SCIENTIFIC JAPAN

PAST AND PRESENT

Third Pan-Pacific
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PREFACE

For several years, the idea of putting together in book form something of the past history and present state of science in Japan has been in the minds of not a few of her scientists, and the Meeting of the Third Pan-Pacific Science Congress in Tokyo this autumn has served as a stimulus for this idea to take definite shape in " Scientific Japan, Past and Present ".

Assertion is often made that science in Japan dates back only as far as the time of the Restoration (1868). It is true that a systematic transplantation of Western sciences took place after the Restoration, but it is equally true that several branches of science had been studied in this country with zeal and success for centuries before that date.

Among these, special mention must be made of Mathematics, which was already developed to an astonishing degree during the latter half of the 17th century. Seki, born in 1642, the same year as Newton, was a man of extraordinary mathematical ability and originality, and his discovery of the " Principle of the Circle " is held by some as comparable with the discovery of Infinitesimal Calculus by Newton and Leibnitz. It is worthy of remark in this connection that the Mathematics Outlivated by Seki and his school neither had a foreign origin nor did it in its later development receive any assistance from outside sources. Astronomy was another subject which was studied from an early period, chiefly in connection with the compilation of almanacs, and, in 1744, an Astronomical Observatory equipped with meridian and other instruments was established at Kanda in Yedo, as Tokyo was then called. The stndy of Botany as a handmaid of Medicine may be traced back even to the 8th century, although it was not until the middle of the 17th century that its independent study began.

Medicine occupies the most important position in the pre-Restoration history of science in Japan, not only because it was the first of Western sciences to penetrate into this country, but also because it paved the way for the importation of other Western sciences. In Chapter XI, Dr. Fujikawa tells us with what zeal and industry and under what difficulties the Japanese physicians of the pre-Restoration period sought for knowledge of the Western art of healing. Their zeal and industry, however, was not limited to the study of Medicine: they felt an almost equally great thirst for other Western sciences. With the aid of what little knowledge they were able to acquire of Dutch, which was then the only language of the West of which it was possible to gain even a most elementary knowledge, they diligently studied these other sciences with more or less success (see Chapter XII), but always under extreme difficulties, because of the governmental policy of seclusion.

It well be seen even from these oursory observations that it was not in a hard and barren soil, but in a soil well-prepared and fertile that, with the Restoration, the seeds of the Western sciences were sown. It will further be seen that this circumstance, combined with all the facilities and encouragement given by the Meiji Government, enabled those seeds to take root at once and grow to bear fruit within a comparatively short time.

In "Scientific Japan, Past and Present", Chapters I–VII are devoted to the Geographical, Meteorological, Geological, Botanical, Zoological and Anthropological aspects of Japan, with the addition of an account of the Great Earthquake of 1923, while Chapters VIII–XIII treat of the History of those sciences that had special developments in this country, including Seismology, which, although of a much more recent origin, is a peculiary Japanese science, and Chapter XIV —the concluding chapter—gives brief accounts of the more important Scientific Institutions.

In conclusion, I have, on behalf of the National Research Council of Japan, much pleasure in tendering my sincerest thanks to those scientists who have contributed valuable articles to this volume and have thus made its publication possible. My special thanks are due to Professor Shinjo, not only for writing the article signed by him, but also for compiling the whole of Chapter XIV and, not least, for the great pains he has taken as Editor-in-Chief in the general supervision of the work.

Joji Sakurai.

Tokyo, October, 1926.

CONTENTS.

LIST OF ILLUSTRATIONS.

PLATES.

MAPS.

I. Geographical Sketch of Japan.

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Contents

I. General Remarks.

i. Position and Area:— The Japanese Empire consists of a long chain of festoon islands along the Pacific coast of the Asiatic continent and the large peninsula of Chosen, or Korea, projecting southward from the same continent. The chain of islands is divided into three arcs, each of which with the continent embraces a sea, viz., the Seas of Okhotsk, of Japan, and of China. The central or main arc constitutes the principal part of the Empire, and consists of four large islands, namely, Honshu, Shikoku, Kyushu and the main island of Hokkaido, or Ezo of Europeans; while the other two arcs consist of chains of small islands, Chishima, or the Kuriles in the north and Ryukyu, or Luchoo in the south.

The large island of Taiwan, or Formosa, and the southern half of the island of Karafuto, or Sakhalin, also belong to this country. Besides these islands and peninsula, there is a small territory in the south end of Manchuria affected by the lease of the Kwantung Peninsula. Many small islands and reefs in the Pacific Ocean north of the Equator have recently come under the mandate of the Empire. They include most of the Marshall, Caroline and Mariana Islands, with the exception of Guam, which is under the American flag.

The area of the Empire is 680,762 sq. kilometres *in toto*, while the areas of some of its principal parts are as follows:–

Honshu	230,209 sq. km.	Taiwan	35,969 sq. km.
Shikoku	18,768 " "	Chosen	220,741 " "
Kyushu	44,202 " "	Kwantung	3,374 " "
Hokkaido	94,784 " "	Mandate in the Pacific	2,149 " "
Karafuto	36,090 " "		

ii. Land forms. All these island arcs are nothing but parts of the great circum-Pacific fold, which was formed during the Tertiary period. The crustal disturbance was enormous here at that time. Lofty mountain chains of various formations were upraised to remarkable heights and extensions. Some of them culminate in peaks over 3,000 metres in height and exhibit landscapes of a typical alpine character. Marine sediments of younger Tertiary formation are often found even on mountains higher than 1,000 metres. As a matter of course, the trend of this folding follows that of the axis of the archipelago. Besides these foldings, blocking movements have not been uncommon since the younger Tertiary period. Extensive tracts of land of this origin are found in Japan side by side with mountains caused by folding.

Repeated volcanic eruptions have occurred during the various geologic ages, and here, as in other districts of the Pacific, they have been exceedingly frequent since the Tertiary period. Many magnificent cones standing on the mountains and fields or rising from the sea, are mostly heaps of lavas or ashes. The volcanic chains run for the most part along the principal trend of the island arcs, sometimes crossing it, as in the case of the Fuji chain. None of these crustal disturbances have yet quite stopped. Volcanic eruptions and earthquakes of various degrees of intensity occur successively, and secular changes of strand lines are also taking place in many districts.

Besides these structural disturbances, the sculptural deformation of the land is likewise very remarkable. Immense amounts of vapor, brought from the surrounding seas by both summer and winter monsoons, are precipitated as rain and snow, intensely eroding the country. Gullies, ravines and valleys are cut, through which flows a complicated network of streams. The islands are thus very mountainous and hilly. Their topography is highly complicated and the gradient is generally very steep.

Rivers are commonly short in the islands, and the largest does not exceed 400 km. in length They often form torrents and rapids, affording scenic beauties everywhere. In mountain districts, and even in the plains, the river beds are commonly stony or are covered by gravels, through which braided streams make their way. Water traffic is very inconvenient, and boats are admitted within certain limits only in the lower courses of the rivers. On the other hand, these rivers afford excellent facilities for hydro-electric plants, which are found everywhere in the mountain districts of the country. The total amount of white coal available is estimated at 8,230,000 horse power, of which only 18% is utilized at present.

Plains are less extensive in countries like this. They are found occasionally along the sea-coast as well as along the banks of large rivers. Sometimes they are well developed in delta districts, where they are generally fertile and densely populated. Most of the large cities of this country are located in such plains. In the mountain districts, we often meet with depressed basins of tectonic origin, like those in northwestern Japan or in the Kinki district in central Honshu. Sometimes lakes nestle among the mountains, as in the cases of the well-known Lakes Biwa and Inawashiro.

As the Japanese islands extend through about 30 degrees of latitude, or from the tropic nearly to the frigid zone, the climate varies considerably. In Taiwan and Ryukyu flourish tropical and subtropical vegetations, while in Karafuto and Chishima we find uninhabited forests of conifer trees amidst severe arctic cold. An oceanic climate, however, prevails everywhere in the country, and the precipitation is generally very plentiful, so that most parts of the country enjoy a very agreeable temperate climate. The floral species are rich in number and abundant in quantity flourishing in the mountains and fields. The marine flora is also abundant along the coast of the islands, especially in the Pacific Ocean. Well cultivated farms in the low plains, and even sometimes far up the hillsides, and rich forests of various kinds of trees on the mountains, tell us of the fertility of the land.

The coast line is more developed along the Pacific Ocean than along the Sea of Japan. Some large embayments and channels, such as the bays of Tokyo, Sagami, Suruga, Ise and Tosa, and the channels Kii and Bungo, are of tectonic origin. Even the famous Inland Sea, or Setouchi, which stretches between the Main Island, or Honshu, and two other large islands, Shikoku and Kyushu, is nothing but a longitudinal zone of depression, consisting of a series of small seas or *nada*. Further, the coast is in many places fringed with small indentations, such as those of *rias* type in the submerged coast of northeastern Honshu and that of Kii Peninsula. The shore of the Sea of Japan is comparatively smooth and straight. The volcanic peninsula of Oga and the projected *horst* of Noto, together with the depressed bays of Toyoma, Tsuruga and Wakasa, break the monotony of this coast line. Similarly, the west and south coasts of the Korean Peninsula are remarkably configurated with numberless bays and inlets, in which are scattered thousands of islands of various sizes, in contrast to the simple shore, bare of islands, of the Sea of Japan to the east.

iii. Seas. The most important sea near Japan is, of course, the Pacific Ocean. Not only for its vast extension but also for the profundity of its abyss near the archipelago, does it merit special attention. Most parts of the Japan trench or *graben*, which extends quite a long distance along Chishima, the main islands of Hokkaido, north Honshu, and farther south along the eastern side of the volcanic islands of Idzu, are deeper than 7,000 metres; and the well-known Taskarora Deep, not far off the Kunashiri Islands, is 8,515 metres. Another deep of 8,491 metres off the coast of the Kitakami mountainland and one of over 9,000 metres to the south of Boso Peninsula, have recently been sounded. An accurate sounding of the latter has not yet been registered. The deep, narrow trench along the outer side of the Ryukyu Islands, with a maximum depth of 7,481 metres, is also a very remarkable one. The existence of other trenches along Palau, Yap and Guam in the southern sea have already been recorded. Quite recently, however, the discovery has been made by a surveying boat of a deep in the Mariana trench with the record depth of 9,814 metres, which surpasses by some twenty metres or more that of the world-known Swire Deep in the Philippine trench.

Between the Japanese islands and the continent, there are three seas, which are barely connected with each other by narrow channels. The most important one is the Sea of Japan. Enclosed by the central arc of the islands to the south and east, and by the Korean Peninsula to the west, it extends over a large area of water, estimated at about 1,043,820, sq. km. It is quite open with a few islands in the midst and is very deep in its northern half, where the depths of most places on the line drawn between the mouth of the River Tumen and the Tsugaru Strait exceed 3,000 metres, and reach a maximum depth of 3,712 metres.

The southern half of the sea is less deep, having the so-called Yamato Bank in the centre, which is joined by a submarine ridge with the coast of Honshu. The northern end of this sea is connected by the Gulf of Tartary and the Strait of Mamiya with the Sea of Okhotsk. This passage is very narrow and shallow. It is only eight kilometres wide, and is totally frozen when winters come. Then the island of Sakhalin is solidly tied to the continent with ice. The mails are carried on sledges across the strait, and similarly the freezing of the strait admits of the free migration of land animals between the continent and the island. The Sea of Okhotsk, which is enclosed by the island chain of Chishima and the Kamchatka Peninsula to the east, is likewise an open depression with a remarkable depth of over 3,000 metres. The deepest sounding, obtained to the north of Nemuro, is 3,374 metres.

In contrast to the seas just mentioned, the China Sea is merely a stretch of shallow water on a great continental shelf, along the edge of which runs the Ryukyu arc. Special attention may be asked for the existence of a trench along the inside of the said arc, with an average depth exceeding 2,000 metres and a maximum depth of 2,681 metres. The China Sea is connected with the Sea of Japan by Korea Strait, which is divided into two passages by the island of Tsushima lying in the channel.

The southeastern coast of the archipelago is washed by the warm Japan current. This stream is commonly called the Kuroshiwo, or "Black current," on account of its remarkable dark blue tint. Tsushima current, a branch of it, enters the Sea of Japan and affords moisture and warmth to the northwestern coast of Honshu. It is indeed an astonishing fact that an enormous amount of snow falls, at least one metre on the coastal plain and sometimes more than three metres on the slopes of those mountains which form barriers against the moisture-carrying northwest monsoon of winter. The northeastern coast of the archipelago is washed by the cold Chishima current or Oyashiwo, which is pale green in contrast to the dark color of the former. In the sea near

Hokkaido, where both currents run along side by side, fog is often generated to the great danger of coasting vessels.

iv. Peoples. Japanese are the predominating people in this country. They live in Japan proper and number nearly sixty million. The peninsula of Chosen is the home of nearly eighteen million Koreans. The aborigines of Taiwan are Malayans, who live for the most part in the mountains and are less civilized. There are many tribes, some of whom understand agriculture, while others, living in the northern mountains, are engaged in chasing game and have not yet given up their barbarous custom of head hunting. The population of these tribes is estimated at about eighty thousand. The low western plain of Taiwan is well cultivated by immigrants from the southern provinces of China, who aggregate nearly four million. In Hokkaido, the Ainu number only about seventeen hundred. In Karafuto, we find at present a few Sakhalin–Ainu, Giliaks and Orochons. The leading people in the Mariana Islands is the Chamorro, while that in the Caroline Islands is the Kanaka. The culture of these tribes is in general not high. Some of the South Sea Islanders are successful in raising plantations of tropical fruit trees. The total population of the Japanese Empire is about eighty–three million, distributed as follows:–

Japan proper	59.73 million	Karafuto	0.2 million
Chosen	18.00 million	Kwantung	0.76 million
Taiwan	3.99 million	Pacific mandate	.05 million

The average density of population in the Empire is 120 per square kilometre, while that of Japan proper is 156, which makes Japan one of the most densely populated lands in the world, coming next to such industrial countries of Europe as Belgium, Holland and Great Britain. The density is greatest in the plain of Kwanto, which is followed by the Osaka plain and Kyoto basin, the Pacific coast of central Honshu, and northwestern Kyushu. Then come the districts of north Honshu, southern Korea and northern Taiwan. Less populated are northeastern Hokkaido and Karafuto.

Since ancient times, the principal industry of the Japanese people has been agriculture; and as most of the population enjoyed a rural life, there were naturally not many large cities. Most of the well–known towns occupy the sites of the castles of ancient feudal lords. Modern development of manufacture and commerce has forced an immense increase in the population of the towns as well as an increase in the number of towns. Sixty-three per cent of the population of Japan proper still consists of village dwellers. There are only twenty-one cities with a population of over 100,000, a condition far different from that of the densely populated countries in northwestern Europe. The cities of Tokyo and Osaka, with populations in the millions, represent the industrial centres of the east and the west of the Empire respectively.

Japanese emigration to foreign countries is not so great as that of some European nations. There are nearly 600,000 Japanese abroad. Of this total, the number of 110,000 in Hawaii is the most remarkable. The number of our emigrants to the Pacific coast of the United States of America is now decreasing on account of unfavorable social and political conditions there. On the contrary, a new field in the Brazilian plateau has in recent years been opened for emigrants from Japan. At present there are already 40,000 Japanese in Brazil, enjoying a peaceful life in the pursuit of coffee plantation and rice culture. There are, besides, many thousands of Japanese in China, engaged for the most part in commerce.

v. Industries. The principal industry is agriculture. Rice is cultivated in most parts of the country with a few exceptions in the northernmost districts. In Taiwan, and even in some of the southern provinces of Honshu, crops are produced twice yearly. Barley and wheat come next; they are produced mostly in the Kwanto Plain. Though the production of these cereals is large, it is not enough for the consumption of the great population of the country. So we import more rice from the tropical monsoon lands of southeastern Asia. Wheat and flour are imported from North America. In the warmer districts of south Japan, especially in Taiwan and Ryukyu, sugar-cane is cultivated. Green tea is produced in the central prefectures of Honshu, such as Shidzuoka, Miye and Kyoto, while oolong tea is prepared in northern Taiwan. Both varieties of tea constitute important staples for export to America.

Stock farming is carried on but little as a separate industry in this country, but horses are kept in the grassy plains of northern Honshu, Hokkaido and southern Kyushu, while cattle are produced in quantity in Chosen, western Honshu, Hokkaido and southern Kyushu. Sericulture is the most important industry in many districts, especially in central Honshu, the Kwanto Plain and the Ou district of north Japan. The annual exports of silk amount to nearly seven hundred million *yen*, making Japan first among the silk producing countries of the world. The silk is consumed for the most part in America and secondly in Europe. Forestry flourishes in the warm and wet climate of Japan. Many kinds of conifers supply good timber in the mountains of Honshu, Hokkaido, Karafuto and northern Chosen. Taiwan is also noted for its lumber as well as for its camphor industry.

The seas near the Japanese Islands are celebrated for their prosperous fisheries. The northern sea around Karafuto and Hokkaido is well-known for its great schools of herring, while the warm Japan current and its branch are the principal places for the fishing of bonito, sardine and porgy. Besides their use for home consumption, these fishes are abundantly exported to China.

Among mineral products, coal comes first. Our coal is produced from younger geologic formations, mostly from Tertiary and partly from Cretaceous deposits. Many collieries are worked in northern Kyushu and Hokkaido Japan is one of the copper producers of the world. Ashio, Besshi, Hitachi and Kosaka are the most noted copper mines. Iron is mined in northern Honshu, Hokkaido and Chosen. But the greater proportion of iron ore used for smelting is imported from Taye in China. The production of petroleum is increasing in many districts on the coast of northern Honshu along the Sea of Japan. Some trials have proved the possibility of its production in Taiwan and Karafuto also.

Japan has for a long time been known for its home industries. Porcelain, lacquerware, silk and other artistic articles are produced in many places in this way even at present. But modern factory industries are on the increase in various districts. The textile industry plays one of the principal rôles at present. Besides the silk industry, mentioned above, cotton spinning and weaving are the most remarkable textile industries in Japan. India supplies most of the raw cotton, and America and China come next. The chief centre of this industry is Osaka and its vicinity. Yarns and various kind of cotton goods constitute the principal materials of export next to silk; they are sent mostly to China and other Asiatic ports. Shipbuilding, iron and machinery works, paper and match mills, sugar refineries, breweries, etc. are other large industries in this country.

Foreign trade has been increasing enormously in recent years. The total import and export trade amounts to four thousand and three hundred million *yen*, which makes Japan rank first of all the commercial countries in the East. There are more than sixty ports open for foreign trade. Yokohama and Kobe stand at the head of the list, accounting for three-fourths of the total trade. The United States of America and China are our most important customers, while we, on the other hand, buy a great deal of merchandise from the United States of America, the British Empire, and also from India, France and Germany.

II. Regional Descriptions.

Now let us treat each of the more important islands in detail.

i. Honshu, *a.* **Ou district:—** The fundamental form of the Japanese islands is outlined by two great mountain systems, which meet in central Honshu and are called the northern and southern arcs. These arcs consist of inner and outer zones of mountains. The outer zone of the northern arc of Honshu lies along the coast of the Pacific and is divided into two spindleshaped mountain groups, Kitakami and Abukuma. These mountains are formed of such older geologic formations as Archean, Palaeozoic and Mesozoic, associated with various kinds of old eruptive rocks. The Kitakami group on the north is sharply separated from the central range by the tectonic valleys of Mabechi and Kitakami. Its external features show no regularity as a mountain system, which can be observed merely in its inner stratified structure. The network of numerous valleys extending in various directions, which have resulted from erosion, divide the district into an irregular group of mountains and hills, of which Hayachiné, the highest peak, measures 1914 m.

As a result of recent submergence, the coast of this region is very deeply indented with numerous small inlets of the *rias* type; and such bays as Miyako, Kamaishi, Onagawa, etc., afford for vessels well protected anchorages. The well-known iron mine of Kamaishi is on the head of the bay of the same name. Near Oshika Peninsula on the south, separated from the mainland by a narrow passage of water, is the granitic island of Kinkazan, whose lofty peak is the sailor's landmark. Dissected and waveworn Matsushima, a group of a hundred small islands in the Bay of Sendai, is noted for its beautiful scenery. In a small plain on the shore of this bay is Sendai, an old castle city and now the seat of a university with large faculties.

Another mountainous region, lying between the Pacific Ocean and the tectonic valley of Abukuma, is commonly called the Abukuma Plateau. This is a broad mountain mass, and consists of an extensive area of crystalline schists with narrow zones of Mesozoic and coal bearing strata of Tertiary formation along the coast. Many collieries working the so-called Joban coal-field are scattered there. The abrasion was much greater here than in the Kitakami Mountainland. The ancient mountain system with its complex strata was once reduced to a peneplain, which was afterward upheaved to form what is now an undulating plateau, whose greatest elevation scarcely exceeds 1000 m. The southern extension of this plateau forms the small ranges of Yamizo and Naka, which gradually sink into the plain of Kwanto. At the extremity of the latter stands an isolated mountain called Tsukuba.

Another extension of the northern arc toward the southwest forms the mountain blocks of Ashio on the one hand and Kwanto or Chichibu on the other, which constitute respectively the north and northwest boundaries of the Kwanto plain. Hitachi, one of the well-known copper mines of Japan, is located in the south end of the Abukuma Plateau, while another, called Ashio, is in the mountain block with the same name. The Kwanto mountain is a square block of the older geological formations. On the west it terminates abruptly in the tectonic valley of Chikuma and the basin of Kofu, and on the east in the plain of Kwanto. Some celebrated mountains of this group are Buko-zan, and Kimpu-zan.

The inner zone of the northern arc consists of two parallel ranges, separated from each other very distinctly by depressions forming low plains. The central range, or the Ou Mountains, begins on the shore of the Gulf of Mutsu. It runs south, forming the backbone of northern Japan as well as the watershed between the Pacific Ocean and the Sea of Japan. Geologically the range is made of liparitic tuff and some other sediments of the later Tertiary period, accompanying a few exposures of older formation. Moreover, this range is crowned with volcanic cones of the Nasu volcanic chain, one of the most important volcanic chains of Japan. At the northern extremity of it stands Osore-yama, 804 m., on the north coast of the Gulf of Mutsu. The chain runs south through such volcanoes as Yatsukoda-san, 1584 m.; Ganju-san, 2041 m., a gigantic volcanic cone of North Japan; Koma-ga-take, 1130 m.; Sukawa-dake, 1628 m.; Zao-san, 1759 m.; Adataro-san, 1710 m.; Adzuma-yama, 1949 m.; Bandai-san, 1819 m.; and Nasu-san, 1917 m., and turns to the southwest and then west through Takahara-yama, 1795 m.; Nantai-zan, 2484 m., the principal peak of the Nikko Group; Nikko Shirané, 2578 m.; Akagi-san, 1828 m.; Haruna-san, 1448 m.; and Asama-yama, 2542 m. Some of these are still active. The great eruption of Asama-yama in 1783 and the explosion of Bandai-san, in 1888, were the most remarkable. The great volcanic district of Kenashi and Iwasuge with the extinct volcanoes of the same names stretches to the north of Asama. Kusatsu-Shirané, 2161, m., and Adzumaya-san, 2333 m., are well known in this district.

The second range of the inner zone, which runs parallel to the central range and along the coast of the Sea of Japan, is similar in geological formation to the central chain. These ranges are separated from each other by a series of low depressed lands such as the valleys of the sister rivers Yoneshiro, Omono and Mogami, the basins of Yonezawa, Aidzu and Inawashiro, etc. The range is divided into two parts by the gorge of Mogami. The northern half, which is composed mostly of hills or low tablelands, is generally comprised under the name of the Dewa Hills. Recently the number of petroleum wells has been increasing in these hill districts. The southern half is very mountainous and is called the Echigo Range. Asahi-dake, 2418 m., and Iidé-san, 2105 m., are prominent peaks of granite mass in this range. The southern prolongation of the range stretches between the Aidzu basin and Echigo plain and terminates in the Mikuni Range.

A volcanic chain runs parallel to this western range. Commencing at Iwaki-san, 1625 m., it passes through Moriyoshi-yama, 1454 m., Chokai-zan, 2230 m. and Gassan, 1924 m. Chokai is well known because of its gigantic proportions and therefore this chain takes the name of this volcano. The coastal line of the Sea of Japan is mostly flat and unbroken. Its monotony is disturbed only by the volcanic peninsula of Oga, which encloses the shallow waters of the lagoon of Hachiro-gata. The plain of Echigo on the same coast is one of the largest plains in the country, and also one of the best rice producing districts in Japan. Niigata at the mouth of the River Shinano is a commercial town on the coast of the Sea of Japan. The hills in the plains Akita and Echigo constitute the principal source of petroleum. Akita, Nagaoka, Kashiwazaki, and Niidzu are centres of the oil industry. The forests of Akita are especially noted for beautiful cryptomeria trees. The apples of Aomori and the cherries of Yamagata and Fukushima are also very remarkable productions of this district.

b. **Kwanto** :— The plain of Kwanto, the largest in the country, stretches between the Kwanto Mountains and the Pacific Ocean. On the south it extends as far as the two hilly peninsulas, Boso (Awa-Kadzusa) and Miura, which enclose the shallow bay of Tokyo, an outshoot of the Pacific. The plain is gently undulating, partly of Tertiary formation, but mostly covered by later deposits. These hills and the neighbouring mountains are groups of tilted blocks of land. The great earthquake of 1923 was also nothing but a repetition of the blocking movement which took place in those peninsulas and especially in the bottom of the Bay of Sagami. The plain is drained by many streams, of which Toné is the most noted. Lakes and lagoons are numerous, and Kasumi–ga–ura near the mouth of the Toné is the second greatest lake of Japan. The plain is well cultivated and very densely populated. There are more than eighty cities and towns with populations of over 10,000. Tokyo, the capital of Japan, is situated on the mouth of the River Sumida, which flows into the Bay of Tokyo. Not only is it a political centre in this country it is also a centre of science and industry. The population of the city with that of the suburbs amounts to more than two million. At a distance of only 30 km. from the capital is the seaport of Yokohama, the greatest in the country and a little to the south is Yokosuka, one of the naval ports. Many towns in the northern part of the plain are noted for their flourishing silk industry.

c. **Central Honshu** :— In the central part of Honshu, where the two great mountain systems coalesce, lies a zone of great tectonic depression, which is represented by the valley of Chikuma–gawa on the east, and those of Fuji–kawa and Kamanashi–gawa and the lowlands of Matsumoto–daira extending to the fault valley of Hime–kawa, which ends near the town of Itoigawa on the coast of the Sea of Japan, on the west. Along this zone runs the volcanic chain of Fuji and many cones stand as boundary posts separating the two topographical districts of northern and southern Japan. The chain originates in the far south in the Mariana Islands in the Pacific Ocean; and running north through the Volcano Islands (Iwo–jima) and Shichito Islands, it reaches the peninsula of Idzu on the south coast of Honshu. Several eruptions on these volcanic islands and of submarine volcanoes have been recorded in recent years. Noteworthy among those volcanic islands is Oshima or Vries Island, which is now active. The Idzu Peninsula with Amagi–san, 1405 m., is linked with Honshu by the Hakoné mountain group, which is well known for its large and beautiful atrio lake, Ashi–no–ko, as well as for its many hot springs. Next Hakoné and over Ashitaka stands the prominent cone of Mt. Fuji, whose snowclad peak of typical conide form reaches the height of 3778 m. The chain tends towards the northwest and north and, passing through Kaya–ga–take, 1704 m., Yatsu–ga–take, 2899 m., and Tateshina-yama, 2530 m., it terminates with the Myoko Group (Myoko–zan, 2353 m.) near the coast of the Sea of Japan.

The southern arc of Honshu was first described as a part of the Sinian System by Pampelly and then as a part of the Kuenlun System by Loczy, both considering it is a single system and an extension of Nan–ling or of Pe-ling (Tsin–ling) respectively on the Asiatic continent. But Baron von Richthofen considers that it consists of two different mountain systems, which unite in southern Japan; one chain on the coast of the Sea of Japan, which he names the Chugoku Mountains, being probably an extension of the Kuenlun System or Tsin–ling, while the other, which runs along the Pacific coast and is called the Kuma–Kii Range, belongs to the mountain system of southern China, or Nan-ling.

Between the tectonic valleys of Fuji–kawa and Tenryu–gawa in Central Honshu lies the Akaishi Mountain System, which from its outline is often called the Akaishi Sphenoid. It is composed of several ranges of various geological formations. The highest peak of Akaishi proper reaches the altitude of 3120 m., while the culminating peak of the whole group with a height of 3192 m. is in the Shiramine Range, which runs parallel to the Akaishi range proper on the eastern side of the Oigawa valley. The northern extension of the Shiramine joins a granitic mass with the precipitous peaks of Koma–ga–take, 2966 m., and Ho–o–zan, 2741 m. The southern extension of the Akaishi Range forms the mountain districts of Totomi and Mikawa, and disappears in the Atsumi Peninsula.

Nearly parallel to the Akaishi Mountains, and between the two great valleys of Tenryu and Kiso, extends the Kiso Range with another Koma–ga–take, 2956 m. This range joins the mountainlands of Mikawa in the south. The spurs of these mountains form a terraced coastal plain which is composed partly of tea gardens and partly of grass–plains or *hara*, such as Takashi–ga–hara, Mikata–ga–hara, etc. In the production of tea, this district ranks first in the country. The lowlands at the base of the mountains are well cultivated and contain many towns and villages, through which runs the trunk line of the Tokyo–Kobé railway. Many large rivers such as the Fuji, the Abé, the Oi and the Tenryu flow towards the south, cutting deep valleys in the Akaishi Mountains and their spurs, and making braided streams on this coastal plain. On the coast is the depression lake of Hamana, which is now connected with the sea by a narrow outlet.

Coming back to the great tectonic valley of Fuji–Kamanashi, we find the small basin of Suwa with the lake of the same name. It lies 800 m. above sea level and is the source af the Tenryu. Further to the north, separated from this basin by the small ridge of Shiojiri–togé, stretches the valley of Matsmoto–daira with an average height of 450 m. Rising precipitously from this level, the lofty Hida Range forms the western boundary of the valley. This range extends south to the east side of the great Kiso valley, and the north end of it terminates abruptly in the precipitous cliff of Oyashirazu on the Sea of Japan. This gigantic scarp of the southern arc constitutes the highest mountain range in the Empire with many peaks of 3000 metres in altitude; hence it is often called the "Japanese Alps." There is no glacier in this range at present, but the presence of cirques or *Kar* at altitudes of 2500 m. in many mountains as well as the striated surface of the rocks of Shirouma–ga–take, one of the prominent peaks, indicate the former existence of one. Like the Akaishi Mountains, it consists of older geological formations and various eruptive rocks. Among numerous peaks, Yari–ga–také, 3180 m. called the "Matterhorn of Japan," Hodaka–yama, 3103 m.; Otenjo–daké, 2922 m.; and Shirouma–ga–také, 2933 m., are the most celebrated. The size and importance of this range is still further increased by its junction with the Norikura volcanic chain. The two largest volcanoes of this chain, Ontaké, 3063 m., and Norikura–ga–také, 3026 m., are next in height to Mount Fuji. Tate–yama is a lofty group including Tate–yama proper, 2992 m., and Ken–ga–mine, 2998 m., and runs closely parallel to the western side of the northern Hida Range, from which it is separated by the great gorge of Kurobe–kawa. The mountainland of Shinano with some separated basins is celebrated for its silk industry. The small town of Okaya on the shore of Lake Suwa is especially noted, having many mills.

The western flank of the whole Hida Range is not so steep as the eastern, but slopes to the mountainland of Hida, sometimes called the Hida Plateau. This comprises a wide tract of the most mountainous district in Japan, which spreads over the province of Hida and a part of Mino and Etchu. In its centre there is the small basin of Takayama. To the north of this mountainland lies the fertile plain of Toyama, along the coast of the deep Toyama Bay, an arm of the Sea of Japan. The Jindzu–gawa and Imidzu–gawa drain this mountainland and then flow through the plain. The western border of the plain is a high ridge, upon which stands the volcano of Haku–san, 2702m. The range slopes gradually through a hilly region to a narrow belt of the coastal plain along the Sea of Japan. The province of Noto is a large peninsula on this coast. It is crossed by a typical rift valley, in which occur the lagoon of Ochigata and the beautiful bay of Nanao. The coastal plain is thickly populated and there are such towns as Kanazawa, the seat of an eminent old feudal lord, and Fukui, famous for its silk manufacture.

To the south of the Hida mountainland, stretch the lowlands of Mino and Owari. They form a part of the great depression whose southern half is now occupied by the Isé–no–umi, an arm of the Pacific. The Mino–Owari Plain is drained by the three rivers Kiso–gawa, Nagara–gawa, and Ibi–kawa. It is extremely fertile and produces rice of an excellent quality. Nagoya is a flourishing commercial and industrial city, especially noted for porcelains and cloisonné, and also an important railway junction. This plain is bounded on the west by the ranges of Ibuki, Yoro, and Suzuka. They are all typical tilted mountains with steep scarps against the plain. Further to the west, there is a series of such depressions separated from each other by north and south *horst* ranges, which finally end in the great depression of the Inland Sea or Setouchi.

d. **Kinki district**:— Next to the Mino–Owari Plain and between the Yoro and Hiei–Kasagi, there lies the depression of the province of Omi, the greatest part of which is occupied by Lake Biwa, the most picturesque and largest freshwater lake in Japan. The waters of the Sea of Japan cut into the land, forming the deep depression of Tsuruga Bay. There is only a narrow tract of land between this bay and Lake Biwa, and it is dissected again by a series of some dislocation lines. Iga is a small basin to the south of Omi. To the south-west of Omi basin there are the basins of Yamashiro and Yamato. There was, however, originally a single depression between Hiei-Kasagi (Hira-san, 1174 m., Hiei-san, 848 m.), and the Kongo mountains, 1112 m., which has been divided into two basins by undulating hills of insignificant height. These basins have played an important rôle in the history of Japan. The basin of Yamato was the seat of the capital of the Nara dynasty, 1000 years ago, and there still remain many ancient buildings, especially Buddhist temples. In the centre of the basin of Yamashiro is situated the city of Kyoto, which was the capital of Japan for a thousand years until Tokyo was made the new metropolis in 1868. The city, which is often called the "Paris of Japan," is well known for its scenic beauties and its many old magnificent palaces and temples, and it is also noted for its artistic and industrial wares, especially for various kinds of silk, embroideries, porcelains and cloisonné ware. It is also a centre of science with a large university.

On the other side of Kongo *Horst* lies the plain of Settsu, which sinks into Osaka Bay on the west. The River Yodo drains Lake Biwa, and passing through both the plains of Yamashiro and Settsu, it discharges into Osaka Bay. Lying at its mouth, Osaka has been for centuries a commercial centre in Japan and at present it is a flourishing industrial city. It is the largest city in Japan, with a population of over 2,000,000. Kobé is an excellent harbour on the shore of the bay and is the largest port for the cotton trade in the country.

On the south of this framework of block mountains and depressed troughs lies the large mountainous peninsula of Kii. On the eastern side of Kumano-gawa, a deep transversal valley, the mountain system attains a considerable height in many peaks of the Omine Group (the culminating point is 1815 m.) and in the case of Odaiga-hara-san. These mountains are nothing but an extension of the noted Akaishi Mountains. The range dips down into the Sea of Ise at the peninsula of Atsumi; but, reappearing in Shima Peninsula on the opposite coast of the sea, it extends westward with an increasing magnitude and height. The continuity of this system may be well traced in the island of Shikoku through Kii Channel. The mountains of the peninsula are famous for beautiful forests of cryptomeria and the hills on the coast afford an abundant production of oranges. Wakayama is an old city, now noted for its cotton industry.

On the other hand, the Palaeozoic mountainlands of Tamba lie north of the Yamashiro and Settsu basins. They occupy an extensive area of older formation, like the Hida Plateau, but are not so high and inaccessible. To the south it makes a steep scarp to the plain of Settsu, while to the north there is the wide bay of Wakasa, its coast indented with many small inlets. On this bay are Maidzuru, a naval port, and also a long sand spit called Amano–hashidaté or "The bridge of heaven," which is noted for its beautiful scenery.

e. **Chugoku** :— The western part of Honshu forms the large peninsula of Chugoku. It is almost wholly a highly dissected plateau with a few plains along the coast and rivers. The plateau, however, scarcely exceeds 1000 metres in height, with the exception of a few volcanoes, which form a volcanic chain through the northern half of this district. Dai–sen, 1713 m., and Sambe–yama, 1126 m., are the most celebrated volcanoes. According to Ozawa, the earlier geologic formation of Chugoku has been greatly disturbed by overthrust foldings which were repeated in the later Palaeozoic and Triassic periods. After a general peneplanation the land was once more upraised forming a plateau landscape, which is, however, dissected by many mountains and hills at present. Granite and other igneous rocks were erupted enormously in earlier periods and are widely exposed throughout this district. Rivers are generally short, often making picturesque ravines; along tectonic lines there are only a few noteworthy ones, such as the Gono–kawa running into the Sea of Japan, and the Higashi–no–okawa, Nishi–no–okawa, Kawabe–kawa, and Ota–gawa flowing into the Inland Sea.

The coastal lines on both sides of this district show great contrasts. Along the Sea of Japan the coast is very poor in bays and islands. There is one independent range, the Shinji, forming the peninsula of Shimane. It is separated from the mainland by a wide rift valley, which is now occupied by the lagoon of Nakano–umi, Lake Shinji and the low plain of Kidzuki. Matsue is a beautiful town, located on the shore of the lake and often spoken of as the "Geneva of Japan." This district has also been well known from protohistoric times because of its communication with the Korean Peninsula. Oyashiro in the Kidzuki Plain is one of the most celebrated shrines in Japan with respect to Korean immigrants of ancient times. The peculiar type of architecture of the shrine deserves special attention.

The south coast of Chugoku shows quite a different aspect. It faces the Setouchi or Inland Sea. This peculiar sea is a zone of depression having Chugoku on one side and Shikoku and Kyushu on the other, and is joined to the outer seas by narrow channels or *seto*. The name *Seto–uchi* means literally, "Within the channels." This sea is divided into several small open seas or *nada* by groups of hundreds of islands, which now remain as detached elevations in this depressed zone. From Osaka Bay, Harima–nada, Midzushima–nada, Bingo–nada, Aki–nada and Suo–nada lie to the west successively. They are generally very shallow and in most parts do not exceed 40 m. in depth. The only portions where great depths are found, are the narrow passages at the outlets to the sea, where the bottom is acted upon most effectively by the erosion of tidal currents.

The coastal line of Chugoku is highly developed on the shore of Setouchi. Numerous inlets cut into the land, and there are many good harbours and anchorages. Among them the Bay of Hiroshima is one of the best, with the city of the same name on its shore. Not far from there and on the coast of an arm of Aki–nada, is the naval port of Kuré with its large docks and arsenal. Itsuku-shima or Miya-jima, situated in Hiroshima Bay, is noted for its beautiful mountain scenery and so–called "Floating shrine." The channel between Chugoku and Kyushu makes an excellent harbour, though the tidal current at the entrance is very rapid. Shimonoseki on the side of Chugoku is a flourishing city, for many centuries known as a rice market. It is now an important terminus of a trunk line of railways in Honshu and is joined with Fusan, the southern front door of Chosen, by daily service of rapid passenger boats. There is also a busy connection of ferries with Moji on the opposite side of the channel.

On the shores of the Inland Sea, both in Chugoku and Shikoku, there are many salt gardens. Lesser precipitation and good evaporation favour this industry and make these regions the principal place for the production of salt in Japan. In the coastal plain near Okayama rush grass is cultivated, and the weaving of fancy matting is a very flourishing industry there. Cattle raising prevails in the mountain villages.

ii. **Shikoku**:— This island is nothing but a detached block of the southern arc of Japan. It is separated from Chugoku by the Inland Sea, while a great depression forms the large bay of Tosa on the south, bounded by the two promontories, Muroto and Ashizuri, projecting southwards into the Pacific. Fractural depression of Kii Channel on the east and Bungo Channel on the west, cut off Shikoku from Kii Peninsula and Kyushu Island. There is great similarity between the mountain formations of Shikoku and the others. The Shikoku Range, which extends east and west through the island, is a continuation of the mountains in Kii Peninsula and Kyushu Island. The greater part of the island is very mountainous, and there are several lofty peaks, such as Tsurugi-san, 1955 m., and Ishidzuchi-san, 1981 m. The northern part of Shikoku, from which the two great peninsulas of Takanawa and Sanuki project into the Inland Sea, is very similar in its geological and topographical features to the Chugoku and Setouchi islands. The peninsula of Sanuki is nothing but a recently elevated tract of the same sea. Many isolated granite mountains and hills stand like islands in the low plain. The so-called median dislocation line of south Japan runs along the Sanuki Range in the northern border of the Shikoku Range. It makes a distinct tectonic boundary, separating the land and sea of Chugoku from the very regular zones of the Shikoku Range, which is formed mostly of crystalline schists and some other old sedimentaries. Among many rivers, the Yoshino-gawa is the most noted. In its upper course it flows eastward, forming a valley in the Shikoku Range, then cutting through the range, it forms the famous gorges of Oboké and Koboké and turns again eastwards parallel to the range, flowing through a wide plain until it empties into Kii Channel. A peculiar development of the coastal line on the western side of the island shows many elongated peninsulas and promontories, such as Sada-no-misaki. Awa-no-naruto, situated in the narrow strait between Shikoku and Awaji, is very remarkable on account of its terrible whirlpools, which are caused by tidal currents.

The coastal plains along the Inland Sea are well cultivated and densely populated. The mountains produce beautiful timber. The well-known copper mine of Besshi is located in this island. Ichinokawa was once known for its magnificent crystals of antimony glance. Fishing is very remarkable in the Inland Sea as well as in the Pacific. Precious coral is dredged in the latter ocean near the coast of Tosa, while multitudes of bonito are caught far off the coast of the same province.

iii. Kyushu:— This is a large island with a very complicated topography and geology. The Kyushu Range, which is a continuation of the Shikoku Range, passes obliquely through the southern half of the island. It culminates in the centre of the island in several high peaks, such as Kunimi–dake, 1739 m., Sobo–dake, 1758 m., and Ichibusa-yama, 1722 m. The well–known river of Kuma–gawa flows from Ichibusa–yama into the Sea of Yatsushiro, forming a picturesque gorge through the mountains. The mountains are covered with beautiful forests, and lumbering is the source of the wealth of this district. It is also noted for the production of large bamboos. Further south, there stretch the two great peninsulas of Satsuma and Osumi, forming the shores of the beautiful Bay of Kogoshima. The geological formation of these peninsulas is mostly mesozoic combined with the other deposits of the Kyushu Range; but its surface is covered to a great extent by ejecta of volcanoes, there having been several violent eruptions in recent ages. The Kirishima group is one of the most celebrated active volcanoes in Japan. Karakuni–daké, 1700 m., and Takachiho–no–miné, 1674 m., are magnificent cones in this group. The volcanic chain of Kirishima commences in this group; Sakura–jima, 1060 m., which was once a volcanic island in the Bay of Satsuma, violently erupted in 1914, sending forth so much lava that the ejecta joined the island to the mainland and made it a peninsula. Kaimon–dake to the south of it is a perfect conide at the extremity of Satsuma Peninsula. The further extension of this chain runs southwards and passes to Formosa through the volcanic islands of Kawabé Shichito (Seven Islands of Kawabé) and those of the inner zone of Ryukyu, some of which are active at present.

In the northern part of Kyushu, on the other hand, there lie the so–called Tsukushi Mountains, a mountain group of various geologic formations, ancient and recent, as well as of plutonic and volcanic rocks. There is no regularity in the mountain forms, and the whole region is divided into many tracts of mountains and hills, the heights of which rarely exceed 1000 m., except in the case of some volcanic cones. In this district vertical displacements of land were not rare and the mountains were dissected by fault valleys. In many estuaries of this origin were deposited in the Tertiary period extensive areas of coal seams, which were afterward elevated as hilly tracts in the mountainland. Many collieries are found there, and nearly 70 % of the coal production of Japan comes from this district. Miike is the most celebrated colliery and exports coal direct to many oriental harbours as far as to Singapore. Moji, situated in the extreme north of Kyushu and along the strait of Shimonoseki, has had a rapid development during the past decades, as an export harbour for coal.

Other harbours such as Wakamatsu, Karatsu, Nagasaki, etc., are also well known for their coal trade. Manufactural industries naturally flourish in this region. There are many towns, large and small. First of all, Yawata on the north coast near Wakamatsu is noted for its sudden development and for the Imperial Steel Works located there.

An extreme development of the coastal line forms the peninsulas of Sonoki and Shimabara, which are connected with the mainland by the narrow isthmus of Isahaya. Omura Bay and Ariaké Bay are separated by these peninsulas from the sea. There are many excellent harbours on this coast. Nagasaki, a beautiful inlet of *rias* type, was first opened for Dutch and Chinese merchants, and centuries ago it was known as the only port for foreign trade. Now it has a large dockyard and a library with books and documents concerning foreign intercourse in the Takugawa period. Sasebo is a good naval port. Many other good anchorages are found on the northern coast. Fukuoka, with Hakata harbour in its neighborhood, is one of the large commercial towns of Kyushu, situated on the beautiful bay of Hakata. There is an Imperial University with large faculties.

Between the two ranges of Tsukushi and Kyushu lies a great volcanic mass, whose ejecta cover an extensive area in the central part of Kyushu. Aso-san in this group is one of the most remarkable active volcanoes of Japan. The diameter of its outermost craterwall is perhaps one of the greatest in the world, 16 km. by 24 km. Surrounded by this wall is a large crater plain, and in its centre stand five volcanic cones, among which Taka-daké is the highest, 1592 m. To the northeast of the Aso volcano proper stretches the Aso volcanic chain. In this chain there are the volcanic groups of Kuju-san, 1764 m., next to that of Aso, Yubu-daké and Tsurumi-daké near the shore of Beppu Bay, and the circular peninsula of Kunisaki with the volcano Futago. Beppu, one of the most celebrated spas in Japan, is located in the skirt of Yubu-daké. The further extension of this chain may be traced to Chugoku and some small islands in the Inland Sea. Another continuation of this chain in the opposite direction is indicated by Kibo-zan in Kumamoto Plain and Unzen-ga-daké, 1360 m., on Shimabara Peninsula. To the north of the latter there is another volcano, Tara-daké, 983 m.

A comparatively wide plain extends along the shore of Ariaké Bay. It is divided into two parts by the hilly region of Miiké. The northern plain is drained by the Chikugo-gawa, the largest river of Kyushu, and is densely populated. Higo Plain on the south has in its centre the city of Kumamoto. This plain is extremely fertile and produces rice of the best quality. The warm climate of the southern provinces favors the production of cane sugar as is the case in Satsuma. Among many islands, there are the twin islands of Amakusa, and the Koshiki and Goto Groups, to the west, while Iki and Tsushima to the north form stepping stones between Japan and Korea. The neighbouring seas are well known for very rich fishing of bonito, inkfish, etc.

iv. **Ryukyu**:— All the islands stretching between Kyushu and Taiwan (Formosa) are comprised under the name of the Ryukyu Group. But politically the northern group of these islands belongs to Kyushu. These islands are nothing but the peaks of a submerged mountain ridge along the edge of the continental shelf. Geologically the arc of Ryukyu is divided into three zones. The islands in the central zone are mostly of older geologic formations while those in the outer zone are of the later Tertiary period. The inner zone is of volcanic origin, and is the continuation of the Kirishima volcanic chain of Kyushu. Coral reefs develop near the coast of the islands, and there are also old raised reefs on some islands. The tilted structure of the land is especially remarkable in the Yaeyama Islands of the southernmost group. Okinawa-jima, the largest island, is situated in the centre of this arc. Most of the islands are hilly, with the exception of Yaku-shima, in which there is the granite mountain of Miyanoura-dake, 1935 m. Many of the islands are very densely populated and cane sugar manufacture is the principal industry.

v. **Taiwan** (Formosa):— This spindle-shaped island is at the southern extremity of the Empire and lies next to the province of Fokien of South China from which it is separated by the Taiwan Channel. Slight development of the coastal line characterizes this island, there being no large indentations. Kelung, the gate to this island on its northern end, is but a small *rias* harbour. The backbone of Taiwan consists principally of Palaeozoic slate and limestone. It begins with the precipitous cliff of Cape Bitō on the northern coast, and stretches southwestwest for some distance, then turns to the southsouthwest. Here stands the second highest peak of the island, the former Mt. Sylvia, now called Tsugitaka-yama, 3931 m. high. From this lofty mountain the range runs along the length of the island projecting many high peaks and pinnacles over 3000 metres high, until it terminates at Garampi or the South Cape. It culminates in Niitaka-yama, or, as it was formerly called, Mt. Morrison, 3950 m., the highest mountain of Japan. This range makes a steep scarp on its eastern side. Sharply separated from this range by a tectonic valley, another small range, that of Taito, stretches north and south along the eastern coast, where it stands abruptly on the roaring waves of the Pacific. Parallel to the west side of the central range lie hills of a later geological formation with a lower altitude. Along their foot extends a strip of fertile plain, where is an excellent delta development of many rivers, which, leaving the mountain region, suddenly discharge their water and silts into the plain.

The island is practically tropical in nature with luxuriant vegetation, as the name "Formosa," given to it by the Portuguese, implies. Among the plants growing in the plains we find betelnut palms, banyans, pandanus, bamboos and tree-ferns. Mangrove trees are very common in the shallow waters of the southern coast. The most important of the cultivated plants are sugar cane, rice and the tea-plant. Sugar plantation has undergone a great improvement and many sugar refineries are found in the southern plain. Tea plantation is carried on in the hills near Taihoku, the metropolis and at the same time the principal market for oolong tea. The cultivation of bananas of a higher grade has greatly increased in recent times. This fruit has become an important staple of the island and great quantities are shipped to Japan proper. Sweet potatoes, pineapples and peanuts are also well cultivated there. The camphor tree, the king of the Formosan forest, grows in woods at slight elevations. Strongly stimulated by the development of the celluloid industry in recent years, its production has enormously increased, until the largest part of the world's demand is supplied by this island. In the higher altitudes of the mountains there are beautiful forests of conifer trees, especially the species of chamaecyparis. Lumbering in Mount Ari is one of the important industries of the island. Among minerals, gold is mined in the mountains near Kelung and petroleum is obtained in the Tertiary hills in central and southern Taiwan. Taihoku, the seat of the government general of the island, is situated in a small basin at the northern end, through which the River Tamsui flows, having

Tamsui harbour at its mouth. The city is connected by railways with Kelung to the north and Taichu, Tainan and Takao to the south. Tainan was once called Taiwan–fu, and there are the ruins of an old Dutch fort called Zeelandia. The anchorage of this town is unfortunately very shallow and too open, so that commercial prosperity is removing to the naturally and artificially well equipped harbour of Takao to the south.

Hoko–to, or the Pascadore Islands, are a group of small islands in Taiwan Channel. They are of basalt, with an insignificant altitude above the sea. The main island of Hoko–to has an excellent shelter harbour, called Mako.

vi. Hokkaido :— Yezo, as it is called by Europeans, is the second great island of Japan. It is rhombic in its general outline with a terraced coast mostly level and low, having a peninsula of fish–tail shape on the southwest, in the south end of which is located Hakodate, the best harbour and main entrance of the island. The continuation of the volcanic chains in northern Honshu extends into this peninsular part. The large bay of Uchiura, or Volcano Bay, commands an excellent view of various volcanoes on its coast. On the south of the bay is the well–known Koma–ga–také, 1140 m. There are many volcanoes, especially in the region to the north of the bay. Makkari–nupuri or Shiribeshi–yama, 1893 m., which is situated at the centre of that volcanic region, is noted for its perfect cone. Other active volcanoes such as Usu, Tarumaye, etc., are also there.

The backbone of the main part of the island consists of older rocks and passes through the island in a S.S.E.–N.N.W. direction from Cape Erimo to Cape Soya. The southern half of this range is called the Hidaka Mountains, and the Yubari Range runs parallel to it along its western side. At the centre of this backbone stand many peaks, most of which are volcanoes. Among these prominent peaks, Nutapkaushibé, 2290, m., Oputateshiké, 2052 m., and Tokachi–daké, 2077 m., are well known, the last one especially being noted for its quite recent eruption of 24. May, 1926. Ishikari–daké, consisting of older eruptive rocks, 2035 m., is also remarkable for its high altitude. The Chishima volcanic chain runs east, from Nutapkaushibé, including several volcanic cones, such as Meakan, 1617 m., and Oakan, 1514 m., in the main island, and Atosa–nupuri, Raushi, etc. in Chishima.

The Yubari Range is made of Cretaceous and Tertiary formations, and is rich in coal seams. Many collieries such as Yubari, Ikushunbetsu, etc., are located there. Seaward from these elevations stretches a gently undulating hilly region through which many large rivers flow, such as the Ishikari–gawa, Teshio–gawa, Tokachi–gawa, etc. Fertile plains are found along these rivers. The largest plain in the island is that of Ishikari, which separates the main body of the island from its peninsular part and penetrates further northward into the mountain district along the river Ishikari. Kamikawa is a basin at the upper course of that river.

Agriculture is largely pursued in this island. Various kinds of cereals and beans, and even rice, are raised everywhere. The island produces also good horses and cattle. Lumbering is one of the principal industries. Pulp is prepared in great quantity for paper mills, and sleepers are exported for the railways at home and abroad. Fishery is the most important industry of this island. Herring is obtained abundantly for foodstuffs and fertilisers. Salmon, codfish and a seaweed, Laminaria, are also collected in quantity and exported to China. Sapporo, the political centre of this island, and the seat of a university, is situated in the plain of Ishikari, and Otaru, its flourishing harbour, lies at a short distance from it.

Chishima, or the Kuriles:— This group of islands stretches from the Bay of Nemuro to the southern extremity of Kamchatka Peninsula, describing a large arc forming the eastern boundary of the Sea of Okhotsk. These islands are entirely of volcanic origin, accompanying Tertiary strata in some islands. The three great islands of Kunashiri, Etorofu, and Uruppu, lie to the northeast of the main island of Hokkaido in the order named. These islands have been explored but little and are very sparsely populated.

vii. Karafuto:— The island of Sakhalin is the northernmost element of the northern arc of the Japanese Islands. It is a large island, with an area of about 78,000 sq. km. It stretches north and south on the meridian of 149° 30′ E., and is about 950 km. long, while the mean width measures scarcely one-tenth of its length. It has a simple form and regular structure. Nearly in the centre of the island, a peninsula called Nishi–Shiretoko shoots out to the southeast, while the principal part of the island extends due south along the axis of the island and bifurcates once more at the south end into two arms, Notoro Peninsula on the southwest, and Shiretoko Peninsula on the southeast.

With respect to its structure, the island is divided into three distinct zones, running parallel to each other in a longitudinal direction. The western zone, called Nishi–Karafuto or West Sakhalin, consists of a long chain of mountains of younger geologic formation, which extend nearly continuously along the whole length of the island. On the other hand, the eastern zone, consisting of older formations, was once a long chain of mountains, which, however, have since been separated into several blocks by depression, making the Northeast Range in the middle of the island, and the Susuya Mountains, with the adjoining peninsula of Shiretoko, in the south.

Between these two zones of elevation, is the central zone of depression. To the north, stretches a low plain drained by the rivers Poronai and Tym, which run in opposite directions, and in the south is a similar plain along the River Susuya and the lower course of the River Naibuchi.

The West Sakhalin Mountains form the backbone of the island. They are mostly composed of Cretaceous and Tertiary formations, and are traversed by volcanic rocks in many places. The principal divide and high peaks of this range are not, however, so high as those in central Japan, and few of them exceed 1,400 m. in height. Mount Notasam in the south, formerly well known under the name of Spanberg, is 1,032 m. in height; while Mount Shiska, the culminating point of these mountains, and the highest mountain in the island, measures only 1,382 m. The principal trend of the Cretaceous formations, as well as that of the old formations in the eastern zone, runs north and south, coinciding with that of the principal mountain chains; while the Tertiary mountains on both sides of the Cretaceous formations, although running to some extent parallel to them, have a different trend, northwest to southeast. Volcanic rocks occur in many localities. They consist of andesite, basalt, and agglomerate. Sometimes they exist as isolated cones like the well-known Mount Notasam, or again, they form volcanic groups like Ushoro, with its four cones. None of these volcanoes is active at present.

The Tertiary formation is an important element in the economic geology of Sakhalin, because of the occurrence in it of many coal seams. For some years many collieries were worked by Russian convicts along the outcrops of the seams in the coast ranges, especially in North Sakhalin. Among them, Due near Alexandrovsk, Rogatzi, Agneo, Mugatzi, Nainai, Petrovskii, etc., were noted, and before the war the total yearly production amounted to about 50,000 tons.

In South Sakhalin, the Kawakami colliery in the Naibuchi coal-field deserves special attention. All the coal produced is consumed locally, for railway engines, coasting steamers, and pulp mills. On the Tertiary hills and foothills, extending some 400 km. along the eastern coast of Russian Sakhalin, many seepages of petroleum have been observed for many years. Russians and others tried drilling in various spots, and at some a certain amount of oil was produced.

For a long time the island was a hermit land of primitive peoples, Ainus in the south, Giliaks and Orochons in the middle and north. They spent their days peacefully, fishing in summer and hunting in winter. The Giliaks led a happy nomad life, possessing herds of reindeer. Then came Russians from the west, and Japanese from the south. The territories of these newcomers were not settled, until in 1878 the two nations came to negotiations, by which Sakhalin became Russian, while Japan obtained all the Kurile Islands.

When Sakhalin became the penal colony of Russia, convicts were sent there to dig coal, or to cultivate bread-stuffs. The island is situated partly within the limits of cultivation. Oats and rye are raised in the plain of the central zone of depression, even on the banks of the River Tym or in the vicinity of Alexandrovsk. Some immigrants at the time of Russian possession were engaged in fishing in the rivers and seas. Instead of the simple huts of the natives, covered with seal-skin, stout log-houses of Slav construction were built here and there. Both on the coast and in the inner plain, new types of villages and towns came into existence, following the Russian style.

For many years the Japanese have called the island Karafuto. In 1905, when the region south of the parallel of 50° N. was ceded by Russia to Japan, the same name was applied politically to that region. The Russians called the island Sakhalin after its Tungusic name.

In Japanese Karafuto, we have at present only a few natives and Russians; 98 % of the population is Japanese. The Japanese have immigrated here since the days of Russian control for the purpose of fishing for herring and salmon. Of course, the population has increased remarkably since 1905, and now most parts of the coast regions and the central plain are pretty well colonized. The number of villages and towns is gradually increasing. Railways already run along the west coast and the central plain, and are connected by a new line built through the west mountain chain. The census of 1920 gives the population as 105,899. It varies in summer and winter, being greater in summer on account of the fishing season. The density of population is only three per sq. km. and is quite insignificant when compared with that of other parts of Japan, even Hokkaido.

The principal industry is fishing. Among the fish products, fried herring, canned crabs and salted salmon are well known. Lumbering, especially the pulp industry, is developing there. Besides oats and rye, wheat is also raised on the plains.

Toyohara, formerly Russian Vladimilovka, is the provincial capital. It is connected by railway with Odomari, the principal port of the island. There is a regular ferry service between this harbour and Wakkanai, the railway terminus of the northern end of Hokkaido. Maoka is the second important icefree harbour and the centre of the fisheries in the Gulf of Tartary.

viii. Chosen :— Chosen or Korea is a large peninsula projected southwards from the Asiatic continent, and its area is a little smaller than that of Honshu. It is separated from Manchuria by the natural boundaries of the Changpai Range and the two large streams of Yalu and Tumen. The topography of the peninsula is not similar in its northern and southern districts. In the former, the Changpai Range forms a wall at the back, upon which stands a gigantic volcano called Hakuto–san or Paik–to–san, 2744 m., with a large crater lake known as Lungwong or "The Dragon King" on its summit. To the south of this range the extensive plateau of Kaima slopes down to end in a steep scarp on the shore of the Sea of Japan. The surface of this plateau is covered with lava–flows from Hakuto, which are dissected into many mesa, especially in the North Kankyo district. These lava–flows on the other side of the range form a more extensive plateau in Manchuria, which is covered by an ocean of virgin forests. The southern part of Chosen consists of many tilted mountains of Archean and Palaeozoic formations, which run mostly in meridional directions. Among them, Taihaku–san is the most noted. It forms practically the backbone of the peninsula, with a steep scarp to the Sea of Japan in the east and dips gently to the west, making many hills and plains. Kongo–san, or the Diamond Mountains, are noted for their scenic beauties of granite peaks, pinnacles and gorges. A remarkable rift valley crosses the neck of the peninsula, through which basalt eruption took place. The lava covers the surface of the valley making a long plateau upon which the Keijo-Gensan railway runs. Naturally there is no remarkable stream here flowing to the Sea of Japan, the formation contrasting with the slope to the Yellow Sea and Korea Strait, where are many large streams such as the Oryoku-ko, or Yalu-kiang, Seisen-ko, Daido-ko, and Kin-ko. They have generally extensive flood plains with many towns and villages. The population is more dense in the southwestern provinces and less so in the north.

Agriculture, mining and fishery are the principal industries of Chosen. The production of rice, wheat, beans and cotton has been increasing in recent years. Ginseng culture deserves special attention. The breeding of cattle and export of their hides constitute a flourishing industry. Lumbering in the Yalu basin of North Chosen has been well known for a long time. Gold is the principal product of the mines. At present more mountain gold is smelted than placer gold. Yun-san is the most noted gold mine. Iron ore from Sainei and Inritsu is exported to the Imperial Steel Works in Yawata. Anthracite of Carboniferous from Pingyang supplies materials for bricket. Graphite is obtained in several places.

Keijo or Seoul on the bank of the Kan-ko in the centre of the peninsula is the present seat of the government general. It is a walled city with many palaces and parks. Jinsen, its harbour, has a well equipped tidal basin. Kaijo and Heijo (Pingyang) to the north and Keishu to the south are noted old towns. Near Heijo there are scattered many thousands of ancient tombs, the recent excavation of some of which tells very clearly of an active intrusion of Chinese civilization of the Han dynasty in the peninsula, some 2000 years ago. Shingishu is a boundary station on the bank of the Yalu. Markets and fairs are the prevailing organs of exchange in Chosen, even at present. Indeed there are at least one thousand markets there. They are opened once every five days, and even in small markets at least 500 customers gather from the environs a score of kilometres distant. When an annual fair takes place, like that of Taikyu in South Korea in August, it is visited by more than a thousand merchants and the trade is said to amount to 6-700,000 yen.

ix. Kwantung. Kwantung is a small peninsula in the southwest end of the Liaotung Peninsula in South Manchuria. Geologically, it is composed of older formations, which are now highly worn, forming wavy hills. The coast line is well developed and has good harbours and coves. It was leased to Russia by China in 1895, and then lapsed to Japan by the Portsmouth Treaty of 1905. The original term was to have expired in 1923, but it was extended to 1997 by the Sino-Japanese Treaty of 1915.

Ryojun or Port Arthur was once a well protected Russian base in the Orient, and is now the seat of the provincial governor. There are also a good museum and a technical college. Many ruins of old fortifications near the town tell of the bitterness of the battles fought there. Dairen, formerly called Dalny, is an excellent harbour open to foreign trade, and constitutes the main entrance to Manchuria. It has a large icefree basin with well equipped quaywork, which always admits many ocean liners. The city is regularly planned after the modern European style. Immense quantities of many different staples, such as soya beans, bean cake, bean oil and coal, come from the hinterland for export from here. The trade is so large that this city ranks commercially next to Shanghai and Tientsin in China.

The South Manchuria Railway Company has its headquarters in this city. It manages the railway service of the trunk line between Dairen and Changchun, which was ceded to Japan in 1905, as well as its branch lines. These lines, in connection with Korean and Chinese railways, form a part of a grand transcontinental railway at present. The company is engaged also in several other businesses, such as mining, shipping, harbour, etc. Among many mines under the railway's management, the colliery of Fushun is the most celebrated. The coal seam is in a Tertiary formation, with an average thickness of 40 m., and is worked at present partly by open-cut mining. The utilization of the oil shale of this mine ensures its future prosperity. The iron ore of An-shan and the dolomite bed near Tashihchiao are likewise noteworthy. Besides these economic undertakings, the company is engaged also in town planning, the management of colleges and schools, and the establishment of libraries, hospitals, technical laboratories and agricultural experimental stations at Dairen and other places in the railway zone. In Mukden, an old Manchurian metropolis and a railway junction, the company has constructed a fine new town in modern style outside the wall of the old Chinese city. Other instances of town construction occur at many stations in the said zone.

X. **Mandate in the Pacific,** or South Sea Islands. These islands are scattered over a vast area of the sea, measuring 4,500 km. east to west and 2,400 km. north to south. They are divided into the Caroline Group in the middle, the Mariana Islands to the north, the Palau

Group to the west and the Marshall Islands to the east. Most of them are volcanic islands or coral reefs. Though their number is as great as 1,458, the total area is scarcely 2,149 sq. km., or nearly equal to that of a small prefecture in Japan proper. During the World War, they were occupied by our navy, and by the Treaty of Peace they became a mandate of the Empire in 1918. They are now administered by a governor whose seat is in the Palau Islands.

Mariana Islands. They were called the Ladrones by their discoverer, the celebrated navigator Magellan. They are a southward extension of the volcanic chain of Fuji of Japan proper. Arranged in a slightly curved arc, they make a chain of volcanic islands, some of which are active at present, for example, Guguan and Pagan. The largest island in the group next to American Guam is Saipan, which is well inhabited and has recently become noted for its cotton and sugar plantations.

Caroline Group. These islands are situated on a broad submarine plateau to the south of the deep Mariana trench. The principal islands of this group are of volcanic origin, but they are not so fresh as the volcanoes of the Marianas, and are so highly dissected that it is difficult to restore in imagination their original forms. Among them Ponape is the largest island, and Kusai comes next. The precipitous cliff of basaltic lava flow in the cape Jokaji in the former and the fanny pinnacles on the top of the latter show how strong was the sculptural process in these islands. The Truk Islands in the middle of the group are a very good example of the relics of a sunken and highly eroded volcano. They are situated in an extensive lagoon, which is surrounded by a long atoll. Of course, coral reefs of various forms are well developed everywhere in this group, both independently and along the volcanic islands.

Yap and Palau are separated from each other and from other islands by deep submarine trenches. Very remarkably, the small island of Yap is a remnant of an old land of schists and other older sedimentaries. It is also noted as "The island of stone money" on account of a curious custom of the aborigines, who still use large discs of marble, which are brought from the distant island of Palau, for money. Beautiful pearl shells are also used for the same purpose. The island is an important cable junction in the western Pacific. Cables run to the Celebes in the southwest, to Guam in the northeast, and to Shanghai and the Ryukyu Islands in the northwest.

The Palau Group. The Palau Islands consist of volcanic rocks and raised coral reefs. In the small island of Koror, next to Palau, the largest one of the group, is the centre of administration of the mandate. Malakal provides a very good anchorage there. The sea near the islands is known for several good varieties of pearl shells. Anguar to the south of Palau is most noted for the production of phosphate ores. The total amount of this mineral has been estimated at 3,500,000 tons, about one third of which has already been worked out. The small reef of Fais is also noted for the occurrence of the same mineral.

Marshall Islands. These islands consist of two chains of coral reefs, Ratak and Ralik, which run parallel to each other in the direction of N.W.W.—S.E.E., coinciding with the general trend of the submarine ridges in this region. Most of these reefs are typical atolls of various sizes and forms; and some of them measure more than 100 km. in diameter, e.g., Kwajalong. Yaluit in the southern end of the Ralik chain is an important reef with a good anchorage in its lagoon. Jabor is the name of the harbour village on the lagoon.

The government authorities are now making an endeavour to promote culture and industries among these islanders. The native children are well educated in many common schools in the principal islands. Plantation and fishing are encouraged in various directions. The principal industry of many of the islands is the production of copra. Its production in 1924 amounted to ten million pounds, worth 767,000 *yen*, 60% of which was raised in the Marshall Islands. Pearl shells and tortoise shells are also noted products of the neighbouring seas. But after all phosphate comes first, with annual exports worth more than one million *yen*.

Fig. A. Gulf of Tartary in winter. *See* p. 5.

Fig. B. Street Scene after a snowfall in a town in Echigo. *See* p. 5.

Fig. A. Mt. Fuji, looking north from the Coast of the Bay of Suruga. *See* p. 13.

Fig. B. Aeroplane view of Mt. Fuji from the east: the highest peak Kenga-mine at the back of the crater; an ascent-trail in the foreground. *See* p. 13.

Fig. A. The rapids of the River Hotsu, near Kyoto: a raft coming down from Tamba Plateau. *See* p. 3 and 16.

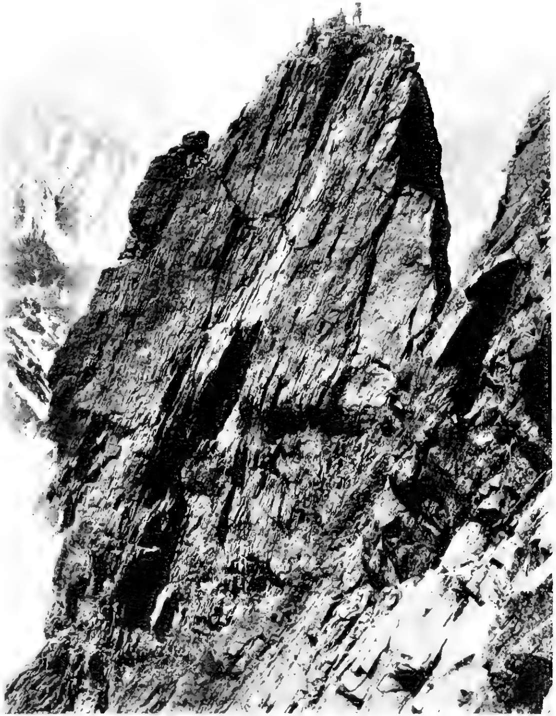

Fig B. A peak near Yari-ga-take in the Hida Range or "Japanese Alps." *See* p. 2 and 14.

Fig. A. Ruins of the Library of Tokyo Imperial University, after the great earthquake fire of 1923. *See* p. 12.

Fig. B. Tokyo Imperial University in reconstruction: through the main gateway appears the assembly hall; faculty buildings on both sides. *See* p. 12.

Fig. A. A scene in the business centre of Tokyo, after the shock and fire of the great earthquake of 1923: the skeleton of a burnt electric car in the centre. *See* p. 12.

Fig. B. A street in partially reconstructed Tokyo. *See* p. 12.

Fig. A. Kiyomidzu Temple in Kyoto: cherry trees in full bloom. *See* p. 16.

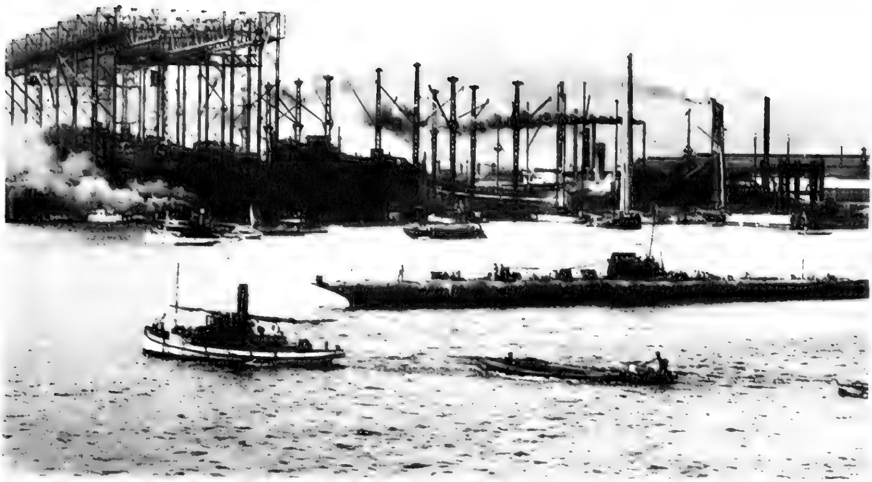

Fig. B. Kawasaki dockyard in the harbour of Kobe. *See* p. 8 and 16.

Fig. A. Ruined astronomical observatory in Keishu (Kyŏng-ju), the capital of the ancient Kingdom of Shiragi (Shinra) in South Korea. This observatory was built in A.D. 647 by a Queen of Shinra. *See* p. 29.

Fig. B. The courtyard of a village house in Yap, "The Island of Stone Money": a huge piece of stone money in the foreground. *See* p. 31.

II. The Climate of Japan,
with a note on the
Meteorological Service in Japan.

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The Climate of Japan.

1. *The character of the climate of Japan* is, in the first place, determined by the prevalence of the monsoons. During the cold season the air temperature in North China and Eastern Siberia falls greatly below the average for the year owing to an excessive nocturnal cooling. The so-called cold pole is formed near Werchoyansk. There the mean monthly minimum temperature is below $-60°$ in January. Due to this intense coldness of the air, the barometric pressure rises generally over these portions of the Asiatic continent, and there the extra-tropical zone of high barometric pressure shifts northwards, forming a grand anticyclonic area over Eastern Siberia with its centre near Lake Baikal. From this high area cold air flows out clockwisely all over the Far East. This is the well-known monsoon current in winter seasons. In Japan proper the winter monsoon comes from the northwest, but in the Riukiu islands it comes from the north. In Formosa the prevailing wind is northeasterly.

During the warm season the air temperature in North China and Mongolia rises excessively owing to the intense insolation and the arid condition of the soil in these districts. The area of high barometric pressure which covered these districts disappears and an area of low barometric pressure takes its place. At the same time the grand anticyclone of the North Pacific becomes intensified, its western margin approaching as far as our east coast. The air flows into this

Mongolian Low from the surrounding portions of the Far East. This system ef air currents is the summer monsoon. It blows from south to east over Japan Proper and the Riukiu islands, and southwesterly in Formosa. But the summer monsoon is weak and intermittent compared with the winter monsoon. The latter often continues for a week or more with the force of a gale.

2. During the prevalence of the winter monsoon, the cold air from the continent blows over the Japan Sea and the Eastern Sea of China undercutting the warmer air stratum lying near this country, and forcing it to rise along the slope of the land. For this reason, gloomy weather with snowfall prevails on the side facing the Japan Sea, and rain-showers occur almost every day in the Riukiu Islands and Northern Formosa. Therefore in Japan Proper on this side, snow covers deep the ground and a thick veil of clouds overcasts the sky. Fine days are phenomenal. In the prefectures of Niigata, Toyama, Ishikawa and Fukui, especially in mountainous portions, snow lies some metres deep during the cold months. In those parts the houses have unduly prolonged eaves and the ground under them is the only thoroughfare for the people since the snow covers the streets so high as to reach the level of the second stories of the houses. In Hokkaido, especially on the west side snow also covers the ground very deep. In the valley of the River Ishikari a snow layer of three metres and more is the rule. In these snowbound districts the rails are often buried deep under the snow. In spite of ploughing the snow by human and mechanical power, traffic is suspended for many days every winter. But on our Pacific side the climatic conditions are quite contrary to those prevailing on the side facing the Japan Sea. In cold months, especially, in November, December and January, fine weather generally prevails. In Tokaido from Nagoya to Tokyo very fine weather continues for many days, and often no single drop of rain falls throughout a month. In the Inland sea district the weather is also very fine, but often snow or rain showers are experienced whenever the monsoon shifts a little west and blows over the sea.

In the warmer season the monsoon has not any marked influence upon the weather and climate of Japan. There is no noticeable difference in climatic conditions on both sides of the island empire. The weather is generally fair or fine except in the rainy season beginning toward the middle of June, and extending through the first half of July.

3. *Barometric pressure and prevailing winds.* During the cold season the barometer stands highest over North China and Eastern Siberia and lowest in the Pacific to the south of the Aleutian Islands, the isobaric lines running from the northeast to the southwest almost parallel to the back-bone of this island. But during the warm season the barometer stands highest over the Pacific to the east of Eastern Japan and lowest over the Continent. In the following table are given average barometric pressures reduced to sea-level at the principal places in Japan and the Continent :—

Table I. Average barometric pressure at sea-level (in m.m.) (See p. 36.)

As described in the introductory paragraph, the direction of the prevailing winds changes about every half year. The winter monsoon bursts forth at the beginning of October and continues to prevail till the end of February. The summer monsoon sets in at the end of April and continues till the beginning of September. In April and September the wind is mostly variable.

Table II. Prevailing winds. (See p. 37.)

In winter the monsoon blows very strong and continues for many days together. In general the monsoon develops strongly when cyclones from the Continent pass over the Japan Sea, increasing in intensity in the vicinity of the southern Kuriles. As a rule the wind is stronger in the daytime than at night, and often a calm prevails in the night time. On the coast of the Japan Sea, snowstorms occur which make communication by ships very hard. Sometimes the ferry services between Moji and Shimonoseki, and in the Korea straits become temporarily suspended. On the Pacific coast the wind blows also very strong, but is not accompanied by rain or snow. Fine weather with cold northwesterly winds continues for many days.

In summer the monsoon is, as we have already remarked, not strong, and is intermittent. In sultry summer days it is refreshing to bathe in the cool air from the Pacific. In the Inland sea district the land and sea breezes develop remarkably. During the evening calm, the air is so still that the leaves of tiny grasses scarcely quiver. It becomes sultry and oppressive. But about 9 or 10 o'clock in the evening a land breeze begins to set in and brings cool air.

Table I.

Mean Air Pressure. (in m.m.)

Month / Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Kôsyun	763.5	762.9	761.6	759.6	757.4	755.7	754.7	754.1	756·2	759.4	761.6	762.8	759.1
Taityu	764.4	763.7	762.2	759.9	757.5	755.5	754.7	753.9	756.3	759.7	762.0	763.7	759.5
Taihoku	766.0	765.0	763.3	760.6	757.8	755.2	754.4	753.8	757.0	761.3	764.1	765.6	760.3
Naha	765.2	764.2	763.0	760.9	758.3	756.9	755.9	754.9	756.8	760.4	763.2	765.1	760.4
Kagosima	766.0	764.9	763.7	761.5	759.0	756.6	756.7	756.3	758.3	762.1	765.1	766.1	761.4
Nagasaki	766.6	765.6	764.2	761.6	759.0	756.3	756.4	756.3	758.6	762.7	765.7	766.7	761.6
Oita	766.1	765.2	764.1	761.7	759.0	756.3	756.3	756.3	758.9	762.8	765.4	766.2	761.5
Simonoseki	766.3	765.4	764.3	761.9	749.2	756.3	756.4	756.4	759.0	763.1	765 6	766.2	761.7
Hirosima	766.0	765.3	764.4	762.0	759.2	756.5	756.6	756.6	759.2	763.1	765.6	766.0	761.7
Okayama	765.7	764 5	764.2	762.1	759.2	756.6	756.6	756.7	759.4	763.1	765.4	765.8	761.6
Kobe	765.3	764.2	763.9	762.0	759.1	756.5	756.8	756.8	759.3	762.7	765.0	765.1	761.4
Oosaka	765.1	764.4	763 9	762.0	759.3	756.7	756.9	756.9	759.3	762.8	765.1	765.1	761.5
Kôti	764.9	764.0	763.3	761.6	759.1	756.7	757.0	756.9	758.9	762.2	764.7	765.1	761.2
Nagoya	764.2	763.5	763.3	761.9	759.2	756.9	757.0	757.2	759.5	762.5	764.5	764.4	761.2
Tokyo	762.4	762.1	762.5	761.6	759.2	756.9	757.2	757.6	759.9	762.7	763.7	762.5	760.7
Isinomaki	762.1	762·0	762.6	761.8	759.2	757.1	757.2	757.7	760.2	762.8	763.6	762.2	760.7
Kyoto	765.1	764.4	764.0	762.2	759.5	756.9	757.0	757.1	759.5	163.0	765.2	765.1	761.6
Nagano	764.4	763.9	763.7	762.0	759.0	756.5	756.5	756.9	759.8	763.2	765.0	764.3	761.3
Nikkô	—	—	—	—	—	—	—	—	—	—	—	—	—
Niigata	763.5	763.3	763.5	762.1	759.3	756.8	756.9	757.2	759.8	763.1	764.4	763.3	761.1
Akita	762.7	762.5	762.9	761.8	759.2	756.8	756.9	757.3	759.9	762.9	763.8	762.4	760.8
Aomori	761 8	761.7	762.1	761.2	758.8	756.9	757.0	757.6	760.1	762.8	763.2	761.6	760.4
Hakodate	761.2	761.3	761.6	761.0	758.7	756.7	756.9	757.7	760.0	762.5	762.6	760.8	760.1
Sapporo	760.6	760 8	761.0	760.3	758.0	756.6	756.6	757.4	760.0	762.1	761.9	760.1	759.6
Asahigawa	760.8	761.2	761.2	760.5	758.2	756.8	756.8	757.8	760.5	762.4	761.9	760.1	759.9
Nemuro	759.1	759.8	760.4	760.4	758.7	757.7	757.7	758.5	760.7	761.8	760.8	758.5	759.5
Ootomari	759·9	760.4	759.4	758.9	758.0	756.8	757.3	757.6	759.9	760.9	759.8	758.1	758.9
Husan	767.0	765.7	764.6	761.8	758.7	755.6	755.9	755.8	759.8	763.6	766.2	767.0	761.8
Moppo	768.3	767.0	765.5	761.9	758.7	755.2	755.1	755.1	759.5	763.9	767.0	768.3	762.1
Zinsen	769.0	767.7	765.8	762.1	758.7	755.4	755.4	755.7	760.2	764.5	767.5	768.9	762.6
Genzan	767.4	766.4	764.9	761.4	758.1	755.2	755.5	756.3	760.6	764.1	766.2	767.0	761.9
Ryuganpo	770.1	768.6	766.2	762.0	758.2	754.9	754.8	755.7	760.7	764.8	768.1	769.6	762.8
Dairen	770.9	769.4	766.8	762.2	758.0	754.5	754.2	755.5	761.0	765.2	768.6	770.3	763.1
Mukden	771.3	769.1	765.8	761.0	756.8	753.3	753.4	755.2	760.6	764.1	768·3	770.1	762.4

Table II.

Direction of the Prevailing Wind.

Station \ Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Kôshun	NE	NE	NE	NE	NE	W	E	NW	NE	NE	NE	NE	NE
Taityû	N	N	N	N	N	S	S	S	N	N	N	N	N
Taihoku	E	E	E	E	E	E	E	E	E	E	E	E	E
Naha	NE	N	N	S	S	SSW	S	SE	NE	NE	NE	NE	NE
Kagosima	NW	NW	NW	NW	NW	NW	NW	NW	NE	NW	NW	NW	NW
Nagasaki	N	N	N	N	SW	SW	SW	SW	N	N	N	N	N
Oita	NW	NW	NW	NW	S	S	S	S	S	S	S	NW	NW
Simonoseki	E	E	E	E	E	E	E	E	E	E	E	E	E
Hirosima	N	NNE	NNE	NNE	S	SW	SW	NNE	NNE	NNE	NNE	NNE	NNE
Okayama	N	W	NE	NE	NE	NE	NE	NE	NE	NE	NNE	W	NE
Kobe	W	N	N	N	N	N	SW	N	N	N	N	W	N
Oosaka	W	N	N	NE	NE	NE	WSW	NE	NE	NE	NE	W	NE
Kôti	SW	SW	SW	SW	SW	SW	SE	SW	SW	SW	SW	SW	SW
Nagoya	NW	NW	NW	NW	NW	S	S	S	NW	NW	NW	NW	NW
Tokyo	NW	NNW	NNW	NNW	S	S	S	S	NNW	NNW	NNW	NW	NNW
Isinomaki	NW	NW	NW	NW	S	S	S	S	N	N	N	NW	NW
Kyoto	W	NW	N	N	N	N	S	N	N	N	N	N	N
Nagano	E	E	N	N	N	SW	SW	SW	SW	W	E	E	E
Nikko	NW	N	SE	SE	SE	SE	SSE	SSE	SSE	SSE	NW	NW	SE
Niigata	NW	S	W	W	W	SE	N	SE	SE	SE	S	NW	S
Akita	NW	NW	W	W	SE	SE	SE	SE	SE	SE	SE	NW	SE
Aomori	W	SW	W	W	SW	N	N	NE	SW	SW	W	W	W
Hakodate	W	W	W	W	SE	SE	SE	ESE	E	N	W	W	W
Sapporo	NW	NW	NW	SE	SE	SE	SE	SE	SE	SE	NW	NW	SE
Asahigawa	W	N	W	W	W	W	W	W	W	W	W	W	W
Nemuro	W	NW	NW	SSW	SSW	S	S	SSW	SSW	SSW	NW	W	SSW
Ootomari	N	N	ENE	SSW	SSW	S	S	S	ENE	W	WNW	N	ENE
Husan	NW	N	NW	N	N	S	S	NE	N	N	N	NW	N
Moppo	N	N	N	N	NNW	S	S	S	N	N	N	N	N
Zinsen	NW	NW	NW	SW	SW	SW	SW	NE	NNE	NW	NW	N	NW
Gensan	W	W	W	W	W	NE	E	E	W	SW	W	W	W
Ryuganpo	NNE	NNE	NNE	NNE	SSE	S	S	NNE	NNE	NNE	NNE	NNE	NNE
Dairen	N	N	N	S	S	S	S	S	N	N	N	N	N
Mukden	N	N	N	SW	SW	S	S	S	S	S	N	S	S

In speaking of winds in Japan it is necessary not to omit mention of the frightful rotatory storms called typhoons. As a matter of fact the typhoons originate in those parts of the Pacific Ocean near the Carolines, Marshall and Mariana islands, and progress towards the west gradually inclining northwards. About half of them enter South China or cross over the Philippines, but the remaining half recurve towards the northeast and pass over Japan or over the neighbouring seas.

Typhoons occur mostly in August, September and October. Sometimes we have visitations of this terrible atmospheric whirl in June and July. The Riukiu islands are often visited by typhoons even in November. We give below the average number of typhoons in each month basing our figures on statistics for the fifteen years from 1897 to 1911:—

July	August	September	October	November
2	4	4	3	1

Usually the typhoons appear in succession, a new one arising after the old one has passed away from our area. In Japan therefore we shall expect the visitation of a typhoon once a week or once every ten days. During the visitation of a typhoon a severe rainstorm prevails within the affected area. A great deal of damage is always caused to houses, ships and crops. Sometimes owing to the abundant rainfall attending the typhoons, many rivers rise suddenly and overflow their banks flooding rice-fields, villages, etc., resulting in the loss of life and property.

4. *Air temperature.*— Japan lies to the east of the Asiatic continent and stands under the direct influence of a cold air current flowing out from the Continent in winter and of the warm inflowing air from the Pacific Ocean in summer. Hence the winters are much colder than would appear from the latitudes, while the summers are very hot. Thus despite her insular position, Japan has an extreme climate characteristic of a continent with also a tint of oceanic climate in many localities.

In winter the mercury stands very low in northern Japan and bitter cold is felt during the prevalence of cutting winds from the northwest. In Hokkaido especially, the cold is intense. In December, January and February the monthly mean temperature is many degrees below the freezing point. At Asahigawa, a flourishing town in Central Hokkaido, the mercury fell so low as $-41°$ C. on January 25th,

1902. In Sendai and its environs, the cold is not so severe, but at night the nocturnal cooling causes frequent chills, and those who are not accustomed to the climate are liable to catch cold unless they take proper precautions. In Tokyo and the neighbourhood the temperature is not so low, though often it falls a few degrees below the freezing point, but as raw northwesterly winds prevail, the cold is rather keenly felt.

Osaka, which has often been compared with Manchester on account of its numerous factories, has much milder winters than Tokyo. Here the temperature also falls a few degrees below the freezing point, but the cold is not severe as high winds do not prevail there. The winter in Kobe is still milder since a range of hills shelters the city from the invading cold winds from the northwest. But Kyoto has the so-called continental climate and cold is keenly felt during the whole winter.

In northern Kiushiu the winter temperature is somewhat similar to that at Tokyo. However, gloomy weather with frequent snowfalls prevails while Tokyo generally enjoys bright sunshine. But at Nagasaki, which lies at the head of a small bay and is surrounded on all sides by mountain ridges almost in its immediate neighbourhood, the temperature is much higher than at Fukuoka and Moji. Due to its very sheltered position, Nagasaki is not influenced so much by the chilly monsoon current from the Continent, though the city lies on the direct route of the invading cold air. Here the absolute minimum temperature ever observed is $-5°.6$ C., which occurred on January 14, 1915. In southern Japan the mean temperature is about two degrees higher than in northern Kiushiu.

At Kagoshima the winter is much milder owing to comparatively high temperature and humidity. Here the hills are covered with a luxuriant growth of camphor-trees. But often a spell of cold weather is experienced when the monsoon bursts forth from the northwest owing to an abnormal rise of the barometer on the Continent.

The Riukiu islands and Formosa have a semitropical climate, the mean temperature in winter ranging from 15° C. in northern Riukiu to 20° in southern Formosa. These parts of the Japanese Empire support a luxuriant plant growth. Even in the Okinawa island we have a tropical flora luxuriantly growing. The betel-nuts grow to a prodigious height. Mosquito nets are used throughout the whole year. In the interior of Formosa the winter temperature falls rather low.

Even at Taihoku hoar-frost is often experienced. The lofty peaks of the Silvian Mountain ranges are usually capped with snow.

In summer, as regards the air temperature, the great stretch in latitude makes no significant difference. In the daytime the mercury rises as high in northern Japan as in the Riukiu Islands. In northern Japan, however, the high temperature continues for only a few hours in the daytime, and the evening is rather cool. At Sapporo in Hokkaido the mean maximum temperature in August, the hottest month of the year is 31°.0 C. and the mean minimum temperature 9°.5 C., the daily range being 21°.5. But at Tokyo the extreme temperatures are 33°.5 C and 18°.6 C, the daily range being 14°.9 C. In southern Japan, however, the temperature continues high till the evening so that often the people hardly get to sleep on account of the closeness of the air. In the Inland sea district the air temperature even in midsummer is not so high, but as a rule an absolute calm prevails in the evening, and an intolerable closeness is experienced till late at night. At Osaka the mean extreme temperatures in August are 35°.3 C and 20°.1 C, the daily range being 15°.2. At Kagoshima the mean maximum temperature in August is 33°.4 C and the minimum temperature 20°.3 C, the daily range being 13°.1. Thus we see that in the summer time in Japan the people wear tropical suits and light straw hats. Most of the foreign residents find refuge from the oppressive heat in the summer resorts of the plateaus in Central Japan.

Thus far we have described the climatic conditions in the two extreme seasons, summer and winter. Now we shall proceed to give a short description of the temperature conditions in spring and autumn. In the north of Japan the transition from winter to summer is sudden. In november snow begins to lie on the ground and continues till the middle of April or the beginning of May. In May, cherry, peach and plum trees blossom almost at the same time. But the spring season is very short. Already in June the summer heat is felt. In October the air becomes so cool that hoar-frost is experienced every clear night. Autumn is also of very short duration. Even at Tokyo and its environs the spring season is also short. In the last half of March or the first ten days of April, the cherry trees blossom in profusion. But these lovely flowers soon fall and give place to fresh verdure which heralds the coming of summer. In May the mean temperature is about the same as that in London in July, the hottest month in that city. In the last half of September, the oppressive heat of summer passes away and the air becomes cool. When the rice fields lose their green, and the singing of insects is heard from out the foliage of the bushes, autumn is already present.

October is the most agreeable month of the year on account of the fine weather and moderate warmth. At the beginning of November hoar-frost is generally experienced. The forests begin to put on colour. The gingko turns yellow and the maple-leaves become scarlet. The beauty and variety of the tints are beyond description. Those who have never seen the maple leaves in Japan in the autumn cannot possibly imagine the beauty of the spectacle. But in the middle of November all the trees are bare with the exception of few species of evergreens, and piercing cold winds prevail.

In southern Japan the transition of the seasons one into another is gradual. Spring and autumn, the most agreeble seasons in the year, are comparatively long at the cost of winter. In southern Kiushiu the cherry trees blossom late in March. On the average the earliest hoar-frost occurs at about the end of November.

We give below the mean and extreme air temperatures at the principal places for each month and year :—

Table III. Mean air temperature. (in °C)
Table IV. Mean maximum air temperatnre. (in °C)
Table V. Mean minimum air temperature. (in °C)
(See pp. 42—44.)

5. *Rainfall.* By rainfall is meant the amount of atmospheric water precipitated, i.e., the quantity of rain, snow and hail, the two latter being measured after melting. The word precipitation is used technically in this sense. Generally speaking, winter is the wettest season for the provinces facing the Japan Sea, the Riukiu islands and northern Formosa. On the Japan Sea side, snow falls every day in this season and fine days are the exception. As we have already mentioned in the introductory paragraphs of this short note, snow lies on the ground two or three metres deep in the valleys of the Shinanogawa, Tetorigawa, Jintsugawa and many other large rivers. When a severe storm passes over these districts, heavy snow a metre or more in depth covers the ground in a single night, and ties up traffic on all the railroads for two or more

Table III.

Mean Air Temperature. (in °C)

Station \ Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Kôsyun	20.3	20.2	22.2	24.6	26.3	27.3	27.5	27.1	26.6	25.2	23.3	21.4	24.3
Tatyû	15.7	15.4	18.2	22.0	24.9	26.7	27.6	27.3	26.2	23.7	20.3	17.2	22.1
Taihoku	15.2	14.7	17.0	20.8	23.9	26.7	28.1	27.8	26.1	23.0	19.7	16.8	21.6
Naha	16.1	16.0	17.9	21.0	23.1	26.4	28.0	27.8	26.7	24.0	20.8	17.6	22.1
Kagosima	7.2	7.5	10.9	15.6	18.8	22.3	25.9	26.7	24.2	19.1	13.8	8.9	16.7
Nagasaki	5.7	5.9	9.2	14.2	17.8	21.5	25.4	26.6	23.4	17.9	12.7	7.8	15.7
Oita	5.5	5.5	8.2	13.1	17.0	21.1	25.1	26.0	22.7	17.3	12.2	7.5	15.1
Simonoseki	5.4	5.3	8.1	13.0	16.9	20.7	24.7	26.4	23.0	17.7	12.6	8 0	15.1
Hirosima	4.0	4.4	7.5	13.0	17.1	21.4	25.4	26.8	23.0	16.8	11.1	6.0	14.7
Okayama	3.6	4.0	7.1	12.9	17.3	21.5	25.7	16.9	22.9	16.5	10.7	5.5	14.5
Kobe	4.5	4.7	7.5	13.3	17.5	21.4	25.3	26.8	23.2	17.4	11.9	6.8	15.0
Oosaka	4.2	4.4	7.6	13.3	17.6	21.8	25.9	27.2	23.4	17.2	11.5	6.5	15.1
Kôti	5.4	6.1	9.6	14.8	18.1	21.7	25.1	26.1	23.2	17.8	12.4	7.3	15.6
Nagoya	3.4	4.0	7.2	13.2	17.4	21.6	25.7	26.6	22.9	16.6	10.7	5.3	14.5
Tokyo	3.0	3.9	6.9	12.6	16.6	20.5	24.1	25.5	21.9	15.8	10 5	5.2	13.9
Isinomaki	−0.3	0.3	3.2	8.9	13.2	17.2	20.6	23.1	19.8	13.8	7.8	2.4	10.9
Kyoto	2.6	3.1	6.4	12.3	16.6	21.1	25.2	26.2	22.2	15.6	9.7	4.6	13.8
Nagano	−1.7	−1.0	2.9	9.8	14.5	19.1	23.0	24.1	19.8	13.0	6.7	1.2	11.0
Nikko	−5.7	−5.0	−2.0	4.1	8.0	13.0	17.5	17.9	14.7	8.3	2.8	−3.0	5.9
Niigata	1·4	1.5	4.5	10.3	14.8	19.4	23.7	25.5	21.4	15 3	9.5	4.1	12.6
Akita	−1.5	−1.3	2.0	8.5	13.2	18.0	22.0	23.7	19.2	12.6	6.9	1.3	10.4
Aomori	−2.6	−2.1	0.8	7.1	11.8	16.3	20.6	22·8	18.5	12.1	5.9	0.0	9.3
Hakodate	−2.9	−2.1	0.9	6.5	10.5	14.5	18.9	21.5	17.8	11.8	5.6	−0.1	8.6
Sapporo	−6.4	−5.3	−1.6	5.3	10.4	14.8	19.0	20.8	16.1	9.6	3.0	−3.2	6.9
Asahigawa	−10.1	−8.8	−4.2	3.6	10.0	15.3	19.3	20.4	14 6	7.4	0.7	−5.9	5.2
Nemuro	−5.1	−5.4	−2.4	2.9	6.5	9.8	14.2	17.1	15.2	10.5	4.3	−1.5	5.5
Ootomari	−11.4	−9.9	−5.8	1.1	5.4	10.0	14.4	17.2	13.4	7.2	−0.7	−7.0	2.8
Husan	2.1	3.1	7.0	12.3	16.3	19.9	23.6	25.4	21.9	16.4	10.1	4.0	13.5
Moppo	1.3	1.7	5.2	11.2	16.2	20.4	24.4	26.0	21.8	16.2	9.4	3.4	13.1
Zinsen	−3.6	−2.0	2.9	9.5	14.5	19.3	23.2	24.6	20.1	14.3	5.7	−1.4	10.6
Gensan	−3.5	−2.4	2.5	9.4	14.7	19.2	22.5	23.2	18.7	13.2	5.4	−1.1	10.2
Ryuganpo	−8.9	−6.1	0.2	7.8	13.9	19.1	22.9	23.7	18.0	11.6	1.4	−6.4	8.1
Dairen	−5.1	−3.5	1.9	9.2	15,2	20.2	23.6	24.6	19.7	13.8	4.9	−1.8	10.2
Mukden	−13.4	−9·5	−1.1	8.5	15.6	21.5	24.7	23.5	16.4	9.2	−1.7	−10.1	7.0

Table IV.

