THE EVOLUTION OF THE CRYPTOGAMS[1]

II.

THE direction and many of the gradations through which the highest classes of the vegetable kingdom have been developed from the lower are preserved in the palæontological record. In order to decipher them, however, certain facts must be kept in view: chiefly, that the higher and more complex organisations, are the most susceptible to changes in the external conditions upon which they are dependent, and therefore more readily destroyed, while the simpler the organisation the more yielding or plastic it is, and the greater the chance that it will be able to survive by adapting itself to change. Thus the superb Cryptogams of the Carboniferous succumbed no doubt to great physical changes, but the more humble of them bent to the new conditions, and even found therein an impetus leading to unexpected developments, which eventually carried them far beyond their more advanced brethren.

Tracing back the origin of vegetable life, we see that it consisted nearest its source solely of Algæ. A little later, Cryptogams appeared, and developed their maximum during the Palæozoic period. Next, almost synchronously, Gymnosperms are met with, and after a long time preponderate; and then Angiosperms, obscure and subordinate at first, begin, towards the close of the Secondary period, to take the first rank.

Most of the lowest Algæ, such as Ulva and Conferva, are scarcely of a texture to have left traces of their existence, but eight still existing Diatoms have been discovered in British Coal.

The next group, morphologically, of Algæ—the Siphoneæ—have been shown by M. Munier-Chalmas to be

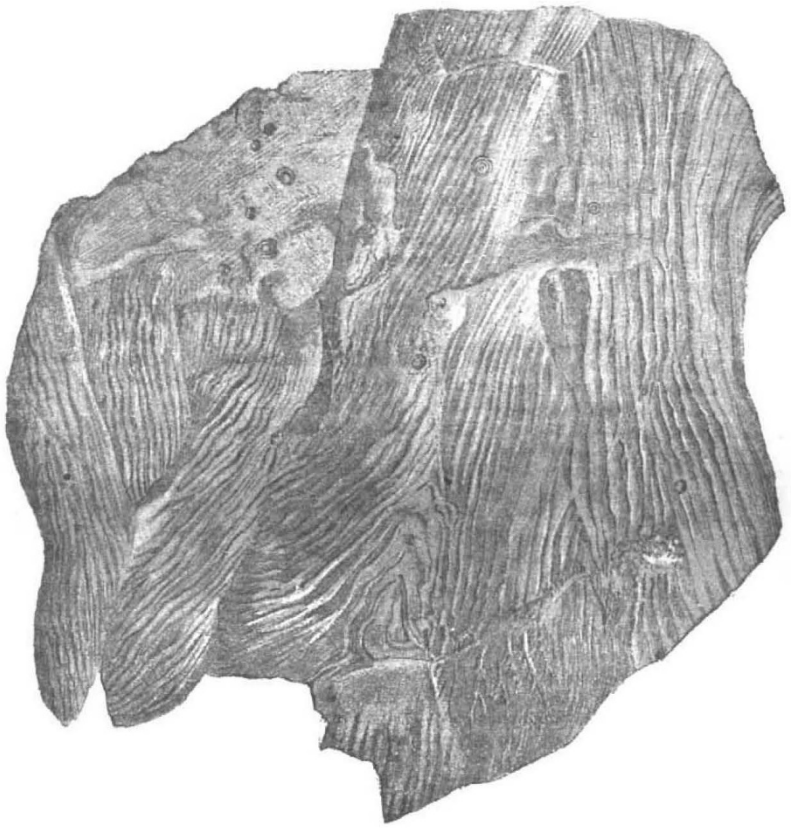

FIG. 1.—*Bilobites furcifera*, d'Orb. Part of a "Phyllome," with traces of expansions and ramifications; half natural size. Silurian of Bagnols.

abundant in the Trias and Secondary rocks, and to be analogous, or perhaps identical, with the existing Cymopolia and Acetabularia. It is unfortunate that, owing to the texture of most of the Algæ, observation has to be concentrated on the few groups that could be preserved. In the Silurian the remains of these are numerous, and of forms completely differing from existing types.

