those islands which do not readily admit of being grouped under other geographical categories: i.e. besides the Pacific Islands, to which the term is usually applied, such isolated spots of land as St. Helena, St. Paul, and Amsterdam island, but also including, erroneously it seems to us, such islands as Formosa, Japan, Sumatra, and Borneo, which the ordinary reader would certainly look for under the head of Asia; and, most important of all, the addition of a classified index of new species to the section devoted to palæontological contributions. To the working palæontologist this index will be an inestimable boon. It is classified only as far as the great zoological groups generally called classes, and under each of these the species are arranged in the alphabetical order of their generic names, so that all the difficulty that might easily arise from the adoption of a classification in more detail is avoided, and the palæontological student has merely to run down a column or two of names to see whether there is in the volume any record of a new fossil in which he may be interested.

The present volume is considerably larger than its predecessor, and includes, with the supplement for the year 1874, no fewer than 2,350 entries of papers and separate works published. The labour of preparing all these notices, most of which include a brief statement of the general contents or bearings of the works referred to, must have been very great, and the thanks of all geologists are due to Mr. Whitaker, the editor, and his staff of assistants, for carrying cut to a successful issue so arduous an undertaking. We can only echo Mr. Whitaker's hope that the number of subscribers will increase sufficiently to enable him for many years to continue and even extend his valuable labours.

DIFFERENT FORMS OF FLOWERS.*

IT is a curious coincidence (though perhaps not without its appropriateness) that the grandson of Erasmus Darwin should be the great authority on what we may venture to call the "prohibited degrees of relationship" among plants. To the older naturalist it was an easy matter to discourse poetically upon the phenomena of the fertilization of plants, then but little known except to the professed botanist; but he might have felt his genius trammelled had he known anything of the wonderful series of restrictions upon indiscriminate fecundity which the persevering researches of his great descendant have brought to light.

In two numbers of this Review published during the present year we have had occasion to notice the appearance of works from Mr. Darwin's hand bearing upon this subject, namely, an original treatise upon "the effects of cross and self-fertilization in the vegetable kingdom," in which the general evidence from which it may be inferred that cross-fertilization is to be regarded as a necessary process, even in the case of hermaphrodite flowers, is brought forward; and a second edition of the wonderful book in which the cross-fertilization of the orchids is described. We have now before us a third volume, the contents of which scarcely yield in interest to those of