Mean Maximum Air Temperature. (in °C)

Station \ Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Kôsyun	23.9	24.2	26.4	28.9	30.3	30.8	30.9	30.4	30.3	28.7	26.4	24.5	28.0
Taityû	21.8	21.0	23.5	27.1	29.7	31.5	32.3	32.0	31.4	29.5	26.2	23.1	27.4
Taihoku	19.1	18.4	20.9	25.1	28.3	31.5	33.1	32.7	30.8	27.2	23.5	20.5	25.9
Naha	19.5	19.3	21.3	24.5	26.6	29.7	31.6	31.3	30.3	27.5	24.2	20.9	25.6
Kagosima	11.9	12.1	15.6	20.2	23.4	26.1	29.9	30.9	28.5	23.9	19.0	13.9	21.3
Nagasaki	9.6	10.0	13.7	18.9	22.5	25.4	29.3	31.0	27.6	22.4	17.1	11.7	19.9
Oita	10.0	9.8	12.6	17.7	21.7	25.0	28.9	30.2	26.7	21.9	17.2	12.4	19.5
Simonoseki	8.6	8.7	11.9	17.0	21.0	24.4	28.3	30.3	26.8	21.7	16.3	11.0	18.8
Hirosima	9.0	9.4	12.7	18.2	22.3	25.6	29.6	31.6	27.8	22.6	16.9	11.4	19.8
Okayama	8.5	8.8	12.1	18.2	22.6	26.0	29.9	31.4	27.3	21.9	16.4	10.8	19.5
Kobe	8.8	9.2	12.4	18.2	22.6	25.8	29.7	31.7	27.6	21.8	16.3	11.1	19.6
Oosaka	8.6	8.9	12.4	18.4	22.6	26.2	30.3	32.1	28.1	22.4	16.7	11.3	19.8
Kôti	11.5	12.0	15.1	20.0	23.1	25.8	29.2	31.0	28.1	23.6	18.7	13.7	21.0
Nagoya	8.2	9.2	12.7	18.7	23.0	26.3	30.3	31.6	27.8	22.1	16.5	10.6	19.8
Tokyo	8.2	8.8	11.9	17.5	21.1	24.5	28.1	29.8	25.9	20.5	15.7	10.8	18.6
Isinomaki	3.3	4.2	7.4	13.3	17.3	20.9	24.3	26.3	23.4	18.1	12.3	6.3	14.8
Kyoto	8.7	9.3	13.0	19.0	23.2	26.6	30.6	32.2	28.0	22.4	16.8	11.2	20.1
Nagano	3.0	4.1	8.8	16.6	21.5	25.2	28.9	30.4	25.5	19.0	12.8	6.2	16.8
Nikko	−0.5	0.5	3.3	10.0	13.8	18.1	22.6	23.1	19.6	13.9	8.8	2.4	11.3
Niigata	4.3	4.8	8.7	15.1	19.9	23.7	27.7	29.9	25.8	19.6	13.4	7.3	16.7
Akita	1.7	2.4	6.1	13.1	17.8	22.3	26.0	28.4	24.3	18.1	11.3	4.6	14.7
Aomori	0.8	2.0	5.0	12.3	17.0	20.7	24.7	27.3	23.4	17.5	10.2	3.4	13.7
Hakodate	0.3	1.4	4.5	10.9	14.8	18.3	22.4	25.2	22.1	16.7	9.6	3.1	12.5
Sapporo	−2.0	−0.6	2.7	10.7	16.2	20.3	24.0	26.0	21.5	15.6	7.6	0.9	11.9
Asahigawa	−4.6	−2.5	1.7	9.8	17.1	22.1	25.5	26.4	21.1	14.2	5.6	−1.3	11.3
Nemuro	−2.1	−2.2	0.9	6.8	10.7	13.7	18.1	20.8	18.6	14.0	7.7	1.5	9.0
Ootomari	−7.1	−5.5	−1.6	4.8	9.8	14.2	18.3	21.0	17.5	11.5	2.8	−3.5	6.9
Husan	6.4	7.3	11.2	16.3	20.3	23.3	26.6	28.8	25.6	21.0	14.5	8.2	17.5
Moppo	5.4	5.9	10.0	16.3	21.0	24.7	28.3	30.2	26.2	21.3	14.1	7.8	17.6
Zinsen	0.4	2.3	7.3	14.4	19.2	23.8	26.9	28.5	24.4	18.9	10.2	2.7	14.9
Gensan	1.3	2.6	7.6	15.2	20.6	24.1	26.5	27.3	23.5	18.6	10.5	3.6	15.1
Ryuganpo	−3.8	−1.0	4.8	12.7	18.7	23.4	26.6	27.8	23.2	17.2	6.1	−1.8	12.8
Dairen	−1.1	0.4	6.0	14.1	20.0	24.8	27.2	28.2	23.8	18.3	9.1	2.1	14.4
Mukden	−6.8	−2.6	4.9	15.3	22.5	28.1	30.2	29.2	23.4	16.2	4.1	−3.8	13.4

Table V.
Mean Minimum Air Temperature. (in °C)

Month / Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Kôsyun	17.6	17.3	19.3	21.6	23.4	24.7	24.8	24.6	23.9	22.8	21.1	19.0	21.7
Taityû	11.5	11.4	14.5	18.3	21.3	23.1	23.8	23.8	22.5	19.7	16.3	13.1	18.3
Taihoku	12.3	11.8	14.1	17.4	20.4	23.0	24.2	24.1	22.6	19.8	16.9	14.0	18.4
Naha	13.0	12.9	14.9	17.9	20.1	23.7	25.0	24.9	23.8	20.9	17.9	14.5	19.1
Kagosima	2.9	3.2	6.4	11.3	14.6	19.0	22.7	23.3	20.9	15.1	9.4	4.5	12.8
Nagasaki	2.3	2.4	5.3	10.1	13.7	18.2	22.3	23.2	20.1	14.3	9.0	4.3	12.1
Oita	1.0	1.1	3.7	8.3	12.2	17.4	21.7	22.2	19.1	12.8	7.3	2.8	10.8
Simonoseki	2.7	2.5	5.0	9.7	13.6	17.9	22.0	23.5	20.2	14.6	9.6	5.1	12.2
Hirosima	–0.2	0.0	2.6	7.7	11.9	17.4	21.7	22.8	18.9	11.9	6.1	1.6	10.2
Okayama	–0.5	–0.3	2.3	7.7	12.1	17.4	22.0	23.0	19.1	11.8	5.8	1.1	10.1
Kobe	1.0	0.9	3.3	8.7	13.2	17.9	22.1	23.4	19.8	13.5	8.2	3.2	11.3
Oosaka	0.3	0.4	3.0	8.4	12.7	18.0	22.5	23.4	19.6	12.7	6.9	2.3	10.8
Kôti	0.7	1.4	4.8	10.1	13.6	18.2	21.7	22.3	19.6	13.5	7.7	2.4	11 3
Nagoya	–0.9	–0.6	2.3	8.0	12.2	17.4	21.8	22.7	19.1	12.0	5.8	0.8	10.1
Tokyo	–1.4	–0.6	2.4	8.1	12.2	17.0	20.9	22.1	18.7	12.3	6.1	0.5	9.9
Isinomaki	–3.8	–3.3	–0.6	4 8	9.4	14.2	18.4	20.3	16.6	9.8	3.6	–1.2	7.3
Kyoto	–2.3	–2.0	0.6	5.9	10.2	16.0	20.7	21.4	17.6	10.2	4.0	–0.8	8.5
Nagano	–5.8	–5.5	–1.9	4.0	8.7	14.2	19.2	19.8	15.8	8.4	2.4	–2.9	6.3
Nikko	–11·6	–11.4	–7.9	–2.0	2.1	7.7	12.3	12.6	10.0	3.0	–3.1	–8.7	0.3
Niigata	–1.2	–1.4	1.1	6.2	10.8	15.9	20.5	22.0	17.9	11.7	6.1	1.2	9.2
Akita	–4.9	–5 4	–1.8	3.9	8.6	14 1	18.6	19.7	14.9	7.9	2.9	–1.9	6.4
Aomori	–6.2	–6.1	–3 2	2.6	7.2	12.8	17.5	19.2	14.4	7.5	2.2	–3.1	5.4
Hakodate	–7.4	–6.9	–3.4	1.6	5.7	10 5	15.4	17.6	12.9	6.0	0.9	–4.4	4.0
Sapporo	–11.9	–11.1	–6.9	0.1	4.6	9.8	14.6	16.1	10.8	3.7	–1.6	–8.0	1.7
Asahigawa	–17.0	–16.6	–11.0	–2.2	3.2	9.3	14.0	15.0	9.6	1.9	–3.6	–11.0	–0.7
Nemuro	–8.8	–9.5	–6.2	–0.5	2.9	6.6	10.9	14.1	12.0	6.8	0.5	–5.1	2.0
Ootomari	–15.9	–14.9	–10.1	–2.6	1.3	6.3	11.0	13.6	9.1	2.6	–4.5	–11.1	–1.3
Husan	–1.6	–0.7	2.9	8.3	12.4	16.7	21.0	22.6	18.7	12.3	5.8	0.1	9.9
Moppo	–1.8	–1.4	1.6	7.3	12.4	17.3	21.6	23.0	18.6	12.4	5.7	0.2	9.7
Zinsen	–7.1	–5.4	–0.6	5.7	11.0	16.1	20.5	21.5	16.4	10.2	1.8	–4.9	7.1
Gensan	–7.8	–6.8	–1.7	4.6	10.1	15.2	19.5	20.0	14.7	8.4	1.0	–5.3	6.0
Ryuganpo	–13.5	–10.8	–3.8	3.3	9.5	15.5	20.1	20.2	13.4	6.7	–2.5	–10.6	4.0
Dairen	–9.0	–7.2	–1.7	5.0	11 0	16.4	20.6	21.5	16.0	9.7	0.7	–5.9	6.4
Mukden	–19.3	–15.8	–6.7	1.9	8.9	15·3	19.9	18.9	10.6	3.4	–7.0	–15.6	1.2

days. In western Hokkaido heavy snowfalls are also experienced. But as the temperature is very low, snow does not fall in large flakes, but in minute crystals, like powder in appearance. In northern Japan snow frequently falls also on the Pacific side, especially in Aomori prefecture. At Nobechi and Karibazawa near Asamushi, noted for its hot spring, railroad traffic is often interrupted by heavy snowstorms. At Sendai snow covers the ground in winter but as there the temperature is sufficiently high to melt it in the daytime, roads which are not paved become very muddy to the annoyance of pedestrians. The Pacific provinces, however, are generally very dry in the winter. Often for many weeks no appreciable quantity of precipitation is measured. So also in the Inland sea district winter is the driest season.

The summer rainy season begins during the second fortnight of June and continues till the first fortnight of July, lasting therefore about thirty days. This rainy season is called the "Bai-u," or the season of plum-rain, since it occurs as the plums are getting ripe. In this season the Pacific high barometric pressure area bulges out towards our east coast on account of the comparatively low temperature which prevails there owing to the increased flow of the cold ocean current known as the "Oyashiwo," which comes from the Behring Sea and flows along our east coast. The cold air coming from this high area causes gloomy weather in Eastern Japan generally, undercutting the warmer air stratum over the district. Moreover, barometric depressions approaching one after another from the Eastern sea and the Yangtse valley, are checked by the high area on their way towards the east, and come almost to a standstill over eastern Japan, gradually decreasing in intensity. Thus gloomy rainy weather continues all over this country, especially from Nagasaki to Tokyo. But the amount of precipitation in this rainy season is not large. Heavy rains accompany the tropical cyclones called "Typhoons" which visit this country frequently in August and September.

As regards the distribution of the annual rainfall, it suffices to say that the total amount of precipitation for the whole year is about 1000 mm. in Hokkaido, 1000 mm. to 1500 mm. in Tohoku or north-eastern Japan, 1500 mm. to 2000 mm. in Tokaido, and about 2000 mm. to 2500 mm. in Southern Kiushiu. In the Inland sea district the rainfall is comparatively scanty, the annual amount being generally less than 1500 mm. In Nagano and Yamanashi prefectures the rainfall is also 1000 to 1500 mm.

Meteorological Service in Japan.

At present there are, besides the Central Meteorological Observatory, Tokyo, 63 Local Meteorological Observatories which are connected with each other, and which are limited by the political divisions. The Tokyo Observatory is the Central Bureau of the Japanese Meteorological Service. All the local observatories make meteorological and seismological observations according to instructions issued by the Central Bureau. All the instruments in use in these local observatories are of the same type and quality. They are carefully examined and tested in the Central Observatory, Tokyo, and their instrumental corrections are determined before they are distributed to the local observatories. The hours of observations and methods of making the observations are the same in all the observatories except that some of them make six-daily observations and others hourly observations. All of them send their meteorological returns to the Tokyo observatory and the results of the observations are published in extenso in the Monthly and Annual Reports of the Central Meteorological Observatory.

The local meteorological observatories belong to the prefectures into which Japan is divided for administrative purposes. There is at least one observatory in each prefecture so that there are at present 63 observatories. In each prefecture there are many raingauge stations and climatological stations. These stations are under the direct control of the meteorological observatory of the prefecture concerned. In 1926 there are about 1600 of them in Japan, including Korea, Formosa and Karafuto.

The results of these observations are published in the monthly and annual reports of the local observatories. They are also reported to the Central Observatory through the local observatories. The rainfall data are published in the "Rainfall" of Japan.

Besides these government observatories, there are a few private meteorological observatories. There are also the Imperial Marine Observatory at Kobe, and the Aerological Observatory at Tateno near Tsuchiura. Both are Government institutions independent of the Central Observatory, Tokyo.

Central Meteorological Observatory. The Central Meteorological

Observatory is situated in Motoecho, Maruno-uchi, Tokyo.

The Observatory is to make

1. Investigations on the meteorology of Japan,
2. Weather forecasts and storm-warnings for the meteorological districts,
3. Investigatiens on the seismology of Japan,
4. Investigations and researches in agricultural meteorology,
5. Investigations on aeronautical meteorology,
6. Observations on and researches in terrestrial magnetism and atmospheric electricity,
7. Researches on "Tsunami" (or *Raz de marée*),
8. Investigations in meteorological science,
9. Testing and repairing meteorological and seismological instruments,
10. Meteorological and seismic observations at Tokyo, and
11. Weather forecasts and storm-warnings for Tokyo.

The Central Observatory receives observations from 112 stations at home and abroad for the purpose of weather forecasting and partly for publication in the daily bulletin. Free telegraphic transmission is allowed by the Department of Communications. A data message reporting synopses of the weather conditions at forty stations is telegraphed to the local meteorological observatories in cipher code morning and afternoon. A similar but shorter message is broadcasted from the wireless station attached to the Observatory to enable the captains of ships at sea to make their own weather charts on board and to judge the coming weather on their routes. The storm warning is also broadcasted whenever a cyclonic system of dangerous nature is expected. For the benefit of navigators of all nationalities, the warning is in plain English. Observations on all the meteorological elements are taken every hour at Tokyo, and their variations are registered by self-recording instruments.

Weather forecasts are issued morning and afternoon every day, and telegraphed to subscribers. They are also posted at every police box and printed in the evening papers. At nine o'clock in the evening the weather forecast is broadcasted from the Tokyo Radio-broadcasting station. The weather chart and daily bulletin are printed and distributed about 10 to 11 o'clock every morning. Attached to the Central Observatory are a large workshop where meteorological and seismological instruments are constructed and repaired, and a training college for observers. The college consists of three classes. Graduates of middle schools who have passed the entrance examinations are admitted to this training college as students. Their expenses are furnished by the Observatory. These students are taught mathematics, including infinitesimal calculus, spherical harmonics etc., experimental and theoretical physics, geophysics, oceanography, general and spherical astronomy, meteorology, etc. They also work in the physical laboratory and are trained in repairing and making instruments in the workshop. The college was inaugurated in 1922. The graduates of this training college are to be appointed observers or assistants in various observatories.

The Kakioka Magnetic Observatory During the sixteen years from 1897 till 1912 there was a magnetic observatory in the compound of the Central Meteorological Observatory. But owing to disturbances caused by the electric tramways it was transferred to Kakioka in 1913. Kakioka is a small town in Ibaraki Prefecture, Eastern Japan. The Magnetic Observatory is situated on the top of an elevated farm field near the southern outskirts of the town. The geographical coordinates of the observatory are

Longitude=140° 11′ 21″ E Latitude=36° 13′ 51″ N

Height above sea-level=28.2 m.

The nearest railway station is Ishioka, which is at a distance of 12 km. from the Observatory. It can be reached by motor car in about thirty minutes.

The main building is of re-enforced concrete construction, and contains seven rooms besides bathroom and kitchen. In one of the rooms is placed Riefler's normal clock. In the next room Wiechert's seismographs for horizontal and vertical components are installed. There is also placed secondary clock which is in synchronization with the mother clock. The variation house is a double walled building of non-magnetic white bricks. The diurnal variation of temperature is scarcely felt inside the rooms. In one of the rooms, variographs and registering apparatus constructed by the Askania Werke after Professor Ad. Schmidt's design, are installed on a solid pier. The old variation house constructed of granite was badly damaged in the last great earthquake of September 1, 1923, but was repaired temporarily. In this old building Eschenhagen's variometers are contantly working. The absolute house is similar in construction to the variation house, but there is more light inside the room. Wild's magnetic instruments and earth-inductor are used in making absolute observations.

The electric potential gradient of air near the ground is recorded by means of Benndorf's self-recording electrometer, and water dropper collector. The results of magnetic and electric observations are published in "The Annual Report of the Kakioka Magnetic Observatory."

Mount Tsukuba Meteorological Observatory. Mt. Tsukuba lies in the southeastern part of the Kwanto plain not far from Tokyo. It can be reached by train from Ueno station in about three hours, by changing cars at Tsuchiura. The Observatory is situated on the top of one of the two peaks of the mountain, and has a height of 869 metres above sea-level. In the Observatory meteorological and seismological observations are taken.

Meteorological stations attached to the Central Meteorological Observatory. Besides the local meteorological observatories there are a number of meteorological stations directly attached to the Central Observatory. These stations are mostly established on the islands and promontories which are regarded as very important localities from a meteorological point of view. These stations are equipped with meteorological and seismological instruments of latest designs. The observations taken at them are daily telegraphed or cabled to Tokyo for the purpose of weather-forecast.

Local Meteorological Observatories. In the local meteorological observatories meteorological observations are made at fixed hours every day, i.e. every four hours beginning at 2 a.m. In some of them hourly observations are made day and night. The variations of the meteorological elements are recorded by self-registering instruments. Seismological observations are also made.

Each observatory issues daily weather forecasts and storm-warnings for the prefecture to which it belongs, and publishes daily bulletins and weather charts upon receipt of the collective weather telegraph messages sent from the Tokyo Observatory or by catching the wireless data messages broadcasted by the observatories at Tokyo and Kobe for ships at sea.

These weather forecasts and storm-warnings are telephoned or telegraphed to subscribers, and are distributed to all the principal towns and villages by telephone. They are also displayed by special weather flags for the benefit of farmers and workmen. We give below a list of our local observatories.

List of Meteorological Observatories.

Locality	Latitude N		Longitude E		Height above sea level
Kôsyun	22°	0′	120°	45′	22.3 m.
Taito	22	45	121	9	8.9
Tainan	23	0	120	13	12.7
Hôko	23	32	119	33	9.4
Karenko	23	58	121	36	17.6
Taityû	24	9	120	41	77.1
Taihoku *	25	2	121	31	8.0
Isigakizima °	24	20	124	10	5.5
Naha °	26	13	127	41	7.5
Naze °	28	23	129	30	2.7
Kagosima	31	34	130	33	4.2
Miyazaki	31	55	131	26	6.8
Kumamoto	32	49	130	42	37.9
Saga	33	12	130	18	11.5
Nagasaki	32	44	129	52	131.5
Itugahara	34	12	129	17	20.8
Hukuoka	33	35	130	25	4.3
Ooita	33	14	131	37	4.5
Simonoseki	33	57	130	56	46.0
Hirosima	34	23	132	27	1.7
Matuyama	33	50	132	45	31.4
Okayama	34	40	133	54	8.4
Tadotu	34	17	133	46	4.0
Kôbe	34	41	135	11	58.2
Oosaka	34	39	135	26	1.5
Wakayama	34	14	135	9	13.6
Tokusima	34	4	134	33	2.9
Asizuri	32	44	133	1	60.4
Kôti	33	33	133	32	40.4
Muroto	33	15	134	11	184.7

* Central Bureau in Formosa.
° Stations attached to the Central Meteorological Observatory, Tokyo.

Locality	Latitude N		Longitude E		Height above sea level
Siomisaki	33°	27′	135°	46′	72.9 m.
Tu	34	44	136	31	3.0
Nagoya	35	10	136	58	51.7
Hamamatu	34	43	137	43	29.2
Numadu	35	6	138	51	6.0
Nagaturo	34	36	138	51	59.7
Yokohama	35	27	139	39	2.9
Tôkyô †	35	41	139	46	4.1
Hatizyozima °	33	6	139	50	79.7
Titizima °	27	5	142	11	2.7
Mera °	34	55	139	50	69.0
Tyôsi	35	44	140	51	18.2
Mito	36	23	140	28	30.0
Isinomaki	38	26	141	19	43.3
Miyako	39	38	141	59	29.0
Yagi	34	31	135	48	63.3
Kyoto	35	1	135	44	41.5
Hikone	35	16	136	15	87.3
Gihu	35	24	136	46	12.8
Takayama	36	9	137	15	560.3
Iida	35	31	137	50	481.8
Kôhu	35	38	138	34	259.8
Matumoto	36	14	137	59	581.0
Nagano	36	40	138	12	418.1
Maebasi	36	24	139	4	111.7
Kumagaya	36	9	139	23	30.2
Tukubasan °	36	13	140	6	868.6
Utunomiya	36	34	139	53	123.6
Hukushima	37	45	140	24	60.7
Yamagata	38	15	140	21	150.6
Morioka	39	42	141	10	154.5

† Central Meteorological Observatory, Tokyo.

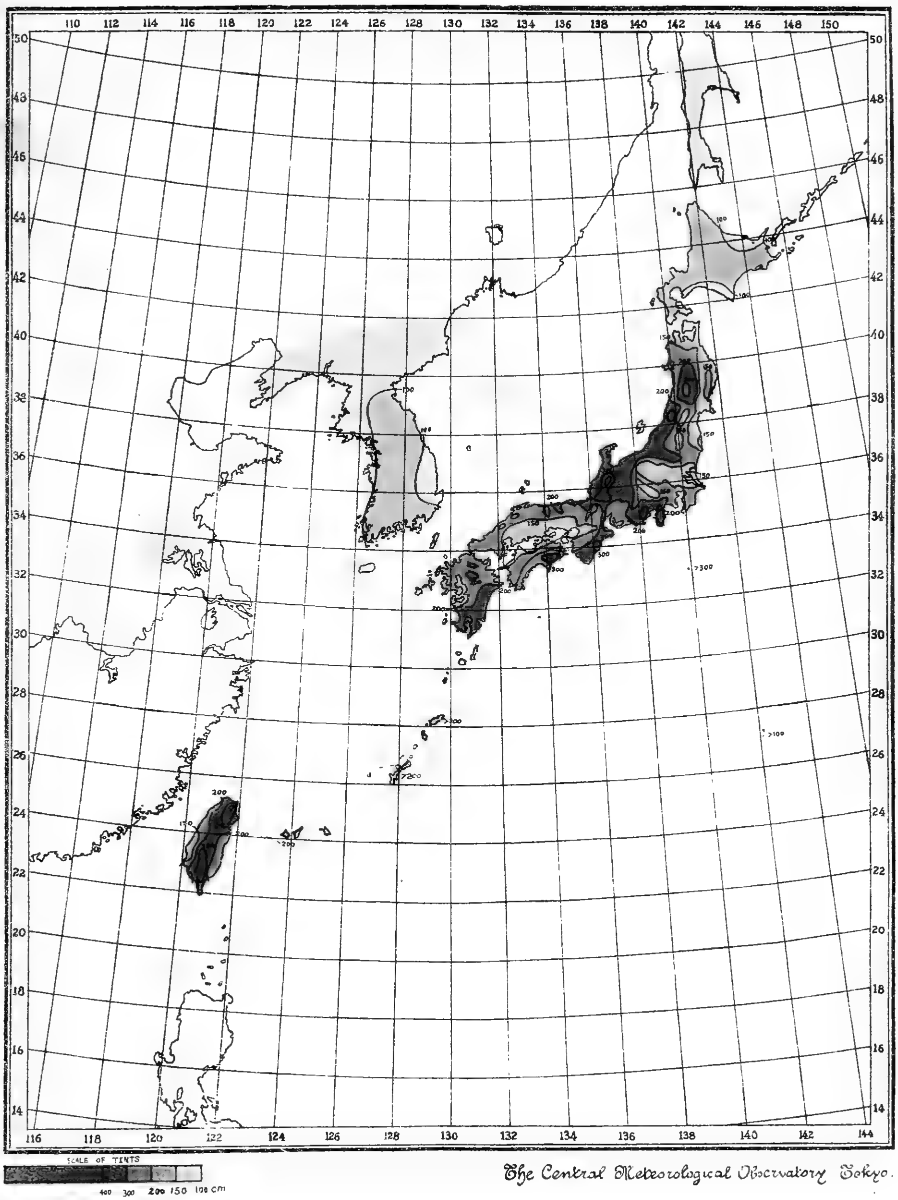
Locality	Latitude N		Longitude E		Height above sea level
Hamada	345°	4′	132°	4′	18.0 m.
Sakai	35	33	133	14	2.1
Hukui	36	3	136	16	9.7
Kanazawa	36	32	136	39	27.0
Minaduki	27	22	136	45	161.0
Husiki	36	47	137	3	12.1
Takada	37	6	138	15	13.4
Niigata	37	55	139	3	24.5
Akita	39	41	140	6	5.0
Aomori	40	50	140	45	3.3
Hakodate	41	47	140	43	2.6
Muroran	42	20	140	57	18.8
Suttu	42	48	140	13	15.7
Sapporo	43	4	141	21	15.1
Haboro	44	23	141	42	19.2
Asahigawa	43	47	142	22	111.3
Obihiro	42	55	143	12	39.0
Kusiro	42	59	144	24	32.7
Abasiri	44	1	144	17	37.6
Nemuro	43	20	145	35	25.7
Syana	45	14	147	53	38.2
Ootomari ×	46	39	142	46	37.3
Husan	35	6	129	1	13.4
Taikyu	35	52	128	35	50.5
Saisyû	33	31	126	32	22.0
Moppo	34	47	126	20	27.1
Zensyû	35	49	127	9	51.2
Zinsen **	37	29	126	37	69.0
Keizyo	37	34	126	59	29.2
Heizyo	39	1	125	41	48.2
Kôryo	37	42	128	48	9.3

× Central Bureau in Karafuto (S. Saghalien).
** Central Bureau in Chosen (Korea).

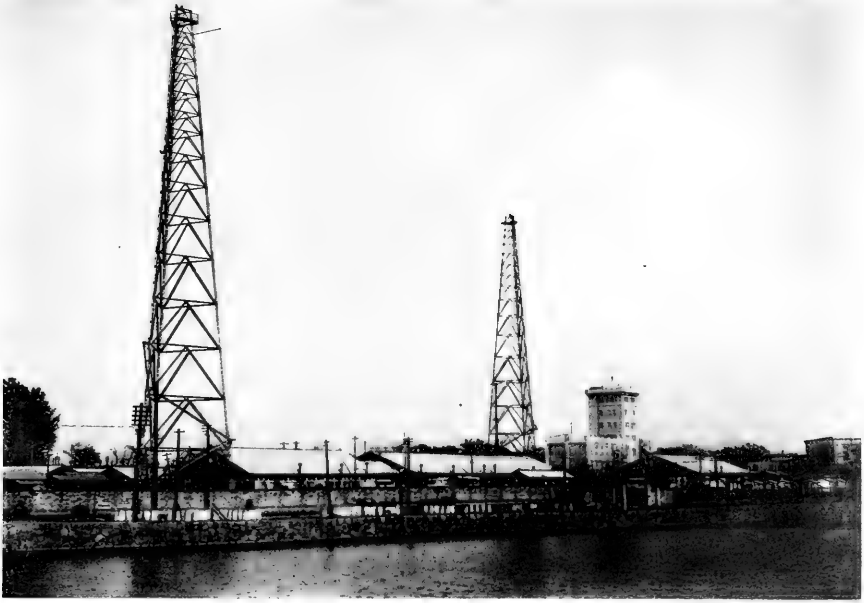
Locality	Latitude N		Longitude E		Height above sea level
Gensan	39°	11′	127°	26′	35.1 m.
Zyôsin	40	40	129	11	30.6
Yûki	42	20	130	24	64.3
Tyûkôtin	41	47	126	53	312.6
Ryûganpo	39	56	124	22	5.3
Dairen	38	54	121	36	95.6
Ryozyun	38	47	121	16	80.1
Yingkow	40	40	122	14	2.4
Mukden	41	48	123	23	42.9
Changchun	43	55	125	18	214.7
Palau	7	20	134	29	31.1

Raingauge and climatological stations. The majority of these stations are placed in the compounds of the village offices, town offices or elementary schools. The observations are entrusted to the village or town officers or to the teachers of the schools. There are also a number of raingauge stations belonging to the Department of Home Affairs. In a raingauge station a raingauge of the Snowdon pattern with a diameter of 20 cm. is set in a flat lawn. Observations are made at 10 o'clock in the morning. Each climatological station has a thermometer screen with maximum and minimum thermometers and a set of psychrometers within it besides the rain-gauge mentioned.

Mean Annual Rainfall 1911 — 1920.



The Central Meteorological Observatory Tokyo.



Upper: The Central Meteorological Observatory, Tokyo.
Lower: The Imperial Marine Observatory, Kobe.

III. Geology of the Japanese Empire.

Part I.
Geology of Japan.

By

Nobuyasu KANEHARA,

Director of the Imperial Geological Survey of Japan.

Contents

1. General Remarks.

From a geological point of view, the islands of the Japanese Empire are nothing but the summits of a great mountain system that flanks the Pacific side of the Asiatic continent, from which they were detached by the depression of the intervening seas. Consequently the country is devoid of extensive plains, and in most parts its features are mountainous.

Along the whole length of the chain from Hokkaidō to Taiwan (Formosa), the geological structure of the islands reveals the existence of two parallel zones curving towards the northwest. Of these, the one that lies on the convex (Pacific) side is usually called the "Outer Zone", and that on the concave side, the "Inner Zone". In the former, the geological formations, ranging from the Pre-Carboniferous to the Cainozoic, are better developed and more regularly arranged, while in the latter there prevails a much complicated structure and various eruptive rocks make their appearance.

Sedimentary Formations			Igneous Rocks
Cainozoic	Quaternary	Recent Pleistocene Loam Terrace Deposits	Liparite, Andesite, Basalt,
	Tertiary	Pliocene; Musashino Formation, Tertiary of Tanabé, Kakegawa, etc., Plant fossil Bed of Mogi, Upper Tertiary of Hokkaidō. Miocene; Plant fossil Bed of Itsukaichi, *Orbitoides*-Limestone of Nakaozaka, Shiramizu (Coal-bearing) Series of the Jōban District, Middle Tertiary of Hokkaidō. Oligocene and Eocene; Lower Tertiary (Coal-bearing Series) of Hokkaidō, Coal-bearing Series of Northern Kyūshū, *Nummulites* Beds of Ogasawarajima and Ryūkyū.	Liparite, Andesite, Basalt,
Mesozoic	Cretaceous	Senonian-Gault; Futaba Series, Izumi-Sandstone, *Trigonia*-Sandstone and *Ammonites* Beds of Hokkaidō. Neocomian; Lower Bed of Miyako Series, Ryōseki Series and Torinosu Limestone.	Granite, Porphyrite, Gabbro, Serpentine, etc.
	Jurassic	Malm; Upper Shizukawa Series, Tetori Series. Dogger; Middle Shizukawa Series. Liasssic; Lower Shizukawa Series.	Porphyrite.
	Triassic	Rhaetic; Plant Bed of Yamanoi. Noric; *Pseudomonotis* Beds. Ladinic; *Daonella* Beds of Rikuzen and Tosa. Anisic-Skytic; *Ceratites* Beds.	Porphyrite.
Palaeozoic	Permian and Carboniferous	Middle and Upper divisions of the Chichibu System.	Granite, Diorite, Gabbro, Diabase, etc.
	Pre-Carboniferous	Mikabu Series (Lower division of the Chichibu system), Sambagawan Series.	Granite, Amphibolite, Serpentine.

Apart from these two zones, Honshū or the Main Island is divisible into two parts, "North Japan" and "South Japan", by the "Fuji Volcanic Zone" which runs across the middle of the island from the Pacific Ocean to the Sea of Japan. This volcanic zone represents a great ruptured tract of the land, where the great cone of Fuji, together with several others like Hakoné, Yatsugataké, Myōkō, etc. were built up.

The sedimentary formations and contemporaneous igneous rocks occurring in Japan may be shown in chronological order as in the annexed table (p. 56).

2. Sedimentary Formations.

(a) Palaeozoic Group.

The Palaeozoic Group may be divided into

(1) Pre-Carboniferous System.
(2) Carboniferous and Permian System.
(3) Ryōké Metamorphics.

(1) Pre-Carboniferous System.

The rocks of this system consist of the crystalline schists of various kinds in the lower horizon, while in the upper, they are pyroxenite or amphibolites with phyllites, intercalating limestone and quartzite layers. The age of these rocks has not yet been determined with certainty, but, as they are usually conformable with the overlying Carboniferous strata, they are provisionally included in the Palaeozoic. According to Dr. B. Kotô, the system is divided into two Series:

(A) Sambagawan Series (crystalline schists)
(B) Mikabu Series (pyroxenite, phyllite, etc.)

(A) Sambagawan Series: This comprises various schists of a phyllitic or highly schistose aspect with the characteristic components such as sericite, chlorite, epidote, glaucophane, piedmontite, etc., but almost free from biotite. They are accompanied by eruptives such as serpentine, gabbro and garnet-amphibolite, but not by granite. Although the rocks of the Sambagawan are easily discriminable from those of the Ryōké Metamorphics, the distinction between the Sambagawan and the Mikabu is not always clear.

The rocks belonging to this Series are distributed over the islands of Honshū, Shikoku and Kyūshū, forming a distinct zone along the Pacific coast of South Japan. The nature of the rocks and their stratigraphical order varies in different places.

Kotô classified the schists of the Chichibu district as follows:—

Upper Sambagawan:— Epidote sericite-gneiss,

Middle Sambagawan:— Spotted graphite-schist and spotted chlorite-schist,

Lower Sambagawan:— Normal sericite-schist, intercalating graphite-schist and piedmontite-schist.

In the middle of Shikoku, the following divisions were made by Prof. T. Ogawa:

(In descending order)

Besshi Beds

Upper
1. Graphite-schist and chlorite-schist;
2. Chlorite-schist, graphite-schist and piedmontite-shist;

Lower
3. Calc-amphibole-schist, amphibole-schist, garnet-sericite-schist, garnet-amphibolite, chlorite-schist, graphite-schist, glaucophane-schist and piedmontite-schist;
4. Sericite-schist;

Ōboké Beds

1. Chlorite-phyllite and graphite-phyllite;
2. Ōboké-gneiss and schist.

(B) Mikabu Series: Heretofore the Series has been known as the lower division of the so-called "Chichibu System". The rocks consist essentially of pyroxenite or amphibolite with phyllites, often accompanied by limestone and quartzite. Phyllites are classified into chlorite-, graphite- and quartz-phyllite according to the predominant component minerals.

It occurs almost always together with and overlying the Sambagawan Series and forms a long zone occupying the outer or southern side of the latter.

(2) Carboniferous and Permian System.

This system corresponds to the upper and middle divisions of the so-called "Chichibu System", and, forming a continuous series, it lies in general conformably upon the Pre-Carboniferous.

The stratigraphical succession of the formation varies in different parts of the country. But the easily recognizable and almost never absent rocks, such as crumpled quartzite and hornstone of various colours, adinole slate, schalstein, radiolarian slate, and *Fusulina* and *Crinoidal* limestones are good marks of correlation.

In the Outer Zone of the Japan arc, the formation is regularly arranged, parallel with and on the outer side of the older Pre-Carboniferous, while in the Inner Zone it is found in small isolated areas irregularly distributed.

The thick limestone of Ōmi near the city of Toyama abounds in fossils including Foraminifera, Corals, Brachiopida, Cephalopoda, etc. Among them, *Fusulina, Schwagerina, Neoschwagerina, Lonsdaleia, Productus, Camarophoria, Pugnax, Spirifer, Syringothyris,* etc., are to be mentioned. The *Fusulina* limestone of Akasaka in Mino is also rich in several kinds of fossils such as *Textularia, Neoschwagerina, Fusulina, Endothyra, Lyttonia, Archaeocidaris, Reticularia, Bellerophon, Pleurotomaria,* etc. In the clayslate and sandstone of the Kitakami mountains, *Lonsdaleia, Lithostrotion, Lyttonia, Productus, Spirifer, Mizzia,* etc. were found.

(3) Ryōké Metamorphics.

Ryōké Metamorphics are chiefly biotite-gneiss and mica-schists, frequently intercalated with quartz-schist and crystalline limestone and rarely accompanied by amphibole-schists. They are usually injected by schistose granites, the so-called gneiss, and cut again by younger granites.

Such metamorphics are best developed in the Ryōké district bordering the Tenryū-gawa, and the late Dr. T. Harada first gave to them the name of the "Ryōké Gneiss and Schist" which has since been applied by many geologists to allied rocks found in several other localities. The same rocks in the Abukuma Plateau form the "Takanuki Series" of Kotô.

By far the greater number of such metamorphic rocks seem to have been derived from the rocks of the Carboniferous or Permian, mainly by the contact action of the schistose granites and also partly through dynamometamorphism; good examples showing the gradual transition between the two are observable in the Tenryū-gawa region, the Kasagi district and the shores of the Inland Sea.

(b) Mesozoic Group.

(1) TRIASSIC SYSTEM.

The Triassic of Japan consists of marine and estuary deposits distributed in small areas in Rikuzen, Awa and Higo in the Outer Zone, and in Mino, Bitchū and Nagato in the Inner Zone.

The ages of the fossiliferous beds are considered as follows:—

Plant Bed of Yamanoi, ... Rhaetic
Pseudomonotis Beds of Isatomae, Nariwa,
Sakawa, etc., ... Noric
Daonella Beds of Sakawa and Rifu, ... Ladinic
Ceratites Bed of Rikuzen, ... Anisic-Skytic

Fossils found in these beds are:

In the *Ceratites* Bed of Rikuzen; *Ceratites* (*Hollandites*) *japonicus* v. Mojs., *C. haradai* v. Mojs., *Japonites planiplicatus* v. Mojs., *Danubites naumanni* v. Mojs., *Gymnites watanabei* v. Mojs., etc.

In the *Daonella* Bed of Sakawa; *Daonella sakawana* v. Mojs., *D. kotoi* v. Mojs., *Arpadites sakawanus* v. Mojs., etc.

In the *Pseudomonotis* Bed of Sakawa; *Pseudomonotis ochotica* Kayserl. var. *densistriata* Tell., *Ceratites sakawanus* v. Mojs., etc.

In the Plant Bed of Yamanoi; *Cladophlebis*, *Dictyophyllum*, *Podozamites*, *Nilssonia*, *Baiera*, etc.

(2) JURASSIC SYSTEM.

The System consists of marine deposits as in Nagato and Tango in the Inner Zone, Iwaki and Rikuzen in the Outer Zone, and of brackish-water deposits as in Echizen, Etchū, Echigo, etc. in the Inner Zone. The Jurassic deposits of Japan may be correlated as follows:

Malm	Shizukawa Series { Upper, Middle, Lower	Tetori Series
Dogger		
Lias		Inkstone Series

The formations consist mainly of sandstones and shales with occasional intercalations of conglomerates or limestones. Violet or green schalsteins of the Inkstone Series are useful as inkstones in Japan.

Fossils found in these formations are:

In the Inkstone Series of Nagato; *Hildoceras, Grammoceras, Coeloceras, Dactylioceras,* etc.

In the Shizukawa Series;

Upper, *Cyrena, Perna, Gervillia, Trigonia,* etc.;
Middle, *Trigonia,* etc.;
Lower, *Harpoceras, Schlotheimia, Lytoceras,* etc.

In the Tetori Series;

Upper, *Cyrena, Dosinia, Turritella,* etc.;
Middle, Many plant fossils belonging to Polipodiaceae, Pecopteridae, Teniopteridae, Salviniaceae, Equicetaceae, Zamieae, Taxaceae and Abietaceae;
Lower, *Perisphinctes, Oppelia,* etc.

(3) Cretaceous System.

The system is spread very well in South Japan, especially in Kii Peninsula and Shikoku Island, extending over a wide area on the Pacific board; while in North Japan it occupies narrow strips of land or small basins, scattered here and there. Jurassic or Triassic strata are often found in the Cretaceous terrain, but as they are hardly distinguishable from those of the Cretaceous, their extent can not be clearly defined.

The geological age of several Series belonging to this System is shown in the following table:

Stage	Hokkaidō	Honshu	Shikoku	Kyūshū
Senonian	Hakobuchi Sandstone	Futaba Series		Ammonites Beds of Amakusa
Turonian	Upper *Ammonites* Beds	Toyajo Series	Izumi Sandstone	
Cenomanian	*Trigonia*-Sandstone		*Trigonia*-Sandstone	
Gault		(Kii)	(Awa, Tosa)	(Amakusa)
Neocomian	Lower *Ammonites* Beds	Miyako Series	Ryōseki Series Torinosu Limestone	

The Torinosu limestone is found at Sakawa, Itsukaichi, the Sōma district, and other localities. The limestone of Sakawa contains *Cyclammina, Textularia, Chaetetopsis, Convexastrea, Cidaris, Terebratula, Rhynchonella, Harpoceras, Metasolenopora, Myriopora, Nerinea,* etc.

The Ryōseki Series has a wide distribution over the provinces of Tosa, Awa (in Shikoku), Kōzuké, Rikuchū and Rikuzen. It is rich in plant fossils, such as *Onychiopsis, Sphenopteris, Cladophlebis, Podozamites, Dicksoniopteris, Zamiophyllum, Nilssonia,* etc.

The Miyako Series in Rikuchū yielded *Trigonia* and *Orbitolina.*

The *Trigonia* sandstone is characterized by various forms of *Trigonia,* besides some *Ammonites.*

The Izumi sandstone, extending from Kii Peninsula to Kyūshū through Shikoku, contains *Turrilites, Cucullaea, Inoceramus, Pachydiscus, Pecten, Natica, Anisoceras, Hamites,* etc.

The Toyajō Series contains *Acanthoceras* in its lower part and *Gaudryceras, Tetragonites, Turrilites, Pachydiscus, Inoceramus,* etc. in the upper.

The *Ammonites* Beds of Amakusa yielded *Mortonioceras, Peroniceras, Gaudryceras, Pachydiscus, Hamites,* etc.

The Futaba Series is found in the Sōma district of Iwaki and contains *Puzosia, Baculites, Gaudryceras, Bostrycoceras, Trigonia,* teeth of *Ichthyosaurus* and *Plesiosaurus,* etc.

The Cretaceous of Hakkaidō is rich in *Ammonites.* Although the lower beds contain only *Lytoceras, Acanthoceras* and a few other, the upper beds are profusely furnished with various forms of *Mammites,* *Acanthoceras, Gaudryceras, Tetragonites, Turrilites, Nipponites, Prionotropis, Mortonioceras, Scaphites, Puzosia, Desmoceras, Phylloceras, Baculites, Placenticeras, Hauericeras*, etc.

(c) Cainozoic Group.

(1) Tertiary System.

The Tertiary of Japan mostly belongs to the Neogene; while the Palaeogene, so far as is known, is of a limited extent.

(A) Palaeogene:

(i) *Nummulites* Beds of Ogasawara-jima (Bonin Islands) Ryūkyū Islands and Taiwan (Formosa):— A volcanic tuff of Haha-jima (Hillsborough) is full of *Nummulites javanus* Verbeek and *N. baguelensis* Verbeek, together with *Pellastispira, Orthophragmina*, etc. Prof. H. Yabe detected also small forms resembling N. *vredenburgi* and *N.* cf. *laevigatus*, and he believes the tuff to represent the upper Lutetian.

A limestone found on Ishigaki-jima, Ryūkyū, contain *Pellastispira* and *Orbitoides*. In an impure limestone of the Clayslate Formation of Taiwan, also numerous specimens of *Orthophragmina* and *Nummulites* are found.

(ii) Coal-bearing Series of Northern Kyūshū, Hokkaidō and Karafuto (Japanese Saghalien):— The Coal-bearing Series of northern Kyūshū is an important representative of the Japanese Palaeogene. The main coal-measure of Takashima has yielded *Sabal nipponica* Kryst., besides *Osmunda, Lastrea, Salvinia*, etc. In the Ashiya Series overlying the main coal-measure in the Miike coal-field *Aturia, Pholadomya, Crassatella, Cardita*, etc. have been discovered. All these fossils are Eocene forms. In the coal-fields of Sasebo and Imari, there is a coal-bearing series of rocks resting on the Ashiya Series, in which an *Anthracotherid* tooth and *Brachyodus* were discovered. These fossils are considered to be Lower Oligocene in age.

The Coal-bearing Series of Hokkaidō and Karafuto also contains plant and shell fossils identical with or allied to those of Northern Kyūshū and is recognized as nearly of the same age.

(iii) Misaka Series:— This consists of various volcanic tuffs and breccias, with sandstones, shales and conglomerates, especially in the lower part, and is well exposed around the volcano Fuji, also in several detached areas in the provinces of Shinano, Echigo, Kōzuké and Iwashiro. Small lenticular masses of limestone in the upper part of the Series contain *Lepidocyclina, Amphistegina, Gypsina, Operculina, Miogypsina, Lithothamnium,* etc. which are of Miocene type, and the lower part of the Series is considered to belong to the Palaeogene or possibly also to the Mesozoic.

(B) Neogene:

The greater part of the Neogene Series consists of shallow sea deposits mixed with some fresh-water ones. The marine Neogene is most widely spread in North Japan and contains "*Thyasira-Phacoides* Fauna" of Yabe.

The older Neogene is characterized by the presence of the plants of the "Pre-Pliocene Flora" of Nathorst, although sometimes also by the occurrence of *Miogypsina* and *Nephrolepidina* limestones.

The rocks are sandstones, shales, cherts and conglomerates with a considerable amount of pyroclastics; and the strata are strongly tilted or folded. They have a wider distribution than the younger Neogene, and constitute high hills and mountainous regions.

The younger Neogene abounds in molluscan fossils which mostly belong to the species living in the neighbouring seas. The rocks are unconsolidated clays, sands, gravels, soft shales, sandstones, conglomerates and tuffs. The strata are in most cases only slightly disturbed or nearly horizontal, and shows in many cases a distinct clino-unconformity with the underlying older Neogene. In some cases, however, especially in the oil-fields of North Japan, the boundary between these formations is not quite clear, so that they are usually regarded as conformable.

The uppermost part of the Neogene Series indicates a shallow sea or fresh-water facies, usually consisting of coarse materials such as loose sands and gravels with some clay layers and occasional tuffs. It forms either low terraces or flanks of hills, frequently covered by the Pleistocene gravel beds. This Series is very often underlaid unconformably by another Tertiary formation and is known as the "Uppermost Tertiary" or "Diluvio-Tertiary".

The mutual relations of the Neogene formations found in the Kwantō district may be given as follows:—

		Tōkyō, Yokohama and Immediate South	Miura Peninsula	Bōsō Peninsula	Chōshi	Ashigara District	Kwantō Mountains	North of the Kwantō Plain
Younger Neogene	Upper Musashino (in part)	Miyata Bed Tōkyō Bed Naganuma Bed		Sanuki Bed	Uppermost Pliocene (Sand and Clay)	Yamakita Gravel Bed		Plant Bed of Shiobara
Younger Neogene	Lower Musashino or Miura Series	Kuragi Shale Kanazawa Sandstone Ōfuna Shale Kamakura Sandstone Zushi Shale		Miura Series: Nokogiri Beds Nabuto Shale	Pliocene (Lower Musashino), Sandy Tuff, Tufaceous Shale & Sand	Ashigara Tertiary	Tertiary of Usui-gawa, Shimonita, Chichibu and Ichinokaya	Liparitic Tuff with Shell Zones of Shiobara
						Thrust Fault		
Older Neogene			Hayama Series	Sakuma Series	Miocene? Tuff	*Lepidocyclina* Bed of Dōshi, and Kaminawa Zone of Misaka Series	*Orbitoides* Limestone of Nakaozaka, Plant Fossil Bed of Itsukaichi	Plant Fossil Bed of Kamikanazawa

In the Jōban district, the Neogene consists of the Shiramizu (Miocene), the Yunagaya (Miocene) and the Shirado (Pliocene) Series. The lowest part of the Shiramizu Series contains coal-seams which are now being extensively worked. The Neogene in the environs of Sendai ranges from the Miocene to the uppermost Pliocene. In the meridional and western parts of Northern Honshū, the Neogene extends from Shinano and Echigo on the southwest, through Uzen and Ugo, to the northern end of Mutsu. The older Neogene of this region often contains coal-seams in its lower part, and the younger is often petroliferous, constituting the greater part of the oil-lands of Echigo, Akita and Aomori. The Neogene in Tōtōmi and Suruga, usually known as the Ōigawa Tertiary, consists of the Lower and Upper.

The Lower belongs to the Miocene and is petroliferous, while the Upper belongs to the Pliocene. The Neogene in the vicinity of Nagoya and Yokkaichi is noted for its lignite-seams, although only of a local importance. The Tertiary on the eastern and southern coasts of Kii Peninsula is of the Miocene and Pliocene ages, while that on the western coast is Pliocene. The Tertiary strata on the southern coast of Shikoku Island seems mostly to represent the Pliocene.

The Neogene formations scattered in the Chūgoku district ranges between the Miocene and the Pliocene, the Coal-bearing Series of the Ubé coal-field and the Shinji Series of Izumo being regarded probably as Miocene. The Tertiary found in the southern part of Kyūshū Island belongs to the Neogene, comprising the Miocene and the Pliocene, whereas that of the northern part is of the Palaeogene, forming important coal-fields as already described.

In the Tertiary of Ogasawara-jima, Ryūkyū and Taiwan, certain strata containing Miocene forms of foraminifera are known to occur, together with the Eocene *Nummulites* beds. The Neogene of Taiwan is coal-bearing in the north, while it is petroliferous in the south. The Tertiary of Hokkaidō is usually divided into four parts; the Lower, the Middle, the Upper and the Uppermost. The Lower is the coal-bearing Palaeogene and the other three range between Miocene and Pliocene or Pleistocene. The Middle Tertiary consists of the Poronai Series in the lower part and the Kawabata Series in the upper, with a transitional formation, the Momiji-yama Series, between. The upper Tertiary is often petroliferous and its rocks resemble those of the petroliferous formation of northern Honshū.

(2) Quaternary.

The Pleistocene deposits occupy an extensive area in central Saghalien, eastern Hokkaidō, central Honshū, central and southern Kyūshū and western Taiwan. Their chief elements are loose sand, gravel, clay, pumice and loam, which interstratify with one another, and form elevated plains as well as coastal and river terraces.

Raised coral reefs are found on the islands of Ogasawara-jima (Bonin), Ryūkyū and Taiwan. They usually form terraces or table-lands and are easily distinguishable from the Recent ones by the difference in height, indurated character and secondary colouration.

They are generally considered to be Pleistocene in age.

The Recent deposits consist of fluviatile sand, gravel and clay, besides beach-sand and subaerial secondary deposits of dune-sand and loam.

3. Igneous Rocks.

It has already been recognized that the igneous rocks of the regions surrounding the Pacific are mostly of the calc-alkaline series. So are those of Japan, although very rarely several alkaline rocks are also found to occur in small isolated areas.

The schistose granite occurs near the Ryōké Metamorphics and penetrates the latter in various forms, changing sandstones and clay-slates into such metamorphics. It embraces the three varieties of schistose hornblende-granite, hornblende-biotite-granite and biotite-granite.

The granite is the most widely spread of all plutonic eruptives. There is little evidence of granite having intruded in the Palaeozoic Era, whereas in the Mesozoic it seems to have come out in great quantities. In several places, granite exerted contact action on the Cretaceous rocks, suggesting the later age of its intrusion. There are many varieties, such as biotite-granite, two-mica-granite, hornblende-granite and pyroxene-granite, although the last-mentioned is of rare occurrence.

The diorite and gabbro are of common occurrence in small areas, usually as the marginal facies of granite or as stocks genetically related to granite. The age of irruption was probably Mesozoic in most cases, but the quartz-diorite intruding the Misaka Series seems to belong to the Tertiary age.

The peridotite and serpentine occur together with gabbro and diorite, intruding into the Palaeozoic and Mesozoic Formations. Northern Hitachi and middle Higo are localities noted for peridotite. Serpentine seems to have been derived from peridotite and gabbro.

The diabase is found intercalated in the Palaeozoic Formation, and the great development of variegated schalsteins which accompany it bears witness to the mighty eruptions of this rock in the Palaeozoic Era. The rock occurs also in the Mesozoic.

The quartz-porphyry occurs as large masses together with granite in Chūgoku, Hida, Mino, Shinano, etc. Other occurrences are mostly as small dykes. In texture, the rock often approaches granite-porphyry on the one side and liparite on the other.

The porphyrite commonly intrudes into the Palaeozoic and Mesozoic Formations. A tolerably large mass of porphyrite occurs in the Triassic Formation of Nagato. The porphyrite found in the Misaka Series is of a later eruption, probably of the Tertiary Period.

The liparite flowed out in the Tertiary Period. Their tuffs, form thick sediments in many places and are of wide distribution, especially in North Japan. There are several varieties which are nevaditic, trachytic or rhyolitic in texture. Yesan in Hokkaidō is an active volcano composed of this rock.

The extensive eruption of andesite occurred in the Tertiary and the Quaternary Periods. Of all volcanics, it has the widest distribution in the Japanese Islands and builds up nearly all active volcanoes. It is accompanied in most cases by great deposits of tuffs, agglomerate-tuffs and lava-breccias, and is sometimes laid as sheets between the sedimentaries. Among various andesites, including mica-andesite, hornblende-andesite and pyroxene-andesite, the last-mentioned is the most frequent. Many sub-varieties of pyroxene-andesite, such as augite-andesite, bronzite-andesite, two-pyroxene-andesite, olivine-bearing pyroxene-andesite, etc. are known to occur.

The basalt occurring in Chūgoku and northern Kyūshū is genuine. It is found in small areas as simple domes, and also as sheets and dykes. Basalts found in Japan are in general andesitic in their mineral constitution, and the olivine may or may not be present among the ingredients; but their silica contents are always less than 52%. They occur in large volcanoes together with pyroxene-andesite. A unique basalt containing quartz phenocrysts is found in the vicinity of Hagi in Nagato.

4. Volcanoes and Hot Springs.

Volcanoes:— Volcanoes are widely and regularly distributed in accordance with the geological structure of the country from Chishima to Taiwan. The majority of them are located in the Inner Zone and are believed to have been formed in the age ranging from Tertiary to Pleistocene.

They are most numerous in the Chishima Islands, Hokkaidō, northern Honshū and Kyūshū. Their number already known in all

Japan is 165, of which 54 are active. Mount Aso in Kyūshū has the largest crater in the world, its diameter measuring 22 km. Mount Fuji is the loftiest of all the volcanoes of Japan and attains a height of 3,778 m. above the sea level. They are all built up of andesites and their derivatives, which are often basaltic.

The volcanoes of Japan can be grouped into several volcanic zones or chains. Of these the most conspicuous is the "Fuji zone" which, running across the middle of Honshū Island from the Sea of Japan to the Pacific Ocean, divides North and South Japan. Beginning from the north, we have such volcanoes as Myōkō-zan, Togakushi-yama, Tateshina-yama, Yatsuga-také, Fuji-san, Hakoné-yama, Amagi-san, etc., all belonging to this zone which continues into the Pacific Ocean through Izu Shichito (the Seven Islands), Ogasawara-jima (Bonin Islands) and Iwō-jima (Sulphur Islands) and even further south to the Mariana and Caroline Islands.

The "Nasu chain" which forms the backbone or meridional mountain range of North Japan, comprises the cones of Osore-zan, Iwate-yama, Nasu-san, Nantai-san, Akagi-san, Haruna-san, Asama-yama, etc. The continuation of the "Nasu chain" is found in Hokkaidō, giving rise to Komaga-také and the group of volcanoes in Iburi and Shiribeshi.

The "Chōkai chain" also in North Japan, runs parallel to the "Nasu chain" along the coast of the Sea of Japan and contains such volcanoes as Iwaki-san, Chōkai-san, Gassan, etc.

The "Chishima chain" extends from Tokachi-daké in the middle of Hokkaidō, through Meakan-daké and Oakan-daké in Kushiro, to the volcanic islands of Chishima, and continues into the peninsula of Kamtschatka.

The "Hakusan chain" in South Japan runs along the coast of the Sea of Japan, and contains several volcanoes such as Haku-san, Dai-sén, Sambé-yama, etc.

The "Kirishima chain" is found near the western margin of the island of Kyūshū, having Kirishima-yama at its center. On the north, it extends to Unzen-daké, while on the south it continues to the volcanic islands of Kuchinoerabu-jima, Suwanose-jima, Takara-jima, etc., in the Ryūkyū arc.

A group of volcanoes near Aso-zan forms another zone with the volcanoes of Unzen-daké and Tara-daké, where it meets the "Kirishima chain" and continues eastwards in the depressed area of the

Inland Sea (Setouchi) where younger eruptive rocks are found to occur.

The eruptions of Japanese volcanoes for the past half a century have been almost invariably of the Strombolian type. Those of Bandai-san in 1888, Azuma-san in 1893, Adatara-yama in 1900 and Torishima in 1902, were remarkable examples of this type that is of destructive explosions. Asama-yama, Yakega-také and Kirishima-yama are famous for their paroxysmal explosions, though not violent heretofore. Recently, there have been displayed explosions of five different types; viz.,

(1) The appearance of a new volcanic island on the south of the Bonin Islands in 1904;
(2) The eruption of a new lava-dome in the crater of Tarumai in 1909;
(3) The formation of 45 craterlets on the slope of Mount Usu with a partial elevation of the land near the craterlets in 1910;
(4) The outflow of an enormous quantity of lava on Sakura-jima in 1912;
(5) The ejection of lava blocks from the craters of Asama and Mihara.

Hot Springs:— All over the country, especially in the northern and southern parts, numbers of hot springs are found at the top or foot of volcanoes.

The temperatures of some springs are extremely high at their sources, being over 100° C. The Ō-yu of Atami in Izu registers 108°C; Unagi-yu of Narugo in Rikuzen, 103°C.; Fukiage-yu at Onikōbe in Rikuzen, 100° C.; and Senami-Funto in Echigo, 102° C. The springs at Noboribetsu in Hokkaidō, Osore-zan in Mutsu, Furosen in Ugo, Futami in Etchū, Nakabusa in Shinano, Yunominé in Kii, Wakura in Noto, Kanegawa, Obama, Myōban, Ureshino, Unzen and Hiraochi in Kyūshū, and Hokuto in Taiwan are well-known. With temperatures below 90°C., there are hundreds of springs covering the entire range down to 25° C.

The springs of Japan are various in their composition, and there are numerous kinds of them in which simple and salt springs predominate, the greater number of the remainder being sulphur springs, closely followed by those that are alkaline carbonated. Kusatsu, Kannawa, Nasu, Noboribetsu, Kirishima and others carrying free mineral acids are distinctive, especially Kusatsu, Kannawa and Nasu in their alumina and iron content. Springs which are bitter, ferruginous, simple or earthy carbonated, etc. are also found in Japan, though they are not of frequent occurrence. Many springs contain small proportions of boric acid, iodine, bromine, lithium, manganese, and other compounds.

The quantity of radium emanations from springs in Japan appears to be more closely connected with the geology than with the chemical composition of the water, and springs of strong radio-activity are found mostly in granite regions.

The mineral springs of strong radio-activity are as follows:

Hot Spring	Mache's units	Cold Spring	Mache's units
Misasa	142.14	Masutomi	1425
,,	102.83	Takayama	281
Sekigané	33.47	Ikeda	187
Tochiomata	25.86	Arima	87
Tōgatta	24.58	Hirukawa	60

5. Minerals and Mineral Deposits.

Minerals:— The number of mineral species hitherto known in Japan amounts to 208, excluding those of organic origin. Minerals or crystals characteristic of Japan are radial concentric aggregations of rhombohedra of arsenic; magnificent crystals of stibnite; large and beautiful crystals of galena, zincblende, enargite, danburite and topaz; beautiful crystals of pyrrhotite, axinite and columbite; needle forms or triangular crystals of chalcopyrite; twinned crystal of quartz; unusually large crystals of augite, andalusite, glaucophane and piedmontite; xenotime and zircon in parallel growth; zircon containing some rare earths; cordierite crystals occurring in lavas, etc.

Mineral Deposits:— By far the greater part of our mineral resources are found in the Tertiary terrain. Gold-quartz and cupriferous pyrite-quartz veins are common in the Tertiary liparite or andesite and their tuffs. In the Palaeozoic schists and clayslates occur bedded cupriferous pyrite deposits which are of a great importance in Japan. Magnetite masses and hematite veins in granite, and galena-blende masses or veins found respectively in the Palaeozoic limestone, and Tertiary tuffs are also known to occur. Coal-seams in the

Tertiary formations of Hokkaidō, Kyūshū and the Jōban district of Honshū are the main sources of supply of coal in Japan, while those found in the Mesozoic strata in Kii and Nagato are poor. Petroleum occurs chiefly in the younger Tertiary of the Inner Zone, forming the oil-fields of Echigo, Akita and Hokkaidō. Sulphur-deposits are also found on many volcanoes.

Part II.

Geology of Korea.

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The geological features of the Korean peninsula agree in general with those of North China and South Manchuria, and differ in many respects from those of the Japanese Islands.

Synopsis of Stratified Rocks

Pre-Cambrian
- Pre-Cambrian Sedimentaries
  - *Igneous Contact*
- Pre-Cambrian Gray Gneisses
  - *Unconformity of dip*

Chosen System (Lower Cambrian to Middle Ordovician)
- *Parallel Unconformity*

Heian System (Upper Carboniferous to Earlier Triassic)
- *Unconformity of dip*

Daido System (Lower Jurassic to Cretaceous)
- Lower Daido Formation (Lower Jurassic)
  - *Unconformity* of dip

Middle Daido Formation (Middle ? Jurassic)
Relation unknown
Lower Keisho Formation (Upper Jurassic)
Apparent conformity
Upper Keisho Formation, Upper Daido Formation, etc. (Earlier Cretaceous)
Unconformity by Denudation
Fukkokuji Formation (Cretaceous ?)
Unconformity of dip

Tertiary
Palaeogene
Unconformity of dip
Neogene
Unconformity by denudation

Quaternary
Pleistocene (?)
Unconformity by denudation
Recent

Pre-Cambrian Sedimentaries :— The Pre-Cambrian sedimentaries are metamorphosed in various degrees; those intensely metamorphosed being biotite-gneiss, calc-silicate hornfels, mica-shist, amphibolite, pyroxene rock, crystalline limestone, quartzite, etc., those less metamorphosed being phyllite, limestone, graphite-schist, etc. The accompanying eruptives are gabbro, nepheline-syenite, serpentine, diorite, etc. Mica, talc, and graphite among the non-metallic minerals, and galena, zincblende and iron ores among the metallic are important in this formation.

Pre-Cambrian Gray Gneisses :— The gneisses are various in composition and structure, the typical one being banded, fluidal or schistose in structure and made up essentially of dark gray feldspar, dark bluish quartz, and biotite, often of a golden colour, besides accessory cordierite and garnet, both often present in abundance. They grade into granite or augen-gneiss often called the Gray Granite-Gneiss. The gray gneisses are commonly rich in xenoliths of the Pre-Cambrian sedimentaries, and the marginal portion of the xenoliths is assimilated by, and passes into, the host. The gneisses occur in general as batholiths or stocks in the Pre-Cambrian sedimentaries, and their genesis is considered to be largely due to the assimilation of the stoped Pre-Cambrian sedimentaries. Gold, which is the most important mineral in Korea, is mostly obtained from the quartz veins found in these rocks.

Chosen System :— The System, also known as the Korean Formation, is apparently a continuous sediments of an enormous thickness. It is divisible into two Series, the lower or the Yotoku Series and the upper or the Great Limestone Series, which are conformable with each other. The Yotoku Series consists of the basal quartzite or conglomerate and shale with intercalations of thin limestone beds, and lies unconformably on the Pre-Cambrian rocks, their dips commonly being different. It is referred to the Mant'o shale of China by the lower Cambrian Trilobite, *Redlichia chinensis* found in the shale of this Series. The Great Limestone Series consists of a thick limestone with intercalated shale, and its lower horizons yield some Middle Cambrian trilobites and brachiopoda, while its upper horizons contain some Ordovician trilobites, cephalopoda, gasteropoda and brachiopoda. A graptolite was also found in a shale intercalated in the limestone.

Of the useful minerals found in this System, iron, zinc, lead and silver ores are of importance.

Heian System :— The system is also of an enormous thickness and divisible into four Series, all conformable with one another. The lowest division, called the Koten Series, rests apparently conformably upon the Great Limestone Series and consists of alternations of sandstone, shale and limestone. From some limestone beds of the Series were obtained some foraminifera, corals and brachiopoda. One of the foraminifera was identified by Prof. H. Yabe with *Schwagerina princeps*. The next division is of terrigenous origin, consisting of sandstone and shale, and intercalates promising anthracite seams, and yields many Permo-Carboniferous plants. This division is called the Jido Series. The third one, called the Kobosan Series, is also terrigenous, and passes below into the Jido Series and above into the next Green Series. It consists of shale and sandstone of variegated colours, and in general intercalates thin anthracite seams. The Series also affords plant fossils, among which many Triassic ones are found. The uppermost Series named the Green Series is a thick complex of alternating layers of sandstone and shale mostly of green colour and calcareous in character. Determinable organic remains have not yet been found in it.

Daido System:— This is not a continuous group of rocks, and divisible into five formations, distant from one another or in unconformity. The oldest one, the Lower Daido Formation, consists of basal conglomerate and alternations of shale and sandstone intercalating anthracite seams. The flora of this Formation consists of a mixture of Rhaetic and Oolitic plants. Animal remains are scarce and an *Ammonites* found in the Formation was identified with one of the Liassic forms of the Japanese Islands. The next division, the Middle Daido Formation, also consists of alternations of shale and sandstone, intercalating thin anthracite seams. The plants obtained seem to be a little younger than those of the Lower Daido and is tentatively regarded as Middle Jurassic. The third formation is the Lower Keisho Formation which again consists of alternating layers of shale and sandstone, intercalating thin anthracite seams near its base. It is considered to be Upper Jurassic from the plants found in it. The fourth or the Upper Keisho Formation in N. and S. Keisho-Do is characterized by its rocks—flinty shale, red shale, tuff, and repeated flows of porphyrite, and covers the Lower Keisho Formation with its thick basal conglomerate, the relation between being apparently conformable. But the presence of a slight unconformity is also reported by some authors. The Formation yields the Lower Cretaceous plants. The Upper Daido Formation in Kokai-Do and Heian-Do petrologically and palaeontologically resembles this Formation. The fifth or the uppermost division, the Fukkokuji Formation, is mostly made up of quartz-porphyry and felsophyre in flows, and a small proportion of their agglomerate and tuff at the base. These rocks are intruded by a granite which is considered to be comagmatic with the acidic volcanic lavas. This Formation is covered by the Older Tertiary, and as the surface on which the latter lies is deeply eroded, the former is considered to be Cretaceous in age.

Tertiary:— The Tertiary System is found in extremely limited areas, that is, in small areas mostly along the eastern coast. It is divisible palaeontologically and stratigraphically into the Palaeogene and Neogene, the latter being known only in the Choki district, N. Keisho-Do and on the southern coast of the island Saishu-tō in the strait of Tsushima.

The older Tertiary is terrigenous or marine in origin, consisting of sandstone, conglomerate, shale and flows of volcanics, intercalating several seams of brown coal. The younger Tertiary is marine, being made up of conglomerate, sandstone, shale, tuff, and flows of volcanics, rarely with thin seams of brown coal. It is always horizontal and covers the older Tertiary or still older rocks unconformably, the dips being different.

Quaternary:— It is always found in a horizontal position, consisting of beds of gravel, sand, clay and peat, often associated with basalt flows. These beds, occupying plateaus or elevated platforms as well as older terraces, and often being associated with basalt flows, are regarded to be Pleistocene in age, while those spread along the plains bordering rivers or seacoasts are considered to be Recent.

IV. General Aspects of the Flora of Japan, including Southern Saghalien, the Kuriles, Korea, Formosa, the Loo-choos, the Bonins, and the Micronesias under the Japanese Mandatory Rule.

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As may be seen from the accompanying map, the Empire of Japan covers a truly vast space, extending from Formosa and, to add the Micronesias under our mandatory rule, the Carolines on the south, to the Kuriles and the middle of Saghalien on the north, i. e., approximately from 120° to 175°E.Long. and from 51°N.Lat. to the Equator. To gain a general idea of the flora and vegetation of this vast area, we may imagine ourselves flying in an aeroplane from the northeastern extremity to the southwestern, and then to the southeast as far as the Equator.

Starting from southern Saghalien, we look down and see on the island a northern flora and vegetation: immense forests of conifers, and boundless plains of tundra-like formation. Then, we fly a little southwards to Hokkaidō and the Kuriles, which stretch out like so many stepping stones as far as Kamchatka. There we find broad forest stretches of coniferous and deciduous broad-leaved trees, and park-like plains with luxuriant growths of herbs. Next, we come down southwestwards to a high aerial level commanding a bird's eye view of the Main Island of Japan. Here, as we proceed to the south, the flora becomes more and more characteristic of warmer regions. Southwards from the middle of the island, evergreen broad-leaved forests are to be found here and there, and bamboo formations become frequent. Then follow the islands of Shikoku and Kiūshū. As we come southwards, the flora becomes more and more of a southern character. Towards the extremity of Kiūshū, it is even of a subtropical nature, comprising palms and *Cycas* with many other tropical elements. From Kiūshū, we go back a little northwards and come to Korea. There, in the northern part of the peninsula, the whole physiognomy of the vegetation reminds us of that of Manchuria and Siberia. We then fly southwestwards as far as Formosa, where vegetation of a subtropical nature is observed. Palms and tree–ferns are frequently found in the lowland regions, while on the peaks are wonderful forests of *Chamaecyparis obtusa*, a species of the Coniferae peculiar to Japan and Formosa.

Next, we go back a little eastwards and come to the Loo–choos. There we find that the flora is also of a subtropical nature. Then, we continue our flying straight eastwards and find the Bonins, quite isolated and bathing in the warm waters of the Pacific. The vegetation here is a good example of an insular flora, possessing as it does a great many endemic elements. Thence advancing due south, and passing the Tropic of Cancer, we find the Micronesias, extending through the Marianas on the east to the Marshalls, on the west as far as the western Carolines, and on the south to the Equator. Here we see that the flora is entirely of an oceanic character and the vegetation is of a tropical nature.

It is clear from this outline that to treat the present subject as one topic is utterly impossible. For the sake of convenience, I have divided the subject into eleven headings and arranged them in accordance with the order in which we have just taken a flying view of the flora and vegetation throughout the whole Empire, including the territories under the Japanese mandatory rule.

I. Southern Saghalien (46°–50°N.Lat., 141°–145°E.Long.).

As may be understood from the geographical position of the island, the flora in the southern part bears considerable resemblance to that of Hokkaidō, while in the north, the flora is similar to that of Kamchatka and southern Siberia. Vegetation of a park–like nature is generally to be seen in the summer. In boggy places, are found plenty of *Sphagnum* and several species of hygrophilous and mesophytic plants. Peat beds have been formed here by the remains of decayed plants. Even in midsummer, the ground is found frozen to a depth of from 5 to 6 feet below the surface. The whole physiognomy of this region bears some resemblance to that of the tundra of Siberia. In shore regions, we usually find dense shrubbery consisting purely of *Pinus pumila* REGEL. Towards the interior, there are many forests in the plains and valleys. The forests are mainly composed of conifers, such as *Abies sachalinensis* MAST., *Picea jezoënsis* CARR., *Picea Glehni* MAST. and *Larix sibirica* LED. Big trees of *Quercus crispula* BLUME and *Quercus mongolica* FISCH. are found associated in the forests. *Sasa kurilensis* MAK. et SHIB. and *Sasa paniculata* MAK. et SHIB. are the principal species forming the undergrowth. *Lycopodium complanatum* LINN. var. *anceps* MILD. is commonly found creeping on the ground. Deciduous broad–leaved trees are also abundant.

The deciduous trees most frequently found are :–

Betula alba LINN.	*Populus balsamifera* LINN.
B. Ermanni CHAM. et SCHL.	var. *suaveolens* LOUD.
Alnus viridis DC.	*Phellodendron amurense* RUPR.
A. incana WILLD.	*Prunus sachalinensis* KOIDZ.
var. *Sibirica* SPACH.	*P. Padus* LINN. var. *typica* KOEHNE
Ulmus campestris LINN.	*P. kurilensis* MIYABE.
Salix sachalinensis FR. et SCHM.	*Sorbus sambucifolia* ROEM.
S. Caprea L.	*Acer pictum* THUNB.
S. daphnoides VILL.	*Euonymus sachalinensis* MAXIM.
Populus tremula LINN. var. *villosa* WESM.	

Climbing plants are not very rare ; they are :–

Actinidia arguta PLANCH.	*A. polygama* MIQ.
A. Kolomikta MAXIM.	*Rhus Toxicodendron* LINN. var. *vulgaris* PURSH.

Much variety is found among the herbaceous plants ; of these may be mentioned :–

Geranium erianthum DC.	*A. refracta* FR. et SCHM.
G. sibiricum LINN.	*Veratrum album* LINN.
Senecio Pseudo–arnica LESS.	var. *Lobelianum* REICH.
S. palmatus PALL.	*V. anticleoides* TAKEDA et MIYABE.
S. nemorensis LINN.	*Fritillaria camtschatensis* GAWL.
Allium lineare LINN.	*Stenantium sachalinensis* FR. SCHM.
Gagea lutea GAWL.	*Hemerocallis Middendorffii*
Angelica ursina MAXIM.	TRAUT. et MEY.
var. *vulgaris* DC.	*Caltha palustris* LINN. var. *typica* REGEL.
A. anomala LALL.	*Lythrum Salicaria* LINN.
	Aconitum sachalinensis FR. SCHM.

In marshy places near the shore in the interior, we find usually

Equisetum pratense EHRH.	*Smilacina trifolia* DESF.
E. fluviable LINN.	*S. davurica* TURCZ.
Drosera longifolia LINN.	*Vaccinium ovalifolium* J. E. SMITH.
D. rotundifolia LINN.	*Vaccinium uliginosum* LINN.
Trigrochin palustre LINN.	*V. oxycoccos* LINN.
Sphagnum spp.	

II. Hokkaidō, together with the Kurile Islands (41°30′–51°N. Lat., 139°–157°E. Long.).

The flora of these regions contains without doubt many northern elements. Deciduous broad-leaved species preponderate over the conifers, so far as the forest-flora is concerned. In the lowlands, the herbaceous plants most abundantly found are:–

Polygonum cuspidatum, S. et Z.
Spiraea spp.
Hemerocallis spp.
Petasites palmatum A. GRAY.
Angelica ursina MAXIM.
A. anomala LALL.
Cacalia hastata LINN. var. *pubescens* LEDEB.

all attaining a very large size. Coniferous forests are everywhere met with. They are mainly composed of:–

Taxus cuspidata SIEB. et ZUCC.
Thujopsis dolabrata SIEB. et ZUCC.
Pinus parviflora SIEB. et ZUCC.
Pinus pumila REGEL
Picea jezoënsis CARR.
Picea Glehni MAST.
Abies sachalinesis MAST.
Larix dahurica TURCZ.

Deciduous forests also cover a vast area. They are mainly composed of:–

Betula Ermanni CHAM. et SCHL.
Quercus dentata THUNB.
Q. crispula BLUME.
Q. serrata THUNB.
Fagus Sieboldi ENDL.
Salix lepidostachys SEEM.
S. repens LINN.
S. arctica PALL.
S. Sieboldiana BL.
var. *Buergeriana* KOIDZ.
S. eriocarpa. FR. et SAV.
S. Caprea LINN.
S. cyclophylla DC.
S. daphnoides VILL. var. *villosa* WESM.
Populus tremula L. var. *villosa* WESM.
Populus balsamifera LINN.
var. *suaveolens* LOUD.
Juglans Sieboldiana MAXIM.
Pterocarya rhoifolia SIEB. et ZUCC.
Ostrya italica SCOP.
var. *virginiana* WINKL.
Alnus viridis DC.
Betula Maximowicziana
Carpinus cordata BLUME.
Ulmus campestris LINN.
var. *vulgaris* PLANCH.
U. montana SM. var. *laciniata* TRAUTV.
Magnolia obovata THUNB.
Lindera umbellata THUNB.
Prunus Grayana MAXIM.
P. Maximowiczii RUPR.
P. Ssiori FR. SCHM.
Sorbus commixta HEDLUND.
S. sambucifolia ROEM.
Acer japonicum THUNB.
A. pictum THUNB.
A. Miyabei MAXIM.
A. spicatum LAM.
Phellodendron amurense RUPR.
Picrasma quassioides BENN.
Tilia Maximowicziana SHIRAS.
Cercidiphyllum japonicum SIEB. et ZUCC.

Climbing plants are abundant. They are:–

Schizophragma hydrangeoides SIEB. et ZUCC.
Vitis Coignetiae PULLIAT.
Rhus Toxicodendron LINN.
Hydrangea petiolaris SIEB. et ZUCC. var. *cordifolia* MAXIM.

Actinidia arguta PLANCH.
Akebia lobata DECNE.
Parthenocissus tricuspidata PLANCH.
Schizandra nigra MAXIM.
Schizandra chinensis BAILL.

Dwarf bamboo formations mainly consisting of *Sasa borealis* MAK. et SHIB. and *S. paniculata* MAK. et SHIB. are very frequently met with.

The most remarkable feature of the flora of Hokkaidō is the inclusion in it of elements characteristic of much warmer regions. Species belonging to this group are as follows :–

List of elements characteristic of warmer regions, found in Hokkaidō.

Polypodiaceæ

Coniogramme fraxinea (Don) DIELS

Lycopodiaceæ

Lycopodium cernuum L. Near the hot spring of Noboribetsu.

Gramineæ

Pennisetum japonicum TRIN.

Araceæ

Pinellia tuberifera TENORE.

Liliaceæ

Smilax China LINN.
Disporum sessile DON.

Orchidaceæ

Arethusa japonica A GRAY.
Calanthe discolor LINDL.
Cremastra appendiculata MAK.
Pogonia japonica REICHB. f.

Chloranthaceæ

Chloranthus japonicus SIEB.
Ch. serratus ROEM.

Urticaceæ

Beohmeria biloba WEDD.

Cercidiphyllaceæ

Cercidiphyllum japonicum SIEB. et ZUCC.

Lardizabalaceæ

Akebia lobata DECNE.

Akebia clematifolia SIEB. et ZUCC.

Magnoliaceæ

Schizandra chinensis BAILL.
S. nigra MAXIM.

Lauraceæ

Lindera umbellata THUNB.

Saxifragaceæ

Hydrangea opuloides K. KOCH. var. *angustifolia* SCHNEID.
H. paniculata SIEB. et ZUCC.
H. petiolaris SIEB. et ZUCC. var. *cordifolia* MAXIM.

Rutaceæ

Zanthoxylum piperitum DC.

Simarubaceæ

Picrasma quassioides BENN.

Anacardiaceæ

Rhus semialata MURREY.

Hippocastanaceæ

Aesculus turbinatus BLUME.

Vitaceæ

Ampelopsis heterophylla SIEB et ZUCC.
Cissus japonica WILLD.

Actinidiaceæ

Actinidia arguta PLANCH.
A. polygama PLANCH.

Elaeagnaceæ

Elaeagnus umbellata THUNB.
E. multiflora THUNB.

Araliaceæ

Acanthopanax japonicum FR. et SAV.
A. senticosum HARMS.
Kalopanax ricinifolium MIQ.

Ericaceae

Gaultheria adenothrix MAXIM.
G. pyroloides HOOK. f. et THOMS.

Vaccinium hirtum THUNB.
V. ciliatum THUNB.

Myrsinaceæ

Ardisia japonica BL.

Primulaceæ

Primula japonica A. GRAY.

Borraginaceæ

Bothriospermum tenellum FISCH. et MEY.

Gentianaceæ

Crawfurdia trinervius MAKINO.

Verbenaceæ

Callicarpa japonica THUNB.

Cucurbitaceæ

Gynostemma pedatum BLUME.
Schizopepon bryoniaefolium MAXIM.

Compositæ

Gerbera Anandria SCHULT.

III. Honshū (33°–41°30′N.Lat., 131°–142°E.Long.).

The flora of the northern part of the Main Island of Japan contains comparatively many elements belonging to much warmer regions, yet in general it may be classified as a northern flora. The bamboo formations, so characteristic of warmer regions, are still very rare. Southwards from the middle part of Japan, elements of warmer regions begin to preponderate over those of colder climates. Deciduous and evergreen broad-leaved trees are found intermixed; the latter increase in number as we go southwards. In the southern part, the vernal aspect of the flora is very fine. *Prunus Mume* S. et Z., *P. Jamazakura* S. et Z., *P. Persica* S. et Z. and *Rhododendron Kaempferi* PLANCH. may be mentioned as the most beautiful of the spring flowering plants. Many species of maples are found growing abundantly in the mountains and their autumnal coloration lends a splendor to the landscape unsurpassed by any other view. Among Gymnosperms,

Pinus densiflora S. et Z.
Pinus Thunbergii PARL.
Sciadopitys verticillata S. et Z.
Podocarpus macrophylla DON.

Cryptomeria japonica DON.
Ginkgo biloba LINN.

are commonly found. The last named species, however, is found only where it has been planted. Common species among the evergreen broad-leaved trees are:–

Lithocarpus cuspidata (OERST)
Quercus glauca THUNB.
Quercus myrsinaefolia BLUME.
Ilex Othera SPRENG.
Pittosporum Tobira AIT.
Elaeocarpus decipiens HEMSL.
Eurya japonica THUNB.
Taonabo japonica SZYS.
Cinnamomum pedunculatum NEES.
Viburnum odoratissimum KER.

Tall bamboo forests are everywhere found in the lowlands, while dwarf bamboo formations of *Arundinaria Chino* MAK., *Sasa albo-marginata* MAK. et SHIB., *S. nipponica* MAK. et SHIB. and *S. paniculata* MAK. et SHIB. are commonly to be met with in the mountains. As to the altitudinal distribution of the plants, we generally find grass formations at the foot of the mountains; then deciduous broad-leaved tree formations, which give way gradually to conifer formations; next comes deciduous shrubbery, which ends in alpine meadows or in stunted growths of *Pinus pumila* REGEL. Formations of evergreen broad-leaved trees are usually found in regions near the shore. In the southern extremity of the Province of Kii (33° N. Lat.), there exists many subtropical elements, such as *Pteris Wallichiana* AG., *P. longipinnula* WALL., *P. biaurita* LINN. var. *quadriaurita* LUERSS. and epiphytic orchids and lycopods.

The flora of Honshū is remarkable in that it includes elements characteristic of much warmer regions. The species belonging to the latter group are as follows:–

Kadsura japonica DUNAL
Michelia compressa MAXIM.
Eurya Ochnacea SZYS.
Ilex Hanceana MAXIM.
Aesculus turbinata BLUME.
Zanthoxylum piperitum DC.
Phellodendron amurense RUPR.
Smilax China LINN.
Acanthopanax aculeatum SEEM.
Cissus japonica WILLD.
Pinellia ternata BREITENB.
Rhus semialata MURR.
Picrasma quassioides BENN.
Lindera umbellata THUNB.
Calanthe discolor LINDL.
Alpinia japonica MIQ.

IV. Shikoku (31°-34°30′N.Lat., 132°–135°E.Long.).

The flora of the island of Shikoku consists entirely of elements characteristic of warm regions, and in its southwestern extremity (32°N.Lat.) are found many subtropical or even tropical elements, such as:–

Angiopteris evecta HOFFM.
Osmunda javanica BL.
Livistona chinensis R. BR.
Ardisia Sieboldi MIQ.
Hibiscus mutabilis LINN.
Ficus Wightiana WALL.

V. Kiūshū (30°–34°N.Lat., 128°–132°E.Long.).

The flora of this island is also that of warm regions. In Ōsumi and Satsuma (31° N. Lat.), are found many tropical elements. Evergreen broad-leaved forests are common. They are composed for the most part of *Lithocarpus cuspidata* (OERST), but the following trees also occur:–

Quercus sessilifolia BLUME
Q. acuta THUNB.
Q. myrsinaefolia BL.
Q. phylliraeoides A. GR.
Lithocarpus edulis (MAK.)
L. glabra OERST.
Actinodaphne lancifolia MEISN.
A. acuminata MEISN.
Machilus Thunbergii S. et Z.
Machilus longifolia BLUME.
Tetradenia foliosa NEES.
Cinnamomum pedunculata NESS.
C. Loureirii NEES.
C. Sieboldi MEISN.
C. sericeum SIEB.
C. Camphora N. et E.
Lindera triloba BL.
Lindera Thunbergii MAK.
L. strychnifolia VILL.
L. umbellata THUNB.
L. praecox BLUME.
L. glauca BLUME.
L. citriodora HEMSL.
Litsea japonica JUSS.
Camellia japonica LINN.
Eurya japonica THUNB.
E. emarginata MAK.
E. Ochnacea SZYS.
Pittosporum Tobira AIT.
Maesa japonica MORITIZ.
Ardisia Sieboldi MIQ.
Ficus erecta THUNB.
F. Wightiana WALL.
Myrica rubra S. et Z.

Epiphytic orchids such as *Dendrobium moniliforme* SW. and *Sarcochilus japonicus* MIQ. and woody parasites such as *Viscum album* LINN: and *Pseudixus japonicus* HAY. are also quite common. Climbing plants like *Ficus foveolata* WALL., *F. pumila* LINN. and the epiphytic ferns are suggestive of a tropical vegetation.

It is interesting to note that, in an island called Yakushima (30°N.Lat.) lying between Kiūshū and the Loo-choo Islands, there are immense natural forests of enormous trees of *Cryptomeria japonica* DON.

VI. Japan in general (30°–51°N.Lat., 128°30′–156°30′E.Long.).

Generally speaking, the flora of Japan, including Hokkaidō, the Kuriles, Honshū, Shikoku and Kiūshū, is on the one hand closely related to that of the eastern part of the Asiatic continent, while on the other, it shows some affiliations with the flora of North America. The following species should be regarded as those showing the close relationship which the flora under consideration bears to that of the Old World on the west, and to that of the New World on the east. The species included in parentheses are those closely related to the Japanese species mentioned on the left, but not quite identical with the latter.

a. List of plants showing the close relationship which the flora of Japan bears to that of the Old World on the west and to that of the New World on the east.

Ophioglossaceæ

Botrychium virginianum SW.
Ophioglossum vulgatum LINN.

Polypodiaceæ

Adiantum pedatum LINN.
Asplenium Ruta-muraria LINN.
A. Trichomanes LINN.
Athyrium thelypteroides DESV.
Dryopteris Linneana C. CHR.
D. Phegopteris C. CHR.
D. Thelypteris (SW) A. GRAY.
Onoclea sensibilis LINN.
Polystichum aculeatum (L) SCHOTT.
Pteridium aquilinum KUHN.
Scolopendrium vulgare SMITH.
Struthiopteris germanica WILLD.
Woodsia ilvensis R. BR.
Diplaziopsis javanica (BL) C. CHR.

Osmundaceæ

Osmunda cinnamomea LINN.
O. regalis LINN.

Equisetaceæ

Equisetum arvense LINN.
E. hyemale LINN.
E. palustre LINN.

Lycopodiaceæ

Lycopodium clavatum LINN.
L. complanatum LINN.
L. Selago LINN.

Potamogetonaceæ

Potamogeton natans Linn.
P. pusillus Linn.

Scheuchzeriaceæ

Trigrochin maritimum Linn.

Alismataceae

Alisma Plantago Linn.

Hydrocharitaceae

Vallisneria spiralis Linn.

Gramineae

Hierochloa borealis Roem. et Schult.
Melium effusum Linn.
Phalaris arundinacea Linn.

Cyperaceae

Bulbostylis capillaris Kunth.
Carex arenicola Fr. Schm.
C. muricata Linn.
C. filiformis Linn.
C. lagopodioides Schk.
C. Michauxiana Boeck. (*C. rostrata* Michx.)
Cyperus rotundus Linn.
Eriophorum gracile Koch.
Fimbristylis squarrosa Vahl.
Rhynchospora alba Lindl.
R. fusca Lindl.
Scirpus Eriophorum Michx.
S. maritimus Linn.
S. lacustris Linn.

Araceae

Acorus Calamus Linn.
Symplocarpus foetida Salisb.

Lemnaceae

Lemna minor Linn.
L. trisulca L.
Spirodela polyrhiza Schleid.

Juncaceae

Juncus bufonius Linn.

J. effusus LINN. (*Juncus communis* E. MEYER)
Luzula campestris DC.
L. pilosa WILLD.

Liliaceae

Allium Schoenoprasum LINN.
Convallaria majalis LINN.
Maianthemum Convallaria WIGG. et ROTH.
Smilacina trifolia DESF.
S. herbacea LINN.
Streptopus ajanensis TILING.
Streptopus amplexicaulis DC.
Trillium obovatum PURSH.
var. *japonica* MAXIM. (*Trillium erectum* LINN.)
Veratrum Maximowiczii BAKER. (*V. parviflorum* MICHX.)
Protolirion Miyoshia-Sakuraii MAKINO.

Orchidaceae

Goodyera repens R. BR.
Liparis liliifolia RICH.
Listera cordata R. BR.
Pogonia ophioglossoides MUTT.

Betulaceae

Alnus incana WILLD.
A. viridis. DC.
Betula carpinifolia S. et Z. (*Betula lenta* LINN.)
Corylus rostrata AIT.

Moraceae

Humulus Lupulus LINN.

Urticaceae

Pilea pumila GRAY.

Portulacaceae

Montia fontana LINN.

Nymphaeaceae

Brasenia Schreberi GMEL. (*B. peltata* PURSH.)

Ranunculaceae

Anemone Hepatica LINN.
Trautvetteria palmata FISCH. et MEY.

Berberidaceae

Caulophyllum thalictroides MICHX.

Cruciferae

Arabis perfoliata LAM.

Droseraceae

Drosera rotundifolia LINN.

Crassulaceae

Penthorum sedoides LINN.

Rosaceae

Aruncus sylvester KOSTEL.
Fragaria elatior EHR. (*F. vesca* LINN.).
Sanguisorba officinale LINN.
Sibbaldia procumbens LINN.

Leguminosae

Lathyrus maritimus REGEL
L. palustris LINN.

Oxalidaceae

Oxolis acetosella LINN.
O. corniculata LINN.

Anacardiaceae

Rhus Toxicodendron LINN.

Vitaceae

Vitis labrusca LINN.

Guttiferae

Hypericum crassifolium NAKAI (*H. virginicum* LINN.)
H. Sampsoni HANCE (*H. petiolatum* WALL.)

Lythraceae

Lythrum Salicaria LINN.

Oenotheraceae

Circaea alpina LINN.
Jussiaea repens LINN.

Halorrhagidaceae

Myriophyllum spicatum LAM.

Araliaceae

Aralia chinensis Linn. (*Aralia spinosa* Linn.)
Fatsia horrida Smith.
Hedera japonica Tobler. (*Hedera Helix* Linn.)

Umbelliferae

Cryptotaenia japonica Hassk. (*C. canadensis* DC.)
Ligusticum scoticum Linn.

Cornaceae

Cornus canadensis Linn.

Pyrolaceae

Chimaphila umbellata Nutt.
Monotropa Hypopitys Linn.
M. uniflora Linn.
Pyrola elliptica Nutt.
P. rotundata Linn.
P. secunda Linn.

Ericaceae

Vaccinium ovalifolium Smith.

Primulaceae

Glaux maritima Linn.
Lysimachia thyrsiflora Linn.
Samolus Valerandi Linn.

Gentianaceae

Menianthes trifoliata Linn.
M. Crista Galli Menzies.

Borraginaceae

Lythospermum officinale Linn.
Mertensia sibirica Don.

Labiatae

Lycopus lucidus Turcz.
Stachys aspera Michx.

Solanaceae

Physalis angulata Linn.

Scrophulariaceae

Ellisiophyllum pinnatum (Wall.) Hemsl.

Euphrasia japonica WETTST. (*E. officinalis* LINN.)
Veronica Anagalis LINN.
V. virginica LINN.

Phrymaceae

Phryma leptostachys LINN.

Rutaceae

Galium trifidum LINN.
G. vernum LINN.

Caprifoliaceae

Sambucus racemosa LINN.
Viburnum furcatum BLUME (*V. lantanoides* MICHX.)
V. Opulus LINN.

Adoxaceae

Adoxa Moschatellina LINN.

Compositae

Anaphalis margaritacea BENTH. et HOOK.
Bidens bipinnata LINN.
B. pilosa LINN.
Inula britanica LINN. (*I. Helenium* LINN.)
Solidago Virga-aurea LINN.
Xanthium Strumarium LINN.

The following is a list of plants which belong mostly to monotypic and endemic genera and may consequently be said collectively to give its peculiar character to the flora of Japan.

b. List of plants belonging mostly to monotypic and endemic genera.

Cycadaceae

Cycas revoluta THUNB., possibly in the southern extremity of the island of Kiūshū.

Ginkgoaceae

Ginkgo biloba LINN., a species constituting a monotypic genus, exact habitat still unknown.

Cupressaceae

Chamaecyparis obtusa S. et Z., exists outside of Japan only in Formosa.

Taxodiaceae

Sciadopitys verticillata S. et Z., constituting a monotypic and endemic genus.

Cryptomeria japonica DON., constituting a monotypic and endemic genus.

Gramineae

Bambusa spp.

Arundinaria spp.

Sasa spp.

Phyllostachys spp.

Shibataea Kumasasa MAK., constituting a monotypic and endemic genus.

Palmae

Livistona chinensis R. BR., a species probably endemic to the islands off southern Kiūshū. Cultivated in India, China and Japan.

Liliaceae

Chinographis japonica MAXIM. constituting a monotypic and endemic genus.

Alectorurus yedoensis (MAXIM.) MAKINO, constituting a monotypic and endemic genus.

Protolirion Miyoshia-Sakuraii MAKINO. The only congener exists in the Malay Peninsula.

Stemonaceae

Croomia japonica MIQ. The genus comprises only two species; this one is endemic to Japan.

C. pauciflora TORR. Outside of Japan, found only in Florida.

Orchidaceae

Stigmatodactylis shikokiana MAXIM. The only congener exists in the Himalayas.

Yoania japonica MAXIM. The only congener exists in the Himalayas.

Dactylostalix ringens REICHB. f., constituting a monotypic and endemic genus.

Juglandaceae

Platycarya strobilacea S. et Z. The only congener exists in China.

Rafflesiaceae

Mitrastemon Yamamotoi MAK. The only congener exists in Formosa.

Cercidiphyllaceae

Cercidiphyllum japonica S. et Z., comprising two species and possibly constituting a genus endemic to Japan.

Trochodendraceae

Trochodendron aralioides S. et Z., constituting a monotypic genus which exists outside of Japan only in the Loo-choo Islands and Formosa.

Ranunculaceae

Anemonopsis macrophylla S. et Z., constituting a monotypic and endemic genus.

Glaucidium palmatum S. et Z., constituting a monotypic and endemic genus.

Berberidaceae

Ranzania japonica ITŌ, constituting a monotypic and endemic genus.

Lauraceae

Cinnamomum Camphora NEES. et EBERM., existing only in China, Formosa and Japan.

Papaveraceae

Pteridophyllum racemosum S. et Z., constituting a monotypic and endemic genus.

Saxifragaceae

Cardiandra alternifolia S. et Z. One congener exists in China, and another in Formosa.

Deinanthe bifida MAXIM., constituting a monotypic and endemic genus.

Kirengeshoma palmata YATABE, constituting a monotypic and endemic genus.

Platycrater arguta S. et Z., constituting a monotypic and endemic genus.

Schizophragma hydrangeoides S. et Z. One congener exists in China and another in Formosa.

Tanakaea radicans FR. et SAV., constituting a monotypic and endemic genus.

Hamamelidaceae

Disanthus cercidifolia MAXIM., constituting a monotypic and endemic genus.

Buxaceae

Pachysandra terminalis S. et Z. The only congener exists in China.

Aceraceae

Acer spp., including over thirty species.

Araliaceae

Fatsia japonica DECNE. et PLANCH., constituting a monotypic and endemic genus. Closely related to *Diplofatsia*, endemic to Formosa.

Ericaceae

Rhododendron spp. of the *Azalea*-section.

Tsusiophyllum Tanakae MAXIM., constituting a monotypic and endemic genus.

Labiatae

Matsumurella tuberifera MAKINO, constituting a monotypic and endemic genus.

Ajugoides humilis (MIQ.) MAKINO, constituting a monotypic and endemic genus.

Orobanchaceae

Phacellanthus tubiflorus S. et Z., constituting a monotypic and endemic genus.

Gesneraceae

Conandron ramondioides SIEB. et ZUCC., constituting a monotypic genus which exists only in Formosa and Japan.

VII. Korea (33°–43°N.Lat., 124°–131°E.Long.)

As may be inferred from the geographical relation existing between the continent and the peninsula on the one hand and between the latter and Japan on the other, the flora of the northern part (38°–43°N.Lat.) of the peninsula bears a great resemblance to that of the eastern Asiatic continent, while the flora of the southern part has a close connection with that of the western part of the Main Island of Japan.

Dense forests of conifers are frequently seen in the northern districts. *Pinus koraiensis* S. et Z. is a species commonly found there. The flora of the northern half has many northern elements and bears a close relation to the flora of Manchuria and Siberia.

Elements characteristic of northern China are also to be found in the flora of the western part of Korea. Endemic genera are comparatively few, — a characteristic of continental floras. Among the endemic genera, *Hanabusaya* NAKAI and *Chosenia* NAKAI may be mentioned as the most interesting. Both genera are monotypic, the former belonging to the family Campanulaceae, and the latter to the family Salicaceae.

VIII. Formosa (22°–25°30′N.Lat., 120°–122°E.Long.).

The vegetation of the island may be roughly divided into three sections according to the place of occurrence:– a) that of the coastal regions; b) of the plain regions; c) of the mountain regions.

The vegetation of each region may be divided into several formations according to circumstances.

a. Vegetation of the coast regions.

The shore of the island is generally sandy or rocky, and sometimes muddy as in the lagoon of Takaw (22°30′N.Lat.) and in the vicinity of Kelung (25°10′N.Lat.). In muddy parts in the above two places, there are mangrove formations in which the following plants are generally to be found.

Kandelia Rheedii WIGHT.	*Avicennia officinalis* L.
Bruguiera gymnorrhiza LAM.	*Lumnitzera racemosa* WILLD.
Rhizophora mucronata LAM.	*Ceriops Candolleana* ARN. var. *Sasakii* HAY.

It is very interesting to notice that these mangrove formations occur in the two extremities of the island, but not in the intervening parts.* They extend through the Loo-choo Islands as far as the southern coast of Kiūshū (Japan). It may be considered that the sea-current is the cause of this curious distribution of the formations. They are very beautifully represented in Takaw where they are found fringing the lagoon on practically every side. The ground here is very muddy, and negative geotropic roots are seen in profusion. On the western side of the lagoon, are many beautiful trees of *Avicennia*

* Some poor formations of *Avicennia officinalis* have been quite recently found on the western coast in the intervening parts of Formosa.

officinalis, which attain a height of nearly 30 ft., with dark green foliage and densely intertwining branches stretching downwards. On the eastern side of the lagoon, are many trees of *Rhizophora mucronata*, growing nearly 6 ft. high, with bright green leaves, sending their branches upwards and their roots down from the middle of the stem. On this side of the lagoon, may be found some *Najas, Zostera, Ruppia* and *Zannichellia*.

On the sandy shore, the most common plants which form the littoral vegetation in the island are as follows:–

Hibiscus tiliaceus L.	*Tournefortia argentea* LAM.
Heritiera littoralis AIT.	*T. sarmentosa* LAM.
Canavalia obtusifolia DC.	*Ipomaea biloba* FORSK.
Derris uliginosa BENTH.	*I. carnosa* R. BR.
Tephrosia purpurea PERS.	*Myoporum bontioides* A. GRAY.
Pongamia glabra VENT.	*Clerodendron inerme* GAERTN.
Sophora tomentosa L.	*Euphorbia Atato* FORST.
Caesalpinia Bonducella BL.	*Excoecaria Agallocha* LINN.
Barringtonia racemosa ROXB.	*Pandanus odoratissimus* LINN.
Pemphis acidula FORST.	*Freycinetia formosana* HEMSL.
Tetragonia expansa MURR.	*Pycreus polystachyus* BEAUV.
Sesuvium Portulacastrum L.	*Spinifex squarrosus* L.
Wedelia biflora DC.	*Dactyloctenium aegyptiacum* WILLD.
Scaevola Koenigii VAHL.	*Zoysia pungens* WILLD.

Ipomaea biloba is one of the most plentiful of flowers among the vegetation on the shore. The plant seems to thrive on ground composed of sand and mud. In such places, we see many trees of *Scaevola Koenigii*, with climbing *Abrus precatorius* and *Tephrosia purpurea*. *Pandanus odoratissimus* is another plant which is commonly met with in the littoral vegetation. The plant thrives very well on the sea-shore, especially on sandy ground. Besides this species, there is another plant belonging to the same order, namely, *Freycinetia formosana*, which is rather small and of creeping habits. The plant is limited to the northern part of the island, where it is very abundant.

