

LITERATURE.

CROSS AND SELF FERTILISATION.

The observations of many leading naturalists of the present day have made all readers of science familiar with the wonderful and varied contrivances for securing the cross-fertilisation of flowers—that is to say, their fertilisation by pollen brought from another flower instead of by that they themselves produce. The mere existence of such contrivances raised, of course, a presumption that the process of crossing they were adapted to effect is in some way beneficial to the plants. Indeed, as Nature presents us with no examples of any such elaborate arrangements which are devoid of any useful purpose, the presumption that these were not wholly aimless and useless amounted to a moral certainty. But the task of testing whether such benefit was really produced, and, if so, of what kind and extent, was unattempted until it was assumed by Mr. Darwin. That great naturalist, who had long paid particular attention, and had, in former writings, drawn the notice of the scientific world to the subject, could not permit the final resting-place of so important a part of the matter to be a mere presumption, however strong that might be. He, therefore, instituted a very numerous and varied set of experiments, extending through several generations of flowers, and lasting for many years. And the result of these experiments, which elevates the presumption in question to a scientific certainty, is given in the volume under notice.

It is not necessary to do more than to allude to the methods by which cross-fertilisation of flowers is made either inevitable or exceedingly frequent. In some cases the sexes are separate, and are found in distinct flowers on the same or on different plants. In others the pollen and stigma of the same flower are matured at different times. Then there are all the means, the secreted honey, the attractive odours, the conspicuous colours by which insects are drawn to the flowers and made to bear away on their bodies the pollen dust from one flower to the stigma of another. There are, moreover, classes which are absolutely sterile to the pollen of their own plant, although perfectly fertile with the pollen of another. And there are also classes

pollen of another. And there are also classes which are not sterile to their own pollen, but are often intercrossed by what Mr. Darwin calls the "prepotency" of the pollen from another individual or variety over their own. The inference suggested by all these contrivances of some great benefit to be derived from crossing is strengthened by the consideration that the ultimate object of the production of seed can be gained with much greater certainty by bisexual flowers and self-fertilisation than by the apparently haphazard method of crossing. To take a single point, if the flowers were, as certain kinds are, completely closed, the production of a very minute quantity of pollen would have sufficed. But to provide for the distribution of the pollen in sufficient plenty to ensure cross-fertilisation either by the wind or by the visits of insects an enormous quantity has to be produced. The amount that is produced by those plants which depend for their fertilisation on the agency of winds is immense. "Bucketfuls of pollen, chiefly of coniferæ and graminæ, have been swept off the decks of vessels near the North American shore; and Mr. Riley has seen the ground near St. Louis, in Missouri, covered with pollen as if sprinkled with sulphur; and there was good reason to believe that this had been transported from the pine forests at least 400 miles to the south. Kerner has seen the snow-fields on the higher Alps similarly dusted." Taking into consideration, therefore, on the one side the preventive precautions against the self-fertilisation which the structure of the great majority of flowers seems intended to secure, and the lavish and elaborate means provided to effect cross-fertilisation, the weight of probability becomes enormously preponderant that some great useful end is obtained by all these arrangements.

Mr. Darwin tells that the thought often occurred to him to try whether seedlings from cross-fertilised flowers were in any way superior to those from self-fertilised flowers. But, judging from the analogy of animals, he thought that, to obtain any perceptible results, it would be necessary to cross and self-fertilise plants for several successive generations, at the cost of too much time and labour. But a chance observation taught him that he might look for marked and significant results in even the first generation, and he thereupon entered upon a series of experiments which he continued for 11 years, carefully noting every point bearing on the question. In the course of these he made and recorded no less than 1605

on the question. In the course of these no made and recorded no less than 1,605 measurements, besides many other observations of the number of seed produced, the comparative weight of the plants and seeds, and many other matters. The kinds tested were of 57 species, belonging to 52 genera, and to 30 great natural families, and were natives of various parts of the world. The method was to enclose a plant under a net so as to exclude the visits of insects, and then to fertilise some flowers, suitably marked, with their own pollen, and to cross an equal number differently marked with the pollen of a distinct plant. The seeds in time were gathered, and the crossed and self-fertilised seeds were planted in pots, care being taken in every case to ensure an absolute equality of conditions for the seeds of the two different classes. The plants having grown and the results been recorded, several flowers on one or more of the self-fertilised plants were again self-fertilised, and several on one or more of the crossed plants were fertilised with pollen from another crossed plant of the same lot. It is obvious that by following this system the full benefit of

* *The Effects of Cross and Self Fertilization in the Vegetable Kingdom.* By Charles Darwin. London: John Murray. 1876.

crossing was not obtained. To do this the flower to be crossed should have been fertilised from not a related but a non-related plant. However, the mode adopted was prolific in valuable and important results and teachings.