Following the primordial Palæozoic forms, there appear successively the more highly organised Groups, Characeæ in the Trias, Laminariaceæ in the infra-Lias, and finally Fucaceæ in the Eocene.

The Mosses and Liverworts, which seem to indicate the stages through which Algæ gradually became adapted to terrestrial conditions, are unknown in the older rocks; yet, far from assuming that they did not then exist, we should rather consider how exceedingly unfavourable are the conditions under which marine and estuarine strata are deposited to the chance of their becoming imbedded.

The order Calamareæ, as the authors prefer to call the Equisitaceæ, include such diverse types as Calamites, Annularia, Asterophyllites, and Equisteum, though Camalodendron and a few other forms are excluded. The group is characterised by the arrangement of their organs in whorls, whether these are true leaves or the modified leaves which support the sporangia. The sporangial whorls either occur together and form a terminal fruit, or are placed alternately with whorls of true leaves, and the sporangial bracts are either disunited or coalesce to form a sheath. Modifications of one or

[1] "L'Evolution du Règne Végétatale." Les Cryptogames. Par MM. Saporta et Marion. Bibliothèque Scientifique Internationale, xxxi. (1881.)
Continued from p. 75.

other of these characters are the foundations of all the Palæozoic genera yet known. In the extinct Carboniferous forms the fertile or sporangial whorls alternated with, and were protected by, the overlapping whorls of barren leaves, while in Equisetum the sporangial whorls are naked and clustered in a terminal spike, an arrangement considered by Saporta and Marion to be more favourable to the dispersion of the spores. Annularia and Asterophyllites were floating or procumbent plants. Calamites strongly resembled the existing aquatic Equisitaceæ, though ex-

FIG. 2.—*Bilobites Vilanovæ*, Sap. and Mar. Base of a "Phyllome." Silurian of Andalusia.

ceeding them twenty times in size, and surpassing them in development by the possession of spores of two sexes. Their more complex structure and consequent inadaptability to changed conditions, favoured, the authors believe, their early extinction in the Permian. In the Trias, and until the Jurassic, several slightly modified genera coexisted with true Equisetum, and the survival of the latter, one of the genera that have persisted almost unchanged from the Carboniferous, is probably due to their simple

FIG. 3.—Prothallus of an Osmunda aged eight months, slightly magnified to show the double row of archegones down the centre.

organisation, easy dispersion of the spores, and the immense depths to which their rhizomes penetrate.

The structure of ferns, unlike that of Equisitaceæ, lends itself to infinite diversity. The fronds may be simple or multipartite, without their form implying the slightest degree of relationship, and supposed alliances between fossil and recent ferns, such as Ettingshausen has based upon the aspect and venation of the frond, are declared by the authors to be valueless and misleading.

The earliest ferns had simple fronds, and probably resembled in their vegetative organs the Hymenophylleæ, a group already well represented in the Carboniferous. Next in order come the Osmundaceæ, if the relative

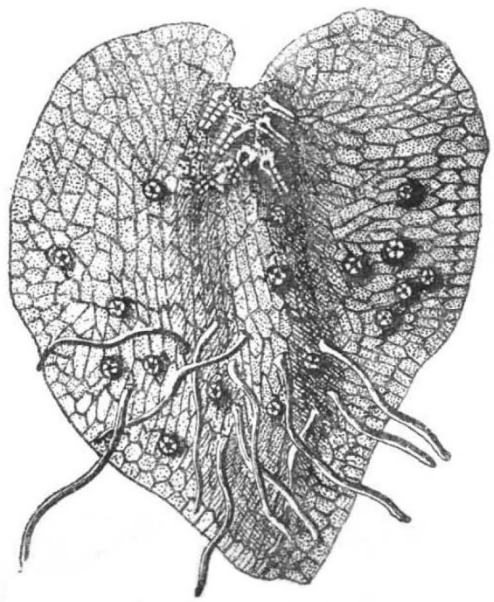

FIG. 4.—Under side of the prothallus of another fern, more magnified, showing the rhizoid radicles, the antherids dispersed over the surface, and the archegones clustered at the terminal notch.

complexity of their prothallus and simplicity of sporangia are accepted as indications of inferiority.