In Takaw, especially on the hills of the coral formation on the sea-side coast of the lagoon, there is found a very peculiar growth of *Euphorbia Tirucalli* with greenish, terete, aphyllous branches forming very dense bushes. The plant is generally 10 ft. high, but sometimes it attains a height of more than 20 ft. It is thought to have been introduced from Africa. Curious to say, the plant is limited in Formosa to the environment of Takaw.

It has been observed by Dr. A. HENRY that the littoral flora of

Formosa is richer than that of the whole coast of China.

b. The vegetation of the plain regions.

The vegetation in these regions is very variable. The lands in the plain are largely under cultivation. There are also many woods of *Acacia confusa* trees. The tree thrives very well in this island, especially in the northern part, where entire woods of this species occur, extending for miles. Species of *Ficus*, such as *F. Beecheyana*, *F. formosana*, *F. nervosa* and *F. Wightiana* are very abundant in woody parts.

Of deciduous trees, *Melia Azedarach* is the commonest found in the lowlands. Lauraceous plants such as *Cinnamomum pedunculatum*, *Machilus formosana*, *M. Thunbergii*, *Actinodaphne pedicellata* and *Litsea lancifolia*, are very common in the lowland woods. *Pinus Massoniana* is abundant in the woods by the sea. This pine is the only species to be found in the lowlands. In marshy places, are many *Eriocaulon*, *Pycreus*, *Juncellus*, *Cyperus*, *Mariscus*, *Eleocharis* and many other cyperaceous and gramineous plants, with *Najas*, *Potamogeton* and *Trapa natans*. In a lake near the mountain districts, *Brasenia purpurea* has quite recently been found. Bomboo-groves are very numerous, especially in the middle part of the island, where they extend for miles. The kinds of bamboo generally to be met with in the lowlands are as follows:–

Phyllostachys Makinoi, *Bambusa angulata*, *B. breviflora*, *B. Fauriei*, *B. Oldhami*; the commonest species is *Bambusa stenostachys*. *Dendrocalamus* is also very numerous.

The vegetation shows still greater variety when we come nearer to the mountain districts. There is probably some mixture of the mountain vegetation with that of the lowlands. Luxuriant growths of ferns occur, such as *Asplenium Nidus*, *Nephrolepis acuta*, *Diplazium esculentum* and many others, together with climbing plants such as *Epipremnum mirabile*, *Pothos Seemanni* and many gramineous plants. Climbing plants are here especially abundant. There are seen *Bauhinia*, *Entada scandens*, *Anodendron*, *Ecdysanthera* and *Calamus*.

c. Vegetation of the mountain regions.

The vegetation of these regions is extremely variable. In this island, as is generally the case with other countries, the mountain vegetation presents four distinct features according to altitude. In the lower parts of the mountains, the evergreen broad-leaved trees predominate; next, coniferous forests; then, shrubs; and then, grasses on the summit.

1) THE EVERGREEN BROAD-LEAVED TREE REGIONS.

As is generally the case, the vegetation of the lower part of these regions is a mixture of the plain and mountain vegetaions. In the woods of the lower region, are found many trees such as *Clerodendron, Viburnum, Callicarpa* and tree-ferns such as *Alsophila, Cyathea* and *Cibotium,* intermixed with various *Querci* and lauraceous plants. The flora of this region includes:–

Idesia polycarpa MAXIM.	*Ficus* spp.
Elaeocarpus decipiens HEMSL.	*Cinnamomun* spp.
Evodia meliaefolia BENTH.	*Machilus* spp.
Rhamnus arguta var. *Nakaharai* HAY.	*Quercus* (not many)
Prunus campanulata MAXIM.	*Viburnum* (a few).
Buxus sempervirens L.	*Alsophila* spp.
Callicarpa spp.	*Cyathea* spp.

The herbaceous plants which are commonly found in the lower parts of these regions are as follows:–

Thalictrum Fauriei HAY.	*Strobilanthes flaccidifolius* NEES.
Boehninghausenia albiflora REICHB. f.	*Urtica Thunbergiana* SIEB. et ZUCC.
Eupatorium formosanum HAY.	*Girardinia formosana* HAY.
Aster trinervius ROXB.	*Pilea Wattersi* HANCE.
A. scaber THUNB.	*Procris laevigata* BL.
Pratia begonifolia LINDL.	*Polygonatum officinale* ALL.
Dischidia formosana MAXIM.	*Alocasia macrorrhiza* SCHOTT.
Cynoglossum micranthum DESF.	*Aneilema divergens* C. B. CLARKE.
Trigonotis formosana HAY.	*Oplismenus undulatifolius* BEAUV.
Solanum lysimachioides WALL.	*Saccharum Narenga* WALL.
Bonnaya veronicaefolia SPRENG.	*Spodiopogon* spp.
Titanotrichum Oldhami SOLERED.	*Pollinia* spp.

Higher up, the vegetation becomes less variable. *Quercus* and lauraceous plants mostly predominate, while *Ficus* gradually diminishes. *Cinnamomum* forests are here most abundant. Trees commonly found in these forests are *Lindera, Litsea, Tetradenia, Octea, Machilus,* various kinds of *Quercus, Castanopsis* and a very few *Castanea.* From elevations of 6000 ft. upwards, beautiful arbors of Camphor and *Quercus* form dense forests, with a liana formation, and with many epiphytic ferns, orchids and mosses.

Here are also found dense forests with climbing plants of *Bauhinia, Hibiscus, Anodendron, Hydrangea* and many others. *Paulownia, Musa,* and *Pyrus* are also to be found. Above elevations of 6000 ft., forests of *Trochodendron aralioides* are found. The plant extends from Formosa through the Loo-choo islands as far north as Japan. It grows most luxuriantly in this region of the island on the boundaries between the conifer and broad-leaved tree regions. The trunks are here so large as to attain a diameter of even 15 ft. These forests constitute one of the most peculiar aspects of the vegetation of Formosa. Trees found in this region are as follows :–

Taonabo japonica Szys.
Eurya japonica THUNB.
Trochodendron aralioides SIEB. et ZUCC.
Illicium spp.
Schima Noronhae REINW.
Acer spp.
Oreopanax formosana HAY.
Eugenia chinensis REGEL.
Pistacia formosana MATSUM.
Diplofatsia polycarpa (Hay.) NAK.
Agalma taiwanianum NAK.
Ardisia spp.
Myrsine spp.
Cinnamomum Camphora NEES et EBERM.
Litsea spp.
Tetradenia spp.
Lindera spp.
Machilus spp.
Helicia formosana HEMSL.
Meliosma spp.
Engelhardtia spp.
Alnus maritima var. *formosana* BURKILL.
Lithocarpus amygdalifolia (SKAN.)
L. formosana (SKAN).
L. Kawakamii HAY.
L. Konishii HAY.
Quercus dentata THUNB.
Q. variabilis BLUME.
Castanopsis indica A. DC.
C. taiwaniana HAY.
Fagus Hayatae PALIB.
Juglans formosana HAY.
Platycarya spp.

On the mountain ridges, which are very unfavourable for forest growth, are found bushes of dwarf trees or areas of gramineous plants. It is interesting to notice that in such grassy places *Carices,* which are found plentifully in the regions above 10,000 ft., are very few, or nearly none.

The undergrowth of the forests in these regions is very luxuriant. Here *Alocasia macrorrhiza, Colocasia, Epipremnum, Musa,* and *Calamus Margaritae* are all very beautiful. Shrubs commonly found in these regions are as follows :–

Stachyurus praecox SIEB. et ZUCC.
Thea brevistyla HAY.
Skimmia spp.
Euonyms Spraeguei HAY.
Rubus pectinellus MAXIM.
Aucuba japonica THUNB.
Damnacanthus indicus GAERTN.
Vaccinium emarginatum HAY.
V. Merrillianum HAY.
Gaultheria Cumingiana VIDAL.
Pieris ovalifolia D. DON.
Rhododendron spp.

Symplocos spp.
Elaeagnus spp.

The climbing plants in the forests of these regions are as follows:–

Rhus Toxicodendron L.
Hydrangea glabra HAY.
H. integra HAY.
H. longifolia HAY.
Bauhinia spp.
Entada spp.
Calamus spp.

Herbaceous plants commonly met with in the vegetation are as follows:–

Anemone vitifolia BUCH. HUM.
Clematis spp.
Cardamine spp.
Viola spp.
Polygala spp.
Dianthus spp.
Silene spp.
Geranium spp.
Oxalis Griffithii EDGEW. et HOOK.
Impatiens uniflora HAY.
Astilbe spp.
Chrysosplenium spp.
Parnassia palustris LINN.
Cardiandra formosana HAY.
Ribes formosana HAY.
Halorragis spp.
Osbeckia spp.
Barthea formosana HAY.
Sarcopyramis sp.
Thladiantha sp.
Gynostemma sp.
Sanicula spp.
Acanthopanax spp.
Knoxia spp.
Patrinia spp.
Hoeckia Aschersoniana ENGLER et GRAEBN.
Carpesium spp.
Chrysanthemum spp.
Artemisia spp.
Petasites tricholobus FRANCH.
Gynura spp.
Senecio spp.
Saussurea spp.
Ainsliaea spp.
Lobelia spp.
Wahlenbergia spp.
Codonopsis spp.
Campanumoea sp.
Peracarpa sp.
Adenophora sp.
Primula sp.
Lysimachina sp.
Hemiphragma heterophylla WALL.
Gentiana spp.
Swertia spp.
Ellisiophyllum pinnatum (WALL.)
Scrophularia sp.
Torenia spp.
Veronica spp.
Sopubia sp.
Euphrasia sp.
Orobanche sp.
Lysionotus pauciflorus MAXIM.
Rhynchoglossum hologlossum HAY.
Chirita bicornuta HAY.
Conandron ramondioides SIEB. et ZUCC.
Scutellaria sp.
Polygonum spp.
Peperomia sp.
Balanophora spp.
Mercurialis spp.
Lecanthus sp.
Elatostema sp.
Orchidaceae (many kinds of)
Peliosanthes sp.
Arisaema spp.
Alocasia spp.
Bulbostylis spp.
Panicum spp.
Arundinella spp.
Miscanthus spp.

Orchidaceous plants are especially abundant in these regions. Some are terrestrial, others epiphytic. They are:–

Bletilla	*Appendicularia*
Calanthe	*Didymoplexis*
Chrysoglossum	*Goodyera*
Bulbophyllum	*Habenaria*
Cleisostoma	*Platanthera*
Cymbidium	*Liparis*
Phalaenopsis	*Oberonia*
Collabium	*Saccolabium*
Dendrobium	*Sarcochilus* and many others.

They are generally not very conspicuous. Among them, the most beautiful orchid is *Phalaenopsis Aphrodite*.

2) Vegetation of the conifer regions.

At elevations of 7000 ft. appear the conifer forests. The trees predominating in these regions are *Chamaecyparis obtusa* and *C. formosensis*. The conifers are here wonderfully large, the trunk attaining a diameter of even 10 ft. Intermixed with *Taiwania cryptomerioides* and *Cunninghamia Konishii*, these conifers occupy the greater part of this region and constitute the most peculiar feature of the vegetation of Formosa. Vegetation of this kind is seen elsewhere only in the mountainous districts of Japan, but the growth is not so enormous as in Formosa.

Higher up, at elevations of 8000 ft. there appear some forests of *Tsuga formosana*, intermixed with *Abies Kawakamii*, *Picea morrisonicola* and *Pseudotsuga Wilsoniana*. Forests of this kind can be distinguished from a distance by the peculiar dark color of the foliage. The forest trees of the conifer region are as follows:—

Libocedrus macrolepis Benth. et Hook.	*Pinus Armandi* Franch.
Chamaecyparis formosensis Matsum.	*Pinus formosana* Hay.
C. obtusa Sieb. et Zucc.	*Pinus taiwanensis* Hay.
Cunninghamia Konishii Hay.	*Picea morrisonicola* Hay.
Taiwania cryptomerioides Hay.	*Keteleeria Davidiana* Beissn.
Cephalotaxus Wilsoniana Hay.	*Tsuga chinensis* Bung.
Taxus cuspidata Sieb. et Zucc.	*Pseudotsuga Wilsoniana* Hay.
var. *chinensis* Rehd. et Wils.	*Abies Kawakamii* Itō.

At this elevation, the undergrowth is not so luxuriant as it is in the preceding region. *Pieris*, various kinds of *Rhododendron*, *Barthea* and many other plants are commonly met with in the undergrowth. Here, ferns are very plentiful. *Plagiogyria glauca* var. *philippinensis* is very numerous, and there are many other species such as *Acrophorus stipellatus*, *Microlepia*, *Monachosorum*, *Asplenium laciniatum*, *Asplenium* *resectum* and many others. Some ferns such as *Davallia parvipinnula, Asplenium Trichomanes, Cyclophorus subfissus, C. linearifolius, Polypodium lineare, P. cucullatum* and *P. irioides* are found on the trunks of trees.

3) THE VEGETATION OF THE SHRUBBERY REGIONS.

Further up, at elevations of 10,000 ft., the conifer forests gradually give way to shrubbery formations of *Juniperus formosana* and *squamata*, together with *Berberis, Prinsepia, Ilex* and *Salix*. Herbaceous plants commonly met with in regions at this height are as follows :–

Clematis lasiandra var. *Nagasawai* HAY. and other kinds of *Clematis*
Cucubalus baccifer LINN.
Geranium uniflorum HAY.
Mitella formosana HAY.
Cricaea alpina L.
Ainsliaea spp.
Picris hieracioides LINN.
Disporum spp.
Juncus effusus LINN.
Peperomi spp.
Fatoua pilosa GAUDICH.
Smilacina japonica A. GRAY.
Tricyrtis spp.

4) THE VEGETATION OF THE GRASS REGIONS.

From elevations of 12,000 ft. upwards, come the grass regions. Many gramineous plants mixed with *Carices* and other flowers are to be found. There is seen *Gaultheria bornensis* with enormous quantities of fruits, mixed with *Pteridium aquilinum* var. *lanuginosum*. The plants which generally constitute the summit vegetation are as follows :–

Arabis alpina LINN.
A. trigynum VILL. var. *morrisonensis* HAY.
Cerastium morrisonense HAY.
Cerastium subpilosum HAY.
Stellaria stellato-pilosa HAY.
Rubus elegans HAY.
Fragaria Hayatae MAK.
Potentilla Morii HAY.
P. leuconota D. DON. var. *morrisonicola* HAY.
Sibbaldia procumbens LINN.
Rosa spp.
Nertera nigricarpa HAY.
Oreomyrrhis involucrata HAY.
Scabiosa lacerifolia HAY.
Erigeron morrisonicola HAY.
Deschampsia caespitosa BEAUV.
D. flexuosa TRIN.
Trisetum subspicatum BEAUV.
Brachypodium sylvaticum BEAUV.
Leontopodium microphyllum HAY.
Anaphalis spp.
Gnaphalium lineare HAY.
Artemisia oligocarpa HAY.
Gaultheria bornensis STAPF.
Pyrola albo-reticulata HAY.
Shortia rotundifolia MAK.
Gentiana caespitosa HAY.
Origanum vulgare LINN.
Metanarthecium foliatum MAXIM.
Luzula effusa BUCH.
L. spicata DC.
Carex spp.

Isachne Clarkei Hook. f.
Agrostis Clarkei Hook. f.
Calamagrostis arundinacea Roth.
Festuca ovina Linn.
Arundinaria niitakayamensis Hay.
Lycopodium obscurum Linn.
Botrychium ternatum Linn.
Cryptogramme Brunoniana Wall.

The flora of Formosa, so far as is known to us up to the present time, comprises 3,658 species and 79 varieties, belonging to 1,197 genera and 170 families, including flowering plants and vascular Cryptogams. The endemic elements are comparatively numerous, as is to be expected in an island. They are represented by *Oreopanax formosana, Leontopodium microphyllum, Titanotrichum Oldhami, Helicia formosana, Chamaecyparis formosensis, Cunninghamia Konishii, Taiwania cryptomerioides, Pinus formosana* and many others, and by the endemic genera, *Diplocarex, Titanotrichum, Diplofatsia, Taiwania, Alniphyllum* and others. Of these genera, the two latter, *Taiwania* and *Alniphyllum,* have recently been found on the Chinese continent.

IX. The Loo-choo Islands (24°–30° N.Lat., 122°–130° E.Long.)

The islands stretch out one after another like so many stepping stones between Formosa and Japan. The flora of the islands is in its general aspect of a tropical character. Southern elements such as *Ficus retusa* Linn. var. *nitida* Miq. and *Terminalia Cattapa* Linn. are everywhere found. On the shore, we meet with pure stands of *Pandanus odoratissimus* Linn., while in the interior we find *Cycas revoluta* Thunb. at home. Tree-ferns such as *Cyathea spinulosa* are commonly found in groups at the foot of the mountains. In the lagoons, exist mangroves mainly of the species *Avicennia officinalis* Linn. *Lumnitzera racemosa* Willd., *Bruguiera cylindrica* Bl., *Kandelia Rheedii* Wight et Arn., *Rhizophora mucronata* Lam., *Barringtonia racemosa* Roxb , *Barringtonia speciosa* Forst., *Sonneretia alba* Smith., *Livistona chinensis* R. Br. and *Arenga Engleri* are found wild in the plains. An endemic banana, *Musa liukiuensis* Mak. is common. *Trochodendron aralioides* S. et Z. and *Mitrastemon Yamamotoi* Mak. are plants worthy of notice, the former being the only representative of the Trochodendraceae and the latter, a parasite belonging to the Rafflesiaceae. Endemic species are many :– they are represented by *Tashiroea okinawensis* Matsum., *T. yayeyamensis* Matsum., *Pinus luchuensis* Mayr, *Juniperus lutchuensis* Koid., *Cycas revoluta* Thunb. and others.

X. The Bonin Islands (26°–28° N. Lat., 142°–143° E. Long.)

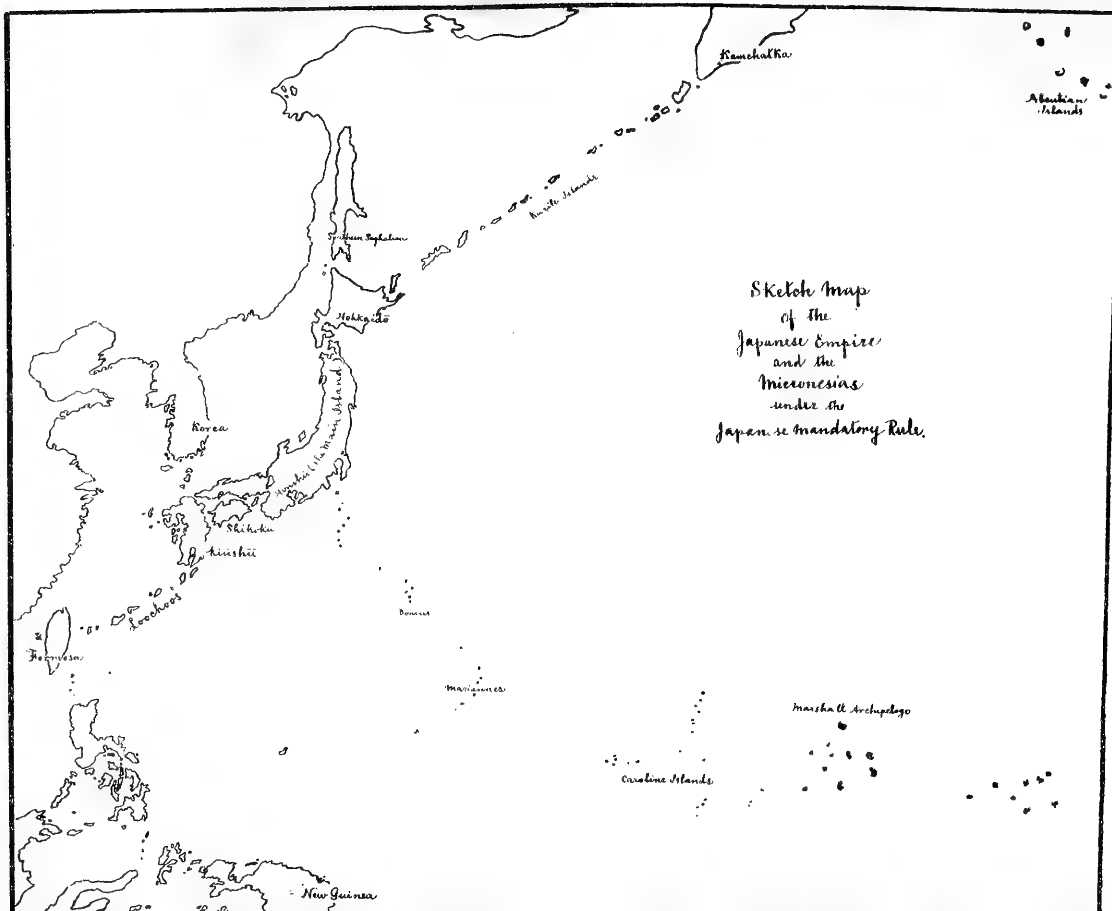
The flora of the islands is of a semi-tropical character. Endemic elements are very many, as is usually the cace with an insular flora. They are represented by *Alsophila Bongardiana* METT., *Juniperus taxifolia* HOOK. et ARN., *Pandanus boninensis* WARB., *Boninia glabra* PLANCH., *Boninia grisa* PLANCH., *Platypholis boninsimae* MAXIM. and many others. *Boninia* is an endemic genus belonging to the Rutaceae, and *Platypholis* is also endemic and even monotypic, belonging to the Orobanchaceae. *Livistona chinensis* R. BR., *Sideroxylon ferrugineum* H. et A., *Ardisia Sieboldi* MIQ. and *Rhaphiolepis japonica* S. et Z. are trees common in the islands.

XI. The Micronesias under the Japanese mandatory rule. (0°–22° N.Lat., 130°–173°E.Long.).

The Micronesias under the Japanese rule include the Marshalls, the Marianas (except Guam) and the Eastern and Western Carolines. They number as many as seven hundred or more; but all of them being very small, their total area amounts to no more than 2780 sq. km. The vegetation of the different islands is similar in many respects.

On the shores we usually find *Pemphis acidula* FORST, forming dense littoral thickets and reaching down to the high-tide level, along the lagoon side of the atolls. *Scaevola frutescens* and *Tournefortia argentea* LINN. also grow on the shore. The former species forms usually a very thick impenetrable mass. *Guettarda speciosa* LINN., *Allophylus timorensis* BL. *Morinda citrifolia* LINN., *Triumfetta procumbens* FORST and *Barringtonia speciosa* FORST are usually found mixed in the littoral formations of *Scaevola* and *Tournefortia*. Coconut palms and screw pines grow among the littoral bushes.

Thick undergrowth consisting generally of *Lepturus* and *Thuarea* is met with in the palm-forests. *Allophylus timorensis* BL. and *Wedelia biflora* P. DC. are the most common species and form a dense growth in the interior of the islands. *Terminalia Cattapa* LINN., *Pipturus incanus* WEDD., *Cordia subcordata* LAM., *Cerbera lactaria* HAM., *Hernandia peltata* MEISM., *Callophyllum Inophyllum* LINN. and *Erythrina indica* LAM. are usually found mixed in the beach formations. *Ipomaea pes-caprae* ROTH. predominates among the plants found on the sandy beaches. Generally speaking, the flora of the islands is extremely poor as far as the number of species is concerned. This suggests that it is of comparatively recent origin.



Sketch Map of the Japanese Empire and the Micronesias under the Japanese Mandatory Rule. Owing to limited space, the map has been shortened vertically and lengthened horizontally.

V. On the Fauna of Japan.

By

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The problem of the origin of the fauna of Japan is of great importance on account of its bearing upon many questions relating to the Pacific. To permit a clear and satisfactory solution, however, the present state of our knowledge is not yet sufficient; consequently I feel that I can fulfil the duty which has fallen upon me in no better way than by offering a concise summary of the facts at present known of the fauna of this country.

As is well known, the Japanese archipelago consists of three series of island arcs, forming as a whole a barrier off the eastern coast of the Asiatic continent. It has a great extension in latitude as well as in longitude, facing the depressed seas of Okhotsk, Japan and East China to the west, and the mighty oceanic basin of the Pacific to the east, and enjoys the paramount influence of two oceanic currents of different temperatures. Its variety in climate and other conditions tend to give variety and richness to the fauna of its lands and seas.

Organised scientific research first took form in Japan with the Restoration of the Emperor to his full power in 1868. Before that time the study of zoology had prospered less, as compared with that of botany, and was probably similar in method and aim to that of the middle ages in Europe. It appears to have concerned itself mostly with making commentaries on Chinese works of natural history, like the "Honzō Kōmoku." Excepting a little on birds, fishes, and some other groups, practically no work that can be called scientific in any modern sense seems to have been accomplished. Nevertheless this school did an immense service. Amongst the most honoured names in the annals of learning might be mentioned Hakuseki Arai, Jakusui Ino, Ekken Kaibara, Ranzan Ono, Keisuke Ito, and Zuiken Kurimoto. Thus, our science of zoology has for a long time developed independently along a different line, but has converged towards that followed by Western nations.

As great stimuli to our zoological knowledge, mention should be made of the visits of E. Kaempfer (1690–92), C. P. Thunberg (1775–76), and Philipp Franz von Siebold (1823–30), who devoted their energies to the study of natural history. It was indeed the second of the three who first introduced to us the system of Linné. The last published, in conjunction with C. J. Temminck, H. Schlegel and W. de Haan, the well known "*Fauna Japonica*" which appeared at various dates between 1834 and 1851.

With the Restoration, the old school of natural history was almost swept away, and the study of modern zoology took form with the creation of the Chair of Zoology in the Tokyo University in 1877. Two American scholars, E. S. Morse and C. O. Whitman, were the successive occupants of that chair, and stood sponsors to the modern school of zoology in this country.

Since 1881, the development of zoology has been almost entirely in the hands of Japanese, though due credit must be given to a number of foreign zoologists, such as Blakiston, Döderlein, Hilgendorf, Jordan, Pryer, Seebohm, Stejneger, Swinhoe, Thomas, and others. The spirit of earnest study which signalized the natural history school of the pre-restoration days is happily revived, but with greater facilities for successful achievement. Though less than 50 years have passed since the "new departure," the decided progress in the faunal exploration of this country may be said to be rather extraordinary. So far as concerns our present knowledge, the approximate number of known species and varieties in some principal animal groups may be stated as follows:–

mammals	270,	amphibians	80,
birds	800,	fishes	2,500,
reptiles	110,	insects	10,500.

The zoogeographic studies, or the determinations of faunal areas, along with the pursuit of their interrelationship, involve a more vexed problem than the mere enumeration of living animals. The distribution of animals in certain regions is influenced not only by physical but also by historic factors. In order to point out the nature and quantum of the peculiarities in the fauna of Japan, we would pass on to the consideration of the fauna, first dividing it into two fields, land and marine.

It is a pleasure to acknowledge the aid received in the matter of distributional data from the following zoologists — Professor K. Kishinouye, in many respects; Professor S. Watasé, some general aspects; Professor J. Hara, oceanic currents; Dr. S. Tanaka, fishes; Mr. K. Tago, whales and salamanders; Mr. K. Kishida, mammals; Mr. Y. Okada, frogs; and Mr. Y. Yokoya, crustaceans.

Land Fauna.

As previously pointed out, Japan possesses an exceedingly rich and varied fauna closely related to the adjacent continent, and presents us with two pricipal groups, one Palaearctic, the other Oriental. Of these the Palaearctic elements are chiefly found in the northern territories, such as the Kuriles, Saghalien, Hokkaido, Japan proper, and Korea, while the Oriental ones range over the islands of Formosa and Loochoo. With regard to the boundary line between these two regions there is a difference of opinion. Making use of some data on the distribution of certain insects, Miyake and Esaki are inclined to locate it between Kyushu and Tanegashima. On the other hand, some authorities (Watasé, Aoki, Kuroda, Okada, Kishida, and others), approaching the question from the consideration of vertebrates and others, adduce arguments of considerable weight in favour of the view that the pass between Yakushima and Amami-Oshima must be considered as forming a distinct boundary. At present, the latter view is generally accepted.

As is the case with the Eurasian continent, two more or less distinctly marked subregions can be distinguished in the island group of a Palaearctic character, the northern subregion generally known as the Eurasian (Siberian), and the southern, or Eastasian (Manchurian). From a consideration of the distribution of some birds and mammals, Blakiston puts forth the view that Hokkaido and the more northern islands are, zoologically speaking, portions of the Eurasian subregion, from which Japan proper is cut off by a decided line of demarcation in the Tsugaru strait. This boundary we call Blakiston's line.

Judging from the data on the distribution of reptiles and amphibians, Hatta maintains that it may be advisable to put great stress upon the line passing through the Soya strait, instead of the Tsugaru strait. Considering the Tsugaru strait as the southern boundary of the Eurasian elements, as well as the Soya strait as the northern boundary of the Eastasian ones, Matsumoto infers that Hokkaido presents us with the mixed fauna of the two different types. Thus, the question is subject to further investigation. For the sake of convenience, I follow here Blakiston's view.

To judge from the facts just given, the Japanese archipelago may be divided into the following faunal areas:–

1. Palaearctic region.
   a). Eurasian subregion, consisting of the Kurile group, Saghalien, and Hokkaido.
   b). Eastasian subregion, including Korea and Japan proper, the latter of which consists of Honshu, Shikoku, and Kyushu.
2. Oriental region, comprising the islands of Formosa and Loochoo.

The Kurile Group. — Extending in a north-westerly direction from Hokkaido to Kamchatka lies the Kurile group, which comprises some barren islands. In order to have a clear conception of the peculiar character of its fauna, we may divide the group by the 200 metre line into three subgroups, the northern (Shimushyu-Shiashkotan), the middle (Raikoke-Shinshir), and the southern (Urup-Kunashir). Owing to the incomplete state of our knowledge it is hardly possible to pursue their faunal relations satisfactorily, but I think enough examples have been given to throw some light on this subject.

Of about 22 species of mammals which are at present known from this group, two appear to be endemic and are spread over the two northern subgroups. Such are *Microtus uchidae* and *Mus kurilensis*, of which the former is most closely related to that found in Kamchatka. On the other hand, the remaining species, with the exception of some introduced forms, belong to those which occur in Hokkaido, and are found confined to the southern subgroup, for example, *Eutamias asiaticus*, *Myotis mystacinus*, *Pipistrellus abramus*, *Ursus arctos yesoensis*, *Lutra lutra lutra*, etc. The Kurile red fox (*Vulpes anadyrensis splendidissimus*) and the sable (*Martes zibellina*) are important fur-bearing species, forming the basis for a most extensive commerce. The former abounds in the northern subgroup, and the latter in the southern.

The birds which have been observed at the islands are much less in number than those of Hokkaido and apparently less peculiar, the following four being supposed to be characteristic: *Lagopus mutus kurilensis, Hemichelidon griseisticta habereri, Troglodytes troglodytes kurilensis,* and *Pyrrhula pyrrhula kurilensis.* Exclusive of the second species which inhabits Yetorup, they are found to range over the two northern subgroups. The great majority of the species which are known from the southern subgroup may be supposed to represent migrants from Hokkaido. The woodpeckers seem to offer a good example. Of these found in Hokkaido, *Dryobates major tscherskii, D. major japonicus, Yungipicus kizuki seebohmi,* and *Dryocopus martius silvifragus* are known to extend northwards up to Urup but not beyond.

This similarity is also true of reptiles and amphibians, which are represented by only a few species, such as *Gekko japonicus ?, Elaphe quadrivirgata, E. climacophora, Rana temporaria,* etc. They appear to have a very limited area of distribution, being observed only on the southern islands.

Very little is known of the freshwater fishes, of which the most common are *Gasterosteus aculeatus, Pygosteus sinensis,* etc. Some interest attaches to the occurrence of *Oncorhynchus nerka, O. kisutch,* and *Salvelinus malma,* the first becoming fewer and fewer as we proceed towards Hokkaido.

As may be evident from the above, there is a radical difference between the subgroups of islands not very far removed from each other. Beyond doubt, the northern subgroup belongs zoologically to Kamchatka, and the southern to Hokkaido. Notwithstanding its resemblance to the northern, the middle subgroup is still uncertain, because of the introduction of some animal forms by human agency.

Saghalien. — It has long been contended that Saghalien was geologically until recent time a peninsula connected with Amurland; it is still separated from its parent land by an extremely shallow water. There can be no doubt whatever that the island possesses land animals in large proportion identical with those of Amurland. Of about 30 species of mammals at present known from the island, 13 are identical with those of Amurland; of the 13 the following species remain, without making their way to Hokkaido: *Evotomys amurensis amurensis, Ursus arctos collaris, Lynx lynx, Gulo gulo, Rangifer* sp., *Moschus moschiferus moschiferus,* etc. Of the remaining species, the majority, though decidedly of a Eurasian character, present well-marked differences of form and colour, and afford examples to mark the island off from the continent. Such species are *Sorex shinto saevus*, *S. minutus gracillimus*, *S. daphaenodon daphaenodon*, *Sciurus vulgaris rupestris*, *Sciuropterus russicus athene*, etc. The long-tailed mouse (*Sicista caudata*) is supposed to represent a solitary species in existence nowhere else. The Schrenck fox (*Vulpes anadyrensis schrencki*) furnishes a very valuable quality of fur. This has led to the establishment of farms for the breeding of it, in company with some imported foxes.

Some additional light may be thrown upon this question by the avifauna which is less rich, having about 150 species, of which the majority are forms almost or quite identical with those found on the adjacent land and islands. Distinctive species amount to about 10, such as *Strix nebulosa sakhalinensis*, *Troglodytes troglodytes daurica*, *Picoides tridactylus sakhalinensis*, *Perisoreus infaustus sakhaliensis*, *Pinicola enucleator sakhalinensis*, *Anthus spinoletta borealis*, etc.

Reptiles and amphibians are extremely scanty, being known only from 6 species, of which the following two are considered as endemic: *Bufo sachalinensis* and *Hynobius cristatus*. The remaining four are of the same species as are found on the continent. They are *Lacerta vivipara*, *Coluber berus*, *Rana amurensis*, and *R. temporaria*, of which the last appears in Hokkaido.

The fauna of freshwater fishes exhibits an identity in general character with, and a close similarity in species to, that of Hokkaido. *Orthrias oreas* and *Hucho perryi* are those which are common to the two islands. Some peculiarity may be attributable for the existence of *Lucius reichertii* and *Oncorhynchus gorbuscha*.

Of butterflies more than 50 species and varieties are at present known from the island, most of them being representatives of forms found on the continent. Amongst them can be seen a number of forms which are limited in distribution to the north of the Soya strait. Such forms are *Vanessa urticae connexa*, *Cyaniris argiolus levetti*, *Melitoea maturna intermedia*, *Argynnis amathusia miyake*, *Lycoena karafutonis*, *Ly. optilete sibirica*, *Pamphila silvius*, etc. The distinctive species recorded hitherto are *Cyaniris sachalinensis*, *Adopoea lineola*, etc.

As just sketched out, there is no room for doubt that the Soya strait forms an important line of demarcation in the distribution of animals.

Hokkaido. — Concerning its faunal relations accounts are much at variance. In order to understand what are the actual facts, we have now to consider peculiarities presented by its more important animal forms. In mammals the island appears to be less rich, having only about 25 species, of which more than a half are related to those of Saghalien and the continent, either as identical or allied species. Amongst those the species common to the districts just mentioned are *Eutamias asiaticus, Mustela erminea kanei, Martes zibellina,* and others, which are not found in Honshu. The species which present well-marked differences of shape and colour as compared with those found on the parent land are as follows: *Sorex daphaenodon yesoensis, Lepus gichiganus ainu, Evotomys bedfordae, Sciurus vulgaris orientis, Ursus arctos yesoensis,* etc. Besides, we find two groups, one which ranges over to northern Honshu, the other which must be considered as a southern derivation. The latter are very few, being represented by *Apodemus speciosus ainu, A. geisha hokkaidi, Nyctereutes albus, Cervus nippon nippon,* etc.

Turning to birds we find enormous numbers of species which are quite identical with, or closely allied to those found in Saghalien as well as on the continent. Of these comparatively few range over to northern Honshu. The species which are considered as peculiar are the Yeso-ptarmigan, *Sittiparus varius varius, Dryobates leucotos subcirris, Jynx torquilla hokkaidi,* etc.

Of reptiles the case is rather different, because the number of the species which may be considered as those with southern affinities appear to exceed that of the Eurasian types. The species with which we are at present acquainted are as follows: *Eumeces latiscutatus, Takydromus tachydromoides, Natrix vibakari, Elaphe climacophora, E. quadrivirgata,* and *Agkistrodon blomhoffii.*

Amphibians are represented by such forms as *Bufo vulgaris hokkaidensis, Hyla arborea japonica, Rana temporaria, R. temp. ornativentris,* and *Hynobius retardatus.* Of these the first and last are supposed to be peculiar.

In comparing the freshwater fishes of Hokkaido and of Saghalien, we find a close similarity in species, as already pointed out. The species which appear to be endemic are scanty, being represented by *Acipenser mikadoi, Lefua nikkonis,* etc. Some peculiarity may be attributable for the absence of *Oryzia latipes, Parasilus asotus,* and others, which are very familiar in Honshu. Abundantly caught on this island are the salmons, which form one of the most important of the fisheries. Experiments in the artificial propagation of the salmon are now going on.

Passing on to the insect fauna, we find it with a large number of species which inhabit also Saghalien and Amurland. Of butterflies we have several species of a Eurasian character, of which the following are those which do not appear in Honshu: *Parnassis stubbendorfii hoenei, Aporia crataegi, Coenonympha hero perseis, Limenitis sydyi latefasciata, Argynnis selene sachalinensis, Ar. thore borealis, Araschnia levana, Lycoena orion orion*, etc. With them are associated some Eastasian and Oriental forms. *Papilio sarpedon, Pap. macilentus, Pap. alcinous,* and *Danais tytia nipponica* are considered as the species with Oriental affinities.

Frequently to be met with are such freshwater bivalve shells as *Corbicula japonica, Pisidium japonicum, Cristaria plicata, Anodonta arcaeformis,* and *Margaritina margaritifera.* Of these the last species ranges over to the southern Kuriles, while some of the others appear in Japan proper.

Notwithstanding an indication of the mixed fauna of two different elements, Eurasian and Eastasian, there can be seen a series of far more remarkable similarities in character between Hokkaido and Saghalien than between Hokkaido and Honshu. This appears to stand in favour of the view that the Tsugaru strait forms a marked line of demarcation in the distribution of animals of the said different characters.

Korea. — In the Korean peninsula the fauna belongs decidedly to the Palaearctic region, but with a small number of Oriental types. Of its animal forms a large number make their appearance in Japan proper. Of mammals it possesses more than 50 species, of which about a half are like those found in adjacent countries, such as China and Siberia. The species and varieties which are considered as peculiar are numerous, comprising *Lepus coreanus, Evotomys regulus, Cricetulus nestor, Sciurus vulgaris coreanus, Eutamias orientalis, Sciuropterus alco, Canis lupus coreanus, Vulpes peculiosus, Meles melanogenys, Charronia flavigula koreana, Martes melampus coreensis, Felis tigris coreensis, Hydropotes argyropus, Moschus moschiferus parvipes, Nemorhaedus raddeana*, etc.

Of birds we are now acquainted with more than 300 species and varieties, of which the majority are almost or quite identical with those of the continent. The endemic species are comparatively few, amounting to 8. Such as *Sitta canadensis corea, Dryocopus martius morii, Strix aluco nivicola, Troglodytes troglodytes peninsulae, Thallasoaëtus pelagicus niger, Picus canus griseoviridis,* etc.

Recorded from the peninsula are about 16 species of reptiles, most of which are not discovered in Japan proper. Such species are *Hemidactylus frenatus, Takydromus amurensis, Eremias argus, Natrix tigerina lateralis, Elaphe rufodorsata, Zamensis spinalis, Agkistrodon blomhoffii brevicaudus,* etc.

Coming to the fauna of amphibians we find it with many species which are known to occur on the adjacent mainland. Of those the following forms remain as residents: *Bufo bufo asiaticus, Rana nigromaculata koreana, Hyla arborea stepheni, Onychodactylus fischeri,* etc. The characteristic species are *Cacopoides tornieri, R. temporaria koreana, Hynobius leechii,* etc.

Very little is known of the freshwater fishes, most of which belong to those found on the adjacent land, such as *Pygosteus sinensis, Gobio gobio, Ladislavia taczanowskii,* etc. The species supposed to be peculiar are *Liobagrus andersoni, Gnathopogon coreanus, Siniperca aequiformis,* etc.

Dwelling on the peninsula are found a large number of butterflies, which are in large proportion species inhabiting the immediately surrounding countries, China and Siberia, for example, *Aporia hippia, Ypthima motschulskyi, Lethe sicelis, Sericinus telamon, Pieris daplidice, Apatura iris amurensis,* etc. An interesting feature here met with is the appearance of Palaearctic forms quite identical with, or allied to those which are found in Hokkaido. Intermingled with them are seen such Oriental types as *Papilio protenor demetrius, Eurema hecabe, E. loeta, Dichorragia nesimachus nesiotes,* and others, some of which range over to Japan proper.

Freshwater bivalve shells are here represented by *Corbicula elatior, Cristaria parvula, Anodonta woodiana subtetragona, Nodularia douglausiae,* etc.

In comparing the faunas of northern Korea and of Hokkaido, one is struck with the identity or similarity of several species of frogs, freshwater fishes, and insects.

Here then we come to glance at the general character of the fauna in Tsushima which is separated from the peninsula by the west channel of the Tsushima strait. Some naturalists insist upon the close affinity of its fauna to Kyushu, in company with Iki which belongs zoologically to the latter. Putting great stress upon the occurrence of *Felis microtis, Mustela sibirica, Thriponax richardsi, Dinodon rufozonatum, Bombina orientalis,* and others, hewever, we think that this island must be considered as forming the southern out-post of the Korean section. The animals which are supposed to be peculiar to the island are as follows: *Urotrichus talpoides adversus, Apodemus geisha sagax, Micromys minutus aoki, Martes melampus tsuensis,* and *Myotis tsuensis* in mammals; *Yungipicus kizuki kotataki, Garrulus glandarius namiyei,* and *Periparus ater teraokai* in birds; *Rana tsushimaensis, Hynobius tsuensis,* and *H. tagoi* in amphibians. Here mention should be made of Tristram's woodpecker (*Thriponax richardsi*) which is limited in distribution to the island and Korea. Owing to indiscriminate shooting to meet the demand abroad for specimens of its skin, in 1896–1901, it is in danger of extinction on the island. In 1922, it was specified as a "natural monument" and its thorough protection authorized.

Japan proper. — Japan proper consists of the three main islands of Honshu, Shikoku and Kyushu, in close proximity to which lie a number of important islands. Considering Japan proper as distinct, we find it with an exceedingly rich and varied fauna which presents indications of there having been two or more lines of migration at different epochs. The majority of its animals are related to those of the two Palaearctic subregions, viz. Eurasian and Eastasian, either as identical or allied species, but a small number are of an Oriental character.

Of mammals there are known more than 60 species, of which the majority are almost or quite identical with those of the Eastasian subregion, but a small number are either of an Oriental or of a Eurasian character. The forms with Oriental affinities are invariably confined to the south of the Tsugaru strait. This similarity can also be traced to Eastasian elements, such as *Mogera wogura wogura,* the mole-shrew, *Glirulus japonicus, Sciurus lis, Sciuropterus momonga amygdali, Canis lupus hondophylax, Vulpes japonicus,* and *Meles anakuma.* Of course, there are some Eastasian elements making their way to Hokkaido, but much less in number as compared with the Eurasian types from the north. *Sorex shinto shinto, S. hawkeri,* the hares, *Mustela erminea nippon, M. rixosa namiyei,* and *Cervus matsu-*

motoi represent the latter elements, chiefly occupying the northern district of Honshu. Some remarkable species are *Urotrichus talpoides talpoides, Dymecodon pilirostris,* and *Macaca* (*Inuus*) *fuscata,* of which the last is known to extend northwards to Aomori prefecture but not beyond. Quite recently specified as a "natural monument" is the "tanuki," *Nyctereutes viverrinus,* which, with other species of this genus, is the most typical representative of the animals characteristic of the Eastasian subregion (Watasé, Shiseki Meisho Tennen-Kinenbutsu, I, 1926).

The birds ascertained to inhabit the islands reach enormous numbers, the great majority of them being decidedly represented by forms widely distributed in China and Korea. The number of species and varieties which appear to be peculiar are 6 in Kyushu, such as *Phasianus versicolor kiusiuensis, Graphophasianus soemmerringii soemmerringii, Yungipicus kizuki kizuki,* etc., and 17 in Honshu, such as *Bradypterus pryeri pryeri, Y. kizuki nippon, Pterodroma longirostris, Picus awokera awokera, Dryobates major hondoensis, Pernis apivorus orientalis, Ph. versicolor versicolor, G. soem. scintillans, Lagopus mutus japonicus, Strix uralensis hondoensis,* etc. No peculiar species is found in Shikoku, where the avifauna closely resembles that of southern Honshu as well as of Kyushu. Of the species recorded above, one of the most notable is the Japanese ptarmigan, which finds its home in the Japanese Alps at the snow line.

Recently specified as "natural monuments" are some birds, which comprise, besides the ptarmigan recorded above, the cranes (*Megalornis monachus, M. japonensis, M. grus lilfordi, Pseudogeranus vipio, Sarcogeranus leucogeranus,* and *Anthropoides virgo*), the Japanese stork (*Ciconia ciconia boyciana*), black-tailed gull (*Larus crassirostris*), swans (*Cygnus cygnus* and *Cy. bewickii minor*), long-tailed fowl, the Chinese magpie (*Pica pica sesicea*) and the Japanese shearwater (*Puffinus leucomelas*). Of the above six species of cranes, the commonest forms which have come over to this country since olden times are the hooded crane and the white-necked crane, and it seems that the Japanese crane (Tancho) has been rather rare. They are winter residents, now appearing in flocks in two regions, Yashiro-mura, Yamaguchi prefecture, and Akune-mura, Kagoshima prefecture. Their breeding takes place in summer in Manchuria and eastern Siberia. Next comes the Japanese stork, which, differing from the European form which migrates, remains as resident all the year round in the same locality. Tsuruyama in Idzushi, Hyogo prefecture, is famous as a place where it breeds. As a summer resident the black-tailed gull appears in flocks and breeds on small islands along the coasts of the Japan Sea as well as on the Pacific side, its famous breeding grounds being Kabu-shima in Aomori prefecture and Fumi-shima in Shimane prefecture. This bird migrates in winter southwards to Formosa, or Amoy in China. There are two kinds of swans which come over to Japan, viz. the wooper swan (*C. cygnus*) and the eastern Bewick's swan (*C. bewickii minor*). They are migrants from Siberia where they breed in May, spending winter on our coasts. Kominato in Aomori prefecture furnishes them with a very favourable situation where they fly over the sea. The long-tailed fowl is a breed of the domestic fowl, its peculiarity lying in the possession of very long tail feathers, which sometime reach from 3 m. to more than 4.5 m. This remarkable fowl is not a native of Japan. It is considered that this form originated in Korea and was improved in Tosa after having been introduced there. Notwithstanding its introduction from Korea, the Chinese magpie, which is distributed over Korea, Manchuria, China, Formosa, Hainan, and Upper Burma, is now found to occur in a wild state only in some parts of northern Kyushu. Finally, we come to the Japanese shear-water, which, although occasionally migrating southwards to Australia, abounds and breeds around this country. Kammuri-shima in Kyoto prefecture is known as a famous breeding ground.

Reptiles to be met with are about 13 species, most of them being related to those of Korea and chiefly occupying the southern region. The endemic species are *Achalinus spinalis, Dinodon orientale, Amyda japonica,* etc.

At present we are acquainted with about 13 species of frogs and toads, which, with the exception of an Oriental type, seem to be of a Palaearctic character. The species and varieties which are not found elsewhere are as follows: *Bufo vulgaris japonicus, B. vulg. formosus, Rana japonica, R. temporaria martensi, R. limnocharis, Rhacophorus schlegelii, Polypedates buergerii,* etc. Of these the first, fourth and fifth three forms occupy situations in the southern district, while the second abounds in the northern.

Coming to the urodele, we find various species of it, the majority of them being considered as peculiar and finding their homes in the southern district. Such species are represented by *Hynobius nebulosus, H. stejnegeri, H. vandenburgi,* etc. One of the most noteworthy is the giant salamander (*Megalobatrachus japonicus*), which inhabits the cool mountain streams of provinces in Honshu, south of Mino, and also in Kyushu. Although not common, it is not very rare. It is known to occur also in China, and may be said to represent a good example which marks off the Eastasian subregion from the others. As the representative of the northern district may be recorded *H. peropus*, which is found at high altitudes. Extensively distributed in Japan proper are *Diemictylus pyrrhogaster* and *Onychodactylus japonicus*, the former being the commonest of all.

The freshwater fishes are known from an immense number of species, many of which appear to be rather limited in distribution. Some are confined to particular river valleys, others inhabit the lakes of a limited district only, while some are restricted to a comparatively narrow area. Generally speaking, the southern district presents us with the following species: *Acheilognathus limbatus, Sarcocheilichthys variegatus, Opsariichthys uncirostris, Zacco temminckii, Brittosus kawamebari, Sicyopterus japonicus, Rhinogobius hadropterus*, etc. Ranging over the northern area are found such forms as *Oncorhynchus, Pseudoperilampus typus, Chloea senbae*, etc. Widely spread over Japan proper occurs *Plecoglossus altivelis.* The river Nagara, in the province of Mino, is famous for its fishing with the cormorant.

Intermingled here are found enormous numbers of insects which are of three different characters, Eurasian, Eastasian, and Oriental. Of these the Eastasian, and especially the Oriental elements, find congenial habitats in the southern district. Such species may be represented by *Ypthima motschulskyi, Argynnis hyperbius, Curetis acuta paracuta, Arhopala japonica, Ar. bazalus, Papilio dosum mikado, Pap. helenus nicconicolens, Danais melissa septentrionis, Melanitis leda determinata, Erasmia purchella, Cicindera chinensis, Euterpnosia chibensis, Cryptotympana pustulata, Tramea chinensis, Orthetrum sabina, Coptotermes formosanus*, etc. Spread over to the northern district are frequently found some southern elements, which do not appear in Hokkaido, for example, *Pap. protenor demetrius, Eurema hecabe, Dichorragia nesimachus nesiotes, Chrysochroa elegans, Xylotrupes dichotomus, Kirkaldyia deyrollei*, etc. The forms with northern affinities are found to abound chiefly in the northern district. Such are *Vanessa urticae connexa, Luedortia puziloi inexpecta, Pieris napinesis, Smerinthus coecus, Phyllosphingia dissimilis, Mimas christophi, Urochela jozankeana*, etc. The so-called alpine species inhabit the high mountain districts of central Honshu. They are represented by *Aporia hippia*, *Erebia ligea takanonis*, *Oeneis jutta*, *Pamphila palaemon*, etc.

The molluscs are very rich and varied. Very likely to be met with are in the southern region the following freshwater bivalve shells and land snails: *Corbicula orthodonta*, *C. sandai*, *C. viola*, *Nodularia gladiolus*, *Pseudodon loomisi*, *Eulota sieboldiana*, *Pupinella rufa*, *Cyclophorus herklotsi*, etc. In the northern region we find that there inhabit such species as *Sphaerium inutilis*, *N. japonensis*, *Pyramidula pauper*, etc. Besides, some interesting species in the middle region can be seen, such as *Sph. heterodon*, *N. haconensis*, *N. parcedenta*, *E. peliomphala*, *E. callizona*, etc.

Extensively distributed are a number of dangerous parasitic worms which infest men and domestic animals. Some of the most notable are *Ankylostoma duodenale*, *Filaria bancrofti*, etc. in round worms; *Dibothriocephalus latus*, *Taenia saginata*, etc. in tape worms; the liver fluke (*Clonorchis endemicus*), the lung fluke (*Paragonimus westermanni*), *Schistosomum japonicum*, *Metagonimus yokokawai*, *Fasciolopsis buski*, *Fasciola hepatica*, etc. in distomes.

As regards the faunal affinities of the islands of Tanegashima and Yakushima, situated in the Pacific just south of Kyushu, much discussion has hitherto arisen, as already noticed. At a glance these islands appear to be widely different in character from Kyushu. According to close examination, however, it is clearly made out that notwithstanding the poverty of their fauna, a large number of animal forms, exclusive of certain insects, are closely related to those found in Kyushu, either as identical or allied species, so that the islands must be considered as forming the southern out-posts of the Palaearctic section. Species which are supposed to be peculiar are *Mogera wogura kanai*, *Crocidura dsinezumi umbrina*, *Apodemus speciosus dorsalis*, *Ap. geisha yakui*, *Mustela itathi sho*, etc. amongst mammals; the Yakushima jay, *Zosterops palpebrosa insularis*, *Picus awokera takatsukasae*, *Merula celaenops yakushimaensis*, *Troglodytes troglodytes ogawae*, etc., amongst birds; and *Bufo vulgaris yakushimaensis* amongst amphibians.

Formosa. — As this island is interrupted only by a narrow channel from the continent, we should naturally expect a close resemblance between the productions of the two districts. In fact, there can be seen a certain feature, the identity or affinity of several animals, with the Oriental as well as with the Palaearctic species, the former being far more numerous than the latter. The mammals which have hitherto been discovered are more than 60 in number, while, those which appear to be peculiar amount to 45, of which the majority may be considered as being only varieties of species found in the Oriental and Palaearctic regions, such as the mole, hare, squirrels, large flying squirrels, *Ursus tibetanus formosanus*, *Helictis subaurantiaca*, *Charronia flavigula xanthospila*, *Muntiacus reevesi micrurus*, etc. The following species are those which are not found outside of the island: *Petaurista grandis*, *P. pectoralis*, *P. lena*, *Pteropus formosus*, *Macaca formosana*, *Paradoxuris larvatus*, etc. The squamata is represented by a single ant-eater, *Manis pentadactyla*.

Of birds we find more than 330 species and varieties, of which 33 are common to the island, China, and the Philippines, and about 87 belong to peculiar forms. Some of the latter are *Neocalophasis mikado*, *Hierophasis swinhoii*, *Otus hambroecki*, *Glaucidium pardalotum*, *Strix newarensis caligatus*, *Cyanops nuchalis*, *Picus canus tancolo*, *Yungipicus wattersi*, *Pycnonotus sinensis formosae*, *Spizixus cinereicapillus*, *Myiophonus insularis*, *Lanthia goodfellowi*, *Brachypteryx goodfellowi*, *Trochalopteron taewanum*, *Captia brauniana*, *Urocissa caerulea*, *Dicaeum formosum*, and *Pyrrhula erythaca arizanica*. One of the most notable species is the mikado pheasant, which lives in the high mountain districts, such as Arizan and Niitaka.

More than 65 species of reptiles and amphibians are now known to inhabit the island, of which the majority are the same species as are found on the adjacent land and islands. The characteristic species are *Japalura swinhonis*, *Eumeces elegans*, *Takydromus formosanus*, *Natrix swinhonis*, *Holarchus formosanus*, *Dinodon septentrionale*, *Calamaria berezowskii*, *Boiga kraepelini*, *Trimeresurus mucrosquamatus*, etc. amongst reptiles; *Bufo bankorensis*, *Microhyla stejnegeri*, *Rana rugulosa*, *Rhacophorus robustus*, *Rh. moltrechti*, *Hynobius sonani*, etc. amongst amphibians. Frequently to be met with is *Tr. gramineus*, a poisonous snake, which is of an almost uniform green colour and is widely distributed in tropical districts.

The list of freshwater fishes is a rich one, presenting us with about 70 species. Putting aside a few species which are capable of inhabiting both fresh- and brackish-waters, and some others, 52 species may serve, according to Oshima, as basis for the consideration of the faunal relations. Of these, 27 are forms which are supposed to be of an Oriental character, and the remainder exhibit Palaearctic affinities. Strange to say, the amount of the latter element is a great deal larger than that expected. It is an interesting fact that the Oriental elements increase in number, as we proceed towards the southern district. So far as we can learn, the species which are not found elsewhere amount to about 32, there being included the following forms: *Salmo formosanus, Aoria brevianalis, A. taiwanensis, Formosania gilberti, Hemimyzon formosanum, Scaphhesthes tamsuiensis, Barbodes paradoxus, Spinibarbus hollandi, Leuciscus achisturus, Zacco pachycephalus, Leucisculus fuscus*, etc. Some interest attaches to the occurrence of *Ophicephalus maculatus* which flourishes in the Philippines and China. There is, however, no room for doubt that it has been introduced by human agency.

The insect fauna is exceedingly rich and varied, there having been recorded enormous numbers of species and varieties. Up to the present, we are acquainted with about 280 forms of butterflies, most of which are forms known to occur in tropical countries.

Glancing at the vertical distribution of butterflies, we can distinguish four zones, viz. the tropical, the subtropical, the temperate, and the subarctic or arctic. Some of the species are, of course, common to two adjacent zones. The tropical forms occur in the plains up to an elevation of about 1,524 m. and are represented by *Papilio aeacus, Pap. aristolochiae, Pap. erithonius, Hestia leuconoë, Kallima inachis, Danais tytia, Stichophthalma howqua, Junonia asterie*, etc. Ranging from 1,524 m. to 2,134 m. are such subtropical forms as *Pap. horishanus, Pap. eurons, Lethe insana, L. gemina, Neope pulaha*, etc. The temperate forms occur at a greater elevation, approximately up to 3,048 m. and include such characteristic species as *Argynnis paphia, Vanessa xanthomelas, Abisara burni*, etc. Extending from the upper limit of the preceding zone to an elevation of 3,658 m. are found such arctic or subarctic butterflies as *Colias hyale, Lethe niitakana*, and *Oenis* sp.

Of freshwater bivalve shells we find such species as *Corbicula producta, C. orientalis, Anodonta swinhoei, Unio swinhoei, Nodularia douglausiae taiwanica*, etc. Of those the first is also found in Korea.

The Loochoo Group.—Composed of some clumps of islands, such as the Sakishima, the Okinawa and the Amami-Oshima, is the Loochoo group, which presents us with animal forms of two different characters, Oriental and Palaearctic, the former types considerably exceeding the latter in number. In reviewing the faunas of the above-named subgroups, we find such great differences, that they are each readily marked off from the other. Up to the present, about 36 species of mammals have been recorded, of which the most notable are *Hipposideros turpis* in the Sakishima subgroup, *Rattus rufescens* in the Okinawa, and *R. coxingi* and *Pentalagus furnessi* in the Amami-Oshima. *Sus riukianus* ranges all over the subgroups; *Lenothrex legata* is found to occur in Okinawa and Oshima. Amongst the species just recorded the Amami hare is zoologically of remarkable interest, presenting a blackish colour. It is nocturnal in its habits and hides away in the hollows of trees during the day. Its thorough protection was authorized.

Of birds the species which appear to be peculiar amount to 11 in the Sakishima, 6 in the Okinawa, and 8 in the Amami-Oshima subgroup. Such are as follows: *Spilornis cheela, Rallina euryzonoides sepiaria, Parus nigriloris, Halcyon miyakoensis,* etc. in the first; *Sapheopipo noguchii, Otus bakkamoena pryeri, Icoturus kamadori namiyei,* etc. in the second; *Scolopax rusticola mira, Dryobates leucotos owstoni, Microscelis amaurotis ogawae, Oreocinchla dauma amami, Lalocitta lidthi, Yungipicus kizuki amamii,* etc. in the third. Be it observed that Yonakuni, an island at the southern end of the Sakishima subgroup, is regarded as bearing very close relations in its avifauna to Formosa. Amongst the forms recorded above, *L. lidthi* and *S. noguchii* are each of one genus and one species. The former, Lidth's jay, furnishes very beautiful feathers, which are used to trim ladies' hats. Before the great war the skins of this bird were exported to Europe and America to a large amount annually. It is now specified as a "natural monument," and strictly preserved.

The reptilian fauna is very rich, having 30 species, of which one-third is the same as found in the Oriental region, and the remaining two-thirds those not discovered elsewhere. So far as our present knowledge is concerned, each subgroup possesses some endemic species. Thus, in the Sakishima, *Eumeces kishinouyei, Takydromus dorsalis, Elaphe schmackeri, Liopeltis herminae, Trimeresurus elegans*; in the Okinawa, *Lygosaurus pellopleurus, Hemibungarus boettgeri, Tr. okinavensis*; in the Amami-Oshima, *Hem. japonicus,* and others appear to be peculiar to those subgroups. Ranging over the islands of Okinawa and Oshima is found *Tr. flavovirridis* which is of a seriously toxic nature.

Amphibians are at present known from about 15 species, of which the characteristic forms are in the Sakishima subgroup *Bufo bufo* *miyakoensis* and *Rana ijimae*; in the Okinawa *R. ishikawae, R. namiyei, Bombina holsti,* and *Rhacophorus owstoni*; and in the Amami-Oshima *Hyla hallowelli* and *Babina subaspersa.* Recorded hitherto are only two species of salamanders, such as *Diemictylus encicauda* and *Tylototriton andersoni,* which range over the latter two subgroups.

The list of freshwater fishes is extremely poor, including *Oryzia latipes Fluta alba, Plecoglossus altivelis,* and others, which are also found on the adjacent land and islands. An interesting species here met with in abundance is *Macropodus opercularis.*

As is the case with other classes, the insect fauna comprises two principal groups, one Oriental, the other Palaearctic. Of the butterflies recorded hitherto the majority are representatives of forms found in India, the Malay peninsula, China, the Philippines, and Formosa. According to Fritze and Sonan, about four-fifths of the whole belong to the Indo-Malayan forms, and the species which are worthy of notice are *Papilio helnus, Pap. memnon, Hebomia glaucippe, Hestia leuconoë, Kallima inachis, Cyrestis thyodamas, Hypolimnas bolina, Charaxes weismanni,* etc.

Of freshwater bivalve shells we have three such species as *Cyrena luchuana, C. fissidens,* and *C. yaeyamaensis.* Of these the first is also found near Kagoshima.

The Bonin Group. — This oceanic island group, together with the Sulphur group, shows tropical features in its fauna and flora, possessing a number of endemic animal forms. Quite the most remarkable of mammals is *Pteropus pselaphon* which flourishes here. Notwithstanding its introduction in 1853, *Cervus unicolor* presents well-marked subspecific differences, and is now found to occur in a wild state. One of the most notable features of the fauna of the said island groups is the fair abundance of birds. Each group presents us with some endemic species. Thus, in the Bonin group, *Aegithocichla terrestris, Chaunoproctus ferreirostris, Horornis cantans diphone, Apalopteron familiare, Microscelis amaurotis squamiceps, Janthoenas janthina versicolor,* and in the Sulphur, *Zosterops palpebrosa alani, Poliolimnas cinereus brevipes, Micr. amaur. magnirostris,* and others are regarded as peculiar to those groups. Of the above named species in the former group the first two are extinct. *Cryptoblepharus boutonii* is the only one representative of reptiles found in the Bonins. Poverty is also true in the case of freshwater fishes, the most notable being *Anguilla* *mauritiana.* Molluscs oftentimes met with are *Succinea ogasawarae, Eulota similaris,* and *Opeas pyrgula.*

Marine Fauna.

When we turn to consider the marine fauna of the Japanese waters we find that all of the zoologists who have worked out on it are inclined to think that our marine animals are closely related not only to a part of the Indo-Pacific region but also to that of the Behring Sea. The main factor which affects this state of animal life is that due to the physical conditions of the sea. Setting aside the daily and seasonal changes, and those, which rarely happen, by volcanic agency, we find a great factor in the temperature of the water as well as in the motion of the oceanic currents. As thermal regulators of the water are first of all to be taken into account the oceanic currents. We may here take a glance at the currents around the Japanese islands.

On the Pacific side we have two principal streams of different temperatures. The warm current is known as the Japan stream, or Kuro-shiwo, which is peculiar for its high salinity. This stream has its origin in the north Pacific current from the east, and passes into the East China Sea, moving northwards by way of Luzon and Formosa. Near the south cape of Formosa it sends off a branch, which runs towards the Formosan channel, along the western coast of the island, and merges finally into the main stream. After flowing out to the Pacific chiefly by the pass between Yakushima and Amami-Oshima, the stream moves in an east-north-easterly direction towards the Shiwo-no-misaki where it comes very close to the shore, and then turns more to the east. In its course the stream floods the bays of Kagoshima, Tosa, Suruga, Sagami, and others. After travelling along the coast of the Bōsō peninsula, the current debouches into the open sea between 30° and 50° N. lat., and passes in part northwards to the Aleutian islands.

The cold current is the well-known Kamchatka stream, or Oya-shiwo, which rises from the Behring Sea, and passes down south along the eastern coast of the Kurile group and Hokkaido, extending farther southwards off Kinkwasan, or beyond, where it meets the aforesaid Kuro-shiwo. Both streams vary in strength at different seasons; the Kuro-shiwo is strongest in the warmer season and weakest in the colder, while the reverse is true of the Oya-shiwo; hence the meeting point of these streams is shifted sometimes up and sometimes down, oscillating along the northern coast of Honshu.

The Japan Sea is an enclosed basin with four narrow outlets, in which there are two streams. The more influential one emerges from the Kuro-shiwo at the west of the Osumi strait, and passes as the Tsushima stream into the sea basin, a part of which pours in through the west channel of the strait and runs for some distance along the eastern coast of Korea. Its main part intrudes into the east channel and travels towards the north-east, bathing the north-western coast of Japan. Through the Tsugaru strait a minor branch goes out into the Pacific and runs down close to the coast of the north-eastern part of Honshu, taking for some distance a course parallel with the Oya-shiwo. The remaining part continues to proceed northwards as far as the Soya strait where it gives off a branch, which flows out to the Okhotsk Sea through the said strait. After skirting the coast of Hokkaido, this branch stream appears to rush in part into the Pacific chiefly through the de Vries strait. The main stream, keeping its original course, extends to the western coast of south Saghalien and turns round towards the Amurland. Finally it disappears. The Tsushima stream, though a branch of the Kuro-shiwo, is distinguished from the latter, being by no means so high in salinity.

The cold stream takes its origin from the Mamiya strait, and runs south-westwards along the Amur coast. Recently it has been clearly made out that coastal waters circulate in two different directions on either side of the line stretching from about Vladivostock to Tsuruga bay, one counterclockwise, the other clockwise.

Receiving a paramount influence of the currents just sketched out, Japanese waters command a very rich and varied marine fauna, there being found two types of animal life, the northern and the southern. Neglecting here some southern and northern elements, which have their limits north in the Behring Sea and south off the Loochoo group, respectively, the following three faunal areas may be more or less clearly recognized, though contiguous zones blend one into the other:—

1). Northern zone, extending from the shore of the Kurile group to that of the northern part of Honshu which lies to the north of Kinkwasan.

2). Middle zone, extending from off Kinkwasan to near the Shiwo-no-misaki, on the Pacific side, and representing the zone of mingling of the arctic or subarctic and tropical or subtropical forms. The Japan Sea may be dealt with as corresponding as a whole to this zone.

3). Southern zone, comprising the shores of the parts of Japan proper lying to the south of the Shiwo-no-misaki, the Loochoo group, the Bonin group, and Formosa.

Now, we may proceed to consider in somewhat greater detail peculiarities presented by the more important animal forms in these three districts.

Northern Zone. — This district is frankly subarctic, containing animals characteristic of the Behring Sea on the one hand, and of the Okhotsk Sea on the other. Amongst the carnivorous mammals the sea otter (*Enhydra lutris*) is circumpolar in range, being confined to the north of Hokkaido, while the Steller sea lion (*Eumetopias jubata*) and several seals (*Phoca vitulina, Ph. fasciata,* etc.) frequent the more southern waters, some of them occasionally appearing in the seas off Hokkaido and Amurland. The northern fur seal (*Callorhynus ursinus*) which is of economic importance particularly abounds in Kaihyo-to, a small island near Saghalien and also on some islands of the Kuriles. In winter it extends to as far south as the Inubō-saki, on the Pacific side, and Korea, on the Japan Sea side.

Turning to cetacea, we find three whalebone whales, such as *Balaena glacialis, B. mysticutus,* and *Rhachianectes glaucus.* Of these the first two right whales are circumpolar in range, being found in the farthest northern waters in summer, and migrating in winter southwards to the Okhotsk Sea, or even to the northern parts of the Japan Sea and the Pacific. The third, the Californian gray whale, is an inhabitant of the northern Pacific, and undertakes an annual migration on both sides of the Ocean as regularly as the seasons. On the Japanese side it frequents the Okhotsk Sea in summer. From late November to early February it makes its appearance on the eastern coast of Korea, probably passing steadily through the Soya strait and the Japan Sea. Then it travels southwards to the East China Sea, to give birth to its young. In spring it reappears on the eastern coast of Korea, in company with its young, and proceeds northwards to the Okhotsk Sea, swimming in all probability slowly along the coasts of the Asiatic continent and Saghalien. Besides, there occur some toothed whales, such as the True porpoise (*Phocaenoides truei*), the striped porpoise (*Lagenorhynchus obliquidens*), the northern porpoise whale (*Barardius bairdii*), etc. Of these the first two extend southwards down to off Kinkwasan, and the last to near the Bōsō peninsula.

Around the Kuriles, Hokkaido, and Saghalien are found in immense quantities many fishes like the cods, salmons, and herring, which are of the same greatest economic importance as in Norway, Scotland, Newfoundland, and other countries. Amongst the cods, *Eleginus navaga* is circumpolar in range, being confined to the north of Hokkaido, while *Gadus macrocephalus* and *Theragra chalcogramma* make their way southwards to off Miyagi prefecture, on the Pacific side, and to off Shimane prefecture, on the Japan Sea side. *Clupea pallasii* is found to come down to near the Inubō-saki and Ishikawa prefecture. Amongst the other farthest north fishes we find *Trichodon trichodon* extending down to near Hokkaido; *Arcotoscopus japonicus* ranging over to off Shimane prefecture; *Percis japonica* having its southern limit on the neighbouring coast of Niigata; *Blepsias draciscus* and *Pholis fasciatus* confined to the north of Aomori; and *Ammodytes personatus* appearing in the Inland Sea. Generally speaking, the northern forms, though occasionally extending down to as far south as the East China Sea, appear to be confined in distribution to the north of Kyushu.

Comparatively shallower in the waters are found some ascidians, like *Halocynthia roretzi, Chelyosoma siboja, Molgula crystallina, M. redikorzevi*, etc. The first two are largely eaten in this country,

Much less developed here than in the tropics are a number of echinoderms, amongst which we find the following species: *Ophiura cryptolepis, Ophiacantha rhachophora, Gorgonocephalus caryi*, etc. in brittle-stars; *Leptychaster anomalus, Pentagonaster japonicus, Hippasteria spinosa, Pseudarchaster parelii*, etc. in star-fishes; *Coptosoma crenulare, Strongylocentrotus drobachiensis*, etc. in sea-urchins; and *Stichopus japonicus, Cucumaria japonica, C. chronhjelmi*, and *Psolus squamatus* in sea-cucumbers. Some of them are found spread into the middle zone on both sides, the Pacific and the Japan Sea. Amongst the sea-cucumbers, the first two species are of economic value in this country.

Ranging from the Behring Sea to the Japan Sea occurs *Paralithodes camtschatica*, which attains a large size and is one of great economic importance. Its famous fishing grounds are the coasts of Kunashir and Saghalien. With this is associated the most edible crab, *Chionecetes opilio*. The prawns likely to be met with are several species of *Pandalus*, such as *P. platyceros* and *P. hypsinotus*, which range widely from the Behring Sea southwards to the Kumano Sea or beyond, as well as to off

Shimane prefecture,

A large number of molluscs are known from this district, of which the most valuable species are *Ostrea gigas, Mactra sachalinensis, Pecten yessoensis, Ommastrephes sloani pacificus,* etc. The oyster attains a large size, its famous natural bed being found in the lake of Saruma in Hokkaido. On the shores of the northern islands as well as in Aomori bay abounds the above named *Pecten,* which is of very large size. The cuttlefish is of great commercial value, being caught in great quantities to be consumed as food or used as bait. Besides, we find that there appear in this district such squids as *Gonotus fabricii* and *G. magister.* The former is limited in distribution to the north of Hokkaido, while the latter comes down to as far south as Miyagi and Shimane prefectures. The bays of Hokodate and Aomori are famous for some species of branchiopods, like *Terebratella coreanica,* etc.

Extensively distributed here are numerous worms, such as *Ichthyobdella uobir, Ich. virgata,* etc. amongst leeches; *Nereis ezoensis, Harmothoë yendoi, H. imbricata, Polynoë gymnonota,* etc. amongst polychaetes; *Dendrostoma blandum, Echiurus pallasii,* etc. among gephyreans. Of these some forms extend southwards down to the shores of Shikoku and Kyushu.

Amongst medusae, such forms as *Haliclystus* spp., *Aurelia limbata, Cyanea* spp., *Chrysaora* spp., *Staurophora discoidea,* and *Sarsia* spp. frequent the northern waters. Spread into the middle zone are oftentimes seen some species of a northern character, such as *Phacellophora* spp., etc. Growing along the weed and on other objects are seen a number of hydroids, such as *Rhizocaulus verticillatus, Obelia longissima, Grammaria scandens,* and species of *Halicium, Abietinaria,* and *Salacia.*

The sponge fauna is comparatively poor, the notable species being *Chonelasma calyx, Aphrocallistes vastus,* etc. They are found to extend south down to the Sagami Sea.

Middle Zone. — In this district the arctic or subarctic overlaps the tropical or subtropical fauna, there being distinguished a great variety of animals. Most of the types characteristically Japanese belong here, abounding in rock pools and about the rocky islands. Setting asidesome mammals, northern and southern, some whalebone whales may be recorded here, which are of great economic importance. The blue whale (*Balaenoptera sibbaldii*) which is of wide distribution and of migratory habits, appears off Kinkwasan and Hokkaido in summer, and about Shikoku and Kyushu in winter. Swimming in schools in the seas around Japan proper and Hokkaido is found the common fin-whale (*Bal. physalus*) which appears in the north in summer, and in the south in winter. The Sei whale (*Bal. borealis*) has a range almost similar to the preceding, extending from the southern Kuriles in the north to as far south as the Gotō group. Their famous hunting grounds are off the southern Kuriles, Nemuro in Hokkaido, Kinkwasan, the Shiwo-no-misaki, the Gotō group, and Korea.

Here intruded from the southern seas are found a few species of reptiles, like *Disteria cyanocincta, Hydrus platulus, Caretta olivacea,* and *Eretmochelys squamosa* which sometimes extend north up to Hokkaido.

The chief species of fishes, the occurrence of which marks this zone off from the others, may be said to be *Cynias manazo, Hyporhamphus sajori, Apogon semilineatus, Halichoeres poecilopterus,* etc. Some valuable fishes, as the Japanese porgy, bonitos and tunnies are caught here in immense quantities. Of scombroid fishes, *Scomber japonicus* and *Thunnus orientalis* are found on both sides, the Pacific and the Japan Sea, extending from Saghalien and Hokkaido in the north to the East China Sea in the south. Besides, this district abounds in sardine (*Sardinea melanosticta*), which is replaced in the north by the herring and in the south by *Etrumeus micropus. Engraulis japonicus* also occurs in much abundance, having a range somewhat wider than the sardine. Here it may be noticed that, assuming the Bōsō peninsula to be a boundary, the species of the northern area gradually drop off, and the species of the southern area become more and more conspicuous. The reverse is true of the southern elements.

Amongst ascidians we find some species like *Halocynthia karasboya, Microcosmus hartmeyeri, Styela kroboja,* etc.

Echinoderms are plentiful, being comprised of a number of interesting species. The following are those of the most noteworthy: *Ophiostiba hidekii, Asteroschema japonicum, Ophiacantha anchilabra, Ophiura monostoecha,* etc. of brittle-stars; *Ctenodiscus crispatus, Astropecten polyacanthus, Luidia quinaria,* etc. of star-fishes; *Cidaris biserialis, Mespilia levituberculatus, Pseudocentrotus depressus, Sphaerechinus pulcherrinus, Astrichypeus manni,* etc. of sea-urchins; and *Bathyplotes golden-hindi, Laetmogone neglecta, Periamma kumai, Enypniastes eximia, Stichopus owstoni,* etc. of sea-cucumbers.

Amongst crustaceans, one of the most notable is a giant crab, *Macrocheira kaempferi*, which appears to be confined to this zone, on the Pacific side. *Neptunus trituberculatus* is also endemic and ranges all around Japan proper. Having a range nearly similar to the giant crab is an edible spiny lobster, *Palinurus japonicus*. Besides, there is a good catch of penaeid prawns which are decidedly stragglers from the southern zone.

Widely distributed in this zone are found a few ear-shells, of which *Haliotis diversicolor*, an inhabitant of the southern sea, abounds in shallow water. Amongst varieties of *H. gigantea*, *discus* has a range much wider than *mekai*, extending from Kyushu in the south to as far north as Kinkwasan, on the Pacific side, and to the Tappi-saki, on the Japan Sea side. *Turbo cornutus* finds a favourable situation here. Deep in the Sagami Sea occurs *Pleurotomaria beyrichi*, which is of great interest on account of its representing a relic of the geological period. Amongst the cephalopods we find such distinctive species as *Idioteuthis latipinna*, *Meleagroteuthis separata*, *Opisthoteuthis depressa*, and *Amphitretus pelagicus*. Of these the last is of a beautiful and almost jelly-fish-like appearance and inhabits the Sagami Sea.

Just outside of Tokyo bay lies a coral-bed, which presents us with species entirely different from those found in the waters around Shikoku and Kyushu. They are *Corallium boshuensis*, *C. sulacatum*, and *C. pusillum*.

Medusae and hydroids are very much in evidence. Some of the most remarkable are *Olindioides formosa*, *Branchiocerianthus imperator*, etc.

Now, let us turn to glance at peculiarities of the fauna in some of the rock-pools in this zone. The bay of Sagami is zoologically an interesting body of water and commands, as is well known, a very rich fauna with the same types of animals as are found in the southern, or northern seas. In the shallower areas above the 200 metre line we can distinguish the home of *Metacrinus* and of many forms of pennatulids (*Sclerobelemmon schmeltzii*, *Virgularia abies*, *Funiculina quadrangularis*, *Pteroides sagamiense*, etc.). In the deeper parts there can be found *Hyalonema*, *Euplectella*, *Rhabdocalyptus*, and other siliceous sponges. It is also the home of *Chlamydoselachus*, *Pleurotomaria*, and *Macrocheira*.

Remarkable is it that a few southern or tropical fishes are found denizens of a pond and streams of hot mineral water at Ito, Shidzuoka prefecture. The following are those which are discovered in the pond of Jo-no-ike and elsewhere: *Anguilla mauritiana, Lutianus vaigiensis, Therapon servus, Th. oxyrhynchus, Megalops cyprinoides,* and *Mugil oeur.*

In the bay of Suruga, the water is very deep close up to the shore, and here has been found a very remarkable oceanic plankton, including siphonophores, heteropods, medusae, and oceanic cephalopods. *Sergestes phosphoreus* is of great economic importance, being caught in immense quantities.

In the bay of Agu, Miye prefecture, there occur an abundance of the pearl-oyster, *Margaritifera martensii,* and there is formed a large establishment for the cultivation of this which promises to give very good results.

In the Japan Sea the water is by no means simple or isolated, but compound and connected with those of other seas. As may be evident from the account already given, the cold water circulating in the Sea is partly combined with the warm water coming through the Tsushima strait, which water consists, in its turn, of branches of the Kuro-shiwo and the coastal water of the East China Sea, so that the Tsushima stream is a mixed water from three different sources, of which the relative proportions, of course, vary greatly according to different seasons. Thus, the water is not really oceanic but rather coastal and is apparently different in its physical conditions from the Kuro-shiwo on the Pacific side. Accordingly, the Japan Sea, in spite of representing as a whole the zone of mingling, exhibits in its forms of animal life a relatively great variance from the Pacific side, being found to receive migrants from the northern much more than from the southern district.

Instead of passing on to the consideration of the fauna in greater detail, I would here offer some remarks on a few forms. Of fishes the bonitos and *Euthynnus* are scarcely found in the Sea. Some crabs, like *Chionecetes opilio,* etc., are of great commercial value and huge quantities are caught. Besides, some shrimps and prawns, belonging to the genera *Pandalus* and *Crangon,* are also found in much abundance. Amongst the cephalopods, one of the most notable is an oegopsid, *Watasenia scintillans,* which emits luminescence. It appears abundantly in Toyama bay, about May. *Ommastrephes sloani pacificus* is thickly and extensively distributed in the Sea, its thickest distribution roughly coinciding with the extension of the Tsushima stream.

Southern Zone. — The fauna about Kyushu and Shikoku is less characteristically Japanese, having much in common with the neighbouring shores of the islands of Bonin, Loochoo, and Formosa, where we find forms which are almost or quite identical with those met with about the islands of Java, Celebes, Borneo, etc.

Exclusive of the hair seal (*Zalophus lobatus*), occasionally appearing in this zone, there can be seen a few species of whalebone whales and toothed whales. Of the former the humpback whale (*Megaptera nodosa*) is one of the most important and of wide distribution, being found in the waters around the Empire. It makes its way to high northerly latitudes in summer, and migrates to the south of Formosa in winter. Amongst toothed whales we find the sperm-whale (*Physeter macrocephalus*) which is very wide in distribution and swims in schools in all tropical and subtropical waters. About our country it migrates along the Kuro-shiwo. Off Kinkwasan is specially famous for great catches of this whale. Frequenting the southern waters are also found such toothed whales as *Phocaena phocaena*, *Neophocaena phocaenoides*, *Delphinus delphis*, *Orcinus orca*, etc. The last, the killer whale which feeds on fishes and other warm-blooded forms like seals extends oftentimes to as far north as off Yetorup. Besides, worthy of notice is the appearance of the *Halicore dugong* in the waters around the Loochoo group. It abounds especially near the Sakishima islands.

Extensively spread over this zone are some species of reptiles, such as *Laticauda laticaudata*, *L. colubrina*, *Emydocephalus ijimae*, *Disteira melanocephala*, etc., most of them being found not to range over to the middle zone.

Of fishes we find a number of forms which are of great economic importance. Of scombroid fishes, such forms as *Rastrelliger chrysozonus*, *Grammatorcynus bilineatus*, and *Gymnosarda nuda* which inhabit the tropical seas have their range to Loochoo; *Acanthocybium solandri* and *Euthynnus yaito* are spread, on the Pacific side, into the middle zone; and *Katsuwonus pelamis* is of very wide distribution, ranging from Formosa to Hokkaido, on the Pacific side, and to middle Honshu, on the Japan Sea side, though very few in number. *Cybium chinense* and *Sarda orientalis* are rather abundant about Kyushu, but they are found in northern Honshu, both off the Pacific and the Japan Sea coast. Of other important fishes, *Pagrosomus major*, *Evynnis cardinalis* and *Taius tumifrons* are distributed from Formosa to middle Honshu. Besides, some forms like *Embolichthys mitsukurii*, *Halichoeres opercularis*, *Chaetodon setifer*, *Ch.. vagabundus*, and others are found to extend to, or about southern Kyushu; *Kuhlia marginata* ranges from the southern seas to Idzu, and *Safole toeniura* to Misaki. There can be seen a number of forms limited in distribution to the south of the Kumano, or the Yenshu Sea, such as *Corias aygula, Thalassoma lutescens, Cheilio inermis, Paraluteres prionurus, Balistes capistratus,* etc.

As they proceed southwards, ascidians seek a lower level of the sea for their habitat. The species which are frequently to be met with are *Halocynthia mirabilis, Molgula vannamei, M. hartmeyeri,* etc. Of these the first is found to extend to as far north as Misaki.

Echinoderms are very much in evidence, presenting to us a number of species which inhabit the southern tropical seas. Such are *Ophiarachnella infernalis, Ophiactis modesta, Ophiocentrus verticillatus, Ophiura flagellata,* etc. of brittle-stars; *Anthenea pentagonula, Culcita novoeguineoe, Choriaster granulatus, Gymnasteria carinifera, Asterina novoe-zelandioe, Palmipes rosaceus, Luidia maculata,* etc. of star-fishes; *Diadema setosum, Echinothrix calamaris, Heterocentrotus mammilatus, Strongylocentrotus purpureus, Toxopneustes pileolus, Laganum decagonalis, Schizaster japonicus, Maretia planulata, Lovenia elongata, Metalia maculosa,* etc. of sea-urchins; *Bathyplotes moseleyi, Mülleria echinites, M. maculata, Holothuria argus, H. cinerascens, H. edulis, Stichopus ananas, Thyone sacellus,* etc. of sea-cucumbers. Amongst them some forms are found to extend north up to the middle zone.

Coming now to crustaceans, we find some crabs, like *Scylla serrata, Neptunus pelagicus* and *Trapezia,* which are representative forms in the tropical seas and extend their range northwards to about Loochoo and Kyushu. This similarity holds also true of some species of *Palinurus,* like *P. fasciatus, P. ornatus,* and *P. bürgerii*; they appear to cease to exist north of the Shiwo-no-misaki. Besides, there can be seen a number of prawns which are of great commercial value, such as *Penaeus japonicus, P. semisulcatus, P. monoceros, P. curvirostris,* and *P. velutinus.* They are found spread into the middle zone.

The most common ear-shells are *Haliotis ovina, H. asinina,* and *H. diversicolor,* of which the first two have their northern limit near Amami-Oshima, differing from the last species which is known to extend to as far north as the shore of Chiba prefecture. Oftentimes to be met with in this district are some terebrids, like *Terebra nebulosa, T. subulata, T. dimidiata, T. maculata, T. crenulata,* etc. Of these the larger species are confined to the neighbouring coasts of the islands of Formosa, Loochoo, and Bonin, while the smaller abound in the region extending from Kyushu to the Bōsō peninsula. *Cypraea*, though flourishing in the southern zone, is found to extend northwards to the Bōsō peninsula. Of cephalopods the following species are sometimes met with: *Onychoteuthis banksii, Abralia andamanica, Stenoteuthis bartrami, Symplectoteuthis ovalaniensis, Chiroteuthis imperator,* and several species of *Loligo* and *Sepia*. Many of them extends northwards up to the middle zone, or beyond.

A large number of worms have hitherto been recorded from this zone, of which we find the following forms; *Cleloeia flava, Nereis mictodonta,* etc. amongst polychaetes; *Phymosoma antillarum, Sipunculus cumanensis, Aspidosiphon truncatus, Dendrostoma bladum, Bonellia minor,* etc. amongst gephyreans; *Pseudoceros lacteus, Prostheceraeus meleagrinus,* etc. amongst planarians. Some of them are found to extend farther north.

Ranging from off the Gotō group to the Kumano Sea is a famous coral-bed, where we have such forms as *Corallium japonicum, C. elatius, C. konojoi,* and *C. inutile*. The first two corals are also found forming a bed in the waters near the Bonin group, as well as north to Formosa.

The jelly-fishes are numerous and varied, representing many genera, most of which are of wide distribution. Some common species are *Mastigias papua, M. ocellata, Sanderia malaeyensis, Charybdea* spp., *Rhopilema esculenta, Rh. hispidium,* etc. Of these some species make their appearance in the middle zone. Near the coast of Kyushu occur in much abundance *Rh. esculenta,* and *Rh. hispidium,* which attain a large size and are eaten largely in this country. In this district we find a number of hydroids, such as *Synthecium tubithecum, Sertularella sinensis, Pycnotheca mirabilis, Hemicarpus pennarius,* etc.

The sponges are very rich and varied, of which some interesting siliceous forms are *Semperella schultzei, Hyalonema apertum, Eurete schmidti, Hexactinella ventilabrum,* etc. Most of them extend northwards up to the Sagami Sea. The sponge of some commercial value is represented by *Euspongia irregularis,* which abounds in the southern seas.

The Inland Sea is zoologically an interesting body of water and bounds in a sense with southern fauna, though containing some northern types of animals. Its shores command a very rich littoral fauna. It is the breeding ground of many kinds of fishes (e. g. *Pagrosomus major,* etc.), which enter from the two channels and spawn in about the middle of the Sea. Certain experiments with a view to the cultivation of this porgy are now going on at Ōchō, Hiroshima prefecture. Besides the sardine and *Etrumeus micropus,* we find in this sea *Sardinelia zunasi* in much abundance. A lancelet, *Branchiostoma belcheri,* inhabits the waters, off Sumoto in Awaji-shima, off Onomichi, Hiroshima prefecture, and off the province of Bungo. Besides, it is also found near Shikajima in the province of Chikuzen, and in Amakusa, in the province of Higo.

This sea is the home of *Limulus longispina.* Prawns belonging to *Penaeus* are extremely plentiful, being one of the most important of our fisheries. The region around Hiroshima is famous for a very perfect system of oyster-culture that has been carried on for centuries. In the bay of Kojima, the cultivation of *Arca granosa* and *A. subcrenata* has been very successfully inaugurated. Some peculiarity may be attributable for the inhabitance of a medusa, *Cyanea nozakii,* which breeds in this sea.

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VI. Races of the Japanese Empire.

By

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and Nenozo Utsurikawa, Ph.D,

Consisting as it does of numerous island-groups and a peninsula, the Japanese Empire extends from the frigid to the tropic zone. So, as one might expect to find, we do actually find in wide-apart areas different customs, different languages as well as peoples, and races belonging to different stocks.

What constitutes the main part of the population of the Empire is of course the Japanese. Their number, according to the latest national census of 1925, reaches to about 59,000,000 (30,000,000 males and 29,000,000 females), most of whom occupy the main group of the Japanese archipelago, although they are also found scattered in almost any part of the Empire.

Of late, constant emigration and immigration are taking place between Korea and Japan, but the main population of Korea is Korean and numbers about 19,000,000.

The Ainu inhabit Hokkaido, Chishima (the Kuriles) and the Japanese part of Karafuto (Saghalien).

They are commonly called the Yezo Ainu, the Chishima Ainu and the Karafuto Ainu, according to where they live, but these different designations have no other significance. Most of them are found in Hokkaido, espesially in the province of Hitaka, their number being 16,000. In Karafuto there are about 1,500 according to the national census of 1925; formerly they lived scattered along the sea coasts of Karafuto, but the government policy made a point of collecting them in a few prescribed Ainu villages for the purpose of better protection. Those in Chishima are very few in number and do not exceed one hundred. In Hokkaido, as a result of daily contact with the Japanese, they are greatly mixed and are fast changing their customs and manners to accord with the fashion of the Japanese neighbours.

As to the position of the Ainu in the ethnic system, there is no consensus of opinion. It was, and still is, a conundrum in anthropology. Years ago the view that the Ainu formed a "Race Island" was put forward by Y. Koganei.

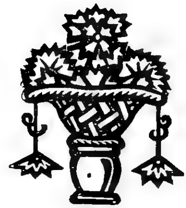
The Gilyaks, whose home is in the Amur region of Siberia, are also found along the Poronai River in the southern part of the Japanese possession in Saghalien. They call themselves "Nickbun" and were reported in 1925 to be 77 in all, 40 being males and 37 females. Their affinity with other races is not clear, and they are simply classed as one of the palae-Asiatics.

The Orokes who inhabit the same region in Saghalien as the Gilyaks, are also immigrants from the mainland of Asia. They are a branch of the Tungusic group, but are said to show a considerable influence of the Ainu, Gilyaks and also of the Russians.

The inhabitants of Formosa may be roughly divided into two groups., one is chiefly made up of the Chinese immigrants from Kwan-tung and Fo-kien provinces, and occupies the lowland districts and the western half of the island; and the other is made up of the wild hill-tribes inhabiting the mountainous eastern half, and is the more aboriginal of the two. These, on the basis of physical anthropology, ethnology and linguistics, are usually subdivided into eight tribes, namely: Taiyal, Seddaka, Saiset, Tsuou, Bunun, Paiwan, Ami and Yami. They are estimated to be about 130,000 in number and to belong either to Malay, or to the Indonesian family.

The Natives of Micronesia:– Micronesia which is under our mandatory administration, as is well known, consists of innumerable small islands, some of which are uninhabited; hence, the native population is only about 49,000. The natives of Saipan, Palau, Yap, Truk, Ponape, Kusaie, Jaluit, etc., constitute the main part of the population. They are usually divided into two ethnic groups. One is known as the Chamorros and is chiefly found in Saipan, although some have emigrated to the islands of Palau and Yap, and comprises about 2,800 in all according to the census of 1923. The other, commonly known as Kanakas, and found scattered in almost every island, is estimated at 46,000 in number.

In addition, it may be said that in the Ogasawara group of islands known as the "Bonin" (corruption of "Mujin" or "Bujin"—uninhabited) there are the naturalized descendants of European and American fishermen, Italian, English, Portuguse, etc., numbering about 120 and these form a sort of foreign settlement of their own.



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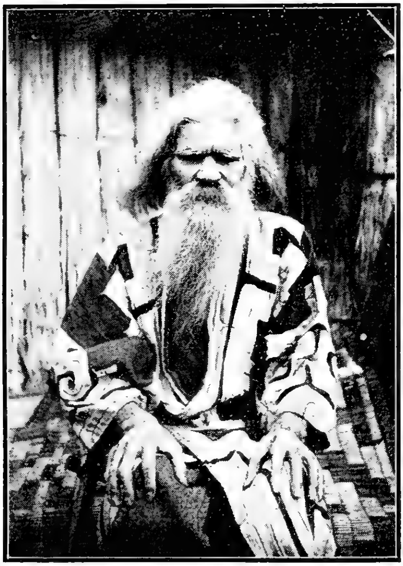

Ainu, Hokkaido.

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Giliak, Saghalien.

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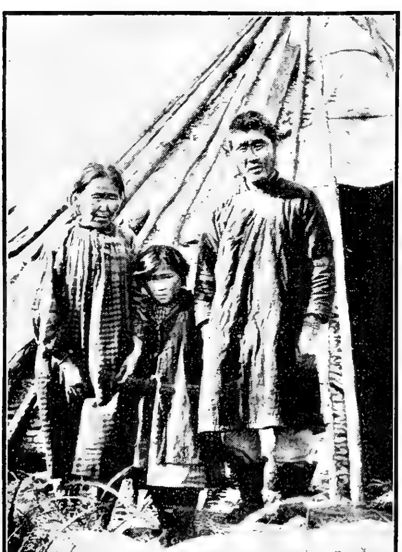

Oroke, Saghalien.

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Taiwal, Formosa.

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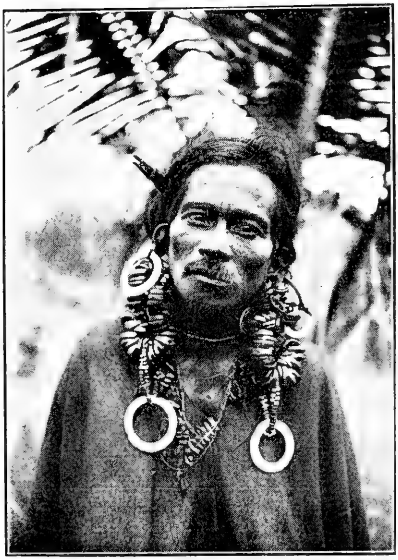

Truk man, Coroline Islands.

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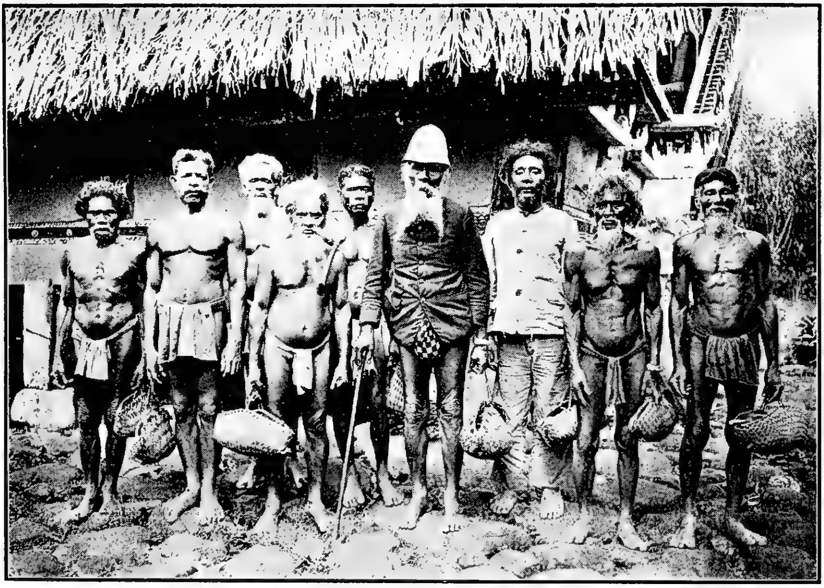

Group of chiefs, Palau.

VII. The Great Earthquake of S. E. Japan on Sept. 1, 1923, with two Appendices.

By

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1. **Introduction.** The great earthquake which devastated S. E. Japan on Sept. 1, 1923, was by no means the most severe that has visited this country, but perhaps if we search recorded history fro seismic disasters of appalling magnitude, not one can be found to equal it in the number of lives lost and the amount of property destroyed through its agency. Its scientific investigation was without a moment's delay undertaken by different experts and institutes, among which I must mention the name of the Imperial Earthquake Investigation Committee as the one which was most successful. The committee, consisting of about 30 members, mostly professors in the Imperial Universities, appointed different subcommittees to study the earthquake and its subsequent phenomenon the great fire, each from the standpoint of, first, pure seismology; second, geography, geology, geodesy and hydrography; third, architecture; fourth, civil engineering and mechanics; and fifth, meteorology, physics, chemistry, &c. Full reports were given by each subcommittee and have already been published with the exception of the third and the fourth reports. My own share in the matter was naturally to treat the earthquake from the standpoint of pure seismology; a short note written in English was submitted at first[1], but a more detailed description has been

1) Seismological Note of the Imp. Earthq. Inv. Comm., No. 6.

given in the subcommittee's reports just alluded to[2]. In the present paper, I intend to describe the earthquake as seen not only from my own special viewpoint, but also from wider points of view, so as to convey to my readers a general idea of the character of the catastrophe as far as possible.

As I have stated above, the disaster was extraordinarily heavy in comparison with the magnitude of the shock. More than 95% of the loss of property was due to the fire caused by the first quake. It is to my utmost regret that we seismologists were able to take no measures of precaution to avert such a disaster; but I ask your indulgence while I tell you of the facts. Our colleagues, especially Prof. Omori, often advised the citizens of Tokyo to improve the construction of the water-pipes which had frequently proved inefficient even in the case of moderate shocks. In addition, I announced in 1905 through the Journal "Taiyo" my opinion that there was a possibility that Tokyo might be visited by a destructive earthquake in the near future, to be followed, should the system and equipments of fire protection remain unimproved, by a general conflagration in the course of which a loss of lives to the extent of 100,000 or more might be experienced. I discussed this view in full detail, giving first, a short history of previous earthquakes in Tokyo, secondly, a description of certain destructive earthquakes which had been followed by great fires, and thirdly, a statistical study of seismic casualties in Japan, which shows that while in the case of destructive earthquakes without fire we experience, as a rule, a loss in the proportion of only one life to every eleven houses which collapse, this ratio increases three or four fold in cases when the quakes are followed by a general outbreak of fire. People, however, refused to believe me; indeed, there was even an eminent scientist who once at that time and again in 1915, ridiculed my opinion as nothing but a rumour which might cause a general panic.

2. **The Seismological Institute.** As a seismologist, I was very lucky to be able to experience the great shock at Tokyo. I was in our Institute at the moment, could appreciate fully the earth-movement, and after half an hour was able to give to more than a score of journalists some brief information about the exact time of the earthquake occurrence, the position of the epicentre, the character of the

2) Reports (in Japanese) of the Imp. Earthq. Inv. Comm., No. 100, A.

earth-movements and the possible effects on land and sea in the disturbed area, which now I find to have been not so much mistaken.

