DARWIN'S OBSERVATIONS ON THE PHYSIOLOGY OF THE PROCESS OF FERTILIZATION IN PLANTS.

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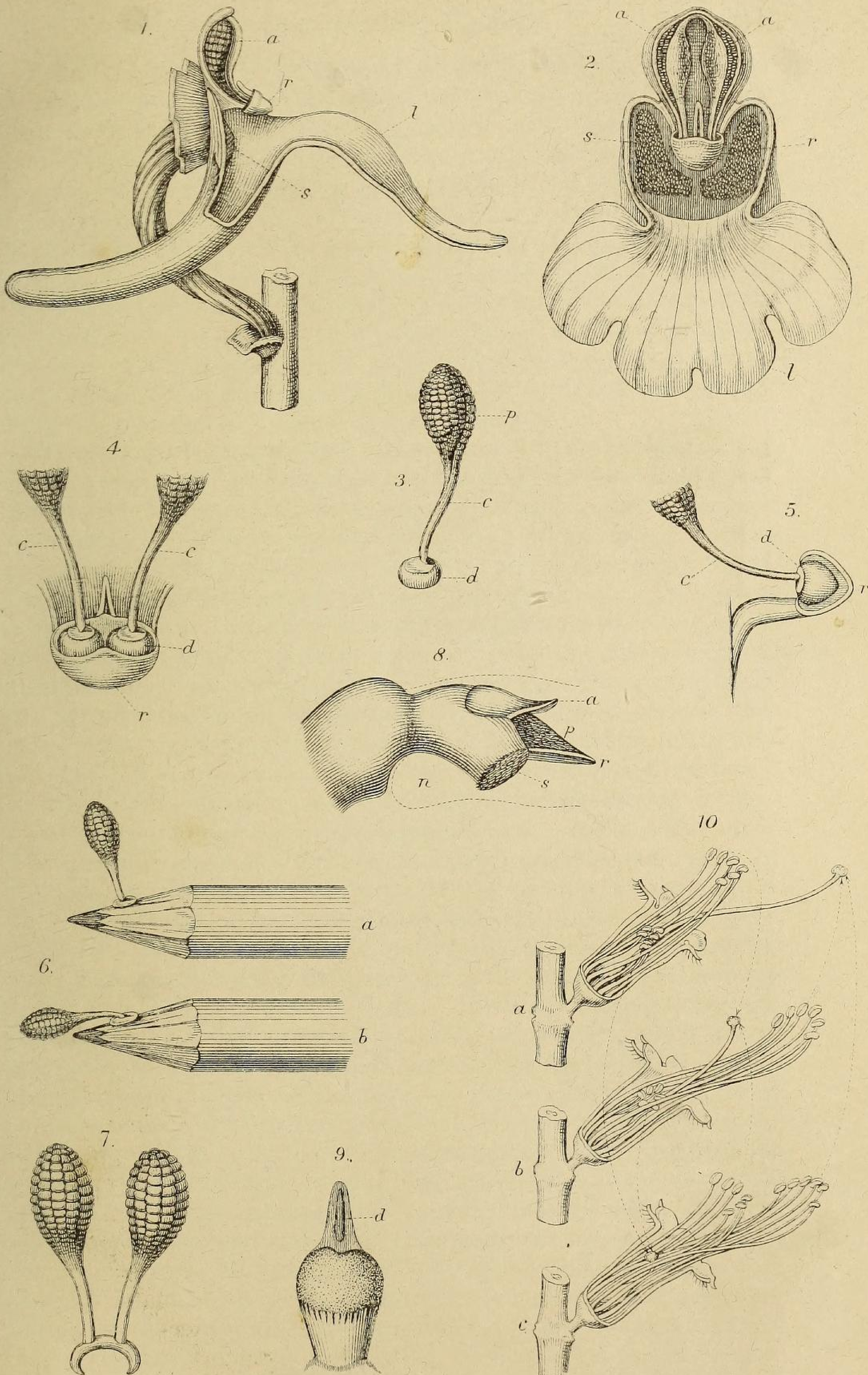
HISTORY affords us examples of philosophic minds, like bright stars illumining dark ages, and darting rays through the long vista of centuries into remote times. Whenever and wherever such lights have broken forth they have determined a point from whence a new era commenced, and created as truly a revolution in thought as more social or political manifestations have ripened into revolutions in action. The "revolution of ideas" is often claimed by the partisans of convulsions which have metamorphosed the Governments of States, but the revolution of ideas emanating from philosophic minds, to which our attention is more particularly directed, is not less positive, but more insinuating; is less rapid, but more certain; and though no less the result of power, it is that of mind, not matter; of brains, not brawny arms. No one can gaze backwards through the history of science during a few centuries, without noticing how certain men, with powerful minds, determined wills, untiring industry, unity of purpose, and clear perception, have given a tone and direction to all thought within the sphere of their labours long after their bodies have mouldered into dust. Compared with the bulk of men eminent in science, such bright particular individuals are not common; but, as compared with other "reformers," if we may use a term often degenerated in its application, in art, religion, literature, politics, such men are not rare. Such a one, though still living and working amongst us, even his opponents will almost admit is Charles Darwin. Dispute every step of his advance, quarrel with every conclusion as they may, in despite of antagonists and antagonism, there is already sufficient evidence to prove that the author of "The Origin of Species" has inaugurated a revolution in thought, which is gradually spreading through the whole scientific world. Whether his conclusions will all be accepted, whether his theory will establish itself as a complete fact, is quite another question, which we are even disposed to doubt, but there is too much positive

Plate XVII.



after Darwin.

