Notices of Books.

The Effects of Cross- and Self-Fertilisation in the Vegetable Kingdom. By CHARLES DARWIN, M.A., F.R.S. London: John Murray. 1876.

IT has for some time been known, and had long previously been suspected, that great benefit is derived from the cross-fertilisation of plants. Indeed, to have a feeling approaching certainty on this subject, it is sufficient to observe Dichogamy—the disagreement in point of time between the bursting of the anthers and the ripening of the stigma—or to examine superficially a few irregular flowers, of which the structure is such as entirely to prevent self-fertilisation. Hitherto, however, we have not known to what precise extent the benefit derived from crossing reaches, neither is there any record of experiments which, lasting through several generations, can yield a clear notion of the cumulative evils of continued interbreeding. In this remarkable volume, a result of the labours of eleven years, Mr. Darwin has brought together a vast array of facts bearing on the subject of fertilisation, flanked by observations and interpretations, which are handled with the masterly grasp, both of details and of generals, which is so peculiar a mark of all his work.

As might be expected, no exception worth mention can be taken to Mr. Darwin's method, which was as follows. Each plant experimented on was placed under a net stretched on a frame large enough to cover the plant without touching it. Several flowers were then marked and fertilised with their own pollen, and an equal number, marked in a different way, were crossed with pollen from a distinct plant. In order to have the experiments as like as possible to nature, the crossed flowers were never castrated. "In some few cases of spontaneously self-fertile species, the flowers were allowed to fertilise themselves under a net, and in still fewer cases uncovered plants were allowed to be freely crossed by the insects which incessantly visited them." Care was taken not to gather the seeds before they were ripe, and they were afterwards usually placed in damp sand on opposite sides of a glass tumbler covered by a glass plate, with a partition between the two lots, and the apparatus was kept in a warm room. If any seeds germinated on one side before any on the other, they were thrown away; but as often as a pair germinated simultaneously, they were planted on opposite sides of a pot, and this was done until from half-a-dozen to a score or more pots were brought into requisition. If one of the young seedlings fell sickly or was injured, it was pulled up and thrown away, as well as its companion on the other side of the pot. The seeds which remained after the requisite number of seedlings had been placed in pots, were sown crowded on opposite sides of larger pots, or sometimes out of doors. The soil was well mixed, and the plants on both sides of the partitions were watered at the same time, and as equally as possible. Usually the height of each plant was carefully measured, and often more than once; sometimes also, each was cut down close to the ground after the height-measuring, and an equal number of crossed and self-fertilised were weighed. In the cases of crowded sowings, where there was a great struggle for existence, only the tallest of the full-grown survivors were measured. This method was pursued during the whole series of experimental generations.

The chief real or supposed sources of error alluded to are: the presumed detriment to the health and fertility of plants covered by a net while in flower; if this objection is valid, which Mr. Darwin doubts, the legitimacy of the results is not interfered with, since both the crossed and self-fertilised plants were covered by a net: the liability of some of the self-fertilised plants to become crossed by means of *Thrips* and other small insects which it is impossible to exclude; but this cross would almost always be with plants on the same stem, and such crossing Mr. Darwin finds to be either not at all or only slightly beneficial: thirdly, as the crossed flowers were never castrated, it is possible that the cross-fertilisation was ineffectual in some instances, and that afterwards the plants were self-fertilised; now it must be observed that if this ever occurred, it would only cause the effects of cross-fertilisation to be underrated, and the same remark would apply to the second source of error.

It will be convenient to take *Ipomæa purpurea* as a type, and to exhibit the main results obtained from this species in two tables.

Ipomæa purpurea. *Summary of Measurements (in Inches) of the ten Generations.*

Number of the generations.	Number of crossed plants.	Average height of crossed plants.	Number of self-fertilised plants.	Average height of self-fertilised plants.	Ratio between average heights of cross and self-fertilised plants.
First generation	6	86·00	6	65 66	as 100 to 76
Second generation	6	84·16	6	66·33	as 100 to 79
Third generation	6	77·41	6	52·83	as 100 to 68
Fourth generation	7	69·78	7	60·14	as 100 to 86
Fifth generation	6	82·54	6	62·33	as 100 to 75
Sixth generation	6	87·50	6	63·16	as 100 to 72
Seventh generatn.	9	83·94	9	68·25	as 100 to 81
Eighth generation	8	113·25	8	96·65	as 100 to 85
Ninth generation	14	81·39	14	64·07	as 100 to 79
Tenth generation	5	93·70	5	50·40	as 100 to 54
All the ten generations taken together.	73	85·84	73	66·02	as 100 to 77

The second table deals with the respective productiveness of the crossed and self-fertilised plants of the successive generations; the fertility of the crossed plants is taken as 100.