Perhaps our readers may feel convinced of the conclusiveness of such evidence even when we are furnished with seismographic observations from a single station only and nothing else; yet it may interest some of you if I explain a method of determining the seismic focus. As you know, earthquake movements consist of waves of two different kinds when the origin is near us; namely, first, the elastic or longitudinal waves, and second, the rigid or transverse waves. The former are quicker in transit speed, but smaller in vibration range than the latter, which constitute the principal portion of the earth-movements. The transit speed of the initial phase of the elastic waves is as high as about 5.5 km. per sec., while that of the rigid waves is about 3.2 km. per sec. The instrumental observation of the initial earthquake movement gives the direction of the origin, and the difference of time arrivals of the two different waves, which is commonly called the duration of the preliminary tremors, gives the distance between the focus and the observatory. Thus you will see that these two data aid us in determining the position of the origin.

Soon after the first shock, fire broke out at two places in the university, and within one and a half hours, our Institute was enveloped in raging smoke and heat; the shingles, now exposed to the open air, as the tiles had fallen down as a result of the shock, began to smoke and eventually took fire three times. I can not tell you how desperately I fought against the fire without water or any help from outside, commanding at the same time the rest of the men to carry away the more important things into safe places. It was 10 o'clock at night before I found our Institute and Observatory quite safe. Whenever I recollect the scene of that calamitous day and evening, I cannot help feeling deeply grateful to our men for having performed their duty so well; for, even an assistant, who had been lying in the University Hospital, and a mechanician, who had been on holiday in the city, came to the Institute at once, and we all, 10 in number, did our best partly in continuing earthquake observations, and partly in extinguishing the fire, taking no food or drink till midnight, while four of us who were residing in the lower part of the town lost our houses and property by fire. (Pl. XXIV A.)

3. **Seismographs.** Most of the seismographs in the Institute

were wrecked, and only one component of a seismograph with the index magnification of two times kept going throughout. The instruments, however, were soon adjusted or repaired, and 6 minutes after the beginning of the quake the following seismographs were running :—

1. A complete set of seismographs with the index magnification of two times.
2. A complete set of seismographs registering the earth movements in actual size.
3. E. W. component seismograph with the magnification index of 1.5 times.
4. N. S. component seismograph similar to No. 3.

Besides these, two more instruments each with an automatically starting record-receiver were available. A few instrument with higher magnification index were running after a day or two.

4. **Actual feeling at Hongo.** I was sitting in the Seismological Institute. At first, the movement was rather slow and feeble, so that I did not take it to be the forerunner of so big a shock. As usual, I began to estimate the duration of the preliminary tremors, and determined, if possible, to ascertain the direction of the principal movements. Soon the vibration became large, and after three or four seconds from the commencement, I felt the shock to be very strong indeed. Seven or eight seconds passed and the building was shaking to an extraordinary extent, but I considered these movements not yet to be the principal portion. At the 12th second from the start, according to my calculation, came a very big vibration which I took at once to be the beginning of the principal portion. Now the motion, instead of becoming less and less as usual, went on increasing in intensity very quickly and after 4 or 5 seconds I felt it to have reached its strongest. During this epoch the tiles were showering down from the roof making a loud noise and I wondered whether the building could stand or not. I was able accurately to ascertain the directions of the principal movements and found them to have been about N. W. or S. E. During the following 10 seconds the motion, though still violent, became somewhat less severe, and its character gradually changed, the vibrations becoming slower but bigger. For the next few minutes we felt an undulatory movement like that which we experience on a boat in windy weather, and we were now and then

threatened by severe after-shocks. After 5 minutes from the beginning I stood up and went over to see the instruments.

5. **Instrument observations.** None of the instruments provided with magnification index higher than 5 times registered even the preliminary tremors completely, but they gave important data as to the direction of the initial phase. Two seismographs writing the earth-movements, one in two-time magnification and the other in natural size, registered the preliminary tremors completely, but their writing index went out within 6 seconds after the beginning of the principal portion, except the E. W. component of the former which kept working throughout. Consequently it will be most convenient to trace the earth-movements according to this instrument, and if necessary, to supplement these results with the data given by the rest of the instruments. (Pl. XIII.)

The time of commencement at Hongo was 11h 58m 44s. This is the mean value of the times given by all the available instruments in the institute. Later on, I will give the time of commencement at the origin.

The initial phase of the earth movements was equally perfectly observed by all the instruments. It consisted of a displacement of 1.5 mm. towards N26°E and 0.5 mm. upwards in 2.3 sec., indicating that the origine was in the opposite direction, that is, in the direction S26°W. Further, the duration of the preliminary tremors was indicated to have been equal to 12.4 sec., from which we obtain the focal distance in km., if we multiply this by the coefficient 7.4.

Let us now go on to describe the principal portion of the quake, which consisted chiefly of, or was at least preceded by, rigid or transverse waves. In the seismogram, its beginning was clearly shown by a very big displacement marked with the letter *a*. Comparing both components, the N. S. one was found to be more conspicuous than the other. It indicated three distinct waves *abc*, *cde* and *efg* each with a period of 1.35 sec. Just at the end of these vibrations, the writing index went out of the record-receiver. The annexed diagram (Pl. XIV.) shows the resultant horizontal earth-movement corresponding to these three waves. The displacement *fg* is equal to 8.86 cm., from which the intensity of the earth vibration comes out to have been about 1/10 of the acceleration of gravity; that is to say, every construction standing on the ground of the University was shaken at that moment by a lateral force equal to 1/10 of the weight of the construction itself. This must be regarded as the maximum intensity of the earthquake motion at the site of Tokyo Imperial University. During this epoch the vertical component did not exceed 1 cm.

After that time, the earthquake motion was registered only by the E. W. component. From this register and the seismogram produced by an aftershock which took place at 14h 22m on the same day and originated very near the place of origin of the first destructive shock, (Pl. XVI. A) it seems that later the motion became much greater but slower, and possibly there existed an enormously large vibration with a range as great as 20 cm. and a period between 2.5 and 4 sec. During the first two minutes, the motion was most conspicuous, and during the following 8 minutes, less so. It has been remarked by Prof. Sida[3] that the same seismogram shows the existence of a very slow earth movement, with its period as long as 110 seconds and its range as large as 1.2 metres, corresponding possibly to the bodily oscillation of the Japan Island itself.

Before the earthquake motion was yet finished, there took place many after-shocks, some of which attained to the category of a semi-destructive nature. Consequently the end portion of the first shock was often masked by after-shocks, and therefore it is impossible to estimate the exact time of the final phase. Prior to the earthquake of 14h 22m, very minute slow undulations were recognizable; these may perhaps correspond to the latter part of the end portion, so that I assume 2h 20m as the duration of the total earthquake motion of the first shock.

6. **The origin.** From the data given above, I put the origin, that is the place where the earthquake action began, at a point 92 km. distant from Hongo, Tokyo, in the direction of S26°W. Combining the initial horizontal displacement (=1.5 mm.) with one half of the vertical component (=0.25 mm.), we get 10° and 15 km. as rough estimates of the dip and depth of the origin respectively. The co-ordinates of the epicentre turn out as follows:—

$$\lambda = 139^\circ\ 21'.8\ \text{E}, \qquad \phi = 34^\circ\ 53'.6\ \text{N}.$$

It must, however, be added that there are a few investigators who

3) See Prof. Matuyama's Notes on the nature of the Kwanto Earthquake: *Publ. du Bureau Central Sism. Int., Serie A, No. 2,*

put the origin in the western part of the Province of Sagami. The discrepancy is due to the facts that some of them misunderstood the direction of the initial earth movement at near stations like Numadu, and that others made their observations at stations which are too distant to obtain an accurate determination of the origin.

7. **Observations in different meteorological stations.** The annexed table shows the results of observations at different meteorological stations.

Table I.

Station.	Focal Distance.	Time of Occurrence.			Direction of Initial Movement.
	km.	h	m	s	
Mera	43	11	—	—	W
Numadu	49		58	39	S 56° E
					S 68° E
Tôkyô	92			44	N 26° E
Kôhu	107			—	N 73° W
Kumagai	130			51	S 23° W
Tukuba	155			53	——
Hamamatu	155			—	S 60° W
Maebasi	160			—	S 3° E
Tyôsi	162			57	S 83° W
Mito	187			56	S 17° W
					N 38° E
Nagano	216			56	N 26° W
Nagoya	228			—	S 84° W
Takayama	232		59	3	S 67° E
Gihu	244			2	W
Takata	257			10	N 5° W
Kanazawa	303			—	N 45° W
Niigata	331			14	N 6° W
Kanayama	350			—	N 18° E
Yagi	350			21	S 77° W
Osaka	360			24	——
Sionomisaki	377			—	S 56° W
Kôbe	386			26	——
Sendai	390			21	N 18° E
Wakayama	395			—	S 56° W

Station.	Focal Distance.	Time of Occurrence.			Direction of Initial Movement.
	km.	h	m	s	
Isinomaki	420	11	59	30	—
Midusawa	489			40	N
Tadotu	522			42	—
Akita	529			—	N 18° E
Hamada	565		60	6	—
Matuyama	619		59	58	N 45° W
Hakodate	761		60	13	—
Simonoseki	781			22	—
Hukuoka	839			22	—
Kagosima	903			36	—
Nagasaki	910			30	—
Titizima	917			—	N 14° W
Kusiro	987			33	—
Zinsen	1175			—	N 24° W
Oodomari	1228		61	20	—
Naha	1480			19	—

The data shown in the table furnish a good illustration of the relation between the time of the commencement of the earthquake and the focal distance. The time curve thus obtained is practically a straignt line given by the equation $y=7.5x-16$, where y represents the focal distance in km. and x the time in seconds. It gives 11h 58m 32s as the time of commencement at the origin, and 7.5 km./sec. as the transit velocity of the elastic wave in the vicinity of the origin.

The direction of the initial phase is very important first, in the determination of the seismic origin, and secondly in conjecturing the character of the seismic action. For the former, the observations at Mera, Numadu, Kohu and Tokyo are most important, especially the last in consequence of its having given the most accurate result; and now I find that the coordinates of the origin already given do not require any correction. In regard to the character of the seismic action, it is to be remarked that within a radius of 170 km. there exist four different sectors; namely, the first including Numadu, Mera and Tyôsi, the second including Tokyo, the third including Kumagai and Maebasi, the fourth including Kôhu. Of these, observations at stations in the first and third sectors showed the pull towards the origin, while those at stations in the second and the fourth showed the push from it. It is also to be remarked that in all the other stations except Titizima the earth movements began by the push. Consequently the seismic action may have been applied in such a manner that the compression along a deep stratum was directed towards the north and the west while the counter action took place in the upper side along the sectors which showed the pull. (Pl. III.)

Pl. XVII. shows isochronals and isoseismals deduced from observations made at different stations. Irregularities in these curves are due to the variety of physical characters of the media through which the seismic waves were propagated. The area in which the earthquake was actually felt is about 1000 km. in diameter, rather smaller than that of the great Japan Earthquake of 1707 or the Lisbon Earthquake of 1755.

8. **Observations at foreign stations.** The present earthquake was registered at seismological stations distributed in different parts of the world. I have compiled a table showing the results of observations at 48 such stations concerning the time arrivals of the first phase, the second phase and the long waves[4]. It gives a pretty good "Laufzeitkurve," i. e. a curve showing the relation between the arcual epicentral distance and the time of transmission of each phase. The fairness of the curve may be due to the extraordinary magnitude of the original disturbance and the accurate knowlege of the position of origin.

9. **Statistics of the casualties and the distribution of seismic intensity.** Table II shows the number of casualties in different prefectures.

I have prepard another table showing the numbers of casualties in the cities, towns, and villages most severely affected, and of the houses which existed there before the catastrophe. Here this table is omitted, but the general results are shown. The distribution in space of the percentage of destroyed houses serves to indicate roughly the distribution of seismic intensity. These data are useful in determining the isoseismal lines.

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4) Reports (in Japanese) of the Imp. Earthq. Inv. Comm., No. 100 A, p. 32.

Table II.

Number of casualties in different prefectures due to the earthquake of Sept. 1, 1923.

Prefecture	Killed	Injured	Missing	Houses				
				completely collapsed	half collapsed	burnt	washed away	total (omitting half collapsed)
Kanagawa including Yokohama & Yokosuka	29,065	56,269	4,002	62,887	52,863	68,569	136	131,592
(Yokohama)	23,440	42,053	3,183	11,615	7,992	58,981		70,496
(Yokosuka)	540	982	125	8,300	2,500	3,500		11,800
Tokyo including Tokyo City	68,215	42,135	39,304	20,179	34,632	377,907		398,086
(Tokyo City)	59,065	15,674	1,055	3,886	4,230	366,262		370,148
Tiba	1,335	3,426	7	31,186	14,919	647	71	31,904
Saitama	316	497	95	9,268	7,577			9,268
Yamanasi	20	116		1,763	4,994			1,763
Siduoka	375	1,243	68	2,298	10,219	5	661	2,964
Ibaraki	5	40		517	681			517
Nagano				45	176			45
Totigi		3		16	2			16
Gumma		4		107	170			107
Total	99,331	103,733	43,476	128,266	126,233	447,128	868	576,262

10. **Phenomena in the most severely shaken areas.** In order to obtain some concrete data on the seismic intensity, I visited the most disturbed area and studied the effects of shocks on buildings, bridges, short and tall columns, etc., with special reference to the direction of the principal earth-movements. I will give a few examples in the next lines.

In Kôdu, a very simple flat wooden house of the ground area of 4m. × 4m. was displaced as much as 91 cm. towards N25°E. (Pl. XXIV B.) In Odawara, a single-storied wooden house of the ground area of

8m. × 5m. was displaced as much as 35 cm. towards N13°E; a similar one of 10m. × 10m., as much as 130 cm. towards N10°E (Pl. XXV A); and another of 7m. × 7m., as much as 75 cm. towards N10°E. In this town, houses as a rule collapsed towards the south and mostly took fire; only a narrow area escaped the flames and some houses therein made displacements such as I have just described. (Pl. XXV B-XXVI). These enormous displacements seem to have taken place in some cases at a single stroke, and in other cases after continued action. Such phenomena can be explained only by assuming a strong horizontal vibration accompanied by a big vertical one. For the first step, let us suppose an earth-movement capable of causing the displacement of a structure from its foundation-stone. The acceleration of the earth-movement required must be at least $g \times 0.6$, because the coefficient of friction between wood and stone is equal to 0.6. Repetitions of such horizontal vibration, however, would cause the structure to move to and fro from its initial position, a suppositon which contradicts the facts. Again, if we suppose the earth-movement to consist of large horizontal as well as vertical movements, then the critical condition for sliding would be as follows:—

$$\mu\ (g - a \sin\ \theta) = a \cos\ \theta,$$

where μ, a and $\tan\ \theta$ represent respectively the coefficient of friction, the acceleration of the resultant earth-movement, and the ratio of the vertical acceleration to the horizontal one. If $\mu = 0.6$, then θ is approximately equal to 31° for the minimum of a; in this case, a, its horizontal and vertical components are equal to $g \times 0.51$, $g \times 0.43$ and $g \times 0.26$ respectively. If vibration of such magnitude take place repeatedly parallel to a straight line, then the structure would slide and stop alternately according as the sense of the vertical component of the earth-movement was downward or upward, so that such structures standing within a narrow area, would undergo enormously large displacements in a common direction.

The phenomenona of large displacements were first observed in this country by the late Prof. Omori in the case of the great Mino-Owari Earthquake of 1891. Here, in the most disturbed area, a wooden temple gate having 8 pillars was found displaced as much as 90 cm. along the underlying stone pavement. I had also an opportunity of observing the same phenomena in the case of the Anegawa Earthquake of 1909 in the meizoseismic area, where I found two belltowers, 1.2 km. apart, displaced in the same direction as much as 98 and 97 cm. from their respective original positions, the former moreover leaving traces on the hard ground in intermediate positions. Similar phenomena are rare, but in the present catastrophe they were not so uncommon, especially in or near Odawara, showing that there occurred a shaking of the severest category possible in this district.

The railway bridge at Isibasi had two rows of seven girders each laid in the direction of S15°W., the eastern row being not yet fully connected by rail; at the time of the earthquake, the northern end of each of the disconnected girders except the one at the centre fell and the girders hung by the other end like a ladder. Some piers were fractured near their bases, each upper part making a twist counter-clockwise about an axis near the western edge of the pier. (Pl. XXVII.)

The severest damage, however, to railway bridges was suffered by that at the River Banyû. Here all the brick piers were broken near the water mark and overturned longitudinally towards the lower stream, or speaking more precisely, towards S28°E on the average. (Pl. XXVIII. A) The locality extending from here to Hudisawa showed an intensity of earth movement as great as 1/3 of gravity or more, with the direction of motion roughly parallel to that in Tokyo (Pl. XXVIII B -XXXI.).

In Kamakura, the seismic intensity varied in different places according to the geological structure of the situation, having been maximum in the sandy district near the coast with a possible intensity as great as 2/5 of gravity and minimum, i.e. 1/10 of gravity, in the districts of tertiary formation. The Daibutu, a famous big bronze image of the sitting Buddha, sank as much as 45 cm. at the side toward S15°E and was displaced as much as 30 cm. towards the depressed side (Pl. XXXII. A). Here the temple gate showed a counter-clockwise rotation of 10° and a displacement of 20 cm towards N5°W, while that at Kômyôzi was displaced as much as 50 cm. towards N35°W. Afterwards I installed two seismographs, one on the grounds of Kanagawa Normal School—representative of the tertiary formation —and the other at the villa of Prince Simadu (Pl. XX B)—representative of the sandy districts—in order to compare the differences in seismic intensity. I made the surprising observation that the latter place is shaken in cases of near earthquakes as much as 4 or 5 times more than the former, notwithstanding that the intervening distance is only 2.3 km.

In the Bôsô Peninsula, the sandy disirict around Hôdyô showed a maximum intensity almost equal to that in the district of the same geological nature at Kamakura. Here the phenomena of displacement were observable in a few simple houses, but the amount did not exceed 30 cm. The direction of the principal earth-movements seems to have been SE-NW for the most part in the peninsula. (Pl. XXXIII)

Another interesting phenomenon was observed on the ground of a primary school at Hôdyô. Here two parallel fissures each having a length of about 22 metres were formed; they opened and closed alternately several times, intermittently emitting turbid water as high as three meters. This geyser-like phenomenon was witnessed by the school-master and teachers, who estimated the period of eruptions to have been about 10 seconds. When I visited the place two months later, traces of the mud-volcanoes and of the fissures which had extended in the north-southerly direction were still recognizable. The site of the school had formerly been part of a paddy field, but was changed into the present state a few years ago, dry soil having been laid at the place as high as 60 cm. above the original level. The paddy field covers an area elongated from north to south and is enclosed by comparatively hard ground from which the school ground now projects towards the east like a peninsula in the semi-liquid field. In such places, gravity waves of stationary character are liable to occur, so that phenomena similar to those described above may be produced at places corresponding to the loop of the undulation. The large fissures which are recorded to have swallowed men and cattle in the cases of the great earthquakes of Lisbon in 1755 and of Jamaica in 1692 may possibly be due to similar causes, though Japan has never experienced such awful cases.

11. **Earthquake phenomena in Tokyo.** The ground of the city of Tokyo also shows differences in seismic intensity. Previously I have drawn a map showing the distribution of intensity areas in Tokyo, taking into account the results experienced in the cases of the destructive earthquake in 1855 and the semi-destructive one in 1894, the geological structure, the history of the formation of certain parts as residential land and the seismographic study of four different places in or near the city. Soon after the last catastrophe, I took up this problem again, and began to study the phenomena not only in the

light of the seismic effect on buildings in the city including the burnt areas, but also in the light of seismometric comparisons of the aftershocks at 32 stations in the city. This involved very troublesome work. Meanwhile I may mention only a few interesting results: namely, first, the intensity distribution differs according to the nature of the shock, especially according to the vibration period of the earthquake waves; secondly, soil of alluvial formation, especially made ground, is shaken fully three times as intensely as ground of diluvial formation such as that at Hongô; and thirdly, this difference of intensity is due not only to differences in amplitude of the earth-movement but also to differences in vibration periods, which are generally shorter in the alluvial soil of the lower town than in the harder diluvial ground (Pl. XVIII, XXXIV—XXXVIII).

12. **Conflagrations**[5]. As has already been stated, the loss by fire was most serious. The flourishing cities of Tokyo, Yokohama and Yokosuka were thus destroyed. As to the statistics concerning this topic, readers are referred to the table of casualties given above. In the following lines, statistics for other towns which were devastated by great fires are given, the number in each bracket showing that of the burnt houses in the corresponding town.

In Sagami Province:	Odawara (5684),	Uraga (115),
	Kamakura (562),	Atugi (717),
	Hatano (928),	Manaduru (882).
In Awa Province:	Hunagata (405),	Tateyama (74),
	Hôdyô (33).	

I am now going on to give an account of the conflagration in Tokyo. As shown in Table II, the houses completely burnt numbered as many as 366,262 in the city alone, covering an area of 35,850,000 square metres. According to the investigations of the fire brigade, the total number of fire-centres which caused the conflagration amounted to 212, more than 40 places where the flames were successfuly extinguished almost as soon as they broke out being excluded from the above number. Some of these fires broke out at varying intervals, but 136 of them are said to have originated within 30 minutes after the quake, thus causing great confusion in the minds of the people

5) For details, refer to Reports (in Japanese) of the Imp. Earthq. Inv. Comm., No. 100, E.

and making fire-prevention almost impossible. It is interesting to observe that the geographical distribution of these fire centres is very similar to that of the centres of seismic intensity, the area crowded by fire centres corresponding to the land badly shaken. It is also to be remarked that there were numerous cases of fire due to chemicals; the authorities estimate them to have constituted at least 44 out of the total number.

As to the cause of the rapid growth of the fire (Pl. XIX), we must attribute it first to an unfavourable condition of the wind. At the time of the quake, the wind in the city was blowing nearly from the south with a speed not less than 10 metres per second; in the evening, it changed its direction to the west and then to the north, attaining at midnight an enormous speed greater than 20 metres per second. This was enough to cause the current of the fire to sweep very rapidly from district to district and back again, and to reduce the whole lower part of the city to ashes. The fatal progress of the wind in the city on those days may be well understood from Table III, which is the result of observations made at the Central Meteorological Observatory located in the burnt area. Conditions were, however, quite different in the surrounding suburbs, where the weather was generally calm.

Table III.

Observations of wind at the Central Met. Obs.

Sept. 1

Hour	12	13	14	15	16	17	18	19	20	21	22	23
Direction	SSW	S	SSW	SW	SW	S	W	W	WNW	NNW	NNW	NW
Speed (m/s)	12.3	11.7	11.3	11.0	10.7	13.7	14.5	13.1	18.1	18.5	19.2	21.8

Sept. 2

Hour	0	1	2	3	4	5	6	7	8	9	10	11
Direction	NNW	NNW	N	N	N	NNW	NNW	NW	N	SSW	SW	SW
Speed (m/s)	17.6	16.9	15.4	13.8	10.5	10.2	7.9	7.9	5.4	4.6	4.4	5.1

I must mention another causes which helped the growth of the conflagration. That is the lessened resistance to fire which many houses exhibited as a result of damage from the earthquake. Even buildings which had been believed to be perfectly fire-proof lost their safety against fire through the falling down of tiles from the roof, or the fracturing of gables or outer walls.

The total number of houses which collapsed in the city is likely to have amounted to as much as 10,000, so that the loss of lives due to the direct effect of the shock would have been not much greater than 1000, but this number was increased nearly a hundred fold as a consequence of the great fire. The majority of the houses which collapsed were burnt up with people buried under them, but the number of deaths thus caused can by no means reach to such a vast total as shown in the table. In the next few lines I will explain how crowds of people were killed in different quarters of the city.

First of all, I must mention the falling down of bridges caused by the quake and fire, which made it difficult for refugees to escape out of the flames. The total number of bridges within the burnt area amounted to 353. Of these, only 76 remained intact, and 277, or 80 per cent, were destroyed. Of these bridges, 246 were destroyed by fire, mostly caused by the refugees' goods placed on them. This obliged thousands of people to flee into the water where most of them were drowned.

Soon after the outbreak of fire, people in less dangerous situations observed a strange cloud whirling up in the sky of the burning area; this was a kind of cumulus (Pl. XXXVII A.). It is said that such a cumulus is liable to be accompanied by squalls and consequently to give rise to the occurrence of a tornado. In fact, many tornadoes were observed in the different burning towns, intensifying the flames in their way and causing sad scenes among the refugees here and there. The most remarkable tornado was one which appeared at first in the northern corner of the city near the right bank of the River Sumida; it swept down along the same side of the river and crossed it near Ryôgoku Bridge to occasion there one of the most pitiful scenes the world had ever witnessed. I think it will not be out of place to quote here Prof. S. Nakamura's address read before the meeting of the Pan-Pacific Club.

"The most unhappy and sad catastrophe of this sort happened on a tremendous scale at the now notorious ground formerly occupied by the Clothing Department of the Army in Honzyo (No. 6 in Pl. XVIII). This is a piece of quite open ground of 60,000 square metres, and nearby, only separated by a street, there is an extensive garden of a wealthy banker, Mr. Yasuda, covering an area of about 40,000 square metres. Thus we had here an area of 100,000 square metres, or about 250 acres, lying just on the eastern bank of the River Sumida. People assembled here from all quarters to save their lives and property. What a sad fate it was for the people seeking refuge, not knowing in the least the calamity impending over them! The whole space was so thickly packed, according to eye-witnesses, with men, women and children and their belongings that they found themselves almost unable to move.

"At 4 o'clock on September 1, fire approached from three sides, leaving only the side next the river. Suffocating fumes and horrible fires threatened the unhappy people, sparks falling over them in showers. All at once the people heard some unearthly sound approaching them, the heavens darkened, and they were terror-stricken to find that a furious tornado was sweeping toward them lifting or setting in flames everything before it. When it had passed over the ground, what was left behind? The charred remains of 35,000 human beings!"

It is said that the exact number of those who perished was 38,015; only about 2000, who were mostly seated in the southern corner of the ground, were left alive, but the majority of the people were terribly burnt On the other hand, there were many corpses which had quite peaceful countenances with hardly any effect of heat perceptible on their skin or clothes; their death seems to have been due to the poisonous action of carbon-monoxide, which is decomposable from dioxide under temperatures higher than 850°.

According to Prof. Terada, the burning area of the city was successively visited by a few score of tornadoes, the majority of them having taken place during the four hours from 3 p.m. to 7 p.m., Sept. 1. Most of these tornadoes were mere whirlwinds produced at corners of acute-angled areas bounded by firefront, yet there were nevertheless a few others which showed characteristics of real tornadoes such as that which has just been alluded to.

It is said that the progress of the fire was more rapid in Yokohama than in Tokyo; 65% of the former city was burnt in 12 hours, while in the latter it took 18 hours to burn 64% of the houses and 46 hours to consume 71% or the maximum. Many whirlwinds were also experienced in Yokohama and Odawara.

13. **Intensity distribution in Yokohama.** Variety in seismic intensity was also observed in the city of Yokohama. In the lower parts of the town, the intensity is likely to have attained two-fifths of gravity in the case of recently-made ground like Isezakityô, and one-third of gravity in districts of rather old formation like Hontyô-dôri, while the intensity was only one-sixth to one quarter of gravity in diluvial ground on the hills. The severe damage in the case of the softer ground may also be due to the irregular subsidence of the ground (Pl. XXXIX, XL.).

14. **Differences in intensity due to geological formation.** The fact that the seismic intensity was moderate (about one-tenth of gravity) in the area covered by tertiary formation or solid volcanic rock in the peninsulas of Bôsô, Miura and Idu, notwithstanding their having been very near the origin of the quake, may be understood from a consideration of the nature of the rocks and of their resistance to the seismic waves as shown in the results of observations at two different seismic stations in Kamakura. Pl. XX. B shows the relation between the ratio of intensity in the alluvial ground and that in ground of tertiary formation, as well as the period of corresponding earth movements in the latter place. Special relations are likely to exist between them in the case when the period is less than 0.8 sec., but for the present purpose, it will be sufficient to consider only cases in which the period is 1-2 sec., as such a period is common in destructive earthquake motion, thus showing an increase of seismic intensity of four or five times that of harder ground.

15. **Change of landscape.** Thousands of conspicuous land slides took place in the Miura and Idu Peninsulas, the southern part of the Bôsô Peninsula and the mountainous district of south-western Sagami, the most fearful having been the mud-flow which buried the whole village of Nebukawa with its 700 inhabitants in the southwestern part of the province of Sagami. The area along which this mud-flow swept down is a narrow ravine about 6 km. long and 150 m. wide with an average slope of 1/9 (Pl. XXI.). Avalanches of soil and rock, which had been disintegrated from three or four spots in the eastern flank of the *somma* of the Hakone Volcano, united on their way to

develop into a volume not less than one million cu.m., and ran down the whole course within five minutes, while the earth was still in motion (Pl. XLI.).

The most remarkable phenomenon of this kind, however, is the upheaval of land which showed itself along the coast of the disturbed area (Pl. XV). The bench-mark survey undertaken soon after the catastrophe by the Land Survey Department of the Imp. Military Staff has furnished us with the following results.

1. In the city of Tokyo, subsidence of less than 5 cm. has taken place to the west of the River Sumida, and of 38, 28 or 35 cm. to the east of it.
2. In the Bôsô Peninsula, upheaval has taken place generally, namely, 8 cm. at Hunabasi, 11 cm. near Tiba, 15 cm. near Yawata, 39 cm. near Kisaradu, 69 cm. near Huttu, 91 cm. near Sanuki, 121 cm. near Takeoka, 134 cm. near Katiyama, 157 cm. in Hôdyô, 182 cm. in Kokonoe, 99 cm. at Kamogawa, 47 cm. at Kominato, 28 cm. at Katuura, 26 cm. at Itinomiya, 21 cm at Mohara, 16 cm. at Ooami, and 11 cm. at Naritô.
3. South of Tokyo, upheaval is first noticed near Kawasaki and continues as follows; 10 cm. near Yokohama, 70 cm. near Hudisawa, 85–90 cm. in Kamakura, and 139 cm. at the tidegauge station of Aburatubo in Misaki.
4. From Hudisawa to the west and then to the southwest along the coast, upheaval has taken place as follows; 105 cm. in Tigasaki, 182 cm. at Ooiso, 201 cm. near Umesawa, 188 cm. at Kôdu, 121 cm. near Odawara, 72 cm. near Manaduru, 10 cm. near Atami, 14 cm. near Aziro, and 5 cm. in Itô.
5. West of Tokyo, depression has taken place as follows; 20 cm. at Hutyû, 27 cm. at Hatiôzi, 56 cm. at Kobo-togetôge, 39 cm. near Uenohara, and 14 cm near Sasagotôge.
6. South of Ito down to Simoda, almost no change of level was observed.
7. West of Atami, over the volcanic district down to Numadu, only a very slight change not greater than 5 cm. was observed.

The above data were obtained under the assumption that the standard bench-mark at the ground of the Military Staff did not undergo any change, but it is likely that it suffered a depression of about 50 mm., if the level shown at the tidegauge station of Aburatubo be taken as the standard.

Early in 1925, the survey was repeated along two lines, one from Tokyo to Aburatubo and the other from Hudisawa to Atami. The result is that the places which had shown upheaval in the previous observation, indicated a slight depression not greater than 6 cm., so that there is evidence of the recovery of the land from topographical changes caused by the earthquake. This phenomenon is said to have been very conspicuous in the most elevated localities shortly after the catastrophe.

Now let us add a few words about the results of land surveying in the central part of the province of Sagami. By accurate observations made soon after the earthquake, it was found that one of the base lines, about 5 km. in length and with the approximate orientation of north to south, increased in length as much as 24.5 cm. and raised its south end higher than the other by 14.7 cm. This observation corresponds with the result of the benchmark survey.

16. **Change of the sea-bottom.** In comparison with the upheaval of the land, quite startling is the change of the sea-bottom in Sagami Bay, which was discovered by elaborate work on the part of the Imperial Naval Hydrography Department. The result is shown in Pl. XV, in which only the elevations and depressions exceeding 30 m. are represented, those less than that amount being omitted. It is estimated that the area and volume of depression amount to 700 sq. km. and 50 cu. km. respectively, and those of elevation to 240 sq. km. and 20 cu. km. in all. This result was obtained after soundings had been carried out at 83,286 points distributed in the area between Tyôsi in the east and Suruga Bay in the west, and between Tokyo Bay in the north and the Miyake Island in the south, and comparisons made with the results of the former soundings carried on mostly during the year 1912, corrections due to the tides of the different periods and meteorological disturbances being, of course, taken into account. The results seem at a glance to be extravagant, but nevertheless it is highly probable that they do not deviate so much from the actual state, though it is slightly doubtful whether the change took place wholly on the present occasion. Thus we may conclude that the following

topographical change occurred; first, a vast depression extending from the central part of Sagami Bay to Oosima, and second, an elevation extending over the bottom of that part of the bay lying to the north-east of the depressed part. Evidently this was the seat of origin of the last great commotion; the distribution of seismic intensity and of tidal waves as well as the position of the seismic focus deduced from instrumental observations all support this view. Possibly a very remarkable fault may have been produced along the belt which divides the depressed and the elevated areas, but so far it has not been discovered.

17. **Fault lines.** Prof. Yamasaki, among others, has made elaborate investigations of fault lines. His description of the topographical changes in the sea-bottom[6] is very instructive and would convince every reader of his paper of the possibility of the main fault line just alluded to. Further, his description goes on to mention several faults of a secondary nature as follows:—

1. Sitaura Fault, which took place in the Miura Peninsula, almost crossing it in the direction N70°W, and with its maximum vertical dislocation as much as 1.5 m.
2. Arakawa Fault, which took place to the west of Yokohama and whose direction, total extension and maximum vertical dislocation are respectively N25°W, 1 km. and 1 m.
3. Hatusima Fault, which crosses an islet of that name near the N. E. coast of the Idu Peninsula and whose direction, total extension and maximum vertical dislocation are respectively N30°W, 1 km. and 1 m. in all.
4. Group of faults crossing the central part of Awa Province approximately in the east-westerly direction, namely, Enmeizi Fault (total extention=3 km., max. vertical dislocation=1 m.); Uto Fault (total extension=0.7 km., max. vertical dislocation=1 m.); and Takigawa Fault (total extension = 2.5 km., max. vertical dislocation =1 m.). (Pl. XLIII.)

18. ***Tunami*, or tidal waves.** *Tunami* in the strict scientific meaning of the term were observed not only on the Pacific coast of

6) Reports (in Japanese) of the Imp. Earthq. Inv. Comm., No. 100, B.

Japan but also far beyond it. Disasters caused by them, however, were experienced only at a few sea-side places bordering Sagami Bay, as follows:—

Atami (height 12 m.), Ito (height 8 m.), Aziro (height 8 m.) and Ainohama (height 9 m.) (Pl. XV, XLIV.). In these places, the flood washed away some houses and vessels and caught people and cattle. The northern coast of Oosima, the southern coast of the Miura Peninsula, and the coast between Kamakura and Enosima were also visited by waves of the heights of about 8 m., 6 m. and 4 m. respectively, but without much resultant loss. According to observations made at Tateyama Meteorological Station, the water ebbed a few minutes after the shock had been experienced as low as about 7 m. below the former level, and after 5 min. flooded as high as 2 m. above the former mark; during the next 15 min., it ebbed again as low as 3 m., and 15 min. later it had flooded again as high as 1 m.; after this the waves became less and less, but were observable until 2 o'clock in the afternoon. Here it must be remarked that the new level soon after the first shock must be lower by 1.6 m. than the former one.

The height of *tunami* is not so great in an open sea; it increases as the waves gradually approach shallow water and enter into a v-shaped port. According to Dr. Ikeda, the height of *tunami* at Atami was only 1.5 m. at the two promontories, and 3 m. midway between the northern promontory and the corner of the port, while it attained the enormous height of 12 m. at the corner. Similar observations were made by him as to the *tunami* at Aziro and Ainohama.

One more interesting investigation by Dr. Ikeda was on the direction of wave propagation. In Atami, the *tunami* came in from ENE and was principally reflected towards the opposite direction except its southern part which was reflected towards ESE. In Aziro it was propagated from NE and was reflected eastwards. In Ainohama it came in from W and its northern part was reflected towards the opposite direction, while its southern part was reflected towards S or SW. Comparing these modes of wave propagation with the map of submarine change, it will be found that wherever *tunami* came from, there lies unmistakably an area of conspicuous elevation in the sea-bottom nearby. Thus the present *tunami* seem to have been caused for the most part by the elevation of the sea-bottom, the enormous depressions playing only a small part in producing *tunami* which rose in flood above the original sea-level.

Some of the inhabitants of Oosima observed on the western coast two *tunami* propagated soon after the first shock, one from the north and the other from the south, which met one another in front. This can readily be understood by reference to the above-stated map which shows elevation in the north and depression in the south across the strait between Idu and Oosima.

19. **The cause of the earthquake and the seismic zone.** So far I have described certain seismic phenomena which will probably help us in determining the real cause of the earthquake in question. The enormous depression and elevation of the sea-bottom in the heart of Sagami Bay indicates that this area was the seat of an extraordinary commotion which took place thereabout at a certain depth. Possibly a fault line, as I have stated before, may have been produced along or across the boundary of the areas of depression and elevation, containing the seismic focus in it.

From these phenomena, it may be inferred that the commotion was caused by stress which had been applied for many years in such a way as to push the lower depressed side of the bay towards the north or the northwest, and the upper elevated side towards the opposite direction. Later on, I will describe the slow, gradual elevation of the land in the Miura Peninsula which had been continuing for three years until at last it reached a critical condition on Sept. 1, 1923, and there suddenly occurred the remarkable upheaval already mentioned. Indeed, upheaval of the adjacent coast seems to be a phenomenon common to every great destructive earthquake which has originated on or off the coast of the Bôsô Peninsula.

The focal areas of the three destructive earthquakes which took place on Dec. 31, 1703, Sept. 1. 1923, and Sept. 2, 1923, form one continuous belt in themselves, and this belt is very likely a part of the great seismic zone running along the Pacific coast of Japan. It may not be out of place to remark here that the first two earthquakes were in many respects similar to each other, especially in their topographical changes, isoseismals and the tidal waves generated by them, the only difference being that the centre of the recent earthquake was further to the west than that of the earlier one.

20. **Secondary causes and antecedent phenomena.** The secondary causes of the last shock together with antecedent phenomena may

be enumerated as follows: namely, the lowering of the water level in wells, the abnormal eruption of geysers, the crossing of a low barometric pressure along Hokurokudô towards Kinkwasan in N. E. Japan and consequently the development of a secondary low pressure in the northern part of the seismic area, etc.

It must also be remarked that there were some evidences of the existence of the fundamental cause before the occurrence of catastrophe. One is the recent active state of the dependent seismic zone in Japan, and the other is the gradual upheaval of the seismic area.

In connection with the first, let us enumerate the large earthquakes which have taken place in the same zone during the last few years. They are shown in Table IV.

Table IV.

Recent large earthquakes in N. Pacific Seismic Zone.

No.	Date	Region	No.	Date	Region	No.	Date	Region
1	1916 X 31	J	20	1918 XI 18	P	39	1921 IX 5	J
2	1917 I 20	P	21	1919 I 1	P	40	IX 19	T
3	I 30	J	22	I 1	T	41	X 15	T
4	V 1	T	23	IV 30	T	42	XI 11	P
5	V 9	P	24	V 3	J	43	1922 I 1	T
6	V 24	T	25	V 6	P	44	I 31	C
7	V 31	A	26	VIII 29	P	45	III 4	J
8	VI 13	T	27	VIII 31	T	46	V 12	T
9	VI 24	T	28	XI 20	T	47	VI 12	C
10	VII 29	P	29	1920 II 2	P	48	VII 2	A
11	VIII 30	P	30	V 7	P	49	X 24	J
12	XI 16	T	31	V 13	P	50	1923 I 22	C
13	1918 II 7	P	32	V 20	T	51	II 3	J
14	IV 21	C	33	VI 5	J	52	III 2	P
15	VII 3	P	34	VIII 15	T	53	IV 13	J
16	VIII 15	P	35	IX 8	T	54	VI 1	J
17	IX 8	J	36	1921 III 21	J	55	VII 13	J
18	X 27	P	37	IV 1	P	56	IX 1	J
19	XI 8	J	38	V 21	P			

The regions of these earthquakes are represented by the letters J, A, C, P and T according as the earthquakes took place in or near Japan, the Aleutian Islands and Alaska, California, the Philippine Islands, and Tonga Deep respectively. The table serves to show how the centres of seismie activity approached gradually from distant localities to Japan. Indeed, there were five Japan earthquakes among seven which took place during the year previous to the great shock on Sept. 1, the most noteworthy having been that of June 1. This earthquake was accompanied by a dozen fore-shocks, was so big that the double amplitude of the earth-movement at Hongô was as large as 6.6 cm., and originated at a distance of 250 km. from the seat of the last destructive shock.

No remarkable fore-shock seems to have preceded the last catastrophe. Only a few shocks were registered in August at Hongô as follows: two unfelt on the 7th, one unfelt on the 17th, and one slight one on the 24th. All these originated in or near Sagami Bay. It is said that rumblings like earthquake-sounds were heard in the Miura Peninsula before the great shock.

The gradual upheaval of the land was very definitely shown by the tide gauge register at Aburatubo in Misaki. Here the annual mean sea-level had gradually risen during recent years until in 1920 it abruptly began to fall, while those at Ayukawa, Wazima, Kusimoto and others were moving during the latter epoch in the opposite sense and parallel to one another. This means that the land of Aburatubo was notwithstanding the fact that it had previously been gradually falling, elevated as much as the difference of the levels of the two categories during the last three years; and that is equal to 8 cm. (Pl. XXII.). Further, the monthly mean in 1923 showed the same tendency before the earthquake, indicating at Aburatubo an upheaval of about 10 cm. during the two months before the catastrophe. This topographical change is doubtless an evidence of the extraordinary stress which had been in action. It was the most striking antecedent phenomenon, and may perhaps throw light on the study of predicting destructive earthquakes.

21. **After-shocks.** Hitherto the after-shocks which have been studied by different investigators have related, so far as I am aware, to those in which the fundamental shock was simple, such that its after-shocks originated within definite limits and in a narrow space.

It is, however, quite different in the present case. Not only was the seismic focal area very wide, but another destructive earthquake belonging to the same seismic zone but originating at a far distant position took place on the next day and thenceforth it became necessary to distinguish to which system each after-shock belonged (Pl. XXIII.). Consequently I have divided the area of the origin into the following four different localities:—

A. The area including the Bay and the Province of Sagami as the main part.

B. The Bôsô Peninsula and the vicinity of its S. E. coast.

C. The drainage district of the River Tone.

D. Tokyo and its environs.

Such a classification is based upon the following reasons:—

(1). The destructive shocks, one on Sept. 1 and the other Sept. 2 at 11h 47m were of almost equal size but quite different in their origins. (Pl. XIII, XVI B.)

(2). The geographical distributions of the after-shocks were quite distinct in the two systems of Bôsô and Sagami.

(3). The time distributions of the principal after-shocks were quite distinct in the two systems. (Tables V—VII)

(4). The earthquake which originated in the drainage area of the River Tone is not to be treated as a pure after-shock in the strict sense, and I am treating it so in the wider sense only for the sake of convenience.

(5). The geographical distribution of the earthquakes which have originated in the vicinity of Tokyo during the years 1914—1922 coincides to a large extent with that of the present after-shocks. This coincidence may perhaps be due to the geological construction of the stage.

(6). Thousands of local shocks mostly accompanied by sounds and felt over areas not greater than 100 sq. km. were registered in different districts; shocks of this category observed at Tokyo include only a part so that they must not be treated as of equal weight with ones belonging to other categories.

Table V shows observations made in Tokyo of the great earthquakes and their principal after-shocks. Of these, nos. 2, 4, 7 and 8 were semi-destructive in Kanagawa Prefecture, while nos. 12 and 14 were equally so in the southeastern part of the Bôsô Peninsula (Pl. XVI

Table V.

Tokyo observation of the great earthquake and its principal after-shocks.

No.	Date	Time of occurrence			Duration			Max. motion		Epicentre				Locality
					Prel. tr.	Princ. por.	Total	2a	T	λ		φ		
		h	m	s	s	m	m	mm	s	°	′	°	′	
1	IX 1	11	58	44	12.4	10	140	88.6	1.35	139	21.8	34	58.6	A
2	1	12	01	49	9.	<5		60.	2.0	139	28	35	10	A
3	1	12	17	47	12.0	1.5	> 5	4.8	2.4	139	02	35	02	A
4	1	12	24	00	7.2	1.2	7	48.0	1.2	139	19.0	35	25.0	A
5	1	12	30	20	6.5	0.2	1	8.5	0.5	140	0.0	35	50.0	C
6	1	12	36	48	7.4	0.5	2	7.5	2.0	140	05	35	54.0	C
7	1	12	40	20	9.1	3	> 8	39.4	2.0	139	31.7	35	03.8	A
8	1	12	48	03	13.3	3	>20	57.6	2.0	139	26.4	35	09.7	A
9	1	13	58	32	12.8	2.5	30	6.1	1.7	138	55.2	35	23.0	A
10	1	14	22	49	12.9	3	60	21.2	1.5	139	32.1	35	07.5	A
11	1	16	38	21	12.0	3	15	59.3	4.0	139	00.0	35	20.0	A
12	2	11	46	55	16.2	4	100	69.7	2.3	140	20.0	34	40.0	B
13	2	14	10	21	6.4	1	20	9.1	1.2	140	00.0	35	32.7	B
14	2	18	27	04	11.3	3	>20	57.6	2.6	140	32.0	35	27.6	B
15	2	18	49	02	12.0	3	20	9.1	2.3	140	37.5	35	23.8	B
16	2	22	09	29	17.0	2.5	30	45.5	4.6	139	42.2	35	07.0	A
17	2	23	16	46	12.3	2.2	20	9.1	1.5	139	27.5	35	14.1	A
18	26	17	24	03	16.0	3	80	26.0	2.3	139	28.3	34	40.7	A
19	X 4	0	54	29	11.1	1.3	30	10.2	0.8	139	04.6	35	18.6	A
20	5	22	05	46	9.3	3	30	3.7	0.8	139	07.3	35	24.6	A
21	XI 5	5	45	51	7 0	1	20	15.0	0.5	139	20.0	35	31.8	A
22	23	11	33	52	8.8	2	10	7.8	0.8	139	29.4	35	15.4	A
	1924													
23	I 15	5	50	24	10.2	4	60	59.0	1.8	139	16 6	35	26.2	A

Table VI.

Four-hourly numbers of after-shocks felt at Tokyo.

Locality		A				B				C				D			Total
Magnitude		III	II	I	III–I	III	II	I	III–I	III	II	I	III–I	II	I	II–I	
Sept. 1	h h 12—16	24	38	54	116	0	0	0	0	2	2	2	6	2	8	10	132
	16 – 20	1	2	35	38	0	0	0	0	0	0	1	1	0	8	8	47
	20 24	1	0	12	13	0	0	1	1	0	0	0	0	0	0	0	14
Sept. 2	0— 4	0	0	5	5	0	2	6	8	0	0	2	2	0	0	0	15
	4— 8	0	0	8	8	0	3	6	9	0	0	1	1	0	0	0	18
	8 – 12	0	1	5	6	1	0	3	4	0	0	1	1	0	0	0	11
	12—16	0	0	5	5	1	2	10	13	0	0	0	0	0	2	2	20
	16—20	0	0	3	3	1	2	16	19	0	1	0	1	0	3	3	26
	20—24	2	0	1	3	0	0	5	5	0	0	2	2	0	3	3	13
Sept. 3	0— 4	0	0	2	2	0	0	7	7	0	0	2	2	0	7	7	18
	4— 8	0	0	2	2	0	0	5	5	0	0	0	0	0	2	2	9
	8 –12	0	0	0	0	0	2	2	4	0	0	0	0	0	1	1	5
	12—16	0	0	4	4	0	0	0	0	0	0	1	1	1	11	12	17
	16—20	0	1	1	2	0	0	7	7	0	0	0	0	0	5	5	14
	20—24	0	1	3	4	0	0	5	5	0	0	1	1	0	6	6	16

Table VII.

After-shocks felt at Tokyo, Hongô, during the month following the great earthquake.

Date	A				B				C				D		Total
	III	II	I	III–I	III	II	I	III–I	III	II	I	III I	II	I	
1	26	41	119	186	1	5	16	22	2	2	7	11	2	16	237
2	2	0	13	15	2	6	45	53	0	1	4	5	0	18	91
3	0	2	11	13	0	0	15	15	0	0	2	2	1	34	65
4	0	0	10	10	0	0	12	12	0	1	3	4	0	9	35
5	0	0	12	12	1	0	10	11	0	0	0	0	0	7	30
6	0	0	8	8	0	0	5	5	0	0	1	1	0	11	25
7	0	1	5	6	2	0	8	10	0	0	1	1	0	12	29
8	1	0	3	4	0	1	9	10	0	0	1	1	0	10	25
9	1	0	6	7	0	0	7	7	0	0	0	0	1	10	25
10	0	0	1	1	0	0	5	5	0	0	1	1	0	6	13
11	0	0	4	4	0	1	4	5	0	0	0	0	0	7	16
12	0	0	3	3	0	0	2	2	0	0	0	0	0	4	9
13	0	0	2	2	0	0	5	5	0	0	0	0	0	7	14
14	0	1	1	2	0	0	0	0	0	2	0	2	0	3	7
15	0	0	1	1	0	0	3	3	0	0	1	1	0	4	9
16	0	0	3	3	0	0	2	2	0	0	0	0	0	5	10
17	0	1	0	1	0	0	2	2	0	0	1	1	0	4	8
18	0	0	4	4	0	0	0	0	0	0	0	0	0	5	9
19	0	0	3	3	0	0	3	3	0	0	0	0	0	3	9
20	0	0	1	1	0	0	3	3	0	0	0	0	0	0	4
21	0	0	0	0	0	0	2	2	0	0	0	0	0	4	6
22	0	0	1	1	0	0	3	3	0	0	0	0	0	1	5
23	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
24	0	0	1	1	0	0	1	1	0	0	0	0	0	0	2
25	0	0	1	1	0	0	2	2	0	0	0	0	0	3	6
26	1	0	5	6	0	0	1	1	0	1	1	2	0	3	12
27	0	0	2	2	0	0	1	1	0	0	0	0	0	2	5
28	0	0	2	2	0	0	1	1	0	0	1	1	0	0	4
29	0	0	1	1	0	0	0	0	0	0	0	0	0	1	2
30	0	0	1	1	0	0	4	4	0	0	0	0	0	0	5
Total	31	46	224	301	6	13	171	190	2	7	24	33	4	190	718

Date 1 covers 24 hours beginning at noon, Sept. 1, &c.

B.). No. 11 originated near Hakone and no. 23 in a belt running from west to east in the central part of Sagami Province; in many respects they were similar to each other, having both been semi-destructive in the province of Sagami. Casualties in the latter case numbered 1273 collapsed houses and 14 victims. Lastly, no. 18 was felt very severely in Oosima, especially in the southeastern part, where the intensity rather surpassed that of the main shock.

From the same table, it is clear that the after-shocks in the first day originated mostly in the district A, while those originating in the district B took place for the most part after the occurrence of no. 12, the great earthquake of the next day. This correlation is more clearly shown in Table VI, in which four-hourly numbers of the after-shocks are given. All these earthquakes are limited to those which gave bodily feeling at Tokyo, the magnitudes represented by Roman numerals III, II or I corresponding to earthquakes in which the double amplitude exceeded 3 mm., or was greater or less than 1 mm. respectively. The frequency of the shocks or rather earthquake sounds which occurred in Tokyo and its environs attained its climax on the third day, but in general their occurrences were comparatively irregular.

The frequency variation in each district may be studied more closely from Table VII, in which 24-hourly numbers are given, beginning at noon on Sept. 1. According to Mr. Yasuda, the numbers of earthquakes felt at Tokyo during October and the three months following were 96, 86, 139 and 167 respectively. The revival of seismic activity in the last two months is due to the occurrence of many minute local shocks in the northern part of Sagami in December and of the after-shocks of the large earthquake of Jan. 15, 1924. Since then, it has become rather quiet except for the months of August and September, 1924, and now the people of Tokyo, Yokohama, and other places in the vicinity are enjoying the usual tranquility from seismic activity peculiar to their district, namely two shocks a week on the average.

22. **Rehabilitations and prospects.** According to the authorities on statistics, the total destruction of property caused by the shock as well as its subsequent fire amounted to 5,500,000,000 *yen*; a destruction too great to be restored within a few years or even a decade. The people of the devastated cities and towns wandered about in distress for two or three days; however, they soon began to return to their usual occupations and, somewhat encouraged by sympathy given to them

from different parts of the world, started to reconstruct their habitations. We may now expect that it will not take so long a time for the complete rehabilitation of the cities of Tokyo and Yokohama with, among other improvements, more security against earthquake and fire, though the authorities of the Metropolitan Reconstruction Board seem to feel anxious about overcoming many difficulties which they must encounter.

The catastrophe was, on the other hand, very instructive to the people who had formerly refused to believe the seismologists' words of advice. In the summer session of the Imperial Diet in 1924, each House proposed and passed a bill for the extension and encouragement of earthquake investigations, and the government has recently provided the means for enlarging the existing meteorological observatories in this connection, and for establishing, instead of the hitherto existing Imperial Earthquake Investigation Committee, the Imperial Earthquake Investigation Council and the Earthquake Research Institute of Tokyo Imperial University. The latter will, when completed, have 11 investigators freed from the necessity of giving university lectures—perhaps one of the best means of responding to the sympathy given us by different nations.

November 1925.

Appendix I.

The Seismic Zones in Japan.

1. **Important problems in earthquake countries.** In countries subject to earthquakes, the seismic problems which are of most importance and interest are probably those relating to the prediction of shocks and to earthquake-proof construction. In Japan, the latter of these problems has been in some measure solved by various architects and civil engineers, who have achieved some success in the study of constructing buildings, bridges, etc. On the other hand, the progress

of the former has been very slow but not without some results, such as I shall now describe.

2. **Earthquake prediction.** Several methods for the solution of the problem of earthquake prediction have been proposed and tried by different investigators but almost all have, so far as I am aware, ended in failure. Japanese seismologists, especially the late Prof. Omori, have, however, conveniently divided the subject into two parts; first, the place of occurrence, and second, the time. Of these, the first was investigated by Prof. Omori, with definite success, and his results were published under the title of the "Seismic zone." His investigation of the seismic zone of the Pacific coast of America and of that of Italy led him to predict the Valparaiso Earthquake in 1906, and two Italian earthquakes, namely the Messina-Reggio Earthquake in 1908 and the Avezzano Earthquake in 1915.

The seismic zones in certain localities can be simply determined by the geological formation and the topographical features; nevertheless it is very necessary to know the space distribution of past earthquakes in the particular locality in order to be able to forecast the places where large earthquakes are sooner or later likely to occur. In fact, the accuracy of the determination of seismic zones depends upon that of the determination of the position and area covered by past earthquakes.

Let us first suppose the site of a future earthquake to be given; then the problem as to when the earthquake will occur presents itself. It is apparently very hard to solve this question, but it does not seem to be impossible, especially when we consider such indications as foreshocks, slow changes of land levels and other phenomena, which are often manifested in or near the origin of a big earthquake before it takes place. For this reason, the study of seismic zones now plays a very important part in investigations undertaken in countries subject to earthquakes.

3. **Catalogue of Japanese earthquakes.** The history of Japanese earthquakes dates back as far as the fifth year of Emperor Inkyô, i. e. 416 A. D. The Imperial Earthquake Investigation Committee has compiled a catalogue containing more than 2200 earthquakes which have taken place during the successive 1451 years[1]. Of these records, the part relating to the years previous to 1595 is considered to be rather imperfect, so much so that it is liable to give an inaccurrate

1) Report (in Japanese) of the Imp. Earthquake Inv. Comm., No. 46

idea of the seismic activity in Japan during the period covered. The annexed table may, however, serve as a comparatively reliable compilation of destructive earthquakes in Japan, though it covers only the short period from 1596 to the present day.

Earthq. no.	Date			Seismic zone	No. of victims	No. of destroyed houses	Remarks
1	1596	IX	1	VIII	807		Uryû Is. sank down.
2	1596	IX	4	VI	2000		
3	1605	II	3	I	5000		Extraordinary *tunami.*
4	1611	IX	27	IV′	3700		Inawasiro depressed.
5	1611	XII	2	I	1783		*Tunami.*
6	1614	XI	26	II			*Tunami.*
7	1633	III	1	V	150		
8	1649	VII	29	IV	A few hundreds		
9	1659	IV	21	IV′	39	400	
10	1662	VI	16	VI	500	5500	
11	1662	X	30	I	20	2500	*Tunami.*
12	1666	II	2	III	1500		
13	1676	VII	12	II′	7	133	
14	1694	VI	19	II	394	2760	
15	1703	XII	31	I	5233	20162	*Tunami.*
16	1704	V	27	II	58	1314	
17	1707	X	28	I	4900	29000	Extraordinary *tunami.*
18	1711	III	19	II′	4	500	
19	1714	IV	28	III	56	300	
20	1729	VIII	1	II	5	791	
21	1751	V	20	III	2000	9100	
22	1766	III	8	II	1335	7500	
23	1771	IV	24	I	9400		
24	1792	V	21	VIII	15000	12000	Unzen erupted, extraordinary *tunami.*
25	1793	II	8	II	12	164	*Tunami.*
26	1802	XII	9	II	19	1100	
27	1804	VII	10	II	333	5500	Kisakata elevated, *tunami.*
28	1810	IX	25	II	59	1129	
29	1828	XII	18	III	1443	11750	
30	1830	VIII	19	VI	151		
31	1833	XII	7	II	42	1013	*Tunami.*
32	1847	V	8	III	12000	34000	
33	1853	III	11	V	79	3300	

Earthq. no.	Date			Seismic zone	No. of victims	No. of destroyed houses	Remarks
34	1854	VII	9	VII	1352	5000	
35	1854	XII	23 24	I	3000	60000	Extraordinary *tunami.*
36	1855	XI	11	IV	6757	50000	
37	1862	VI	6	X	>1000		
38	1872	III	14	II′	537	4049	*Tunami.*
39	1889	VII	28	VIII	20	239	
40	1891	X	28	VII′	7273	142177	
41	1894	III	22	I	0	11	*Tunami.*
42	1894	VI	20	IV	24	90	
43	1894	X	22	II	726	6006	
44	1896	VI	15	I	27122	10617	Extraordinary *tunami.*
45	1896	VIII	31	II	209	5911	
46	1904	XI	6	X	145	611	
47	1905	VI	2	VIII	56	11	
48	1906	III	17	X	1258	6769	
49	1906	IV	14	X	17	1794	
50	1909	VIII	14	VII	41	976	
51	1911	VI	15	I	6	420	
52	1914	I	12	IX	29	120	
53	1914	III	15	II	94	640	
54	1917	I	5	X	50	130	
55	1918	IX	8	I	24		*Tunami.*
56	1922	XII	8	VIII	20	194	
57	1923	IX	1	I	99331	576262	
58	1924	I	15	V	14	1273	
59	1925	V	23	II′	395	3300	

4. **Seismic zones.** It will be seen that the origins of some of these earthquakes are included within a narrow space or long belt which corresponds to certain weak lines on the earth's crust. Such a belt constitutes a so-called seismic zone. We may recognize ten such zones in all, the most noteworthy being that which runs off nearly parallel to the Pacific coast. The earthquakes belonging to this zone have generally been un-local; and the disasters due to *tunami* or the seismic tidal waves were sometimes more serious than the direct effects of the earthquakes themselves. The seismic zone along the Sinano-gawa Valley (zone III) has been ably studied by Prof. Omori, who has shown that there exists a certain regularity in the transference

of seismic activity from time to time and from place to place thus giving a hint as to the prediction of the place of earthquake occurrence[2]. It is, however, our deepest regret that he was unsuccessful in predicting the last great Kwantô Earthquake, notwithstanding he had previously been criticized for his opinion relating to this problem. (Pl. XLV.)

Appendix II.

Further account of the topographical changes accompanying the great earthquake.

So far I have described in the text the results of the soundings and the land-surveys carried on respectively by the Naval Hydrography Department and the Land Survey Department of the Military Staff, quite startling changes in the topography of land and sea-bottom having been thus brought to light. Perhaps it may interest my readers further if I tell them of the results obtained recently by the Land Survey Department, which is still continuing its work of exhaustive investigation of the phenomena.

Before going further, it will be convenient to recapitulate here the work of surveying which has already been done or is in progress.

1. **The first series of the bench-mark surveys in the whole seismic area.** (See Pl. XLVI.) The vertical component of the topographical change at each station is shown in the plate by the figures (in metres) along the bench-mark lines, the + or − assigned to the number indicating respectively elevation or depression. The work was carried on during the time from Oct. 1923 to Nov. 1924.

2. **The repetition of the bench-mark survey on two lines, one joining Tôkyô to Misaki and the other, Hudisawa to Atami.** This was carried on during the three months from Jan. to March in 1925; the results showed that the land, which had once risen so conspicuously in the southern part of Sagami, now showed a depression not greater than 5 cm. when compared with the previous observations. This result agrees fairly well with other observations showing that a partial

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2) Bulletin of the Imp. Earthq. Inv. Comm., Vol. II, pp. 136–143.

restoration of the ground to the original level was perceptible in some places during a few days soon after the great earthquake.

3. **The survey of the base lines in Sagami Province.** The network of these base lines is indicated in Map II by a quadrilateral and its diagonals, the former occupying an area to the west of Yokohama. One of the diagonals, which joins Simomizo to Zama and is nearly 5210 metres long, was found to have increased its length as much as 245 mm., while its north and south ends rose as much as 283 and 430 mm. respectively. This result also agrees with the general phenomena relating to the topographical changes due to the great earthquake.

4. **Observations at trigonometrical points of the first class.** Thirty-seven stations lying in the most disturbed area (Pl. XLVI) were examined; but no definite results have yet been obtained.

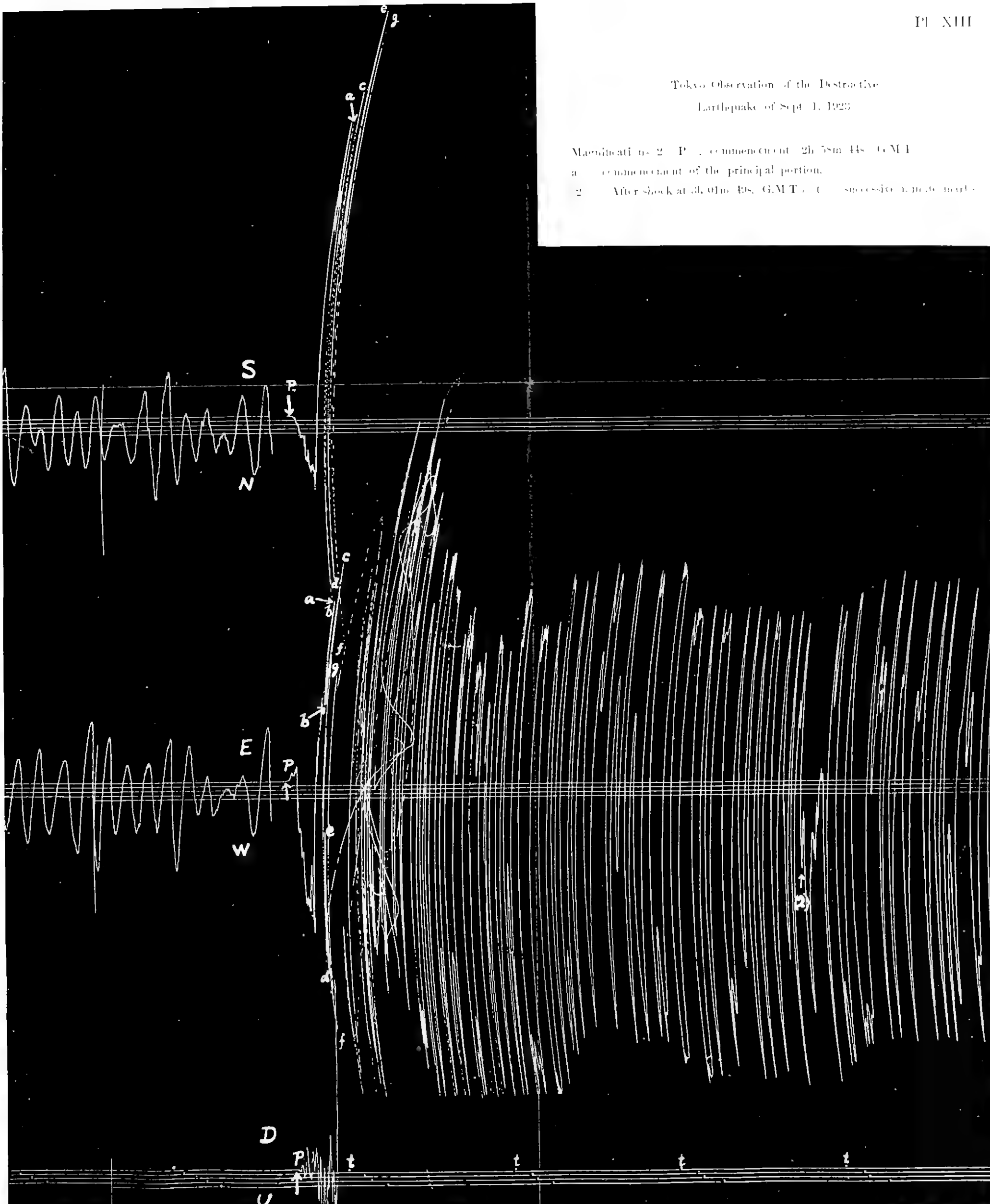
5. **Observations at trigonometrical points of the second and third classes.** This work was begun in 1925 and is still in progress. The areas in which the survey has already been finished or is to be done this year, are shown in Pl. XLVI. For the position of the stations and the results of the observations, the readers are referred to Map. II.

In that map, the position of each station is indicated by a dot, and the vertical component of topographical change at that point by figures attached to it. The latter was in each case estimated from the results of triangulation at the different stations, taking the results of the bench-mark survey as the standard. It will be seen that the present observations give us some definite knowledge as to the areal distribution of the topographical changes on land, which the foregoing ones did not give. Among the characteristic changes thus found to have taken place, there are two noteworthy ones; first, a belt of elevation traversing the southern part of the Bôsô peninsula in the direction NNE—SSW, and second, a depressed area covering the NW part of Sagami Province. Perhaps we can now picture roughly the actual change in that part of the earth's crust lying in the NE side of the assumed dislocation line across Sagami Bay, namely, a wavy flexure with the southeastern side convex and the northwestern side concave, both areas being bounded by a nodal line passing through Hakone in the southwest and Atugi in the northeast.

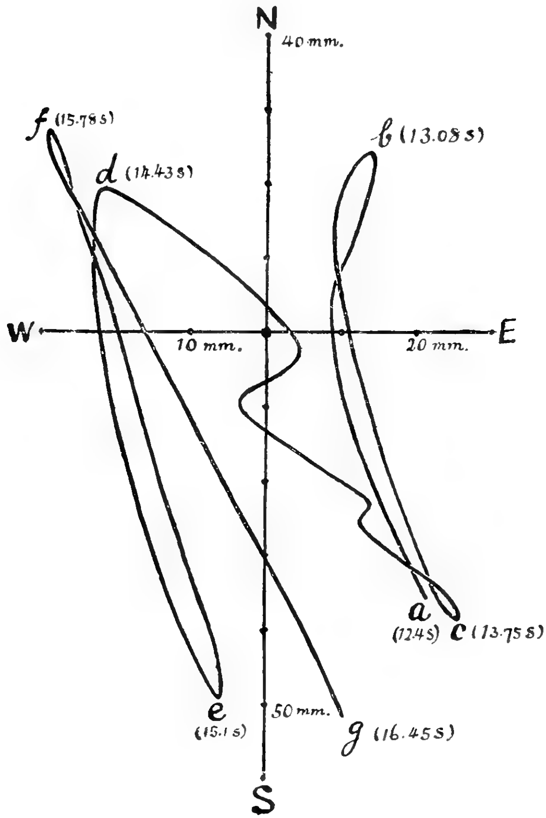
Pl. XIII

Tokyo Observation of the Destructive Earthquake of Sept. 1, 1923

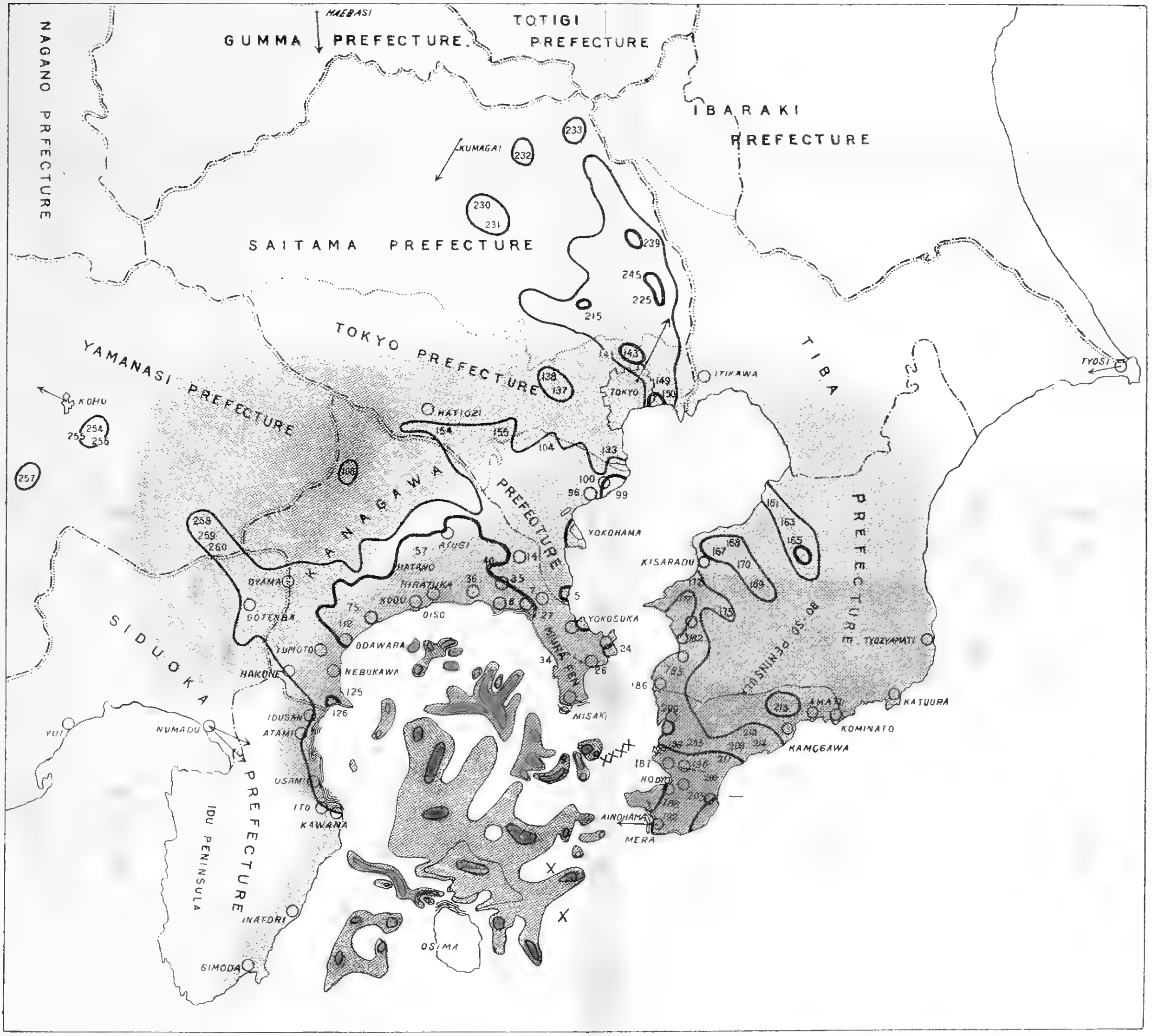
Magnification 2. P: commencement, 2h 58m 44s G.M.T.
a: commencement of the principal portion.
(2): After shock at 3h 01m 49s G.M.T.; t: successive minute marks.



The principal horizontal movement of the
destructive Earthquake of Sept. 1, 1923.

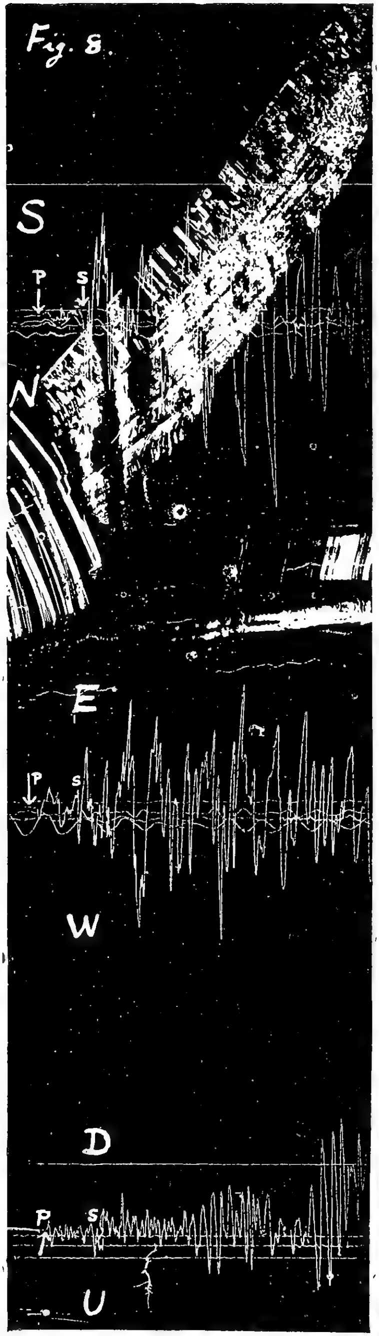


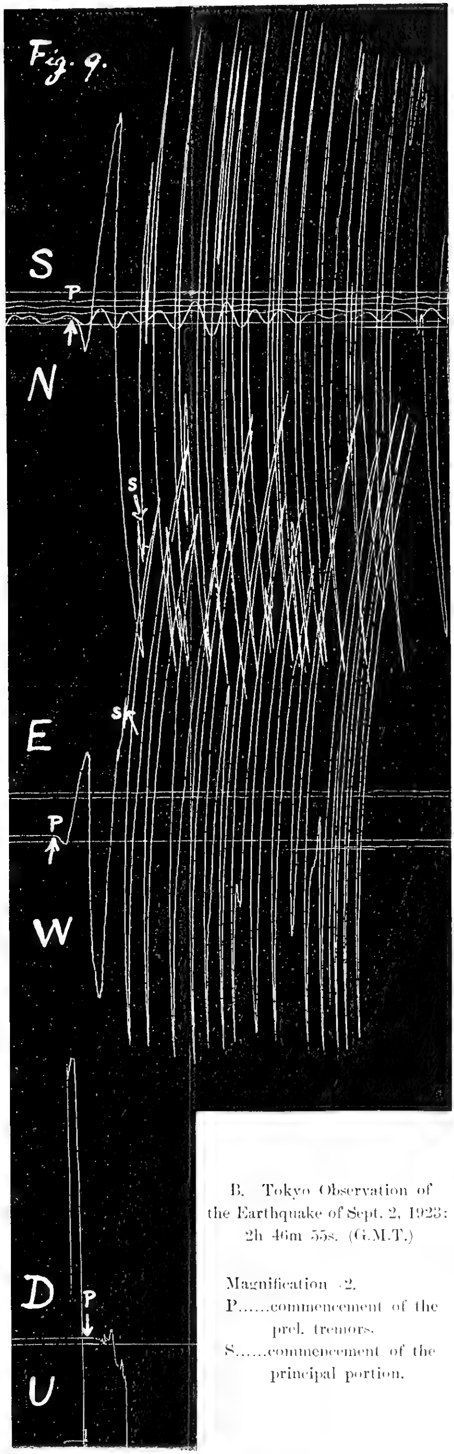
Map showing the Seismic Area of the Great Earthquake of Sept. 1, 1923.



1. Isoseismal lines. The thinner and the thicker curves correspond to the boundaries of the areas in which the collapsed houses reached 5% or 30% of the total number in such areas respectively. 2. Areas of elevation or depression are indicated by red or blue colour; the more pronounced the change of level was, the more deeply shaded is the colour. Submarine areas where the level change was less than 30m. are not indicated. 3. The direction of the initial movement is indicated by a small arrow. 4. Each number shows the position of locality corresponding to that of the same number in Table III. 5. Wavelike lines along the coast indicate *tunami*: max. height is shown by number of the lines (one line to every 3m.). 6. Each cross indicates the position where submarine cable was broken. Localities……No. 7=Kamakura, No. 24=Uraga, No. 35=Hudisawa, No. 36=Tigasaki, No. 125=Manaduru, No. 182=Sanuki, No. 187=Hunagata, No. 188=Tateyama.

A. Tokyo Observation of the
Earthquake of Sept. 1. 1923: 5h 22m 49s. (G.M.T.)

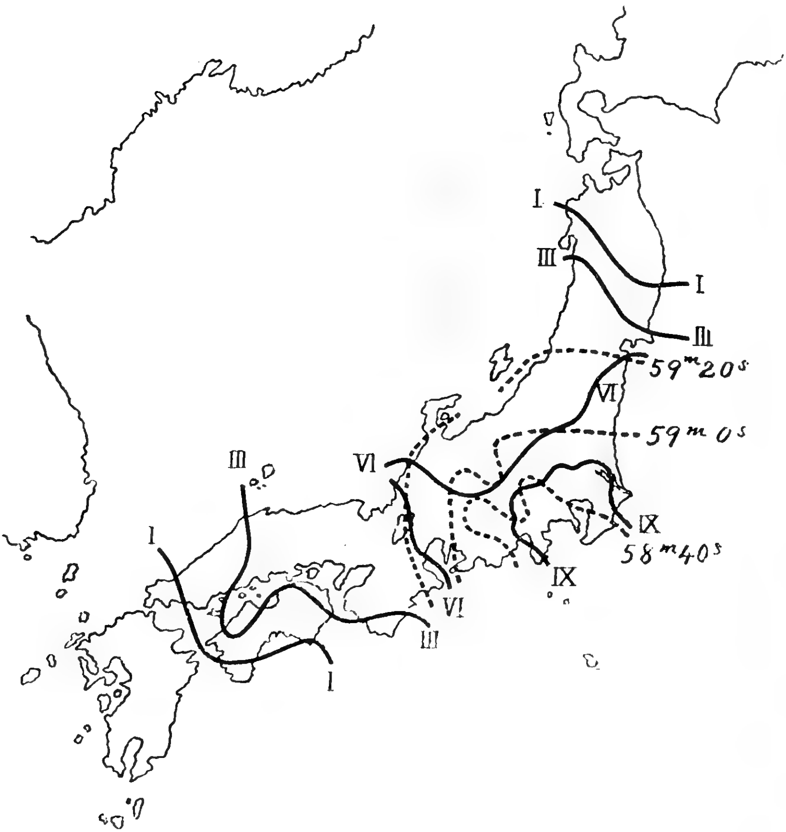




B. Tokyo Observation of
the Earthquake of Sept. 2, 1923:
2h 46m 55s. (G.M.T.)

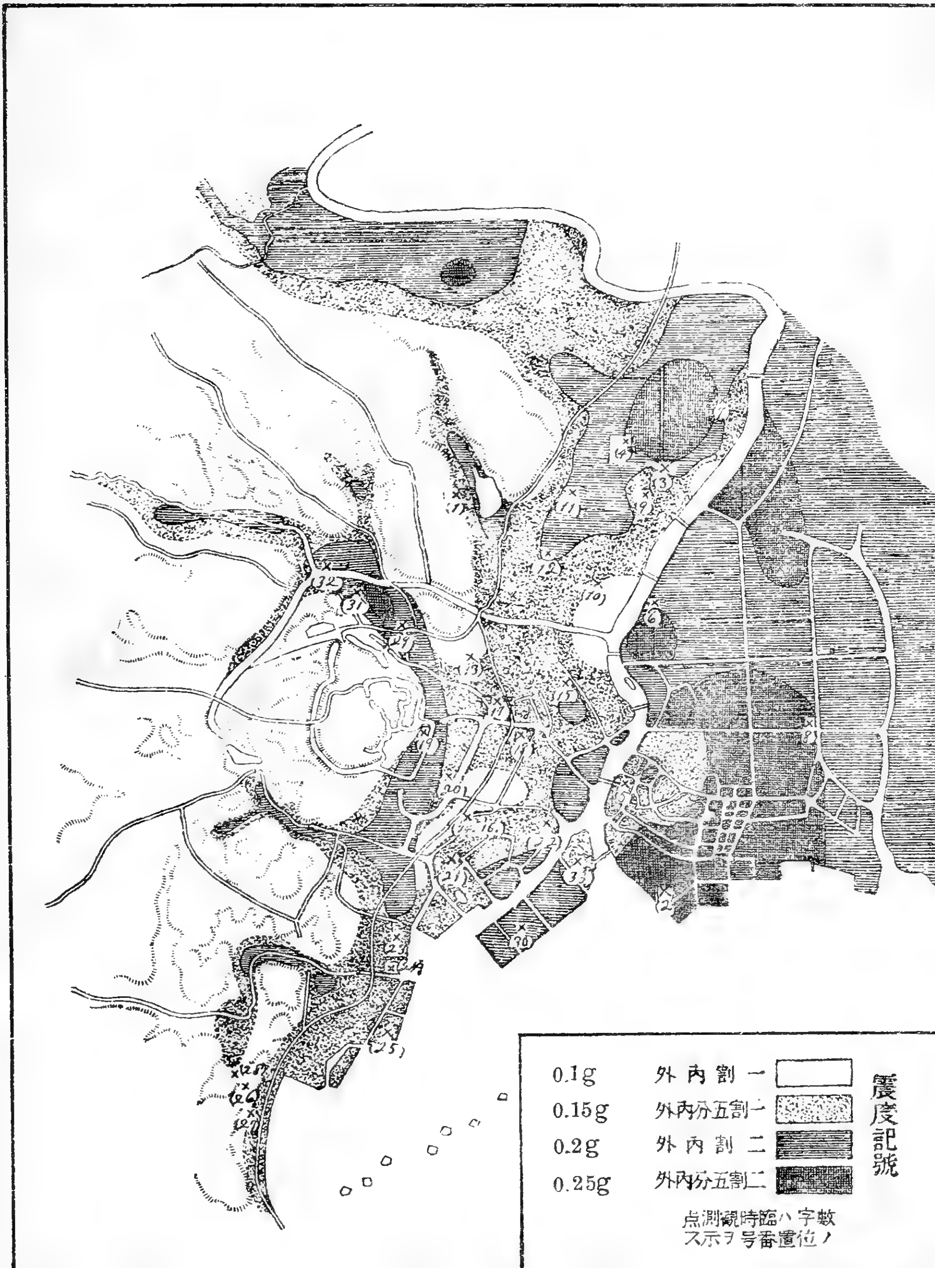
Magnification =2.
P......commencement of the prel. tremors.
S......commencement of the principal portion.

Isoseismals and isochronals.



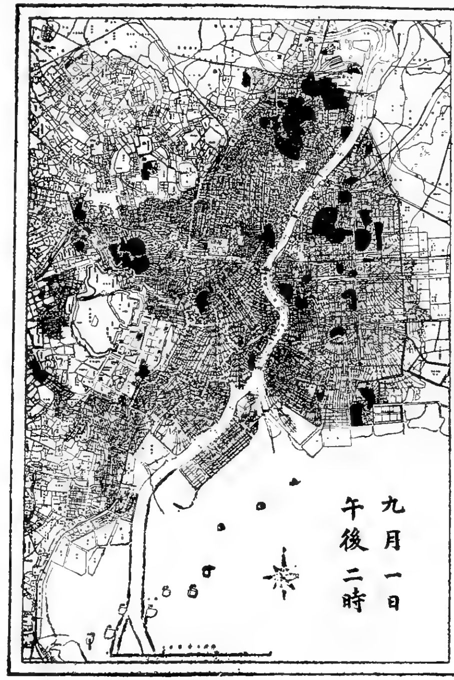
Isoseismals are given in Rossi-Forel scale.

Map showing the distribution of seismic intensity (α/g) in Tôkyô.

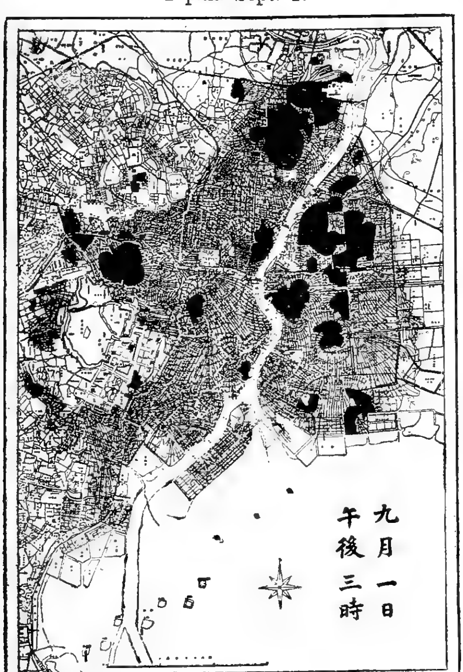


Maps showing the progress of fire in Tokyo.
Shaded areas indicate ones burnt up already. Pl. XIX A

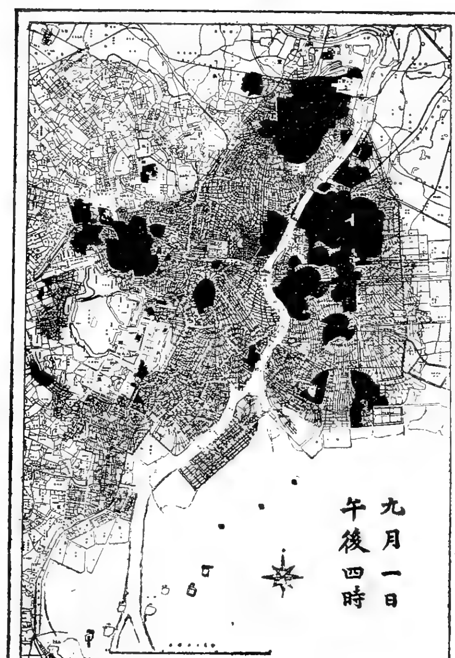
1 p.m. Sept. 1.



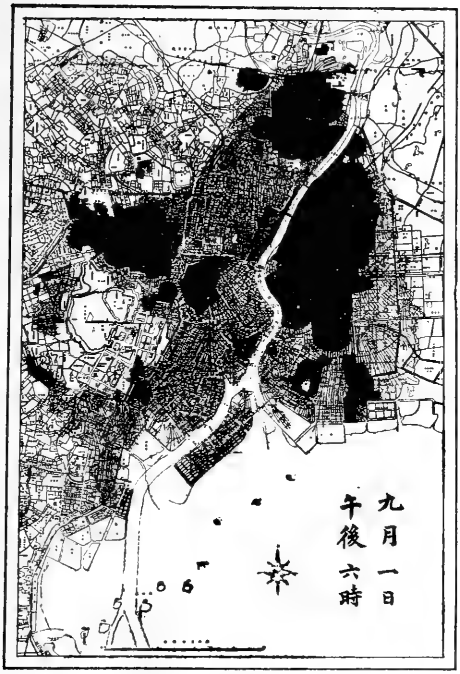
2 p.m. Sept. 1.



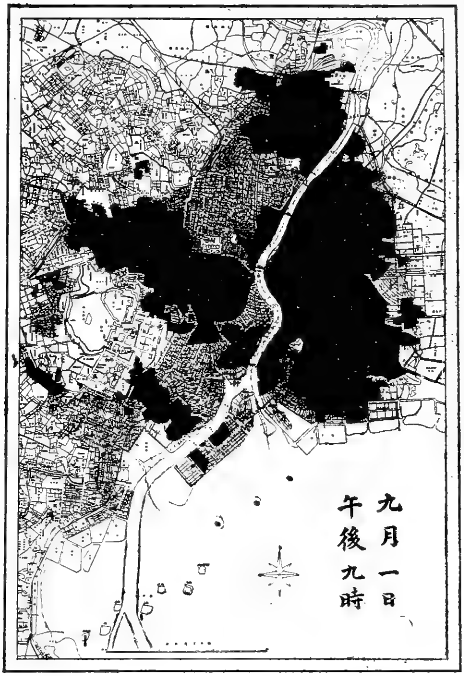
3 p.m. Sept. 1.



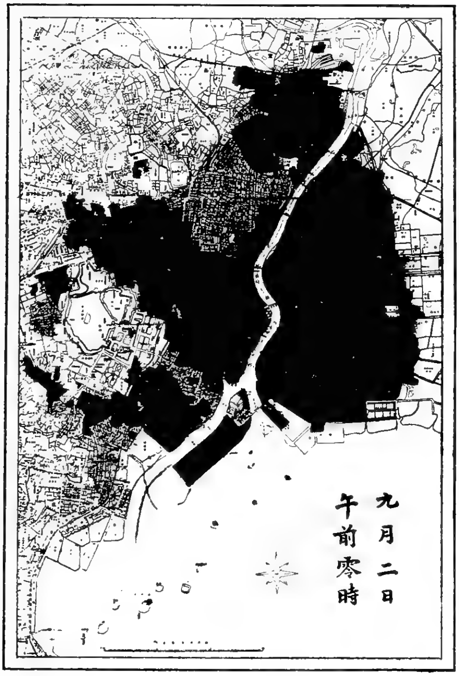
4 p.m. Sept. 1.



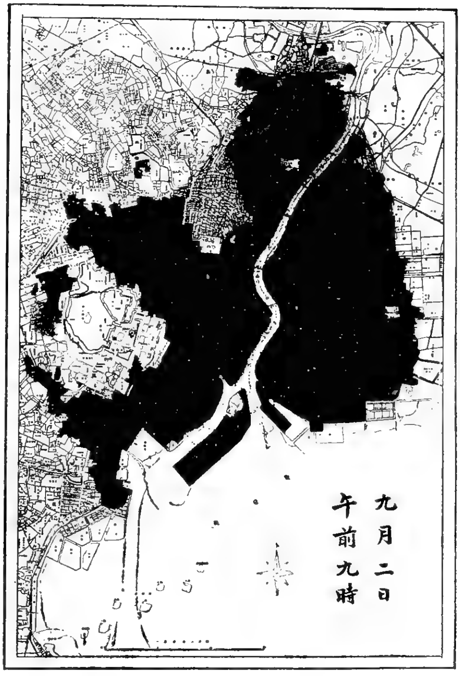
6 p.m. Sept. 1.



9 p.m. Sept. 1.

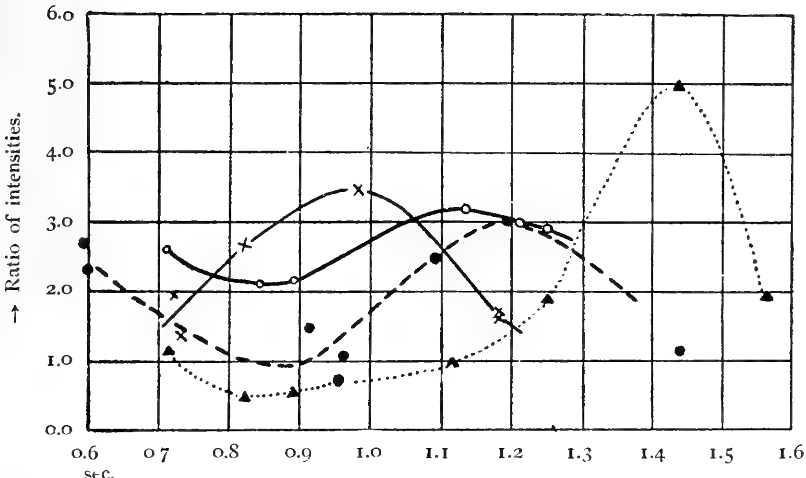


0 a.m. Sept. 2.



9 a.m. Sept. 2.

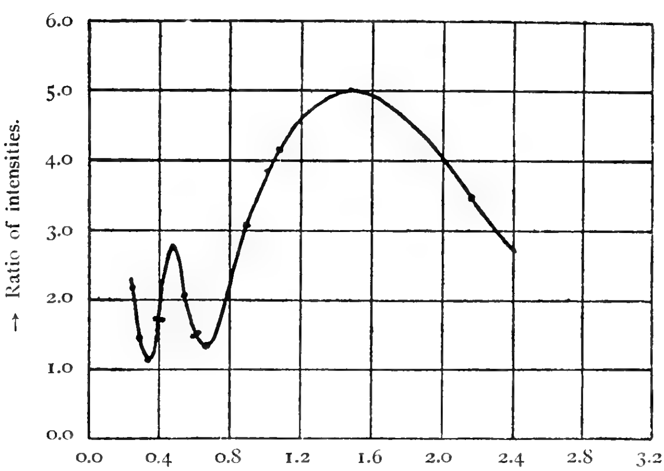
A. Graph showing the relation between seismic intensity at the alluvial soil. to that at the diluvial one in Tokyo.



→Vibration period at the Seismological Institute.

○ —— Yokoami. (No. 6 in Pl. XVIII.)
× —— Mikawatyô, Kanda. (No. 13)
● ––– Ettyûzima. (No. 2)
▲ .... Hasiba. (No. 7)

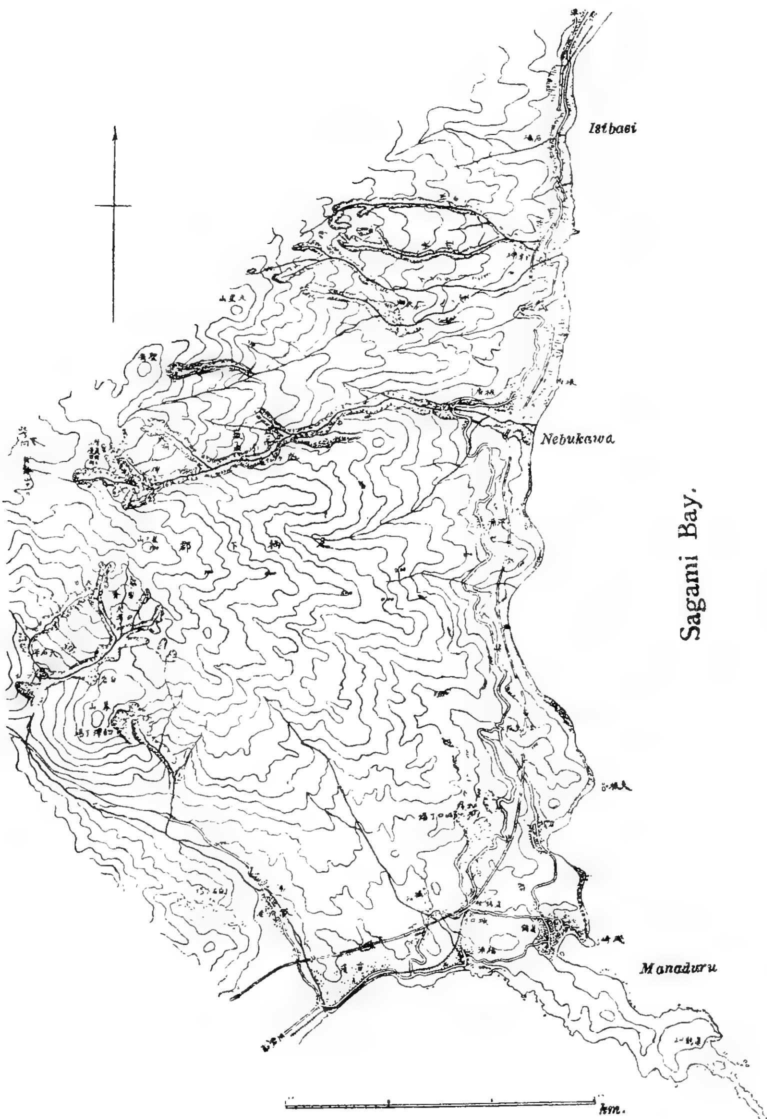
B. Graph showing the relation between seismic intensity at the alluvial soil to that at the tertiary ground in Kamakura.



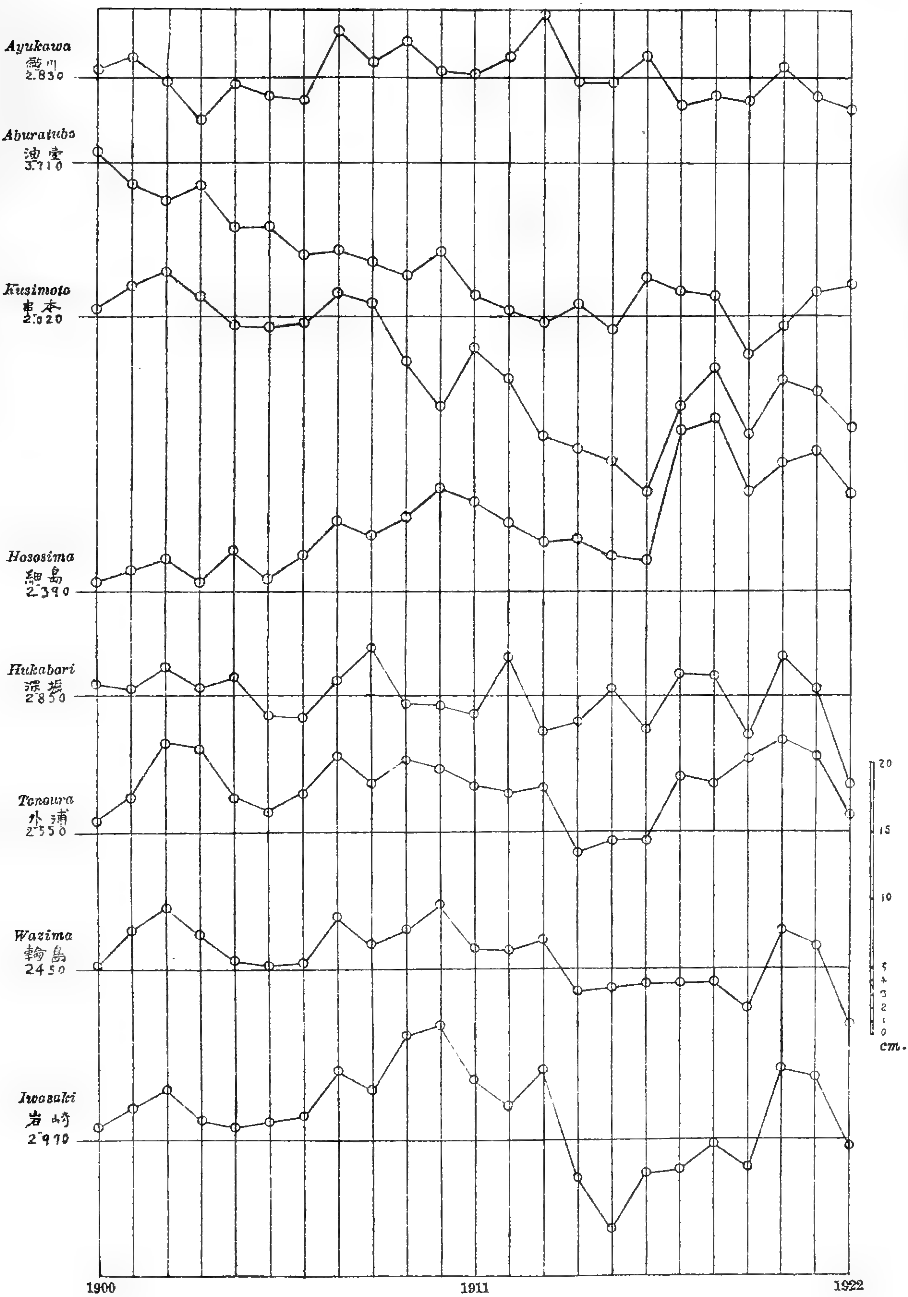
→ Vibration period at the Seismological Institute.