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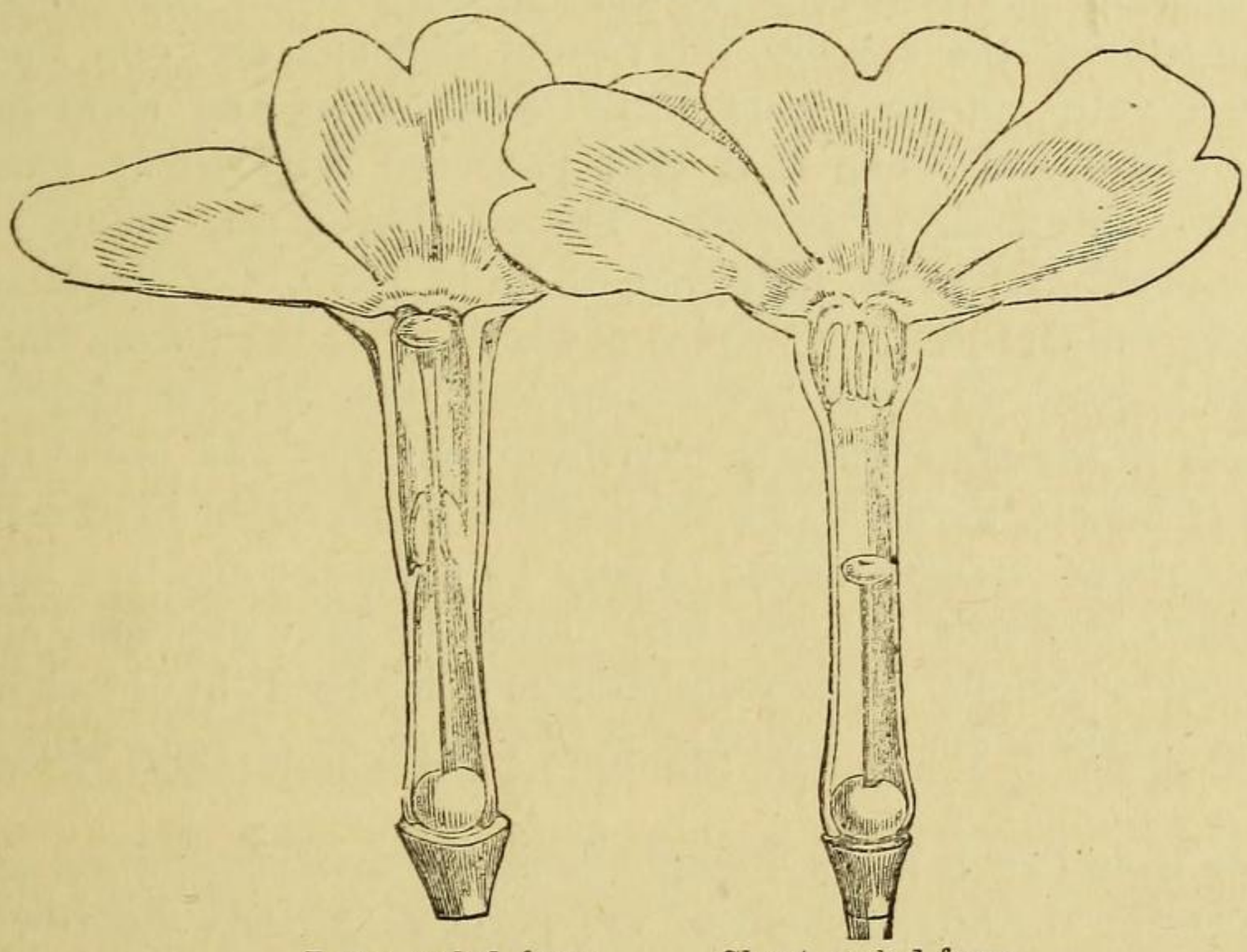
* "The Different Forms of Flowers on Plants of the Same Species." By Charles Darwin, M.A., F.R.S. 8vo. London: John Murray. 1877.

the second work above-mentioned, namely, the description of the different forms of flowers which occur on plants of the same species, with a discussion of the purpose served in Nature by these curious and sometimes complex arrangements.

The phenomena discussed in this volume have attracted Mr. Darwin's attention for many years, and very soon after the first publication of his "Origin of Species" (namely, in 1862) he communicated to the Linnean Society his first paper on the subject, which related to the dimorphism of the flowers in the genus *Primula*. Other papers followed on phenomena of the same order occurring in the genera *Lythrum* and *Linum*, and these constitute the foundation of a portion of the present work, in which, however, the author has added his own more recent observations upon other plants, and supplemented his personal work with information derived from many trustworthy sources. The whole constitutes a most interesting record of facts and inductions of great scientific importance; and the popular interest of the book is enhanced by the facility with which many of the observations may be repeated, so that anyone who has a garden and a magnifying-glass may with ease enter upon a course of practical investigation under the best possible guidance.

Mr. Darwin's first published researches related to certain species of the genus *Primula*, in the cultivated forms of which known as the polyanthus

FIG. 1.



Long-styled form. Short-styled form.

