies. In the more recent "Fishes of Japan with Pictorial Keys to the Species", published in 2002, the number of gobioids, including subspecies, increased to 412, but 45 of them have only Japanese names and have no scientific names yet.

There were two studies that particularly interested me as I embarked on my research on gobioids. One was "The osteology and relationships of certain gobioid fishes, with particular reference to the genera *Kraemeria* and *Microdesmus*" by Dr. William Gosline published in 1955, and the other was "Studies of the gobioid fishes in Japanese waters; on the comparative morphology, phylogeny, taxonomy, distribution and bionomics," which was an unpublished doctoral thesis by Dr. Takagi Kazunori.

With these papers as reference, I proceeded with my taxonomical research. On the one hand, I studied the relationships among many kinds of gobioids, analysing their bones stained with alizarin red. I studied, on the other hand, the differences among species of gobioids by comparing the arrangement of their head sensory canal pores and sensory papillae.

Back in the 1960's, no one in Japan was yet classifying gobioids on the basis of the arrangement of their head sensory papillae. Therefore, in 1967, when I published the classification of the four species of the genus *Eleotris* found in Japan based on the arrangement of their sensory papillae in the Japanese Journal of Ichthyology, apparently there were some people who had considerable doubts about my classification. However, the arrangement of the sensory papillae has now become an important factor in classifying gobioids, and I am glad that I have been able to make some contribution in this field.

The binomial nomenclature established by Linné has been immensely beneficial, providing a universal basis for taxonomy throughout the world and enabling taxonomists around the world to communicate with each other through a common language about things existing in nature. Since then, taxonomy to this day has continued to develop on the basis of this binomial nomenclature.

As I mentioned at the beginning, Linné's classification system based mainly on the number of stamens was eventually replaced by a system based on a more comprehensive evaluation of all characteristics. It is understandable that the idea of using phylogeny as the basis for taxonomy had not yet appeared at Linne's time. It was almost a hundred years after Linné that the theory of evolution proposed by Darwin and Wallace was presented here at the Linnean Society, and the idea of phylogeny became newly accepted in the academia.

In academia today, an even newer field of research, molecular biology based on evolution, is seeing remarkable development. As a result, more importance is placed on phylogeny, and systems based on phylogeny are considered to be more accurate and are now the mainstream of taxonomy.

As I have been familiar with classifications based on morphology since I was young, the appearance of the electron microscope which enabled me to observe minute morphological characteristics, and my encounter with an even smaller world, where classification is based on DNA analysis at a molecular level, have been great experiences for me as a researcher.

In the years ahead, I think the analysis of mitochondrial DNAs will open up great possibilities of discovering new species which cannot be distinguished morphologically but which can be clearly distinguished at a molecular biological level. I hope to understand and take into consideration this newly developing field of research, but at the same time, I intend to continue to give my attention to and keep up my interest in morphology, which is a field of study carried on from Linné's days. I would like to continue my research, always keeping in mind the question of what will be the importance and role of morphology in the field of taxonomy in the future.

On the 300th anniversary of Linné's birth, I feel that taxonomy, which used to be based solely on morphology, is entering a new era.

In closing, I would like to thank you again for this invitation and I offer my best wishes for the further prosperity of the Linnean Society of London.