First Generation of crossed and self-fertilised Plants growing in competition with one another.—Sixty-five capsules produced from flowers on five crossed plants fertilised by pollen from a distinct plant, and fifty-five capsules produced from flowers on five self-fertilised plants fertilised by their own pollen, contained seeds in the proportion of . . . . 100 to 93

Fifty-six spontaneously self-fertilised capsules on the above five crossed plants, and twenty-five spontaneously self-fertilised capsules on the above five self-fertilised plants, yielded seeds in the proportion of . . . 100 to 99

Combining the total number of capsules produced by these plants, and the average number of seeds in each, the above crossed and self-fertilised plants yielded seeds in the proportion of . . . . 100 to 64

Other plants of this first generation grown under unfavourable conditions, and spontaneously self-fertilised, yielded seeds in the proportion of . . . . . . 100 to 45

Third Generation of crossed and self-fertilised Plants.—Crossed capsules, compared with self-fertilised capsules, contained seeds in the ratio of . . . . . 100 to 94

An equal number of crossed and self-fertilised plants, both spontaneously self-fertilised, produced capsules in the ratio of . . . . 100 to 38

And these capsules contained seeds in the ratio of . 100 to 94

Combining these data, the productiveness of the crossed to the self-fertilised plants, both spontaneously self-fertilised, was as . . . . 100 to 35

Fourth Generation of crossed and self-fertilised Plants.—Capsules from flowers on the crossed plants fertilised by pollen from another plant, and capsules from flowers on the self-fertilised plants fertilised with their own pollen, contained seeds in the proportion of . . 104 to 94

Fifth Generation of crossed and self-fertilised Plants.—The crossed plants produced spontaneously a vast number more pods (not actually counted) than the self-fertilised, and these contained seeds in the proportion of . . . . 100 to 89

Ninth Generation of crossed and self-fertilised Plants.—Fourteen crossed plants spontaneously self-fertilised, and fourteen self-fertilised plants spontaneonsly self-fertilised, yielded capsules (the average number of seeds per capsule not having been ascertained) in the proportion of . . . . 100 to 26

Plants derived from a cross with a fresh stock compared with intercrossed Plants.—The offspring of intercrossed plants of the ninth generation, crossed by a fresh stock, compared with plants of the same stock intercrossed during ten generations, both sets of plants left uncovered and naturally fertilised, produced capsules by weight as . . . . 100 to 51

The following summary exhibits in a very condensed form the additional advantages gained by crossed seedlings over self-fertilised ones. The former usually rise higher, and so rob the others of nourishment and sunlight. The cross-fertilised, if sown in soil in which other plants have long been growing, invariably show greater vigour than do their self-fertilised competitors. Again, if the seedlings are sown very thickly, the crossed are almost always much superior to the others. The former also are more capable of resisting the effects of cold and of change in external conditions. Independently of any external cause, too, the self-fertilised are the more liable to premature death. Moreover, as the number of self-fertilised generations increases, there is often observed a coincident tendency to a decrease in the size of the anthers and in the production of pollen, and the flowers, besides becoming uniformly coloured, sometimes show signs of monstrosity, and they will fall off after fertilisation, in the manner of hybrids. Finally, the crossed usually flower before the self-fertilised; this occurred in 44 cases out of 58, and was shown very strikingly by a cross-flowered *Cyclamen* flowering *some weeks* before its self-fertilised opponent.

The consideration of the relations between insects and the dusting of flowers is, of course, treated in detail. With regard to the exclusion of insects, Mr. Darwin found that out of 125 species, 65 were either quite sterile under these circumstances, or produced less than half the usual number of seeds; while in the other 60 fertility was perfect, or else not impaired to the extent of a half. The cause of bees constantly visiting flowers of the same species, and so favouring crossing, is attributed to the fact that they have just learnt exactly how to place themselves in order to get at the nectar; they are therefore enabled to work more quickly by remaining constant to one species.

Mr. Darwin thinks that the assumption of hermaphroditism, due to a process of budding, may perhaps be explained by the risk which diœcious plants ran of not being fertilised. The relations between monœcism, diœcism and hermaphroditism are discussed in a most interesting manner. Thus it is shown that diœcious plants have a great advantage over other plants in their cross-fertilisation being assured, counterbalanced though by the necessity to produce a vast superfluity of pollen, and by the risk of fertilisation sometimes failing. Moreover, half the flowers evidently cannot bear seed, and as Delpino has remarked, diœcious plants cannot spread as easily as others, because a single individual arriving at a new habitat would not be able to propagate. Monœcious species would often be diœcious in function (*e.g.*, by Dichogamy), and they would possess the advantage of sometimes producing self-fertilised seeds. Hermaphrodite plants are generally capable of producing some self-fertilised seeds, while they are also capable of cross-fertilisation usually either by the aid of insects or of the wind; when, however, the structure of the flowers is such as to preclude self-fertilisation, they are in the same position one to another as are monœcious and diœcious species, with the additional advantage that every flower is able to produce seed.