TWO FORMS OF FLOWERS OF THE COWSLIP (*Primula veris*), enlarged.*
The floral envelopes on the near side removed.

and the auricula florists have long been familiar with two kinds of flowers, which they denominate "pin-eyed" and "thrum-eyed." In the common cowslip (*P. veris*) this difference between the two forms is sufficiently remarkable (see Fig. 1.) In the "pin-eyed" plants the style is much elongated, so as to carry the nearly globular and rough stigma right up into the throat of

* For the loan of this and the following figures, we are indebted to the kindness of Mr. John Murray.

the flower, where it stands, like the head of a pin, far above the level of the anthers, which spring from the interior of the tube about half-way down. In the "thrum-eyed" plants, on the contrary, the anthers are placed quite in the throat of the flower; and the style, which is much shorter than in the preceding form, only carries the somewhat flattened and much smoother stigma about half-way up the tube of the corolla. In other words, the relative positions of the anthers and stigmas in the two forms are as nearly as possible reversed. For this difference in structure Professor Hildebrand long since proposed the term "heterostyled," which Mr. Darwin retains in the present work, although he gives the preference—justly, as it seems to us—to the term "heterogonous" proposed by Dr. Asa Gray, to express the same condition of the reproductive parts.

There are certain other differences in the two forms. Thus the long-styled plants have the pollen-grains smaller than those of the short-styled, and of an oblong form, whilst the pollen of the short-styled plants is nearly spherical; and further, the long-styled flowers have larger ovules and produce fewer seeds than their short-styled fellows. The two forms of flowers never occur upon the same plant, and the long-styled flowers seem to open a little earlier than the short-styled. The short-styled flowers are more fertile than the long-styled, the proportion of seed produced being by weight nearly as four to three.

To ascertain the meaning of these curious phenomena, which he naturally believed to point towards cross-fertilization, Mr. Darwin instituted a series of experiments on the cowslip, the results of which are very interesting. He covered with net six plants of the short-styled and eighteen of the long-styled form, and found that they produced respectively twenty-four and seventy-four umbels of flowers. The six short-styled plants furnished altogether about fifty seeds, weighing 1·3 grain, but not a single seed was produced by the eighteen long-styled cowslips. "Judging from the exposed plants which grew all round in the same bed," says Mr. Darwin, "and had been treated in the same manner, excepting that they had been exposed to the visits of insects, the above six short-styled plants ought to have produced ninety-two grains' weight instead of only 1·3; and the eighteen long-styled plants, which produced not one seed, ought to have produced above two hundred grains' weight. The production of a few seeds by the short-styled plants was probably due to the action of Thrips, or of some other minute insect."