Map showing the course of mud-flows in and near Nebukawa

(. . . Mud-flow)



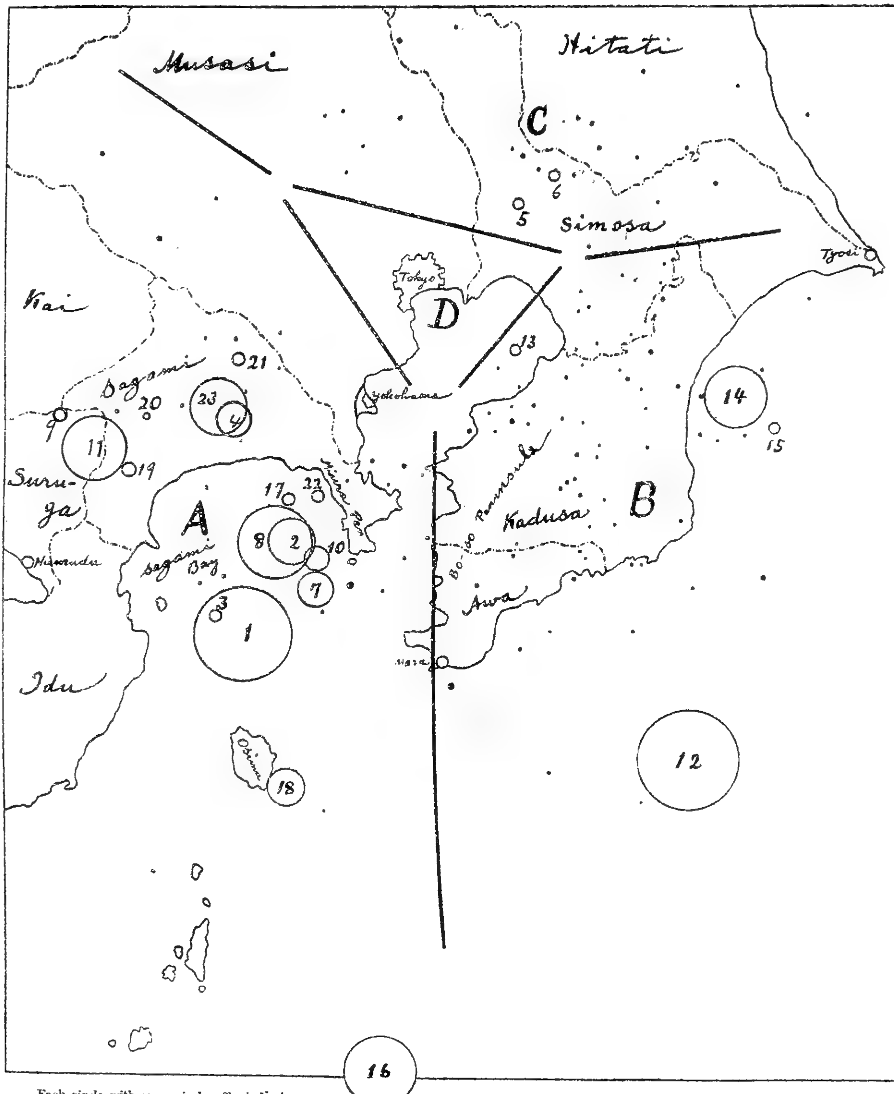
Graphs showing the variation of Annual mean sea-level at the different tide-gauge stations. Each ordinate indicates the height of the standard bench mark above the mean sea-level.



Variation of mean sea-level (1900—1922):

(1)—(4) in the Pacific coast, (5)—(8) in the Japan Sea coast, (2) at Aburatubo.

Map showing the distribution of the origins of the earthquakes registered at Tokyo in Sept., 1923, and of the principal aftershocks of later occurrence.

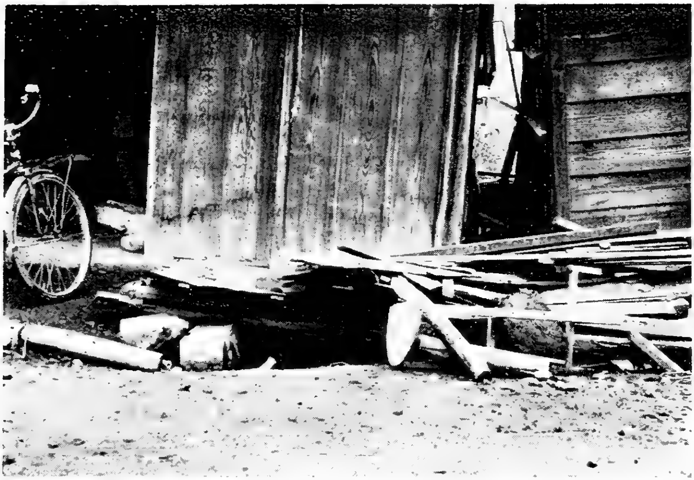


Each circle with numerical suffix indicates the earthquake in Table V

Each dot ithout suffix indicates the earthquake with its intensity as follows: –
• ......slight, • ......moderate, • ......strong.

A. Ruins of the Tokyo Imp. University as seen from the Seismological Institute.

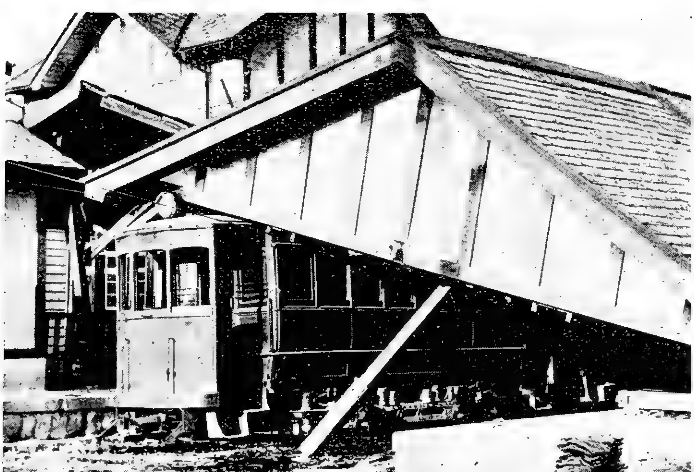
B. Large displacement (91 cm.) of a simple structure in Kôdu.



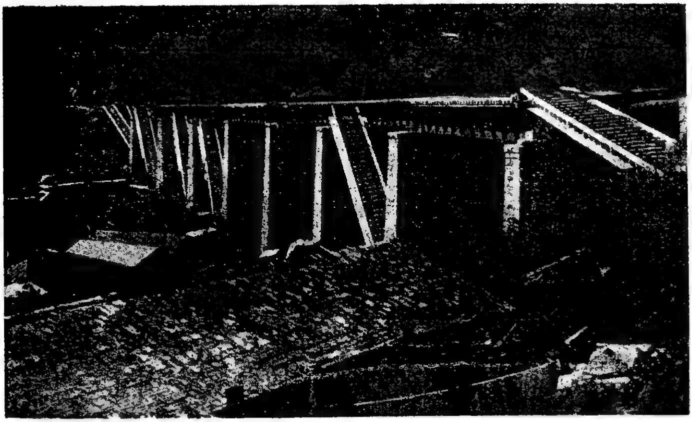
A. A flat wooden house in Odawara, making an extraordinary displacement (130 cm.) towards the right hand side.

B. Engine overturned near the station of Odawara.

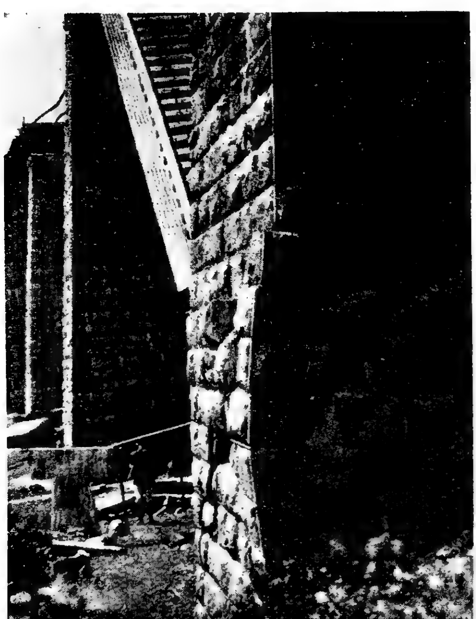
A. Collapse of the house of Uirô, a famous druggist in Odawara.



B. A tram car store in Odawara.



A. Damages to the Tamagawa railway bridge at Isibasi in the Atami line.



B· A damaged pier of the Tamagawa railway bridge.

A. The complete destruction of the Banyûgawa railway bridge, near Hiratuka.

B. A part of Sakawa Bridge, Odawara.
(Recently constructed; reinforced-concrete.)

A. Damages in Yumoto, NE entrance of Hakone.

B. Damages due to land slides in the Hakone railway.

A. Ruins of Sokokura, a nice hotspring place in Hakone.

B. Roots of ancient bridge piers believed to have been buried for 700 years, but now exposed to the air. (Near Tigasaki.)

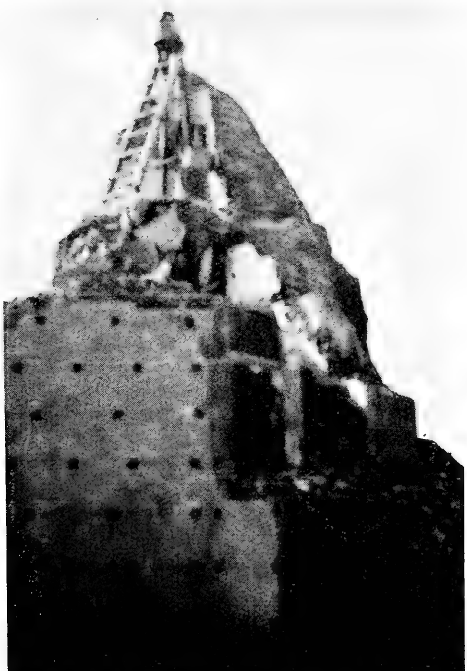
A. Ruins of the temple of Yûgyôzi, Hudisawa

B. Collapse of a two-storied wooden house, Katase near Kamakura.

A. The bronze statue of Buddha, Kamakura. Displaced towards, and depressed in the right-hand side.

B. Collapsed houses in the villa of Prince Simadu, Kamakura.

A. Ruins of the town of Hôdyô, Awa Province. A reinforced-concrete building in the back ground was intact.



B. Ruins of the light-house of Nozimazaki, S promontory of the Bô-sô peninsula. It was built by a French engineer in 1870.

A. Collapsed wooden houses at Akasaka Mituke, Tokyo.

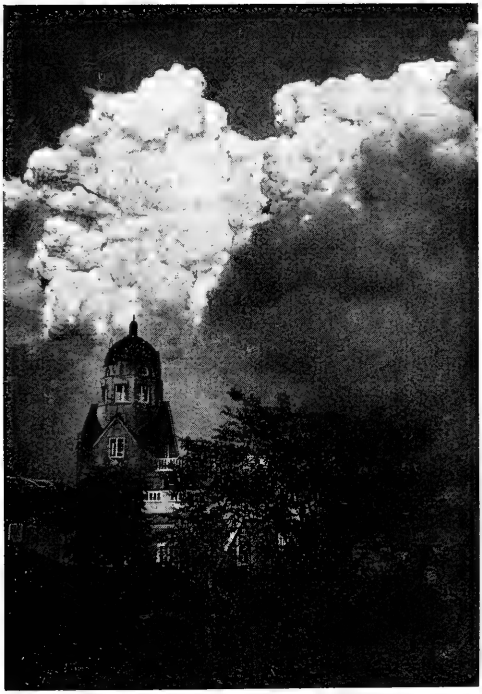
B. Naigwai-building in Marunouti. An example of reinforced-concrete buildings badly executed.

A. Land slide at Otyanomidu, N boundary of Kanda Ward.

B. Ruins of Surugadai, S part of Kanda Ward. Greek Orthodox Cathedral in the right-hand back ground.

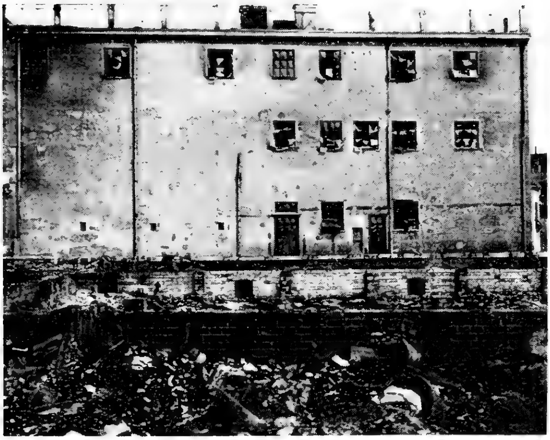
A. Ruins of NE part of Kôzimati Ward as seen from Kamakuragasi, Kanda Ward.

B. Ruins of "the 12-storied Tower" at Asakusa Ward, and a part of Asakusa Park saved from fire.



A. Cumulus over the burning area of Tokyo seen from Ookubo, a suburb in the west of Tokyo.

B. House constructed with porous glassy liparate withstood blazing fire. Things inside intact. (Hukagawa Ward, Tokyo.)

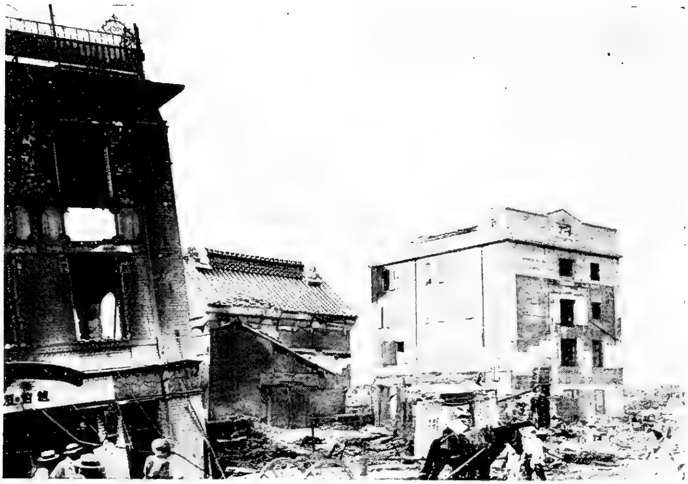


A. Reinforced-concrete building in Misakityô, Kanda Ward, Tokyo. Glass window-panes melted, allowing ingress of flames.

B. Steel-framed building of Maruzen, a bookstore in Nihonbasi Ward. It was intact by shock, but its frames were bent by heat.

A. Ruins of the City of Yokohama, as seen from Hudô-yama.

B. Hontyô street, near the port of Yokohama. Here the shock was next the severest in the city.



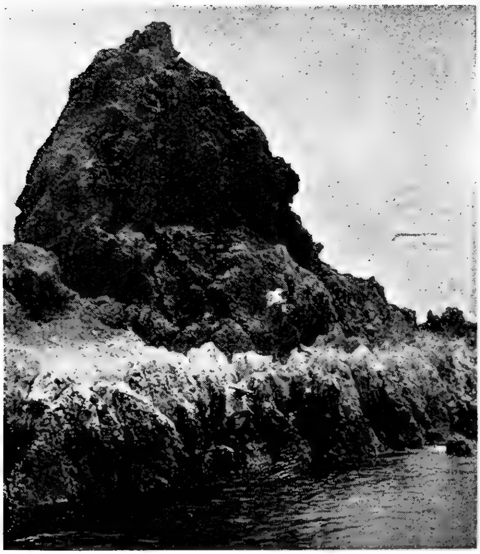
A. The central part of the City of Yokohama. A building inclined bodily with its foundation.

B. The central part of the City of Yokohama. Unequal settling down of the ground.

A. Mud-flow of Nebukawa in its upper course.
(Looking towards the west.)

B. Mud-flow of Nebukawa in its lower course.
(Looking towards the east.)

A. Upheaval of Terugasaki, Ooiso. Shells formerly hidden under the sea-level, are now exposed to the air.



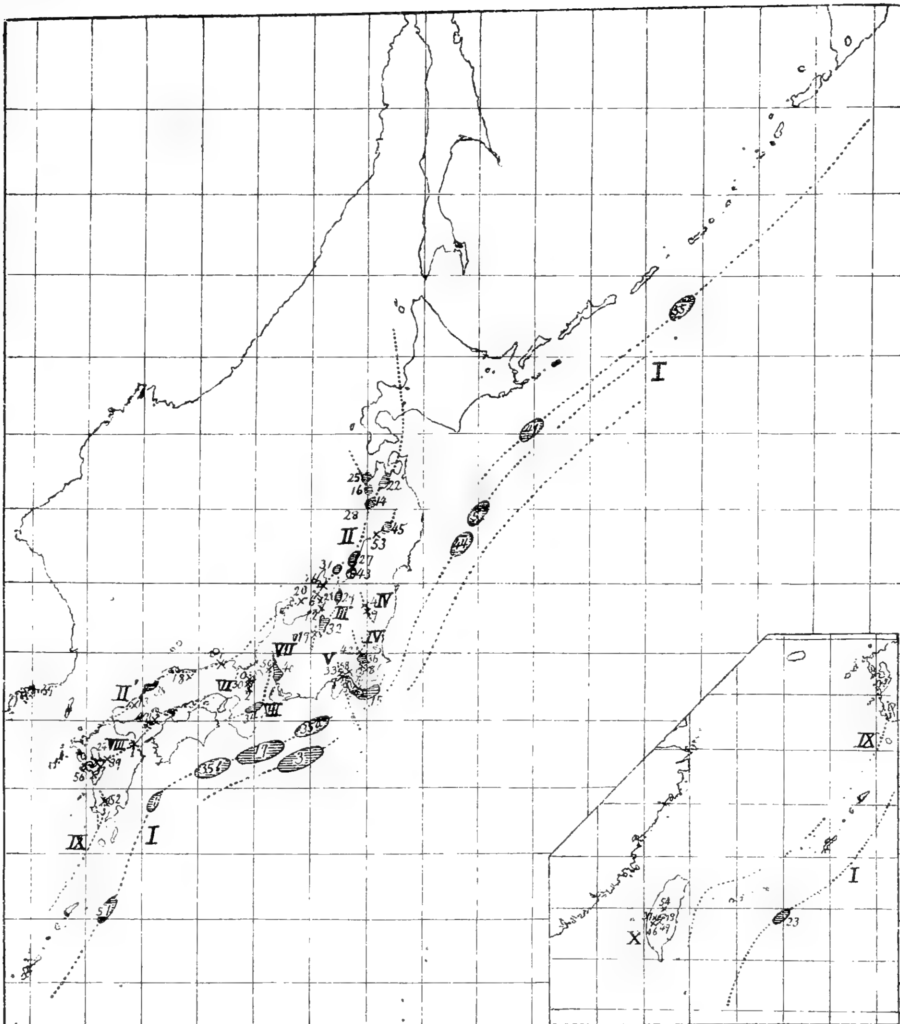
B. Upheaval of "the Three Stones," Manaduru Cape. The former beach-line is indicated by the remains of boring shells.

A. Fault in Nako, Awa, produced across a rice-field. (Looking towards the west.)

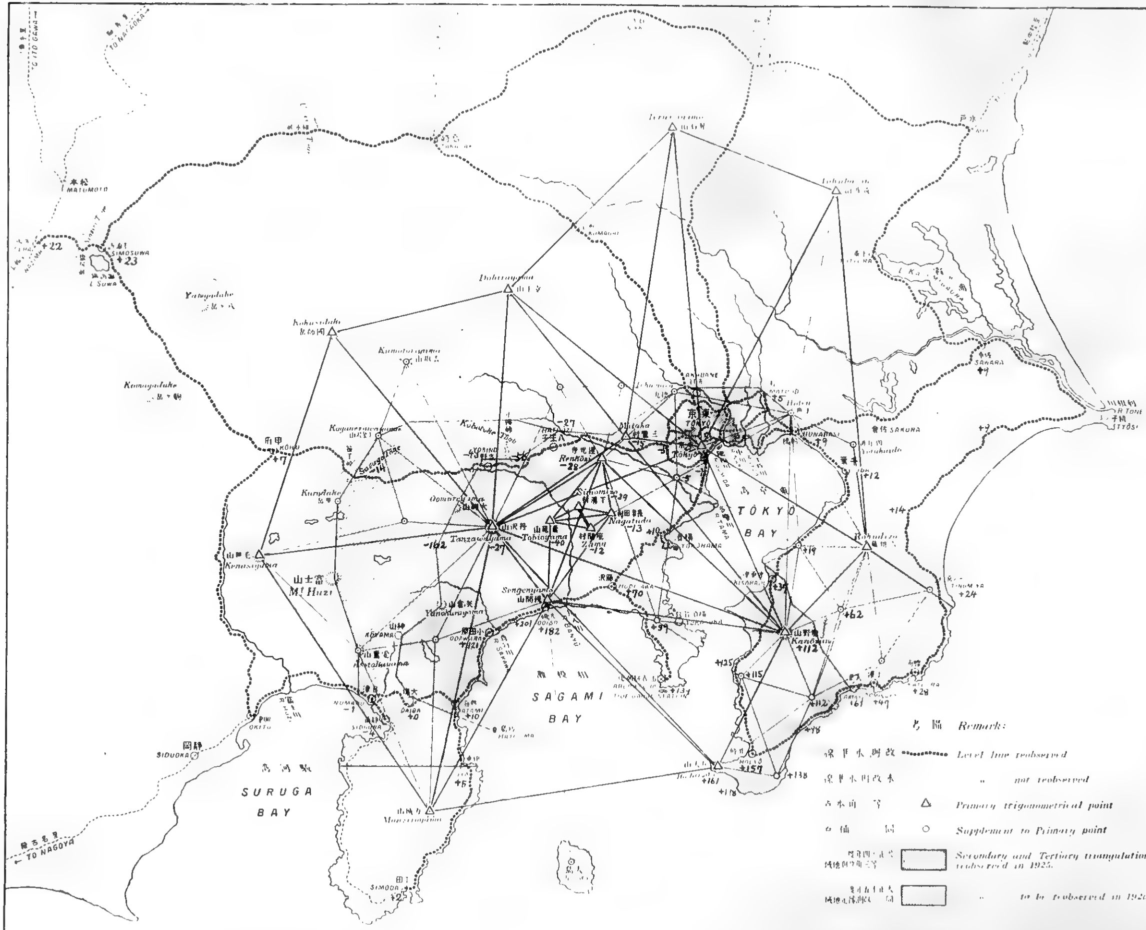
B. Ditto.

A. The town of Itô, Idu, after being swept by *Tunami.*

B. Ditto. Note a boat blockading a road.



Map showing the seismic Zones in Japan.


TŌKYŌ BAY
SAGAMI BAY
SURUGA BAY
Mt Huzi
Tanzawayama
Tōkyō
Kanōzan
Sengenyama
Dohiryōyama
Kokusidake
Kenasiyama
Manzirōyama
SIMOSUWA
+23
MATUMOTO
+22
SIMODA
+25
SIDUOKA
TO NAGOYA
SAKURA
SAKARA
TYŌSI
Remark:
Level line reobserved
" not reobserved
Primary trigonometrical point
Supplement to Primary point
Secondary and Tertiary triangulation reobserved in 1925.
" to be reobserved in 1926
RIKUTISOKURYŌBU

VIII. Mathematics in China and Japan.

By

Yoshio Mikami.

Part I. China.

1. The history of mathematics in China may be conveniently divided into five periods. The first period is that of ancient times, from which no authentic mathematical treatises have been handed down and of which little is known concerning the achievements made in the field of mathematics. The second period comprises some ten or more centuries beginning about the Christian era, during which the oldest treatises now existent, which are ten in number, were composed or used. The third is a brief period covering the age of the ascendency of the Mongol invaders, when the study of the older mathematics was pursued and brought into a prominence never known before; it was followed by an age of mathematical decline. The fourth period follows, beginning with the end of the 16th century, during which European missionaries introduced the European sciences of astronomy and mathematics into China. During this period, the older mode of mathematics was also studied side by side with the newly brought methods. The fifth and last is our own age; and nowadays the Chinese are chiefly studying the systems of mathematics now prevalent in the Western World.

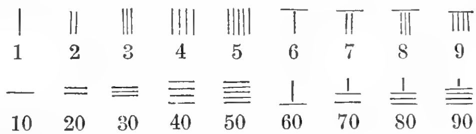
2. The study of the older mathematics down to the Han 漢 Dynasty (B. C. 206-24 A. D.) is very obscure, because there are now no mathematical books dating from such remote ages. But the art of calendar-making had reached a high development in antiquity, although it is still a moot question whether it was original with the Chinese as maintained by Prof. S. Shinjo or of Greek origin as Prof. T. Iijima believes. In either case, however, the Chinese made astronomical observations and calculations from at least the third or fourth centuries before Christ. To answer the astronomical demands of the time, there must have been a certain amount of mathematical knowledge. Some

fragments of such knowledge are recorded in various old documents, the dates of which, however, are hard to determine. There is recorded a very remarkable device in connection with the calendrical art. The circumference of a circle was equally divided to represent the directions. and the same method was used for the representation of seasons, hours and the revolutions of heavenly bodies, the designations being made by the ideographs of the *pa-kua* 八卦 and *kan-chih* 干支. Thus it happened that various subjects were arranged in one and the same diagram. This no doubt arose for the sake of convenience in astronomical observations, but it must not be denied also, that the ideographs proved very appropriate for the purpose of such a representation. The natural fondness of the Chinese mind for the association of ideas was also a factor in its conception. The ancient Chinese also constructed a vessel which represented the standards of lengths, measures, weights and musical notes simultaneously.

3. It is also said that the Chinese in ancient times used string-knots or knotted strings for the purpose of reckoning. Nothing is known as to how they were used. But the Luchu 琉球 Islanders are accustomed in modern times to reckon by means of straw, and in Japan also some similar modes of counting, though very seldom used, have been preserved until quite recently. From these methods, we may justly form some idea of what the old Chinese mode was like.

Somewhat later probably, sticks called by the several names of *suan* 算, *tsê* 策, and *ch'ou* 籌 were used in reckoning. These different names certainly indicate differences in form, size or use, but all three were used to designate some kind of sticks. The *sangi* 算木 or calculating sticks, which the Japanese mathematicians of the 17th to the 19th century abundantly used, consisted of small wooden pieces and were similar to the older Chinese ones, which, however, were certainly made of bamboo, as the structure of the ideographs used reveals. Various documents show their use ever since the Han Dynasty, and there is some further evidence of their having been used still earlier. It is certain that they were evolved from the older use of knots or straw in reckoning. These sticks are very important in history, because they were a stimulating factor in the development of the Chinese as well as the Japanese modes of arithmetic and algebra.

The representation of numbers by the use of sticks is recorded in the *Sun-Tsê Suan-ching* 孫子算經, the method described being the same as that used by later Japanese mathematicians. As there is a passage in the *T'so-chuan* 左傳, that is to be explained by the same arrangement, we may infer its antiquity. The sticks are to be arranged thus:



Here a question arises: the ideographs for 1, 2 and 3 are 一, 二, 三; 4 was also represented by 亖 in old times instead of the present form 四; while 十, 廿, 卅, 卌 were used for 10, 20, 30 and 40, but in the diagram the forms 一 二 三 亖, instead of representing 1, 2, 3, 4, stand for 10, 20, 30, and 40, respectively. This fact seems to show that the arrangements of the sticks, have undergone a change. A passage in the works of *Mo-Tsê* 墨子 (5th-4th century B. C.), though very obscure in expression, implies, when properly interpreted, the same arrangements of the sticks as in the forms of the ideographs. In the time of Mo-Tsê, either the change had not yet taken place or there was a transitional stage between the two forms.

The doctrine of *I* 易, as expounded in the *I ching* 易經, occupies a most important position in the history of Chinese thought. According to this system, two sorts of sticks are employed, one sort longer and the other shorter. The shorter sticks, consisting of two varieties, serve to arrange the symbols of the *pa-kua* 八卦 in a horizontal way. The longer sticks are used for divination, being held within the hand in a vertical position. Both forms bear a close relation to the calculating sticks. Besides the use of sticks, the Chinese also attempted to represent numbers in various other ways, some of which are recorded in the *So-shu Chi-i* 數術記遺.

Numerical systems other than decimal were used of old in connection with weights and measures. But in the science of numbers itself the decimal system early found favour. The number ten thousand was called *wan* 萬, and for numbers above this, three or four ways of numbering existed, of which the most customary was that which was marked by the recurrence of eight digits, *wan-times-wan* being employed. For decimal numbers each digit was separately nominated.

4. Multiplication-tables, or more properly, tables of multiplication verses, are found in complete form in no Chinese work older than the 13th century. But the *Shih-chi* 史記, the *Kuan-Tsê* 管子 and other old works contain portions of such verses, which accordingly seem to

have been used in ancient China. The Japanese work *Kuchizusami* 口遊 of the 10th century gives a table of multiplication-verses, which begins with 9×9 and ends with 1×1.

A passage in the *Sun-Tsê Suan-ching* 孫子算經 indicates the use of the table in the same order in old China. Another piece of evidence was recently furnished by the discovery of a fragment of such a table at Tun-Huang, near the western border of Kansu Province in China.

The tables of multiplication-verses given in the Chinese treatises of the 13th century and after are in the natural order. In Japan, however, the reversed order remained in use until still later. Tables of division-verses were also used in China after the 13th century. The Chinese ideographs lent themselves very well to the formation of such verses.

5. There are ten separate works on mathematics now existent, which belong to ages not later than the T'ang 唐 Dynasty (618-907 A.D.). Of these, six are known to have been written during or after the 3rd century A.D. The seventh work *Wu-t'sao* 五曹 is of little value. The remaining three, *Chou-pei* 周髀, *Chiu-chang* 九章 and *Sun-Tsê* 孫子, have sometimes been believed to be of a very remote age. But all three of these are missing in the list given in the *Han Shu* 漢書; their texts also contain some things that could not be anterior to the Han age. Thus these works are shown, at least in the forms now existent, to be compositions made during the later Han Dynasty or thereafter. The *Chiu-chang*, or "Nine Sections," however, was certainly in existence at the close of this Dynasty, which lasted until 220 A.D. These ten works were among the twelve that were used officially by the government of the T'ang 唐 Dynasty and also by that of the Sung 宋 Dynasty (960-1280 A.D.). It is doubtless due to this circumstance that they have been handed down to us, notwithstanding the fact that all other mathematical treatises of these early times have long since disappeared. Most of them have, however, lost their commentaries, and even the "Nine Sections," the most important of all Chinese treatises on mathematics, seems to be out of its proper order in some of ist parts, while its commentaries also are somewhat out of order, and the figures once annexed have all been lost.

In the "Nine Sections," are explained the extractions of square and cube roots, the operations being carried out as in the case of Horner's method of approximately solving numerical equations. There are also cases in which the operations are to be extended to numerical solutions of quadratic equations. In the 7th century, Wang Hsiao-t'ung 王孝通 solved various problems by means of cubic equations, whose solutions, it is implied, were effected in the same way as in the cubic root-extraction, as the technical terms employed show very sufficiently. In the "Nine Sections," linear simultaneous equations are solved very ingeniously. Liu Hui's 劉徽 commentaries, composed in 263 A. D., contain a new method of solving them. It is notable that these operations of root extraction and also of solving linear systems were executed by means of the calculating sticks, which consisted of two sorts, red and black, representing positive and negative numbers. Without noting this fact, it will be hard to understand the real nature of the Chinese system of algebra. Its later development was to follow the same course.

Though important for the historical study of arithmetic and algebra, yet the algebraical methods employed in these calculations were chiefly built up on a geometrical basis, as is apparent from the commentaries on the older works. The arithmetical root-extraction as well as the treatment of quadratic equations were both explained by the use of geometrical figures.

The cubature of some solids was tried with considerable care. In the quadrature of the circle, a considerably high degree of logical exactness was observed. Liu Hui inscribed a 96-gon within a circle and tried a kind of correction upon the values obtained for successively inscribed polygons, doubling each time the number of their sides up to the 96-gon, so as to get the value for the circle. Tsu Ch'ung-chih's 祖沖之 (429-500) method of quadrature is not thoroughly understood, because his writings are not extant; but we may not unjustly guess that he used a method like the *chao-ch'a* method 招差法 or "the method of differences," which has developed in subsequent years. Liu Hui's method of correction was certainly the starting point for the *chao-ch'a* method. The commentaries on the "Nine Sections" and the short article in the *Sui Shu* 隋書 (History of the Sui Dynasty, 589 to 618 A. D.) on Tsu's quadrature seem clear when compared with the works of Seki Kôwa 關孝和 and other Japanese mathematicians. The early Japanese method of quadrature, as described in the *Kwatsuyô Sampô* 括要算法, may closely resemble that used by Tsu. The latter's fractional value of $\pi=355/113$ was probably obtained by a process similar to that used by Seki. In this case, Tsu's treatment would have been decidedly algebraical, deviating from the Greek geometrical method. The cubature of a sphere by Tsu Hêng-chih 祖暅之, another Tsu's son, as given in the commentaries on the "Nine Sections," was effected by a sort of integration.

The finding of the greatest common measure in the "Nine Sections," Sun-Tsê's problem of finding the number whose rests are given when divided by 3, 5 and 7, together with its solution, and Chang Ch'iu-chien's 張邱建 "problem of a hundred fowls,"—all these appear to be based on the Chinese method of calendrical calculations. The use of the indeterminate equation

$$ax + by = 1,$$

which became very prominent in the 13th century, is said to have orginated with the calendrical method of I-Hsing 一行 (683 727). But before him, its use was certainly implied in the solution of Sun-Tse's problem.

The method of differences is usually attributed to Kuo Shou-ching 郭守敬 (1231-1316), who used three differences. But the case of two differences originated with Pien Kang 邊岡 long before Kuo (in 892). As mentioned above, however, Tsu Chung-chih and Liu Hui may perhaps have used the method still earlier.

6. After I-Hsing's time, the study of mathematics long remained at low tide. In the 11th century, at the time of the ascendency of the Sung philosophy 宋儒, there was a false dawn seeming to herald further progress in the science, but it soon disappeared. It was not until the 13th and 14th centuries that Chinese mathematics underwent a brilliant development. Some sixty years during this period may be said to constitute the golden age of Chinese mathematics. The algebraical method known as *li-ten-yuen-i-shu* 立天元一術, or *tengenjutsu* 天元術 in Japanese, appeared during this period, and higher numerical equations were approximately solved by means of calculating sticks, and according to a principle that may be compared with Horner's method. But it was no other than a direct extension of the root extracting operations of old times to the case of higher equations, the operations being carried out with calculating sticks. Arrangements of algebraical expressions were also made by the same method.

Chu Shih-chieh 朱世傑 discovered the *szu-yuen-shu* 四元術, or "the method of four elements," at the beginning of the 14th century. In the *li-ten-yuen-i-shu*, one element or one unknown only was contained in an equation. But in Chu's method, there were admitted elements or unknowns up to four in number, the four elements being arranged at the four sides around the absolute term which was placed in the middle.

Of these four elements, one represents the unknown and the other three are taken as parameters. Four of such equations serve for the elimination of the three parameters. The abacus algebra of the four elements was the highest development of the Chinese in the field of algebra. We know nothing of any kind of abacus algebra that was developed outside of China except in the countries to which the Chinese science was brought.

7. For nearly three centuries after this period, the study of mathematics remained in an unfavourable state. At the close of the 16th century, there was an inclination toward progress, when the European sciences of astronomy and mathematics were brought to China by Christian missionaries. Shortly after, trigonometry was introduced in connection with calendrical matters. Still later, the logarithmic tables were brought. The Frenchman Pierre Jartoux at the beginning of the 18th century taught three formulae of trigonometric functions expressed in infinite series.

Thus the Chinese science would have been Europeanised altogether, had not a reactionary tendency, characteristic of the Chinese, arisen. Mathematical treatises of old times were searched for and were studied diligently side by side with the newly brought European mathematics. The works of Mei Wên-ting 梅文鼎 (1633-1721) well represent this tendency. But the introduction of Western works was soon interrupted, until in the middle of the 19th century Alexander Wylie began for a second time the work of translation by rendering into Chinese Loomis' work on analytic geometry and calculus. Several other translations were subsequently made by a few foreign scholars. The Chinese mathematicians were content with these translated works, and none are known to have studied the European or American works themselves. But in the 20th century, those among the Chinese who went abroad in quest of mathematical knowledge were not a few. Foreign mathematicians also came to China to teach mathematics in Chinese schools and colleges. Japanese works based on recent Western science were read abundantly in China. All these factors are now working together to make Western mathematics popular in China of our own day. But it lies beyond our immediate purpose to discuss the present state of mathematics in China.

During the three centuries after the end of the 16th century, there appeared a good many mathematicians and also many writings on this subject. Some of them are not without merit, but only a few are in the class of works of discovery or originality. This fact must not be ascribed, however, to lack of genius, but mainly to the attitude of attack of the Chinese scholars. To this matter we shall return later, but now hastily pass it over in order to consider Japanese mathematics, for the limited space does not allow us to enter here in further detail into the progress of mathematics in modern China.

Part II. Japan.

8. In the oldest times of which there is a record, Japan had no kind of mathematics worthy of the name. But the roots of the Japanese numerals: *hi* (1), *hu* (2), *mi* (3), *yo* (4), *tsu* (*tu*)(5), *mu* (6), *ya* (8), *to* (10), are noteworthy in being so formed that a change in the vowel, the consonant remaining the same, denotes a double, characteristic not known to occur in any language of neighbouring or distant tribes. The word *itsutsu*, that represents 5, consists of the prefix *i* and suffix *tsu* attached to the root *tsu*, which is the middle syllable. In Japanese classical works frequent mention is made of great numbers like *Yaoyorozu* 八百萬, or "Eight hundred myriads," literally, and the like, the enumeration recurring in myriads. This was, however, a usage certainly learned from China. Some documents of the 8th century give such actual examples of counting as 12 *sen* 5 *hyaku* or "12 thousand and 5 hundred," recurring in thousands instead of in myriads. The Japanese knew of mathematics only after the introduction of the Chinese science.

The capitals of the Emperor at Nara and Heian (the present Kyoto) were built according to the scheme of the Chinese capital Chang-an 長安, but they differed notably from the latter in the method of naming or numbering the streets, in that the idea of coordinates was employed, which was altogether foreign to the Chinese.

The *mamako-date* 繼子立 was a kind of game resembling the European Josephus' problem and not found in China. It was in use in Japan after the 11th century, being recorded in a number of old documents. It was destined to attract much attention when the Japanese science of mathematics arose in subsequent years. It will be worth remembering that such a game prevailed in an age when nothing was done in the domain of mathematics.

9. In Japan for a very long period after the introduction of the Chinese science of mathematics, nothing worthy of mention was accomplished, except those casual occurrences referred to above. But under the Tokugawa Shogunate, there came a change. At that time, appeared

many mathematicians, in whose hands the *Wasan* 和算, or "Japanese mathematics," properly so called, was established. It was based, indeed, on the study of Chinese mathematics, imported for a second time, but it began to take a course of its own and arrived at results unknown in China.

Japanese Mathematics arose in the 17th century in and near the Emperor's capital, Kyoto. But this city soon yielded precedence to Yedo (now Tokyo), the Shogun's residence, which at the time of Seki Kōwa 關孝和 (?-1708) became the centre of mathematical learning in Japan and so remained up to the end of the *Wasan* in the 19th century. This state of things widely differs from that which prevailed in the study of medicine for which Kyoto continued to be the centre. Japanese mathematics had a side of practical utility, but it was in essence a sort of game or art, and as such it was cultivated by the Japanese. It owes its nature to the artistic temperament of the Japanese in general and also to the disposition prevalent in Yedo, a large city of consumers, which was controlled by a leisure class. Contemporary with Seki, there were certain noted mathematicians at Kyoto and Osaka, but their works were not so eminent as Seki's nor did there arise such influential Schools in these cities as that of Seki in Yedo. Osaka in fact proved to be a second centre of mathematical learning for a long time, but the scholars of this commercial city were possessed of less propensity than their brethren in Yedo to go down into the depths of unpractical game-like problems, in which Japanese mathematics abounded. This is certainly the reason why the study of pure or abstract mathematics in Osaka was never able to equal the work done at Yedo. On the other hand, the way for the work of the great Inō Tadataka 伊能忠敬 (1745-1818) in land surveying had been paved for him by his masters and friends at Osaka.

Japanese mathematicians used to keep their work or art secret and to reveal it only to a few of their most advanced pupils. It followed, therefore, that even talented men were not able to acquire sufficient knowlegde without entering the school of an influential person or persons. Under such circumstances, it was natural that schools were formed, of which that of Seki was the sole one that exercised a vast influence. Aida Ammei's 會田安明 (1747-1817) contention against the illustrious head of the Seki school, Fujita Teishi 藤田貞資 (1734-1807), was obviously the result of the former's brightness of talent, which he could not bring to subordination under the traditional dignities of an old school. After the controversy between these men, a large number of gifted scholars appeared, the learning of mathematics became more popular than before, and rapid progress was made. The custom of secrecy was still, however, a lamentable barrier to progress. The consequence was that there were no Japanese mathematicians of those times who had done creditable work in their younger days.

The teaching of mathematics was not systematic. Almost nothing efficient was done in the way of teaching, for the pupils were only given problems, which they were left to solve themselves. When they succeeded in solving them, they were given further problems; but if they did not succeed, they were left to the study of the same problems, thus making their progress very tedious. But in this way, selections were naturally effected, and talented persons only were left to continue in their studies, a fact which certainly did much to foster creative work.

10. The *sangi* 算木, or "calculating sticks," formed the abacus commonly used in Japan, having been brought from China in old times. They were still in use when Japanese mathematics was rising in the 17th century, and were aiding in the development of Japanese algebra, which was based on the *tengenjutsu* 天元術, or the Chinese abacus algebra of the single element. It was through the *Suan-hsüeh-Ch'i-mêng* 算學啓蒙 of 1299 that early Japanese mathematicians studied this sort of Chinese algebra. In China, the same abacus algebra had long been forgotten and its meaning was only restored by a comparison with the *chieh-ken-fang* 借根方, or "root borrowing process," literally, which meant the algebra that had been newly brought from Europe.

The Japanese, on the contrary, succeeded in understanding how to proceed in the matter, without borrowing any external aid from European knowledge, although the subject was presented in the Chinese book in a hardly intelligible manner. They soon succeeded also in establishing a written system of algebra, which was a direct extension of the Chinese science. The *endan-jutsu* 演段術 and the *tenzan-jutsu* 點竄術 both deal with this system; they are usually ascribed to Seki. The Japanese system of algebra being carried out in writing, it might be doubted not without reason whether it had not been influenced by European algebra, a doubt that might well be strengthend by the knowledge of the existence of intercourse between the Japanese and the Dutch, though under very limited conditions, contemporaneously with Seki's work. There was also a Japanese who had learned mathematics at Leyden, and another who had learned medicine in Namban 南蠻, possibly a European colony in the south of Asia, and had returned to Japan. But this doubt will be dispelled, when we trace the origin of the Japanese notations and operations from the Chinese abacus algebra of the *tengen-jutsu,* which the Japanese had remodelled in the form of a written system previously unknown in China.

In the algebra of the *tengen-jutsu,* problems were solved by forming two expressions of one and the same quantity in terms of the quantity to be found, the *tengen,* or "heavenly element," literally, and cancelling the two so as to form an equation. But in a problem somewhat complicated, it was not easy to find two such expressions to cancel one another. On this account, a parameter was adopted besides the quantity in question, and two equations were formed containing these two quantities, the elimination of the parameter leading to the final equation. This procedure resembled in a way the Chinese algebra of the four elements; but there lay an essential distinction between the two, in that the latter was carried out by the arrangements of calculating sticks, while the Japanese *endan-jutsu,* or "method of analysis" so called, did not resort to sticks but was carried out wholly in writing. There is no record of the four elements algebra of the Chinese ever having been noticed or studied in old Japan. The algebraical operations of the Japanese being thus executed in writing, certain notations were necessary, for which ideographs were found suitable. This is very notable in the history of Japanese mathematics, because nothing of the kind had developed in China.

11. The elimination processes of the *endan-jutsu* were managed in various ways, of which the use of determinants was the most notable. It was in Seki's work of 1683 that the expansion method of determinants was treated for the first time, while certain other mathematicians contemporary with him also gave their theories on the subject. Seki had committed two grave mistakes in his explanation, which were corrected by his successors. During the century or more after Seki, several extended ways of expansion were attempted. After the end of the 18th century, however, no further studies of any consequence appeared on the subject. Nothing of the sort is known in China, although the Japanese theory seems to be a development from the old Chinese treatment of linear simultaneous equations.

12. Various contrivances for the solution of equations were devised in old Japan. The old Chinese way of evaluating the root digit after digit was abridged by Seki by the use of division. Repeated applications of the old Chinese way of surplus and efficiency were also attempted

for certain types of problems, and thus there appeared a number of methods of successive approximations. There were tried also several ways of expanding the root of an equation in the form of an infinite series or other infinite expressions. *The Kaishiki Shimpô* 開式新法 of 1803 was one work dealing with this type of problem. The treatise elucidates a process of approximating by degrees all the real roots of a rational algebraical equation of any degree.

13. The *kakujutsu* 角術, or "polygonal theory," relates to the measurement of regular polygons. After Seki, attempts were made to construct equations representing the radii of the circumscribed and inscribed circles of a regular polygon in terms of one of its sides. Seki gave results from the triangle up to the 20-gon. Soon mathematicians began an examination of these equations in order to obtain the formulae in a general form, the considerations being carried out inductively. A method called *shokaku tôtetsu-jutsu* 諸角蹈轍術 was based on this way of induction. Accompanying the development of the circle-measurement, the polygonal theory underwent a related formulation and there appeared some formulae expressed in double series. Among those engaged in this study, Kurushima Gita 久留島義太 (?-1757) did some good work. There are a large number of documents about this theory, nearly all of them being manuscripts.

Inductive considerations were profusely used by Japanese mathematicians, being applied to a variety of problems, but the inductions employed were all imperfect. Seki and others used the method of induction for determinants though imperfectly and also for the enumeration of piles of various kinds, by which process a large number of interesting formulae were obtained. *Renjutsu* 廉術 and *chikusaku-jutsu* 逐索術 were mathematical methods that related to the application of inductive reasoning to obtain successive values for a certain quantity. The polygonal theory was one of the problems to which such a method had been applied. It appears also that the method of mathematical induction was nearly arrived at.

14. Circle-measurement was also early studied by Japanese mathematicians. The method given in the *Kwatsuyô Sampô* 括要算法 of 1709 may be noticed first of all. Similar considerations appeared in various other works. Within a circular arc were inscribed two equal chords, and the number of inscribed chords was successively doubled; by this means the values of the successively inscribed perimeters or their squares were calculated, a kind of treatment that is reminiscent of the

"method of differences"—*shôsahô* 招差法. In the method of circle-measurement used by the Takuma School 宅間流, expansions in infinite series were obtained from similar data by the direct application of the method of differences. The writers of the *Taisei Sankyô* 大成算經 and other manuscript works employed similar methods and arrived at formulae more convenient for numerical calculations.

In these considerations some were evidently anticipating expansions in infinite series, still others obviously based their deductions on such expansion. As an example of the mathematical method by which an infinite expansion was openly aimed at, we may refer to the analytical treatment described in the *Yenri Tetsujutsu* 圓理綴術, a method usually called by the name *yenri* or "circle-principle." It is sometimes believed to be Seki's discovery, but a work of 1726 is the first treatise in which it is described as now known. By this method succesive numerical values are not found, but successive calculations are all made analytically, using binomial expansion, and applying the method of induction, though imperfectly.

Binomial expansion was executed in exactly the same manner as in the operation of numerically solving an equation by means of calculating sticks, with the only difference that the processes were applied to the case of a literal quadratic equation, and were committed to writing. This will be obvious when we make a comparison of the two. In this matter the Japanese had advanced a step further than the Chinese. The expansion of literal equations higher than the second was executed in like manner. The circle-principle was effected by applying such an expansion method and making the number of divisions infinitely great.

15. In the circle-measurement of early days, an arc was divided into 2, 4, 8, ... equal parts. But in the cubature of a sphere, it was divided into parts of equal height. For a spiral too, the arc of the generating circle was divided into a number of equal parts. These studies evidently had a fruitful influence on the treatment of the circle. In his study of the circle-principle, Takebe Kenkô 建部賢弘 (1664-1739) had early attempted an equal division of the chord instead of the arc, but it remained for Ajima Naonobu 安島直圓 (?-1798) to achieve success along this line, thus improving the circle-principle very considerably. He effected the measurement of an arc of a circle by dividing its chord into an infinite number of equal parts. His method may be compared in some respects with the Occidental method of definite integration.

Ajima also succeeded in finding the volume of a circular cylinder which is pierced perpendicularly by another, thus employing for the first time the method of double integration. In this he made use of a double series, which he integrated term by term and thus found the resulting sum. The double or multiple series had been used after Kurushima's 久留島 and Matsunaga's 松永良弼 (?-1744) times and the expanded formulae for the polygons had been obtained in the form of a double series, but now Ajima was able to apply the double series to problems of integration. After his days, the double or multiple series were always abundantly used in the treatment of various complicated problems of integration, which now came into existence. The integration method of the circle-principle was again improved by Wada 和田寧 (1787-1840), who constructed a number of tables, by means of which the operations were remarkably simplified. He also attempted to consider one of the parts as equally divided any number of times, or the "differential" so to speak, for the purpose of integration. Wada's construction of the circle-principle tables was certainly made after the use had become known of the logarithmic tables, which, imported direct from Holland or studied through Chinese translations, were highly prized by Japanese mathematicians.

In the hands of the disciples of Ajima who had improved the circle-principle, the rectification of an ellipse was effected by using the double series. Wada again simplified the process and reduced the double to a single series. At the same time, there arose a variety of problems, which concerned the intersections of two solids, new curves and surfaces, the sections of circular and elliptic wedges, etc But all these problems concerned the quadrature, rectification and cubature of curves and surfaces, whose properties had never before been discussed. The ellipse was thoroughly studied, but the parabola received but slight attention, while the hyperbola hardly came into notice except casually on the part of careless problem-solvers. Such a state of things happened because the ellipse was commonly formed by cutting a cylinder and not a cone.

16. Japanese mathematicians were accustomed to handle their problems chiefly in an algebraical way. It was even so with problems about geometrical figures. The term "*tenzan* problems," although *tenzan* originally denoted nothing but algebra, came to be applied to problems concerning geometrical figures, showing how algebraically coloured Japanese mathematics had been. The cause is doubtless to be traced to the Chinese superiority in algebraical matters and to the fact

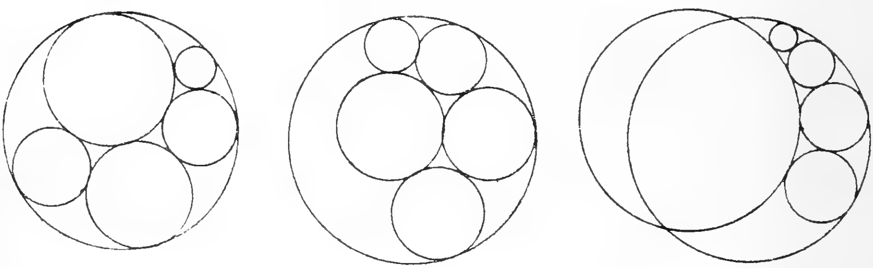
that the Japanese science was founded on the Chinese system. Nevertheless Japanese mathematics was by no means entirely defective in geometry. Geometry in its Greek sense, of course, did not develop in Japan. Japan, where the science of logic was little studied, was not a favourable soil for the fostering of a rigorous kind of mathematics and consequently the science of geometry as a logical system of deductions never developed. But at the same time, it is true that Japan gave birth to a peculiar sort of geometry indigenous to the land.

Though Japanese mathematicians were accustomed to seek algebraical means for their solution of geometrical problems, yet they could not accomplish their purpose without making certain geometrical considerations. Some preliminary knowledge of a geometrical nature thus being indispensable, even in early times such treatises were composed as Hoshino's *Kokôgen-shô* 星野實宣股句弦鈔 (1672), Seki's *Kendai* 見題 and the like. Yamada 山田正重 (1659) and Isomura 礒村吉德 (1660) proved the relation of the volume of a triangular pyramid. The proof of the sides-relation of a right triangle was given in a variety of ways. Thus, there gradually accumulated a group of what might be called geometrical theorems, or geometrical relations more properly, among which were certainly a number of beautiful ones.

During the early years of Japanese mathematics, problems were often proposed which could be solved only by resorting to very complicated equations of high degrees, such complication being regarded as elegant. But by and by arose claims for simplicity, which caused the atmosphere of the mathematical circle to undergo a complete change. Seki was one of the first mathematicians to lay claim to this merit, and the subsequent efforts of Kurushima, Ajima and others were instrumental in simplifying the nature of the geometrical problems attempted and of their solutions. Now those problems only were highly prized, which could be solved without using complicated equations. Afterwards appeared a variety of problems, whose solutions corresponded to beautiful geometrical theorems. It was then that there were made a number of collections of formulae.

The *yôdai* 容題 and *yôjutsu* 容術 were favourite subjects of Japanese mathematicians. These were names given to the problems and methods relating to figures inscribed one within another. Those geometrical problems which were studied in Japan always concerned figures in contact, both inscribed and circumscribed. Figures whose parts were separated were hardly ever considered.

The problem probably most worthy of notice is the one proposed by Sawaguchi 澤口一之 (1670) and solved by Seki. in which a great circle was circumscribed around a middle circle and two equal small circles. Various modifications occurred. Sometimes the two small circles were made unequal. Then another circle was added also in contact. Lastly there were inscribed successive circles always in contact. Similar figures were also considered where the successive circles were described touching two intersecting circles, and the like, cases where the successively



described circles form a crown also being considered. There was devised a method called *chikusaku-jutsu* 逐索術 for the evaluation of the diameters of these successively inscribed circles. The method evidently bears a close relation to the recurring calculations of successive values, applied by Japanese mathematicians to various sorts of problems. It proved a long step forward in the advancement of Japanese geometry.

Another important problem was that which related to three circles inscribed within a triangle. This problem obviously corresponds to Malfatti's problem; and it was solved before Malfatti. It was not considered, however, as a problem of construction, but as one of evaluating the diameters of the inscribed circles. This problem was soon extended to the case of inscribing four circles. There were also considered problems in which circles were inscribed between three circular arcs. And further there appeared a number of figures, in which successive circles were variously inscribed, this problem being solved by the application of the above mentioned process of successive calculations. Ajima tried to make use of a geometrical relation concerning the tangent common to two circles for the solution of a large number of problems of contact. Some years later there appeared another relation for the same, which was more convenient in application.

It was by the aid of this relation, that the problem of the six tangents to four circles touching another was solved, the solution being nothing but Casey's theorem, obtained tens of years ahead of Casey. The relation of the six tangents was in turn used to solve many other problems. Thus there arose various problems in which a number of circles were variously inscribed within a larger circle.

There also appeared a certain method that may remind us of inversion. In this connection, Hasegawa Kwan's 長谷川寛 (1782-1838) *Kyokugyô-jutsu* 極形術, or "method of limiting figures," is to be noticed. It was not an accurate method indeed, because it sometimes erred in its conclusions, but it proved to be a step toward further progress. The work of Hôdôji Zen 法道寺善 (1820-1868) in establishing a new method of inversion–let us be allowed to use such a term–was based on Hasegawa's method, as he himself acknowledged. Hôdôji had no idea of inversing a figure into another, it is true, nor did he think of the center of inversion. But his transformations gave the same results as inversion. Moreover he had the idea of a tangent common to two circles, even when one of them was entirely within the other. By means of this method he was able to solve many a problem. His method, however, was neither printed nor otherwise made public. Before him, Ushijima Seiyô 牛島盛庸 (1756-1840) had certainly discovered a similar method, though his researches are little known. Ômura Isshu 大村一秀 also gave the same. In considering the development of this sort of treatment, we must take into account, besides the progress of the considerations of variously inscribed circles, also the fact that the geometrical interpretations of the roots of algebraical equations had exercised no small influence.

In this manner the branch of geometry in Japanese mathematics had been gradually advancing in organization, many noticeable results being established from time to time. But now all advancement on a sudden came to a stop, for the study gave way to the importation of Western mathematics on a large scale.

17. The theory of numbers and the solution of indeterminate problems were also themes fondly attacked by Japanese mathematicians. The use of the equation

$$ax \pm by = 1$$

was certainly due to China, but it was used in Japan to solve a large number of problems unknown in China. For integral solutions of a right triangle, a number of results were obtained. The oblique triangle was also solved in several ways. There were many other sorts of figures, of which solutions were obtained by whole numbers. Those problems in which a crown of successively circumscribed circles was considered, come under our present heading, thus showing an intimate relation with the progress of treating successively described circles. Of this kind of problem, some very beautiful solutions were obtained by Ajima and Gokai 御粥安本. Japanese mathematicians solved in integers not only problems about certain specified geometrical figures, but used also always to give integral value solutions for all the sorts of geometrical problems which they considered.

The calculations of the integers for a right triangle were soon extended to the case of a rectangular trapezoid. At the same time, there were considered a number of indefinite equations without making any reference to geometrical figures. Most meritorious of these were the equations

$$y^2 = x_1^2 + x_2^2 + \dots\dots + x_n^2$$
$$y^2 = 1x_1^2 + 2x_2^2 + 3x_3^2 + \dots\dots + nx_n^2$$
$$y^2 = 1x_1^2 + 3x_2^2 + 6x_3^2 + \dots\dots + u_n x_n^2, \text{ etc.}$$
$$x^3 + y^3 = z^3 + u^3.$$

The factorization of numbers and the section of prime numbers were also attempted, leading to worthy results.

There were numerous studies in connection with magic squares, which had been first imported from China. The ancient Chinese diagram called *Lo-shu* 洛書 was a contrivance for arranging the first nine natural numbers in a magic square, certainly the oldest example of the kind in the world. Other magic squares and magic circles were recorded in a work of the 13th century and were reproduced in the *Suan-fa T'ung-tsung* 算法統宗 of 1593. It was these that had stimulated the Japanese to make further studies along the same line. In Japan many interesting results were obtained that were not encountered in China. Japanese mathematicians also attempted to find out the greatest possible number of magic squares which could be arranged with certain given numbers. Magic cubes were noticed too, although very rarely.

18. So far, we have given a rough general survey of the work of the old Japanese mathematians. It is of course out of the question for us to give every detail of their work in this short article. The development of differentiation, of the theory of limits, and of the treatment of continued fractions, as well as the cubature of certain solids of revolution and numerous other themes, have all been omitted.

Japanese mathematicians learned very much at the outset from

Chinese works, but they were soon able to establish their own new science and to surpass their Chinese predecessors in the details of their studies. The subjects mentioned above were all unknown in China. Japanese mathematics may be truly said to be modelled on the Chinese science; it proceeded, however, into regions previously unexplored.

Japanese and Chinese mathematicians of modern times have sometimes considered similar problems and used similar methods, a circumstance obviously due to the fact that both were following the older Chinese science along parallel lines. But in most of these cases, the Japanese were ahead of the Chinese. Moreover, the former generally obtaind superior results, sometimes problems being attempted that were altogether unknown in China. The foundation of algebra in the written style, the organization of a peculiar sort of geometry, and studies in the theory of numbers, in the polygonal theory, and so on, were themes in the study of which the Japanese only, and not the Chinese, were able to arrive at brilliant results. In the measurement of the circle, the studies of equations, method of differences, summation of progressions, etc., the Japanese were superior to the Chinese. There is almost nothing, however, to record of contrary cases.

The *soroban* 算盤 was brought from China to Japan. The oldest examples in existence are one in Ise Province belonging to the Bun-an Era (1444-49) 文安 and one that was used by Mayeda Toshi-iye 前田利家 and handed down to his family, Marquis Mayeda. The Japanese at first used instruments imported from China or those made after the Chinese fashion. But there soon arose Japanese styled instruments, in which the balls were made sharply edged, whereas the Chinese abacus was provided with somewhat rounded balls. In China there is no evidence that the development of mathematics was influenced by the *soroban*. It was otherwise in Japan. As the *soroban* was simpler to manipulate than the calculating sticks, Japanese mathematicians were in general desirous of making as much use of the former as the case would permit. But higher equations could be solved only by means of the sticks, and not by the *soroban*. Consequently mathematicians hoped to devise a method by which calculations of all sorts could be carried out by means of the *soroban*. The establishment of infinite expansions and successive approximations resulted. There appears no trace, on the contrary, in Chinese mathematics contemporary or otherwise, of the *soroban's* having had so important an influence.

19. After the end of the 16th century, Chinese mathematics

received considerably more influence from Western science than did the Japanese. Nevertheless, the achievements of the Chinese fell behind those of the Japanese, who pursued their own course in this field more brilliantly. This does not force us, however, to conclude that the Japanese were superior to the Chinese in ability. The Japanese mathematicians were most of them experts only in the field of mathematics, little accomplished in other departments of learning, and thus were able to concentrate their efforts on their subject matter. There was, however, among the Chinese practically no one who made a specialty of mathematics to the same extent. The Chinese scholars were all learned in the study of calendars, which they studied, in turn, not for the sake of the subject itself, but for the necessity of being intimate with the classics. They were therefore classical philosophers of a sort, who were also versed in calendars and mathematics. As a matter of course, their entire attention could not be directed towards the single subject of mathematics. But now in China there are appearing specialists in mathematics, who pursue their studies after the Western mode and thus the state of Chinese mathematics will soon be improved.

20. The old Japanese system of mathematics was not without some European influence, of course. Contemporary with Seki, there was a Japanese who had learned mathematics in Holland. There were imported into Japan some of the Chinese translations of European mathematical and astronomical works. But they were soon listed as forbidden books. The Japanese in Holland, it appears, did not come back to Japan. The importation of the *Li-suan Ch'üan-shu* 歴算全書 and other works constituted the main source of European mathematics for Japanese students. Trigonometry was introduced into Japan in this manner, and was highly prized. The logarithmic tables were brought to Japan both through Chinese translations and also directly from Holland, and were also greatly admired.

The ellipse was studied from early times in Japan, but it was Aida Ammei 會田安明 who studied it thoroughly for the first time, it having been of some interest also to his immediate predecessors. These studies were probably the result of the influence of the European theory of elliptic orbits which had newly been learned from foreign sources in connection with calendrical matters. Problems on the centre of gravity also began to appear based on European knowledge. The same is true in the case of roulettes, too.

The study of Chinese translations of European astronomical works and the calendrical reform in the Kwansei Era (1789-1801) 寛政 were powerful factors in introducing European mathematics into Japan. Takahashi Yoshitoki 高橋至時 (1764-1804) studied the astronomical work of La Lande and composed volumes of reviews about it, in which he recorded something of the formulae of integration, which he compared with the results of the Japanese method of limits and thus acknowledged the correctness of the method. It appears therefore that he had understood the Occidental mathematics in this work by dint of his previous knowledge of Japanese mathematics. If he had been an expert in mathematics besides being an astronomer, or had he been in intimate relationship with specialists in mathematics, he might well have considerably influenced the Japanese mathematicians of his day in favor of the study of the European science. But such was not the case. The custom of schools based on the principle of inherited traditions seems to have shut the doors of the studies of Japanese mathematicians to new knowledge from without.

Some of the writings of Japanese mathematicians contain passages in which it is maintained that China and the West are superior in astronomy and calendrical subjects, but that in the field of mathematics, Japan surpasses China and the West. Such was certainly the general opinion among the mathematicians of the day. Although the astronomer Takahashi had justly acknowledged the true value of European mathematics, there were none among the mathematicians who shared his view. It happened in considerably later years that Uchida Gokan 内田五観 called his school by the European name "Mathematica" and that Yanagi Narayoshi 柳楢悦 studied the differential and integral calculus of the West. Uchida knew a little Dutch, but his linguistic knowledge was very limited. It is very remarkable that there was not a single person well versed in Dutch or other European languages among the old Japanese mathematicians even in the latest years of the *Wasan*, whereas the astronomers contemporary with them were most of them learned in European languages and European science. The mathematicians of those days would have had little to learn, if they had read European works on arithmetic or algebra; as to advanced works, they could not have understood anything and so these must have been left untouched. Such circumstances made it very hard for the European science to exercise a powerful influence over Japanese mathematics. It follows therefore that the *Wasan* or old Japanese mathematics was left, on the whole, to pursue its own course until its last days without undergoing any considerable transformation from without.

21. The development of the so-called Japanese mathematics was restricted to the duration of the Tokugawa Shogunate. After the Restoration of 1868, European mathematics being adopted for school classes, the adherents of the *Wasan* at first contended strenuously with the newly rising Europeanised mathematicians. They withered one by one, however, and there appeared no new partisans; thus the way was clear for the progress of the Western science. The adoption of the new mathematics was by no means because of its intrinsic superiority over the *Wasan*, but because of its value as a basis for the study of the physical and technical sciences of the *West*. The lack of knowledge of these sciences had been strongly felt by the Japanese, because it was just this defect that had left Japan too feeble to contend with the Western powers. Original studies subsided for a time after the adoption of the Western system of mathematics. But some twenty years after the Restoration, certain researches were undertaken after the mode of the new science, and further progress has been made, ultimately leading us to the present state of affairs.

22. Of historical studies on the old Japanese mathematics, mention must be made first of T. Endo's *History of Japanese Mathematics* (in Japanese) (1896) and the revised and enlarged edition of 1918. After Endo's work appeared the studies of D. Kikuchi, T. Hayashi, Y. Mikami, K. Yanagihara and others, in whose hands details as well as general and historical views were given. Besides these, there are C. Kawakita, N. Okamoto, K. Kano, J. Kawai and others who are deeply versed in the subject but whose works have, for the most part, not been published.

The Chinese have published a number of studies based on European and American histories of mathematics. The Chinese Li Yen 李儼 has published a number of historical articles and his works are well known. Besides Mr. Li, there are also others who occasionally bring out their writings on the subject, and the historical studies of the Chinese are gradually advancing.

IX. On the Development of the Astronomical Science in the Ancient Orient.

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Contents

1. Introduction.

It is regrettable that the history of astronomy in the ancient Orient is still buried in much obscurity in these days. To take only a single instance of contrary opinions, we see, on the one hand, that in the 11th edition of the Encyclopedia Britanica, the remote antiquity of Chinese astoronomy is put forward as a hypothesis by the author, who mentions, though with hesitation, the much talked about and yet suspected cases, of a solar eclipse which is thought to have been due to be predicted by calculation at a date as early as the 22nd century B.C., and also of an exact determination by Chou-kung in the 12th century B.C., of the obliquity of the ecliptic, giving a value 23°54′ 3.″15, closely coinciding with the value theoretically found by Laplace for that date. On the other hand, Mr. Iijima, a noted sinologue, is of the opinion, and has repeatedly expressed it in many professional papers, that the origin of Chinese astronomy goes only as far back as the 4th century B.C., and that it most probably started its course under the influence of the Hellenistic civilization, which he assumes to have been imported into China subsequent to the time of Alexander's Indian expedition (326–5 B.C.).

Between these extremely divergent views, we must endeavor to find out the true course, putting our steps always on a solid basis, that of scientific investigation of the existing materials, subject to text-criticism in the strict sense.

As far as may be inferred from our thorough study, the development of the astronomical science in China, from the remotest ages down to the epoch of the foundation of the calendar system in the T'ai ch'u 太初 period (i.e. 104 B.C.), seems to have followed on the whole a quite natural order of evolution, showing no trace whatever of an abrupt discontinuity caused by foreign influences. We may, however, notice certain epochs during which important improvements seem to have been introduced:

(a) Introduction of the solar calendar at the time of the Emperor Yao 堯, presumably about the 24th century B.C.

(b) Introduction of the 28th *hsiu* system 二十八宿法, about the beginning of the Chou dynasty 周, in the 12th century B.C.

(c) Introduction of the gnomon 土圭, a little before the middle of the Ch'un ch'iu period 春秋 (722–481 B.C.), for observing the exact epoch of the solstices.
This seems to have aroused the idea of considering the winter solstice the ideal beginning of the year.

(d) Important progress was made about the middle of the Chan kuo age 戰國時代 ("Struggle age," 480–250 B.C.):
Foundation of a definite calendar system, the *Chuan yü* calendar 顓頊歷 in this case;
Observation of the five planets;
Foundation of the *wu hang* theory 五行說 ("Theory of the five essentials");
Systematic observation, naming and cataloguing the constellations, etc.

(e) Adoption of the first official calendar system, the *T'ai ch'u li* 太初歷 in 104 B.C.

2. The Lunar Calendar.

It can not be doubted that from time immemorial the pure lunar calendar had been long in use, as is usual among almost all primitive nations. In fact, the lunar calendar, i.e., the mode of reckoning days according to the lunar phase, is nothing but a convenient contrivance for utilizing the lunar illumination at night for the purpose of human life.

Since a month of 29 or 30 days is rather too long to be used as a convenient interval for primitive life, it is quite natural that a mode of dividing it into three or four parts was soon adopted in these old days. The mode of dividing a lunar month into four quarters seems to have been widely in use in western Asia, and it is generally accepted that the present use of weeks in almost all civilized countries is nothing but a modified or improved form of the ancient lunar quarters. In China also, we suspect that there was some trace of the use of lunar quarters about the beginning of the Chou dynasty; their use, however, seems not to have been general.

The mode of dividing a lunar month into three decades was in general use in the Orient until recently, the trisected part of 9 or 10 days being called *hsün* 旬. The ten ordinals, or *chia i ping ting mou chi kêng hsin jèn kuei* 甲乙丙丁戊巳庚辛壬癸, usually known as the "Ten stems" 十干, whose original meaning is almost lost in oblivion, can be nothing but the ordinals marking the days of a decade (旬). We see, indeed, that the ten ordinals were called "Ten days" 十日 in the older classics, the nomination "Ten stems" 十干 being no earlier than the Han dynasty 漢 (206 B.C.–221 A.D.)

3. The *Ch'èn* 辰, or Standard Asterisms.

The steady increase of population soon necessitated the production of provisions in abundance; and since this could be effected only by the systematic cultivation of food-plants, utilizing in fact the seasonal variations to the utmost, the preparing of a good solar calendar became an urgent necessity. The date of the first introduction of the solar calendar probably corresponds to the time of the sacred but at the same time somewhat fabulous emperors Yao 堯 and Shun 舜, which is estimated to fall at about the 24th century B.C.

As the length of a tropical year was not at all known at that remote age, the only reasonable way must have been to determine the seasonal epochs by observing certain cardinal asterisms just after sunset or just before sunrise. Thus the Egyptians used to observe the heliacal rising of Sirius, and the Chaldeans the same of Capella, as means of fixing the beginnings of their respective agronomical calendars.

In China, many such asterisms seem to have been in use, probably in different localities, or in different ages, all being called by the name of *ch'ên* 辰, or standard asterism. We can trace at least five of them: *Ta-huo* 大火, Antares; *Ts'an* 參, Orion; *Pei-tou* 北斗, the Dipper, or the seven stars of Ursa Major; lunisolar conjunction points 交會點; and the sun itself (meridian altitudes being observed with gnomon 土圭). Of these, the first three seem to have been in use anterior to the beginning of the Chou dynasty in the 12th century B.C.; the fourth was then introduced probably as a successor to the *Pei-tou* 北斗, the Dipper, which in turn gave place to the fifth about 600 B.C., the gnomon being then used for observing the solar altitude.

We see, in the *Ch'un-ch'iu Kung-yang-chuan* 春秋公羊傳, which is a commentary on the *Ch'un-ch'iu* 春秋 by Kung-yang, written presumably about the third century B.C., the passage:

> "*Ta-huo* (Antares) is a large asterism, *fa* (=*Ts'an*, Orion) is a large asterism, and the northernmost asterism (=*Pei-tou*, the Dipper) is also a large asterism."
>
> 大火爲大辰。伐爲大辰。北極亦爲大辰。

Ta-huo 大火, i.e., *α* Scorpii, had been long observed from the earliest times, as the asterism indicating midsummer (i.e., the fifth month of the year according to Chinese counting) by its meridian transit in the evening just after sunset. Since it had been in use as the standard asterism for several hundred years throughout the whole of the Yin dynasty 殷 (1766–1122 B.C., according to the common chronology), it came at last to be worshipped as the patron-god of the people of Yin; and further, in later days to be worshipped as the holy celestial dragon (Scorpion) by the whole nation. Thus it gradually monopolized the name *ch'ên* 辰, and on the occasion of preparing 12 symbols for the designation of the 12 months, presumably towards the end of the Yin dynasty, the character 辰 was made the symbol denoting the fifth.

Ts'an 參, the three stars in the belt of Orion, seem to have been observed as the asterism fixing mid-winter (i.e., the eleventh month according to Chinese counting) by their appearance in the eastern sky just after sunset. The eleventh sign *hsü* 戌, in the row of 12 symbols (十二支) designating the 12 months, seems to be nothing but a figure standing for an ax, which the configuration around the asterism 參 seems to have been thought to resemble. The Chinese character 歲 *sui*, a year, is composed of two characters, 戌 *hsü* and 步 *pu* (to step), obviously denoting the interval between the month of 戌 (i.e., the eleventh) in one year and the same month in the next year.

Pei-tou 北斗, or the seven stars of Ursa Major, were configurated as a dipper (a vessel with a handle), and the direction of the handle just after sunset was taken as an indicator of the seasons. In particular, the vertical hanging of the handle seems to have been taken as indicating the beginning of the new year. Very probably this device had been mainly used by the people flourishing in the northern districts, — perhaps the forefathers of the people of the Chou dynasty, down to the 12th century B.C.

The sequence of the standard asterisms, from *Pei-tou* 北斗 to the 28 *hsiu* system 二十八宿法, seems to be confirmed by the existence of many traces of interrelation remaining in the 28 *hsiu* system.

It may be noticed here that the 12 symbols, *tzŭ ch'ou yin mao ch'ên ssŭ wu wei shên yu hsü hai* 子丑寅卯辰巳午未申酉戌亥, usually known as the "Twelve branches" 十二支, seem to have been originally devised for the designation of the 12 months of a year, and probablly came into general use in the course of the Yin dynasty. Having then at hand 10 ordinals for counting days and 12 ordinals for designating 12 months, it is quite natural that these two series of ordinals came to be combined to form the convenient system of the sexagesimal cycle. Evidences from several sources, including that of recent excavation at the site of an ancient capital of the Yin dynasty, convince us that the counting of days by the sexagesimal cycle had begun at least before the end of the Yin dynasty.

The row of 12 animals, standing usually in place of the 12 symbols, seems to have been first attached to the latter somewhat about the *Chan kuo* age 戰國時代 ("Struggle age," 480–250 B.C.).

4. The 28 *hsiu* system and the gnomon.

About the beginning of the Chou dynasty (in the 12th century B.C.), the ingenious idea of utilizing the lunar positions for the determination of the seasons seems to have been introduced If we observe the daily march of the moon through the starry heavens, beginning f.om the first appearance of the crescent (i.e., the new moon in its verbal sense), and then in imagination follow the moon's course for two days backward from this position, we should then arrive at the conjunction point of the sun and moon. The determination of the conjunction point in the starry heavens (i.e., on the ecliptic), gives us, of course, the true seasonal position of the epoch at once.

The 28 *hsiu* system 二十八宿法, widely in use in the ancient Orient, is nothing but a mode of dividing the whole ecliptic into 28 parts, roughly corresponding to the number of days in a sidereal month (27.3 days), thereby providing 28 reference points for the determination of the position of the conjunction points. Although the original meaning has long been lost in oblivion, we see that the system is still in use in China, India, and Persia, with variations necessarily resulting from long ranges of transference to different countries.

The birth-place of the 28 *hsiu* system has been and is now also in dispute among scholars. Permit me to call attention here, however, to some important points regarding this question. If we notice that by prolonging the direction of the handle of the *Pei-tou* 北斗, we arrive at the bright star Arcturus and still further at Spica, then the facts, first that the Chinese system begins with Spica, secondly that Arcturus is called *Tai-chiao* 大角, while Spica is called *Chiao* 角, and thirdly that the Indian system contains Arcturus among its members, notwithstanding the distance of this star from the ecliptic, — all these facts seem to indicate that the 28 *hsiu* system must have come into use as a sequence to the *Pei-tou* system. Further, the fact that the Indian system contains Vega and Altair among its members, both distant from the ecliptic, seems to suggest the origin of the system in a country like China, where the love-story of Chien niu 牽牛 and Chih nü 織女, i.e., Vega and Altair, has been very familiar to the public since remote ages.

From this and other evidence, it seems to me almost without doubt that the 28 *hsiu* system was first invented and adopted in China about the 12th century B.C. in sequence to the Pei-tou system, that it was transferred into India, probably about the *Chan-kuo* age in China (480 B.C.– 250 B.C.), and that the Chinese system has since undergone several readjustments, of which at least one in the Han dynasty is recorded in history, while the Indian system still represents the primitive form.

A further important step was made by the introduction of gnomon, a little before the middle of the Ch'un-ch'iu period 春秋時代 (722–481 B.C.). Although the use of the gnomon 土圭 is described in the *Chou-li* 周禮, the date of compilation of which is commonly taken to be at the beginning of the Chou dynasty, we shall not consider this point, the *Chou-li* itself being surely the production of a later date.

Once the gnomon was used for observing the length of the shadow thrown by the meridian sun, two important results should be expected to follow: first, the determination of the epochs of solstices should become far more exact than before, giving rise in turn to the production of good solar calendars, and secondly, the idea of considering the winter solstice the ideal beginning of the year might be expected to arise. We see now that exactly these two effects did take place a little before the middle of the Ch'un-ch'iu period.

5. The *Ch'un-ch'iu* 春秋 and *Tso-chuan* 左傳.

The *Ch'un-ch'iu* 春秋 are systematized annals of the Province of Lu 魯, covering the reigns of 12 princes and an interval of 242 years from the first year (722 B.C) of Prince Yin 隱公 to the fourteenth year (481 B.C.) of Prince Ai 哀公; and being, as is said, compiled with strict cautiousness by so great an authority as the sage Confucius 孔子, they afford us invaluable material for the study of the history of ancient China.

The dates are given in years, months and days. The years are counted from the accession of the princes to the throne, and the months are lunar, being numbered every year from the first to the twelfth with an occasional intercalary one. The days are, however, counted according to a continuous sexagesimal system, quite independent of the months or years. It is nowhere stated what kind of calendar system is used; that is, we have no mention of the rule for the insertion of intercalary months, or for the correspondence of the sexagesimal system with the beginnings of the months. We must, on the contrary, clarify all these points by thorough study of the annals themselves, beginning indeed with an enquiry into the genuineness of the text, as transmitted to our hands.

There are from olden times many commentaries on the annals, the oldest and most important for our present purpose being the *Tso-chuan* 左傳, which contains a large amount of extended narrative material, valuable for study in every direction. Sad to say, it is an open question when and by whom the *Tso-chuan* was written. Old tradition says it was written by Tso Ch'iu-ming 左丘明, a contemporary of Confucius; and one view of the modern critics is that it was fabricated by Liu-hsin 劉歆 about the time of the Christian era.

The chronology of the *Ch'un-ch'iu* 春秋, and the date of the compilation of the *Tso-chuan* 左傳, are two quetions very important for the study of ancient history, which, though much discussed, have not yet been solved. We find in the *Ch'un-ch'iu* 春秋 records of 36 solar eclipses, of which 5 cases must be cancelled as mistakes, leaving 31 cases to be utilized for study, and also the mention of 389 dates, given according to the sexagesimal system. Now comparing these 31 records of solar eclipses with the results of modern calculation (e. g., with Oppolzer's *Canonen der Finsternisse*), we should obtain 31 fixed epochs during 242 years, and then studying the distribution among these fixed spochs of the 389 dates in the sexagesimal system, we should able to find out the proper arrangement of the intercalary months, i.e., the arrangement practised at that time.

As the result of a thorough study made in 1920, I have been able to carry out this procedure, and have obtained the arrangement of the intercalary months shown in the diagram (Pl. XLVII.) If the positions of the intercalary months be once found, then the real chronology of all the date can be put forward at once.

We observe that for the latter half of the Ch'un-ch'iu period (722–481 B.C.), the insertion of the intercalary months is tolerably regular, amounting to seven in nineteen years, and so the beginning of the year is kept at a nearly constant seasonal epoch, the first month being always adjusted so as to include the winter solstice. During approximately the first third of the period, the beginning of the year seems to have been about one month later in every case, the interval following it and preceding the latter half of the period being a time of transition, and hence showing a comparatively large variation in the beginning of the year. This clearly shows that an important improvement must have taken place a little before the middle of the Ch'un-ch'iu period.

It may be well to notice here that the procedure of inserting seven intercalary months in 19 years, is just a mode of keeping the mean length of the year equal to 365.25 days, at the same time that the lunar calendar is used, with lunar months of a mean length of 29.53 days. In fact, we have the relation

$$29.53085 \times (19 \times 12 + 7) = 6939.75 = 365.25 \times 19.$$

This is exactly the same as the calendar system, known in the Occident by the name of Callipos, compiled in 334 B.C. The coupling of the solar with the lunar calendar to form a kind of lunisolar calendar has been always practised in the Orient until recently.

To fix the date of the compilation of the *Tso-chuan* 左傳 is a very interesting problem. Fortunately, we find in the *Tso-chuan* 左傳 and also in the *Kuo yü* 國語 which is without doubt intimately associated with the former, many astrological narratives, giving therein the positions of Jupiter in the heaven. By comparing these positions with the results of modern calculations (e.g., with Neugebauer's *Tafel der Planeten*), and studying the increase of deviation toward the earlier age, we may easily infer that all these positions of Jupiter are nothing but products of an erroneous calculation at an epoch about 370–360 B.C., made with an assumed period of 12 years instead of 11.86 years for the period of revolution.

It is, then, evident that the epoch of the compilation of the *Tso-chuan* can not be earlier than circa 360 B.C.; further study of the text-content shows that it can not be much later than that epoch. If the epoch of the compilation of the *Tso-chuan* be thus once fixed to about 360 B.C., then we have in our hands voluminous material originating from a definite period, and hence immensely valuable for the investigation of ancient Chinese civilization. We see, that the *Chan-kuo* age, 480–250 B.C., although it has been usually looked upon as a kind of dark age, must have been in reality a period of progress, perhaps as a result of free competition in a wider circle. In the scope of astronomy, we see that remakable progress at least along the following lines was made during this period:

(i) Foundation of the calendar system *Chuan yü li* 顓頊歷,

(ii) Observation of all of the five naked-eye planets, giving rise to

(iii) The foundation of the *Wu hang* theory 五行說, according to which all the phenomena in our universe in general may be looked upon as the various combinations of five essential elements, wood, fire, earth, metal, and water. The school holding the *Wu hang* theory predominated among the learned classes in the Orient for as long as over 2000 years after this time.

(iv) Systematic observation of the starry heavens.

6. Foundation of the Calendar System.

We have seen that in the latter half of the Ch'un-ch'iu period (722–481 B.C), the determination of the seasonal epochs had been greatly improved, and hence the harmonizing of the lunar and solar calendar by the intercalation of seven months in nineteen years, seems to have been effected almost without a failure. We even suspect the existence in that early period of a definite calendar system, by means of which the intercalation may have been mechanically effected.

It seems quite certain, however, that in the latter half of the Chan kuo age, a certain calendar system, called *Chuan yü li* 顓頊歷, had been founded and was afterwards in general use, until the adoption of the *T'ai ch'u li* 太初歷 (or "First calendar system") in 104 B.C., under the reign of the Eemperor Wu-ti 武帝. In the *Chuan yü* calendar system, it is assumed that

the length of a year = 365.25 days,

the length of a month = 29.53085 days,

making

$$29.53085 \times 235 = 365.25 \times 19,$$

that in the year 366 B.C.,

the seasonal epoch *li-ch'un* 立春, the 1/24 part of a year preceding the vernal equinox, and considered at that age as the ideal beginning of a year,

the new-moon (conjunction), considered as the ideal beginning of a month,

the day *chia-yin* 甲寅, considered as the first in the sexagesimal system,

and the dawn, considered as the ideal beginning of a day,

—all these happened just to coincide with one another, that this coincident epoch ought to be taken as the natural origin of the calendar system, and that hence the year 366 B.C. was to be counted as the year *chia yin* 甲寅, the first year of counting in the sexagesimal system.

From evidence from variour sources, we assume the epoch of foundation of the *Chuan-yü* calendar system to have been somewhere about the time 360–330 B.C. As a sidelight on this matter, I may quote a passage from the book of *Mencius* 孟子, a collection of sayings of the great sage Mencius, who is believed to have been active about 300 B.C. "The heaven is high, the stars are remote; yet if we proceed on the right way in the search for truth, we should be able to find out the epoch of solstices even thousands of years hence."

天之高也。星辰之遠也。茍求其故。千歲之日至。可坐而致也。

This passage is especially interesting to us, as showing first that about the time of Mencius, a difinite calendar system must have been already long in practical use, so as to give a layman like Mencius strong confidence in its reliability, and secondly, that the success of the astronomers in preparing a good luni-solar calendar must have aroused in the general public a keen interest in the science in general.

The year 104 B.C. is an important epoch in the history of astronomy in China. A large-scale conference was held in order to discuss the problem of calendar-reform, and after some controversy, it resulted in the acceptance of an official calendar system by the name of the *T'ai-ch'u-li* 太初歷 ("The first calendar system"). It is indeed the first calendar system sanctioned as official, and after that all the succeding calendar system, about 50 in number until recently, being equally sanctioned as official reformations, are always fully described in the official records of the dynasties. They are all of course according to the luni-solar system.

As to the *T'ai-ch'u-li* 太初歷 itself, although the records are not without ambiguity, and hence have been at times much debated, yet it seems to me certain that it is in essence nothing but the calendar system *San-t'ung-li* 三統歷, fully described in the *Han-shu* 漢書 (history of the Han dynasty). We see that it is therein assumed that

$$\text{the length of a year} = 365\frac{385}{1539} = 365.2502.$$

$$\text{the length of a month} = 29\frac{43}{81} = 29.53085,$$

making

$$365\frac{385}{1539}\times 19 = 29\frac{43}{81}\times 235,$$

that, in the 11th month of the year preceding 104 B.C.,

the winter-solstice, the new-moon (conjunction),

the day *chia-tzŭ* 甲子, midnight, and also an eclipse,

—all these happened just to coincide with one another, and that hence this coincident epoch ought to be taken as the beginning of the calendar system.

It may be noticed here that theoretically the approximate period of eclipses might be taken as any one of the series, 88 135 223 358 .... months; and that here in the *T'ai-ch'u-li*, the period of 135 months is used, while in the Occident the period of 223 months was known under the name of the Chaldean Saros. This fact gives us strong evidence that Chinese astronomy was free from Western influences at least until the date 104 B.C.

7. The Star-catalogue of Shih-Shên 石申.

We find in historical records, that there were in the *Chan-kuo* age (480–250 B.C.), two eminent astronomers Shih 石 and Kan 甘, that they observed the five planets and the starry heavens, and that they each compiled a catalogue of fixed stars. These catalogue have, however, long been lost in oblivion.

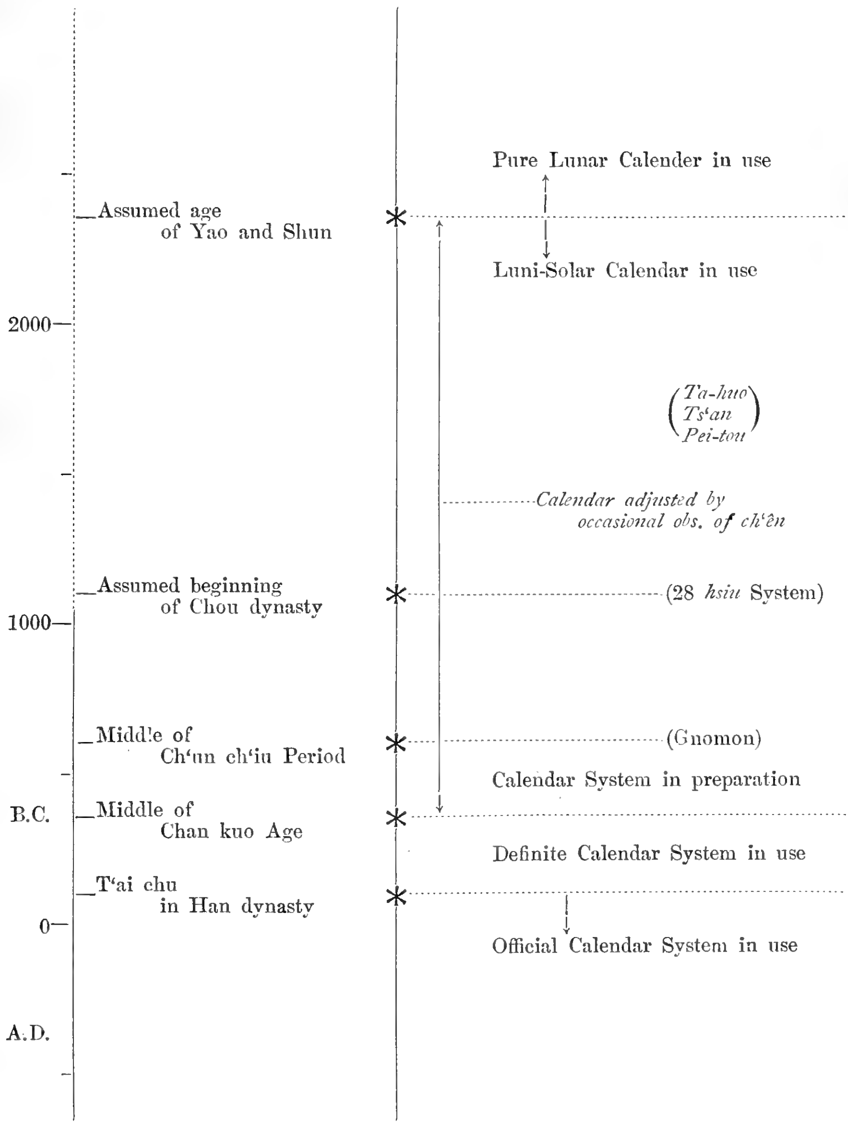
Quite recently, I happened to make a study of the remnants of these catalogues scattered as quotations among several books from the early T'ang dynasty (about the 7th century A.D) — the *K'ai-yüan-chan-ching* 開元占經, *T'ien-wen-yao-lu* 天文要錄, *T'ien-ti-jui-hsiang-chih* 天地瑞祥志, and also a book recently excavated in Tun-huang 燉煌, and I was lucky enough to be able to reproduce a catalogue of about 120 stars, all with positions as measured by Shih-Shên 石申. I was also able to estimate the probable date of observation as ca. 300 B.C., by utilizing the phenomenon of precession. If we remind ourselves that the oldest star-catalogue in the Occident is that of Ptolemy containing 1020 stars with positions observed by Hipparchus at about the second century B.C., we see that the catalogue of Shih-Shên stands not at all inferior to it. The degree of accuracy of the star-positions is also about the same for both.

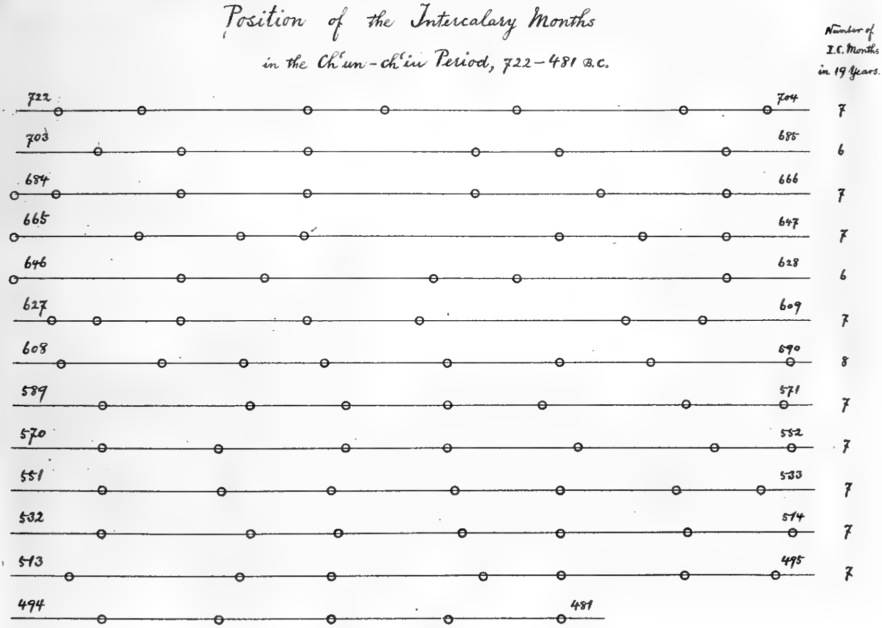
8. Concluding Remarks.

I have so far followed the development of the astronomical science in China, from the remotest ages down to the Han dynasty in the second century B.C. It is just for this earliest period that the true nature of things has been to some degree buried in the remote obscurity of ancient times, and hence concerning this period there are many divergencies of opinion among scholars. I believe I have been able to take off the veil and disclose the true state of affairs to a certain extent.

We see that there is no trace at all at least before 104 B.C. of the introduction of the Western science of astronomy to the Orient; we see, on the contrary, that the development in the Orient was rather a little in advance of that in the Occident.

After the epoch of T'ai-ch'u (104 B.C.), the further development of the astronomical science in China, its propagation to India on one side, and to Japan on the other, the introduction of Western astronomy in the T'ang (618–906 A.D.) and the following dynasties, etc., are all interesting topics for study, which may be investigated with comparative ease. All these we refer to future study.




Position of the Intercalary Months
in the Ch'un-ch'iu Period, 722–481 B.C.
Number of I.C. Months in 19 Years.
722
704
7
703
685
6
684
666
7
665
647
7
646
628
6
627
609
7
608
590
8
589
571
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570
552
7
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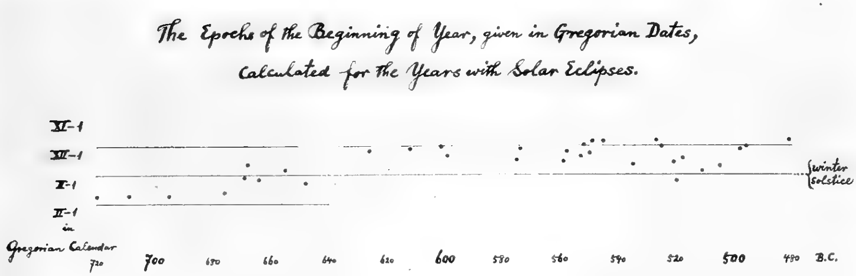
533
7
532
514
7
513
495
7
494
481


The Epochs of the Beginning of Year, given in Gregorian Dates,
Calculated for the Years with Solar Eclipses.
XI-1
XII-1
I-1
II-1
in
Gregorian Calendar
winter solstice
720
700
680
660
640
620
600
580
560
540
520
500
480
B.C.

X. *A brief history of Botany in old Japan.*

By

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In tracing the history of botany in Japan we can distinguish three periods, i.e. the pents'ao period, the natural history period, and the scientific botany period. In the pents'ao period which extends from prehistoric times to the end of the fifteenth century, investigations of plants were carried on principally to get the knowledge of their medical uses. In the natural history period which begins from the sixteenth century and ends in 1868, investigations of plants were extended to useful plants other than medicinal plants. In 1868 the Imperial power was restored and the European mode of education was adopted and the arts and sciences of Western nations were introduced to Japan. The science of botany was introduced, its use and value understood, and it has persisted down to the present time. In the following pages we will consider in some detail the principal events relating to the botany which prevailed in old-world Japan, that is in the pents'ao and natural history periods.

The Pents'ao Period.

Some primitive methods of curing human diseases might have obtained in prehistoric times, but from lack of records we do not know how they were practised and what sort of drugs were used. The utilization of wild and cultivated plants and other natural products must have opened the way to discriminate them and thus the dawn of natural history investigation is to be found in the very remote antiquity. It is said Onamuchi and Sukunahikona invented medicine in the mythological period in the history of Japan. In 285 in the reign of the

Emperor Ōjin, Wani, a Korean professor of Chinese learning was invited to the Imperial Court. He brought with him Chinese Classics and taught Chinese learning to the prince Wakairatsuko. At that time the translation of Chinese lore relating to plants must have been attempted for the first time. In 415 in the reign of the Emperor Ingio, a Korean physician Kimmu was invited to Japan in order to cure the severe illness of the Emperor. After the recovery of the Emperor from his illness, the Chinese method of medicine was acknowledged as superior to the home method. Thus the investigation of Chinese materia medica must have been commenced at this time.

In 554 in the reign of the Emperor Kimmei, a professor of Chinese medicine named Ōyuda and two explorers of drugs named Hanriohō and Teiyuda came to Japan from Korea and contributed much to the advancement of medicine and of the knowledge of drugs. In 562 a Chinese learned man, Chisō of Wū (呉) Kingdom, came to Japan accompanied by Sadehiko, a Japanese general on the occasion of the victory of the Japanese troops over the Korai forces in Korea. Chisō brought with him many Chinese books on medicine and musical instruments besides. These books afforded great aid to the investigation of the materia medica of Chinese medicine.

In 602 a Korean priest Kwanroku came to Japan and brought with him many books on the natural sciences. Hinitachi learned medicine from him, and is said to be a pioneer student of Chinese medicine in Japan.

In the *Kojiki* or *Records of Ancient Matters*, the oldest Japanese history written in 712, several scores of plant names are mentioned in Chinese ideographs. This is the first document which shows the efforts of the comparative study of Chinese and Japanese plants. In 701 in the reign of the Emperor Mommu, a university was erected in Nara, then the capital of Japan. At the same time a medicinal bureau was established and the science of medicine was enforced. A botanic garden of medical plants was put under the charge of the bureau, and two professors and six students of drugs belonged to it. There the professors gave lectures on *pents'ao* and taught the students about the terminology of medical plants and other drugs and how to prepare, and where to collect.

Between 898 and 900, a professor of medicine, Fukae Hojin, compiled by the Imperial order *Honzō-wamei*, or Japanese names of Chinese drugs, and mentioned 1025 names of the Chinese materia medica with corresponding Japanese names.

In 906 in the Imperial Medical Bureau, *Tō Honzō* (*Tăng Pents'ao*) was used for the first time as the text book in the investigation of Chinese materia medica. The *Tang Pents'ao* in 20 volumes was compiled in 669 in China. This book was brought to Japan by a Japanese student who went to China soon after its compilation. In China this book is not extant, only extracts being found in the later *Pents'ao*. Fortunately in Japan ten out of the twenty volumes were maintained in their original condition, and the reproduced edition of these volumes can be had even at present.

Between 925 and 929, Minamoto no Shitagō wrote *Wamyoruiziushō* in 20 volumes. This book treats of the Chinese names of all things with Japanese translation, in which names of natural objects are also to be seen.

In 984 Tamba Yasuyori wrote an elaborate work on Chinese medicine, *Ishimpō*, in twenty volumes, in which a list of the Chinese materia medica with corresponding Japanese names is given.

In 1156 Henchiin Seiken wrote three books, one on drugs, one on perfumery, and the other on cereals, entitled *Yaku Shu Shō*, *Kō Yō Shō*, and *Kokuruishō* respectively. These books contain extracts from different Chinese *pents'ao* and from Indian literatures. One interesting point to be noticed in these books is the reproduction of the illustrations of the *Jūkō Honzō Dsukyō* (重廣本草圖經) published in 1060 in China. In China, the original edition of this work is not extant, and the illustrations of Seiken's work only give the original condition of the figures of the Chinese work.

In 1267 *Bai zu Kan*, or colored illustrations of seventeen medical plants for horse diseases by Seia appeared. The figures are exactly depicted, and are very artistic and are famous as a treasure of the fine arts as well as of botany. In 1282 Koremune Tomotoshi wrote the *Honzō Iroha Shō*. This is an index of the names and synonyms of the plants mentioned in the *Cheng lei Pents'ao* (證類本草) and other medical works. The *Cheng lei Pents'ao*, published in China in 1086, was brought to Japan soon after and served as a handbook of materia medica till the appearance of the *Pents'ao kammu*. In about 1530 Gessū is said to have written a commentary on the introduction of the *Cheng lei Pents'ao*. In 1582 Manase Dōsan gave lectures on this work, and Yoshida Ian in 1603 wrote a detailed commentary on the introduction in seven volumes which was put in print in 1641.