The relative perfection of the sporangium when taken

FIG. 5.—Sporangium of Hymenophyllum, girt transversely by the ring of cellules which disrupt the spore-case.

as the essentially important organ, leads to a classification coinciding approximately with the order in which the groups made their appearance :—Hymenophylleæ

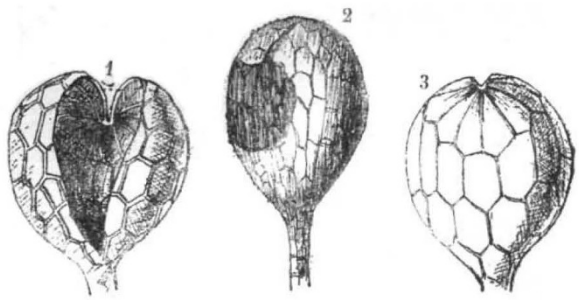

FIG. 6.—Sporangia of Osmundaceæ, showing dorsal dehiscence. 1 and 2, sporangia of *Todea Africana*—1, ventral surface; 2, dorsal surface; 3, sporangium of Osmunda seen dorsally, and showing the infra-apical group of cellules which disrupt the spore-case.

Osmundaceæ, Schizeaceæ, Gleicheniaceæ, Marattiaceæ, Cyatheæ, Polypodiaceæ.

From the simplest type of sporangium, two lines of

increasing differentiation in the organ, or its support, can be traced—one leading to the Polypodiaceæ through the Cyatheæ, the other to Schizeaceæ, Gleicheniaceæ, and Marattiaceæ.

The earliest fern of which the fructification is known is the Devonian Palæopteris, Schimper. Its fructification consists of aborted leaflets supporting groups of oblong, ringless sporangia opening into two valves and disposed in threes on pedicles. Rhacopteris, of the same age, and perhaps not generically differing, has fructification which unites in a higher degree the characteristics of Osmunda and Botrydium, and giving birth probably to the Botryopterideæ of the later Carboniferous flora. Another genus, Seftenbergia, is allied by the structure of its sporangium to Angiopteris (Marattiaceæ), though each sporangium is as yet isolated. The Palæozoic ferns did not at this period essentially differ from Osmunda and Todea.

The earliest example of definite grouping in the

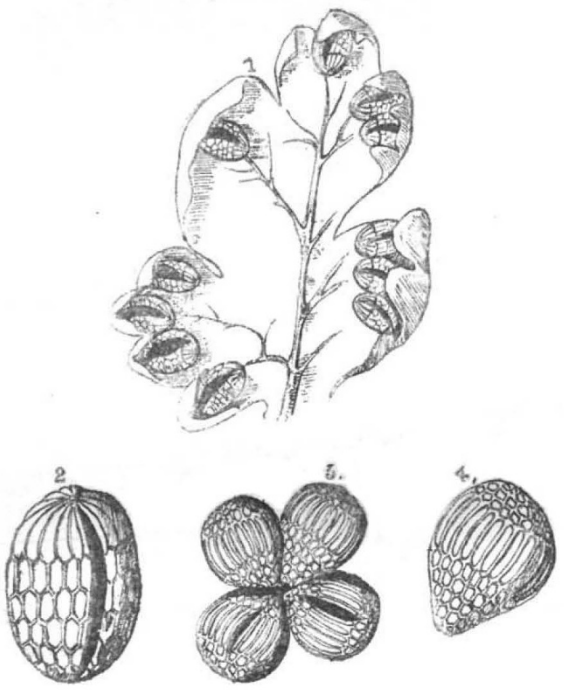

FIG. 7.—1, magnified pinnule of one of the Lygodieæ of the genus Mohria, showing the arrangement of the sporangia on the under side of the frond; 2, sporangium of the same, showing the group of apical cellules which disrupt the spore-case; 3, sorus of Gleichenia, showing the peripheral arrangement of the cellules which disrupt the spore-case; 4, sporangium before dehiscence.