The following extract contains a brilliant elucidation of the *raison d'être* of the existence of large dichlamydeous trees with an abundance of bisexual flowers. "The case of a great tree covered with innumerable hermaphrodite flowers seems at first sight strongly opposed to the belief in the frequency of intercrosses between distinct individuals. The flowers which grow on the opposite sides of such a tree will have been exposed to somewhat different conditions, and a cross between them may perhaps be in some degree beneficial; but it is not probable that it would be nearly so beneficial as a cross between flowers on distinct trees, as we may infer from the inefficiency of pollen taken from plants which have been propagated from the same stock, though growing on separate roots. The number of bees which frequent certain kinds of trees when in full flower is very great, and they may be seen flying from tree to tree more frequently than might have been expected. Nevertheless, if we consider how numerous are the flowers, for instance, on a horse-chestnut or lime-tree, an incomparably larger number of flowers must be fertilised by pollen brought from other flowers on the same tree, than from flowers on a distinct tree. But we should bear in mind that with the horse-chestnut, for instance, only one or two of the several flowers on the same peduncle produce a seed; and that this seed is the product of only one out of several ovules within the same ovarium. Now we know, from the experiments of Herbert and others, that if one flower is fertilised with pollen which is more efficient than that applied to the other flowers on the same peduncle, the latter often drop off; and it is probable that this would occur with many of the self-fertilised flowers on a large tree, if other and adjoining flowers were cross-fertilised. Of the flowers annually produced by a great tree, it is almost certain that a large number would be self-fertilised; and if we assume that the tree produced only 500 flowers, and that this number of seeds were requisite to keep up the stock, so that at least one seedling should hereafter struggle to maturity, then a large proportion of the seedlings would necessarily be derived from self-fertilised seeds. But if the tree annually produced 50,000 flowers, of which the self-fertilised dropped off without yielding seeds, then the cross-fertilised flowers might yield seeds in sufficient number to keep up the stock, and most of the seedlings would be vigorous from being the product of a cross between distinct individuals. In this manner the production of a vast number of flowers, besides serving to entice numerous insects and to compensate for the accidental destruction of many flowers by spring frosts or otherwise, would be a very great advantage to the species; and when we behold our orchard trees covered with a white sheet of bloom in the spring, we should not falsely accuse Nature of wasteful expenditure, though comparatively little fruit is produced in the autumn."

And here it may be asked, Why is it that so little has been done in the elucidation of function among tropical vegetation? At present the number of residents in the tropics who contribute anything to this department of knowledge is ludicrously small. During the last century the application of a mere convenience in nomenclature, coupled with that peculiar glory of a master, generous and utterly disinterested sympathy with younger workers, conferred on Linnæus the privilege of heading a general movement having for its object the extension, to exotic vegetation, of the then best-known botanical method. It is much to be desired that observers imbued with the latest views should be found in all parts of the tropics. X.

Extracts and Abstracts.

The Nomenclature of Spiral-direction in Plants.

Sur la désignation de la direction des spires dans les plantes, par A. de Candolle. ("Bulletin de la Société botanique de France," tome xxiii., Séance du 9 juin, 1876.)—It is quite time that botanists should come to some agreement as to the direction intended when a given spiral or convolution is said to be right-handed, so as to distinguish it from the corresponding left-handed direction, and it is important that such distinction should stand on an intelligible basis and accord with the language of other sciences for similar cases. In this matter the above-mentioned note is well calculated to do full service. In the first place, it is obvious that rotation around an axis is a geometrical conception, and that the axis itself is in general the proper line from which the direction of rotation should be conceived; and therefore it is more appropriate to call that direction right-handed which appears so from the axis rather than that which appears so from some other points or lines in space wholly exterior to the rotating body or figure. In order to obtain a consistent plan for describing the direction of rotation or convolution, which shall apply in general to various kinds of bodies and conditions, it is necessary to make the rule dependent alone on the rotating or convoluted body itself, and entirely independent of the accidental position of any actual observer. For example, the direction of convolution of the corolla-lobes in a *Gardenia* is really the same whether an observer views it from above so as to look into the interior of the flower, or from one side so as to see the back only of some of the lobes, and similarly whether he examines the unfolded bud externally or a transverse section of it. The practice of some botanists, who prefer to adapt their terms to what they expect will suit the immediate convenience of an ordinary observer of the rotation or convolution under description, does not rest on a good philosophical basis, and is liable to run counter to a like convenience when the conditions are somewhat shifted, and consequently to give rise to confusion.

A. de Candolle shows that Linnæus adopted the just method of regarding the centre as the place from which the direction should be estimated, and that he was followed by other excellent botanists; the former forcibly points out that the right-hand side of an animal is that which is so to it and not to persons observing it. In like manner the right-hand side of the presidential chair in a public meeting is what appears as the left to the members of the assembly, and though