In the middle of the 16th century European ships reached Japan and the missionaries of Spain and Portugal began the propagation of Christianity among the Japanese people. In 1569 the Shogun Oda Nobunaga held an interview with the Jesuit priests of Portugal, and gave them permission to erect a church in Kyoto and at the same time allowed them to establish a botanic garden of medicinal plants five *cho* square in the Ibuki mountain. For a while Christianity flourished in Japan. But as Jusuit priests abused the religious power, the following Shoguns, Hideyoshi and Iyeyasu, determined to drive away the Jesuits from Japan.

Japan was shut up from all nations except China and Holland, and as a consequence a pause in the introduction of western arts and sciences obtained for a long time. At the time of the Korean expendition of Hideyoshi which was undertaken in 1592, Ukita Hideiye brought back a great many Chinese and Korean books as booty. Among which five volumes of the illustrations of the *Shōkō Kōtei Keishi Shōrui Bikiū Honzō* (紹興校定經史證類備急本草) compile l in 1159 were found. The figures are generally very exact and faithfully depicted, unlike those of later works and comparatively large. From the preface of the work we know that, these figures are chiefly the reproduction of former pents'ao, i.e., of the *T'u hing Pents'ao* (圖經本草) which was printed in 1061, and now not extant in China. The book is not only in itself very important but also important in enabling us to surmise or rather to restore the lost figures of the *T'u hing Pents'ao.*

THE NATURAL HISTORY PERIOD.

In 1601, peace was restored by Tokugawa Iyeyasu after a battle on Sekigahara (plain of Seki) and a new start in the progress of oriental civilization was made. In 1607, Hayashi Dōshun got a copy of the *Pents'ao Kammu* from Nagasaki and presented it to the Shogun Iyeyasu. Dōshun made a commentary on the preface of the same work and also a translation of the Chinese names of materia medica mentioned in the same work into Japanese in 1612, and this was printed in 1631.

In 1637, a Japanese edition of the *Pents'ao Kammu* appeared, and in 1652 a second edition with improved illustrations. In 1666, Nakamura Tekisai wrote a book entitled *Kimmō zui* in 21 volumes, and illustrated all the visible objects, with Japanese and Chinese names affixed, for the use of ignorant boys to instruct them by intuition in the names and Chinese ideographs denoting those objects. This book was brought back by Kämpfer and is often referred in his Amœnitates exoticæ (1712). In 1672, another revised edition of the *Pents'ao Kammu* by Kaibara Ekiken was published in 39 volumes. He added a translation of the Chinese names into Japanese, and an appendix of two hundred and seven more species of natural objects. In 1717, another revised edition of this work was published by Inō Jyaksui. In this edition two plants Jin (荏) and Botsureiri (沒黎離) which were wanting in the text of the original work were added by the editor. In 1803, a most elaborate commentary on the *Pents'ao Kammu* by Ono Ranzan in 48 volumes was put in print. His identification of the Japanese natural objects with those of China is in general correct and the explanations very exact, so the work is regarded as a most useful publication on the natural history of Japan.

Three great naturalists appeared in the Natural History period of Japan. They are Inō Jyaksui, Kaibara Ekiken, and Ono Ranzan. Inō Jyaksui was born in 1655 and died in 1715. He published in 1692 a catalogue of the natural products of Japan, and in 1696, a treatise on the food plants in which 189 species of herbaceous edible plants are described. In 1697 he commenced to compile a great encyclopedia of natural products entitled *Sho Butsu Rui San* with the intension of completing it in one thousand volumes. The costs of this compilation were paid by the feudal lord of Kaga. Inō divided the natural products into 26 groups, i e. the air, fire, water, earth, stone, metals, jewels, cereals, beans, fermented food, melon-like fruits, sea weeds, water plants, fungi, bamboos, vegetables, flowers, herbs, trees, fruits, snakes, birds, beasts, fishes, insects, molluscs, and taste. He arranged under these headings natural products with Chinese names and under each name explanations extracted from all accessible Chinese literature, not only the various *Pents'ao*, but the classics. history, geographical works, etc. When he had compiled three hundred and sixty-two volumes, he died. In 1719, the lord of Kaga presented the unfinished books to the Tokugawa government, and in 1729, the Shogun Yoshimune ordered Niwa Seihaku, a pupil of Inō Jyaksui to complete the set as originally planned. After seven years, in 1735, the remaining six hundred thirty eight volumes were written and the work completed.

Kaibara Ekiken, or Ek'ken, was born in 1630, and died in 1714. He was a universal genius. He was at the same time, philosopher, man of letters, physician, geographer, historian, agronomist, and naturalist. He wrote books on sixty different subjects in two hundred and seventy volumes, among which we find a treatise on garden flowers in five volumes, on vegetables in three volumes, and on the natural history of Japan entitled *Yamato Honzō* eighteen volumes. His great work *Yamato Honzō* was published in 1707 when he had attained the age of eighty years. The work is full of originality. He classified all natural objects in thirty seven groups and described 1362 sorts of objects in the work proper, and 205 sorts in the supplement. Of the 1362 sorts of objects 772 sorts with Chinese names identified from the *Pents'ao Kammu*, 203 sorts identified from other Chinese literature, 358 sorts without Chinese names considered as of pure Japanese origin, and 29 sorts considered as of foreign origin.

Ono Ranzan was born in 1729, and died in 1810 at the age of 82. His great work is the commentary on the *Pents'ao Kammu* already mentioned. He came to Yedo in the 71st year of his age and gave lectures on the *Pents'ao* in the College of Chinese Medicine. During six years, from 1800 to 1805, he went out from Yedo to the mountain districts of middle Japan every summer, and investigated the natural products of those districts. In 1765, a *Kwai* or collection of flowers was published under joint authorship with Shimada Jūbō, of which the explanations and figures of herbs, 2 volumes, and of trees, 4 volumes, were carried out by Ono alone. This work was translated into French by Dr. L. Savatier, and published in Paris in 1873. He also wrote a monograph on birds. He gave lectures on the *Rhuya*, the *Kiu huang Pents'ao*, the *Hua king*, the *Yamoto Honzō*, and other works, and the manuscripts of these lectures are very much esteemed.

Inō Jyaksui lived in Kyoto and was succeeded by his intimate friend, Matsuoka Joan. Joan was also a great naturalist. He compiled monographs on plants such as orchids, fungi, bamboos, cherries, Mumes, and also on molluscs. He gave lectures on the *Pents'ao Kammu*, and on the natural objects mentioned in the *Shi king*, in his own house in Kyoto. He published a book on drugs entitled *Yoyaku Sūchi*, or important knowledge in the use of drugs, eleven volumes in all. He was succeeded by his pupil, Ono Ranzan. Ono Ranzan was succeeded by his pupil, Yamamoto Bōyō, who lived till 1859. He assisted Siebold in his investigation of the Japanese flora.

The state of the progress of natural history in Tokyo or Yedo during this period was somewhat different. Abe Shōwō was a talented natural historian, especially in the field of drugs. In 1722, he was appointed an investigator of materia medica by the Tokugawa government, and was sent to different parts of Japan to find out drugs of the Chinese pharmacopoeia. His pupil, Tamura Ransui, was also appointed an investigator of drugs and sent to different parts of Japan, and discovered many Chinese medicines new to Japan. He was born in 1718 and died in 1776. Among his works a treatise on the cultivation of gingseng in one volume, illustrated descriptions of Loo choo plants in 15 volumes with 3 supplementary volumes, are most noted. He had two sons, the elder was named Tamura Seiko and the second Kurimoto Zuiken. Seiko was appointed Physician-in-Ordinary to the Tokugawa Shogun. He was noted for his profound knowledge of natural history. This saying prevailed at one time, "in the west, Ranzan; in the east, Seiko," which points to popular belief in the parallelism of the knowledge possessed by these two persons in natural history. His famous work is *Dsushūshoto Sanbutsu Dsusetsu*, or illustrated descriptions of natural products of the seven isles of Idsu. He died in 1808 at the age of 41. Zuiken was also appointed Physician-in-Ordinary to the Tokugawa Shogun. His attention was inclined toward zoology. His famous works are Senchū Fu, or descriptions of a thousand insects, and Hyakuchō Fu, or descriptions of a hundred birds. His knowledge of ichthyology was also very deep. He died in 1837 at the age of 79. He had the opportunity of making the acquaintance of Phillip Franz von Siebold who came to Yedo in 1826.

Zuiken taught natural history to Manase Futan, Ōbuchi Yūgen, and Kurimoto Hōan. These three persons survived till the early part of the Meiji era. Manase Futan compiled a book consisting of illustrated descriptions of flowering plants. Ōbuchi Yūgen published a treatise on musk deer in 1859. Kurimoto Hōan had diplomatic talents, and was appointed ambassador to France in 1867, and collected plants in the Swiss Alps.

In 1638, gardens of medicinal plants were established in two places in Yedo, one in Azabu and the other in Ōtsuka. In 1681, the botanic garden of Ōtsuka was annexed to the Azabu garden, and in 1684, the Azabu garden was removed to Koishikawa where it still continues at the present day; perhaps this is the oldest botanic garden in the Pacific regions. In 1720, another botanic garden of medicinal plants was established in Komaba in the suburb of Yedo. This continued till the beginning of the Meiji era. At these early dates the Tokugawa government possessed still more medicinal plant gardens, for example, one in Nagasaki, one in Kyoto, and another in Shizuoka, and cultivated the medicinal plants of Chinese and Korean origin together with those of native origin.

The exploration of the natural products of Japan with special regard to the materia medica and plants available in case of scarcity was undertaken by the Tokugawa government in the reign of the Emperor Nakanomikado. The Shogun Yoshimune sent out investigators of natural products to all parts of Japan, among whom may be mentioned the names of Abe Shōwō, Uyemura Masakatsu, Niwa Seihaku, Noro Genzō, Iida Dōchō. This enterprise was commenced in 1720, and continued till 1752. At the same time the Shogun's government ordered the feudal lords of different parts of Japan to make catalogues of the natural products of their own territories, and deliver them to the Central Government. This act aroused attention and gave a stimulus to the ruling classes to acknowledge the necessity of the investigation of natural products. Each feudal lord began to establish in his cabinet a bureau for natural products research, and thus the demand for naturalists was suddenly augmented. For example, in 1744, the lord of Owari established a botanic garden in Nagoya in order to cultivate Chinese medicinal plants and other useful plants. Matsudaira Kunzan was appointed its director. He had a profound knowledge of natural history, and wrote the Honzô Seikwa in 6 volumes in which he criticized Kaibara's and Matsuoka's opinions of the Chinese names of plants. In 1756, a medical college and a botanical garden were established in Kumamoto by the lord of Higo, Hosokawa Juken. He himself was fond of the study of natural products. and compiled many sketch books of natural objects.

In 1765 in Yedo a private medical college of Chinese medicine was established by Taki Angen to supply up the needed physicians and naturalists. The first professors who delivered lectures on the *Pents'ao* in this college were Ōta Chōgen and Gotō Rishun. The former wrote a commentary on the *Shen nung Pents'ao King* and the latter on the *Pents'ao Kammu*. In 1791, this college was changed to a government establishment, and in 1801, Ono Ranzan was called forth at the age of 71, to this college to teach the students about *Pents'ao*. After his death the chair of Natural History was occupied by Sō Senshun, Kurimoto Zuiken, and afterward by Manase Seitei, Ema Kwatsudō, Mori Risshi, and others.

In 1782, a natural products bureau was established in Kagoshima by the lord of Shimadzu. Two important publications were issued from this bureau, the one is the *Shitsu mon Honzô*, and the other the *Sei kei Dsu setsu*. *Shitsu mon Honzô* or inquired *Pents'ao* is an illustrated description of the plants of the Loo choo islands with Chinese names determined by 43 Chinese physicians in 8 volumes in 1789. The *Sei kei Dsu setsu* is an illustrated agricultural botany in 30 volumes published in 1804. This work was intended to be completed in 100 volumes; but the great fire of 1806 in Yedo burnt to ashes the woodcuts of the already published portion, and also the manuscript of the following volumes and the enterprise ceased to be continued. This work was chiefly written by Sō Senshun. He was also a great naturalist and wrote many books on natural history, among which a commentary on the *Pents'ao Kammu* in 20 volumes, descriptions of fishes in 2 volumes, of molluscs in 2 volumes, of fungi in 1 volume, on plants of Yezo in 1 volume, on orchids in 1 volume, on plants and animals of Japanese history in 12 volumes, are worthy of notice.

In 1794, the lord of Kii established a bureau for natural products research in Wakayama and trusted the conduct of it to Ohara Genzaburo, a pupil of Ono Ranzan. Ohara wrote a miscellany of natural history entitled *To to ihitsu* in 9 volumes published in 1833, and *Kishu san butsu ko,* or treatise on the natural products of the province of Kishu. He was succeeded by Kuroda Suizan who was born in 1792 and died in 1859. The latter wrote many useful books, among which may be mentioned: *Ancient names of natural products* in 85 volumes, *Natural products of Kumano* in 8 volumes, *Natural products of Kōyasan,* in 2 volumes, *Kinan roku gunshi* in 8 volumes, *Natural products of Yoshino* in 2 volumes, a treatise on fishes and molluscs in 2 volumes. In 1800 a bureau for natural products research was established in Mito, and Sato Seiyo worked as naturalist in that bureau. In 1808, he wrote a book on cage birds in 20 volumes. In 1830, he wrote the *San kai Sho hin,* or products of mountains and seas in 100 volumes by the order of the lord of Mito.

In 1757, a private exhibition of natural products, called in Japanese *Butsu San Kwai* or *Yaku hin Kwai* or drug exhibition, was for the first time held at Yushima in Yedo by Tamura Ransui. This was a kind of conversazione of naturalists in which each person brings some specimen or specimens of natural objects to exhibit and also to discuss whether the nomenclature of the objects is correct or not. In 1758, it was held at Kanda under the auspices of the same man. In 1759, it was held in Yushima by Hiraga Gennai. In 1760, it was held at Ichigaya in Yedo by Matsuda Chōgen. In the same year a meeting was held in Ōsaka by Toda Kyokuzan; the record of that exhibition was published under the title *Bun Kwai Roku*; the number of specimens exhibited on this occasion amounted to 241 and the members assembled 100. In 1761, it was held at

Higashiyama in Kyoto by Toyoda Yōkei. The record of this exhibition is entitled *Sha ben yo roku.* In April of 1762, it was held at Yushima in Yedo by Hiraga Gennai. At this meeting 1300 specimens of natural objects were exhibited. Explanations of the exhibits are to be found in a work entitled *Butsu rui Hin pitsu* in 6 volumes published by Hiraga Gennai. In April of 1763 the conversazione was held at Higashiyama in Kyoto by Kan ko do, and 240 specimens were exhibited. In April of 1764 the same man held exhibition at Higashiyama again, and Hiraga Gennai at Yushima, Tokyo, and Toda Kyokzan in Ōsaka, and also Murai Tou in Kumamoto. In 1765, Himi Dōsai held the exhibition at Maruyama in Kyoto. In 1781, the exhibition was héld in the medical college of Yedo, and it was opened to the public, and from this year onward held every year. In Kyoto, Yamamoto Bōyo held the exhibition from 1809 onward every year until his death. In 1827, Ito Keisuke held for the first time a natural history exhibition in Nagoya.

Investigations of flowering and ornametal plants were carried out by men other than naturalists. The oldest work on this subject is the *Kwa dan Gomoku* written by Midsuno Motokatsu in 1664, and printed in 1681, which treats of the culture method of 117 species of herbaceous flowering plants. In 1695, the *Kwadan chikinsho* in 6 volumes by the florist Sannojyo was published in which garden varieties of Mutan, Camellia Japonica, Camellia Sazanqua, Azaleas, Cherries, Mumes, Chrysanthemums, and other flower are faithfully enumerated and also the culture methods of great many ornamental plants are described· This work was afterward supplemented and enlarged to 20 volumes and is looked on as one of the most useful books in Japanese garden botany. In 1698, Kaibara's *Kwa fu* appeared in which the culture methods of 190 species of ornamental plants are described. In 1699, the *Sōkwa ye zenshū* was printed in 3 volumes, which contain illustrations of 110 species of garden flowers. The oldest publication on chrysanthemum culture is the *Chiyo mi Gusa,* published in 1699, later works are the *Shūi ko shin shū* in 1712, the *Nochi no hana* in 3 volumes in 1713, the *Kwa dan yo Kiku Shū* in 3 volumes in 1715, the *Kiku Habutaye* in 1 volume in 1716, the *Kiku kwa taizen* in 3 volumes in 1717, the *Fuso Hyakukiku Fu* in 1735, the *Kikukyo* in 5 volumes, and the *Kiku Kwadan Yashinai Gusa* in 1 volume in 1846. Let me here seize the opportunity to tell about the exhibition of the cultivated chrysanthemum flowers.

An exhibition of the cultivated large-flowered Chrysanthemum sinense was for the first time held in 1717 at Higashiyama, Kyoto, on the 17th, 19th, 21st, and the 26th of October, and the records of these exhibitions were published under the title of the *Higashiyama Kiku Dai Kwai* in which are mentioned the names of 249 members present, and the descriptions of 710 different forms of flowers exhibited. On the 25th of the same month, another chrysanthemum flower exhibition was opened at Kitano in Kyoto, which 92 members assembled, and 260 forms exhibited. A record entitled the *Kitano Kiku Daikwai* was published on that occassion.

In the same year chrysanthemum shows were held in Yedo on the 2nd, 7th, 11th, 15th, and 19th of September in which 835 forms were exhibited. In 1818, Saito Eiho held on the 16th Sept. at Yotsuya in Yedo, an exhibition of the middle-sized chrysanthemum flowers. In 1820, on the sixth of Sept., the same person held at Yotsuya, Yedo, an exhibition of middle-sized chrysanthemum flowers and printed a catalogue. In 1821 Hanai Rakugun on the 23rd, and Saito Eiho on the 17th Sept., held chrysanthemum flower exhibitions, and issued printed catalogues. From this time onward exhibitions of chrysanthemum flowers gradually became one of the customary attractions in the daily life of the people.

In 1727, the *Shuhotaidsu Sahen* in 13 volumes by Emura Jokei was written in which 400 species of flowering plants are described. In the same year the *Somoku kihin Kagami* in 3 volumes by Kinta appeared which treats of the variegated ornamental plants and their originators. In 1733, a monograph in 5 volumes on the Rhododendron cultivated in Japanese gardens was published by Ito Ihei. In 1735, the *Somoku Roha Shō* was published in which 208 species of ornamental plants are described. In 1805, the *Shiki Sho kwa Shū* in 2 volumes was published by Takatori Son'an; the book treats of more than 200 species of plants used as Ikebana or floral arrangement. In 1829 the *Sōmoku Kinyo Shū* which treats of variegated garden plants in 7 volumes by Midsuno Issai was printed. The illustrations annexed are very artistic and accurately depicted.

At the end of the eighteenth century, cultivation of the forms of *Ardisia Tachiba* prevailed, and books relating to that plant appeared one after the other. In 1797, three books the *Kippin*, the *Sō Ho Hen*, and the *Kippin Ruiko* appeared at the same time treating of the different cultural forms of this species. In the beginning of the nineteenth century, the cultivation of the morning glory (Pharbitis Nil) became exceedingly popular, and books relating to this plant appeared in rapid succession. In 1815, the *Kengyu Hinruikō* appeared, treating of 160 forms of the flower, with illustrations; and also the *Kwadan Asagawo Tsū* in 2 volumes. In 1817, the *Kengyu Hin* with 20 colored plates, and the *Asagawo Sō* also with colored plates, and the *Tei chū Asagawo Fu* which treats of 50 forms of the morning glory appeared simultaneously. In 1818, the *Asagawo Midsu Kagami* in which different forms of leaves and flowers of the morning glory are described and also the best mode of its cultivation. In 1821, an exhibition of the flowers of the morning glory was held at Uyeno, and catalogue of the exhibited flowers printed. From this year onward lovers of the morning glory often held exhibitions, and this custon was gradually transmitted to Ōsaka, Nagoya and other places. Almost synchronously with the cultivation of the morning glory, the cultivation of different forms of the Rhoedia Japonica, Goodyera Schlechtendaliana, Psitolum triquetrum, Primula cortusoides, and Dendrobium moniliforme commenced and books with illustrated descriptions of these flowers appeared.

Investigations of food substances in general was begun as early as 1630 and a book entitled the *Shoku motsu Waka Honzô* in 2 volumes was published, but we will here mention only those books relating to plants available in case of scarcity. In 1675, Inō Jaksui compiled a book on edible plants in 12 volumes in which wild edible plants are also mentioned. In 1716 three Chinese works on edible plants in case of scarcity namely the *Kyu Kwo Honzô* (救荒本草), the *Kyu Kwo Ya Fu* (救荒野譜), and the *Hoi* (救荒野譜補遺) were reprinted by Matsuoka Joan. In 1789, the wood cuts of the reprint were burnt to ashes in the great fire in Kyoto. However, the works was once more reprinted in 1799 by Ono Ranzan, revised and the explanations lacking in the fruit section filled up by adding a supplemental volume. In 1758, Takebe Seian wrote, the *Min kan bi kwo Roku* in 2 volumes in which edible plants in case of scarcity are described in great detail. This was printed in 1770 with the illustrations in a supplemental volume. In 1817, Iwasaki Tsunemasa wrote a commentary on the *Kyū Kwo Honzō* in 8 volumes but this has not yet been printed. In 1829, a catalogue of edible wild plants with provincial names of the plants was printed and distributed among people gratis in the territory of the lord of Komatsu in Kaga. In 1833, Tate Ryuwan wrote a book entitled *Ko nen jū ryo Shi* in which he described methods of preparing food for human being from acorns, horsechestnuts, the roots of the Pueraria hirsuta, and from the rhizomes of the Pteridium aquilinum. In 1836, Yendo Tsū published a book in 3 volumes about the making provision against barren year, and in this work we find a section on wild edible plants. In 1837, Ito Keiske delivered a lecture on the plants available in time of scarcity; this was dictated and printed by Nishio and Matsuoka. In 1842, a commentary on the *Kyū Kwo Honzô* in 14 volumes by Ono Keiho, grandson of Ono Ranzan was published. Several other publications on this subject are to be found, but the above are the principal productions.

Two great works on the flora of Japan were produced in this period, the one by Iwasaki Tsunemasa and the other by Iinuma Yokusai. Iwasaki's work is entitled *Honzō Dsu Fu*, or the illustrations of the objects of *Pents'ao*, in 93 volumes. This consists of illustrations of more than 2 thousand species of plants chiefly of Japanese origin. The work was completed in 1828, and manuscript was distributed at the rate of 4 volumes a year, begun in 1829, and required 25 years to the issue of the final volumes. Lately this work was put in print. The *Somoku Dsusetsu*, or illustrated descriptions of herbs and trees in 30 volumes, was worked out by Iinuma Yokusai, a pupil of Ono Ranzan. The work was begun in 1832 and finished in 1856, of which 20 volumes which describe 1201 species of herbaceous plants was put in print in 1856. This work is of greater scientific value than that of Iwasaki's, and the figures and descriptions are far more accurate. The part which treats of about 600 species of trees is yet in manuscript.

In this period Japan was shut up to all nations of Europe except Holland. At first it was strictly forbidden to read and study Dutch books and language for fear of introducing Christianity. But this prohibition was relaxed in some degree at the time of the eighth Tokugawa Shogun, Yoshimune. The Shogun himself was eager to acquire knowledge of Western sciences, especially of astronomy and also that of natural history. He ordered one of his librarians, Aoki Konyo, to learn to read the Dutch language. At the same time, he ordered Noro Genjyo, one of the physicians-in-ordinary to meet and make inquiry of the Dutch captain who came every year to Yedo in order to deliver presents to the Shogun, touching Dutch materia medica. In March 1741, Noro Genjyo visited the hotel of the Dutch captain, Jakob van der Waijen, and made inquiries about the animal described in Jonston's zoological work published in 1665 which was brought by the captain Hendrik Indiik, 77 years ago to Yedo, and also about the medicinal plants described in the *Kruid Bock* of Dodoneus published in 1618, which was preserved in the Library of the Shogun. The dialogue of this meeting which was carried on mostly between the assistant surgeon Musculus is recorded in the *Oranda Kinjiu Chugyo Wakai* (阿蘭陀禽獸蟲魚圖和解) and in the *Jin jitsu Oranda Honzô Wakai* (壬戌阿蘭陀本草和解). From this year onward till 1750 Noro Genjyo visited the captain's hotel every year and made inquiries upon the medicinal virtues of the plants mentioned in Dodoneus's book, and those dialogues are all on record and preserved. Aoki Konyō also visited the hotel every year and studied the Dutch language, but as the stay of the captain in Yedo was very short Aoki could not get hold of much, so he went to Nagasaki in 1744 in order to acquire better knowledge of the language. He became the pioneer of the study of the Dutch language in Yedo, and taught Maino Riotaku and Riotaku in his turn brought up many able Dutch scholars.

In 1775, Carl Peter Thunberg came to Nagasaki and in the following year to Yedo. Katsuragawa Hoshū and Nakagawa Junnan visited the hotel of the Dutch captain and met Thunberg. These two Japanese physicians spoke the Dutch language pretty well and served him with great earnestness in order to get the knowledge of Western learning from this great botanist. In 1817 Ōtsuki Gentaku published the *Ran yen Teki hō* in 3 volumes, a treatise on natural objects translated from the Dutch.

In 1822, Phillip Franz von Siebold came to Nagasaki and stayed till 1829, studying the flora and fauna of Japan. He came to Yedo in 1826 and made the acquaintance of Otsuki Gentaku, Udagawa Yōan, Kurimoto Zuiken, Iwasaki Tsunemasa, and others. Udagawa Yōan, Itō Keiske, Midsutani Sukeroku, Yamamoto Bōyō assisted him in his botanical researches. In 1816, Udagawa Yōan studied Dodoneus's *Kruid Boek*, and picked out 670 species which can be identified with, or are similar to, Japanese species and made a list of them. In 1827, Udagawa Yōan and Udagawa Shinsai published a revised edition of the *Waran Yakukyo* in 18 volumes. This is a treaties on the materia medica of Dutch medicine. In 1829, Itō Keiske published the *Taisei Honzô Meiso* in 2 volumes, with 1 volume of supplement. This is a catalogue of Japanese plants with the appropriate Latin nomenclature. In 1833, Udagawa Yōan compiled the *Shokugaku Keigen* in 3 volumes and explained the general botany in the European way. In 1836, the *Keiga Shyashin Sō* in 2 volumes was printed. This is a collection of sketches of plants made by Kawara Keiga when he served as sketch-maker under Siebold. In 1856, Iinuma Yokusai published the *Somoku Zusetsu* in 20 volumes, in which plants were arranged according to the Linnean System of classification.

In 1846, commander Perry came to Uraga, and in 1859, five ports of Japan were opened to Western nations, and the flow of Western civilization pouring into the bosom of the awakened nation suddenly increased. In 1857 a bureau called the *Bansho Shirabe jo* was established in Yedo in which researches in Western learning were intended to be carried on. This bureau was the origin of the Tokyo Imperial University of the present day. In this bureau Itō Keiske and Tanaka Yoshio worked as representatives of the Natural History Investigation Section. Now we pass to the present period which begins from 1868. The first botanist who appeared in this period is Yatabe Riōkichi. He studied botany in Cornell University in the United States of America and came back to Japan in 1877, and became professor of Botany in the Tokyo Imperial University. He it was who educated most of the Japanese botanists of the present century.

The above is a brief history of botany in Japan.

XI. A brief outline of the history of Medicine in Japan.

By

Yu Fujikawa, M.D., D. Litt.

Intercourse between Japan and Korea is recorded as having taken place even in the remote age of the gods, and in the history of the *Chou* dynasty in China (B. C. 1122—255) mention is made of intercourse with Japan. However, these relations of the Japanese people with the Koreans and Chinese were at first limited to those who lived in the western part of Kyushu Island. According to authentic history, the inhabitants of the main island of Japan came into contact with the Koreans, only so late as B.C. 33 (the 65th year of Emperor Sujin), when the state of Mimana first sent tribute. After this date, intercourse between the two countries became more and more frequent; and when during the reign of Emperor Ojin, the state of Pekche (Kudara or Hyakusai) brought in her tribute, which included the famous Confucian Analects, or *Lun-Yü* (*Rongo*) and other books, Chinese culture through the medium of Korea began to profoundly influence Japan.

When Emperor Inkyo was ill, he sent for a medical doctor from Silla (Shinra, Shiragi), and in response to this request Dr. Kimbu 金武 came over to examine the case in the autumn of A.D. 414, and succeeded in curing the disease. In the 3rd year of Emperor Yuryaku (A.D. 458), Doctor Tokurai 德來 of Koryo (Korai, Koma) came over to live in Naniwa (an old name for Osaka). His descendants also professed medicine and were called *Naniwa no Yakushi* ("Medical professors of Naniwa").

In A.D. 552 (the 15th year of Emperor Kimmei), there came to Japan from Pekche the medical doctor Oyu-Rhyoda 王有陵陀 and the druggists Hanryoho 潘量豐 and Teiyuda 丁有陀. They brought with them Korean drugs which they presented to the court. From this time on, the medical science of Korea gained greater and greater popularity. At about the same period, Buddhism first came to Japan, and Buddhist monks versed in medical science came from Korea to give medical instruction to Japanese students.

Up to this period, the importation into Japan of Chinese and Indian art and culture was carried on through the medium of the Koreans. A departure was made in A.D. 608 (the 16th year of Emperor Suiko), when students were sent to China to learn the art of medicine directly from Chinese scholars. The direct importation of Chinese medicine dates from this period.

The famous code of laws known as *Taiho-ryō* compiled in A.D. 701 (the first year of Emperor Mommu) contains regulations about medical and educational matters. In it, medical students are required to study the subjects of internal medicine ("The curing of the body"), surgery ("Sores and wounds"), pediatrics, diseases of the ear, eye, mouth and teeth, and the art of puncture. The required number of years for these subjects was seven for internal medicine, five each for surgery and pediatrics, and four years for diseases of the ear, eye, mouth and teeth. There was also a system of examinations by which those candidates for the profession who were prepared by private study were examined for public license.

These regulations concerning the medical profession and educational matters were modelled on the Chinese system of those days and the text books on medical subjects were those published in the Sui (589—618 A.D.) and Tang (618—907 A.D.) dynasties in China.

During the 8th century, Buddhism was held in great respect by the Japanese Imperial court and the medical profession was largely swayed by Buddhist influence, so much so that many medical practitioners were at the same time Buddhist monks, just as was the case with Christian monks in the European Middle Ages. Most of the noted medical doctors of those days were either Koreans or Chinese who had come over to practice in Japan or Japanese doctors who had learned the art in Korea or China. The influence of Buddhist teaching upon medical science was so great that in A.D. 730, the 2nd year of Tempyō, a Buddhist charity hospital was instituted at the Imperial order.

Towards the end of the 8th century, in A.D. 784, Emperor Kwammu removed the capital from Nara to Kyoto and during his reign intercourse between Japan and China continued to prosper and

China was made the model of all political and social institutions in Japan. All of the text books used in medical education were books published in China during the Sui and Tang dynasties. In 808, during the period of the Daidō era, a medical work called *Daidō-Ruijuhō* 大同類聚方 was compiled in Japan. Between A.D. 859 and 876, during the Jokwan period of Emperor Seiwa, another medical book called *Kinran-hō* 金蘭方 was compiled. These first two books compiled upon the foundation of the clinical experience of the Japanese medical profession are now forever lost to us and it seems that there is no hope of their coming to light. There is, however, another medical book of this period which has come down to us. It is the *Ishinhō* 醫心方, written by Tamba Yasuyori 丹波康賴 in A.D. 982. It consists of fifty volumes, and includes besides a general introduction, chapters on the art of punctures, diseases of the air passages, diseases of the internal organs, diseases of the skin, diseases of the eye, ear, and teeth, diseases of the limbs, tumours and eruptions, wounds, diseases of children, diseases of women, hygiene, sex hygiene, food and nutrition, and the science of drugs.

Towards the end of the twelfth century, there was a political change and Minamoto-no-Yoritomo became Viceroy (*Seii-tai-Shogun*). The actual political authority was exercised at Kamakura by officers of the *Bakufu* instead of by the Imperial court in Kyoto. The aristocratic culture of the previous period was now changed to one more closely related to the life of the common people. There was a change as well within the Buddhist religion, due to the rise of several new sects. Intercourse with China greatly increased and medicine under the stimulus of the new conditions made material progress. Not only were Chinese medical books imported and translated as before, but also original writings on medical subjects began to apear more frequently.

During the 14th century, the vice-royal government was moved from Kamakura to Kyoto and peace reigned for some time, during which literature, art, and religion prospered. Towards the end of this period, however, disturbances set in again and the so-called age of wars followed. Schools were suspended, and the pursuit of learning ceased for a time, although Buddhist monks continued to visit China to study Confucianism and Buddhism. The Ming dynasty (1368—1644 A.D.) then reigned in China and among the noted medical authorities there, were such names as Li Tung-Yüan and Chu Tan-ch'i (李東垣, 朱丹溪). The writings of these authors were widely read in Japan, while Japanese authors also produced books on special medical topics.

During the 16th century, Chinese medicine of the Ch'in dynasty (1115—1260 A.D.) and Yüan dynasty (1280—1368 A.D.) made its way to Japan and revolutionized her medical literature. In the medicine of ancient China and of the T'ang dynasty, diseases were regarded as caused by the air and by cold. In the dynasties of Ch'in and Yüan, the causes of diseases were classified into internal and external. Internal causes included natural constitution, nutrition, feeling, and overwork; external causes included moisture and heat. The best known Japanese medical man of this period is Manase Dōsan 曲直瀬道三 who was the pioneer of the Li-Chu School 李朱醫學派 in Japan. At about the same time, lived Nagata Tokuhon 永田德本, who taught that the secret of curing lay in helping natural agencies in their work of healing. In this respect, his medical theory resembled that of Hippocrates.

Some vague notions concerning Japan were already held in Europe in the 13th century through the writings of Marco Polo. But it was only in the middle of the 16th century that the first Europeans landed in Japan. In 1530, the 3rd year of Kyōroku, certain merchant vessels of the "Southern Foreigners" (Portuguese) visited the province of Bungo, and in 1542, the 11th year of Temmon, the "Southern Foreigners" came to the island of Tanegashima, south of Kagoshima, to which they brought for the first time guns, among other things. After this, the number of the "Southern Foreigners" that came for trading purposes increased year by year.

By the devoted exertion of Franciscus Xavier, who came to Kagoshima in 1549, and of his successors, the teachings of the Jesuits spread rapidly in different parts of the country and the number of converts was not small. Even provincial military governors were among those converted. Otomo Sorin, the military governor of Bungo, founded charity hospitals in his city and made Father Louis Almeida a dispenser of medicine to the poor. There were also some Japanese doctors who studied medicine under the Portuguese. One of these is known under his adopted name of Paul.

In 1568, the 11th year of Eiroku, the Viceroy Oda Nobunaga allowed Portuguese missionaries to build a Christian Church in Kyoto and permitted several of them to devote themselves to preaching and proselyting. Of these, Gregoria and Louis knew the medical art; they dispensed medicine among the poor and taught the art to students, thus using medicine as a means of missionary work. The medical art thus transmitted by the Portuguese gradually grew into a school of its own, called "Surgery of Southern Foreigners" 南蠻派外科.

In the beginning of the 17th century, Tokugawa Ieyasu opened the Vice-royal government in Yedo (Tokyo) where learning and culture prospered. The philosophy of nature and the human intellect propounded by Chu Hsi (Shushi) and his school of the Sung dynasty (960—1280 A.D.) in China exerted some influence upon the teaching of medicine of that day. The works of Liu Wan-Su 劉完素 and Chang Tsü-Hou 張子和 were then respected as the highest authorities.

After a short while, the famous scholar Ito Jinsai came to the front, who strongly opposed the philosophy of Chu Hsi (Shushi) and inculcated a return to the ancients. At the same time, Nagoya Gen'i, the famous medical scholar, also raised opposition to the medical teachings of the *Li-Chu* school 李朱醫學 and advocated the teaching propounded by Chang Chung-Ching 張仲景 of the T'ang dynasty in his *Shan-han Lun* 傷寒論, thus reviving the so-called "classical medicine." In this school of classical medicine in Japan, the principal names are Goto Konzan (1659—1733), Kagawa Shuan (1683—1755), Yamawaki Tōyō, Yoshimasu Tōdō (1702—1773) and Yoshimasu Nangai (1750—1813).

Yamawaki Tōyō dissected in 1784 corpses of criminals and wrote a book on the anatomy of the viscera based on his observations, entitled *Zō-Shi* 藏志. In this work he pointed out the errors in the anatomical teaching of the Chinese and Japanese authors. He also insisted on the importance in medical study of empirical observations, and strongly dissented from habit of formulating theories and opinions founded only on speculation and phantasy.

Yoshimasu Tōdō took a further step forward and insisted on rejecting even the teaching of the classical authors when found by practical application to be useless or incorrect. He rebuked the worship of authority and himself propounded the theory of "A single poison for all diseases", thus making himself a hero among his innumerable followers.

As has been already mentioned, it was in the middle of the 16th century that the Portuguese first visited Japan. They were followed by the Spaniards and the English. The Dutch also came to Hirado where they were permitted to trade in the beginning of the 17th century and soon afterwards the Dutch East Indies Company (founded in 1602) entered into commercial relations with the Japanese at this place. In 1641, the 8th year of Kwan-ei, the Dutch were permitted to live in Dejima, on the outskirts of Nagasaki. After this, all the European except the Dutch were forbidden to have any intercourse with the Japanese and Japanese scholars were forbidden to read European books. It was only through intercourse with the Dutch in Dejima that European culture and learning were transmitted to the Japanese.

There were always in the Dutch settlement of Dejima physicians who gave instruction through interpreters in Nagasaki. They also always accompanied the Dutch Envoy on the latter's annual visit to Yedo (Tokyo), where they had opportunities to transmit their medical art to some of the physicians of Tokyo. The best known of the Dutch medical men in Dejima was Caspar Schambergen, who in 1649 (the 2nd year of Keian) accompanied the Dutch envoy on his official visit to Yedo. His influence on the medical profession was so great that there sprang up a school of surgery named after him.

Besides Caspar Schambergen, there were several other Dutch physicians who transmitted their art to Japanese physicians. Their names are Hoffmann (1650), Almans Katz (1661), Danner (1663), Palm (1666), Stieven, William Ten Rhyne (1673), Engelbert Kämpfer (1690), et al. The number of Japanese interpreters who learned the medical art in this way from Dutch physicians in Nagasaki gradually increased so that at last there sprang up the so-called Dutch school of surgery.

Toward the end of the 17th century, a Dutch version of a French book on surgery by Ambrose Paré was imported into Japan and Narabayashi Eikyū published in 1706 an abridged translation of it under the title *Gekwa Soden*. Nishi Gentetsu then published in 1713 the *Kinso-Chitsuboku-Ryōji-Sho* which was patterned largely on Paré's book. Paré's influence was so great as to start a new school of orthopedics as a subdivision of the science of surgery.

Although the medical science of Europe gradually permeated through the Japanese medical profession through the agency of interpreters of the Dutch language in Nagasaki, the prohibition against European books was still stringent and it was mostly through the medium of direct conversation that European knowledge was gained.

There remained yet very much to be desired. Yoshimune, the eighth viceroy of Tokugawa, at last found out that the Dutch science was excellent and in 1720 raised the ban upon the importation of Dutch books. He also ordered the official scholar Aoki Bunzo and the official physician Noro Genjō to learn Dutch letters. Upon the petition of the interpreters Nishi, Yoshio, and others, permission to read foreign books was granted.

At this time, there was a physician in Yedo by the name of Mayeno Ryōtaku He was a medical officer in the service of the provincial governor of Nakatsu, in Kyūshū. He studied the Dutch alphabet under Aoki Bunzō and had a desire to pursue Dutch learning. It happened that in March 1771, there was a dissection of the cadavers of criminals at the execution ground of Kotsuka-hara near Yedo. Mayeno Ryōtaku was given permission to attend the dissection, together with Sugita Genpaku and Nakagawa Jun'an. They took with them the Dutch book of anatomy, *Tabula Anatomica,* by Johann Adams Kulmus, and found with astonishment that what they actually observed agreed perfectly with the drawings in the book. Thereupon, they decided to translate the book, appointing Mayeno Ryōtaku leader of the enterprise. They began the work on the following day with Sugita Genpaku, Katsuragawa Hoshū, Nakagawa Jun'an, Ishikawa Genjō, Mine Shuntai, Toriyama Shōen, and Kuriyama Seitetsu as associates. They met several times a month to discuss the meaning of the words they tried to decipher, with Sugita Genpaku as general editor-in-chief. After four years, the epoch-making work of translating the first European work into Japanese was completed after rewriting the proof sheets eleven different times. In 1773, it was published in five volumes under the name of *Kaitai-Shinsho* meaning a "New Manual of Anatomy."

Upon the publication of the "New Manual of Anatomy", the educated circle recognized with astonishment the facts that first, a Dutch book had been intelligibly translated into Japanese and secondly, that the construction and logic in the Dutch work were forceful and exact. Able young men of the country now vied with each other in studying the language. Among them, we may count Udagawa Genzui, Otsuki Gentaku, Udagawa Genshin, Sugita Hakugen, Koishi Genshun, and Inamura Sanpaku. They studied by the aid of Dutch books the subjects of anatomy, therapeutics, pharmacology, the preparation of drugs, physics and chemistry, astronomy, and military science. Thus, there came into existence a new school called the *Rangaku,* which means "The science of Holland".

In 1783, there was published the famous *Rangaku-Kaitei,* ("A Staircase to Dutch Learning"), by Otsuki Gentaku. This was the first book on Dutch grammar published in Japanese. In 1795, Inamura Sanpaku published his Dutch-Japanese dictionary under the name of *Harma-Wakai.* In this manner the way was now being paved for the study of the Dutch language, which afterwards flourished.

The science of anatomy was, as we have seen, imported from Europe in a fragmentary manner during the course of the 17th century. It could not but be in very coarse and rough outlines. In the 18th century, Yamawaki Toyō disproved by his *Zōshi,* (literally, "Records of the Viscera"), the traditional teachings of the ancient Chinese authors, but at the same time his own statements were vague and inexact. After the publication of the "New Manual of Anatomy", there were on the one hand scholars who translated other Dutch books on anatomy, and on the other hand, medical men who reported their own observations on autopsies. Numerous monographs on anatomy thus appeared one after another. The most famous of these is the *Ihanteiko* ("Essentials of Medicine") published in 1805 by Udagawa Genshin. It is a compilation chiefly from the anatomical works of Brankart, Parfin, Winslow and others. This book had a very wide circulation in the medical world of Japan. Shingū Ryōtei then translated Plenck's book on anstomy and the science of anatomy grew in depth and exactitude

European physiology was introduced into Japan in 1836, the 3rd year of Tempō, by Takano Chōei with his *Igen-Sūyo* ("Central Truths of Medical Teaching"). This book was an abridged translation of a book by Blumenbach and Rose. Richerand's *Nouveaux Eléments de Physiologie* was then translated by Hirose Genkyō and Mitsukuri Genpo. Hirose's translation of Adolph Ypeys' *Elementa Physiologiae* appeared in 1856. Shingū Ryōtei's *Seirisoku* was a translation of Plenck's book on anatomy and Shimamura Kanaye's *Seiri Hatsumo* was a translation of Lieback's book on physiology. There were all widely used as text-books of physiology.

The first complete work on internal medicine ever translated from a European language was that of Johannes de Gorter. It was published in 1793, the 5th year of Kwansei, by Udagawa Genzui under the title of *Naikwa Senyo,* or "The Essentials of Medicine." Other translations followed in rapid succession:

1. Consbruch's book on medicine, translated in abridged form by Koseki San-ei and published in 1824 under the title of *Taisei-Naikwa-Shūsei.*
2. Anton Stoerch's book on medicine translated by Adachi Chōshun in 1832 under the title of *Iho-kenki.*
3. Van Swieten's book on medicine translated by Uno Ransai under the title of *Sei-i-Chiyo*
4. Boerhaave's work translated in abridged form by Tsuboi Seiken under the title of *Manbyo Chijun,* published in 15 volumes.
5. Bischoff's work translated in complete form by Ito Genboku in 1835 in 24 volumes under the title of *Iryo-Seishi.*
6. Conradi's work translated by Kodama Junzō in 1860 under the title of *Iso-Gyokukai.*
7. Lebert's work translated by Tsuboi Hōshu in 1866 under the title of *Iryo-Shinsho.*
8. Tissot's work translated by Ema Ryūen under the title of *Tissot Naikwasho.*
9. Constatt's work translated by Tsuboi Shinryō in 20 volumes under the title of *Constatt Naikwasho.*

While the study of European medicine was rapidly spreading in Japan through the translation of authoritative works, there were also some European medical men who came to Japan and personally taught their art directly to Japanese practitioners. Among these was Karl Peter Thunberg, a Swedish doctor, who came to this country in 1775 and taught medical students both in Nagasaki and Yedo. Yoshio Kōgyū, Katsuragawa Hoshū, and Nakagawa Jun'an are among the most famous who received instruction from Thunberg. In 1794, the German doctor Bernhard Keller came over and another German doctor, Hermann Retzke, followed him. Otsuki Gentaku and some other noted scholars in the field of "Dutch learning" received instruction from them. Hermann Hellke, who came to Japan in 1815, was a pupil of Plenck and the famous physician Shingū Ryōtei studied under him.

Philipp Franz von Siebold came to Japan in 1822. In order to get facility in making investigations in the fields of the natural history and anthropology of Japan, he made special acquaintances among Japanese Physicians and interpreters of the Dutch language and opened a medical school in Narutaki, a section of Nagasaki.

He also gave clinical instruction at the private homes of the official interpreters Narabayashi and Yoshio. Among the famous doctors who thus obtained instruction from Siebold, were such well-known men as Totsuka Seikai, Ito Genboku, Takeuchi Gendo, Haniu Gentaku, Takano Chōei, and Taka Ryōsai. Before this, Japanese medical men had studied European medicine chiefly through the medium of printed books. Now they began to learn medicine in direct and personal touch with the Dutch authority at actual clinics. Siebold thus made the medical learning of Japan more practical than before, contributing enormously to the progress of the science.

In 1824, Siebold ordered the vaccine lymph from Java and tried Jenner's vaccination. The result was negative. In 1837 Lischur again imported the lymph from Java and the result was again negative. However, in 1848 Mohnike succeeded in importing an efficacious lymph and in getting the desired result of vaccination. The practice of vaccination began to spread now for the first time in this country, encountering at the outset much opposition. In time, its beneficial effect was recognized on all sides and the practice has at last become customary in the country.

Hagemann's Dutch version of the "Enchiridion medicine" by the German doctor Hufeland was imported to Japan and Ogata Kōan translated the part on praxis and published it in 1843 under the title "Hufeland's Keiken-Ikun" ("Advices from Experience"). The part on medicaments was translated by Sugita Seikei under the title *Saisei-Sanpo* ("Three Recipes for Life Saving"). The part on medical discipline was translated also by Sugita Seikei. Thus, Hufeland's books became a necessary part of the library of Japanese doctors and had a profound influence on the profession.

The first translation of a European work on surgery was Otsuki Gentaku's *Yoi-Shinsho* ("A New Manual of Surgery") published in 1822. Its original was a work by Lorenz Heister. The most popular parts which were widely read, were those on bandage and Venesection. Sugita Kinchō's complete version of Plenck's *Compendium Institionum Chirurgicum* was published in 1832 in five volumes under the title *Yoi Shinsen* ("A New Treatise on Surgery").

The European art of surgery was first transmitted to Japan in a rough and fragmentary manner by the importation of the surgical art of the "Southern Foreigners". It was restricted to small operations such as venesection, the cutting of tumors, and the application of adhesive plasters. Upon the appearance of translated books on surgery, the dexterity and superiority of the European art was at once recognized, but it was impossible to put it immediately into actual practice. Toward the end of the 18th century, however, Hanaoka Seishū took up the art of European surgery and practised it with great skill and dexterity, thus revolutionizing the surgical practice of the time.

Hanaoka Seishū (1760—1835), although he started with the study of Chinese medicine, had a strong, independent and original mind and was profoundly stimulated by reading Japanese translations of European books on surgery. He was remarkably successful in removing tumours, especially the Carcinoma of the mammary glands, in the amputation of limbs, and in operations on hydrocele, liquigual carcinoma, and *rectum fistula*. To stop bleeding he employed pressure, tying of the blood vessels, and canterization. It is also especially remarkable that he made use of anaesthetics for operations. The anaesthetic used by Hanaoka was an extract prepared by boiling certain proportions of anotium, Datula alba, Angelica, Ligusticum, and Canoselium in water. The extract was administered internally.

The surgical art of Hanaoka Seishū was learned and enlarged by his pupil Homma Genchō. The latter's work in 19 volumes entitled "Secrets of Surgery", (*Yōkwa-Hiroku*), was the medium by which Hanaoka's art gained a widespread acceptance. Homma Genchō succeeded in some great operations which even his master did not dare to attempt, such as the removal of aortic aneurism and the amputation of the thigh bone. He even succeeded in 1858 in making a lateral incision in the bladder and removing a large bladder stone.

European teaching on the diseases of the eye was made accessible by the translation of Plenck's book by Sugita Kinchō. However, the actual practice of the new art was made for the first time by Haniu Gentaku (1768—1854) who learned the art under Siebold and became the pioneer among oculists in Japan.

The art of obstetrics had already passed through a revolution in the hands of Kagawa Gen-etsu before the publication of the *Kaitai Shinsho* ("The New Manual of Anatomy") by Sugita Genpaku and others. Before Kagawa, the art of obstetrics was exceedingly primitive and was almost exclusively in the hands of midwives. Indeed the science of obstetrics in Japan may be said to have been revolutionized in 1765 by Kagawa when he began to teach the art of midwifery founded on his own experiences. The versions of several European books on midwifery were published and the *Sankwa Hatsumo* ("Elements of Midwifery") published in 1774 by Katakura Genshū is an abridged translation of the works of certain English and Dutch authors.

Towards the latter half of the 17th century, the orthopedic art, a new branch of surgery, sprang up under the influence of the European medical teaching. This art makes as its object the cure or restoration of fractured or dislocated bones. It was built up to its full importance by Ninomiya Ken and Kagami Bunken.

The European school of medicine underwent a sure and gradual growth as described in the preceding pages until in 1857, the 4th year of Ansei, its practitioners united to start an institution called the *Shutō-Sho,* literally an "Office for vaccination", the object of which was to cultivate medical science. The control of this institution was handed over in 1860 to the government. It was then known by the new name of *Seiyo Igakusho* ("Institution for Western Medicine"). Ito Genboku, Hayashi Dokai, Otsuki Shunsai, and Ogata Kōan succeeded each other in the office of Director of the Institute. The Medical Department of the Tokyo Imperial University has its origin in this Institute.

In 1860, the first year of Man-en, Matsumoto Ryōjun, a government medical officer, received a commission to found a hospital in Nagasaki with an attached school of medicine. He invited Pompe von Meerdervoort, a Dutch naval surgeon, to be a professor and had him give instruction to students of medicine. Two students were chosen to be sent abroad to Holland for further pursuance of medical science. These two were Itō Hosei and Hayashi Ki, and they became the pioneers of Japanese studying medicine in Europe. After their return home, they both contributed to the onward progress of medical science in Japan.

After Pompe left Nagasaki, Bauduin succeeded him as Director of the Hospital, and Bauduin was later succeeded by Mansfeld. They taught students in conjunction with their assistants. In Kyoto, there was also a medical school, founded by Shingu Ryōtei, where medicine was taught with the use of books translated from the works of European authors. The medical schools of Kanagawa, Tokushima, Fukui, and Hagi were founded in 1854, 1858, 1856, and 1840 respectively.

At the time of the Restoration in the beginnig of the Meiji era, the Medical school in Tokyo originally controlled by the Tokugawa government, was closed. Soon after, the Imperial government founded a hospital in Tokyo to which a medical college was attached and an English surgeon, Dr. Willis, was appointed to professorship in it. On the proposal of Dr. Iwasa Jun, the Director of the college, Sagara Kōan, decided to invite professors from Germany. As a result of this invitation, Drs. Müller and Hoffmann came to Japan in 1871. New regulations and curricula for medical study were formulated and Drs. Wernich, Gierke, Schulz, Dänitz, Langgard, Disse, Ziegel, Scriba, and Baelz succeeded each other in the professorial chair. A system of medical education was thus established according to the German model.

Besides the medical college of Tokyo University, there were also hospitals belonging to the Army, to the Navy and to the local prefectural offices where Dutch, English and American doctors served as physicians and professors. Among these latter, the following deserve special mention:

Dr. Wheeler (1871—1874) in the Naval Hospital of Tokyo.
Dr. Anderson (1872—1879) ,, ,, ,, ,, ,, ,,
Dr. Massais in the Tokyo Prefectural Hospital.
Dr. Manning ,, ,, ,, ,, ,,
Dr. Benkema ,, ,, ,, ,, ,,
Dr. Eldridge in Yokohama.
Dr. Ermerins (Dutch) in the Osaka Prefectural Hospital,
Dr. Junker von Langegg (1872—1876).
Dr. Scheube (1877—1881) in the Kyoto Prefectural Hospital.
Dr. Junghaus in Nagoya.
Dr. Röretz in Nagoya.

In the well-nigh sixty years that have elapsed since medical professors were first invited from Germany in the beginning of the Meiji era, medical science in Japan has made wonderful progress. Today we have medical departments in the Imperial Universities of Tokyo, Kyoto, Fukuoka, and Sendai besides the prefectural colleges of medicine in Chiba, Kumamoto, and Nagasaki. In addition to these institutions controlled by the national and local governments, there are six medical schools founded by private endowment. Of these latter, one forms part of a University, two are independant schools of

University rank, two are colleges ranking as special schools, and the remaining one is exclusively for women students and ranks also as a special school.

The system and equipment of medical education in Japan are now thoroughly organized and the results of original investigations are also worthy of appreciation so that, generally speaking, the present situation in the field of medicine is not much behind that of Western countries.

XII. Physical Sciences in Japan.

From the time of the first contact with the Occident until the time of the Meiji Restoration.

By

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The first occasion of Japan's contact with the West was the arrival of some Portuguese merchant ships at a small island to the south of Kyushu in the fifth decade of the sixteenth century. The intercourse of Japan with Europe was thus opened at a time when the country was in the midst of constant internal wars and disturbances. With the dawn of the seventeenth century, the people began to enjoy peace while the policy of seclusion was pursued until the fall of the Tokugawa Shogunate at the Restoration of Meiji. These circumstances were not calculated to be beneficial to the importation to this country of the sciences which were being developed in Europe during the period. In spite of adverse circumstances, however, the fact that research interest in scientific knowledge was active among the people is clearly to be noted by the works and translations published during this time. In the following sketch, the development of physics and astronomy only will be touched upon.

The interval of the three hundred years in question can be divided into three periods, namely: the first period of about one hundred years comprising the first arrival of the Portuguese ships in 1543, the first arrival of the Christian Missionaries, the prohibition of Christianity, and finally the absolute prohibition of the importation of all the European books in 1630. The second period included the years of the strict enforcement of absolute seclusion, this period ending in 1720 when foreign books on subjects other than religious were relieved of the offical ban. The third period comprised the time of flourishing of the so-called "Dutch learning" culminating in the complete abolishment of the policy of seclusion at the Restoration of Meiji in 1868.

The first arrival of the Portuguese ships in the sixteenth century is made significant by the historical fact of its being the occasion of the first importation of fire arms and the opening of the country to commerce with Europe. Soon thereafter the Jesuit missionary, Saint Francis Xavier, arrived in Kyushu from his station in India. During his two years' stay in Japan, Xavier not only ardently preached the Gospel but also commanded a great popular interest by his talks on astronomical and geographical subjects. As Xavier had left Europe before the time of the publication of the theory of revolution of the earth by Copernicus, his astronomical knowledge was confined to that of the geocentric theory well fitting his scholastic doctrines. For the Japanese scholars who had no knowledge other than that of the Indian and Chinese cosmology, the teachings of Xavier were unexpected revelations. There were, however, some scholars, such as Hayashi Razan, who did not approve of the new ideas and said to one of the Catholic missionaries that the man was to be pitied who insisted on the existence of a heaven underneath our earth. Xavier and his Catholic successors also brought over with them some clocks and spectacles. At this period, the Japanese people in general got the impression that in the West, besides a special religion of its own, various mechanical inventions and devices were also undergoing development. Some were even afraid of these devices as tricks of magic. As Japan was involved in a long period of internal wars, there was little chance here for these newly imported ideas to attain scientific development. In China, on the contrary, the European missionaries busied themselves not only in propagating Christian doctrine but also in publishing, with the aid of the Imperial Court, large volumes on astronomy and calendology in the Chinese language, these being in their turn later imported into Japan. In the meanwhile, the internal feuds in Japan gave place to political unification and the restoration of peace. Notwithstanding this, the government entertained certain suspicions against Christians, then forbade strictly any belief in Christianity and finally took steps, forbidding absolutely the importation of all European books and their Chinese translations. The Portuguese and Spaniards were expelled from the country and the Dutch only were permitted to reside in Nagasaki for the sole purpose of trade. There were appointed in Nagasaki hereditary official interpreters of conversation in the Dutch language but they were forbidden to read printed books in that language.

Thus ended the first period of Japan's intercourse with the West and the second period was ushered in. This was the flourishing period of the Takugawa Shogunate during which the policy of seclusion was stringently adhered to. In 1634, there were some European Christians shipwrecked off the coast of the province of Chikuzen in Kyushu. One of them was found to possess a book on astronomy which was sent by the Governor of the province to the mayer of Nagasaki who asked Christovao Ferreira to translate it into Japanese. Ferreira was a Portuguese naturalized in Japan and then living in Nagasaki. His original manuscript in the Japanese language, written in Roman letters, was the very first book of European astronomy ever produced in Japan, but it has not been preserved. About ten years later, this book was transliterated into the Japanese characters by Mukai Gensho, a scholar of Chinese, with the collaboration of Nishi, an interpreter. This revised version with Mukai's critical commentary was entitled "Kenkon Bensetsu" meaning "An Explanation of Heaven and Earth." It was never printed but had a certain degree of circulation in the form of manuscript copies. The original of this book was based on the Aristotelian theory of the four elements while the critical commentary was based on Chinese theory of "positive" and "negative" and the "five elements" in juxtaposition with the astronomical theory. It is said, however, that the scholars of that age believed the original argumeut rather than the critical commentary on it.

About this time, there lived Hayashi Kichiyemon who learned astronomy from the Portuguese and Spaniards in Nagasaki. Among the pupils of Hayashi, were Kobayashi Kentei and others. Kobayashi wrote some books and taught pupils. They were the first Japanese scholars who served to spread the knowledge of European astronomy, though it seems there were certain others who had earlier learned European navigation, with astronomy as its accompaniment.

There was a family in Kyoto whose hereditary office was the compiling of the calendar. This calendar was based on the Chinese calendar of the Tang dynasty, then already eight or nine hundred years old, and the difference between the calendar and observed facts was very great. Some people made their own observations with sun dials and others studied more recent Chinese calendars while still others, like Kobayashi above spoken of, learned the European art of calendar making. The arrangements for the revision of the calendar grew more and more persistent. At last, in 1685, the revision was accomplished by Shibukawa Shunkai who was a scholar of Chinese calendology.

This so called revision of the Jô-Kyô era marked an epoch in the development of astronomy in Japan and henceforth came a continuous stream of publications on Japanese chronology, on commentaries of Chinese calendology, and on explanations of astronomical problems from writers in Yedo, Kyoto, Nagasaki, and other places. Among these were, besides those expounding the old Chinese astronomical theoreis, books based on recent astronomical works of the Jesuits in China which had been placed under the ban some years previously· Nishikawa Joken of Nagasaki, was not only well versed in Chinese astronomical knowledge of this kind, but also had some acquaintance of the recent Dutch calendar. Nakane Genkei of Kyoto was also famous as a calendologist.

The orthodox learning of Japan at this epoch was the Chinese philosophy of Chu-Tse originating in the Sung dynasty of China. Its metaphysical principle was a dualism based upon "Ri" (principle) and "Ki" (matter).

Against this predominating doctrine, Ito Jinsai of Kyoto, Kaibara Ekiken of Chikuzen, and later Miura Baien of Bungo propounded a monism based on "Ki" (Matter). Among these, Baien attempted most elaborately to formulate a system of natural philosophy, while science in Japan was in the meantime confronting a serious crisis.

As has already been mentioned, the more vulgar of the Japanese astronomers of that day were nothing more than mere astrologists while the more scientific ones were adherents of the geocentric theory taught by the Jesuit missionaries. As actual observations of the heavens were attempted with more and more exactness, these also began to recognize the crudeness of their theory. Asada Kôritsu, a friend of Miura Baien mentioned above, was the most prominent of these actual observers. He later left his native province of Bungo and started a private school in Osaka, where he counted many brilliant students among his pupils. Ino Chukei who attained great fame by his successful survey of Japan's coast lines before and after 1800 was initiated into his science by one of the pupils of Asada.

Tokugawa Yoshimune, who was the Shogun from 1716 to 1745, was fond of astronomical observations and founded an observatory in the rear garden of his castle. In 1718, he invited Nishikawa Joken from Nagasaki and Nakane Genkei from Kyoto and instituted enquiries on astronomical questions. This scientific interest of the Shogun became the motive power for raising, in 1720, the ban upon European books and their Chinese translations except for those on religion.

Knowledge of European geography had been introduced by Arai Hakuseki in a preceding decade and was followed by the science of cavalry and medicine. Now Yoshimune took the above mentioned momentous steps because of his taste for astronomical knowledge. He saw a Duch book on astronomy in his library and was quite struck by the minute details of the pictures and figures in it and ordered, in 1739, his librarian, Aoki Konyô, to study the Dutch language. Konyô began his lessons in Dutch with the "Capitain" (?) (or the Resident) of the Dutch Company in Nagasaki, who made his official visit to Yedo once a year. He then went to Nagasaki where he learned the language from the official interpreters who, as was said before, spoke the language but were not allowed to read the printed books. Yoshimune at last gave permission to the interpreters to read the Dutch books. When Konyô returned to Yedo after some years' stay in Nagasaki, Yoshimune was dead and thus a sudden stop was put to the forward progress of the course of science. However, the impetus given by him to the cultivation of science could not but constitute a great turning point and the history of the progress of modern science in Japan entered the third period.

After the pioneering labors of Aoki Konyô, the number of students of the Dutch language gradually increased in Yedo. While Aoki was originally a Chinese scholar, his successors in the Dutch learning were mostly medical men such as Maeno Ryōtaku, Sugita Genpaku, and Otsuki Gentaku among others; and the translation and publication in 1774 of an anatomical handbook "Kaitai-Shinsho" was an epoch-making event in the history of European learning in Japan. Some of the official interpreters in Nagasaki specialized in the medicine and surgery of the Europeane school, some in the language, while others took up navigation, astronomy, artillery and cavalry as their principal studies. Motoki Nidaiu was one of the official interpreters who began to read printed Dutch books with Aoki Konyō and he early translated more than ten defferent works on astronomy, calendology, and other subjects. The official interpreters in Nagasaki had heard from earlier days that the cosmology then prevalent in Europe was the heliocentric theory in contrast to the geocentric theory which was already out of vogue. They did not, however, dare to speak of it for fear of offending official and public opinion of the day. When Motoki explained in detail this new theory, it attracted attention as a marvelous view of the universe and spread gradually from Osaka to Yedo. Shiba Kôkan, a famous painter of Yedo, had heard this theory when he was in Nagasaki and popularized it by publishing in Yedo, between 1790 and 1800, his books on "the Dutch Theory of the Heavens", "Illustrated Astronomy of Copernicus", and other works.

Shidzuki Tadao, an official interpreter and a pupil of Motoki, was an ardent scholar who gave up his profession and entered into seclusion in order to concentrate on the study of Dutch books. He wrote books on astronomy and physics besides those on the Dutch grammer. His translation from the Dutch version of a book by the English astronomer John Keil appeared in 1798 and was entitled "Rekishô-Shinsho" meaning a "New Handbook of Calendology". This containing commentaries by Shidzuki himself, had a wide circulation in munuscript form. As the general public looked on the heliocentric theory with some doubts and suspicions, the translator tried also to explain it by means of the dynamic principle of relativity, as it is called today. With regard to the cosmogony, he also expounded a kind of nebular hypothesis which was of course independent of that of Kant and Laplace.

After this epoch, Dutch learning spread from Yedo and Nagasaki to various parts of the country including Kyoto, Osaka and other cities where it attained conspicuous popularity. It is to be understood, however, that at this time both Dutch books and Dutch teachers were scarce and the difficulties met with by students were enormous. The story is told that the Governor of Chikuzen once happened to stay over two or three days in Osaka on his journey to Yedo. The late Fukuzawa Yukiti and his fellow students in the Ogata Institute heard that the Governor carried with him a Dutch translation of Faraday's work on electricity for which he paid 80 gold yen. Upon their earnest entreaty the book was loaned to the students for a while. Thereupon they set themselves to the brave task of copying the book. One read aloud while the others wrote and when these got fatigued a fresh group took their turn and thus they worked ceaselessly day and night until they finished copying the book before the Governor's departure for a further journey. There were also some captains of the Dutch ships as well as the ship's doctors who, staying in Japan for the purpose of investigating the manners and cutstoms of the country became teachers of Japanese students. Among such pioneers, the names of Thunberg, Titsingh, Doeff, and Siebold are most famous.

During the interval between 1800 and 1868 the number of published works and translations on physics, chemistry, astronomy, mathematics, and natural history was very great, the most prominent being books on Physics by Hoashi Banri and Aoji Rinsō and books on Chemistry by Udagawa Yōan.

The knowledge of magnetism in Japan dates from an early age, when it was brought in from China. The knowledge of electricity, on the other hand, was first brought in 1760 from Holland with the importation of a frictional electric machine. Hiraga Gennai made such a machine for himself and the interest in this science spread to Yedo, Osaka and other places. It was popularly called "Electeer" and was looked upon as one of immeasurable manifestations of unfathomable European knowledge. A little later, Hashimoto Sōkichi made somewhat systematical experiments on electricity.

During the feudal age of Japan, the education of a knight (Samurai) comprised chiefly, besides the art of fighting with swords, the study of the Chinese philosophy of Tsutsi (Chu-Tse) of the Sung dynasty. The chief religion was Buddhism. It was in the latter half of the eighteenth century that the school of ancient Japanese learning and the school of Shintoism sprang up in addition to the school of Dutch learning as discussed above. Although the last two schools represented two extremes, the one ultra-nationalistic and the other the worship of foreign sciences, yet they united in antagonizing the traditional influences of Confucianism and Buddhism. Their relation to each other was somewhat similar to that of the humanist and realist schools of the Renaissance period in Europe which stood against the traditional scholastic school. The analogy may be pushed a little further. The school of natural philosopy, based on the monism of "Ki" (Matter), which flourished during the first period gave way to the geocentric theory of the Aristotelian school which in its turn was displaced by the heliocentric theory of Copernicus, ushered in by the rise of Dutch learning. These successive changes are just like a miniature picture of the history of scientific progress in Europe, which moved on from the period of the natural philosophy of the Greek school to the period of the Renaissance following the Middle Ages.

The mathematics of this age in Japan had an indigenous development along the line called "Wasan", meaning Japanese mathematics. Due to the scarcity of imported Dutch books on mathematics, the native mathematicians had a certain degree of self confidence in the practical side of their science. It was somewhat the same with medical science and the physicians thought that, although Japanese medicine was much behind the European in anatomy and physiology, it had much to pride itself on in the matter of medicaments and therapeutic experience.

On the contrary, in the theories of astronomy and the practice of electricity, even the most jingoistic and stiff-necked acknowledged that the country was behind Europe. Thus the fact that the scholars professing Chinese science realized that they were inferior in their views of nature on the theoretical rather than on the practical side, is considered to have had an influence in changing the tide of advance of public thought in general. Consequently, it was easy at the time of the Meiji Restoration of 1868 to entirely remodel the system, without any hesitation and without any respect to tradition, not only in matters of government and diplomacy but also in education and in science.

The seemingly radical changes achieved at the Meiji Restoration are thus found to have been the result of a long series of historical vicissitudes which were overcome and turned into foundation stones for the solid scientific structure of modern Japan lain by the infinite perseverance and brave and untiring labors of the pioneer scholars. Unfalteringly, in spite of overwhelming odds they held up high the flaming torch of scientific research, passing it on till our better trained modern hands could carry it to the heights of its modern triumph.

XIII. A Historical Sketch of the Development of Seismology in Japan.

By

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I. Introduction.

The islands of Japan, extending over 29 degrees of latitude from the torrid wilderness of Formosa to the cold solitudes of the Kuriles, have often suggested a comparison with a narrow strip of the continental mass torn off from the worn out margin of the vast Eurasian main body. To say nothing of the theories of Richthofen, Hobbs, Wegener, and others the shape and position of the land cannot but suggest something very unusual in the physical and chemical conditions of this part of the earth's crust, either as the remnant effect of the past processes which must have occurred in course of the genesis and the subsequent evolution of the land, or as the physical consequence of the prevailing states of things. Things may happen which could never be experienced in other parts of the world where the simple and uniform structure of a large crustal mass is enjoying the golden era of peaceful stability. From time immemorial, the islands have, indeed, been the site of incessant displays of volcanic and seismic activities. The present features of the land covered with an intricate net-work of cracks and creases bear infallible witness to these past cataclysms. To cite a single example, the vast plain of Kwantô is covered with volcanic ashes to a depth of several metres beneath which relics of former populations are from time to time turned up. In the myths and folklore of the nation, we may not infrequently trace the repercussion of emotions which natural calamities must have aroused in the unenlightened minds of our remote ancestors. Earthquakes have been counted in a vulgar adage[1] as the foremost of the four things terrible. According to tradition, the shaking of the earth was attributed to the stirrings of a monstrous catfish which had been imprisoned under the earth by the God of Kasima[2].

The most ancient record of great earthquakes dates back to 416 A.D. In 684, a district (estimated at about 8 sq. km. in area) in the Pacific coast of Tosa disappeared beneath the sea. Since that time, the history of this country is remarkably rich in records of earthquakes, especially of those which shook the districts near the site of the Imperial Residence. The name of the era, or *Nengô*, has been changed on the occassions of destructive earthquakes, as was customary in the case of any incident of grave significance, good or evil, caused by nature or by man. A comprehensive collection of these records is published as No. 46A,B of the Report of the Earthquake Investigation Committee which supplies an almost inexhaustible source of materials for investigators.

Though speculative theories have often been propounded by some of the thinking minds of the Tokugawa era, about the nature of the remarkable natural phenomenon, no one dreamed of making it a subject of investigation under the light of experimental physical science, from which the eyes of our fathers were long since turned by the deep-rooted influences of oriental metaphysics. After the Meiji Restoration, European sciences were freely introduced and cultivated with ever-increasing zeal. In the Imperial University of Tôkyô a number of European and American scientists were engaged in awakening the scientific spirit of the younger generation, a spirit which had remained dormant in the blood of the nation. John Milne was among these learned worthies, giving lectures on mining, engineering, geology, and mineralogy. A local earthquake which occurred on 22 Feb., 1880, in the vicinity of Yokohama happened to kindle the enthusiasm of this

(1) i.e. earthquake. thunder, fire and *dad*.

(2) There is a stone in the confine of the shrine of Kasima, known by the name of *Kanameisi* which is said to be the top of an enormous piece of rock weighing upon the head of the monster catfish, so that the locality is saved for ever from destructive earthquakes. The late Dr. Kusakabe wrote an interesting paper on this stone, referring to it as an example illustrating his theory of the relation of earthquake intensity and the geological structure, T.S.B.K., **3** (1906), 88.

talented man, and resulted in giving birth to the Seismological Society of Japan. Among the members of the Society we find those whose names will be remembered for ever as the fathers and nurses of the physical sciences in this country, i.e. C.G. Knott, J.W. Ewing, T.C. Mendenhall. E. Knipping, T. Gray, E. Naumann, and others. Among the Japanese members the names are to be seen of D. Kikuchi, K. Yamakawa, K. Furuichi, K. Nakamura, T. Kochibe and other pioneers, among which stands the name of K. Sekiya, the first seismologist proper of this country. On turning over the leaves of the 16 volumes of the Transactions of the Society we cannot but be struck by the stimulating atmosphere of enthusiasm in which those members pursued their aim. It will not be too much to say that the seed of everything pertaining to the problems of seismology was sown in these times. Not only the statistical side of the investigations which has been followed specially by later students in this country, but physical investigations, experimental as well as theoretical, into the nature and the mode of generation of seismic phenomena received due attention. To cite a few examples, experiments on earth waves caused by explosions were carried out and the results discussed with such a thoroughness as would be considered exemplary, at least for those days. The study of the slow deformation of the earth crust had been proposed, and even a design of a water level suitable for that purpose suggested. The electrical phenomena accompanying earthquakes have not been neglected. It is rather a remarkable fact that these valuable labours of the pioneers have apparently fallen into utter oblivion, and yet remote echoes of their pick and spade have been heard in the foremost files of modern seismology.

After the dissolution of the Seismological Society of Japan, due to the gradual decrease in the number of the supporting members, the activity of Milne was continued for two years in editing the Seismological Journal of Japan up to 1895, with the zealous collaboration of Sekiya and Omori who successively laid the foundation of the Seismological Institute of the Imperial University of Tôkyô. A timely fresh impetus to the study of earthquakes was given by the severe shocks of 1891 in the Mino-Owari districts. By the initiative of Baron Kikuchi, supported by the scientific staff of the University, the Earthquake Investigation Committee was organized under the auspices of the Department of Education of the Imperial Government. The members of the Committee consisted of those who stood foremost in the scientific circles of the age, and represented the highest levels in different branches of science. The aims and tasks accomplished of this institution, as well as the results of investigations obtained up to 1904, have been summarized by the lucid pen of its founder, Baron Kikuchi, in No. 19 of the Publications of the E.I.C. which gives an excellent bird's eye view of the various fields of activity in which the members of the Committee were working, viz. statistical, instrumental, physical, geological and practical. Since that date, the activities of the Committee were continued in the same lines with unfailing zeal up to the present day. The following list of publications issued is an eloquent witness of the deeds achieved by this organization:

Reports of the Earthq. Invest. Comm.			(in Japanese)	100	Vols.
Publications	,,	,,	,,	26	,, .
Bulletin	,,	,,	,,	11	,, .
Seismological Notes				6	,, .

Besides these official reports presented to the Committee, many important works written by the members of the Committee, as well as by other physicists, have been published in different scientific journals, such as the Journal of the College of Science, Proceedings of the Tôkyô Physico-Mathematical Society, Journal of the Meteorological Society of Japan, Umi to Sora(1), etc.

Those who take a glance at the list of papers which have appeared in the different publications of the E.I.C. will wonder at the inexhaustible activity of Prof. Omori to whom by far the great majority of the items are due. To do justice, however, to the other members of the Committee, it must be remarked that they were all, at the same time, engaged in their own proper professions of grave importance, in different branches of the government's scientific investigations and this study of earthquakes and attendant phenomena was in the nature of a parergon. It is probably due to this circumstance that seismology in Japan is said to have taken a somewhat one-sided course of development.

The study of seismology has not, however, been monopolized by the authorities of the E.I.C. The cradles of the younger generation of seismologists have been set up here and there in various quiet

(1) Umi to Sora (Sky and Water), a monthly journal published by a body of meteorologists in the Imperial Marine Observatory of Kôbe.

nooks and corners of our scientific world. The Central Meteorological Observatory of Tôkyô had taken up regular seismological observations into its routine work from the earliest days of its existence. The numerous Meteorological Stations widely distributed in different parts of the country have been equipped with more or less competent seismographs under the supervision of the Central Meteorological Observatory. The net work of systematic observations has developed into an increasingly valuable organization owing to the incessant efforts of the central staff to improve the instruments and the methods of observation and especially to effect a reliable control of time. Meanwhile, disinterested theoretical investigations of earthquake phenomena have by no means been neglected. A number of valuable papers in this line have appeared in the Bulletin of the Central Met. Obs. and Journal of the Met. Soc. of Japan. Since the foundation of the Marine Observatory at Kôbe, by Prof. Okada, earthquake observations have been included in the routine program of its work. The invaluable contributions made by the authorities of this institute on the occasion of the recent Great Earthquake will be remembered by all seismologists of this country.

Another school of seismology has been in the meanwhile in breeding in the Imperial University of Kyôto, under the influence of Prof. Shida. At the Kamigamo Observatory, in that picturesque suburb of the ancient metropolis, many kinds of original investigations have been carried out. Recently, Prof. Shida succeeded in founding a new Geophysical Observatory at Beppu, in the Prefecture of Oita, a famous site of the unique group of hot springs where various lines of interesting researches are now in prospect.

On the other hand, the Tôhoku Imperial University, in Sendai, has by no means been indifferent to this branch of natural sciences. The late Prof. Kusakabe founded the Mukaiyama Observatory in the vicinity of the city of Sendai, where beside the usual meteorological observations seismological investigations were in progress under his able guidance. Recently, Prof. Saem. Nakamura who was formerly the Expert in the Centr. Met. Obs., has succeeded to his chair. With the able assistance of Mr. Shiratori, he is now keeping watch on the terrestrial phenomena in the northern quarter of this country.

The great earthquake of Sept. 1, 1923, with all its sacrifices in lives and properties, has not been without some compensatory benefit at least regarded from the scientific point of view. The urgent necessity of promoting the study of the phenomena with more scientific thoroughness has strongly appealed to every thinking mind, not only among scientists, but also of the Government as well as of the general public. The Department of Education, in conjunction with the Imperial Universities, held council to deliberate upon the immediate reorganization of the E.I.C., and at last decided on the foundation of a new Earthquake Research Institute with the collaboration of the Universities. The original E.I.C. was to be dissolved and an advisory council organized in its place. The members of the Research Institute will consist of some veteran seismologists and a number of younger members who can devote their activities exclusively to research work, without being distracted by other duties. Prof. K. Suyehiro who has played an active part in promoting the foundation of the Institute was recently appointed as the first Director. Those who are acquainted with his numerous works and his former activity as the Director of the Mitubisi Research Institute will not hesitate to foretell a prosperous future for the newborn institute.

Together with this, a Course of Seismology in the Faculty of Science, Tôkyô Imperial University, has been newly established and the Chair of Seismology has now been connected with its own specialist students, to enjoy an independent existence as a site of academic education.

We may now entertain the hope that seismology in this country will take a fresh start by the active co-operation of the younger generation and the seeds sown by John Milne in the early days of its existence will now send up new shoots in the fertile ground of modern physical science. To borrow the words of Milne, the recent destructive earthquake has been thus "after all, a blessing in disguise."

Turning now to the main object of the present note and endeavouring to give a summary of the results of the investigations made in this country, the writers feel most keenly the difficulty of the tasks charged upon them. The materials to be passed under review are too abundant to allow a recondite summary in the number of pages here allotted, without failing to do justice to some one or other of the important works of different investigators. Fortunately, Baron Kikuchi's monograph above cited is before us and this has summarized everything of significance rendered up to 1904. We may therefore be excused if we prefer to shift the *centre of gravity* of the present review to the more recent contributions, and sometimes put too much weight on those researches made into byways departing from the routine work pursued by the authorities of the E.I.C.

Lastly, we hope we may be excused if we have sometimes presumed to make here and there something akin to critical remarks, as such remarks seem to be allowed for writers in our position, in order to relieve their writings from the utter dryness of a veritable catalogue of scientific literature.

The following is the key to the abbreviations of the names of the scientific periodicals cited:

Ho.	Sinsai-yobô-tyôsakwai-hôkoku (Report of the Imperial Earthquake Investigation Committee), in Japanese.
Pub.	Publications of the E.I.C., in Foreign Languages.
Bull.	Bulletin of the E.I.C., (English).
Seism. N.	Seismological Notes, E.I.C., (English).
Journ. Coll. Sci. Tok.	Journal of the College of Science, Tôkyô Imperial University, (English and other languages).
Journ. Fac. Sci. Tok.	Journal of the Faculty of Science, Tôkyô Imperial University, (English and other languages).
Mem. Kyo.	Memoirs of the College of Science and Engineering, (later College of Science), Kyôto Imperial University, (English and other languages).
Sci. Rep. Toh.	Science Reports of the Tôhoku Imperial University, (English and other languages).
T.S.B.K.	Tôkyô Sûgaku-Buturigakkwai Kiji (Proceedings of the Tôkyô Mathematico-Physical Society), (English and other languages).
N.S.B.K.	Nippon Sûgaku-Buturigakkwai Kizi (Proceedings of the Physico-Mathematical Society of Japan), being the continuation of the above.

Jap. J. Astr. Geophys.	Japanese Journal of Astronomy and Geophysics, National Research Council of Japan, (English and other languages).
J.M.S.	Journal of the Meteorological Society of Japan, (mostly Japanese); 'e.' before the number of page means that the paper is in English; 'e.' after the page number means that an abstract beside the Japanese text is given.
Bull. C.M.C.	Bulletin of the Central Meteorological Observatory, Tôkyô, (mostly in English).
U.t.S.	Umi to Sora (Sky and Water), issued by Zisyûkwai, Imperial Marine Observatory, Kôbe, (in Japanese).
Mem. Imp. Mar. Obs.	Memoirs of the Imperial Marine Observatory, Kôbe, (English).
Geogr. Rev.	Chirigaku-hyôron (Geographical Review), Tôkyô, (in Japanese).
Chikyu	Chikyu (the Globe), Kyôto, (in Japanese).

An exhaustiveness of reference can scarcely be looked for. We have refrained, to our great regret, from reviewing those valuable periodicals such as:

Journal of the Geological Society, Tokyo,

Chigaku-Zassi,

Tôyô-Gakugei-Zassi, etc.,

and also many important publications of Government Offices as Tisitu-tyôsazyo (Geological Survey). For the incompleteness of reference we beg forgiveness(1).

Statistical Investigations.

As it is quite natural and legitimate in the earlier stage of the development of a science concerning natural phenomena, the statistical sides of the investigation have been mostly favoured by the pioneer seismologists of this country who had more than ample materials for the investigation at their disposal. Among the various important

(1) Papers referred to in this review are those which appeared up to the end of Feb., 1926. Unpublished results are also freely quoted, as far as the writers are aware. For this freedom, they wish to be excused.

results obtained by their efforts, only a few will be summarized below.

(1) *Time distribution of earthquake.*

(a) **Annual variation of frequency.** Annual or seasonal variation of the frequency of earthquakes has been extensively studied by Omori since the earliest days(1). The variation shows quite different and nearly opposite courses for destructive earthquakes and ordinary or weaker ones(2). For the data taken without regard to the locality, the frequency shows a summer maximum for the former and a summer minimum for the latter. The amplitude or range of variation is about one half and one quarter respectively, of the average number, so that the possibility of the result being due to accidental fluctuation can safely be excluded. Besides, since the number of the destructive earthquakes is only a small fraction of the total number of earthquakes, the chance of obtaining the opposite variation for the two classes merely due to the arbitrary choice made in the discrimination of the intensities of individual shocks, is out of the question.

When different districts are treated separately, a remarkable fact is revealed that there are two distinct types or groups of seasonal variation, i.e. Group (A) in which the seasonal maximum falls in spring and the minimum in summer or autumn, and Group (B) in which the maximum is in summer and the minimum in winter or autumn. The geographical distribution of these two types of district shows some characteristics. Omori remarked that the difference of the two groups consists in the difference of location of the seismic origins which contribute to the frequency in the districts. If we may be allowed to use our own words, the districts belonging to Group (A) are those localities which are 'sensitive' to the earthquakes of inland origin, while the districts of Group (B) are those mostly liable to be disturbed by shocks of submarine origin. Thence, the opposite annual course of variation for the two groups is attributed to the difference of the annual variation of frequency for the origins situated in land and sea. The physical agency giving rise to these modes of variation was considered to be due to the effect of the variation of pressure exerted upon the earth crust. The subject seem worth further study,

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(1) Ho. **2** (1894), **26** (1899), **30** (1900), **32** (1900), **54** (1906); Pub. **8** (1902); Bull. **2**, No. 1. (1908); Journ. Coll. Sci. Tok., **11** (1899), 389.

(2) Ho. **30** (1900); Pub. **8** (1902).

referring directly to the position of the origins instead of taking the districts disturbed.

Recently T. Terada[1] mentioned a peculiar fact that the distribution of the two groups of districts which show opposite relations with regard to the correlation between the yearly fluctuation of atmospheric pressure on the one hand, and a factor determining the distribution of faculae on the solar disc on the other, is quite similar to the distribution of the two Groups above cited. On the other hand, T. Tokuda[2] has remarked a striking difference in the geotectonic structure of the Pacific and of the Japan Sea coast, the block structure and the folded structure being respectively conspicuous in the tertiary formations of the two zones. These latter facts, though apparently quite separate from each other, may suggest some connection with Omori's result here cited.

(b) **Diurnal variation.** The diurnal variation has also been studied most extensively by Omori[3] who found that the frequency of earthquake is closely related to the variation of the barometric pressure. For the most districts, the maximum of pressure corresponds to the maximum of the frequency.

(c) **Lunar variation.** The periodic variation of frequency related to lunar day or tidal level has also been investigated by Omori[4]. Though the lunar effect is much complicated, it has been inferred that the frequency is enhanced in the epochs of the upper and lower quadratures. The results have been explained by the effect of the oceanic tides

Honda[5], in his investigation of the level change of wells, remarked some relation between the frequency of earthquakes and tidal phases.

On the other hand, Imamura[6] studied the synodic-monthly distribution of the frequency. The results obtained are rather complicated. Four maxima or two were found for the earthquakes of submarine and of inland origin. The results have been explained by the interference of the effects due to the barometric and tidal pressure.

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(1) Journ. Coll. Sci. Tok., **44**, Art. 6. (1923).
(2) Geogr. Rev., No. 10 (1925).
(3) Ho., **2** (1894); **30** (1900).
(4) Ho., **32** (1900); **54** (1906); Bull., **5**, No. 2 (1913).
(5) Pub., **18** (1904).
(6) Ho., **18** (1904); T.B.S.K., **2** (1904), 109.

(d) **Secular variation.** At least with regard to destructive earthquakes the materials are sufficiently rich for studying the secular variation of frequency. Several attempts have been made to establish the 'period', or more properly the cycle of earthquake occurrences(1). As for an instance, the sequence of destructive earthquakes in the districts near the Province of Sagami has shown a remarkable succession of nearly equal intervals(2). Unfortunately, no reliable criterion has yet been established to discriminate the true periodicity with a definite physical significance from the apparent ones which may be brought forth by more or less arbitrary choice of the points distributed irregularly on the line of chronology(3). The fact that the destructive earthquakes seem to occur in groups is also a statistical truth, though a similar grouping may happen also in the cases of purely arbitrary distribution. In this connection, Saem. Nakamura's method of investigation may be cited(4), though his paper refers to a much shorter duration of time. He studied the frequencies of the days with 0, 1, 2,·········9 earthquakes recorded instrumentally, with reference to the data observed in Tôkyô during four years. On comparing the results with the theoretical expectations corresponding to the random distribution, it was found that the number of the days with no shock was less than the theoretical value, while those with one or two shocks were above the expectation. On the other hand, T. Terada(5) suggested another method of statistical investigation regarding the time distribution of earthquakes which may in some case be utilized for getting some insight into the physical cause governing the time distribution. At any rate, it seems desirable to elaborate the method of statistics in this direction, before we may arrive at any definite conclusion on the much discussed periodicity of earthquakes.

(e) **Other periodic variations.** Omori(6) remarked that with regard to the aftershocks of some destructive earthquakes, there exist

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(1) Omori, Ho., **26** (1899); **57** (1906); **68**B (1910); **88**C (1920). Imamura, Ho., **77** (1913); **95** (1922).

(2) Among others, M. Matsuyama, Comptes Rendus des Séance de la 2m Conference, Madrid, 1924, Union géodesique et géophysique, Section de Séismologie, 72.

(3) See Suda's discussion on this point, Mem. Imp. Mar. Obs., **1** (1924), 215—216.

(4) Journ. Met. Soc., **39** (1920), 79; T.S.B.K., [iii] **2** (1920), 82.

(5) T.S.B.K., **9** (1917), 515.

(6) Ho., **57** (1906).

the periods with durations of 4.5, 12, 33 days, and 3 months respectively. Sunspot period has also been spoken of. In these respects, a similar remark as given at the end of the last paragraph may be applied. It may be added here that Terada[1] drew attention to the fact that an apparent or 'phantom' periodicity may be brought forth by a quite arbitrary sequence of events.

(f) **Occurrence of fore-shocks.** Examples of fore-shocks observed before the main shocks have often been cited on the occasions of many conspicuous earthquakes[2]. The data are, however, not yet sufficiently abundant to allow of statistical treatment. The apparent existence or non-existence of weak fore-shocks depends evidently on the sensibility of the instrument. In this respect, Shida's investigations[3] now in progress with an extremely sensitive seismograph is to be awaited with much expectation.

(g) **Time distribution of after-shocks.** Omori's hyperbolic formula regarding the decay of the frequency of aftershocks is well known[4]. He showed that the same formula holds good even after the lapse of eight years in the case of the Mino-Owari earthquake, though in some cases it failed, as in the case of the Hukuoka earthquake of 1898. He also noticed a quasi-periodic character of the deviation from the formula. The physical interpretation of the formula has been attempted by O. En'ya[5] and later elaborated by Kusakabe[6] based on his researches on the elastic properties of rocks. The latter inferred that the rate of decrease of the frequency of after-shocks is determined by the duration of time required for the accumulation of the stress before the break down is effected. His conclusion has been applied by Saem. Nakamura[7] and K. Suda[8] in the discussions of the time-frequency relation with regard to the after-shocks of the Oomati earthquake and

(1) T.S.B.K., **8** (1916), 492.

(2) Omori, Ho., **68**A and B (1910); Bull., **2**, No. 2 (1908). A. Imamura, Ho., **70** (1910); **77** (1913); **82** (1915); **92** (1920). N. Yamasaki, Ho., **11** (1897). T. Iki, Ho., **29** (1899). N. Fukuchi, Ho., **38** (1902).

(3) Not yet published.

(4) Ho., **2** (1894); **30** (1900); **32** (1900); **54** (1906); **94** (1921); Bull., **2**, No. 2 (1908); Journ. Coll. Sci. Tok., **7** (1895) 112. See also Imamura, Ho., **70** (1910); **77** (1913); **100**A (1925); Seism. N., **6** (1924).

(5) Ho., **35** (1901); **57** (1907); **61** (1908).

(6) Pub., **17** (1904).

(7) J.M.S. 38 (1919), 147.

(8) Mem. Imp. Mar. Obs., **1**, No. 4 (1924).

the recent Kwantô earthquake respectively. On the other hand, the characteristic deviation from the algebraic formula was studied by T. Terada[1] who showed that the apparent periodic fluctuation may result from purely accidental causes, but that the apparent period may give some clue for studying the elastic property of the earth crust.

Saem. Nakamura[2] remarked a periodicity of $1^m\ 40^s$ in the case of the Hakone earthquake of 1907. R. Hirano[3] made an interesting investigation with respect to the after-shocks of the recent Kwantô earthquake. He assumed an empirical formula $y=b/(x+a)^c$ where y is the number of after-shocks on the x-th day, and a, b, c are constants. It is remarked that the values of the constants change abruptly at $x=19$. Besides, he observed a marked periodicity of 19.2 days in the 10 days mean of $\log y$, which he tries to explain by the alternating excitation of a number of discrete sources of activity.

K. Suda[4] classified the after-shocks of the Kwantô Earthquake into two families according to the position of the origins. Some characteristic behaviour of these families as well as the mode of migration of activity among them are discussed. He also noticed a marked discontinuity in the hyperbolic course of decay.

Imamura[5] also made a careful examination on the distribution of the origin of after-shocks of the same earthquake and obtained three distinct groups of the localities of the origins. The different groups behaved differently in the time distribution of the frequency.

A similar study by K. Shiratori[6] may also be mentioned who arrived at an N-shaped zone of the origin of the after-shocks.

(h) **Relation of the frequency of earthquakes with meteorological and other phenomena.** As already cited, Omori[7] discussed the effects of barometric pressure with regard to the annual and diurnal variations of the earthquake frequency. In the meanwhile, he[8] studied

(1) N.S.B.K., [iii] **1** (1919), 180.
(2) Journ. Met. Soc., **36** (1917), 67, e.
(3) Journ. Met. Soc., **43** (1924), 77.
(4) Mem. Imp. Mar. Obs., **1**, No. 4 (1924).
(5) Ho., **100**A (1925); Seism. N, **6** (1924). C. Yasuda, Ho., **100**A (1925).
(6) Jap. J. Astr. Geophys., **2** (1925), 173.
(7) loc. cit; also Bull. **2**, No. 3 (1908); T.S.B.K., **2** (1904), 113.
(8) Ho., **68**A (1910); Bull., **1**, No. 2 (1907); **2**, No. 1 and 2 (1908); **5**, No. 2 (1913).

the change of sea-level at different mareographical stations and came to the conclusion that the combined effect of the barometric and tidal pressure is to be considered as an important secondary cause of earthquake. T. Terada(1) investigated the relation between the annual variation of barometric gradient and that of the frequency of earthquakes in different districts and found that the latter shows a parallelism with the component of the gradient in a certain direction proper to each district. K. Hasegawa(2) studied the same relation with respect to fifty local earthquakes in the Gihu district, of which the locations of the origins were ascertained. He confirmed that the gradient 30^m before the occurrence of the individual shock is most frequent in the direction NE. or S. which differs distinctly from the gradient most prevalent in that district. These directions were respectively perpendicular to the conspicuous fault lines previously located in this district. Neither the barometric height relative to the surrounding regions nor the time-rate of variation of the pressure showed any sensible influence. The subject has since been investigated by Saem. Nakamura(3), S. Masuzawa(4), D. Nukiyama(5), etc. Saem. Nakamura showed, with respect to earthquakes in Wakayama Prefecture, that the effect of the barometric gradient reveals somewhat different aspects for annual and diurnal variations. Masuzawa found that the gradient most probable on the occasion of earthquakes originating in the Pacific submarine zone, between Idu and Tyôsi, is in opposite directions for both sides of a line crossing the land transversely. D. Nukiyama and M. Mukai verified Masuzawa's result and, moreover, showed that the time variation of the gradient vector on the occasion of an earthquake has also a predominant direction transverse to the axis of the land. Saem. Nakamura(6) studied again the effects of barometric and tidal pressure on the frequency of aftershocks of the recent Kwantô Earthquake. His result seems to confirm Masuzawa's, as far as the effect of the barometric gradient is concerned. Besides, he noticed peculiar relations regarding the anomaly

(1) Journ. Met. Soc., **28** (1909), 1; T.S.B.K., **4** (1908), 454.

(2) J.M.S., **32** (1913), 397; T.S.B.K., **7** (1913), 181.

(3) J.M.S., **34** (1915), 71; **41** (1922), 420; T.S.B.K., **8** (1915), 69; [iii] **2** (1920), 82.

(4) T.S.B.K., [iii] **1** (1919), 343.

(5) Jap. Journ. Astr. Geophys., **1** (1922), 49.

(6) Jap. Journ. Astr. Geophys., **3** (1925), 115.

of the sea-level at, before or after the occurrence of the earthquake, though the physical meaning of these facts is not clear.

Recently T. Isikawa(1) found that the earthquake due to the dislocation of a fault line is liable to occur when the barometric gradient is changing its direction and tends to fall in with the direction of the fault line, or when a conspicuous line of discontinuity of barometric pressure passes over the epicentral region.

Among the relations which have been suspected to exist between the frequency of earthquakes and meteorological phenomena, the most remarkable is that found by Omori(2) between the yearly number of shocks in Tôkyô and the precipitation in the Japan Sea coast of Hokurikudô. The frequency is greater for the years with greater amounts of rain and snow. T. Terada(3), from his studies on the geographical distribution of precipitation, is inclined to believe that it is the general barometric gradient in the central part of Japan which determines both the earthquake frequency and the amount of precipitation in the respective districts.

The relation between the weather and earthquakes has also been investigated by Omori(4), Saem. Nakamura(5) and others. The results are not quite decisive as might have been well expected. Nakamura also remarked a possible relation between the mean diurnal range of the magnetic declination of a year and the number of earthquakes in the next year(6).

A probable relation between the occurrence of strong earthquakes and the variation of latitude has been pointed out by Omori(7), though we must wait a longer time before the relation may be verified an abundance of material.

(i) **Other problems regarding time distribution.** Remarkable examples in which earthquakes have occurred in a district in the same hours of a day or on the same day of the same month have often been cited by Omori(8).

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(1) J.M.S., [ii] **3** (1925), 255, e.
(2) Ho., **68A** (1910); Bull., **1**, No. 2 (1907); **2**, No. **2** (1908).
(3) Journ. Coll. Sci., **41**, Art. 5 (1919).
(4) Ho., **2** (1894); Bull., **2** (1908); J.M.S., **29** (1910), 87.
(5) J.M.S., **40** (1921), 173.
(6) T.S.B.K., **9** (1918), 319.
(7) Ho., **49** (1905).
(8) Ho., **57** (1906).

Some sympathetic or contagious interrelation between the activities of distant earthquake zones has also been suspected by Omori[1] who cited many examples of Japanese destructive earthquakes which occurred within a short time interval after remarkable ones in other parts of the world. He remarked the alternation of activities in the submarine epicentral zone off the coast of Sanriku and that off the southern part of the Pacific coast. He[2] also pointed out a tendency of sympathetic occurrences of volcanic eruptions and great earthquakes. On the occasion of the recent Tazima Earthquake, K. Suyehiro[3] noticed the remarkable fact that the strong earthquakes in the Japan Sea coast of San'indô occur mostly within a few years after the conspicuous destructive shocks in the Pacific zone. These facts, which require of course further verification by ampler data, seem to afford us valuable material for the geophysical investigation of the actual mechanisms of earthquakes.

(2) *Space Distribution of Earthquakes.*

(a) **Earthquake zones.** Omori[4] and Imamura[5], during the long years devoted to their seïsmic investigations, succeeded in sorting out, from the chaos of abundant materials, complete sets of the principal epicentral zones in Japan. Among these zones, the most conspicuous are those two running parallel to the arc of the islands, one off the entire Pacific coast and another along the Japan Sea coast. Other groups of zones are those running across the arc with a more or less definite angle of inclination to the axial line. The Sinanogawa zone, the triangular zones surrounding Lake Biwa, a zone across Kyûsyû probably extending to the Inland Sea with a trend parallel to the Pacific zone, the Formosan zones, etc., may be cited as the most conspicuous ones.

A certain statistical law of occurrence on alternative zones, or on the different parts of the same zone, has been pointed out by Omori on many occasions. Though such a law may probably exist, it seems that a greater sufficiency of data must be accumulated, and the method

(1) Ho., **57** (1906).

(2) Bull., **2**, No. 2 (1908).

(3) A Report read before the E.I.C.; not yet published. K. Suda also remarked this fact, Special Report on the Tazima Earthquake (1925), Imp. Mar. Obs.

(4) Ho., **49** (1905); **54** (1906); **68**B (1910); **88**C (1920); **96** (1922); Bull., **1**, No. 2 and 3 (1907); **2**, No. 2 (1908); T.S.B.K., **4** (1907), 126; **4** (1908), 288.

(5) Ho., **53** (1906); **70** (1910); **77** (1913); **82** (1915); **92** (1920); **95** (1922).

of statistics improved, before anything positive may be said about this matter.