sporangia is furnished by Oliogocarpia, in which three to five sporangia are inserted on a point near the ultimate terminations of the venules; but even here, though contiguous, they are distinct, and can be separated. In the later Carboniferous, Marattioid ferns for the first time occur with the sporangia united in a composite organ called a synangium, and soon after the Marattiaceæ reached their maximum development, and commenced, through forms now extinct, to differentiate towards the Gleicheniaceæ. The stages of development of the latter, and of the Schizeaceæ, are more difficult to trace, though both are represented in the Palæozoics by Howlea and Seftenbergia respectively. The actual genus Gleichenia does not appear until the inferior Oolite, and Lygodium until the Cretaceous.

The Cyatheæ are represented in the Carboniferous by Thyrsopteris and in the Jurassic by Dicksonia, while true Polypodieæ cannot be traced farther back than the Rhætic. They seem to have developed suddenly, and among them are a number with their sporangia grouped in sori as in Gleichenia, yet possessing in other respects the structure characteristic of Polypodium.

The Ophioglossaceæ are related to the most ancient ferns by the arrangement and structure of their sporangia, and to Isoëtes and Lycopods by the form of their prothallus. They even present affinities with Sigillaria, and represent, the authors conjecture, an almost unchanged type, older than the differentiation of either ferns, Lycopods, or Rhizocarps.

The Lycopodiaceæ are divided into isosporous and

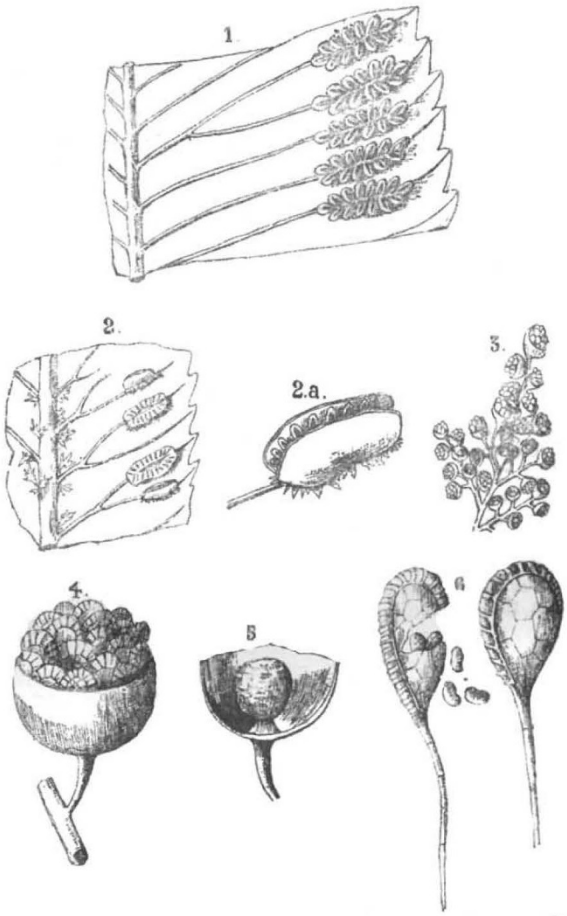

FIG 8.—1, part of pinnule of Angiopteris, with sporangia clustered in groups, but not united; 2, part of pinnule of Marattia with sporangia joined together in a synangium; 2a, a synangium magnified; 3, extremity of the fertile frond of one of the Cyatheæ, *Thyrsopteris elegans*; 4, a magnified receptacle of the same, in form of a pedunculated cup, full of sporangia which are girt with a jointed ring of cellules; 5, section through an empty cup, showing the support to which the sporangia are attached; 6, two highly-magnified sporangia of Polypodiaceæ, one dehiscent, girt vertically by a jointed ring and on pedicles.