We cannot give any of the details of the experiments so carefully made and recorded by Mr. Darwin. But it is sufficient to say that, testing the rival plants by the height of their growth, their vigour, weight, and the number and weight of their seeds, the result was conclusive in favour of the presumption that crossing was beneficial to the plants. Some of the cases, indeed, yielded anomalous results, but there was not a single one "which affords decisive evidence against the rule that a cross between plants, the progenitors of which have been subjected to somewhat diversified conditions, is beneficial to the offspring. This is a surprising conclusion, for from the analogy of domesticated animals it could not have been anticipated that the good effects of crossing or the evil effects of self-fertilisation would have been perceptible until the plants had been thus treated for several generations."

have been perceptible until the plants had been thus treated for several generations." Besides this leading result there were several subsidiary points on which important light was thrown by the experiments. It was shown, for instance, that no benefit whatever was derived from a cross between one flower and another of the same plant. The advantages, moreover, of the constant system of intercrossing from related plants seemed in certain cases to diminish as the process of intercrossing was continued, and could not compare with the marked benefit resulting from a cross from a strange and independent stock. All the evidence appeared to prove "that the advantages of cross-fertilisation do not follow from some mysterious virtue in the mere union of two distinct individuals, but from such individuals having been subjected during previous generations to different conditions, or to their having varied in a manner commonly called spontaneous, so that in either case their sexual elements have been in some degree differentiated. And secondly, that the injury from self-fertilisation follows from the want of such differentiation in the sexual elements."

To the many interesting and significant facts with which the book is filled we can only briefly refer. The extraordinary fact is quoted, as illustrating the precautions taken by nature against self-fertilisation, that the pollen masses of some orchids act on their own stigmas like a poison. It is shown by abundant evidence also that the fertilising power of pollen from another variety or individual is greater than that of a plant's own pollen. Thus, even if the pollen of the flower has lodged upon and acted upon the stigma, if the pollen of another variety or another individual is placed upon the stigma it will overpower the former effect and impress its own character upon the seed. Some very interesting observations are given about the habits of insects in their relations to flowers. It is a curious instance of the continuous communion of scientific minds to find that one of these habits—the custom of bees and certain other insects to visit the flowers of the same species as long as they can before going to another species—was noticed by Aristotle more than 2,000 years ago. It was then noticed by that great observer as a curious fact, but it is only now that the habit is quoted as a part of the systematic provident economy of nature. It is evident that when insects are unknowingly engaged in the work of cross-fertilising flowers it is of great importance that they should, as long as possible, visit flowers of the same species, as it promotes the efficiency of the work. Not that they have this in view in adhering to the habit. They, as is pointed

Not that they have this in view in adhering to the habit. They, as is pointed out in the work under notice, but consult their own convenience. To the minute and patient observations of our author upon the method, the diligence, and the industry of bees, when engaged in rifling a garden of the pollen or nectar of its flowers, often by the felonious mode of cutting a hole from outside into the nectaries instead of penetrating by the legitimate way, we can but refer. These form but a part of the interesting and instructive matter which awaits the student of the book.

It is characteristic of the candid and modest disposition of Mr. Darwin that at the close of his work he affirms that, although Sprengel, who first showed how important a part insects play in the fertilisation of flowers, called his book *The Secret of Nature Displayed*, the science of the present day, which has gone far beyond the observations of Sprengel, must still admit that "the veil of secrecy is as yet far from lifted." If it is shown that all of the contrivances pointed out by Sprengel find their *raison d'être* in the fact that it is beneficial that an additional element of differentiation should be introduced into the work of reproduction, it is still unknown why such differentiation should confer a benefit. In the words of our author, the "secret" will not be really "displayed" "until we can say why it is beneficial that the sexual elements should be differentiated to a certain extent, and why, if the differentiation be carried still further, injury follows. It is an extraordinary fact that, with many species, flowers fertilised with their own pollen are either absolutely or in some degree sterile; if fertilised with pollen from another flower on the same plant, they are sometimes, though rarely, a little more fertile; if fertilised with pollen from another individual or variety of the same species, they are fully fertile; but if with pollen from a distinct species, they are sterile in all possible degrees until utter sterility is reached. We thus have a long series with absolute 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." To attempt any condensation of the few suggestive pages which follow this quotation and terminate the book, pages in which pregnant suggestions are thrown out concerning the mysterious laws which govern sterility between different species, would be to no purpose. The reader of them will not be less struck by the efforts of the author to trace and group all the analogies at hand which might aid to throw any light on an obscure and yet little explored subject, than by the manner in which all of his labours in this and in every part of the book derive their stimulus from, and find their goal in, the desire to remove difficulties and to supply additional proof to the great theory of evolution by

move difficulties and to supply additional proof to the great theory of evolution by natural selection which he has given to the world of thought and science.