The relation of the seismic zones with the geological structure of the land has been investigated from the earliest dates, by the geologist members of the E.I.C.[(1)]. On the occasion of the recent Kwantô Earthquakes, many important contributions on this line have been made by the geologists, T. Kato[(2)], N. Yamasaki[(3)], T. Ogawa[(4)], and H. Yabe[(5)], among others. Structural lines in the district in question have been identified and their distributions discussed by Ogawa, who has also studied the case of the Simabara earthquake of 1922, and confirmed his view that the orotectonic and the seismotectonic lines coincide with each other.

Yamasaki made an extensive study on the block structure of the Kwantô districts and drew attention to the extension of the same structure into the bed of the Bay of Sagami, where the origin of disturbance of the recent catastrophe is to be sought. Yabe gave a very concise representation of the geological structure of the Kwantô Plain as an individual geological unit. These investigations have thrown much light on the nature of the seismic zones.

Recently S. Ono[(6)] made an original study on the block structure of land from the physical point of view and suggests the existence of definite mean dimensions of these blocks which he estimate at about 60 km. in the horizontal extension. K. Sezawa[(7)] also made an application of the theory of elasticity on the block formation of the earth crust and offered many interesting suggestions as to the origin and nature of earthquake phenomena.

It seems after all that we have now arrived at an epoch when the vague conception of the seismic zone needs a thorough revision and its exact physical meaning scrutinized much more thoroughly than in former days.

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(1) to be cited later.

(2) Journ. Geol. Soc., **30** (1924), engl. p. 17; Ho., **100**B (1925).

(3) Ho., **100**B (1925); Geogr. Rev., **1** (1925), 1; Journ. Fac. Sci. Tok., **1** (1925), 35.

(4) Chikyu, **1** (1924), 1, 113, 199 and 287; Mem. Coll. Sci. Kyo., B. **1**, No. 2, Art. 4 (1924); Jap. J. Geogr., **3** (1924), 1.

(5) Saitô Hôonkwai Zigyô Nempô. No. **1** (1925).

(6) Kensin Zihô, **1** (1925), 1, 11.

(7) Read before the Engineering Society of Tôkyô Imp. Univ., also in the Seismological Colloquium of the Seism. Inst.; not yet published.

II. Instrumental Investigations.

(a) **Instruments.** The invaluable services of Omori's horizontal pendulum and tromometer[1] which have been rendered for the development of seismology in this country need no special comment. Among the other instruments, Imamura's form[2] with two-fold magnification has proved excellent for recording near earthquakes and was the only instrument which furnished us with the most precious record of the recent great earthquake which put all other instruments out of action.

The introduction of a damper on Omori's instrument has also been contemplated in this country. Saem. Nakamura's modification[3] with a special damping device and other points of improvement has been in actual use in some quarters. He later[4] made some discussions on the theory of vertical seismometer.

Tamaru's vertical seismograph[5] with two springs for suspension is devised to avoid the instability due to the third power of the angle of deviation appearing in the expression of the potential energy of the system. With successive improvements at different points, the instrument is now in actual use in a number of observatories. Tamaru also elaborated the design of a new seismograph which is intended to record the two or three components of acceleration, by using a single suspended weight. A model is now under construction and being tested under his supervision.

Omori[6] devised also an improved form of horizontal pendulum by introducing the principle of the duplex pendulum. Tanakadate[7] constructed a strong earthquake recorder by making use of Watt's parallel motion arrangement. A form of vertical seismograph is also due to him which was later utilized by S. Yokota for recording the vibrations of ships.

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(1) Ho., **50** (1905); Pub., **12** (1903); **18** (1904); Bull., **1**, No. 4 (1907); T.S.B.K., **1** (1902), 143; Journ. Coll. Sci. Tok., **11** (1899), 121.

(2) J.M.S., **31** (1912), 171.

(3) J.M.S., **39** (1920), 1. See also K. Hasegawa, J.M.S., **31** (1912), 297; K. Suda, Umi to Sora, **2** (1922), 2, 38 and 65.

(4) T.S.B.K., [iii] **3** (1921), 101.

(5) J.M.S., **30** (1911) special pages in *Romazi*; **37** (1918) same; see also Hasegawa, J.M.S. **33** (1914), 239.

(6) T.S.B.K., **2** (1904), 118.

(7) Pub., **7** (1902).

Shida(1) gives a design of a special horizontal pendulum with which he proposes to study the possible free vibration of the earth. He also constructed recently an extremely sensitive seismometer with which he is now continuing a special investigation in his Kamigamo Observatory(2).

Imamura(3) lately introduced several points of improvement in the registering mechanism of Omori's tromometer and succeeded in obtaining fine records of those minute vibrations which had hitherto escaped our observation. With this instrument, it is hoped that it will become practicable to determine the epicentres of minor earthquakes.

Lastly, the recent investigation by S. Takaya and K. Tanabasi(4) on the coefficient of the damping of the tromometer and its dependence on the period is worth notice.

(b) **Velocity of propagation of seismic waves; duration of preliminary tremor.** The velocities of the propagation of the different phases of seismic waves have been investigated by Omori(5) and Imamura(6) from the earliest days. The former early noticed the difference of the velocities for continents and oceans. Velocities of waves due to artificial shocks have also been investigated.

Omori's formula(7) giving the relation between the duration of the preliminary tremor and the epicentral distance is very well known. The great service rendered by this formula for the advancement of seismology in this country can scarcely be overestimated. It has its own merit on account of its utmost simplicity and practical applicability at least for the first approximation, though indeed its physical

(1) Nagaoka Anniversary Volume (1925), 109.

(2) Communicated to a Meeting of the E.I.C.; still unpublished.

(3) Read before the Colloquium of the Earthquake Research Inst., 24 Feb., 1926; not yet published.

(4) U. t. S., **6** (1926), 31.

(5) Ho., **3** (1895); **4** (1895); **21** (1898); **29** (1899); **50** (1905); **73** (1911); Pub., **5** (1901); **13** (1903); **24** (1907); Bull., **1**, No. 1 and No. 2 (1907); **2**, No. 2 (1908); **3**, No. 2 (1909); T.S.B.K., **1** (1903), 207, 218; **2** (1905), 193.

(6) Ho., **21** (1898); **32** (1900); **53** (1906); **70** (1910); Pub., **7** (1902); **16** (1909); **18** (1904); Seism. N., **6** (1924); T.S.B.K., **1** (1903), 261; **2** (1905), 151, 159.

(7) Journ. Coll. Sci. Tok., **11** (1899), 147; Ho., **29** (1899); **50** (1905); **88A** (1918); Pub., **5** (1901); Bull., **1**, No. 1. (1907); **2**, No. 2 (1908); Seism. N., **1** (1921); T.S.B.K., **2** (1905), 290. Also Imamura, Ho., **82** (1915); **95** (1922); S. Nakamura, J.M.S., **35** (1916) e.

meaning and the degree of accuracy have often been subjects of much discussion, especially among the adherents of the physical school of seismology. The improvement of the formula has often been attempted, for examples by K. Hasegawa[1] and Saem. Nakamura[2]. The latter derived a parabolic formula instead of the linear one, for the cases of near earthquakes, from a theoretical consideration consisting of an extension of Wiechert's theory on the seismic wave propagation. Nevertheless, Omori's formula has survived with all its proper practical merits.

For finding the position of the epicentre by means of Omori's formula, many practical methods have been devised, for example by T. Usiyama[3] and M. Kawazoe[4]. The latter pointed out the difficulty of identifying the introduction of the S-phase and proposed to take the direction of motion into account for this purpose. He also made a statistical study of the ratio of the durations of the P- and the S-phases.

Omori's formula has also been utilized for the determination of the depth of the seismic focus, on the assumption that the formula preserves its validity for any distance up to the origin. The method has been discussed by Hasegawa[5], K. Yamazawa[6], M. Kawazoe[7], H. Maruoka[8], etc. The depth obtained by these methods for different earthquakes varies within the wide range of 10 to 60 km. R. Hirano[9] made an elaborate use of the above mentioned formula for the case of the great Kwantô Earthquake and obtained 40 km. On the other hand, Saem. Nakamura[10] obtained, from his application of Wiechert-Geiger's theory in the case of near earthquake, a depth so great as 160 km., which is much at variance with the above values. The latter investigator gave also another method for estimating the focal depth from the intensity distribution, assuming after Shida, that the

(1) J.M.S., **36** (1917), 359,
(2) J.M.S., **36** (1917), 425; T.S.B.K., **9** (1918), 224; [iii] **3** (1921), 116.
(3) J.M.S., **41** (1922), 114.
(4) J.M.S., **35** (1916), 185; **38** (1919), 173; **39** (1920), 228.
(5) J.M.S., **35** (1916), 385.
(6) J.M.S., **30** (1911), 99.
(7) J.M.S., **36** (1917) 332.
(8) J.M.S., **30** (1911), No. 10, 16.
(9) J.M.S., [ii] **2** (1924), 112.
(10) J.M.S., **37** (1918) e. 10, 43.

seismic ray emitted in the horizontal direction from the origin is most intense.

Recently, S. Kunitomi[1] found from his own examination of the reliable records of a number of earthquakes that the velocity of the longitudinal waves is decidedly greater in the direction perpendicular to the arc of the Japanese Islands than along the arc when the origin lies on the Pacific side of the land, the velocities being respectively 9.6 and 6.5 km/sec. The difference is not so marked in the case of Japan Sea earthquakes. The velocity of the surface waves show, in the meanwhile, no sensible difference with the direction of propagation. His subsequent investigations in a number of local shocks have verified the above inference. The explanation of the remarkable fact has been sought in some aeolotropy of the rocks forming the backbone of the land. On this latter point an alternative explanation has been proposed by T. Matuzawa[2], from his theoretical discussion of the mode of propagation of waves in crystalline media.

The existence of the so-called Mohorovičić wave has drawn but little attention in this country, till recently K. Wadati[3] fell upon this kind ef waves independently in the course of his studies on the Tazima Earthquake of 1925. His results turned out to be a beautiful confirmation of Mohorovičić's view. Wadati found that the $\overline{P}$-phase was overtaken by P at a distance of about 120 km. This distance has also marked a very conspicuous boundary, within which the first motion is directed inwards, i.e. towards the origin, with a conspicuous amplitude, while outside this boundary the motion is directed outwards and is decidedly small. According to his calculation, the focal depth of the said earthquake was 32 km., while the depth of the layer of discontinuity turned out to be 42 km. Kunitomi[4] showed that the difference of the velocities in different directions as above cited holds good for the $\overline{P}$-wave, i.e., for the upper layer of the earth crust, as well as for the lower layer, but to a less marked degree in the latter.

K. Suda[5] made also some detailed investigations on the Mohorovicič waves and found that these waves appear more frequently on the

(1) J.M.S., [ii] **3** (1925), 55, 176, 281, e.
(2) Jap. J. Astr. Geophys., **4** (1926), 1.
(3) J.M S., [ii] **3** (1925), 201.
(4) J.M.S., [ii] **3** (1925), 281, e.
(5) U.t.S., **5** (1925), 182, 202.

Japan Sea side than on the Pacific coast. Theoretical discussions are adduced in these papers.

(c) **Direction of first motion.** The first motion of the earth due to the arrival of the shock has been utilized from early days for the estimation of the direction of the epicentre, and even of the focus. Kawazoe[1] showed by his statistical investigation on a number of seismograms that the direction estimated by this method falls within a few degrees of that of the epicentre determined by the usual method from the data of different stations, though sometimes a deviation amounting to 10°, say, is met with.

At a meeting of the Tôkyô Physico-Mathematical Society and also of the E.I.C., in 1917, T. Shida[2] read a paper on his investigation of the space distribution of the direction and sense of the initial motion as an important indication of the type of disturbance at the origin of the earthquake. Different examples of the case in which two straight lines could be drawn, passing through the epicentre and intersecting each other at an angle nearly equal to a right angle, such that they divide the area of the map into four quadrants and mark the boundaries of the regions with an alternate sense of the first motion. Thus, while the stations lying in a certain quadrant show a 'push' from the epicentre, those situated in the adjacent quadrants show a 'pull' from the same point. His results have aroused great interest among seismologists in this country. His step forward has been successfully followed by Saem. Nakamura[3], K. Suda[4] and others[5]. The cases with much more complicated trends of the 'nodal lines,' i.e. the lines marking the boundaries of two adjacent regions with the opposite motion, have been brought forth and discussed with regard to the mode of disturbance at the origin, which was considered as a combination of simple or multiple 'sources'. Theoretical considerations have been applied to different examples with success, so that the distribution has now become a most important clue for the classification of the types of the original disturbances.

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(1) J.M.S., **37** (1918), 53.

(2) Not published.

(3) J.M.S., **41** (1922), e. 1; **37** (1918), 390; **38** (1919), 395; **39** (1920), 134; **41** (1922), 139; **42** (1923), 1; Saitô Hôonkwai Gakuzyutu Kenkyû Hôkoku, No. **1** (1925).

(4) U.t.S., **3** (1923), 14; **5** (1925), 36, 80.

(5) T. Usiyama, J.M.S., **40** (1921), 135; **41** (1922), 4, 222; Kensinzihô, No. 1 (1925), 171. S. Aoki, J.M.S., **39** (1920), 192. K. Taguti, U.t.S., **4** (1924), 199.

Wadati's recent investigation above cited has furnished us with another kind of nodal line, if we may call it so, which will serve as an excellent means for studying the structure of the crust.

Theoretical investigations connected with the above subject by Nakano and Matuzawa will be referred to later in the proper place.

(d) **Nature of earthquake motion; anomaly of propagation.** Omori[(1)] and Imamura's[(2)] works regarding the analysis of seismograms are classical and cover a wide domain including the most important problems of seismology. The discrimination of different phases of motion, the determination of the direction of motion and the average period of each phase, the investigation of the relation between the duration, the period, the amplitude, or the character of wave and the epicentral distance, etc., have been exhaustively pursued, with regard to local as well as world-shaking earthquakes[(3)]. The results of these works, we may presume, are too familiar to most of the readers of this note to require to be enumerated here at considerable length.

The analysis of seismograms into a series of distinct typical phases corresponding to definite physical existences is however not always an easy matter, especially in the case of near earthquakes. Even at the present day, there seems to exist ample room for different *schools* of seismology so that it is no wonder if the European methods were not promptly adopted by our earlier seismologists.

Omori[(4)] early remarked that there were many distinct types of seismograms, according to the different combinations of the origins and the stations of observations. H. Maruoka[(5)] also gave some examples of such types in the cases of distant earthquakes. Imamura[(6)]

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(1) Ho., **29** (1899); **32** (1900); **41** (1903); **50** (1905); **54** (1906); **68**A (1910); **73** (1911); **79**(1915); **99** (1925); Pub., **4** (1900); **5** (1901); **6** (1906); **10** (1902); **11** (1902); **13** (1903); **18** (1904); **21** (1905); **23** (1907); **24** (1907); Bull., **1**. No. 1, 2 3 and 4 (1907); **2**, No. 1 aud 2 (1908); Seism. N., **2** and **3** (1922); T.S.B.K., **1** (1903), 148, 221; **2** (1904), 193; **2** (1905), 325, 458.

(2) Ho., **35** (1901); **77** (1913); **82** (1915); **99** (1925); **100**A (1925); Pub., **16** (1904).

(3) For the data of distant earthquakes, see also: H. Maruoka, J.M.S., **26** (1907); **27** (1908) 151; **30** (1911), 79, 239; **31** (1912), 285; **33** (1914), 339. F. Nakano, J.M.S., **26** (1907), 185. K. Hirata, J.M.S., **28** (1909), 111. K. Sibano, J.M.S., **31** (1912), 61. K. Hasegawa, J.M.S., **32** (1913) e. 27.

(4) Pub., **21** (1905); T.S.B.K., **2** (1905), 193.

(5) J.M.S., **41** (1922), 481.

(6) Not yet published.

from his long experience, succeeded in sorting out a number of characteristic types of seismograms obtained in Tôkyô so that he can, in the majority of cases, tell the provenance at the first look at the graph.

Though the variety of the seismograph curves has been usually attributed to the effect of the heterogeneity of the earth crust on the way to the propagation of seismic waves, we have not yet reached the point of analysing the complicated spectrum of waves into their components with anything like indisputable accuracy. The difficulty is of course connected with the reliability of the seismograph as the faithful recorder of the actual motion of the earth. In this latter connexion, Saem Nakamura's[1] attempt to analyse the seismic motion into a succession of distinct pulses may be mentioned.

The existence of the long surface wave of the Rayleigh type has been difficult to ascertain in many cases of near earthquakes. As shown by Omori[2], Imamura[3], Kusakabe[4], Hasegawa[5], S. Nakamura[6], Suda[7] and others[8], the first conspicuous motion of the principal portion of the waves is sometimes in the radial, but more frequently in the transverse, direction relative to the origin. One of the most remarkable examples is the case of the Simabara earthquake of 1922[9] in which the greatest motion was everywhere tangential to the circle with its centre at the origin. On the other hand, it was pointed out by Omori[10] that, in Tôkyô, the first maximum motion is almost invariably in a definite direction, E—W, for different earthquakes with their centres at or near the Bay of Tôkyô. In this respect, the recent theoretical investigation by H. Nakano[11] is of interest for it

(1) N.S.B.K., [iii] **1** (1919), 88; Bull. C.M.O., **3**, No. 2 (1920).

(2) Among others, Ho., **54** (1906); Seism. N., **3** (1922).

(3) Ho, **77** (1913).

(4) T.S.B.K., **3** (1906), 10.

(5) J.M.S., **33** (1914), 269.

(6) J.M.S., **37** (1918), 390; **41** (1922), 139; **42** (1923), e. 1.

(7) U.t.S., **3** (1923), 14.

(8) Ohasi, Ho., **82** (1915). G. Isida, J.M.S., **34** (1915), 61. T. Sasaki, J.M.S., **35** (1916), 147. K. Taguti, U.t.S., **4** (1924), 199. T. Isikawa, Kensinzihô, **1** (1925), 171; etc.

(9) Omori, Ho., **99** (1925). Imamura, Ho., **99** (1925). S. Nakamura, J.M.S., **42** (1923), 1. Suda, U.t.S., **3** (1923) 2, 14. T. Ogawa, Mem. Kyo., **B1**, No. 2 Art. 2 (1924).

(10) Loc. cit.

(11) Jap. J. Astr. Geophys., **2** (1925), 233.

shows that the Rayleigh wave requires a certain distance to be traversed by the bodily waves before it is developed into a conspicuous existence. Nakano[1] also treated of the propagation of elastic waves caused by different kinds of ideal sources of disturbance, consisting of multiplets of displacements, and obtained a variety of possible distributions of earthquake motions which could be cited for the explanation of different actual examples. More recently, T. Matuzawa[2] discussed a similar mathematical problem and arrived at various inferences of practical importance. According to their results, the case of the Simabara earthquake, above cited, may be accounted for by assuming a rotational centre of disturbance.

At any rate, it seems beyond doubt that in most cases of near earthquakes, the first part of the principal motions is not directly associated with the Rayleigh wave.

On the other hand, Saem. Nakamura[3] carried out the simultaneous observations of local earthquakes in the inside and the outside of a railway tunnel. Though the results are not yet conclusive, they seem not wholly unfavourable to the assumption of the existence of the Rayleigh wave, so far as the ratio of the amplitudes of motions in and outside the excavation is concerned.

On the other hand, examples have been pointed out by Omori[4] and Kawazoe[5] in which the preliminary phases were absent or very faint in some stations, whereas in other stations comparable in distance from the origin they appeared with the usual magnitudes. Terada[6] suggested a possible explanation by assuming a mosaic structure of the superficial crust consisting of loosely connected blocks with more or less independent freedom of vibration. Matuzawa, in his paper just cited, showed that if the blocks were to be regarded as embedded bodies in an infinite solid lying in the line of propagation, the growth of their motion would be very gradual. He showed that such anomaly may be plausibly explained by assigning a proper mechanism of disturbance at the origin. Other

(1) Seism. Bull. of C.M.O., **1** (1923) 92.

(2) Jap. J. Astr. Geophys., **4** (1926), 1.

(3) T.S.B.K., [iii] **7** (1925), 88, 127. See also K. Sekiya and F. Omori, Journ. Coll. Sci., **4** (1891), 249.

(4) Bull., **1**, No. 3, (1907).

(5) J.M.S., **38** (1919), 173.

(6) Geogr. Rev., **1** (1925), 841.

anomalies could also be accounted for by assuming different kinds of multiplet sources. K. Suda[1] also discussed the cause of the anomaly and laid stress on the effects of the mechanism of the origin.

The fact that the geographical distribution of the *intensity* of earthquakes shows a very conspicuous anomaly, has long since drawn the attention of seismologists[2] in this country. One of the most conspicuous cases is that of the earthquake which originated on or off the Pacific coast. In most of these earthquakes we may observe a characteristic elongation or bulging out of the isoseismal curves along the Pacific coast, as if the coastal districts were specially *sensitive* to the seismic waves from these quarters. Again examples have been cited by Shida[3] and Hasegawa[4] in which earthquakes which originated in the Japan Sea were felt only on the Pacific coast, while the Japan Sea coast immediately facing the origin suffered no perceptible shocks. Terada[5] tried to explain this anomaly by the special block structure of the Pacific coast as revealed by the investigations of Yamasaki and Tokuda already cited. In this connexion, S. Ono's[6] studies on the isostatic blocks may be referred to. He points out the existence of long waves with a period of 26 to 27 sec. which may possibly be connected with the proper period of the block, the horizontal dimension of which he estimated at 60 km.

The problem of the anomaly of isoseismals is also closely connected with that of the dissipation of wave energy on the way of its propagation. In this respect, the investigations of Kusakabe[7], Saem. Nakamura[8] and Suda[9], may be mentioned. Kusakabe based his consideration on the results of his extensive experiments on the elastic properties, especially on the hysteresis and after-effects, of different specimens of rocks, and borrowing an analogy from the problems of magnetic induction and of heat conduction, introduced the idea of

(1) K. Suda, U.t.S., **6** (1926), 24, et seq.

(2) Omori, Ho., **3** (1895); **29** (1899); **34** (1901). Yamasaki, Ho., **11** (1897). Imamura, Ho., **53** (1906); **70** (1910); **77** (1913); **82** (1915). Y. Kikuti, Ho., **35** (1901). N. Fukuchi, Ho., **38** (1901); H. Hatiya, Ho., **53** (1906).

(3) Communicated to a Meeting of the E.I.C.; not published.

(4) J.M.S., **37** (1918), 202.

(5) Geogr. Rev., **1** (1925), 841.

(6) Kensinzihô, **1** (1925), No. 2.

(7) T.S.B.K., **3** (1906), 88; Bull. C.M.O., **3**, No. 2 (1920).

(8) J.M.S., **37** (1918), e. 43; **38** (1919), 147; N.S.B.K., [iii] **1** (1919), 142.

(9) J.M.S., **41** (1922), 426; Mem. Imp. Mar. Obs,, **1** (1923), 52.

the *susceptibility* and *conductivity* of seismic waves, by means of which he succeeded in accounting for the anomalies in some actual examples. Nakamura found from his investigations on the relation between the intensity of an earthquake and the epicentral distance that the geographical distribution of the 'active' regions, i.e., the regions which show an abnormally large intensity compared with the average for the same distance, reveals some regularity or symmetry about the epicentre. This latter result seems worth further studies with respect to more abundant examples, especially under the light of the recent theoretical research of Nakano and Matuzawa above quoted. Nakamura also assumed a formula for the law of the *decay* of the intensity with the distance and remarks that the coefficient of absorption is larger for local earthquakes than for shocks of wide extent. Suda investigated the rate of decrease of the intensity with the epicentral distance, up to 1500 km. with respect to 28 conspicuous, i.e. *strong* or *weak*, earthquakes. Diagrams showing the relation between the distance and log A^2/T^2, where A is the maximum amplitude and T the period, were classified into two principal types, i.e. the *ordinary* type and the *extraordinary* type, according as the intensity falls off continuously with the distance, or shows a maximum at a certain distance. The relative frequency of the two types were 70% and 30% respectively. The former type is attributed to the case when the displacement at the focus is nearly vertical, while the latter, i.e., the extraordinary type is considered to correspond to the case when the original disturbance is directed horizontally or obliquely. He also remarks that the ordinary type is manifested mostly in weak earthquakes, whereas the extraordinary one is characteristic of the strong or destructive shocks.

The absurdity of regarding the seismic origin as a mere geometrical point has been repeatedly emphasized by most seismologists, especially with respect to cases of strong earthquakes observed near the origins. Hirano[1] remarked in the case of the Kwantô Earthquake that it becomes necessary to assume a region with an infinite velocity of propagation, if we apply the ordinary linear formula, giving the epicentral distance as the function of the duration of the preliminary tremor, for coordinating the data of observations obtained at numerous

(1) J.M.S., [ii] **2** (1924), 112.

stations. K. Suda[1], in a series of papers, proposed to distinguish the *physical* source, i.e. the seat of energy stored up for the occurrence of the earthquake, from the *apparent* origin of disturbance, as is usually determined by the geometrical construction. In these papers, he also adduced some theoretical considerations on the mechanism of the origin, similar to that treated by Nakano and Matuzawa, and suggested a new mode for the classification of earthquakes.

(e) **Pulsations.** The fact that the pulsatory motion of the earth is intimately connected with the appearance of conspicuous cyclones or typhoons has been early recognized by Omori[2] and confirmed by N. Simono[3] and others. The former noticed also that the phenomenon appears most conspicuous when the centre of atmospheric disturbance lies on the sea, especially on the Pacific side. He investigated later the relation between the periods of ocean waves and those of the pulsations and found some common periods in these two kinds of waves.

The seasonal variation[4] of the frequency of occurrence of the pulsations shows generally a maximum in December and a minimum in September. The daily variation[5] shows a maximum in the daytime.

The frequency is markedly great on alluvial plains and less in mountainous regions[6]. The frequency of waves with different durations, or degrees of coherence, shows maxima near 6 and 10 waves[7].

The comparison[8] of observations made at two stations in Tôkyô, one in Hongô, situated on tertiary ground at a height of 16 m, from the sea-level, and the other at Hitotubasi, situated on the low alluvial plain, has revealed that the identification of waves for the two stations is not easy. Recently, Imamura[9] made, with his improved tromometer already mentioned a comparison of the pulsations observed at

(1) U.t.S., **5** (1925), 46, 64, 80.

(2) Ho., **43** (1903); **50** (1905); **89** (1918); **94** (1921); Bull **3**, No. 1 (1909); **5**, No., 3 (1913).

(3) J.M.S., **27** (1908), 317; **28** (1909), 85.

(4) Omori, Ho., **50** (1905).

(5) Omori, Ho., **50** (1905); Bull., **2**, No., 1 (1908).

(6) Omori, Ho., **50** (1905).

(7) Omori, Bull., **3**, No. 1 (1909).

(8) Omori, Pub. **13** (1903); **18** (1904); Bull., **2**, No. 1 (1908); **3**, No. 1 (1909).

(9) Not yet published.

Hongô, at Komaba in the suburbs of the city, and at Mitakamura The relative amplitudes were found to be 1, 1/3 and 1/10 respectively. In this connexion, the recent theoretical investigation of Matuzawa[1] into the possible gravitational waves in the superficial soil layer may be referred to.

Omori's[2] extensive studies on microseisms at Asama Volcano is noteworthy. He found that the tremors consist of two distinct classes: one is a train of rapid vibrations not accompanied by any eruption of the volcano, while the other begins with slow oscillations and is followed after a few seconds by rapid vibrations usually accompanied by an eruption. The former is attributed to the occurrence of a subterranean fissure at a great depth, while the latter is considered to be due to the eruption itself. He also noticed that the first motion of the earth due to the eruption is invariably directed toward the crater. Omori[3] also observed the microseisms on the crater wall of Mihara Volcano, Oosima, and noticed the difference of the periods of vibration for the radial and tangential directions.

Imamura[4] investigated the pulsations which appeared after the Anegawa Earthquake of 1909 and was led to the conclusion that the phenomena may be interpreted as the rapid sequences of slight after-shocks.

Shida[5] constructed a highly sensitive baro-variometer, or micro-barograph with which he established the existence of atmospheric waves with periods similar to those of the terrestrial waves observed as pulsations.

Matuzawa[6] recently studied the pulsations observed at Tôkyô, According to his results the essential factor of the exciting agency consists in the behaviour of the atmospheric pressure while other factors play only trifling rôles, if any. The occurrence of two different types of motions as distinguished by Omori, that is, regular and irregular, can also be explained by the behaviour of the atmospheric pressure. The comparison of motions at different places reveals that each locality possesses some kind of oscillating system peculiar to it.

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(1) N.S.B.K., [iii] **7** (1915), 88; Jap. J. Astr. Geophys, **3** (1926), 161.
(2) Ho., **73** (1911); **87** (1918); Bull., **5**, No. 3 (1918).
(3) Ho., **81** (1915).
(4) Ho., **70** (1910).
(5) T.S.B.K., **5** (1909), 76.
(6) Not yet published.

The mechanism of occurrence is inferred, as a natural course, to be akin to that assumed by T. Terada and stated below, though the nature of the impulses is considered to be somewhat different.

Nagaoka's theory of the nature of the phenomena of pulsation will be referred to later.

T. Terada and U. Nakaya[1] recently made an experiment on the motion of a pendulum subjected to a rapid irregular succession of impulses by the impinging stream of birdshot. The records of the motion of the pendulum show an appearance very similar to the seismograms of pulsations. Thence, Terada is inclined to suppose a mechanism for the production of pulsations in which a discrete geological unit or block might play the rôle of the pendulum in the above experiment upon which numerous irregular swarms of impacts due to meteorological, oceanic, as well as terrestrial causes of disturbances, are acting as an assemblage of impulses.[2]

Phenomena Accompanying Earthquakes.

Among the phenomena accompanying earthquakes, one having the most important significance is the deformation of the earth crust as revealed by the formation of apparent fault lines, or by the sensible upheaval or depression of the surface. The fault lines have been traced and discussed by many geologists and seismologists on the occasions of different destructive earthquakes. Among others, those in the earthquakes of Mino-Owari,[3] Akita,[4] Anegawa,[5] Oomati[6] and Simabara[7] may be especially mentioned. Remarkable fault lines have been identified also in the cases of strong Formosan earthquakes.[8]

(1) To be published shortly in Scientific Papers of the Institute of Physical and Chemical Research, Tôkyô.

(2) T.S.B.K., **9** (1917), 142.

(3) Omori, Ho., **2** (1894); **32** (1900); Bull., **1**, No. 2 (1907); T.S.B.K., **4** (1907), 30.

(4) B. Koto, Ho., **8** (1896). Yamasaki, Ho., **11** (1897). Also Imamura, Ho., **77** (1913). K. Aomi, Ho., **82** (1915).

(5) B. Koto, Ho., **69** (1910).

(6) S. Tuboi, **98** (1922). Omori, Ho., **94** (1921); **98** (1922); Bull., **10**, No. 1 (1922). Saem. Nakamura, J.M.S., **37** (1918), 390; **38** (1919), 41, 147.

(7) Imamura, Ho., **99** (1925). S. Nakamura, J.M.S., **42** (1923), 1. K. Suda, U.t.S., **3** (1923), 2, 14. T. Ogawa, Mem. Kyo., B. **1**, No. 2, Art. 2 (1924).

(8) Omori, Bull., **1**, No. 2 (1907).

On the occasion of the recent earthquakes of Kwantô[1] and Tazima,[2] a number of papers appeared to which we are unable to refer in this limited space.

The mutual physical connexion between the different fault lines, their relations to the geological or topographical structure, etc., have been extensively investigated. The recent results obtained by Yamasaki and Ogawa already cited are most noteworthy from the seismological and geophysical points of view, as they afford some tangible basis for any theory or speculation by theoreticians.

Earth fissures observed after the Kwantô Earthquake have been pursued and closely investigated by H. Obata.[3]

Discussions have often been as to the significance of the fault lines appearing on the occasions of earthquakes, whether they are the immediate causes of earthquakes or merely secondary phenomena brought about as the effects of the disturbance. In this connection, the discussions[4] on the causes of Kwantô Earthquakes by Ogawa, Matsuyama, Terada, Fujiwhara, and others may be referred to.

The systematic levelling works carried out by the Military Land Survey, with the collaboration of the Japanese Members of the International Geodetic Commission have rendered invaluable services to seismology, by ascertaining the vertical displacements of bench-marks after destructive earthquakes. Not to mention the case of the Mino-Owari Earthquake which is perhaps known the wide world over, the contributions to our knowledge made by the survey on the occasion of the Sakurazima eruption,[5] the Omati Earthquake,[6] the Simabara Earthquake[7] and the recent great earthquake[8] were and

(1) Imamura, Yamasaki, Koto, Inouye, Suzuki, Nakamura, Omura, Uchida and Terada, Ho., **100**A and B. Ogawa, Chikyu, **1** (1924), 1, 113, 199, 287.

(2) Imamura, Geogr. Rev. **1** (1925), 511. Yamasaki, Geogr. Rev., **1** 1925), 517. Suda, a Report issued by Imp. Mar. Obs. (1925). Saem. Nakamura, Saitô Hôonkwai Gakuzyutu Kenkyû Hôkoku, No. **1** (1925). S. Ishikawa, J. Makiyama, F. Homma, Y. Kamikawa, etc., Chikyu, **4** (1925), 1. N. Kumagai, Chikyu, **4** (1925), 181. M. Funakoshi, Chikyu, **5** (1926), 120.

(3) H. Obata, Ho., **100**B (1925).

(4) To be quoted later.

(5) Omori, Bull., **8**, No. 1–6 (1914–22). A pamphlet issued by Mil. L. Surv. (1915).

(6) Omori, Ho., **94** (1921); **98** (1922); Bull., **10**, No. 1 (1922).

(7) A. Imamura, Ho. **99** (1925). The result of the survey after the Miyosi Earthquake is yet unpublished.

(8) H. Omura, Ho. **100**B (1925); besides some pamphlets, partly unpublished. A map showing the depression and upheaval according to the results of the re-examination up to Oct., 1925, was recently completed. A depression of 1.6 m at Tanzawa district and an elevation of over 1.6 m in Awa and southern Kadusa are shown.

will be the most precious data for seismologists and geophysicists. Horizontal displacements of triangulation points were also measured in the Sakurazima eruption and the great Kwantô Earthquake. In the latter case, the points observed are sufficiently numerous, so that an analytical study seems possible for the determination of the precise mode of deformation of the surface in this region. Equal merit must be acknowledged for the work of the Hydrographic Office(1) of the Imperial Japanese Navy by which the remarkable upheaval and depression in the sea bed of Sagami Bay after the recent great earthquake were brought to light. The phenomena revealed are quite unique in the history of earthquakes. Various interpretations have been proposed as to the nature of the change observed. T. Muramoto(2) and T. Ogawa(3) attribute the change to the sliding of the submarine deposit along the slopes of the sea-bed, while T. Terada(4) quotes Wegener's hypothesis regarding the different natures of the crust under land and sea and suggests the possibility of a remarkable plastic deformation of the sea-bed near the disturbed *sial* mass.

A similar work of sounding was carried out on the occasion of the recent Tazima Earthquake.(5) No remarkable change in the sea-bed was ascertained in this case.

Connected with the above, a fact of considerable significance was reported by H. Nagaoka,(6) Saem. Nakamura,(7) K. Suda(8) and others, that for several years preceding the great earthquake, the region which underwent upheaval by the earthquake, had been experiencing a gradual depression. Suda(9) compares this case with that of the *rebound* observed in the case of the San Francisco Earthquake of 1906; while Terada(10) proposed a simple mechanical model for explanation. Imamura,(11) however, remarks, from his examination of mareograms

(1) T. Uchida, Ho., **100**B (1925). A special Report (1924) issued by Hydr. Off. Soundings of shallow waters have also been carried out by the authorities of the Fishery Institute of Tôkyô; the results were published in a pamphlet.

(2) A pamphlet issued by the Hydrographical Office.

(3) Chikyu, **1** (1924), 405; Jap. J. Geol. Geogr., **3** No. 3-4 (1924), 1.

(4) Ho., **100**B (1925).

(5) A pamphlet issued by the Hydr. Off.

(6) Syôka-manroku, (1924), 124.

(7) Report on the Kwantô Earthquake (1924), Centr. Met. Obs.

(8) U. t. S., **3** (1923), 177.

(9) Mem. Imp. Mar. Obs. **1**, No. 4 (1924).

(10) Ho., **100**B (1925).

(11) Ho., **100**B (1925).

that, while the other Pacific stations were showing depression, Aburatubo, i.e., the station nearest the origin of the recent earthquake showed an upheaval in the few years prior to the earthquake.

On the other hand, Imamura,[1] from his studies on the distribution of lagoons on the coast of Kadusa, the investigation of some erosion marks on the coast of Awa, as well as the examination of an old document found infallible evidences of the remarkable vicissitudes which the sea level must have suffered in ancient times. N. Yamasaki[2] studied the distribution of deposits and prehistoric remains found in an erosion cave on the coast of Awa and succeeded in tracing the sequence of terrestrial events back to the ages of our remotest ancestors.

Among the other phenomena accompanying earthquakes, changes in some hot springs or artesian wells have often been reported,[3] especially in connection with the recent Kwanto[4] and Tazima[5] Earthquakes. In the former catastrophe, the geyser of Atami which had been declining in activity for several years, was abruptly awakened into a continuous eruption after the earthquake. In the case of the Miyosi Earthquake[6] of 1919, the wells situated on the north side of a line passing through the epicentre decreased, while those on the southern side of the same line increased in their out-put after the earthquake.

It was reported that at the Idusan spa[7] the temperature of the water was so abnormally high on the morning of the very day of the great earthquake that bathing was impossible.

Destructive sea waves or *tsunami* accompanying great earthquakes of submarine origin have formed a subject for special investigations by Japanese seismologists, since the terrible damage suffered in the

(1) Ho., **100**B (1925).

(2) Chikyû, **3** (1925), 74; Journ. Fac. Sci. Tok, [ii] **1** (1925).

(3) B. Koto, Ho., **69** (1910). Imamura, Ho., **70** (1910). K. Aomi, Ho., **82** (1915). Omori, Ho., **88**C (1920). I. Ikegami, J.M.S., **28** (1909), 307. G. Isida, J.M.S., **34** (1915), 61. T. Sasaki. J.M.S., **35** (1916), 147. K. Kondo, J.M.S. **37** (1918), 153.

(4) In different papers on the great earthquakes already cited.

(5) Among others Nakamura, Saitô Hôonkwai G.K. Hôkoku, No. **1**.

(6) S. Nakamura and S. Aoki, J.M.S., **38** (1919), 395.

(7) Saem. Nakamura., Ho. **100**A (1925).

Sanriku Earthquake[1] of 1896 in which 27000 lives were lost. Omori[2] early recognized the proper period of the oscillation of the bay or gulf as an important factor in determining the height of the waves to be observed at such a place. Nagaoka[3] discussed from a mathematical standpoint the effects of the sea bed on tsunami. Systematic observations and theoretical investigations on the secondary undulations of tides of bays and gulfs along the entire coast of Japan have been carried out by K. Honda[4] and others. For this purpose, special types of self-recording tide-gauges had been devised.[5] Waves due to typhoon,[6] and also seiches[7] of lakes have been studied in this connexion.

The velocity of sea-waves has been determined in many cases[8] and compared with the calculated values. For some discrepancies between the observed and calculated values, explanation have been proposed.[9]

It must be remarked that among the periods of long waves on free coasts in cases of earthquakes as well as on ordinary occassions, a period of about one hour is always very conspicuous. Nagaoka[10] proposed an explanation of this peculiar fact which is based on the consideration of the free elastic vibration of the earth as a whole.

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(1) T. Iki, Ho., **11** (1897). Imamura, Ho., **29** (1899). Omori, Ho , **34** (1901). For *tsunami* observed in the case of the Kwantô Earthquake, see: T. Ikeda, Ho., **100**B. Terada and Yamaguti, Ho., **100**B (1925). T. Ito, Chikyu, **1** (1924), 70. S. Nakamura, also K. Suda in their different papers and reports cited.

(2) Ho., **34** (1900); T.S.B.K., **2** (1905), 455.

(3) T.S.B.K. **1** (1902), 126.

(4) Honda, also with others, Pub., **26** (1908); Journ. Coll. Sci., **24** (1908); T.S.B.K., **2** (1904), 222; **2** (1905), 302, 307; **4** (1907), 79; Sci. Rep. Toh., [i] **1** (1911 – 12), 61. Terada, T.S.B.K., **6** (1912). S. Yamaguti, Jap. J. Astr. Geophys., **2** (1924), 115.

(5) Seiji Nakamura, T.S.B.K., **1** (1902), 123. Honda, **2** (1905), 302.

(6) Omori, Ho., **63**B (1910); **89** (1918). Honda and others, Pub. **26** (1908). Honda, J.M.S., **32** (1913), 399. K. Asakura, J.M.S., **21** (1902), 686; **31** (1912), 153; **38** (1919), 259; **39** (1920), 257. Z. Hagiwara, J.M.S., **31** (1912), 342. Y. Iwase, J.M.S., **31** (1912), 349. G. Isida, J.M.S., **34** (1915), 194, 273, 341. Kumamoto-ken Tyôgaisi (潮害誌), quoted in J.M.S., **37** (1918), 218. H. Nagaoka, T.S.B.K., **4** (1907), 210. Saem. Nakamura, J.M.S. **38** (1918), 32, 219; **39** (1920), 217; T.S.B.K., **9** (1918), 548; Kisyô-zassan, **1** (1918), 189, 278.

(7) Cited later.

(8) Honda, T.S.B.K., **3** (1906), 165. Saem. Nakamura, Bull. C.M.O., **3**, No. 2. (1902). K. Suda and Seki, U. t. S., **3** (1923), 95.

(9) Nagaoka, T.S.B.K., **4** (1907), 113. T. Terada, T.S.B.K., **6** (1912), 260.

(10) T.S.B.K., **4** (1907), 35.

On another occasion,(1) he also suggested a possible influence of an ocean current such as the *Kurosiwo* on the generation of some long waves observed along the Pacific coast.

Mareograms obtained at numerous stations on the occasion of the recent great earthquakes have been collected by the E.I.C. and published in Report No. 100 B, which will be of great value for future investigators. Terada and S. Yamaguti in the same volume discussed some of these records and called attention to some points of geophysical moment. An interesting compilation of the facts observed concerning the destructive sea waves experienced on the coast of Sagami and Awa is reported by T. Ikeda, in the same volume of the Report.(2) It was, indeed, a very lucky incident that the general swell of the sea level due to the sea wave was just cancelled by the upheaval of the coast, otherwise the damage caused by the tsunami would have been immeasurable.

The most difficult mathematical problem on the mode of generation of tsunami by an abrupt change in the sea-bed has been treated by Keizô Sano and K. Hasegawa,(3) and applied to some actual examples with success.

Records of sea-shocks have also been described in some cases.(4) Phenomena of earthsounds have been studied by Omori(5) who found that sounds are most frequently noticed in mountainous regions, whereas they are rarely or only weakly heard on alluvial plains. Sounds heard in strong earthquakes(6) have often been described and discussed. Though there are many cases in which the directions of the apparent source of sound converge toward the epicentre, cases have not also been rare in which the sound was heard to come from opposite directions. No serious attempt has yet been made to elucidate the physical nature of this kind of sound, since the earliest one by C.G. Knott.

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(1) T.S.B.K., **1** (1902), 126.

(2) See also T. Ito, Chikyu, **1** (1924) 70.

(3) Bull. C.M.O., **2**, No. 3 (1915); T.S.B.K., **8** (1915), 187.

(4) Miscell. Art. U.t.S., **3** (1923), 127. Suda, U.t.S., **3** (1923), 138; Special Rep. on the Tazima Earthquake, (1925).

(5) Omori, Ho., **22**A (1908); **57** (1906); **68**B (1910); **94** (1921). N. Kanahara, Ho., **35** (1901). T. Hiki, Ho., **38** (1902). Anonym., J.M.S., **21** (1902), 640.

(6) Miscell. Art., J.M.S., **32** (1913), 300; **35** (1916), 150; **40** (1921), 36. G. Isida, J.M.S., **34** (1915), 61. Saem. Nakamura, J.M.S., **36** (1917), 67; **37** (1918), 390; 38 (1919), 41; **41** (1922), 629; **42** (1923), 1. K. Taguti, U.t.S. **4** (1924), 199.

The abrupt change of earth's electric potential has been recorded by K. Shiratori[1] on the occasion of the Kwantô Earthquake, though the physical interpretation of it has not yet been attempted.

Volcano and Earthquake.

Different problems regarding the earthquakes directly associated with volcanic activity have been extensively studied by Omori.

Generally speaking, this class of earthquakes is of markedly local nature, being only felt within a limited area around the volcano, apparently manifesting the shallowness of the origin of disturbance. As already cited, two classes of volcanic earthquakes have been distinguished in the case of Mt. Asama.[2]

The eruption of Mt. Usu,[3] in July-August of 1910 was a unique occurrence, giving birth to a veritable *monto nuovo*, of about 500 feet of height, besides forming more than forty craters and revealing an upheaval of 5 feet along the shore of Lake Tôya. On this occasion slight earthshocks foreboding the eruption began four days earlier. The number of shocks increased gradually and attained a maximum a few hours before the first symptom of eruption set in.

The great eruption of Sakurazima[4] in 1914 was also ushered in by a remarkable swarm of earthquakes. The time sequence of the earthquakes associated with the activities of this volcano together with all accompanying phenomena, has been exhaustively reported by Omori.

The levelling work carried out by the Military Land Survey after the eruption has revealed a marked depression of land to a wide extent, a bench-mark at Kagosima showing a depression of about 0.4 m. relative to Hososima. The depression on the north shore of the

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(1) Jap. J. Astr. Geophys., **2** (1925), 173.

(2) Omori, Ho., **67** (1910); Bull., **4**, No. 1 (1912), No. 2 (1914), No. 3 (1914); **7**, No. 1 (1914), No. 2 (1917), No. 3 (1919). Also: S. Ootuki, J.M.S., **32** (1913) 61, 113. T. Itô, J.M.S., **32** (1913), 41. Y. Tsuiji, J.M.S., **32** (1913), 41. Miscell. Art., J.M.S., **35** (1916), 120; **38** (1916), 142; **40** (1921), 34.

(3) Bull., **5**, No. 1 (1911), No. 3 (1913); **9**, No. 2 (1920).

(4) Omori, Bull., **8**, No. 1 (1914), No. 2 (1916), No. 3 (1916), No. 4 (1920), No. 5 (1920), No. 6 (1922). Also, Kagosima Met. Obs., J.M.S., **33** (1914), 59, 144, 156, 191. K. Hasegawa, Kisyô-yôran, March, 1914. Military Land Survey, J.M.S., **34** (1915), 747; also a pamphlet. Miscell. Art. J.M.S., **34** (1915), 58; **35** (1916), 274, 318.

island of Sakurazima was estimated at 2 m. In the meanwhile, horizontal displacements of 3 to 4 m. have also been discovered.

The distribution of the regions where the sound and air waves due to the eruption were felt, as well as those places where the ashes ejected were scattered, were fully investigated.(1)

The latter subject has also been studied by S. Fujiwhara(2) who developed his mathematical theory on the anomalous propagation of sound in the atmosphere which is well known to meteorologists.

The hot springs region of Mt. Hakone was visited by a swarm of local shocks in Jan., 1917, which caused a panic among the inhabitants. It is recorded that a similar activity was experienced in the spring of 1786. The time distribution of the shocks studied by Saem. Nakamura(3) resembled that of the ordinary volcanic earthquakes, though no proper volcanic activity was observed, nor could it be expected from the dormant state of this ancient volcano. Only, on the end of March, the hot springs of Oowakudani displayed unusual activity. A similar activity was repeated afterward in December, 1920.(4)

Another swarm of weak shocks experienced in Suwa hot spring district in May, 1922.(5) This type of earthquakes is worth special notice, since the mechanism of these phenomena may represent a miniature of that of earthquakes on a larger scale.

The annual and daily frequency of volcanic activity and its relation to atmospheric or tidal condition has been investigated statistically by Omori.(6) He found, with respect to the monthly number of eruptions that the activity of inland volcanoes is associated with the fall of barometric pressure, while the volcanoes on islands are sensitive to the fall of sea-level. Later, the subject was resumed by S. Kanda(7) who calculated the correlation coefficients with regard

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(1) Omori, Bull., **6**, No. 1 (1912); **7**, No. 1 (1914); **8**, No. 2 (1916); **8**, No. 3 (1916). S. Ootuki, J.M.S., **32** (1913), 61, 113. Y. Yosida, J.M.S., **33** (1914), 257. K. Hasegawa, Kisyô-yôran, March, 1914.

(2) Bull. C.M.O., **2**, No. 4 (1916); T.S.B.K., **6** (1911), 132. Also K. Aichi, N.S.B.K., [iii] **2** (1920), 63.

(3) J.M.S., **36** (1917), 67. Also Miscell. Art., J.M.S., **36** (1917), 319.

(4) Miscell. Art., J.M.S. **40** (1921), 36.

(5) Saem. Nakamura, J.M.S., **41** (1922), 233, 629.

(6) Ho., **56** (1907); Bull., **5**, No. 1 (1911); **6**, No. 1 (1912), No. 3 (1914); **7**, No. 3 (1911); **8**, No. 2 (1916); J.M.S., **29** (1910), 87. Also I. Hattori, J.M.S., **30** (1911), 5.

(7) J.M.S., **39** (1920), 222.

to these effects. According to his results, not only the islands, but also most of the inland volcanoes give large correlation coefficients above 0.7, with respect to the tidal pressure, while the correlation with the barometric pressure, though quite sensible for most of the volcanoes on the central zone of Honsyû, yet is not so conspicuous as in the case of tidal pressure. Mt. Asama turned out an exception to his results. His results generally confirm Omori's, but he remarks that volcanoes situated near the coast decline in activity when the barometric pressure decreases.

Recently T. Isikawa(1) remarked that a volcanic eruption is apt to occur when the mountain lies in the midst of an anticyclonic area.

The correlation between the different volcanoes,(2) as well as that between earthquakes and volcanic eruptions have been investigated by Omori.(3) S. Ono(4) recently alluded to the latter subject in connection with his original research on the isostatic block structure of the land. Though it seems quite certain that such relations exist, the time has perhaps not yet come when we may state anything very definite on this matter.

Mathematical and Physical Investigations.

The development of seismometry has brought to light many interesting characteristics of earthquake phenomena which furnish a number of problems concerning the mathematical theory of elasticity. In the earliest days, C. G. Knott(5) treated of the reflection and refraction of elastic waves at the boundary between two different media. As a special case he considered the refraction into air, for explaining the origin of the earth sound. Introducing the ideas of purely elastic and quasi-elastic vibrations, he identified the principal portion of earthquake motions to the latter and the preliminary part to the former.

A somewhat similar idea was adopted later by S. Kusakabe.(6)

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(1) J.M.S., [ii] **3** (1925), 255, e.

(2) Bull., **6**, No. 1 (1912); **8**, No. 2 (1922).

(3) Ho., **43** (1903); **67** (1910); Bull., **2**, No. 2 (1908); **5**, No. 1 (1911); **8**, No. 6 (1922) Also, T. Ogawa, Mem. Kyo., B. **1**, No. 2, Art. 2 (1924).

(4) Kensinzihô, **1** (1926) 221.

(5) Trans. Seism. Soc. Jap., **12** (1888).

(6) Pub. **14** (1903); **17** (1904); T.S.B.K., **1** (1902), 103; **2** (1904), 142, 197; **2** (1905), 341; **3** (1906), 110.

His considerations were, however, based on the characteristic elastic properties of rocks on which he made extensive experimental studies, developing Nagaoka's[1] research on the same matter. He found that the elastic constants of rocks become apparently smaller when the range of applied force is larger. This fact was theoretically treated as the result of elastic yielding, for which he obtained the law as a logarithmic function of time, both from theoretical and experimental grounds. The elastic constants turn out smaller for larger deformation, and hence the small quick vibrations outrace the larger slow motions. The latter is after all the principal portion and the former the preliminary tremors of an earthquake.

By the way, Kusakabe's[2] experiment on the effect of heat on the elasticity of rocks has revealed a remarkable fact that a plutonic rock such as granite shows a considerable plasticity at the comparatively low temperature of 400°–500°C. This property is quoted by him in association with the liability of this kind of rock to form veins or intrusions into subterranean fissures. In the applications of his theory, he introduced the idea of seismic-wave-conductivity,[3] as already mentioned, with which he made a general discussion on the relations between the geological structures and the intensity of the frequency of earthquakes.

On the other hand, different valuable suggestions on the nature of earthquake motions as well as many allied problems, were proposed by Nagaoka. In his discussion on the rigidity of the earth,[4] he noticed that the velocity of elastic waves deduced from seismic observations agrees with that estimated from the Chandler period. In another paper,[5] he remarked that the deviation from Hooke's law may result in the formation of overtones and combination tones also in the case of seismic disturbances.

The formation of tails in distant earthquakes was explained by Nagaoka[6] as a result of discussions on damped progressive waves. Starting from the equation for damped plane waves in its generalized form

$$\frac{\partial^2 U}{\partial t^2} = c^2 \frac{\partial^2 U}{\partial x^2} - 2\beta \frac{\partial U}{\partial t} - \gamma^2 U,$$

(1) Pub., **4** (1900).
(2) T.S.B.K., **3** (1906), 110.
(3) T.S.B.K., **2** (1905), 395, 447; **3** (1906), 88.
(4) T.S.B.K., **2** (1905), 353.
(5) T.S.B.K., **2** (1905), 443; Omori's discussion, 460; reply, 463.
(6) T.S.B.K., **3** (1906), 17.

the expressions for the tails following the principal disturbances were deduced, which appear as the effects of damping and a certain reaction $\gamma^2 U$, for example the reaction of an underlying layer.

Interesting remarks on the dispersion of seismic waves[1] have also been made by the same investigator. Mountains, mountain ranges, small islands, lakes, plains, etc. were considered as bodies embedded in the transmitting medium and their effects on the incident plane waves were discussed, after the method of treating the anomalous dispersion of light. According to his argument, the principal portion of earthquake motion is explicable as waves satisfying a differential equation of the type $\frac{\partial^2 U}{\partial t^2} = c^2 \frac{\partial^2 U}{\partial x^2}$, i.e. longitudinal or transverse waves. On the other hand, the preliminary portion could be associated with waves of the flexural type. The period corresponding to the anomalous dispersion was supposed to be 14 seconds or so in Tôkyô. Next, as a natural sequence, the problem of group velocities[2] to be expected in distant earthquakes, was taken up. The group velocity of a flexural vibration is approximately twice the wave velocity. If the liquid interior be assumed, gravitational waves are also possible. Thus the group velocity of sea waves is one half of the wave velocity. A tentative explanation has been proposed for the presence of the first and second preliminary tremor.

K. Aichi[3] treated the case of transverse waves on the surface of heterogeneous material and showed the existence of dispersion in a special case. Recently, K. Suda[4] discussed the diffraction of seismic waves, developing Stokes's theory on the diffraction of light and attempted to explain the directions of earthquake motion.[5] T. Matuzawa[6] in his recent paper to be quoted later, touched on the problem of the motion of bodies embedded in the medium through which elastic waves are propagated.

As a secondary cause of earthquakes, the effects of surface loading over a circular area were considered by Nagaoka.[7] Even a very

(1) T.S.B.K., **3** (1906), 44.
(2) T.S.B.K., **3** (1906), 52.
(3) T.S.B.K., [iii] **4** (1922), 137.
(4) J.M.S., **41** (1922), 426.
(5) U.t.S., **5** (1925), 80.
(6) Jap. J. Astr. Geophys., **4** (1926), 1.
(7) T.S.B.K., **3** (1906), 75; Pub., **22**A (1908).

remote centre of atmospheric depression can affect the equilibrium of the earth crust and give rise to pulsatory motions. Later, he[(1)] treated an allied problem in connection with the effect of a barometric gradient on earthquake frequency, and showed that the rupture of the crust is to be expected near the maximum of the gradient. As to the pulsatory motions,[(2)] he also discussed the stationary vibration of one end of a semi-infinite solid with two parallel edges.

A similar problem of surface loading has been treated later by K. Terazawa.[(3)] The periodic disturbance of the level arising from the load of neighbouring oceanic tides was discussed. The result arrived at by him has recently been utilized by Suda[(4)] in his investigation of the level changes of a well.

O. Enya[(5)] made an early attempt to explain the time distribution of the number of after-shocks observed at the origin. His theory was based on a hypothesis made on the manner in which the instability of the crust determining the occurrence of the after-shocks, is removed by these shocks He arrived at a logarithmic form of the formula for the relation between the frequency and time. He also treated the number of after-shocks observed at a place distant from the origin, though the results obtained are somewhat complicated.

S. Kusakabe[(6)] treated the same problem based on the results of his experimental researches on the elastic properties of rocks. His assumption was that the frequency of aftershocks is proportional to the time rate of recovery from the state of residual stress to which the crust is subjected. Both Omori's hyperbolic and Enya's logarithmic law could be deduced as special forms of approximation.

On the other hand, Nagaoka[(7)] pointed out a way of regarding the decay of the frequency of after-shocks after the analogy of the radioactive transformation and showed that the simple exponential law of decay may be expected only in exceptionally simple cases. Terada[(8)] drew attention to some analogy existing between the variation of the

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(1) T.S.B.K., **6** (1912), 208.

(2) T.S.B.K., **3** (1906), 79; Pub., **22A** (1908).

(3) Journ. Coll. Sci. Tok., **37**, Art. 7 (1916); Sci. Rep. Toh., [i] **7** (1918), 205; Proc. Roy. Soc. Lond., A **94** (1917), 13; Phil. Trans., A**217** (1918), 35.

(4) U.t.S., **5** (1925), 223.

(5) Ho., **35** (1901).

(6) Pub., **14** (1903).

(7) T.S.B.K., **4** (1907), 66.

(8) N.S.B.K., [iii] **1** (1919), 180.

light intensity of Nova Aquilae and that of the frequency of after-shocks and remarked that an analogous fluctuation may also be brought forth by mere accident.

S. Sano(1) treated the problem of the wave produced by normal pressure exerted on the surface of a semi-infinite elastic solid and obtained a mathematical solution by applying Fredholm's theorem. No practical application has been made.

Recently, H. Nakano(2) made an important contribution on the problem of the Rayleigh waves. He treats the two-dimensional problem with a free boundary plane, below which a line source of disturbance is situated at a certain depth, parallel to the plane. First, the periodic disturbances of compressional and distortional types are respectively considered and, later, the discussion is extended to the case where the disturbance at the source is an arbitrary function of time, by making use of Fourier's integral. According to his result, the Rayleigh wave does not appear in the vicinity of the origin, but becomes perceptible only beyond a certain distance great in comparison with the depth of the origin and determined by the velocities of waves and the depth. Nearer the origin, the Rayleigh wave appears gradually with no marked phase for identifying the beginning of this kind of wave.

Nakano(3) also treated the problem of wave propagation in infinite solid due to different kinds of mechanisms of disturbances at the origin consisting of pairs of simple sources, and explained various instances of the distribution of the direction of motion revealed by the actual observations.

Most recently Matuzawa(4) treated a similar problem and applied his results for the explanations of different examples of the anomalous propagation of seismic waves, as already mentioned, for instance, the case with no apparent preliminary tremor observed by Omori, the difference in the behaviour of waves propagated in directions perpendicular and tangential respectively to the arc of the land, as pointed out by Kunitomi, etc.

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(1) T.S.B.K., **7** (1914), 343.

(2) Jap. J. Astr. Geophys., **2** (1925), 233.

(3) The Seism. Bull. of C.M.O., **1** (1923), 92. The paper was printed just before the Great Earthquake and almost all the copies were destroyed in the conflagration. See for an allied problem also: S. Nakamura, J.M.S., **41** (1922), e. 1; K. Suda, U.t.S., **5** (1925), 46, 64, 80.

(4) Jap. J. Astr. Geophys., **4** (1926). 1

Matuzawa[1] also discussed the criterion for the existence of gravitational waves in the superficial soil layer of the crust which he treats as a highly viscous fluid. He tabulates the lower limits of wave-length for which the periodic motions are possible for different values of viscosity. From his result, he concludes that the furrow-like corrugation formed on the surface of the soil in destructive earthquakes is not due to any wave motion, as was sometimes believed, but to aperiodic deformations caused by solitary impulses. He also considers the vibration of a soil layer to be expected when the underlying rock layer is subjected to a wave motion. The result of calculation is applied for the explanation of the relative intensities of shocks in different quarters of Tôkyô on the occasion of the recent great earthquake. N. Nasu[2] had investigated the relative intensities for different points in Tôkyô from the instrumental observations of the after-shocks of the great earthquake as the functions of the periods of vibration. The result obtained by the latter may partly be explained by Matuzawa's result of calculation. Moreover, Matuzawa remarks that the pulsatory motions may partly be attributed to the effect of the superficial soil layer.

Lastly, we may cite here some of the theories regarding the causes of earthquakes which were propounded in connexion with the recent great earthquake. Among the others, the most original is perhaps that proposed by S. Fujiwhara.[3] He has been for some years studying the significance of the occurrence of some characteristic torsional or vortical forms in the arrangements of mountain ranges, chains of islands, etc, together with the distribution of cracks and creases accompanying these forms. On the other hand, he carried out a series of very simple but ingenious experiments with different kinds of pasty masses. He accepts the hypothesis of the continental drift after Wegener and Joly, but lays his stress on the effect of the rotation of different moving parts and of the shearing thereby produced. In one of his recent papers,[4] he points out a peculiar regularity in the arrangement of volcanoes in Japan, which may be accounted for in connexion with the échelon cracks obtained by his experiments. The

(1) Jap. J. Astr. Geophys., **3** (1925), 162.

(2) Ho., **100**A (1925).

(3) J.M.S., **43** (1924), 6; Jap. J. Astr. Geophys, **3** (1925), 103; Nagaoka Anniversary Volume, 333.

(4) Geogr. Rev., **1** (1925), 735.

remarkable échelon formations of mountains and islands of this country have already been pointed out by T. Tokuda.[1] Fujiwhara's investigations seem to throw some light on the probable mode of formation of these forms. Further, Fujiwhara[2] discussed recently the mechanism of the occurrence of the Kwantô Earthquake from his point of view, making full reference to the other's opinions on this matter.

Among the other opinions, we may cite those by T. Ogawa, N. Yamasaki, T. Kato and H. Yabe from the geological points of view, and of K. Suda, S. Ono, M. Matsuyama, T. Terada and many others from the seismological or geophysical sides. Most of these theories have already been quoted here and there so that repetition would be superfluous. We may perhaps here specially mention Matsuyama's[3] view which was developed in consideration of the remarkable slow oscillation with a period of 110^s observed in the seismogram of the great earthquake. According to his view, the remarkable deformation of the crust subsequently established must have taken place by plastic yielding, not by any abrupt process.

In this latter connexion, we may cite the interesting result of Imamura's[4] latest investigation into the seismograms of the recent earthquakes. He compared the records of the peculiar slow motion at the initial phase obtained with an instrument having different degrees of magnifications, and found that they were quite irreconcilable with each other if the slow motion be assumed to be due to a horizontal displacement, while they can be fairly explained as caused by a suitable tilting of the crust.

Geophysical Investigaton.

The importance of geophysical investigations in general for the advancement of the science of earthquakes, has early been recognized by Milne and other pioneers whose attempts in that line may be found in the volumes of the Transactions. Among the earlier mem-

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(1) Journ. Geol. Soc., **25** (1918), 534. Also Geogr. Rev., **2** (1925) 946.

(2) Kensinzihô, **1** (1925), 161.

(3) Comptes Rendus des Séances de la 2-me Conférence a Madrid de l'Union Géodésique et Géophysique Internationale, Section de Seismologie, 1924; Kokumin-Eisei. **1**, No. 3 (1923).

(4) To be published shortly.

bers of the E.I.C., A. Tanakadate and H. Nagaoka stood foremost in this line of attack. Numerous investigations on various subjects, though apparently remote from the field of practical seismology, but of prime importance in the scientific study of earthquake phenomena, owe their initiation to the proposals of these eminent scholars.

The determination of the acceleration of gravity was made early in 1881–1884 by Tanakadate and others(1) in a few stations, after the memorable work of Mendenhall on Mt. Huzi in 1880. Systematic measurements in different localities all over the land was planned and has been carried out since 1900, under the auspices of the International Geodetic Committee.(2) It was H. Nagaoka himself who led the earlier expeditions, in the meanwhile improving and elaborating the apparatuses and methods of observations. The work has been continued by the competent hands of S. Shinjo, T. Shida, R. Otani, M. Matsuyama and others. The complete report of these recent labours has not yet been given out.(3) It is beyond doubt that the full data obtained, if properly examined, will not fail to throw considerable light on the distribution of the earth mass in this part of the earth crust and thereby afford us a tangible clue for grasping the actual mechanism of earthquakes. Matsuyama(4) has already taken a step toward this direction. He observes that the anomalies of gravity along the Pacific and the Japan Sea coast are inexplicable as the effect of mere topography. Moreover, he remarks the tendency of the districts most frequented by earthquakes to be associated with apparent defects of subterranean mass.

Nagaoka(5) elaborated the design of a pendulum for the determination of g, made with metallic tungsten, the material which is gifted with unique properties suitable for the purpose. The instrument was recently constructed in the Institute for Physical and Chemical Research, Tôkyô, and will be later used in the expedition in Manchuria.

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(1) Memoirs of the Science Department, Imp. University, Tôkyô, No. 5 (1881) and Appendix.

(2) Nagaoka, Shinjo and Otani, T.S.B.K., **1** (1901), 6. Shinjo, Otani, Shimidzu, Shida and Homma, ibid, **1** (1903), 178. Shinjo, Otani and Yamakawa, ibid, **2** (1903), 41. See also T. Takamine, T.S.B.K., **7** (1914), 265.

(3) The results obtained up to 1906 are summarized by E. Borras, Comptes Rendus des Séances de la 6-me Conférence Générale de l'Association Géodesique Internationale, **3** (1911).

(4) The Report cited above.

(5) N.S.B.K., [iii] **1** (1919). 347.

The use of Eötvös's gravity variometer has also been contemplated by the Geodetic Committee and entrusted to the able hands of Messrs. Shinjo, Matsuyama and I. Yamamoto of the Kyôto Imperial University. The results of observations made in the Jaluit Atoll in the Pacific,(1) the Volcano Sakurazima,(2) the Toné River Basin(3) near Tôkyô, the Niitu Oil Field(4) near Niigata, and the Fushun Colliery(5) in Manchuria, have already been reported and have brought out many points of interest. In the course of these works Matsuyama elaborated the methods of observation and reduction in many respects, working with meticulous care on every source of error both experimental and theoretical. His results in Jaluit and Fushun have shown remarkable regularity in the distribution of the differential coefficients of g which he succeeded in bringing to fair agreement with the results of theoretical calculations based on some plausible assumptions with respect to the geological structure of the terrains concerned. The result of I. Yamamoto's observations on the Toné Basin have also been revelant in many respects regarding the mass distribution of the region. Niitu Oil Field showed an anomalous irregularity in the form of the geoid which suggests the existence of its counterpart in the mass distribution under the field.

The results of the investigation on the deviation of the plumb line in the region near Tôkyô, carried out under the auspices of the Geodetic Committee have recently been summarized by T. Matukuma,(6) and these will be of much interest for the seismologist, especialy with respect to the Kwantô Earthquake.

Rebeur Paschwitz's horizontal pendulum for registering the tilting of the crust relative to the direction of gravity has been installed in the Kamigamo Observatory, and observations carried out by Shida and his assistants since Feb. 1910. In spite of the considerable distance of the station from the sea, the tilting due to the tidal load was remarkable compared with the component due to the variation of the level directly derivable from the tide-generating potential, so that the difficulties to be overcome in analysing the different components were considerable. For instance, he had to take account of the actual

(1) Mem. Kyo., **3** (1918), 17.
(2) An abstract, T.S.B.K., **9** (1917), 103.
(3) Rep. Imp. Jap. Geod. Comm., **3** (1923).
(4) Rep. Imp. Jap. Geod. Comm., **5** (1924).
(5) Jap. J. Astr. Geophys., **2** (1924), 91.
(6) Jap. J. Astr. Geophys., **2** (1924), 1.

tides instead of assuming simple ideal tides, as was done in the previous undertakings. His results[1] thus obtained are interesting from seismological as well as from geophysical points of view by showing a reliable measure of the actual deformation of the crust caused by the water load applied along the coast.

Later, R. Sekiguti[2] investigated a similar problem at Jinsen, Korea, where the tidal range is abnormally large, amounting to 35 ft. in the extreme case. From the records of an ordinary Omori horizontal pendulum seismograph, he succeeded in sorting out the tilting of the earth crust due to tidal loading and obtained a value for the rigidity of the crust which is in good agreement with that obtained by Shida at Kamigamo. It must be remarked that in these investigations Nagaoka's theory of the elastic deformation due to surface loading, already cited, has been of great aid in the analytical parts of the work.

Since the recent great earthquake, the need has been keenly felt of some means which may serve for continuously watching the crustal movement, as it may be reasonably expected to give some sensible predictory symptom previous to a catastrophic fracture of the crust. While the use of Michelson's instrument was being much spoken of, an ingenious simple apparatus meeting the need was devised by T. Shimizu.[3] It consists essentially of a water tube, of which the free surfaces at both ends are read by means of micrometers. The uniformity of the temperature of the water is insured by circulating it through the pipe by the action of a pump. Though the apparatus is apparently simplicity itself, he has succeeded in attaining with it an accuracy of 0.1 mm./km., by carefully avoiding sources of possible errors, an accuracy which seems quite sufficient for most purposes here concerned.

On the other hand, D. Nukiyama[4] chose a still simpler way of using the ordinary sensitive spirit level of an astronomical instrument for his investigation of the tilting of the crust on the coast of Mera, Awa, where the tidal effect could be expected to be considerable. Besides, the place was near that part of Sagami Bay where the origin of the recent great earthquake is believed to have been situated.

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(1) Mem. Kyo., **4** (1912), 1; T.S.B.K., **6** (1912), 242, 273.

(2) Mem. Imp. Mar Obs., **1** (1917), 1.

(3) Jap. J. Astr. Geophys., **2** (1924), 67; N.S.B.K., [iii] **6** (1924), 54.

(4) Not yet, but to be shortly, published.

Though the duration of the observation was not very long, the results seem to show some effect of the tidal loading, among others.

Connected with these subjects, we cannot pass on without making allusion once more to the service rendered by the Military Land Survey and the Naval Hydrographic Office in revealing the remarkable change in the earth crust connected with the great earthquake. If the investigation of the most minute variations of the level at a selected number of stations, is important, it will be at least equally desirable to keep watch of the gradual movement of the crust over an extensive area, not only of the land but also of the submarine bed of the neighbouring seas. We may be allowed, therefore, to take this opportunity for expressing our hope that our Military and Naval authorities would graciously continue of their most useful and efficient participation in our peaceful warfare against the most dreadful natural calamities.

For the studies regarding the deformation of the earth crust, the mareographic data are of no small importance. Fortunately, continuous records for thirty years have now been gathered by the Military Land Survey for a number of stations(1) distributed over the entire coast. These data have already been occasionally utilized by Omori(2) in his research on the relation between earthquake frequency and sea-level, especially with respect to the seasonal variations. In the latter respect, Nagaoka(3) discussed the effects of the temperature variation of water on the sea-level and alluded to its possible relation to the annual term of the variation of latitude.

The secular variation of sea-level has also been cited and discussed with reference to the cause of earthquakes. Even a kind of prediction of earthquakes based on the crude observations of daily levels has been spoken of in some quarters. In this respect, the recent work by N. Kawakami(4) is noteworthy. Following an investigation by K. Taguti, he analysed the slow variation of the sea-level into a secular term proportional to time and the conspicuous 19-year tide depending on the moon's ascending node, with respect to the chief mareographic stations. After evaluating the correlation coefficients with respects to

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(1) A great majority of the stations have recently been transferred to the supervision of the Imperial Marine Observatory, Kôbe.

(2) T.S.B.K., **2** (1904), 160; **2** (1905), 297, 321.

(3) T.S.B.K., **4** (1908), 382.

(4) Mem. Imp. Mar. Obs., **2** (1925), 71.

the barometric data and winds, he attributes the principal part of the secular change thus analysed to the actual upheaval or depression of the crust. According to his results, the secular subsidence has been most remarkable in Kusimoto, Aburatubo and Hanasaki. These stations lie on the Pacific coast of Central Japan and Hokkaidô respectively. On the contrary, a conspicuous upheaval has been found at Hososima, situated on the Pacific coast of Kyûsyû. An upheaval was shown only in the latter station and at Iwasaki on the Japan Sea coast, the remaining six stations giving depressions. Besides, it seems that the Japan Sea side and the western side of Kyûsyû show generally a less amount of vertical movements, positive or negative. R. Sekiguti, in his discussion of the above results, appended to this paper, computed the secular acceleration of the rate of depression at Aburatubo, the station lying near the origin of the recent great earthquake, and obtained a positive value which is not in accord with the retardation to be expected from the traditional depression of this district.(1) Sekiguti also gives a vectorial representation of the 19-year tide, and remarks that the Japan Sea stations form a quite distinct type or group in this respect.

It need not be remarked that for the mareographic studies of the crustal movements, the careful investigations of the influences of meteorological elements, especially of the barometric pressure and winds are of primary importance. Omori frequently touched on this matter in his papers on allied subjects. Saem. Nakamura(2) also made some studies on this problem. Kawakami's result has just been cited. S. Ogura(3) recently made an elaborate investigation of the effect of the atmospheric pressure on the sea-level, especially in the island-stations in the western part of the Northern Pacific. Isolated island-stations were chosen in order to make evident the pure pressure effect undisturbed by winds. The daily mean level was compared with the daily mean pressure, and the pressure-factor as well as the time of retardation was estimated. On the other hand, T. Terada and S. Yamaguti(4) made an investigation into the combined effect of pressure and wind upon sea level in a few stations, in 1923 and 1924. From the results

(1) Compare result of Imamura's investigation on the level change at Aburatubo, loc. cit., Ho. **100**A (1925).

(2) Jap. J. Astr. Geophys., **3** (1925), 115; Kisyôzassan, **1** (1918), No. 3.

(3) Jap. J. Astr. Geophys., **2** (1925), 209.

(4) To be published in Jap. J. Astr. Geophys., **4** (1926).

obtained they point out some anomaly observed in the month following the great earthquake.

The importance of investigating the variation of latitude was recognized early by the E.I.C. The observation was begun in 1895 in Tôkyô by H. Kimura. Afterwards, the work was transferred to the Geodetic Committee and carried out continuously in Mizusawa according to the international scheme. Kimura's discovery of the z-term and his subsequent contributions in this line are well known.(1) Omori(2) remarked some possible relation between the occurrence of destructive earthquakes with the extreme values of latitude. In the most recent report by Kimura(3) the resumé of the variation of latitude from 1918.0 to 1923.9 is given. It is interesting to observe that the deviation of the earth's pole showed a rapid turn in the epoch 1923.8 – 1923 9, viz. near the occurrence of the great earthquake, though of course it may be merely a matter of accident and the author has adduced no speculation on this point.

It may perhaps be added here that S. Shinjo(4) disc ssed the possibility of explaining the physical meaning of the z-term by the influence of atmospheric refraction. I. Yamamoto(5) carried out a special series of observations with the purpose of testing his idea. The final decision has not yet been given, though the results thus far obtained seem to be not altogether unfavourable for his theory.

The possibility of detecting some change going on underneath the earth's surface by the observations of the terrestrial magnetic elements had occurred early to the pioneers of the E.I.C. Five Magnetographic Stations were established in different selected districts for investigating the changes of the magnetic elements which might appear associated with earthquakes. Some examples of such changes were cited in Kikuchi's Report. Later, Tanakadate perceived the necessity of increasing the sensibilities of the recording instruments to extreme values and constructed, with the able aid of H. Kadooka, a set of extraordinarily sensitive self-recording instruments. With these instruments, the observations were carried out at Aburatubo, Misaki, for a few years. The results, with some discussion, have been reported

(1) T.S.B.K., **1** (1902), 35; **2** (1905), 357; Astron. Nachr.. No. 3783; A.J., 517,

(2) Pub., **18** (1904).

(3) Jap. J. Astr. Geophys., **3** (1925), 153.

(4) Mem. Kyo., **4** (1912), 287, 325; T.S.B.K., **6** (1912), 236.

(5) T.S.B.K., **9** (1918), 387.

by Terada[1] who was not able to detect any magnetic disturbance indisputably connected with an earthquake. Rapid pulsatory variations of the magnetic field were mostly not local phenomena, but probably of atmospheric origin. It is greatly to be regretted, however, that observations at Aburatubo had been suspended early, and no record of this sensitive magnetograph could be obtained on the occasion of the last great earthquake, of which the origin was situated very near the station.

On the other hand, the investigation of the geographical distribution of the terrestrial magnetic elements has been considered important, especially because Tanakadate and Nagaoka[2] found a remarkable change in the isomagnetics of the Mino-Owari district after the destructive earthquake of 1891. A general magnetic survey of Japan was planned and carried out by Tanakadate under the auspices of the E.I.C.[3] The field work was conducted by a number of parties of observers consisting chiefly of Students and Graduates in Physics, of Tôkyô Imperial University, among whom we find the names of the prominent physicists of the present days. The results of the survey were thoroughly examined and discussed by Tanakadate and published as Vol. 14 (1904) of the Journal of the College of Science,[4] in which the formulae as well as the charts for the different elements, all reduced to 1895.0, are given. Charts of the distribution of magnetic disturbances there appended will be of much interest for future seismologists and geophysicists.

The second general magnetic survey was undertaken by the authority of the Naval Hydrographic Office, during the interval from April 1912 to May 1913, with the collaboration of Messrs. Tanakadate, N. Watanabe and Tokuro Nakano. The results are published as Vol. 2 (1918) of the Bulletin of the Hydrographic Office, I.J.N.,[5] in which the data are all reduced to 1913.0 and the formulae and tables for secular variations and accelerations for extrapolation are adduced.

For the above survey works, the set of magnetometers was designed and improved and the methods of observations and reduction were

(1) Journ. Coll. Sci. Tok., **37,** Art. 9 (1917); T.S.B.K., **8** (1916), 566.

(2) Journ. Coll. Sci. Tok., **5** (1893), 149.

(3) See for the earlier survey: C.G. Knott and A. Tanakadate, Journ. Coll. Sci. Tok., **2** (1889).

(4) Also, T.S.B.K., **2** (1904), 149; **2** (1905), 405; **8** (1915), 122.

(5) A resumé by T. Nakano, T.S.B.K., **8** (1915), 126.

scrutinized and elaborated by Tanakadate himself, by which the reliability of the results obtained was ensured. Recently, N Watanabe[1] succeeded in devising and constructing a very convenient form of portable electric magnetometer. It enables us to make a set of observations in a remarkably short interval of time, with a sufficient accuracy for most purposes, and promises to be of great use in future survey work.

The abundant data afforded by these two general magnetic surveys have, however, not yet been analysed and discussed in connexion with the seismological points of view and remain reserved for future investigators.

As already mentioned, K. Shiratori observed in Sendai on the occasion of the recent Kwantô Earthquake, an abrupt change in the potential difference between the two metallic electrodes driven into the soil. Though a similar phenomenon had been early studied by J. Milne[2] and attributed to some change in the electrodes themselves, yet a further investigation of the matter seems desirable.

The measurement of the underground temperature has been undertaken by the E.I.C. from the earliest dates, in wells and tunnels.[3] Later, K. Fuji[4] made observations on some deep borings in mines and oil fields. No systematic general survey has, however, yet been attempted.

In this respect, K. Misawa's[5] recent investigation into the temperature distribution in the hot spring district of Suwa, Province of Sinano, is worth notice. The springs are arranged in zones in a characteristic way, among which he remarked a regularity of temperature distribution connected with the tectonic structure of the district.

Here, K. Honda and T. Terada's investigation into the geyser of Atami,[6] and K. Honda and T. Soné's study of the geyser of Onikôbe[7] may also be mentioned.

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(1) N.S.B.K., [iii] **2** (1920), 210; Jap. J. Astr. Geophys., **1** (1924), 191.

(2) Trans. Seism. Soc. Jap., **15** (1890) 135; **19** (1894) 23.

(3) Tanakadate, Ho., **45** (1903).

(4) Ho., **67** (1910); **79** (1915).

(5) Chikyu, **2** (1924), 190; Jap. J. Astr. Geophys., Abstr., **3** (1925) (2).

(6) Pub., **22**B (1906); T.S.B.K., **2** (1904), 164; **2** (1905), 433; Phys. Rev., **22** (1906), 300.

(7) Sci. Rep. Toh., [i] **5** (1916), 249; T.S.B.K., **8** (1915), 118.

On the other hand, the radioactivity of mineral spring has been studied by D. Isitani, H. Ikeuti, S. Ono, and others.(1) The results are compiled into a table in R. Ishizu's "The Mineral Springs of Japan," Recently, Saem. Nakamura(2) drew attention to the interesting fact that the contents of the radioactive emanations show a systematic excess in the springs along the Japan Sea side, as compared with those on the Pacific side.

The change of level of the underground water was investigated by Seiji Nakamura and K. Honda(3) and the effects of the barometric and tidal pressures have been established. The disturbance of the level before and after some earthquake was found to continue for several hours. The sensitiveness of the geyser of Atami to the variations of atmospheric pressure has also been established. On the occasion of the recent great earthquake, abnormal changes in the underground water level have been reported from many sides, though unfortunately no record of instrumental measurement is at hand. Recently, K. Suda and K. Tanahasi(4) investigated the change of level in an artesian well on the coast near Kôbe and Osaka. They found an approximate proportionality between the variations of the level of the well and of the neighbouring sea, with a slight lagging of the former after the latter. The influence of precipitation was also examined.

The investigations of the secondary undulations of tides in bays and gulfs, in connexion with the studies on *tsunami* have already been reviewed. The research into the seiches of lakes has also been favoured by many investigators(5) in this country, since Nagaoka

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(1) Isitani, T.S.B.K., **4** (1908), 370, 416; **6** (1912), 275; **7** (1913), 150, 221; **8** (1915), 15. D. Isitani and K. Manabe, T.S.B.K., **5** (1910), 226; **6** (1912), 220, 291, 308. D. Isitani and Yamakawa, T.S.B.K., **6** (1912), 178; **7** (1913), 10, 32. H. Ikeuti, T.S.B.K. **7** (1913), 176, 178; **7** (1914), 422, 424, 425. S. Ono, T.S.B.K., **7** (1914), 419. K. Fuji, T.S.B.K., **8** (1915), 13. T. Okaya, N.S.B.K., [iii] **1** (1919), 351. M. Hayakawa and T. Nakano, Mem. Kyo, **5** (1912–3), 137.

(2) Saitô Hônkwai Gakuzyutu Kenkyû Hôkoku, No. **1** (1925).

(3) T.S.B.K., **2** (1903), 65; **2** (1904), 123; Pub., **18** (1904).

(4) U.t.S., **5** (1925), 223.

(5) Seiji Nakamura and Y. Yoshida, T.S.B.K., **1** (1902), 115. D. Isitani, T.S.B.K., **3** (1906), 170. T. Terada, T.S.B.K., **3** (1906), 174. K. Honda, T.S.B.K., **3** (1906), 220. Seiji Nakamura, T.S.B.K., **4** (1907), 73. K. Aichi, T.S.B.K., **4** (1908), 220. A. Tanaka and Seiji Nakamura, T.S.B.K., **5** (1910), 394. Seiji Nakamura and K. Honda, Journ. Coll. Sci. Tok., **28**, Art. 3 (1911). Keizo Sano, T.S.B.K., **7** (1913), 24; J.M.S., **31** (1912), 446, e.; **32** (1913), 37, e. Honda and Matsushita, Sci. Rep. Toh., [i] **2** (1913), 131. Second Year Students of Physics, Tôhoku Imp. Univ., T.S.B.K., **7** (1913), 24; Sci. Rep. Toh., [i] **1** (1911–12), 243; **2** (1913), 163. T. Okada, S. Fujiwhara and S. Maeda, T.S.B.K., **7** (1914), 210. K. Honda, Sci. Rep. Toh., [i] **4** (1915), 323. Excursion Parties of Tohoku Imp. Univ., Sci. Rep. Toh., [i] **6** (1917), 31; **7** (1918), 197. K. Aichi, T.S.B.K., **9** (1918), 464, 478. Saem. Nakamura, N.S.B.K., [iii] **2** (1920), 82.

brought back from Europe a Sarasin limnometer. The subject has been attacked both experimentally and theoretically. Model experiments have been freely resorted to for studying different possible modes of oscillations and determining the periods and the positions of nodes. The mathematical physicists were furnished with suitable themes for wielding their weapons. Opportunities offered by the summer excursions of students have been utilized for observations. Want of space, however, compels us to pass on without commenting upon even the most interesting of the results obtained by these investigators. It is to be regretted that no limnometer record could be obtained on the occasion of the recent great earthquake which, had there been one, might have yielded data of incalculable value.

Lastly, we may mention in this place some of the physical researches which may be of more or less geophysical significance.

Shida's baro-variometer has already been alluded to. Instruments for similar purposes have also been devised by Tokuiti Yosida,(1) and later also by H. Nagaoka.(2)

The magnetization of rocks and the variation of magnetization by longitudinal stress has been studied by R. Otani.(3) He found that the magnetic susceptibility of different volcanic rocks varies between 0.002–0.006 and increases sensibly with the magnetic field. Compression in the direction of the magnetization decreases the intensity of magnetization which rapidly approaches the asymptotic value. dI/I varies between $0.1-0.01$ for the ultimate value of dI and decreases with the field. The investigation of the susceptibilities of soils, sands and some rocks has also been later accomplished by H. Takagi.(4)

Seiji Nakamura and Seiji Kikuchi(6) determined the magnetic moments and the directions of magnetization of six spindle-shaped volcanic bombs from Mt. Mihara, Oosima, and Mt. Aso, and communicated a valuable hint on the modes of formation of these remarkable forms of bombs.

K. Fuji and T. Mizoguchi(6) devised a method of determining the ranges of melting and solidifying points of lava by measuring its

(1) J.M.S. **31** (1912), 247.
(2) N.S.B.K., [iii] **4** (1922), 92; Sci. Pap. Inst. Phys. Chem. Res., **1** (1923) 135.
(3) T.S.B.K., **5** (1910), 190.
(4) Sci. Rep. Toh., [i] **2** (1913), 15; **3** (1914), 127.
(5) T.S.B.K., **6** (1912), 268.
(6) T.S.B.K., **7** (1914), 243.

electrical conductivity. They also made an observation of the actual temperature of lava in the crater of Mt. Mihara, by means of an optical pyrometer.

The melting points of some Japanese minerals have been determined by Y. Yamashita and M. Majima.(1) Different thermal properties have been investigated by A. Tadokoro.(2) On the other hand, researches into the different physical properties of Japanese minerals have been carried out by S. Kozu(3) and his collaborators. All these reports were contributed by the Tôhoku Imperial University. In this connection, T. Okaya's(4) determination of the specific heats of different specimens of rocks may also be mentioned.

We may here also cite a very original investigation by S. Suzuki(5) of the number of pieces into which a plate of some brittle substance was broken. This field of research appears the more interesting with respect to the recent investigations into the mechanisms of earthquakes by S. Fujiwhara, S. Ono, and others, already cited. Lastly, we may mention a paper by Suzuki on the age of the earth.(6) His theory is based on the assumption that the heat loss is covered by the liberation of the latent heat of the solidifying crust, neglecting the effects of shrinkage and of radioactive minerals. The age thus estimated turns out to be of the same order of magnitude as that obtained by other methods.

Practical Sides.

As is fully implied by the proper name of the E.I.C., *Sinsai-yobô-tyôsa-kwai* (literally committee for investigating the prevention of earthquake damage), the practical application of seismology, especially in alleviating the woeful disasters due to the natural calamity, has been one of the immediate aims of the Committee. From the earliest date of its existence up to the present day of its dissolution, the

(1) Sci. Rep. Toh., [i] **2** (1913), 175.
(2) Sci. Rep. Toh., [i] **10** (1921), 339.
(3) Sci. Rep. Toh., [iii] **1** (1921–23), 1, 19, 25, 233; **2** (1924–25), 1, 9, 187, 203; Jap. J. Astr. Geophys., **2** (1924), 107.
(4) Jap. J. Astr. Geophys., **3** (1925), 45.
(5) N.S.B.K., [iii] **3** (1921), 168.
(6 T.S.B.K., **6** (1912), 204.

engineer members[1] of the Committee have been eagerly active in studying the effects of shocks, both natural and artificial, upon different structural elements of various kinds of buildings. The Reports and other publications of the E.I.C. actually abound in the most valuable results of these investigations. The names of K. Furuichi, B. Mano, K. Tatsuno, I. Ishiguro, A. Inokuty, T. Soné, S. Tanabe and Tat. Nakamura as the pioneers in this line of research, must be remembered for ever by our countrymen in consideration of the merits of their labours which have contributed directly or indirectly to the mitigation of the injuries caused by the recent earthquakes. By their efforts, a standard method of antiseismic construction[2] has been gradually established. Actually, a number of brick buildings constructed after their designs have beautifully stood the most severe test in the form of the recent Kwantô Earthquake, while, a remarkable contrast, some of the reinforced concrete buildings of modern design with no proper precaution against earthquakes have suffered considerable damage. If the frequent occurrence of past destructive earthquakes has been useful for accumulating a mass of experience, that mass was perhaps doubled by the recent case. The materials gathered in various quarters, if fully systematized and properly discussed will probably leave but a few problems to study on this side of practical seismology.[3]

The theoretical or mathematical side of the matter has also not been neglected. R. Sano's[4] extensive theoretical discussions on anti-

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(1) For the studies on the effects of earthquakes and the precautions to be attended to, see, inter alias: T. Nakamura, Ho., **3** (1895); **22** (1898). T. Nakamura and T. Sone, Ho., **11** (1897). Emori, Ho., **2** (1894). T. Sone., Ho., **53** (1906); **69** (1910). I. Ishiguro, Ho., **69** (1910). S. Tanabe, **53** (1906); **69** (1910). R. Sano, Ho., **70** (1910). Omori, Bull., **2** No. 2 (1908); Ho., **88C** (1920); Seism. No., **3** (1922). S. Uchida, Ho., **80** (1915). S. Horikosi, Ho., **99** (1925). Keisityô, Ho., **99** (1925). For experimental investigations, see, among others: S. Tanabe, Pub. **3** (1900). B. Mano, Pub., **3** (1900). Omori, Bull., **2** No. 3 (1908); **4**, No. 1 (1910).

(2) Among others: K. Tatsuno, Ho., **1** (1893). K. Tatsuno, Katayama, T. Nakamura and T. Sone, Ho., **6** (1895). K. Tatsuno and T. Nakamura, Pub., 4 (1900). E.I.C., Ho. **13** (1897). R. Sano, Ho., **83A**, B (1917).

(3) The abundant data obtained on the occasion of the recent great earthquake, will be published as a volume of Ho. **100**. Here we may refer to Matuzawa's investigation of the intensity distribution of the Kwantô Earthquake based on the damage inflicted on wooden buildings, Ho. **100**A (1925). Imamura's different investigations into the same subject, especially in connection with the Ansei Earthquake, etc. and his discussion on the influence of the nature of the underlying ground may be referred to, Ho. **77** (1913); Journ. Geol. Soc., **30** (1924) 378.

(4) Ho., **83**A,B (1917).

seismic structures may especially be mentioned. More recently, N. Mononobe(1) made a wide survey on this problem, discussing the forced vibrations of the most varied structural elements, the extension being made to examples with yielding supports. K. Suyehiro(2) also contributed some papers which treat of the vibrations of chimneys and other structures, to a degree of approximation higher than hitherto resorted to. He drew attention to the existence and its significance of the rocking vibrations of a building as a whole. He(3) also devised with the aid of M. Isimoto an apparatus consisting of an elongated U-tube filled with mercury, by means of which he was able to study closely the vibrations of a building in its different parts simultaneously with those of the underlying earth's surface. A somewhat similar apparatus was constructed by J. Obata(4) which enables us to register extremely minute vibrations by means of an electric micrometer of his own design.

Omori(5) made a widely extended study on the natural periods of different kinds of buildings, towers, chimneys and those large buildings recently constructed in the central quarter of the metropolis. He utilized this method of measurement as a means of diagnosing the strength of buildings against earthquakes. To cite an example, the Marunouchi Building is said to owe its comparative immunity in the last great earthquake to the remedy applied after the former earthquake of the 26 April, 1922, according to the result of his diagnosis.

Imamura is now carrying out an investigation on the vibrations of the iron frame work of the Parliament building under construction, by registering simultaneously the motions of the different stages due to earthquakes. A remarkable occurrence of resonance has been ascertained.

The various investigations of Omori and others(6) on the vibrations of chimneys or towers have also brought forth many interesting results,

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(1) Dobokukwaisi, **5**, No. 3 (1919); **6**, No. 4 (1920). See also his paper on the destructive pawer of earthquakes, Jap. J. Astr. Geophys., **3** (1925), 7.

(2) Read before a Meeting of the Math. Phys. Soc. Jap.; not yet published.

(3) K. Suyehiro and M. Isimoto, N.S.B.K., [iii] **7** (1925), 85.

(4) Not published; the electric micrometer is described in the Report of the Aeronautical Research Institute, Imp. Univ. Tôkyô, **1** (1925) 305.

(5) Ho., **29** (1899); **97**A (1921); Pub., **12** (1903); **20** (1905); Bull., **9**, No. 1 (1918); No. 3 (1921).

(6) Omori, Ho., **28** (1895); Pub., **12** (1903). Tanakadate and Mano, Ho., **21** (1898). Mano and Tanabe, Pub., **3** (1900).

both practical and theoretical. Omori's results on the production of the vibrations of chimneys transverse to the wind has been discussed mathematically by Nagaoka,(1) by an analogy of the eolian harp.

As an application of seismometry, the vibrations of railway trains, and also of different railroad constructions such as bridges and piers, have been extensively studied by Omori.(2)

Damage to water conduits and the like caused by earthquakes has also been the subjects of investigations by Omori, Tanabe and others. Besides, the strengths of various building materials have been extensively investigated.

To our regret, it seems well nigh impossible to refer even to the most important of all these useful and interesting investigations, without making present note unduly lengthy and voluminous.

Lastly, we must spend a few words on the investigation by the E.I.C. of the great conflagration which ensued after the late great earthquake and caused a vast loss of lives and property, far surpassing in degree what might have been expected as the mere result of the earthquake. The results of investigations from various sides, physical, chemical, meteorological, as well as administrational, are compiled as Ho., No. 100 E,(3) the reports being contributed by different members of the Committee, some of them being specially appointed on this occasion. It must be added here that the conflagration was clearly foreseen by Omori and Imamura who took every opportunity to warn the government as well as the inhabitants of the City of Tôkyô wisely to provide beforehand for the terrible calamity to come sooner or later. On reading their writings concerning this matter after the recent disaster, we cannot but regret universal apathy of the general public in listening to the well-founded warnings of scientists.

Geological Investigations

We cannot conclude this brief sketch on the development of seismology in our country without saying a few words on the valuable

(1) N.S.B.K., [iii] **1** (1919), 277.

(2) Omori, Ho., **37** (1901); **40** (1903); **42** (1903); **45** (1903); **74** (1911); Pub., **15** (1904); **20** (1905); Bull., **1**, No. 3 and 4 (1907); **2**, No. 2 (1908); **4**, No. 2 (1911), No. 3 (1912).

(3) For the meteorological sides, see also the special Report on the subject issued by the Centr. Met. Obs., written by S. Fujiwhara.

contributions made by the geologists, though we are fully aware of our incompetency to do justice even to the remarkable of their works, even if the space would have allowed us to comment upon them at some length.

Since the earlier days of the existence of the E.I.C., B. Koto[1] contributed a number of valuable papers on the geological and geotectonic studies of some of the destructive earthquakes, which stand as landmarks among the pages of the Reports of the E.I.C. His paper on the geological structure of the Tyûgoku[2] has been a revelation to seismologists. He also drew an elaborate plan[3] of the complete volcanological survey of Japan which has been and is still being carried out by successive generations of young and competent geologists under his guidance. The results of these investigations are to be found in the volumes of the Reports of the E.I.C., in Japanese, of which we refrain from citing here the list of reference. They will afford most precious sources of data for future seismologists and geophysicists, not to speak of their proper geological and volcanological merits. After his retirement from the University, Koto has been ever active in his own field of research, and we may be allowed to hope that his investigations into the recent earthquakes of Kwantô and of Tazima will bring forth many new facts of importance for seismology.

N. Yamasaki's[4] investigations on the Rikuu Earthquake, N. Fukuchi's[5] on the Oosima Earthquake, K. Aomi's[6] and R. Ohasi's[7] on the Akita Earthquake and S. Tsuboi's[8] on the Oomati Earthquake must be mentioned as inexhaustible magazines of useful informations. The recent great earthquake has naturally increased our list of literature considerably. To cite only the Report of the E.I.C, No. 100 B, it contains the most valuable contributions by N. Yamasaki, T. Kato, K. Inouye, and Z. Suzuki.

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(1) Journ. Coll. Sci., **5** Art., 10 (1892) 295; Ho., **8** (1896); **53** (1906); **69** (1910).
(2) Ho., **63** (1909).
(3) Pub.. **3** (1900).
(4) Ho., **11** (1897).
(5) Ho., **53** (1906).
(6) Ho., **82** (1915).
(7) Ho., **82** (1915).
(8) Ho., **98** (1922).

It will, however, not be fair to confine our reference to the publications of the E.I.C. alone in reviewing, even in a most superficial manner, the activities of our geologists in the special field here concerned. Works by the members of the E.I.C. and especially by the geologists not connected with this official body are before us, scattered widely in various scientific as well as popular periodicals. To give here even a very distorted bird's eye view of this field is however beyond our power.

We may be allowed to conclude this chapter by once more drawing the attention of our readers to the contributions of T. Ogawa, H. Yabe, and others already cited with regard to the recent Kwantô Earthquake.

Lastly, we presume, at the risk of being considered partial, to mention specially the recent work of Y. Ozawa(1) on the geological structure of the western part of Honsyû, which has revealed highly trustworthy evidence on the mode of the most remarkable crustal movement of this part of the land in different geological ages. On the other hand, T. Tsujimura's extensive studies(2) now in progress on the topographical structure of our land, promise to be of considerable interest for seismologists and geophysicists.

In concluding this historical sketch of Japanese seismology, we cannot but lament the untimely death of Prof. Omori which happened by a strange play of chance to be reported just after the great earthquake, of which he had, it seems, some kind of presentiment, though he did his best to avoid exciting useless and pernicious commotion among the public by giving expression to too positive warnings of the coming catastrophe. All who partake in this rare assembly of the Pan-Pacific Scientific Congress in the very cradle of seismology will not fail to miss sincerely the presence of this most erudite and amiable personage.

Once more, we ask the indulgence of our readers and of the scientific investigators of this country for all sins of omission and commission, of which we may be guilty here and there inspite of our earnest desires and faithful endeavours.

Feb. 27, 1926.

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(1) Journ. Fac. Sci. Tok. [ii], **1**, Part 2 (1925), 91; Geogr. Rev. **2** (1926), 153.
(2) Geogr. Rev. **2** (1926), 130 et seq.

XIV. *Learned Institutions.*

Compiled by the Publishing Committee.

A very brief summary of the learned institutions relating to science is here given. For detailed information, publications issued by the respective institutions should be consulted. The greater part of the data was compiled in the summer of 1925; the personal accounts, however, have mostly been revised and are up to date.

Contents

(A) The Imperial Academy.

Location: Ueno Park, Tokyo. ***Founded*** in 1879 as the Tokyo Academy; reformed in 1906 to the present form of the Imperial Academy, consisting of two sections of 30 members each; the membership was further increased in 1925 to 50 each.

Publication:

Proceedings of the Imperial Academy, monthly, Vol. II in 1926.