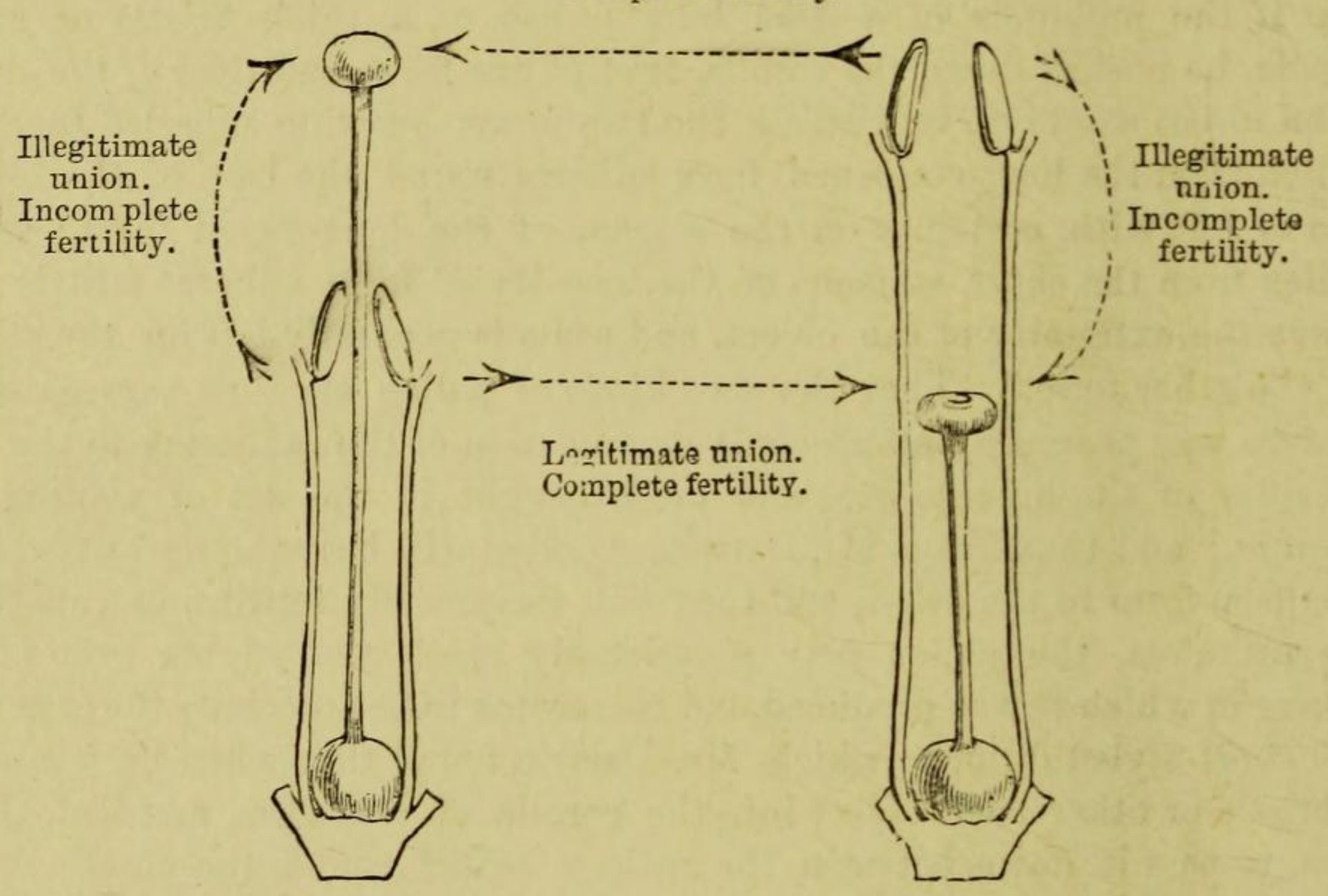
Thus we have insects again brought in as the marriage-priests of plants; and, considering the arrangement of the parts, as already described, in the cowslip, it is easy to see in what manner the visits of insects to the flowers are made available for this purpose. The flowers of the cowslip and of other species of *Primula* secrete an abundance of nectar, and bees and moths may be seen visiting them in search of this sweet food. Mr. Darwin records his observation of two species of humble-bees sucking out the nectar in a legitimate manner by inserting their trunks through the throat of the flower; Mr. H. Müller has seen an *Anthophora* and a *Bombylius* similarly engaged; and one of Mr. Darwin's sons caught *Cucullia verbasci* in the act. There is, indeed, no doubt that insects visit these flowers, and the mode in which their agency is made subservient to the fertilization of the different forms is

explained as follows by Mr. Darwin :—"The pollen," he says, "adheres to any thin object which is inserted into a flower. The anthers in the one form stand nearly, but not exactly, on a level with the stigma of the other; for the distance between the anthers and stigma in the short-styled form is greater than that in the long-styled, in the ratio of 100 to 90. This difference is the result of the anthers in the long-styled form standing rather higher in the tube than does the stigma in the short-styled, and this favours their pollen being deposited on it. It follows from the position of the organs that if the proboscis of a dead humble-bee, or a thick bristle or rough needle, be pushed down the corolla, first of one form and then of the other, as an insect would do in visiting the two forms growing mingled together, pollen from the long-stamened form adheres round the base of the object, and is left with certainty on the stigma of the long-styled form; whilst pollen from the short stamens of the long-styled form adheres a little way above the extremity of the object, and some is generally left on the stigma of the other form." That the two kinds of pollen are thus segregated in Nature was proved by microscopic examination of that adhering to the proboscides of the humble-bees and moth caught in the act of visiting the flowers, "and thus," says Mr. Darwin, "pollen will be regularly carried from the one form to the other, and they will reciprocally fertilize one another." Nevertheless, the pollen may occasionally reach the stigma even of the flower in which it was produced, and this seems to be especially the case with the short-styled form, in which Mr. Darwin found that when he "inserted a bristle or other such object into the corolla of this form, and had, therefore, to pass it down between the anthers seated round the mouth of the corolla, some pollen was almost invariably carried down and left on the stigma." By this means, and also by the visits of minute insects, such as Thrips, crawling into the tube of the flowers, a certain amount of self-impregnation is therefore possible; and indeed Mr. Darwin supposes this to have taken place in his early experiments in covering these plants, when, as already stated, the short-styled individuals produced a minute quantity of seed.