heterosporous kinds. The former, comprising Lycopodium and a few tropical genera, have been found fossil in the Old Red of Thurso and the Carboniferous of Saarbruck and Autun, their small size and retiring habits having doubtless caused their relative rarity in stratified rocks. The heterosporous, or more perfected kinds, obtained a magnificent development in the Carboniferous, favoured by the warm and humid climate, free from seasonal changes, which then seems to have prevailed, and only declined when these conditions ceased. They are at present represented by Selaginella, a genus which has scarcely changed since the Carboniferous. The

sporangia are globose, pedunculated, and situated towards the base of the bracts which compose the fruit-

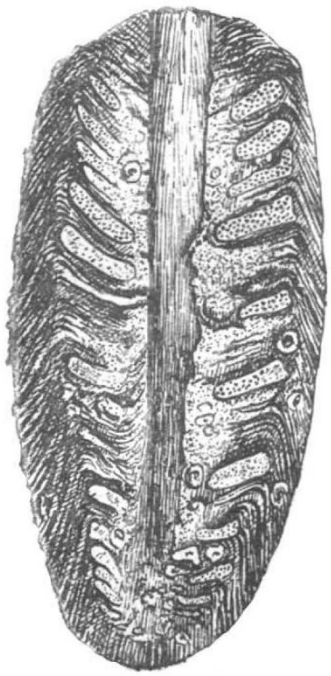

FIG. 9.—Lepidostrobus, the reproductive organ of Lepidodendron. Longitudinal section of sporangiocarp of *Lepidostrobus Dabadianus*, Schimp., showing the lower sporangia containing macrospores and the upper microspores; half natural size.

spikes, and either contain two to eight macrospores, or small and very numerous microspores. In the germination of these spores the approach towards Gymnosperms becomes exceedingly apparent, and is consequently dwelt on at some length, the researches of Sachs, Luersen, and others being largely referred to. An even higher stage was in all probability reached in the Lepidodendrons, the vigorous and splendid growth of which formed the culminating development of the Lycopodiaceæ. The mathematical regularity of their growth, even in the most minute internal structure, is very striking. They formed large trees with acicular or falcate, perhaps deciduous leaves, and bore cones in pairs at the extremities of certain branches, differing exteriorily but little from those of Gymnosperms. The expanded bases of the scales or bracts bore the sporangia, those containing the macrospores being nearest the base. The stem comprised several layers, the centre being of pith formed of elongated prismatic cells. The next layer was woody, and gave off simple vascular threads to each leaflet, these penetrating obliquely the succeeding region of parenchyma and the cortical layers. The bark increases in density towards the exterior, and in some species the interior pith is absorbed in the woody layer.

Lepidodendron, with the greater part of the Palæozoic flora, became extinct during the Permian, leaving as representative the humble Isoëtes. This, however, is not necessarily a degraded type, and may have existed since Palæozoic times, though only known fossil in the later Eocenes, where it in no way differs from existing forms.

The Rhizocarps are beyond doubt the highest existing form of Cryptogam, but though in many respects so nearly approaching to Phanerogams, they are not, as we see them now, in the absolutely direct line of evolution. In all, the sporangia are protected by an enveloping altered leaf, or segment of a leaf, forming a fruit called a sporocarp, which in most cases attains a high degree of complexity. The entire group is aquatic, and stands in the same position towards fossil Rhizocarps that Isoëtes does to the Lepidodendrons. The Carboniferous Sphenophyllum has been shown to correspond to Salvinia, and the Rhætic