List of members:

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Secretary:	Masaharu ANESAKI, D. Litt.,
President of Section I:	Tetsujiro INOUYÉ, D. Litt.,
President of Section II:	Sankichi SATO, M. D.,

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Kumazo Tsuboi, D. Litt.,
Bunyiu Nanjio, D. Litt.,
Masaakira Tomii, Jur. D.,
Yasushi Hijikata, Jur. D.,
Kitokuro Ikki, Jur. D.,
Kazutoshi Ueda, D. Litt.,
Sanji Mikami, D. Littt.,
Noburu Kanai, Jur. D.,
Tatsukichi Minobe, Jur. D.,
Fumihiko Otsuki, D. Litt.,
Junjiro Takakusu, D. Litt.,
KakujiroYamasaki, Jur. D.,
Yaiti Haga, D. Litt.,
Unokichi Hattori, D. Litt.,
Kiheiji Onozuka, Jur. D.,
Sensho Murakami, D. Litt.,
Yorozu Oda, Jur. D.,
Kurakichi Shiratori, D. Litt.,
Bunzaburo Matsumoto, D. Litt.,
Ichiro Haruki, Jur. D.,
Sakutaro Tachi, Jur. D.,
Matataro Matsumoto, D. Litt.,
Tokuzo Fukuda, Jur. D.,
Masaharu Anesaki, D. Litt.,
Kinji Tajima, Jur. D.,
Sanjiro Ichimura, D. Litt.,
Yonekichi Miyake, D. Litt.,
Hideo Yokota, Jur. D.,
Inazo Nitobe, D. Agr., Jur. D.,
Iichiro Tokutomi,
Naoki Kano, D. Litt.,
Yasuji Otsuka, D. Litt.,
Mineitciro Adatci, Jur. D.,
Saburo Yamada, Jur. D.,
Masaharu Kato, Jur. D.,
Iwasaburo Takano, Jur. D.,
Seichi Yoshida, D. Litt.,
Seiichi Taki, D. Litt.,
Genyoku Kuwaki, D. Litt.,
Kaoru Nakada, Jur. D.,
George Matsmoto, Jur. D.,
Torajiro Naito, D. Litt.,
Tōru Shimizu, Jur. D.,

Section II.

Hiidzu Miyake, M. D.,
Kenji Ōsawa, M. D.,
Joji Sakurai, D. Sc.,
Bundjirô Kotô, D. Sc.,
Yoshikiyo Koganei, M. D.,
Wilhelm Nagajosi Nagai, D. Sc., D. Phar.,
Baron Kōi Furuichi, D. Eng.,
Aikitu Tanakadate, D. Sc.,
Baron Shibasaburo Kitasato, M. D.,
Rikitaro Fujisawa, D. Sc.,
Kinnosuke Miura, M.D.,
Hantaro Nagaoka, D. Sc.,
Jinzō Matsumura, D. Sc.,
Kiyoo Nakamura, D. Sc.,
Sankichi Sato, M. D.,
Shin Hirayama, D. Sc.,
Chiyomatsu Ishikawa, D. Sc.,
Hayazo Ito, M. D.,
Toshinojo Mizuno, D. Sc.,
Kikunae Ikeda, D. Sc.,
Katsusaburō Yamagiwa, M. D.,
Manabu Miyoshi, D. Sc.,
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Kotaro Honda, D. Sc.,
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Yoshizumi TAHARA, D. Phar.,
Chūta ITO, D. Eng.,
Kamakichi KISHINOUYE, D. Sc.,
Suketeru KIKKAWA, D. Agr.,
Asajiro OKA, D. Sc.,
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Torahiko TERADA, D. Sc.,
Hisakatsu YABE, D. Sc.,
Matsusaburō FUJIWARA, D. Sc.,
Takuji OGAWA, D. Sc.,
Rikō MAJIMA, D. Sc.,

(B) The National Research Council.

Office: Department of Education; ***Organized*** in 1920, including 8 scientific divisions; the Mathematics division added in 1924;

Membership: 100;

Publications:

Japanese Journal of Astronomy and Geophysics, Vol. 4 in 1926.
Japanese Journal of Chemistry, Vol. 3 in 1926.
Japanese Journal of Physics, Vol. 4 in 1926.
Japanese Journal of Geology and Geography, Vol. 4 in 1926.
Japanese Journal of Botany, Vol. 3 in 1926.
Japanese Journal of Zoology, Vol. 1 in 1926.
Japanese Journal of Medical Sciences, Vol. 3 in 1926; from 1926 onward to be issued in 13 sections:

Section I (Anatomy);
Section II (Biochemistry);
Section III (Physiology);
Section IV (Pharmacology);
Section V (Pathology);
Section VI (Parasitology and Bacteriology);
Section VII (Social Medicine and Hygiene);
Section VIII (Internal Medicine, Pediatry and Psychiatry);
Section IX (Surgery, Orthopedy and Odontology);
Section X (Ophthalmology);
Section XI (Gynecology and Tocology);
Section XII (Oto-rhyno-laryngology);
Section XIII (Dermatology and Urology).

Japanese Journal of Engineering, Vol. 4 in 1926.
Japanese Journal of Mathematics, Vol. 2 in 1926.

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Masazo SONO, D. Sc., *Kyoto Imp. Univ.*,
Takuzi YOSIE, D. Sc., *Tokyo Imp. Univ.*

(C) The Imperial Japanese Geodetic Commission.

Office: Department of Education; ***Organised*** in 1898;

Members:

Shin HIRAYAMA, D. Sc., *Tokyo Imp. Univ.*, (*Chairman*),
Aikitu TANAKADATE, D. Sc., *Emer. Prof. Tokyo Imp. Univ.*,
Kiyoo NAKAMURA, D. Sc.,
Hantaro NAGAOKA, D. Sc., *Emer. Prof. Tokyo Imp. Univ.*,
Tokuro NAKANO, *Hydogr. Dep., Imp. Navy*,
Shiryo KIKKAWA, *Central Bureau of Weights and Measures*,
Hisashi KIMURA, D. Sc., *Mizusawa Lat. Obs.*,
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Toshi SHIDA, D. Sc., *Kyoto Imp. Univ.*,
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Sueki YONEMURA, Rear-Admiral, *Hydrogr. Dep., Imp. Navy*,
Kadzuo AOYAGI, Colonel, *Military Land Survey Dep.*,

Associate members:

Noboru WATANABE, *Central Bureau of Weights and Measures*,
Motonori MATUYAMA, D. Sc., *Kyoto Imp, Univ.*;

Publication:

Report of the Imperial Japanese Geodetic Commission, occasional, No. 5 in 1925.

(D) The Imperial Earthquake Investigation Council.

Office: Department of Education; ***Est'd*** in 1893 as the Earthquake Investigation Committee, and reformed in 1925 to the present form, the research work formerly pursued by the Committee being thereby transferred to the Earthquake Research Institute then newly established.

President: Chinjiro MATSUURA, *Vice-Minister of Education,*
Secretaries: Akitune IMAMURA, D. Sc., *Tokyo Imp. Univ.,*
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Hitoshi OHMURA, Maj.-Gen., *Military Land Survey Dep.,*
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Tatsuzo SONE, D. Eng.,
Wasaburo OISHI, *Aerological Observatory,*
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Tachu NAITO, D. Eng., *Waseda Univ.,*
Sueki YONEMURA, Rear-Admiral, *Hydrogr. Dep., Imp. Navy,*
Toshihiko NODA, *Metropolitan Police Board.*

(E) The Council of Aeronautics.

Office: Department of Education; ***Organised*** in 1921;

President: Ryohei Okada, *Minister of Education,*

Secretaries: Takeo Hori, Colonel, *War Dep.,*
Zengo Den, Captain, *Navy Dep.,*
Nobuyoshi Akama, *Dep. of Education,*
Toyotaro Suhara, D. Eng., *Tokyo Imp. Univ.,*
Shimao Iwai, *Communications Dep.,*

Councillors:

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Tetsuo Kuwayama, *Vice-Minister, Communications Dep.,*
Takurô Tamaru, D. Sc., *Tokyo Imp. Univ.,*
Kikutaro Sasamoto, Maj.-Gen., *Aviation Dep., War Dep.,*
Kenjiro Yamakawa, D. Sc., *Privy Councillor,*
Aikitu Tanakadate, D. Sc., *Emer. Prof. Tokyo Imp. Univ.,*
Baron Chuzaburo Shiba, D. Eng., *Tokyo Imp. Univ.,*
Ken Awaya, *Dep. of Education,*
Minosuke Tamaki, Maj.-Gen., *Aviation Dep., War Dep.,*
Takematsu Okada, D. Sc., *Central Met. Obs.,*
Masatoshi Okochi, D. Eng., *Member of House of Peers,*
Yoshiaki Ogura, Rear-Admiral, *Naval Construction Dep.,*
Hisanori Fujita, Rear-Admiral, *Naval Construction Dep.,*
Ikutaro Inouye, Lieut.-Gen., *Aviation Dep., War Dep.,*
Eitaro Hata, Lieut-Gen., *Vice-Minister, War Dep.,*
Chinjiro Matsuura, *Vice-Minister, Dep. of Education,*
Mineo Osumi, Vice-Admiral, *Vice-Minister, Navy Dep.,*
Yasuji Hatano, *Bureau of Aviation, Communications Dep.,*
Seinen Yokota, D. Eng., *Tokyo Imp. Univ.,*
Yoshitake Ueda, Rear-Admiral, *Naval Exp. and Research Establishment, Navy Dep.,*

Associate Councillors:

Kwan'ichi Terazawa, D. Sc., *Tokyo Imp. Univ.,*
Tsuneo Kodama, *Aviation officer,*
Shuhei Iwamoto, *Tokyo Imp. Univ.,*
Toshizo Komamura, Aviation-Captain, *Aviation Dep., War Dep.,*
Tsuneo Inokuchi, D. Eng., *Tokyo Imp. Univ.,*
Shiryo Kikkawa, *Central Bureau of Weights and Measures,*
Toyotaro Suhara, D. Eng., *Tokyo Imp. Univ.,*

Seiko YOKOTA, Naval Engineer, *Naval Construction Dep., Navy Dep.*,
Ichiro TSUKIYAMA, Aviation-Major, *Tokorozawa Military Aviation Sch.*,
Kensuke HASHIMOTO, Naval Engineer, *Naval Exp. and Res. Est.*,
Saburo MORIKAWA, Aviation officer,
Shiro FUKUI, Aviation-Colonel. *Aviation Dep., War Dep.*,
Masuo HAMANA, Aviation officer,
Kenkichi SHOJI, Engineer-Commander.
Koroku WADA, *Tokyo Imp. Univ.*,
Jun'ichiro NAGAHATA, Naval Engineer, *Naval Exp. and Res. Est.*,
Kiyoshi NISHII, Engineer lieut-commander, *Naval Exp. and Res. Est.*,
Ryujiro FUJII, Military Engineer, *Aviation Dep., War Dep.*

(F) Imperial Universities.

There are six Imperial Universities, viz., at Tokyo, Kyoto, Sendai (Tohoku University), Fukuoka (Kyushu Univ.), Sapporo (Hokkaido Univ.), and Keijo (in Chosen).

1. The Tokyo Imperial University.

The old centers of the western culture founded in the times of the Tokugawa Shogunate were united in 1877 to form the Tokyo University, which was then further reformed in 1886 to the present form of the Imperial University.

President: Yoshinao KOZAI, D. Agr.

Faculty	Est'd	Dean	Professors	Students	Graduates up to 1925
Law	1886	Tatsukichi MINOBE, Jur. D.	30	2125	11499
Medicine	1886	Haruo HAYASHI, M. D.	36	621	4064
Engineering	1886	Yasushi TSUKAMOTO, D. Eng.	89	993	5612
Literature	1886	Unokichi HATTORI, D. Litt.	45	1097	2938
Science	1886	Seitaro GOTO, D. Sc.	45	351	1321
Agriculture	1890	Shokichi MACHIDA, D. Agr.	52	579	2763
Economics	1919	Sen KAWADZU, Jur. D.	23	1008	1355

Publications:

Memoirs of the Science Department, Univ. of Tokyo, No. 1–12 (1879–1885), discontinued.

Journal of the College of Science, Imp. Univ. of Tokyo, Vol. 1–45 (1887–1925), discontinued.

Journal of the Faculty of Science, Imp. Univ. of Tokyo, (Continuation of the Journal of the College of Science) issued in five sections, (1925—),

Section I (Mathematics, Astronomy, Physics, Chemistay), Vol. I in 1926.

Section II (Geology, Mineralogy, Geography, Seismology), Vol. II in 1926.

Section III (Botany), Vol. I in 1926.

Section IV (Zoology), Vol. I in 1926.

Section V (Anthropology), Vol. I in 1926.

Journal of the Faculty of Engineering, Vol. 16 in 1926.

Bulletin of the Engineering Faculty, No. 9 in 1922.

Bulletin of the Imperial College of Agriculture and Dendrology, No. 1 (1887)—No. 8 (1890), discontinued.

Bulletin of the College of Agriculture, Imp. Univ. of Tokyo, Vol. I. No. 9 (1891)—Vol. VIII (1908), discontinued.

Journal of the College of Agriculture, Imp. Univ. of Tokyo, Vol. I (1909)—Vol. VIII (1925), discontinued.

Journal of the Faculty of Agriculture, Imp. Univ. of Tokyo, (Continuation of the Journal of the College of Agriculture), Vol. IX in 1926.

Mitteilungen aus der Medicinischen Facultät, Bd. 31 in 1926.

Besides the institutes belonging to the faculties, there are the following independent institutions under the control of the university:

(*a*) ***The Tokyo Astronomical Observatory.***

Location: Mitaka, west of Tokyo; $\lambda = 9^{h}18^{m}10^{s}.1$, $\phi = 35°40'22''$, h = 57 m.

Est'd in 1888 on the site of the Noval Observatory in Azabu, Tokyo, and removed to the present site in 1924;

Director: Shin HIRAYAMA, D. Sc. Professor of Astronomy, Tokyo Imp. Univ.; *Staff*: 7 experts and 18 assistants.

Publication: Annales de l'Observatoire Astronomique de Tokyo, Tome I–V (1889–1922); Appendices, 1–13 (1915–1924).

(b) ***Earthquake Research Institute.***

The main building to be built in the university compound. *Est'd* in 1925; *Director*: Kyoji SUYEHIRO, D. Eng., Professor of Naval Architecture, Tokyo Imp. Univ.; *Staff*: 13 Experts and 15 assistants. *Publication*: Bulletin, No. 1 in 1926.

(c) ***The Aeronautical Research Institute.***

Location: Yetchujima Cho, Fukagawa Ku, Tokyo; *Est'd* in 1918; *Director*: Chusaburo SHIBA, D. Eng., Professor of Marine Engineering, Tokyo Imp. Univ.; *Staff*: 44 experts and 90 assistants; *Publication*: Reports of the Aeronautical Research Institute, occasional, No. 14 in 1926; Journals of the Aeronautical Research Institute, occasional, (Generally in Japanese), No. 17 in 1925.

(d) ***The Governmental Institute for Infectious Diseases.***

Location: Shiroganedai Machi, Shiba Ku, Tokyo; *Est'd* in 1892 as a privat institute, and reformed in 1899 to the present form of the governmental institute; *Director*: Mataro NAGAYO, M. D., Professor of Pathology and Pathological Anatomy, Tokyo Imp. Univ.; *Staff*: 15 experts and 84 assistants;
Publications: Annual Report of the Institute, Vol. IV in 1926, Japanese Journal of Experimental Medicine, (in Japanese), No. 10 in 1926.

The following institutes belonging to the faculty of science may also be specially mentioned:

(e) ***The Seismological Institute,*** in the University compound.

Est'd in 1880; *Professor in charge*: Akitune IMAMURA, D. Sc.; *Branch stations*: Yuigahama, Kamakura; Hitotsubashi, Tokyo; Kiyosumiyama, Awa Province. The Institute has been active, assisting in various investigations carried on by the the Imperial Earthquake Investigation Committee.

(f) ***The Botanic Garden,*** Koishikawa Ku, Tokyo.

Founded in 1684, in the time of the Tokugawa Shogunate; *Director*: Bunzo HAYATA, D. Sc.; *A branch Garden* at Rengeishi, Nikko.

(g) ***The Marine Biological Station,*** Misaki, Kanagawa Prefecture.

Est'd in 1887; *Director*: Naohide YATSU, D. Sc.

2. The Kyoto Imperial University.

President: Torasaburo ARAKI, M. D.

Faculty	Est'd	Dean	Professors	Students	Graduates up to 1925
Law	1899	Soichi SASAKI Jur. D.	22	890	3155
Medicine	1899	Kurata MORISHIMA, M. D.	44	475	1772
Engineering	1914	Tsuruzo MATSUMURA, D. Eng.	56	594	2194
Literature	1906	Takashi SAKAGUCHI. D. Litt.	38	744	825
Science	1914	Takuji OGAWA, D. Sc.	44	309	502
Agriculture	1923	Denzaemon HASHIMOTO, D. Agr.	28	115	65
Economics	1919	Masao KAMBE, Jur. D.	15	870	896

Publications:

Memoirs of the College of Science and Engineering, Vol. I–VI (1903–1914).

Memoirs of the College of Science, Vol. I–VII, and then Series A, Vol. VIII–IX (1914–1926).

Do., Series B, Vol. I in 1926.

Memoirs of the College of Engineering, Vol. I–IV (1914–1926).

Memoirs of the College of Agriculture, Vol. I in 1926.

Acta Scholae Medicinalis, Vol. VIII in 1926.

The following institutes belonging to the faculty of science may be specially mentioned:

(*a*) ***The Astronomical Observatory,*** in the university compound.
Position: $\lambda=9^h3^m6^s\!.7$, $\phi=35°\ 1'37.''1$, h=55m;
Est'd in 1910; *Professor in charge*: Shinzo SHINJO, D. Sc.

(*b*) ***The Kamigamo Seismological Station.***
Location: On a hill near Kamigamo, 5 km north of the university; *Founded* in 1901 as a magnetic Observatory, reformed in 1909 to the seismological station; *Professor in charge*: Toshi SHIDA, D. Sc.

(*c*) ***The Beppu Geophysical Laboratory.***
Location: Near Beppu, Oita Prefecture, Kyushu; *Est'd* in 1924; *Professor in charge*: Toshi SHIDA, D. Sc.

(*d*) ***The Seto Marine Biological Station.***

Location: Seto near Tanabe, Wakayama Prefecture; *Est'd* in 1922; *Professor in charge*: Taku KOMAI, D. Sc.

(*e*) ***The Otsu Hydro-biological Station.***

Location: By the biginning of the canal to Kyoto, Otsu city; *Est'd* in 1914; *Professor in charge*: Tamiji KAWAMURA.

3. The Tohoku Imperial University. (Sendai)

President: Masataka OGAWA, D. Sc.

Faculty	Est'd	Dean	Professors	Students	Graduates up to 1925
Science	1910	Toshiyuki MASIMA, D. Sc.	41	196	469
Medicine	1915	Gennosuke FUSE, M. D.	43	383	327
Engineering	1919	Hideji YAGI, D. Eng.	33	285	289
Law and Literature	1922	Ushijiro SATO, Jur. D.	44	396	74

Publications:

The Science Reports of the Tohoku Imperial University,
First series: (Mathematics, Physics, Chemistry), Vol. XV in 1926.
Second series: (Geology), Vol. X in 1926.
Third series: (Petrology, Mineralogy, Economic Geology), Vol. III in 1926.
Fourth Series: (Biology), Vol. II in 1926.
The Tohoku Mathematical Journal, Vol. 27 in 1926.
The Science Reports of the Institute of Geology aud Paleontology, (in Japanese), No. 6 in 1926.
Technology Reports, Vol. VI in 1926.
Arbeiten aus dem Anatomischen Institut der Kaiserlich-Japanischen Universität zu Sendai, Heft 11 in 1926.
Mitteilungen über Allgemeine Pathologie und Pathologische Anatomie, Bd. III in 1926.
The Tohoku Journal of Experimental Medicine, Vol. VII in 1926.

Besides the institutes belonging to the faculties, there is an independent institution under the control of the university:

(*a*) ***The Research Institute for Iron, Steel and Other Metals.***

Location: In the university compound; *Est'd* in 1916; *Director*: Kotaro HONDA, D. Sc., Professor of Physics in the university; Staff: 22 experts and 32 assistants. *Publications*: Mainly in the Science Reports of the university; Also, The Study of Metals, (in Japanese), monthly since 1924.

The following institutes belonging to the faculty of science may also be specially mentioned:

(*b*) ***The Mukoyama Observatory.*** (Astronomical and Geophysical)

Location: On a hill, 2 km west of the university. *Est'd* in 1912; *Professor in charge*: Saemontaro NAKAMURA, D. Sc.

(*c*) ***The Marine Biological Station.***

Location: Near Asamushi, a hotspring resort on the Tohoku Railway line; *Est'd* in 1924; *Professor in charge*: Shinkichi HATAI.

4. The Kyushu Imperial University. (Fukuoka)

Founded in 1903 as a department of the Kyoto Imperial University, reformed in 1910 as an independent Imperial University.

President: Gintaro DAIKUHARA, D. Agr.

Faculty	Est'd	Dean	Professors	Students	Graduates up to 1925
Medicine	1903	Makoto ISHIWARA, M.D.	44	428	1528
Engineering	1911	Yoshiro FURUYA, D. Eng.	70	305	928
Agriculture	1920	Matao YUKAWA, D. Agr.	43	209	41
Law and Literature	1922	Tatsukichi MINOBE, Jur. D.	34	489	—

Publications:

Memoirs of the College of Engineering, Vol. III in 1926.

Technology Reports, (in Japanese), Vol. I, No. 2 in 1926.

Mitteilungen aus der Medicinischen Fakultät der Kaiserlischen Kyushu-Universität, Bd. X in 1925, discontinued. Further reports to be published in the Japanese Journal of Medicine, N. R. C.

Medical Journal, (in Japanese), Vol. 19 in 1926.

Jaurnal of the Department of Agriculture, Vol. I, No. 7 in 1926.
La Bulteno Scienca de la Fakultato Terkultura, (in Japanese, with abstracts in European languages), Vol. II in 1926.

5. The Hokkaido Imperial University. (Sapporo)

Founded in 1876 as the Sapporo Agricultural College, made a department of the Tohoku Imperial University in 1907, and reformed in 1918 as an independent Imperial University.

President: Shosuke SATO, D. Agr.

Faculty	Est'd	Dean	Professors	Students	Graduates up to 1925
Agriculture	1907	Takajiro MINAMI, D. Agr.	45	263	1408
Medicine	1921	Yutaka KON, M. D.	35	285	60
Engineering	1924	Taroichi YOSHIMACHI, D. Eng.	33	186	—

Publications:

The Journal of the Sapporo Agricultural College, Vol. 2 in 1906.
The Journal of the College of Agriculture, Tohoku Imp. Univ., Vol. 3 (1908–1909)—Vol. 7 (1916–1917).
The Journal of the College of Agriculture, Hokkaido Imp. Univ., Vo. 8 (1918–1919)—Vol. 18 (1926).
Memoirs of the Faculty of Engineering, Vol. I in 1926.

The following institutions belonging to the faculty of agriculture may be specially mentioned:

(*a*) ***The Botanical Garden.***
Location: In the northwestern part of the city; *Est'd* in 1778; *Director*: Kingo MIYABE, D. Sc.

(*b*) ***The Natural History Museum.***
Location: In the Botanical Garden; *Est'd* in 1883; *Director*: Saburo HATTA, D. Sc.

6. The Keijo Imperial University. (in Chosen)

President: Unokichi HATTORI, D. Litt.

Faculty	Est'd	Dean	Professors	Students	Graduates up to 1925
Medicine	1926	Kiyoshi SHIGA, M. D.	18	66	—
Law and Literature	1926	Yoshishige ABE,	28	79	—

(G) Kei-o Gijuku and Waseda Universities.

Of the private universities, these two only need be mentioned here, as having faculties relating to science.

1. The Kei-o Gijuku University.

Location: The main body and the administration office of the university, in Mita, Shiba Ku; the Faculty of Medicine with attached hospital, in Shinano Machi, Yotsuya Ku, Tokyo. ***Founded*** as early as 1856 by the late Mr. Fukuzawa, a pioneer Western scholar.
President: Kiroku HAYASHI, Jur. D.; ***Professors and lecturers:*** 169.

Faculty	Est'd	Students	Graduates up to 1925
Literature	1920	144	88
Economics	1920	1856	2104
Law	1920	559	647
Medicine	1920	378	298

Publications:

Keio Medical Journal, (in Japanese), monthly, Vol. VI in 1926.
Folia Anatomica, bi-monthly, Vol. IV in 1926.
Clinical Gynecology and Obstetrics, (in Japanese), bi-monthly, Vol. I in 1926.

2. The Waseda University.

Location: Waseda, Tokyo. ***Founded*** in 1882 by the late Marquis Okuma. ***President:*** Sanae TAKADA, Jur. D.;
Professors and lecturers: 93.

Faculty	Est'd	Students	Graduates up to 1925
Law	1920	467	260
Literature	1920	522	298
Commerce	1920	888	2301
Politics and Economy	1920	773	676
Science and Engineering	1920	681	901

Publication:

Memoirs of the College of Science and Engineering, (partly in Japanese), No. 3 in 1926.

(H) Medical and Technical Colleges.

(a) Medical Colleges.

College	Est'd	Dean	Staff	Stud.	Grads. to 1925	Publ.
Niigata Med. Coll. (Governmental)	1923	Keigi SAWADA, M. D.	30	200	18	—
Okayama Med. Coll. (Governmental)	1924	Fumio TANAKA, M. D.	31	202	23	in Japanese
Chiba Med. Coll. (Governmental)	1924	Takasaburo MATSUMOTO, M. D.	29	211	—	in Japanese
Kanazawa Med. Coll. (Governm.)	1924	Kenzo SUTO, M.D.	34	164	—	—
Nagasaki Med. Coll. (Governmental)	1924	Ikuhiko HAYASHI, M. D.	35	173	—	—
Osaka Med. Coll. (Prefectural)	1919	Chozaburo KUSUMOTO, M D.	55	389	769	—
Aichi Med. Coll. (Prefectural)	1920	Chuta KOGUCHI, M. D.	32	304	68	in Japanese (Abs. in Europ. languages)
Kyoto Med. Coll. (Prefectural)	1921	Chuai ASAYAMA, M. D.	24	263	—	in Japanese
Kumamato Med. Coll. (Prefectural)	1922	Seito YAMASAKI, M. D.	26	200	—	—
Tokyo Jikeikwai M.C. (Private)	1921	Yeigoro KANASUGI, M. D.	19	572	—	mostly, in Japanese
Nippon Med. Call. (Private)	1926	—	—	—	—	—
Manchuria Med. Coll. (Private)	1922	Itsuyoshi INABA, M. D.	29	82	—	in Chinese; in European languages

(b) College of Agriculture.

College	Est'd	Dean	Staff	Stud.	Grads. to 1925	Publ.
Tokyo Agr. Coll. (Private)	1925	Jikei YOKOI, D. Agr.	—	267	—	—

(c) College of Engineering.

College	Est'd	Dean	Staff	Stud.	Grads. to 1925	Publ.
Ryojun Eng. Coll.	1922	Kinosuke INOUYE, D. Sc.	10	64	—	—

(I) Higher Medical and Technical Schools.

(includiug those in Chosen, Taiwan and South Manchuria)

Speciality	Number of Schools	Number of Students
Medicine (Governmental)	2	632
do. (for men, Private)	6	1962
do. (for women, Private)	2	810
Dental Surgery (for men, Private)	4	2271
do. (for women, Private)	2	814
Engineering (Governmental)	22	6669
do. (Private)	2	303
Agriculture (Governmental)	14	3095
do. (Prefectural)	1	538
do. (Private)	1	139
Fishery (Governmental)	2	458
Pharmacy (for men, Governmental)	5	1053
do. (for men, Private)	4	1532
do. (for women, Private)	1	354

(J) Research Institutions.

(a) Government and other Public Institutions.

(Commerce and Industry Department)

1. *Imperial Geological Survey.*

Location: Kobikicho 9-chome, Kyobashi Ku, Tokyo; *Est'd* in 1979; *Director*: Nobuyasu Kanehara; *Staff*: 15 experts; *Publications*: Topographical and geological maps of various scales and contents, together with the explanatory texts; also,

Memoirs, No. 1–2, (1907–1910);

Bulletin, Vol. 1–11, (1886–1896), in Japanese, Vol. 12–26, (1898–1923), in Japanese with English abstracts or table of contents;

Reports, No. 1–82, (1907–1921), in Japanese, No. 83–92, (1921–1925), in Japanese with English abstracts or contents;

Mineral Survey Reports, No. 1–34, (1911–1922), mostly in Japanese;

Industrial Mineral Survey Reports, No. 1-22, (1921-1925), mostly in Japanese.

2. ***Central Bureau of Weights and Measures.***
Location: Commerce and Industry Dep.; *Est'd* in 1903; *Director*: Shiryo KIKKAWA; *Staff*: 12 experts and 67 assistants; *Publications*: The result of investigations published (in Japanese) as appendices to the Annual Reports.

3. ***Nitrogen Research Laboratory.***
Location; Nakameguro, Tokyo Prefecture; *Est'd* in 1918; *Director*: Fusajiro KODERA, D. Eng.; *Staff*: 10 experts and 10 assistants; *Publications*: Reports of the Nitrogen Research Laboratory, (in Japanese), Vol. 1-8, (1920-1925).

4. ***Imperial Fuel Research Institute.***
Location: Kawaguchi Machi, Saitama Prefecture; *Est'd* in 1920; *Director*: Yoshikiyo OSHIMA, D. Eng.; *Staff*: 8 experts and 12 assistants.

5. ***Imperial Ceramic Research Laboratory.***
Location: Hon-Machi, Kyoto; *Est'd* in 1919; *Director*: Toyokichi UEDA, D. Eng.; *Staff*: 2 experts and 7 assistants.

6. ***Mine Explosions Experimental Station.***
Location: Mitate Yama, Nōgata Machi, Fukuoka Prefecture; *Est'd* in 1915; *Research Members*: 2 experts and 6 assistants.

7. ***Research Laboratory, Imperial Steel Works.***
Location: Yahata, Fukuoka Prefecture; *Est'd* in 1916; *Research Members*: the officials of the Steel Works; The results of investigations published one or more times annually.

8. ***Imperial Experiment Station for the Silk Industry.***
Location; Honmachi, Yokohama; *Est'd* in 1918; *Director*: Gonshiro HAGA: *Staff*: 6 experts and 8 assistants; *Publications*: Annual Reports, (1920-1922), discontinued since the disaster of 1923.

9. ***Tokyo Imperial Industrial Laboratory.***
Location: Hatagaya, western suburb of Tokyo; *Est'd* in 1900; *Director*: Fusajiro KODERA, D. Eng.; *Staff*: 15 experts and 24 assistants; *Publications*: The results of investigations on more than 200 subjects already published.

10. ***Osaka Imperial Industrial Laboratory.***
Location: Ohito Cho, Nishiyodogawa Ku, Osaka; *Est'd* in 1918; *Director*: Ichitaro SHOJI, D. Eng.; *Staff*: 60; *Publications*: One or more times a month.

(AGRICULTURE AND FORESTRY DEPARTMENT)

11. ***Imperial Agricultural Experiment Station.***
Location: Nishigahara, Tokyo; *Est'd* in 1893; *Director*: Hirotaro ANDO, D. Agr.; *Staff*: 18 experts and 30 assistants;
Publications: The Bulletin of the Imp. Agr. Exp. Station, (in Japanese), No. 1 (1898) - No. 45 (1922).
The Special Report of the Imp. Agr. Exp. Station, (in Japanese), No. 1 (1898) - No. 32 (1921).
The Bulletin of the Imp. Agr. Exp. Station, (in European languages), Vol. 1 (1905) - Vol. 3 (1924).

12. ***Imperial Horticultural Experiment Station.***
Location: Okitsu, Shizuoka Prefecture; *Est'd* in 1902; *Director*: Hirotaro ANDO, D. Agr.; *Staff*: 3 experts and 8 assistants; *Publications*: Reports of investigations, (in Japanese), occasional.

13. ***Tea Experiment Station.***
Location: Kanaya, Shizuoka Prefecture; *Est'd* in 1919; *Director*: Hirotaro ANDO, D. Agr.; *Staff*: 3 experts and 5 assistants.

14. ***Forestry Experiment Station.***
Location: Shimo-Meguro, Tokyo; *Est'd* in 1878; *Director*: Homi SHIRASAWA, D. For.; *Staff*; 15 experts and 30 assistants; *Branch stations*: in Ibaraki Prefecture and Ogasawara Jima; 16 forest meteorolgical stations;
Publications:
Bulletin of the Forest Experiment Station, (in Japanese),
Extracts from the Bulletin, (in Japanese and in English),
Journal of the Forest Experiment Station, (in Japanese),
Report of the Forest Meteorological Stations, (in Japanese),
Special Report of the Forest Meteorological Station, (in Japanese),
Journal of Meteorology relating to Forestry and Hydrology, (in Japanese).

15. ***Imperial Sericultural Experiment Station.***
Location: near Nakano, Tokyo; *Est'd* in 1911; *Director*: Eikichi HIRATSUKA, D. Agr.; *Staff*: 18 experts and 16 assistants;
Publications: The reports in Japanese, Vol. 6 in 1925,
The reports in European languages, Vol. 1, (1917-1920),
Special reports in separate pamphlets, (in Japanese), No. 26 in 1925.

16. *Experiment Station for Ornithology and Mammology.*
Location: Renkoji, Tamamura, Minami Tama Gun, Tokyo; *Est'd* in 1919; *Expert in charge*: Seinosuke UCHIDA; 1 assistant; *Publications*: The report, (in Japanese), Vol. 2 in 1925.

17. *Imperial Zootechnical Experiment Station.*
Location: Miyako Mura, Chiba Gun, Chiba Prefecture; *Est'd* in 1916; *Director*: Wasei KIMURA; *Staff*: 10 experts and 16 assistants; *Publications*: The reports in Japanese, Vol. 2 in 1925; The reports in European languages, Vol. 1 in 1925.

18. *Veterinary Laboratory.*
Location: Nishigahara, Tokyo; *Est'd* in 1910; *Director*: Keikichi YAMAWAKI; *Staff*: 6 experts and 32 assistants; *Branch laboratory*: in Tsintau in 1923; *Publications*: The reports, (in Japanese), Old series, Vol. 8 in 1916, New series, Vol. 1–8, (1918–1925).

19. *Imperial Fisheries Institute.*
Location: Yetchu Jima, Fukagawa Ku, Tokyo; *Est'd* in 1897; *Director*: Kintaro OKUMURA, D. Sc.; *Staff*: 15 professors, 8 assistant professors, 25 technical experts and 108 assistants;
Publications: The reports of research studies, (in Japanese), Vol. 1–20, (1899–1925),
The reports of oceanographical investigations, (in Japanese), No. 1–27, (1918–1925),
The reports of investigations on fisheries, (in Japanese), No. 1–8, (1915–1919).

(OTHER GOVERNMENT DEPARTMENTS)

20. *Imperial Institute for Nutrition, Home Department.*
Location: Kago Machi, Koishikawa Ku, Tokyo; *Est'd* in 1920; *Director*: Tadashi SAEKI, M. D.; *Staff*: 6 experts and 11 assistants; *Publications*: The reports and the Bulletin, (both in Japanese).

21. *Imperial Hygienic Laboratory, Tokyo, Home Department.*
Location: Idzumi Cho, Kanda Ku, Tokyo; *Est'd* in 1874; *Director*: Hirotaro NISHISAKI, D. Phar.; *Staff*: 16 experts and 25 assistants; *Publications*: Reports, in Japanese.

22. *Imperial Hygienic Laboratory, Osaka, Home Department.*
Location: Kyobashi 3-chome, Higashi Ku, Osaka; *Est'd* in 1875; *Director*: Yeizo MACHIGUCHI; *Staff*: 3 experts and 8 assistants; *Publications*: Reports, in Japanese.

23. *Governmental Institute of Brewing, Finance Department.*
Location: Takinogawa, Tokyo Prefecture; *Est'd* in 1904; *Director*: Hideo KURODA; *Staff*: 6 experts and 8 assistants; *Publications*: Reports of the Gov. Inst. of Brewing, (in Japanese), No. 93 in 1925.

24. *Central Research Laboratory of the Monopoly Bureau, Finance Department.*
Location: Hiratsuka Mura, Ebara Gun, Tokyo Prefecture; *Est'd* in 1920; *Director*: Shigeyuki TITAURA; *Staff*: 8 experts and 17 assistants.

25. *Electrotechnical Laboratory, Communications Department.*
Location: Osaki Machi, near Tokyo; *Est'd* in 1891; *Branch laboratories*: in Osaka, Fukuoka, Fukushima, and Hiraiso; *Director*: Kiyoshi TAKATSU; *Staff*: 29 experts and 136 assistants;
Publications:

Research Reports, (partly in Japanese), No. 157 in 1925,
Investigation Reports, (partly in Japanese), No. 16 in 1925.

26. *Railway Research Office, Railway Department.*
Location: Research laboratory for railways proper, in the main building of the Department; Laboratories for chemical, physical and electrical researches, within the grounds of the Shiodome railway station; Research laboratory for fuel, within the grounds of the Ōi railway workshop. *Est'd* in 1910; *Director*: Mitsuo NAWA, D. Eng.; *Staff*: 6 experts and 50 assistants; *Publications*: Reports of investigations, (in Japanese), monthly.

27. *Military Land Survey Department, War Department.*
Location: Nagata Cho, Kojimachi Ku, Tokyo; *Est'd* in 1884; *Director*; Hitoshi OHMURA, Major General; *Staff*: 30 officers, 50 engineers and 500 assistants and labourers; *Publications*: Topographical maps of various scales.

28. *Military Scientific Laboratory, War Department.*
Location: Okubo Hyakunin Machi, Tokyo. *Est'd* in 1919; *Director*: Katsuichi OGATA, Lieut. General; *Staff*: 28 officers, 5 engineers and 30 assistants.

29. *Hydrographic Department, Navy Department.*
Location: Tsukiji, Tokyo; *Est'd* in 1871; *Director*: Sueki YONEMURA Rear-Admiral; *Staff*: 27 naval officers, 12 civil officials and 58 assistants; *Publications*: Catalogue of Charts and Books; Charts; Sailing Directions; Notices to Mariners, weekly; Lists of Lights; Nautical Almanac; Tide Tables; Hydrographic

Bulletin (Suiro Yoho), monthly; Bulletin of Hydrographic Department, etc.

30. ***Naval Experimental and Research Establishment, Navy Dep.*** *Location*: Tsukiji, Tokyo; *Est'd* in 1923; *Director*: Yudzuru HIRAGA, D. Eng., Constructor Rear-Admiral; *Staff*: 95 research members.

(GOVERNMENTS-GENERAL OF CHOSEN AND TAIWAN)

31. ***Geological Survey of Chosen, Government-General of Chosen.*** *Location*: Kokwamon Dori, Keijo; *Est'd* in 1918; *Director*: Shigetaro KAWASAKI; *Staff*: 4 experts and 5 assistants; *Publications*: Geological maps,
Reports of Geological Survey, (in Japanese), Vol. 3 in 1925,
Reports of Mineral Survey, (in Japanese), 11 numbers up to 1925.

32. ***Fuel Research Institute, Government-General of Chosen.*** *Location*: Roryoshin near Keijo; *Est'd* in 1922; *Director*; Masao KAMO, D. Eng.; *Staff*: 15 research members.

33. ***Industrial Experiment Station, Government-General of Chosen.*** *Location*: Tosodo, Keijo Fu; *Est'd* in 1912; *Staff*: 6 experts and 8 assistants.

34. ***Agricultural Experiment Station, Government-General of Chosen.*** *Location*: Main establishment in Suigen, Keiki Do; *Est'd* in 1906; *Director*: Gintaro DAIKUHARA, D. Agr.; *Staff*: 13 experts and 25 assistants; *Publications*: Besides the reports of investigations published in Japanese in several series,
Bulletin of the Agr. Exp. Station, Vol. 2 in 1925.

35. ***Forestry Experiment Station, Government-General of Chosen.*** *Location*: Sojin Men, Koyo Gun, Keiki Do; *Est'd* in 1922; *Director*: Matajiro TOSAWA, D. For.; *Staff*: 5 experts and 41 assistants; *Publications*: Reports of investigations, in Japanese.

36. ***Institute for Veterinary Medical Research, Gov.-Gen. of Chosen.*** *Location*: Saka Men, Torai Gun, Keisho Nando. *Est'd* in 1911; *Director*: Takizo MOCHIZUKI; *Staff*: 23 research members.

37. ***Fisheries Experiment Station, Government-General of Chosen.*** *Location*: Fuzan, Chosen; *Est'd* in 1921; *Director*: Yojiro WAKIYA, D. Sc.; *Staff*: 15 experts and 15 assistants; *Publications*: Reports of investigations, in Japanese.

38. ***Government Research Institute, Government-General of Taiwan.*** *Location*: Main building at Saiwai Cho, Taihoku; *Est'd* in 1921;

Director: Fumio Goto.

(i) ***Department of Aglicultare.***

Location: Main building at Tomita Cho, Taihoku; Sugar experiment station at Shinkwa Gai near Tainan; and 7 more branch stations; *Est'd* in 1903; *Director*: Kintaro Oshima, D. Agr., *Staff*: 16 experts and 33 assistants; *Publications*; Besides those published in Japanese in several series, may be specially mentioned:

The Special Report of the Agr. Exp. Station, (partly in European languages), No. 1 (1910) - No. 20 (1921),

The Bulletin of the Sugar Exp. Station, (in European languages), No. 1 in 1920,

The Report of the Department of Agriculture, (partly in European languages), No. 1 (1922) - No. 19(1926),

The Bulletin of the Dep. of Agr., (partly in European languages), No. 1 (1922) - No. 32 (1926).

(ii) ***Department of Forestry.***

Location: Nanmon Cho, Taihoku; two branch stations; *Est'd* in 1911; *Director*: Ryozo Kanehira, D. For.; *Staff*: 3 experts and 5 assistants;

Publicatoins: The Report of the Forestry Exp. Station, (mostly in Japanese), No. 1 (1914) - No. 7 (1921),

The report of the Department of Forestry, (partly in English), No. 1 (1922) - No. 3 (1924),

The Bulletin of the Dep. of Forestry, (partly in English), No. 1 (1923) - No. 4 (1924),

Icones planarum formosanarum, I–X, (1911–1920), by Dr. B. Hayata,

and some separate papers in English.

(iii) ***Department of Industry.***

Location: Saiwai Cho, Taihoku; *Est'd* in 1909; *Director*: Kinzo Kafuku, D. Sc.; *Staff*: 8 experts and 20 assistants; *Publications*: Reports of investigations published mostly in Japanese.

(iv) ***Department of Hygiene.***

Location: Saiwai Cho, Taihoku; *Est'd* in 1909; *Director*: Tsugio Horiuchi, M. D.; *Staff*: 11 experts and 14 assistants; *Reports* of investigations published in several series mostly in Japanese.

(Prefectural Governments and Municipalities)

39. Hokkaido Industrial Experiment Station, Hokkaido Government.

Location: Kotoni Mura, Sapporo Gun, Hokkaido; *Est'd* in 1922;

Director: Kyu AKAGI; *Staff*: 5 experts and 8 assistants.

40. *Hokkaido Agricultural Experiment Station, Hokkaido Gov.*
Location: Kotoni Mura, Sapporo Gun, Hokkaido; *Est'd* in 1901; 4 *branch stations* and 6 experiment grounds; *Director*: Yasuji MIYAKE, D. Agr.; *Staff*: 16 experts and 51 assistants;
Publications: The Report of the Hok. Agr. Exp. Station, (in Japanese), No. 16 in 1925,
The Bulletin, (in Japanese), No. 36 in 1925,
The Journal, (in Japanese), No. 37 in 1925,

41. *Hokkaido Fisheries Experiment Station, Hokkaido Government.*
Location: Takashima Cho, Takashima Gun, Hokkaido; *Est'd* in 1901; *Director*: Ikushige MORIWAKI; *Staff*: 32 members.

42. *Tokyo Commercial and Industrial Museum, Tokyo Pref. Gov.*
Location: Yurakucho 2-chome, Kojimachi Ku, Tokyo; *Est'd* in 1919; *Director*: Bunsuke KUDARA; *Staff*: 4 experts and 6 assistants.

43. *Institute of Industrial Research, Osaka Municipality.*
Location: Kitaōgi Machi, Kita Ku, Osaka; *Est'd* in 1916; *Staff*: 11 experts and 48 assistants.

44. *Hygienic Laboratory, Osaka Municipality.*
Location: Kitaōgi Machi, Kita Ku, Osaka; *Est'd* in 1906; *Staff*: 7 experts and 69 assistants.

45. *Institute of Technical Research, Kyoto Municipality.*
Location: Higashi Kujo, Shimokyo Ku, Kyoto. *Est'd* in 1920; *Staff*: 4 experts and 11 assistants.

(b) Private Institutions and Laboratories of Business Firms.

46. *Institute of Physical and Chemical Research.*
Location: Kamifujimae Cho, Hongo Ku, Tokyo; *Est'd* in 1917; *Director*: Viscount Masatoshi OKOCHI, D. Eng.;
Research leaders:
Rian IIMORI, D. Sc.,
Kikunae IKEDA, D. Sc.,
Fusao ISHIKAWA,
Yoshio ISHIDA, Ph. D.,
Masaharu NISHIKAWA, D. Sc.,
Takeshi NISHI, D. Eng.,
Tsunekichi NISHIMURA,
Kotaro HONDA, D. Sc.,
Masatoshi OKOCHI, D. Eng.,
Isaburo WADA, D. Sc.,
Masao KATAYAMA, D. Sc.,
Toshio TAKAMINE, D. Sc.,
Hantaro NAGAOKA, D. Sc.,
Tsunetaro KUJIRAI, D. Eng.,

Bennosuke KUBOTA, D. Sc., Toshiyuki MASHIMA, D. Sc., Shoichi MASHIMA, D. Eng., Torahiko TERADA, D. Sc., Genshichi ASAHARA, D. Sc., Gen'itsu KITA, D. Eng., Masamichi KIMURA, D. Sc., Tsuneo SUZUKI, Umetaro SUZUKI, D. Agr.;

Staff-members: 343;

Publications: Scientific Papers of the Inst. of Phys. and Chem. Research, No. 34 in 1925,

Bulletin of the Inst. Phys. Chem. Research, (in Japanese), Vol. 4 in 1925.

47. *Shiomi Physical and Chemical Research Institute.*
Location: Hamadori 3-chome, Dojima, Osaka; *Est'd* in 1916; *Director*: Kinnosuke OGURA, D. Sc.; *Research members*; Tokiharu OKAYA, D. Sc., Yashiro FURUTAKE, Satoshi TAKENAKA.

48. *Saito Laboratory of Electrical Communication.*
Location: in the Faculty of Engineering, Tohoku Imp. Univ.; *Est'd* in 1024; *Research leaders*: Hideji YAGI, D. Eng., Heiichi NUKIYAMA, Shigetaro CHIBA; *Staff*: 8 experts and 22 assistants.

49. *Tokugawa Institute of Biological Research.*
Location: Koyama, Hiratsuka Mura, near Tokyo; *Est'd* in 1918; *Directer*: Hirotaro HATTORI, D. Sc.; *Research members*: 6; *Publications*: Studies from the Tokugawa Institute, published in Japanese and in European languages, Vol. 1 of both series in 1924.

50. *Nawa's Entomological Laboratory.*
Location: Ōmiya Cho, Gifu; *Est'd* in 1896; *Research members*: 1 expert and 3 assistants; *Publications*: The Insect World, (in Japanese), monthly, Vol. 29 in 1925.

51. *Ohara Institute for Agricultural Research.*
Location: Kurashiki Machi, Okayama Prefecture; *Est'd* in 1914; *Director*: Mantaro KONDO, D. Agr.; *Research members*: 7; *Publications*: The Report of the Ohara Inst. Agr. Res., (in European languages),

The Aglicultural Researches, (in European languages),

The Special Report of the Ohara Inst. Agr. Res., (in Japanese).

52. *Kitasato Institute for Infectious Diseases.*
Location: Shirokane-Sankocho, Shiba Ku, Tokyo; *Est'd* in 1914; *Director*: Baron Shibasaburo KITASATO, M. D.; *Vice-Director*: Taichi KITASHIMA, M. D.; *Staff*: 9 department cheifs, 7 associate members and 53 assistants ;

Publications: Journal of Bacteriology, (in Japanese), monthly, No. 366 in Aug. 1926,

The Kitasato Archives of Experimental Medicine, (in European languages), occasional, Vol. 6 in 1926.

53. Takeo Institute for Tuberculosis.

Location: Hamadori Sanchome, Dojima, Kita Ku, Osaka. *Est'd* in 1915; *Director*: Yoshihiko SATO, M. D.; *Research members*: 15.

54. Institute for the Investigation of the Science of Labor.

Location: Kurashiki Machi, Okayama Prefecture; *Est'd* in 1921; *Director*: Gito TERUOKA, M. D.; Research members 4; *Publications*:

Annual Report, (in European languages), Vol. 1 in 1925, The Studies of the Science of Labour, (in Japanese), quarterly.

55. Research Laboratory, Tokyo Electric Company, Ltd.

Location: Horikawa Cho, Kawasaki, Kanagawa Prefecture; *Est'd* in 1917; *Research members*: 50.

56. Research Laboratory, Shibaura Engineering Works.

Location: Kanasugi Shinhama Cho, Shiba Ku, Tokyo; *Est'd* in 1906; *Director*: Teizo ISSHIKI; *Research members*: 18.

57. Furukawa Research Laboratory.

Location: Shimo Jagakubo, Hiratsuka Machi, near Tokyo; *Est'd* in 1918; *Director*: Tsutomu SHIOMI; *Research members*: 27.

58. Laboratory of the Japan Steel Works.

Location: Muroran, Hokkaido; *Est'd* in 1907; *Director*: Munetsugu MAITA; *Staff*: 11 experts and 29 assistants.

59. Investigation Dep., Sumitomo Steel Tube & Copper Works, Ltd.

Location: Ajikawa Kamidori, Konohana Ku. Osaka; *Est'd* in 1918; *Director*: Chozo SUGIURA, D. Eng.; *Research members*: 21.

60. Investigation Dep., Sumitomo Electric Wire & Cable Works, Ltd.

Location: Onkijima, Minamino Machi, Konohana Ku, Osaka; *Est'd* in 1911; *Research leader*: Keiichiro ASANO, D. Eng.; *Research members*: 12.

61. Research Laboratory, Mitsubishi Shipbuilding and Engineering Company, Ltd.

Location: Kami Fujimae Cho, Hongo, Tokyo; *Est'd* in 1918; *Director*: Tatsuya SHODA; *Staff*: 12 experts and 22 assistants; *Reports* of investigations published in separate papers.

62. Mitsubishi Mining and Metallurgical Laboratory.
Location: Minami Shinagawa, south of Tokyo; *Est'd* in 1917; *Director*: Tokutaro SESHITA; *Staff*: 10 experts and 19 assistants.

63. Research Laboratory, Asahi Glass Company, Ltd.
Location: Kikui Cho, Ushigome Ku, Tokyo; *Est'd* in 1919; *Advisor*: Matsuo FUKUI, D. Sc.; *Superintendent*: Motohiro NAMBA, D. Eng.; *Research members*: 16; *Publications*: The Report of the Asahi Glass Co., Ltd., Research Laboratory, No, 1(1919).-No. 14(1925).

64. Research Laboratory of the Sankyo Company, Ltd.
Location: in the Shinagawa Factory, Shinagawa, and the Mukojima Factory, Terashima Cho, Tokyo Prefecture; *Est'd* in 1909; *Director*: Takehiko YUASA; *Staff*: 20 experts and 16 assistants.

65. Chemical Laboratory, Miike Dyestuff and Chemical Works, Mitsui Mining Company, Ltd.
Location: Sako Cho, Omuta, Fukuoka Prefecture; *Est'd* in 1915; *Research members*: 63.

66. Research Laboratory, Mitsubishi Paper Mills, Ltd.
Location: Kami Fujimae Cho, Hongo Ku, Kokyo; *Est'd* in 1920; *Research leaders*: 3.

67. Geological Institute, South Manchuria Railway Company, Ltd.
Location: Kodama Cho, Dairen; *Est'd* in 1907; *Director*: Hanzo MURAKAMI, D. Sc.; *Staff*: 10 research members; *Publications*: Geological and Mineral Maps of various scales, Reports of Geological and Mineral surveys, mostly in Japanese.

68. Central Laboratory, South Manchuria Railway Company, Ltd.
Location: Fushimi Cho, Dairen; *Est'd* in 1908; *Director*: Kendo SAITO, D. Sc.; *Staff*: 42 experts and 23 assistants; *Publications*: Reports of investigations, in Japanese.

69. Agricultural Exp't Station, South Manchuria Railway Co. Ltd.
Location: Main Station in Kōshurei, branch station in Yugakujo, South Manchuria; *Est'd* in 1913; *Director*: Katsui KANDA; *Research members*: 18; *Publications*: Bulletin of the Agr. Exp. Station, (mostly in Japanese), No. 22 in 1925.

(K) Observatories.

(a) Astronomical.

1. The Tokyo Astronomical Observatory.
See p. 321, Tokyo Imp. Univ.

2. ***The Kyoto Astronomical Observatory.***
See p. 323, Kyoto Imp. Univ.

3. ***Mizusawa Latitute Observatory.***
Location: Mizusawa, Iwate Prefecture;
$\lambda = 9^h24^m31.^s5E$, $\phi = 39^0 8' 4'' N$, h = 62m.
Est'd in 1899; *Director*: Hisashi KIMURA, D. Sc.;
Staff: 3 experts and 10 assistants;
Publications:
Annual report of the provisional result of the International work in the north parallel 39°8′,
Annual report of the meteolological and the seismological observations made at the International Latitude Observatory of Mizusawa.

4. ***Mitaka International Time station.***
Location: In the ground of the Tokyo Astronomical Observatory.
Est'd in 1923; *Director*: Shin HIRAYAMA, D. Sc.; *Staff*: The work of the Station performed so far by the members of the Astronomical Observatory.

(b) Meteorological and Geophysical.

5. ***The Central Meteorological Observatory.***
Location: Motoe Cho, Kojimachi Ku, Tokyo; *Est'd* in 1875; *Director*: Takematsu OKADA, D. Sc.; *Staff*: 13 experts and 40 assistants;
Publications:
The Bulletin of the Central Met. Obs., Vol. 3 in 1926,
Annual Reports in several series:
(i) Meteorological Observations in Japan,
(ii) Cyclonic Storms,
(iii) Precipitations,
(iv) Magnetic Observations, Kakioka Magnetic Observatory,
The Seismological Bulletin of the Central Meteorological Observatory, Vol. 2 in 1926,
Monthly Reports of Meteorological Observations in Japan,
The Geophysical Magazine, Vol. 1 in 1926,
Weather Chart, daily,
Kishō Yōran (Meteorological Journal, in Japanese), monthly, No. 323 in 1926,
Meteorological Notes, (in Japanese), occasional, Vol. 2 in 1925,

Seismological Bulletin, (in Japanese), Voll. 2 in 1926.

6. ***Imperial Marine Observatory.***
Location: Nakayamate Dori, Kobe; *Ets'd* in 1919; *Director*: Takematsu OKADA, D. Sc.; *Staff*: 5 experts and 19 assistants; *Publications*:

Memoirs of the Imp. Mar. Obs., Vol. 2 in 1926,
Monthly Bulletin of the Imp. Mar. Obs., Vol. 4 in 1925,
Seismological Bulletin of the Imp. Mar. Obs., Vol. 3 in 1924,
Weekly Weather Charts, (1920-1923),
Daily Weather Charts of the Pacific Ocean, since 1923.

7. ***Aerological Observatory.***
Location: Tateno near Tutiura, Ibaraki Prefecture; *Est'd* in 1920; *Director*: Wasaburo OISHI; *Staff*: 6 assistants; *Publications*: Aerological Reports, thrice a month.

8. ***Kakioka Magnetic Observatory.***
Location: Kakioka, Niibari Gun, Ibaraki Prefecture; *Est'd* in 1913; *Director*: Shuichi IMAMICHI: *Staff*: 3 assistants.

9. ***Local Meteorological Observatories.***
See p. 50–53, "Meteorological Service in Japan" by Dr. Okada.

10. ***Seismological Stations,*** Hitotsubashi, Yuigahama and Kiyosumiyama.

See p. 322, Tokyo Imp. Univ.

11. ***Kamigamo Seismological Station.*** *See* p. 323, Kyoto Imp. Univ.

12. ***Mukoyama Observatory.*** *See* p. 325. Tohoku Imp. Univ.

13. ***Tsukuba Seismological Station.***
Location: Higashi Yama, Tsukuba Machi, Ibaraki Prefecture; *Est'd* in 1921; Under the care of 2 observers.

14. ***Asama Vulcanological Station.***
Location: Yunotaira, up Asama Yama by way of Komoro; *Est'd* in 1911.

15. ***Oiwake Vulcanological Station.***
Location: Oiwakemura on the southern skirt of Asama Yama; *Est'd* in 1913.

16. ***Unzen Vulcanological Station.***
Location: On the summit of Kinugasa, Obama Machi, Nagasaki Prefecture; *Est'd* in 1913.

(L) Museums, Botanical and Zoological Gardens, etc.

(a) Museums. (1925, January)

(i) ***Number.*** (Classification according to Founders).

Government			17
Public	Prefectural	18	36
	Municipal	6	
	Town	12	
Private			8
	Total		61

(ii) ***Principal Museums.***

Name	Place	Founder	Exhibits
Museum of Natural History Annexed to Hokkaido Imperial University-College of Agriculture.	Sapporo	Government	Zoological, Mineral Anthropological
Museum of Historical Data	Nagasaki	Nagasaki Prefecture	Historical Data of Diplomatic relations
Entomological Museum	Gifu	Private	Insect
The Imperial Museum	Uyeno Park, Tokyo	Government	Historical Art
Museum of Communication	Ushigome Ku, Tokyo	Government	Postal and traffic references
Museum of Natural History	Ochanomizu, Tokyo	Government	Natural scientific specimens
Hiroshima Higher Normal-School-Educational Museum	Hiroshima	Government	Educational
Nara Museum	Nara	Government	History, Art
Imperial Gift Monumental Kyoto Museum	Kyoto	Kyoto Municipal	History, Art
Museum of the Rio-Household	Seoul, Korea	Government	History, Art
Museum of Chosen Government-General	Seoul, Korea	Government	Industrial, Art Manufactures
Museum of Formosa Government-General	Taihoku, Formosa	Government	Natural Scientific, Agricultural
Matsumoto Memorial Museum	Matsumoto	Matsumoto-Municipality	Natural History, Geographical, History
The Yushu Museum	Kudan, Tokyo	Government	War-materials (military affairs)
Museum of Naval Information	Tsukiji, Tokyo	Government	War Materials
Tokyo Art Museum	Uyeno Park, Tokyo	Tokyo Prefecture	Art

Name	Place	Founder	Exhibits
Tokyo Jijikai Museum	Uyeno Park, Tokyo	Tokyo-Municipality	Books and Photographs of models of municipal undertakings (works)
The Choko Museum	Uji-Yamada	Government	History
The Agricultural Museum	Uji-Yamada	Government	Agricultural
Memorial Museum of the Siege of Port Arthur	Port Arthur	Government	Ammunition
Railway Museum	Marunouchi, Tokyo	Government	Railway traffic specimens

(b) Botanical Gardens

(i) ***Number.*** (Classification according to Founders).

Government		5
Public	Prefectural 4	4
Private		2
Total		11

(ii) ***Names and Places of Principal Gardens.***

Name	Place	Founder
Botanic Gardens of Tokyo Imperial University	Hakusan Goten Machi, Koishikawa Ku, Tokyo	Government
Nikko Botanic Garden of Tokyo Imperial University	Nikko, Tochigi Prefecture	Government
The Coronation Memorial, Kyoto Botanical Garden	Shimo-kamo, Kyoto	Kyoto Municipality
Botanic Gardens of Hokkaido Imperial University	Sapporo, Hokkaido	Government
The Rio-Household Botanical Garden	Seoul Korea	Governmeut
Forestry Nursery of Formosa Government-General Central Research Laboratory	Taihoku, Formosa	Government

(c) Zoological Gardens.

(i) ***Number.*** (Classification according to Founders).

Government		1
Public	Prefectural 2 Municipal 5 Town 1	8
Private		2
Total		11

(ii) ***Names and Places of Principal Gardens.***

Name	Place	Founder
Uyeno Zoological Garden	Uyeno Park, Tokyo	Tokyo Municipality
Monumental Zoological Garden	Okazaki Park, Kyoto	Kyoto Municipality
The Rio-household Zoological Garden	Seoul, Korea	Government

(d) Aquaria.

(i) ***Number.*** (Classification according to Founders).

Government		1
Public	Municipal . . . . . 1 Town 1	2
Private		3
Total		6

(ii) ***Names and Places of Principal Aquaria.***

Name	Place	Founder
The Aquarium of the Marine Biological Laboratory, College of Science Tohoku Imperial Univ.	Asamushi, Aomori Prefecture	Government
Uozu Aquarium	Uozu Machi, Toyama Prefecture	Uozu Town
Sakai Aquarium	Sakai, Osaka	Sakai Municipality
Hakozaki Aquarium	Katakasu Machi	Private

(M) Libraries.

(a) School Libraries.

Every school has been provided with a library for the benefit of the instructors and of the students. However, the equipment differs according to the sizes of the schools. The number of books in the principal libraries, those attached to the Imperial Universities, in 1925 was as follows:

Tokyo Imperial University Library	87,593
Kyoto " " "	623,063
Tohoku " " "	264,626
Kyushu " " "	107,298
Hokkaido " " "	130,974

Note. Tokyo Imperial University Library had a collection of 756,000 books before the disaster of 1923.

(b) Public Libraries.

The libraries for the general public are classified according to the founders; the number of each class is as follows:—

(i) ***Number.*** (Classification according to Founders).

Government Libraries			3
Public Libraries	Prefectural	44	2,216
	Municipal	78	
	Town	2,094	
Private			1,428
	Total		3,647

(ii) ***Number of Books.***

Government Libraries	716,705
Municipal "	3,957,387
Private "	2,768,853
Total	7,442,945

(iii) ***Principal Libraries.***

Name	Place	Founder	Books
Imperial Library	Uyeno Park, Tokyo	Government	613,595
Hibiya Library	Hibiya Park, "	Tokyo Munic.	82,871
Oriental Library	Komagome, "	Private	85,000
Kyoto Municipal Library	Okazaki Park, Kyoto	Kyoto Munic.	94,229
Osaka Municipal Library	Nakanoshima Park, Osaka	Osaka Munic.	181,135
Kobe Municipal Library	Kobe	Kobe	40,458
Nagasaki Pre. Nagasaki Library	Nagasaki	Nagasaki Pre.	40,465
Meiji Memorial Niigata Pre. Library	Niigata	Niigata Pre.	43,276

Name	Place	Founder	Books
Nagaoka Munic. Library	Nagaoka	Nagaoka	39,742
Ibaraki Prefectural Library	Mito	Ibaraki Pre.	84,196
Nara Library	Nara	Nara Pre.	42,924
Nagoya Munic. Library	Nagoya	Nagoya Munic.	48,877
Miyagi Prefectural Library	Sendai	Miyagi Pre.	82,382
The Imperial Visit Memorial Yamagata Prefectural Library	Yamagata	Yamagata Pre.	25,319
Akita Prefectural Akita Library	Akita	Akita Pre.	74,352
Ishikawa Prefectural Library	Kanazawa	Ishikawa Pre.	53,609
Matsuye Municipal Library	Matsuye	Matsuye Munic.	42,227
Okayama Prefectural Library	Okayama	Okayama Pre.	93,338
Yamaguchi Library	Yamaguchi Town	Yamaguchi Pre.	73,211
Hagi Library	Hagi Town	Yamaguchi Pre.	34,759
Tokushima Pre. Kokei Library	Tokushima	Tokushima Pre.	25,937
Kochi Prefectural Library	Kochi	Kochi Pre.	39,585
Fukuoka Prefectural Library	Fukuoka	Fukuoka Pre.	48,887
Kumamoto Prefectural Library	Kumamoto	Kumamoto Pre.	32,582
Miyazaki Pre. Miyazaki Library	Miyazaki	Miyazaki Pre.	25,405
Kagoshima Prefectural Library	Kagoshima	Kagoshima Pre.	31,941
Okinawa Pre. Okinawa Library	Okinawa	Okinawa Pre.	14,192
Narita Library	Narita-cho, Chiba Prefecture	Private	87,185
Iwase Library	Nishio-cho, Aichi Prefecture	Private	79,243
Saga Library	Saga	Private	30,673
Chosen Government-General Lib.	Seoul, Chosen	Government	12,620
Mantetsu Keijio Library	Seoul, Chosen	Private	14,400
Seoul Prefectural Library	Seoul, Chosen	Seoul Pre.	10,359
Seoul Library	Seoul, Chosen	Private	56,436
Formosa Government-General Lib.	Taihoku, Formosa	Government	90,490
Kilung Library	Kilung, Formosa	Private	19,336
Dairen Library	Dairen, Manchuria	Private	77,246
Mukden Library	Mukden, Manchuria	Private	21,328
Port Arthur, Library	Port Arthur, Manchuria	Private	12,317

(N) Learned Societies and other Associations.

1. ***Japanese Association for the Advancement of Science.***
Office: Zoological Institute, Tokyo Imp. Univ.; *Est'd* in 1925; First annual meeting held in Tokyo in 1925, second annual meeting to be held in Kyoto in Oct. 1926; *President*: Torasaburo ARAKI, M. D., Dir. Kyoto Imp. Univ.; *Members*: 1500; *Publications*: Report of the annual meetings, (in Japanese), vol. 1 in 1926.

2. ***The Mathematical Association of Japan for Secondary Education.***
Office: Tokyo Higher Normal School for Women; *Est'd* in 1919; *President*: Tsuruichi HAYASHI, D. Sc.; *Members*: 1619; *Publications*: Journal of Math. Ass. Jap., (in Japanese), bimonthly, Vol. 7 in 1925.

3. ***The Physico-Mathematical Society of Japan.***
Office: Physical Institute, Tokyo Imp. Univ.; *Est'd* in 1879, as the Mathematical Society of Tokyo; changed to the Physico-Mathematical Society of Tokyo in 1884; and to the Physico-Mathematical Society of Japan in 1919; *Chairman*: Kwan'ichi TERASAWA, D. Sc.; *Members*: 713; *Publications*: Proceedings of the Physico-Mathematical Society of Japan; older series up to 1884, 67 vols.; since 1884, Series I, 9 vols., Series II, 9 vols., Series III, 8 vols. up to the present; 11 numbers annually.

4. ***The Astronomical Society of Japan.***
Office: Tokyo Astronomical Observatory, Mitaka Mura, Tokyo Fu; *Est'd* in 1908; Chairman: Kiyofusa SOTOME, D. Sc.; *Members*: 800; *Publications*; The Astronomical Herald, (in Japanese), monthly, Vol. 17 in 1926.

5. ***The Society of Astronomical Friends.***
Office: Institute of Cosmical Physics, Kyoto Imp. Univ.; *Est'd* in 1920; *Chief secretary*: Issei YAMAMOTO, D. Sc.; *Members*: 1500; *Publications*: The Heavens, (in Japanese), monthly, Vol. 6 in 1926; Bulletin, (in English), occasional, No. 88 in 1926.

6. ***Meteorological Society of Japan.***
Office: Central Meteorological Observatory, Tokyo; *Est'd* in 1882; *President*: Kiyoo NAKAMURA, D. Sc.; *Members*: 336;
Publications: Journal of the Meteorological Society of Japan, monthly, Series I up to 1922; Series II from 1923 onward, Vol. 4 in 1926.

7. ***Jishu Kwai.***
Office : Imp. Marine Observatory, Kobe ; *Est'd* in 1921 ; *President* : Takematsu OKADA, D. Sc. ; *Members* : 38 ; *Publications* ; The Sky and Waters, (in Japanese), monthly, Vol. 6 in 1926.

8. ***The Geographical Society of Tokyo.***
Office : Kobikicho 9-chome, Kyobashi Ku, Tokyo ; *Est'd* in 1879 ; *President* : Marquis Moritatsu HOSOKAWA ; Vice-President : Kiyoo NAKAMURA, D. Sc. ; *Members* : 272 ; *Publications* : Chigaku Zasshi (Geographical Magazine, in Japanese), monthly, Vol. 38 in 1926.

9. ***The Georogical Society of Tokyo.***
Office : Geological Institute, Tokyo Imp. Univ. ; *Est'd* in 1893 ; *Honorary President* : Bunjiro KOTO, D. Sc. ; *President* : Nobuyasu KANEHARA ; *Members* : 553 ; *Publications* : The Journal of the Geological Society of Tokyo, (in Japanese), monthly, Vol. 33 in 1926.

10. ***The Association of Japanese Geographers.***
Office : Geographical Institute, Tokyo Imp. Univ. ; *Est'd* in 1923 ; *President* : Naomasa YAMASAKI, D. Sc. ; *Members* : 64 ; *Publications* : The Geographical Review of Japan, (in Japanese), monthly, Vol. 3 in 1926.

11. ***Chikyu Gakudan*** (Association of Geographers and Geologists).
Office : Geological Institute, Kyoto Imp. Univ. ; *Est'd* in 1924 ; *Chairman* : Takuji OGAWA, D. Sc. ; *Members* : 800 ; *Publications* : Chikyu (The Earth, in Japanese), monthly, Vol. 4 in 1926.

12. ***The Chemical Society of Japan.***
Office : Chemical Institute, Tokyo Imp. Univ. ; *Est'd* in 1878 as the Tokyo Chemical Society, and changed in 1921 to the Chemical Society of Japan ; *President* : Yuji SHIBATA, D. Sc. ; *Members* : 1289 ; *Publications* : The Journal of the Chemical Society of Japan, (in Japanese), monthly, Vol. 46 in 1926.

13. ***The Society of Chemical Industry.***
Office : Institute of Applied Chemistry, Tokyo Imp. Univ. ; *Est'd* in 1898 ; *President* : Izo FUJINO ; *Members* : 3848 ; *Publications* : The Journal of the Society of Chemical Industry, (in Japanese), monthly, Vol. 29 in 1926.

14. ***The Association for Chemical Industry.***
Office : No. 5 Higashi-dori, Marunouchi, Tokyo ; *Est'd* in 1917 ;

President: Toyokichi TAKAMATSU, D. Eng.; *Members*: 862; *Publications*: The Chemical Industry, (in Japanese), monthly, Vol. 6 in 1926.

15. *Japanese Ceramic Association.*
Office: Tohoku Building, Uchi-saiwai Cho, Kojimachi Ku, Tokyo; *Est'd* in 1893; *President*: Viscount Kentaro KANEKO; *Members*: 1300; *Publications*: Journal of Japanese Ceramic Association, (in Japanese), monthly, Vol. 34 in 1926.

16. *The Fuel Society of Japan.*
Office: The Imp. Fuel Research Institute, Kawaguchi, Saitama; *Est'd* in 1922; *President*: Manji YOSHIMURA; *Members*: 1774; *Publications*: The Journal of the Fuel Society of Japan, (in Japanese), monthly, No. 33 in 1925.

17. *Mining Institute of Japan.*
Office: No. 15 Kaga Cho, Kyobashi Ku, Tokyo; *Est'd* in 1885; *President*: Ataru MATOBA, D. Eng.; *Members*: 1186; *Publications*: The Journal of the Mining Institute of Japan, (in Japanese), monthly, Vol. 42 in 1926.

18. *Hokkaido Coal Mining Association.*
Office: Kita-sanjo, Nishi 2-chome, Sapporo; *Est'd* in 1914; *President*: Tetsuichiro TAKASU; *Members*: 51; *Publications*: The Journal of the Hokkaido Mining Association, (in Japanese), monthly, No. 130 in 1925.

19. *The Mining Society of Chosen.*
Office: Minami-yonekura Cho, Keijo; *Est'd* in 1917; *Honorary President*: Hideo IKEDA; *President*: Kichiro KUROKI; *Members*: 243; *Publications*: The Journal of the Mining Society of Chosen, (in Japanese), quarterly, Vol. 8 in 1925; The Bulletin of the Mining Society of Chosen, (in Japanese), monthly, No. 31 in 1925.

20. *The Mining Society of Taiwan.*
Office: Akashi Cho, Taihoku; *Est'd* in 1912; *President*: Yoshihisa KOMATSU; *Members*: 205; *Publications*: The Journal of the Mining Society of Taiwan, (in Japanese), monthly, No. 122 in 1925.

21. *Suiyo Kwai* (The Kyoto Association for Mining and Metallurgy).
Office: Institute of Mining and Metallurgy, Kyoto Imp. Univ.; *Est'd* in 1900; *President*: Daikichi SAITO, D. Eng.; *Members*:

361; *Publications*: The Journal of Mining and Metallurgy, Kyoto, (in Japanese), issued three times a year.

22. *Japanese Association for Textile Industry.*
Office: Shinhori Cho, Shiba Ku, Tokyo; *Est'd* in 1885; *President*: Yeinoshin YOSHITAKE, D. Eng.; *Members*: 1500; *Publications*: The Journal of Fabric Industry, (in Japanese), monthly.

23. *The Cellulose Institute.*
Office: Kami Fujimae Cho, Hongo Ku, Tokyo; *Est'd* in 1924; *Members*: 450; *Publications*: The Cellulose Industry, (in Japanese), monthly, Vol. 1 in 1925.

24. *Japanese Society of Brewing.*
Office: Government Institute of Brewing, Takinogawa, Tokyo Fu; *Est'd* in 1906; *President*: Hideo KURODA; *Members*: 14266; *Publications*: The Journal of the Japanese Society of Brewing, (in Japanese), monthly, Vol. 21 in 1925.

25. *Zymurgy Society of Osaka.*
Office: Osaka Higher Technical School; *Est'd* in 1910; *President*: Yasukichi NISHIWAKI; *Members*: 4500; *Publications*: Former series, The Journal of the Society of Brewing, (in Japanese), fortnightly; present series, The Journal of Zymurgy, (in Japanese), issued twice a month, Vol. 3 in 1926.

26. *Engineering Society.*
Office: Yaesu Cho, Kojimachi Ku, Tokyo; *Est'd* in 1879, and reorganised in 1922 to the present form of a union of learned societies; *President*: Baron Kōi KURUICHI, D. Sc.; *Members*: 12 learned societies; *Publications*: The Journal of the Engineering Society, (in Japanese), older series 9 numbers; new series, No. 434 in 1921, and thence discontinued; The History of the Industry in the Meiji Era, (in Japanese), partly published.

27. *Civil Engineering Society.*
Office: Yuraku Cho, Kojimachi Ku, Tokyo; *Est'd* in 1914; *President*: Benjiro KUSAKABE, D. Eng.; *Members*: 2510; *Publications*: The Journal of the Civil Engineering Society, (in Japanese), bimonthly, Vol. 11 in 1925.

28. *The Society of Mechanical Engineers.*
Office: Yuraku Cho 1-chome, Kojimachi Ku, Tokyo; *Est'd* in 1897; *President*: Baron Chuzaburo SHIBA, D. Eng.; *Members*: 4175;

Publications: The Journal of the Society of Mechanical Engineering, (in Japanese), monthly, No. 98 in 1925.

29. ***Society of Naval Architects of Japan.***
Office: Yuraku Cho, Kojimachi Ku, Tokyo; *Est'd* in 1897; *President*: Kaizo YAMOTO, D. Eng.; *Members*: 1742;
Publications: The Journal of the Soc. of Nav. Arch. of Japan, (in Japanese), twice a year; older series 6 numbers; present series, No. 36 in 1925; The Miscellany of the Soc. of Nav. Arch. of Japan, (in Japanese), bimonthly, No. 42 in 1925; A Study of Ancient Ships of Japan, (in English), in 4 volumes; and others.

30. ***The Society of Ordnance and Explosives.***
Office: Institute of Technology of Ordnance, Tokyo Imp. Univ.; *Est'd* in 1905; *President*: Uhachiro TANEKODA; *Members*: 418; *Publications*: Journal of the Society of Ordnance and Explosives, (in Japanese), bimonthly, Vol. 18 in 1925.

31. ***The Institute of Japanese Architects.***
Office: Marunouchi Building, Tokyo; *Est'd* in 1886; *President*: Tamisuke YOKOYAMA, D. Eng.; *Members*: 4712; *Publications*: Journal of Architecture, (in Japanese), monthly, Vol. 39 in 1925.

32. ***Illuminating Engineering Society of Japan.***
Office: Denki Club, Yuraku Cho, Kojimachi Ku, Tokyo; *Est'd* in 1916; *President*: Takashi NOMURA; *Members*: 1226; *Publications*: Journal of the Illum. Eng. Soc. of Japan, (in Japanese), quarterly, Vol. 9 in 1925.

33. ***The Institute of Electrical Engineers of Japan.***
Office: No. 21 Mitsubishi, Marunouchi, Tokyo; *Est'd* in 1888; *President*: Sannosuke INADA; *Members*: 5521;
Publications: The Jourual of the Inst. of Elec. Eng. of Japan, (in Japanese), monthly; The Selected Papers from the Journal of the Inst. of Elec. Eng. of Japan, several numbers annually.

34. ***The Institute of Telegraph and Telephone Engineers of Japan.***
Office: Bureau of Technical Affairs, Communications Dep.; *Est'd* in 1917; *President*: Yosashichi YONEZAWA; *Members*: 1784; *Publications*: Journal of I.T.T.E.J., (in Japanese), bimonthly, No. 48 in 1925.

35. ***The Iron and Steel Institute of Japan.***
Office: No. 7 Higashi-dori, Yuraku Cho, Kojimachi Ku, Tokyo; *Est'd* in 1915; *President*: Takeshi KAWAMURA, D. Eng.;

Members: 1308; *Publications*: The Iron and Steel, (in Japanese), monthly, No. 125 in 1925.

36. Society of Heating and Refrigerating Engineers.
Office: Imp. Railway Association, Yuraku Cho, Kojimachi Ku, Tokyo; *President*: Seiichiro CHUJO; *Members*: 503;
Publications: The Journal of S.H.R.E., (in Japanese), bimonthly, No. 24 in 1925.

37. The Tokyo Botanical Society.
Office: Botanical Garden, Koishikawa, Tokyo; *Est'd* in 1882; *President*: Manabu MIYOSHI, D. Sc.; *Members*: 400; *Publications*: The Botanical Magazine, (in Japanese), monthly, Vol. 39 in 1925.

38. The Zoological Society of Japan.
Office: Zoological Institute, Tokyo Imp. Univ.; *Est'd* in 1877; *President*: Asajiro OKA, D. Sc.; *Members*: 538;
Publications: The Zoological Magazine, (in Japanese), monthly, Vol. 37 in 1925; Annotationes Zoologicae Japonenses, (in European languages), occasional, Vol. 10 in 1925.

39. Sapporo Natural History Society.
Office: Botanical Institute, Hokkaido Imp. Univ.; *Est'd* in 1891; *President*: Kingo MIYABE, D. Sc.; *Members*: 196; *Publications*: Transactions of the Sapporo Natural History Society, (in European languages), occasional, Vol. 9 in 1925.

40. Tokyo Entomological Society.
Office: Forestry Experiment Station, Meguro, Tokyo; *Est'd* in 1917; *President*: Chujiro SASAKI, D. Sc.; *Members*: 126; *Publications*: Kontyu (The Insect, in Japanese), Vol. 1 in 1925.

41. The Ornithological Society of Japan.
Office: Zoological Institute, Tokyo Imp. Univ.; *Est'd* in 1912; *President*: Prince Nobusuke TAKATSUKASA; *Members*: 214; *Publications*: Aves, (in Japanese), twice a year, No. 20 in 1926.

42. Japanese Genetic Society.
Office: Imp. Agr. Exp. Station, Nishigahara, Tokyo; *Est'd* in 1920; *Chief secretary*: Seiitiro IKENO, D. Sc.; *Members*: 428; *Publications*: Japanese Journal of Genetics, (in Japanese), quarterly, Vol. 3 in 1925.

43. The Phytopathological Society of Japan.
Office: No. 12 Haramachi, Koishikawa Ku, Tokyo; *Est'd* in 1917; *President*: Shunsuke KUSANO, D. Sc.; *Members*: 300;

Publications: Annals of the Phytopathological Society of Japan, (partly in English), No. 6 in 1925.

44. *The Scientific Agricultural Society.*
Office: Faculty of Agriculture, Tokyo Imp. Univ.; *Est'd* in 1887; *President*: Keijiro Asō, D. Agr.; *Members*: 1583; *Publications*: Journal of the Scientific Agricultural Society, (in Japanese), monthly, No. 272 in 1925.

45. *The Agricultural Chemical Society of Japan.*
Office: Institute of Agricultural Chemistry, Tokyo Imp. Univ.; *Est'd* in 1924; *President*: Umetaro Suzuki, D. Agr.; *Members*: 1280; *Publications*: Journal of the Agricultural Chemical Society of Japan, (in Japanese), abstract in European languages), monthly, No. 8 in 1925.

46. *The Society of Forestry.*
Office: Foretry Experiment Station, Meguro, Tokyo; *Est'd* in 1914; *President*: Homi Shirasawa, D. For.; *Members*: 2765; *Publications*: The Journal of the Society of Forestry, (in Japanese), bimonthly, No. 29 in 1925.

47. *Society of Agriculture and Forestry, Sapporo.*
Office: Faculty of Agriculture, Hokkaido Imp. Univ.; *Est'd* in 1908; *President*: Takajiro Minami, D. Agr.; *Members*: 521; *Publications*: Journal of the Society of Agriculture and Forestry, (in Japanese), issued more than 4 times a year, No. 80 in 1925.

48. *The Horticultural Association of Japan.*
Office: 717 Nakashibuya, Tokyo; *Est'd* in 1923; *President*: Hiroshi Hara, D. Agr.; *Members*: 150; *Publications*: The Journal of the Horticultural Ass. of Japan, (in Japanese), No. 2 in 1925.

49. *The Scientific Fishery Association.*
Office: Faculty of Agriculture, Tokyo Imp. Univ.; *Est'd* in 1915; *Members*: 114; *Publications*: Proceeding Sci. Fish. Association, semiannual, Vol. 4 in 1925.

50. *Zootechnical Science Society of Japan.*
Office: Inst. Veterinary Science, Tokyo Imp. Univ.; *Est'd* in 1924; *President*: Ryoji Iwazumi, D. Agr.; *Members*: 350; *Publications*: Japanese Journal of Zootechnical Science, quarterly, No. 5 in 1925.

51. Japanese Society of Veterinary Science.
Office: Inst. Vet. Sci., Tokyo Imp. Univ.; *Est'd* in 1921; *President*: Naoshi NITTA, D. Vet.; *Members*: 317; *Publications*: Journal of the Japanese Soc. Vet. Sci., quarterly Vol. 4 in 1925.

52. The Anthropological Societg of Tokyo.
Office: Anthropological Inst., Tokyo Imp. Univ.; *Est'd* in 1884; *Chief Secretary*; Akira MATSUMURA, D. Sc.; *Members*: 450; *Publications*: The Anthropological Journal, (in Japanese), monthly, Vol. 40 in 1925.

53. The Physiological Society of Japan.
Office: Physiological Inst., Tokyo Imp. Univ.; *Est'd* in 1922; *Secretary in charge*: Kunihiko HASHIDA, M. D.; *Members*; 100.

54. The National Society of Physiology.
Office: Physiological Inst., Kyoto Imp. Univ.; *Est'd* in 1924; *President*: Hidezurumaru ISHIKAWA, M. D.; *Members*: 2623; *Publications*: The Physiological Studies, (in Japanese), monthly Vol. 3 in 1926.

55. The Japanese Association of Hygiene.
Office: Inst. of Hygiene and Bacteriology, Tokyo Imp. Univ.; *Est'd* in 1903; *President*: Chiyonosuke YOKOTE, M. D.; *Members*: 1100; *Publications*: Journal of Hygiene and Infectious Diseases, bimonthly, Vol. 20 in 1925.

56. Japanese Society of Preventive Medicine.
Office: Inst. of Hygiene, Kyoto Imp. Univ.; *Est'd* in 1923; *President*: Shozo TODA, M. D.; *Publications*: National Hygiene, (in Japanese), monthly, Vol. 3 in 1926.

57. Japanese Society of Anatomy.
Office: Inst. of Anatomy, Tokyo Imp. Univ.; *Est'd* in 1893; *President*: Yoshikiyo KOGANEI, M. D.; *Members*: 111.

58. Japanese Pathological Society.
Office: Pathological Inst., Tokyo Imp. Univ.; *Est'd* in 1911; *President*: Mataro NAGAYO, M. D.; *Members*: 754; *Publications*: Journal of the Japanese Pathological Society, (in Japanese); Transactions J. P. S., (in European); both issued annual, Vol. 14 in 1925.

59. *Japanese Microbiological Society.*
Office: Microbiological Inst., Kyoto Imp. Univ.; *Est'd* in 1904; *President*: Kenji KIYONO, M. D.; *Members*: 2000; *Publications*: Journal of the Japanese Microbiological Society, (in Japanese), monthly, Vol. 20 in 1926.

60. *Japanese Society of Internal Medicine.*
Office: 11 Tsukiji 3-chome, Kyobashi Ku, Tokyo; *Est'd* in 1903; *President*: Tetsuzo YAMADA, M. D.; *Members*: 2360; *Publications*: The Journal, (in Japanese), monthly, older series 9 volumes; present series, Vol. 13 in 1925.

61. *Japanese Pediatric Association.*
Office: 60 Omote Cho, Koishikawa Ku, Tokyo; *Est'd* in 1896; *President*: Tsukasa HIROTA, M. D.; *Members*: 3007; *Publications*: Pediatric Journal, (in Japanese), monthly, No. 301 in 1925.

62. *Oriental Medical Association, Kyoto.*
Office: Pediatric Inst., Kyoto Imp. Univ.; *Est'd* in 1926; *President*: Tadashi SUZUKI, M. D.; *Members*: 700; *Publications*: Oriental Journal of Diseases of Infants, (in Japanese), quarterly.

63. *Japanese Society for the Study of Diseases of Digestive Organs.*
Office: Hospital of Digestive Organs, Uchi-saiwai Cho, Kojimachi Ku, Tokyo; *Est'd* in 1902; *President*: Kinzo HIRAYAMA, M. D.; *Members*: 3200; *Publications*: The Journal, (in Japanese), bi-monthly, Vol. 23 in 1925.

64. *The Association of the Research on the Gastro-enterology.*
Office: University Hospital Kyoto Imp. Univ.; *Est'd* in 1926; *President*: Iwao MATSUO, M. D.; *Members*: 1270; *Publications*: The Journal of Gastro-enterology, (in Japanese), monthly.

65. *The Japanese Association for Tuberculosis.*
Office: Tokyo Municipal Sanatorium, Nokata Machi, Tokyo Fu; *Est'd* in 1923; *President*: Tatsukichi IRISAWA, M. D.; *Members*: 1400; *Publications*: Kekkaku (Tuberculosis, in Japanese), monthly, Vol. 3 in 1925.

66. *The Japanese Society of Cancer Research.*
Office: Pathological Institute, Tokyo Imp. Univ.; *Est'd* in 1908; *President*: Tadao HONDA, M. D.; *Members*: 298; *Publications*: The Japanese Journal of Cancer Research, (in Eulopean languages),

annualy; The Japanese Journal of Cancer Research, (in Japanese), quarterly, Vol. 18 in 1925.

67. ***The Japanese Neurological Society.***
Office: Neurological Institute, Tokyo Imp. Univ.; *Est'd* in 1901; *Superintendent*: Shuzo KURE, M. D. and Kinnosuke MIURA, M. D.; *Members*: 1200; *Publications*: Neurological Journal, (in Japanese), monthly, Vol. 25 in 1925.

68. ***The Japanese Society of Surgery.***
Office: Institute of Surgery, Kyoto Imp. Univ.; *Est'd* in 1899; *President*: Ryuzo TORIKATA, M. D.; *Members*: 2000; *Publications*: Journal of the Japanese Society of Surgery, (in Japanese), Vol. 26 in 1925.

69. ***The Japanese Ophthalmological Society.***
Office: Ophthalmological Institute, Kyushu Imp. Univ.; *Est'd* in 1897; *President*: Yoshiakira ONISHI, M. D.; *Members*: 800; *Publications*: Journal of the Japanese Ophthalmological Society, (in Japanese), monthly, Vol. 28 in 1925.

70. ***Japanese Society of Laryngology, Otology and Rhinology.***
Office: Institute of Laryngology, Otology and Rhinology, Tokyo Imp. Univ.; *Est'd* in 1893; *President*: Waichiro OKADA, M. D.; *Members*: 1160; *Publications*: Journal of Japanese Society of Laryngology, Otology and Rhinology, (in Japanese), monthly, Vol. 31 in 1925.

71. ***The Society of Oto- Rhino- and Laryngological Clinic.***
Office: Institute of Oto- Rhino- and Laryngology, Kyoto Imp. Univ.; *Est'd* in 1925; *President*: Sadaji HOSHINO, M. D.; *Members*: 500; *Publications*: The Oto- Rhino- and Laryngological Clinic, (mostly in Eulopean languages), bimonthly, continuing the older series of San'yo Kwai Zasshi, Vol. 20 in 1925.

72. ***Japanese Gynecological and Obstetrical Association.***
Office: Gynecological and Obstetrical Institute, Tokyo Imp. Univ.; *Est'd* in 1902; *President*: Seichu KINOSHITA, M. D.; *Members*: 1500; *Publications*: Journal of Japanese Gynecological and Obstetrical Association, (in Japanese), monthly, Vol. 20 in 1925.

73. ***Kinki Gynecological Society.***
Office: Gynecological Institute, Kyoto Imp. Univ.; *Est'd* in 1915; *Secretaries*: Hidekazu OKABAYASHI, M. D., Juemon OGATA,

M. D.; *Members*: 1250; *Publications*: Kinki Fujinkwa Gakkwai Zasshi, (in Japanese), quarterly, Vol. 9 in 1926.

74. The Japanese Dermatological Association.
Office: 45 Shimo Niban Cho, Kojimachi Ku, Tokyo; *Est'd* in 1901; *President*: Keizo Doi, M. D.; *Members*: 2500; *Publications*: Japanese Journal of Dermatology and Urology, (in Japanese, abstracts in Eulopean languages), monthly, Vol. 25 in 1925.

75. Kyoto Dermatological Society.
Office; Dermatological Institute, Kyoto Imp. Univ.; *Est'd* in 1923; *President*: Shinichi Matsumoto, M. D.; *Members*: 1500; *Publications*: Acta Dermatologica, (partly in European languages), monthly, Vol. 8 in 1926.

76. The Japanese Urological Association.
Office: Dermatological and Urological Institute, Kei-o Gijuku Univ., Tokyo; *Est'd* in 1912; *President*: Kazuichi Hirokawa, M. D.; *Members*: 805; *Publications*: The Journal of the Japanese Urological Association, (in Japanese), 8 per year, Vol. 14 in 1925.

77. The Röntgen Society of Japan.
Office: Institute of Orthopaedic Surgery, Tokyo Imp, Univ.; *Est'd* in 1923; *President*: Yoshinori Tashiro, M. D.; *Members*: 410; *Publications*: Journal of the Röntgen Society of Japan, (in Japanese), twice a year, Vol. 3 in 1925.

78. The Japanese Society of Dental Surgery.
Office: 9 Nishiki Cho 3-chome, Kanda Ku, Tokyo; *President*: Naotaro Takahashi.

79. The Society of Social Medicine.
Office: Forensic Medical Institute, Tokyo Imp. Univ.; *Est'd* in 1887; *President*: Sadamori Mita, M. D.; *Members*: 980; *Publications*: Journal of Social Medicine, (in Japanese), monthly, No. 462 in 1925.

80. The Pharmaceutical Society of Japan.
Office: Shimo Miyabi Cho, Ushigome Ku, Tokyo: *Est'd* in 1881; *President*: Nagayoshi Nagai, D. Sc., D. Phar.; *Members*: 4006; *Publications*: Pharmaceutical Journal, (in Japanese), monthly, No. 520 in 1825.

81. Tokyo Medical Society.
Office: Physiological Institute, Tokyo Imp. Univ.; *Est'd* in 1886; *President*: Tatsukichi IRIZAWA, M. D.; *Members*: 1200; *Publications*: The Journal, (in Japanese), monthly, Vol. 39 in 1925.

82. Kyoto Medical Society.
Office: Faculty of Medicine, Kyoto Imp. Univ.; *Est'd* in 1904; *President*: Akira FUJINAMI, M. D.; *Members*: 1100; *Publications*: The Journal, (in Japanese, abstracts in Eulopean languages), monthly, Vol. 23 in 1926.

83. Tohoku Medical Society.
Office: Faculty of Medicine, Tohoku Imp. Univ.; *Est'd* in 1916; *President*: Gennosuke FUSE, M. D.; *Members*: 1020; *Publications*: The Journal, (in Japanese), 5 per year, Vol. 9 in 1926.

84. Kyushu Medical Society.
Office: L.O.R. Institute, Kyushu Imp. Univ.; *Est'd* in 1907; *President*: Inokichi KUBO, M. D.; *Members*: 1400; *Publications*: The Journal, (mostly in Japanese), monthly, Vol. 19 in 1926.

85. Hokkaido Medical Society.
Office: Faculty of Medicine, Hokkaido Imp. Univ.; *Est'd* in 1922; *President*: Benzo HATA, M. D.; *Members*: 500; *Publications*: The Journal, (mostly in Japanese), bimonthly, Vol. 4 in 1926.

86. Chosen Medical Society.
Office: Gov.-Gen. Hospital, Renkendo, Keijo; *Est'd* in 1911; *President*: Kiyoshi SHIGA, M. D.; *Members*: 1000; *Publications*: The Journal, (in Japanese), monthly, No. 66 in 1926.

87. The Medical Association of Formosa.
Office: Higher Medical School, Taihoku; *Est'd* in 1902; *President*: Tsugio HORIUCHI M. D.; *Members*: 1000; *Publications*: The Journal, (in Japanese, abstracts in European languages), monthly.

88. Manchuria Medical Association.
Office: Manchuria Med. Coll., Hoten; *Est'd* in 1912; *President*: Ginzaburo TODANI, M. D.; *Members*: 625; *Publications*: Oriental Medicine, monthly, Vol. 5 in 1926.

89. Kei-o Medical Society.
Office: Kei-o Univ. Hospital, Nishi Shinano Machi, Yotsuya Ku, Tokyo; *Est'd* in 1920; *President*: Baron Shibasaburo KITASATO,

M. D.; *Vice-President*: Taichi KITASHIMA, M. D.; *Members*: 500; *Publications*: The Journal, (in Japanese), monthly, Vol. 5 in 1926.

90. ***The Medical Association of the Japanese Government Railway.***
Office: Tokyo Railway Hospital, 903 Sendagaya, Tokyo; *Est'd* in 1914; *President*: Sankichi SATO, M. D.; *Members*: 1921; *Publications*: The Journal, (in Japanese), monthly, Vol. 12 in 1926.

91. ***The Military Surgeon Corps.***
Office: Bureau of Medical Affair, War Dep. Tokyo; *Est'd* in 1909; *President*: Korin YAMADA, M. D., Surgeon-General; *Members*: 5500; *Publications*: The Journal, (in Japanese), monthly, No. 145 in 1925.

92. ***The Naval Medical Association.***
Office: Bureau of Medical Affair, Navy Dep. Tokyo; *Est'd* in 1887; *President*: Isamu HIRANO, Surgeon Vice-admiral; *Members*: 790; *Publications*: The Journal, (in Japanese), quarterly, No. 47 in 1925.

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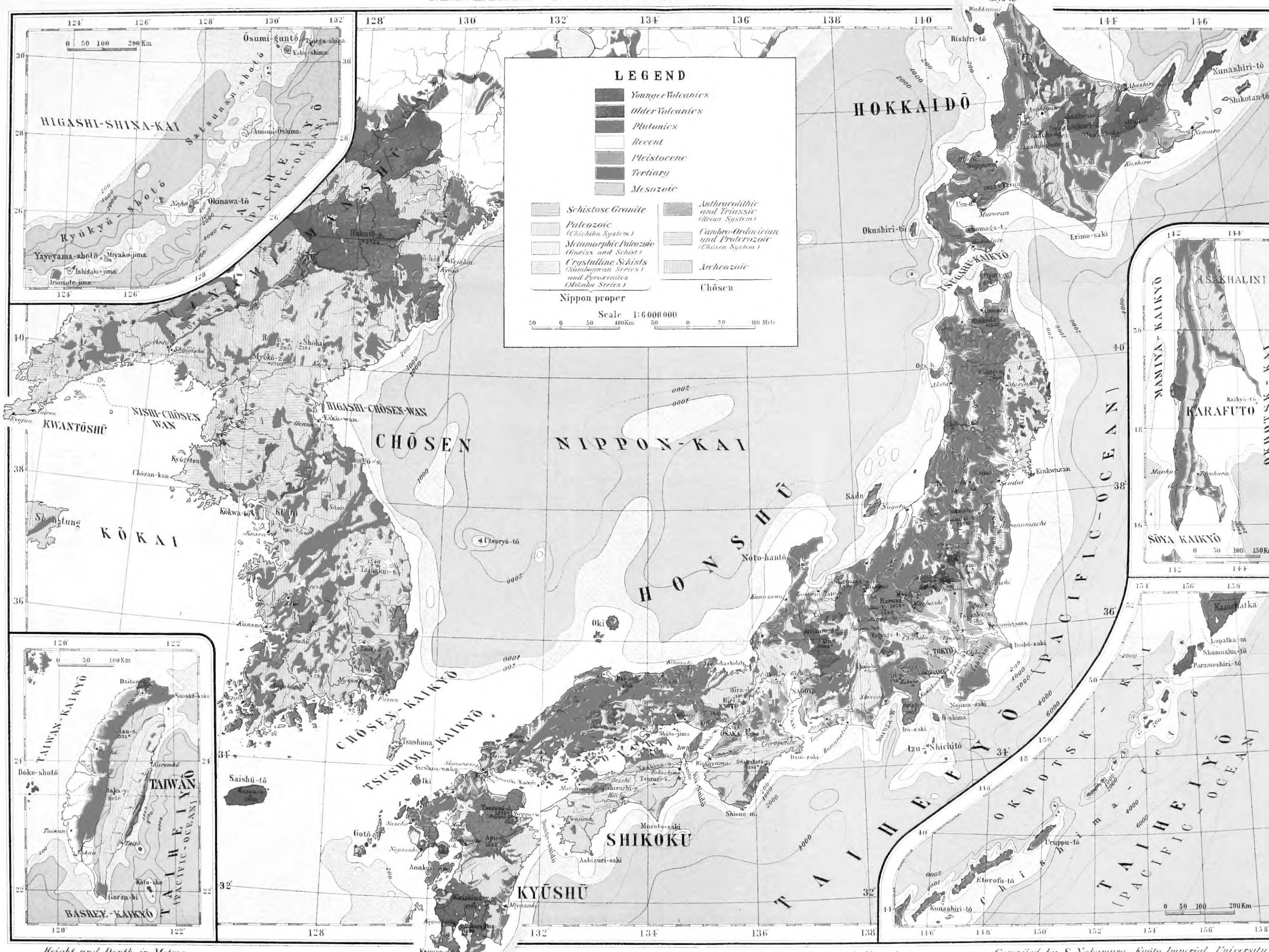
GENERAL GEOLOGICAL MAP OF NIPPON



Height and Depth in Metres.

d. (dake), h. (hō), s. (san or sen), t. (take), y. (yama), z. (zan) = Mount; S. (sammyaku) = Mountain; g. (gawa), k. (kawa) = River; m. (misaki) = Cape; w. (wan) = Bay.

Compiled by S. Nakamura, Kyōto Imperial University.

大正十二年關東震災地垂直變動要圖

(大正十四年十月末迄調査之分)

Map showing the Depression and Upheaval of the Ground produced at Kwantō Districts after the Great Earthquake of Sept. 1st. 1923.

(Results of reexamination up to Oct. 1925.)