By a series of experiments in the fertilization of the stigmas of the two kinds of flowers by pollen from flowers of their own and of the opposite form, Mr. Darwin arrived at results which show clearly enough that the purpose of this peculiar arrangement of the parts is the assurance of cross-fertilization. He says "four essentially different unions are possible; namely, the fertilization of the stigma of the long-styled form by its own-form pollen, and by that of the short-styled; and the stigma of the short-styled form by its own-form pollen, and by that of the long-styled," the fecundation of the stigma by its own-form pollen being regarded by Mr. Darwin as an "illegitimate union," and by that of the other form as a "legitimate union," in accordance with the hypothesis which he had formed (see fig. 2). The tables showing the results of his experiments bear out his prevision in a remarkable manner. From them it appears that in the "legitimate" unions 77 per cent., in the "illegitimate" only 45 per cent. of the flowers fertilized produced capsules; 92·6 per cent. of the former and only 69 per cent. of the latter being what Mr. Darwin calls good capsules; that is to say, capsules containing more than one or two seeds; and the superior

fertility of the "legitimate" unions becomes still more striking when we find that the average weight of seed in good capsules from legitimate and illegitimate unions is as 54 to 35. Thus in this first series of experiments—the results of which, however, are perhaps a little below the average—the fertility of the legitimate and illegitimate unions, as shown by percentage

FIG. 2.



THE STAMENS AND PISTILS OF THE TWO FORMS OF COWSLIP, SHOWING THE FOUR POSSIBLE UNIONS OF THE POLLEN WITH THE STIGMAS.

results, in weight of seeds, would seem to stand approximately in the proportion of 38 to 11; or, in other words, the legitimate unions are $3\frac{1}{2}$ times as prolific as the illegitimate ones.

The inference from these facts appears quite plain—the peculiar arrangement of the parts in the flowers of the cowslip is manifestly intended to insure the occurrence of cross-fertilization. The general facts must have been well-known to botanists for many years, seeing that the distinction of "pin-eyed" and "thrum-eyed" polyanthuses has long been recognized by florists; but their interpretation was a more difficult matter, and could only arise from considerations such as those put forward by Mr. Darwin in support of his much-maligned theory of evolution. As he says, we have here a case to which no parallel was known to exist in the vegetable, or indeed in the animal kingdom, for in this case the individual plants "are divided into two sets or bodies, which cannot be called distinct sexes, for both are hermaphrodites; yet they are to a certain extent sexually distinct, for they require reciprocal union for perfect fertility." But the clue once gained, the phenomena were soon found to be not at all isolated; and the researches of Mr. Darwin himself and of other observers have now brought to light a number of plants in which the same sort of dimorphism prevails. A majority of the species of *Primula*, certain species of *Linum*, several

rubiaceous plants, and some others, are found to exhibit similar characters; and these cases are all described in the work before us.

Fig. 3.

