NOTICES OF BOOKS.

The Effects of Cross- and Self-Fertilisation in the Vegetable Kingdom. By CHARLES DARWIN, F.R.S. London: John Murray.

THAT this work is intended as a contribution to the body of cumulative evidence already collected by Mr. Darwin in support of his views on the origin of species need not be questioned. But consisting as it does not of generalisation or controversial matter, but of the records of careful experiments and observations, it has a value quite independent of theories. Should hereafter the hypothesis of "natural selection" be superseded, should the doctrine of Evolution in any shape be abandoned, the volume before us must still remain a highly important contribution to biological science.

The author on the threshold of his enquiry points to the abundant evidence that flowers are constructed so as to be cross-fertilised, occasionally or habitually, by pollen from another flower, whether growing on the same or on a different plant. To ensure such cross-fertilisation a number of curious arrangements exist, which the author and other observers have elsewhere described, and to which he only therefore refers in passing. We will merely remind the reader that this purpose is in some cases secured by a separation of the sexes of flowers, whilst in others the pollen and the stigma of the same flower are not matured at the same time. Sometimes the impregnation of flowers by their own pollen is prevented, or at least impeded, by beautiful mechanical contrivances. In one class the ovules "absolutely refuse to be fertilised by pollen from the same plant, but can be fertilised by pollen from any other individual of the same species."

Mr. Darwin's present concern is not with the means, but with the ends of cross-fertilisation. It would be "simpler," surely, for every plant to have been fecundated by its own pollen; but finding this state of things in a number of cases so carefully guarded against, we are warranted alike on the principles of the Old and the New School of Natural History in supposing that we have before us no mere accident. The author was led to undertake the experiments hereinafter detailed by the following circumstance:—For the sake of determining certain points with respect to inheritance, and without any thought of the effects of close inter-breeding, I raised close together two large beds of self-fertilised and crossed seedlings from the same plant of *Linaria vulgaris*. To my surprise the crossed plants, when

fully grown, were plainly taller and more vigorous than the self-fertilised ones." Mr. Darwin, however, whom some persons accuse of rushing hastily to conclusions without sufficient evidence, considered it still "quite incredible that the difference between the two beds of seedlings could have been due to a single act of self-fertilisation." The next year he performed an analogous experiment. "I raised, for the same purpose as before, two large beds close together of self-fertilised and crossed seedlings from the carnation, *Dianthus caryophyllus*. This plant, like the *Linaria*, is almost sterile if insects are excluded, and we may draw the same inference as before, namely, that the parent-plants must have been inter-crossed during every—or almost every—previous generation. Nevertheless, the self-fertilised seedlings were plainly inferior in height and vigour to the crossed."

A formal series of experiments was then undertaken with various plants, and was continued for eleven years, the crossed plants in the great majority of cases being found to have the advantage. The general mode of experimentation was as follows:—"A single plant, if it produced a sufficiency of flowers, or two or three plants were placed under a net stretched on a frame, and large enough to cover the plant without touching it. This latter point is important, for if the flowers touch the net they may be cross-fertilised by bees. I used at first white-cotton net with very fine meshes, but afterwards a kind of net with meshes one-tenth of an inch in diameter. On the plants thus protected several flowers were marked, and were fertilised with their own pollen; and an equal number on the same plant, marked in a different manner, were at the same time crossed with pollen from a distinct plant. The crossed flowers were never castrated, in order to make the experiments as like as possible to what occurs in Nature with plants fertilised by the aid of insects. In some few cases of spontaneously self-fertile species the flowers were allowed to fertilise themseves under the net, and in still fewer cases uncovered plants were allowed to be freely crossed by the insects which incessantly visited them."

The seeds from the flowers thus treated were allowed to ripen thoroughly, and were then allowed to germinate, with the following precautions:—"The crossed and self-fertilised seeds were placed on damp sand, on opposite sides of a glass tumbler covered by a glass plate, with a partition between the two lots, and the glass was placed on the chimney-piece in a warm room. I could thus observe the germination of the seeds. Sometimes a few would germinate on one side before any on the other, and such were thrown away. But as often as a pair germinated at the same time they were planted on opposite sides of a pot, with a superficial partition between the two; and I then proceeded until from half-a-dozen to a score or more seedlings, of exactly the same age, were planted on the opposite sides of several pots.

If one of the young seedlings became sickly or was in any way injured it was pulled up and thrown away, as well as its antagonist on the opposite side of the same pot.

"As a large number of seeds were placed on the sand to germinate, many remained after the pairs had been selected; these were soon crowded together on the opposite sides of one or two rather large pots, or sometimes in two long rows out of doors. In these cases there was the most severe struggle for life among the crossed seedlings on one side of the pot and the self-fertilised seedlings on the other side, and between the two lots which grew in competition in the same pot. A vast number soon perished, and the tallest of the survivors on both sides when fully grown were measured. Plants treated in this manner were subjected to nearly the same conditions as those growing in a state of Nature which have to struggle to maturity in the midst of a host of competitors."

Sometimes the seeds, instead of being previously allowed to germinate on damp sand, were sown at once on opposite sides of pots, and the plants measured when fully grown. This plan Mr. Darwin pronounces less accurate, as the seeds sometimes germinated more quickly on one side than the other. He considers, however, that it was necessary thus to proceed in the case of some few species, "as certain kinds of seeds would not germinate well when exposed to the light." We should suggest that such seeds might have been covered with a plate of blue glass, since blue light—though not favourable to plants in the later stages of their life—undoubtedly promotes germination.