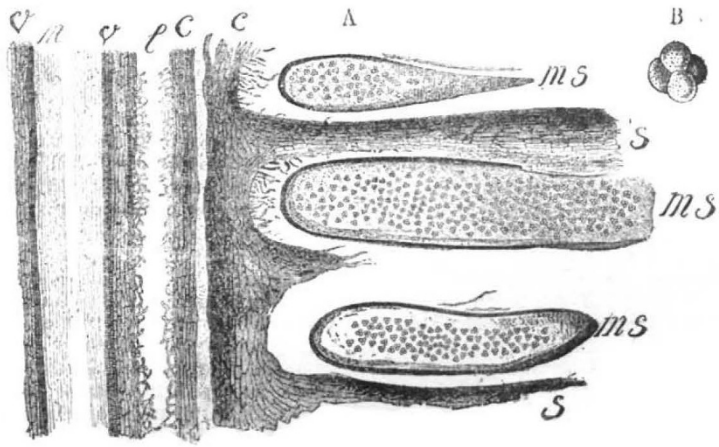

FIG. 10.—Reproductive organs of Lepidodendron with microsporangia and microspores. A, longitudinal section through upper part of sporangiocarp of Lepidostrobus (probably *L. Brownii*, Schimp.), from the neighbourhood of Pézenas (Hérault); M, the central medullary region formed of parenchyma with elongated prismatic cells; V V, the woody layer of fibro-vascular region next the pith, showing large scalariform vessels; L, lacuna, in which delicate and partly disintegrated cells are studded; C C, cortical layer composed of a very dense outer and an inner layer, separated by a loose, nearly destroyed parenchyma; S, "sporangiospores," supporting very elongated microsporangia filled, M S, with microspores aggregated in fours (these are slightly exaggerated in size); B, group of microspores magnified.

Sagenopteris to the Marsiliaceæ. Though the vegetative organs in the extinct forms attained far finer proportions and a higher and more delicate structure, the fructification, in Salvinia especially, appears the more complex. The existing genera have only been met with in the Eocene and Oligocene.

Thus while Angiosperms all present similarity in the reproductive process, Cryptogams preserve many of the stages by which the evolution of the higher forms has been accomplished. They also present every gradation in their vegetative organs, from the simplest and purely cellular plant to the equals of Phanerogams in point of structure. Except the Protophytes, all Cryptogams are impregnated by antherids, and present the antagonistic and alternate asexual and sexual generations, these being in fact their distinguishing characters. The authors' task

—to trace step by step the progressive stages by which the prothalloid phase has been diminished, and the ever, though gradually, increasing approach in the complexity and mode of reproduction to the Phanerogams—has demanded the most patient and prolonged research. The promised second volume will further diminish the hiatus still left between Phanerogams and Cryptogams, and make clear, the authors believe, the precise lines through which the evolution of the one from the other has been accomplished.

J. STARKIE GARDNER

MUSEUMS AND EXHIBITIONS IN JAPAN

THERE is probably no function of Government which the rulers of new Japan have performed so adequately and thoroughly, with such persistence and such unvarying success, as that which consists in the education of the people. It would be impossible in the space at our disposal to describe the course and results of education under the usurpation of the Shôgun; suffice it to say that, though learning of a peculiar kind always received support and encouragement, these were given on no sound or general system. The masses were neglected as beneath consideration, while literary labour of the best kind was always rewarded. No Japanese Horace need ever have lacked a generous Mecænas. But it was not until the restoration of the Mikado and the overthrow of the feudal organisation that a system of universal education which should reach the lowest classes of the people was introduced, and the Government of Japan then looked abroad to those Western lands, to which the eyes of all Japanese were then turned, for models on which to base their new scheme. American teachers of eminence were first brought to the new University established in Tokio; these were soon followed by subordinate instructors for the various schools in the local centres, and in six years after the restoration there were two large educational establishments—the University and the College of Engineering—besides numerous smaller ones in the capital, while every administrative division had its central school—all provided with competent foreign professors or teachers. A large normal college in Tokio trained instructors for the schools in the interior in Western knowledge and Western methods of teaching; and from that time to the present the wise and beneficent system of general education adopted by the Government has gone on extending itself into the remotest parts of the country. As mentioned in a previous article, the number of foreign instructors was gradually reduced, first in the interior, afterwards at the capital, as Japanese trained at home or abroad became competent to take their places. The history of this remarkable spread of education in Japan will be found in the annual reports of the Minister of Education to the Emperor, and in an excellent series of papers published by the Japanese Commissioners to the Philadelphia Exhibition. The spirit in which this work is carried out is well shown in a circular recently issued by the Minister of Education for the guidance of teachers in elementary schools. According to the *Japan Mail* this document contains sixteen clauses, embodying a number of directions for the conduct of school officials. The chief points are (1) "the importance of imparting a sound moral education to the students, both by precept and example, since the condition of a man's heart is of far greater moment than the extent of his knowledge; (2) the necessity of proper hygienic arrangements, which have more effect upon the health of the students than gymnastics or any other physical training; and (3) the value of mental energy in a teacher, for without it he cannot possibly support the fatigue and trouble of really careful tuition." The circular goes on to advise teachers not to constitute themselves advocates of any particular religious or political doctrines, and to take every opportunity of increasing their own stock of knowledge.[1]