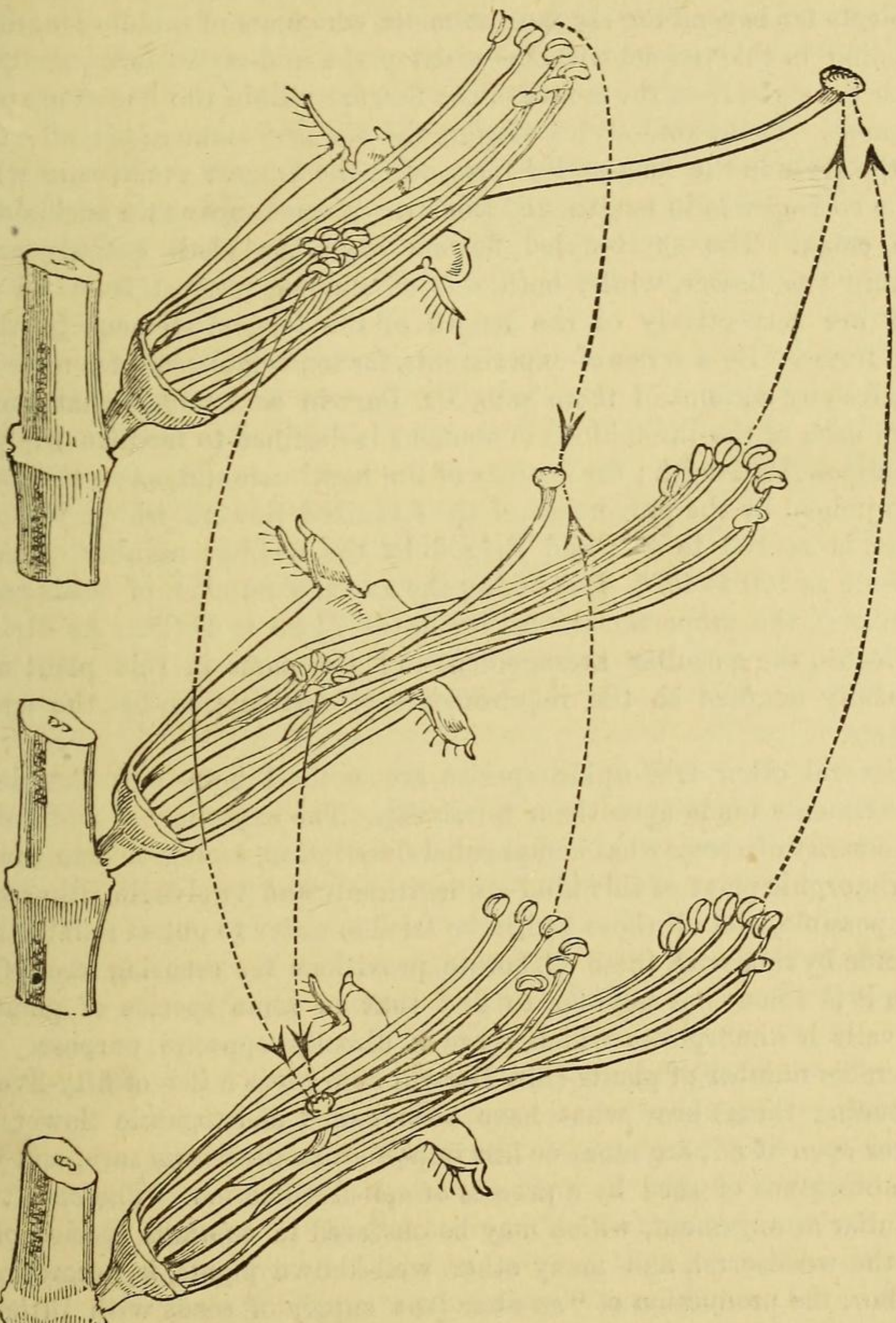


DIAGRAM OF THE FLOWERS OF THE THREE FORMS OF *Lythrum salicaria*, IN THEIR NATURAL POSITION, WITH THE PETALS AND CALYX REMOVED ON THE NEAR SIDE. ENLARGED SIX TIMES.

The dotted lines with arrow-heads show the direction in which the pollen must be carried to each stigma to insure full fertility.