Every precaution was taken that the two classes of seedlings under comparison should in all other respects be precisely on an equality. The soil was evenly and thoroughly mixed, the supply of water and the exposure to light were the same. Yet, as we have already intimated, the self-fertilised plants, when carefully weighed and measured, were decidedly inferior to the crossed.

Hence Mr. Darwin is perfectly justified in the inference that cross-fertilisation is generally beneficial and self-fertilisation injurious. "That certain plants," he remarks, "such as *Cyclamen persicum*, &c., which have been naturally cross-fertilised for many or all previous generations, should suffer to an extreme degree from a single act of self-fertilisation is a most surprising fact. Nothing of the kind has been observed in our domestic animals; but then we must remember that the closest possible interbreeding between such animals—that is, between brothers and sisters—cannot be considered as nearly so close a union as that between the pollen and the ovules of the same flower. Whether the evil from self-fertilisation goes on increasing during successive generations is not as yet known, but we may infer from my experience that the increase, if any, is far from rapid. After plants have been propagated by self-fertilisation for several generations, a single cross with a fresh stock restores their pristine

vigour; and we have a strictly analogous result with our domestic animals."

The question whether a vegetable species can be reproduced asexually, *i.e.*, by rhizomes, stolons, &c., from a very remote period remains open. Andrew Knight maintained that a variety exclusively thus propagated, like the majority of our fruit trees, must ultimately become weakly, and Prof. Asa Gray leans to the same view. It would be interesting, if the Anti-Vivisectionists would allow it, to take some animal capable of propagation by "cuttings," and try for how many generations this mode of reproduction could be carried on without a visible decay of vigour.

Mr. Darwin guards against the inference that cross-fertilisation is, *per se*, beneficial under all circumstances. His experiments show that the "benefit from cross-fertilisation depends on the plants which are crossed having been subjected during previous generations to somewhat different conditions." Thus plants which had been self-fertilised for the eight previous generations were crossed with plants which had been inter-crossed for the same number of generations, all having been kept under the same conditions as far as possible; seedlings from this cross were grown in competition with others derived from the same self-fertilised mother-plant crossed by a fresh stock, and the latter seedlings were to the former in height as 100 : 52, and in fertility as 100 : 4." The advantages of a cross, Mr. Darwin considers, "depend altogether on the differentiation of the sexual elements, a conclusion which harmonises perfectly with the fact that a slight and occasional change in the conditions of life is beneficial to all plants and animals. We thus see that in many species plants fertilised with their own pollen are either absolutely sterile or very sparingly fruitful; if fecundated with pollen from another flower on the same plant, they are sometimes a little more fertile; if treated with pollen from another individual or variety of the same species, their fertility is at its maximum; but if with pollen from a different species their fertility declines, till we arrive at absolute sterility. "We have thus a long series with utter sterility at the two ends; at one end due to the sexual elements not having been sufficiently differentiated, and at the other end to their having been differentiated in too great a degree or in some peculiar manner." But having penetrated so far we must confess our ignorance. "We do not know what is the nature or degree of the differentiation in the sexual elements which is favourable for union, and what is injurious." Some species are greatly benefitted by crossing, while others profit very little. Some plants retain their vigour after having been self-fertilised for untold generations. But for these and for many connected facts we can scarcely conjecture a reason.

Going still further, and admitting—as we are compelled—that fertile eggs can be produced without the co-operation of the male,

we ask, why have the two sexes been developed? Mr. Darwin finds the answer in the fact that the offspring of two distinct parents, especially if descended from stocks exposed to somewhat dissimilar conditions, have an advantage in vigour over the progeny of a single self-fertilised individual. But if, as appears probable, the sexes were primordially separate, why did they become blended into hermaphrodite forms, and why—in all the higher animals and in some plants—have the sexes again been separated? The bilateral structure of animals, as Mr. Darwin suggests, perhaps indicates that they were aboriginally formed by the fusion of two individuals. In connection with this subject we have had occasion to refer to certain curious cases of bilateral hermaphroditism found among moths, where one wing, antenna, &c., bear the characters of the male, whilst the other side is as plainly female. But we have vainly sought for any analogous instance either among other insects or among birds and mammals.

The whole tendency of these researches, when calmly and impartially weighed, must be to shake the confidence commonly felt in the primordially distinct character of "species" as compared with mere varieties. The difference in the affinities of the sexual elements of different species, on which their mutual incapacity for breeding together depends, is caused by their having been habituated for a very long period each to its own conditions and to the sexual elements having thus acquired firmly fixed affinities."

The Various Contrivances by which Orchids are Fertilised by Insects. By CHARLES DARWIN, F.R.S. Second Edition, Revised. London: John Murray.

THIS work is already too widely and too favourably known to require examination or comment. The present edition has been, as the author informs us, enriched with many new and curious facts communicated by correspondents in different parts of the world, among whom especial mention is made of Dr. Fritz Müller. A few errors have also been corrected. We cannot help regarding it as a somewhat unfortunate omission that the author has not given a list of the additions and modifications introduced into the present edition. It must, however, be distinctly understood that the alterations thus made are far from invalidating the conclusions reached in the former edition. A list is appended of all the memoirs and books bearing on the fertilisation of the Orchideæ which have appeared since the first appearance of the present work, in 1862. It is somewhat singular that, whilst the botanists of England, America, Germany, and Italy have laboured diligently in the investigation of this