But while thus caring for the education of the youth of the country, that of its risen generation has not been neglected. Besides annual and triennial domestic exhibitions, museums have been established in most of the large towns in the country, and it is to these we would more particularly refer in the present article. It should be remarked at the outset that the Japanese are a nation of sightseers; not the vulgar, pushing, noisy mob to which we are too much accustomed in this country, but a quiet, orderly, pleased, and pleasing crowd. They are always anxious to see something new; failing this, they are content with their own temples and ancient festivals. In a visit to any of the numerous museums of Tokio on a Sunday or other holiday, the stranger from the West cannot fail to be struck with the order, good humour, and never-failing interest manifested by the people. The descriptions of the objects are generally very full and clear, so as to bring them within the meanest comprehension; and when these are read out to a group by some one more learned than the rest, the exclamations of wonder, admiration, or delight are incessant, and form a pleasing contrast to languid or imperfect interest frequently taken by our own crowds in their museums.

The first museum in Japan—the *Hakubutsu-kuwan*—was opened, as an experiment, in 1873. A few objects of Western manufacture and some Japanese productions were placed in the Confucian Temple, situated in one of the prettiest suburbs of Tokio. Vast crowds, attracted chiefly no doubt by the foreign exhibits, visited the place daily; and the Government, acting, we believe, on the advice of the governor of the city, determined to enlarge the exhibition considerably and make it permanent. It was accordingly removed to a more central position, the partially-dismantled residence of one of the old nobles being chosen for this purpose. Here the collection was deposited and gradually increased, until at the present time it fills a range of narrow buildings nearly a quarter of a mile in length. This may be called the permanent museum of the capital. A visit to it would strike one accustomed to the museums of Europe with a certain sense of incongruity. Close to the lacquered bullock-carts and chairs of the emperors of a thousand years ago we find English machinery of yesterday: in one compartment we see art treasures of a remote antiquity; in the next, Minton and Wedgwood; a corridor containing a large and valuable collection of the old paper currency brings us, it may be, to a collection of modern glassware. This jogging together of the ancient and modern, of articles familiar in the homes in the West with the priceless art rarities of the East; of the products of the skill and loving care of old Japanese artists with, we may almost say, Brummagem, jars unpleasantly on foreign taste. But it must be remembered that this establishment is founded, not for the educated foreigner or even native, but for the Japanese shopkeeper, farmer, artisan, and labourer, whose interest is not a whit diminished when he passes from a beautful antique relic to a Bradford loom or a copy of the Milton shield. Indeed, we are not sure that

[1] As an instance of the general spread of elementary education, the present writer may take this opportunity of mentioning what he saw during an examination of some of the principal Japanese prisons in the summer and autumn of last year He found all the children and youths in gaol—in some cases numbering a few hundreds—attending the prison schools for four or six hours each day, while the adults attended in the evenings and on Sundays. He saw in the chief penal settlement in Tokio about three hundred boys learning reading, writing, and the simple rules of arithmetic. In the senior class the boys were learning ciphering *with European figures* from one of their own number. In the large prisons a teacher or teachers form portion of the staff; they are assisted by convicts who act as ushers or monitors. In the smaller ones an inmate—generally a political prisoner—is selected as master, and enjoys in return certain small advantages. The prison system of Japan, theoretical and practical, would well repay examination at the hands of a competent authority on penal discipline. The present Governor of Hongkong, Sir John Pope Hennessy, who has had much experience in the subject in his various governments, has expressed his high appreciation of the excellent condition of Japanese prisons.