The discovery of still more complex sexual arrangements in the Purple Loosestrife (*Lythrum salicaria*) was made by Mr. Darwin and described by him, soon after the publication of his observations on the

Primulaceæ. In this plant the flowers are trimorphic ; that is to say, they exhibit three different proportions of the style and stamens. We have *long-styled*, *mid-styled*, and *short-styled* flowers, and each of these forms contains stamens of two different lengths (see fig. 3). In the long-styled form the style projects far beyond the six long stamens, which are of middle length, corresponding in this respect with the pistil of the mid-styled form, and protrude, with the style, from the mouth of the flower ; within the flower are six short stamens. In the mid-styled flowers the six long stamens are about as long as the style in the long-styled form, with the longest stamens in which the style corresponds in length, and the short stamens are again enclosed within the calyx. The short-styled flowers have the pistil entirely concealed within the flower, whilst both sets of stamens project from its opening and are respectively of the length of the longest stamens in the other two forms. By a series of experiments, far too complicated for us to attempt to give any account of them here, Mr. Darwin ascertained that the pollen from each of the three kinds of stamens is destined to fertilize the pistil of corresponding length ; the fertility of the legitimate unions on this principle, "as judged by the proportion of the fertilized flowers which yielded capsules, is as 100 to 33 ; and judged by the average number of seeds per capsule as 100 to 46." But taking the average number of seeds per flower fertilized, the proportional fertility is as 71·89 to 11·03. As Mr. Darwin indicates, the peculiar arrangements of the parts in this plant also are specially adapted to the requirements of fertilization by the agency of insects.

Several other trimorphic species are noticed here, and the details of experiments made upon them tabulated. The experiments and tables are necessarily of a somewhat complicated description, seeing that in the case of a trimorphic plant of this kind six legitimate and twelve illegitimate unions are possible, and all these had to be tried in order to get at reliable results.

Side by side with these elaborate provisions for securing cross-fertilization it is somewhat singular to find that in some species of plants there prevails a dimorphism which serve a directly opposite purpose. A considerable number of plants (Mr. Darwin here gives a list of fifty-five genera including them) bear what have been called cleistogamic flowers, which never open at all, are more or less imperfect in their structure, and yet bear an abundance of seed by a process of self-fertilization. The object of this peculiar arrangement, which may be observed in common species of *Viola*, in the woodsorrel, and many other well-known plants, is, according to the author, the production of "an abundant supply of seeds with little expenditure ;" and he adds, "we can hardly doubt that they have had their structure modified and degraded for this special purpose ; perfect flowers being still almost always produced, so as to allow of occasional cross-fertilization," which he has proved to be possible. In some instances, also, of which one is furnished by the pansy (*Viola tricolor*), there are two forms of flowers, one much more conspicuous than the other, and adapted to cross-fertilization by insects ; whilst the smaller flowers, although not closed, like cleistogamic flowers, are more or less modified to insure self-fertilization. In these cases the two forms of flowers are produced upon distinct plants.

Mr. Darwin's researches upon what he calls the illegitimate offspring of

his dimorphic and trimorphic plants proved them to behave very much after the fashion of hybrids between distinct species; and this leads him to discuss the question of hybrids at some length, and more especially the hybrids of the species of *Primula*, which are numerous even in a state of nature. He also notices the peculiarities of monœcious, dicœcious, and polygamous plants, of which he maintains that, "as the separation of the sexes would have been injurious, had not pollen been already transported habitually by insects or by the wind from flower to flower, we may assume that the process of separation did not commence, and was not completed, for the sake of the advantages to be gained by cross-fertilization. The sole motive for the separation of the sexes," he adds, "which occurs to me is, that the production of a great number of seeds might become superfluous to a plant under changed conditions of life; and it might then be highly beneficial to it that the same flower, or the same individual, should not have its vital powers taxed, under the struggle for life to which all organisms are subjected, by producing both pollen and seeds." This explanation is hardly satisfactory, and does not apply at all to monœcious plants. Among polygamous plants Mr. Darwin distinguishes a sub-class which he calls "gyno-dicœcious," in which the unisexual flowers are all females, and he says that they yield a much larger supply of seed than they would have done if they had all remained hermaphrodites—in other words, fewer stamens than would exist in the flowers if all were hermaphrodite are capable of producing sufficient pollen for all their pistils. This is probably true also of the ordinary monœcious and dicœcious plants, but still we cannot see where the necessary saving of material or powers comes in with sufficient force to account for phenomena of such importance. It must be borne in mind, however, that these suggestions of Mr. Darwin's are merely tentative, and that we have still much to learn before the "why and wherefore" of all these things is laid open to our view.

Nevertheless by works such as this, chiefly inspired by the new spirit thrown into natural-history research by the Darwinistic publications, we cannot doubt that progress is being made in the right direction. Any attempt at the explanation of phenomena is a step towards the truth; if it justifies itself it is absolutely an advance; if its justification be difficult, partial, or even impossible, the researches necessary for testing its value must in any case lead to valuable results. Even the steps taken apparently on the most indisputable grounds may open questions that it is very difficult to answer. Thus, to take the case of the Primulas, many species of which, as we have seen, seem to be specially organized so as to render cross-fertilization a necessity, we find, side by side with the "heterostyled" species, others which are "homostyled;" and it is hard to see, from the conditions of existence of the plants, why one set should be so peculiarly modified, and the other set left in what we may call a normal condition. So also with the monœcious and dicœcious plants in groups the flowers of which are normally hermaphrodite. These and many other matters of doubt, which may easily occur to the mind in studying Mr. Darwin's descriptions of the different forms of flowers, furnish objects of study which we recommend to the attention of our readers; they are points not very difficult of investigation under the guidance to be obtained from

the present book, and their investigation certainly possesses a much higher interest for the botanist than the mere collecting, drying, and naming of the plants of his district.

DUST.*

"PHILOSOPHERS have said that 'there is a reason, a meaning, and an end in Nature.' We Dusts require more than this—a proof of the reason, a result of the meaning, and a continuance of the end."

These are the opening words of Mr. Malet's preface to his "Incidents in the Biography of Dust," and we cannot but think that our readers would forgive us if, having read them, we had abstained from any further examination of the book. But, as Thackeray once hinted, there is a power of self-sacrifice in the editorial idiosyncracy, and we endeavoured to the best of our power to make out what the purpose of the little book might be. There used to be a phrase current (whether it is still extant we know not) which ran as follows: "Down with the dust;" and so far as we remember bore a signification not at all agreeable to the impecunious. Mr. Malet's watch-word is, "Up with the Dust," which would sound much pleasanter if we could only make out what "Dust" is. But this is precisely the puzzle before us.

In his first introductory chapter, which, we believe, gives in the form of aphorisms the principles of his theory, Mr. Malet tells us, in the first place, "that the earth consists of air, water, and dust." He then gives us the curious piece of information that "air is composed chiefly of oxygen, hydrogen, and carbonic acid gases;" and after telling us something about water proceeds to say that "the dry land of the earth is dust;" and then that "dust is now chiefly composed of everything that grew or lived on the earth, mixed with the dust from which all things were created." Here we seem to see a glimmer of light, and that by dusts may be signified the non-aeriform constituents of the world; but a little further on this comfort is taken from us, and we are told that "there are gaseous and non-gaseous dusts." In the next paragraph we learn that "everything that lived or grew was composed of air, water, and dust," which sounds like a return to the former conception; and then that "these three elements therefore compose the earth," so that dust is one of the elements; but when we turn to Chapter V., which is headed, "The Birth of Dust," and in which, therefore, we justly look for something conclusive, we find ourselves all abroad again. The author, in his playfully humorous style, writing himself down a Dust, tells us "that the dusts have nothing to do with the beginning." "It is far within the limit of that horizon that we look for the birth of our ancestors. Long previous to this event heaven and earth were created; the waters were divided by the firmament. Light and darkness made the day and night. The second day, that comprehensible measure of incomprehensible time, had passed away; two measures of eternity had run out; all

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* "Incidents in the Biography of Dust." By H. P. Malet. Small 8vo. London: Trübner & Co. 1877.