W. West, lith.

Fertilization.

evidence in the direction in which scientific thought has drifted during the past few years to deny that "Darwinism," as it has been termed, has modified and is continuing to modify opinions on all subjects within its scope. Let it not be supposed that because we have admitted so much, because we dare not refuse to recognize this fact, that we are therefore prepared to swear by the book, the whole book, and nothing but the book, or that it is our purpose to champion its author, and vindicate its cause. There are two phases in which we think that Mr. Darwin is to be regarded—as the advocate of a theory, and as a practical worker—it is the latter phase more particularly which concerns us on the present occasion; and that, too, with more especial reference to vegetable forms and functions.

Three years ago, appeared his work on the fertilization of Orchids,* and since then other shorter contributions to Botanical Science. These will serve as the texts for our brief commentary. To understand the direction of his observations, and the deductions therefrom, it will be necessary to indicate the peculiarities of structure in the plants subjected to experiment. These are amongst the most singular and attractive in the vegetable world, not only on account of the extraordinary forms which their flowers assume, but for the structure of their reproductive organs. In ordinary plants the centre of the flower is occupied by the *pistil,* the lower portion of which encloses the *ovary,* and contains the *ovules,* which, after fertilization, swell, mature, and become *seeds;* the ovary is surmounted by a cellular elongated filament, called the *style* (occasionally absent). The upper extremity of the style is clubbed or divided, and bears a viscid surface, known as the *stigma.* All these parts together constitute the *pistil.* Arranged about this organ stand a series of more or less slender erect threads; there may be three, or five, or twenty, according to the plant which produces them. Each of these threads or filaments bears on its summit an elongated yellowish or brownish sac or vesicle, termed the *anther,* enclosing a yellow powder, which, when ripe, ruptures the vesicle or anther, and is dispersed; this is the *pollen.* The whole organ is a *stamen.* When the pollen is shed from the anthers, some of the granules adhere to the sticky surface of the stigma; a kind of germination takes place; long slender tubes emanate from some portion of the surface of the pollen grains, pass downwards through the cellular style into the ovary, enter the ovules at the base or point of attachment of the ovules to the walls of the ovary or its central axis, the fluid contents of the pollen grain then pass

* "On the Various Contrivances by which British and Foreign Orchids are fertilized by Insects."—London: Murray. 1862.

down the slender tube into the ovule, and mingle with the fluid in the interior, the *ovules are fertilized,* and proceed gradually to become mature seeds, whilst the pollen tubes wither, as well as the style and stigma, their work having been accomplished. Such, in brief, with various modifications, is the mode of fertilization in the majority of plants. It may be added, that in their young state, the above "essential" or reproductive organs are enclosed and protected by one or two series of over-lapping leaves, and, when thus enclosed, we call the whole a *flower bud.* As the flower bud expands, the outer series of leaves, often of a green colour, and termed the *calyx,* expands first, then the inner, or coloured series, which is the *corolla.* The number of leaves in the calyx and corolla is variable, according to the genus or species of the plant. Sometimes both series are coloured, and sometimes only one series is present. These together constitute the *floral envelopes,* which enclose and protect the reproductive organs during their young and tender state.

In Orchids the whole structure of the flower departs widely from this type, there are "reproductive organs," and also "floral envelopes," but how these differ from those of ordinary plants we will endeavour to explain. As we do so, let us hope that those who need no such explanation will bear with us patiently, for the benefit of readers who may not be so fortunate as themselves.

About forty species of Orchids have a place in the British Flora, and the majority of these are lovers of chalky soils. In all there is one point of structure in which they agree. The filaments of the stamens, and the style which surmounts the ovary, are fused together into one thick *column,* which occupies the centre of the flower, so that there are no separate and distinct stamens as in other plants. We shall best illustrate this by taking one common species as a type, and, for the present, confine our observations to that species. The Early Orchis (*Orchis mascula*) has a flower with six divisions, arranged in two series; the outer three correspond to the calyx, but, instead of being green, are coloured; the inner series, also of three parts, corresponds to the corolla, and each part may be called a petal; these, of course, are coloured, and are placed alternately with the outer series. One of these petals, that is the lower one, is larger than the rest, and differs in shape; in some species it is very large, and shaped almost like a slipper. This is the *labellum.* This lower petal, or labellum, has a spur, or long pouch, which extends backwards, which, on account of its secreting nectar, so grateful to insects, is called the *nectary.* In fig. 1, all the floral leaves have been removed, except the labellum (*l*) and its nectary (*n*). In fig. 2, a front view of the labellum is shown (l) with the opening to the nectary. All the reproductive organs are combined together into one compound organ, which is the column already referred to. The stigma is seated beneath a projection of the column, and consists of two nearly confluent stigmas (fig. 1, *s*), the surface of which is soft and viscid. The projection above this is a curious adaptation of the upper portion of the column, and is named the *rostellum* (fig. 1, *r*), which supports the pollen masses. Here, again, a vast difference occurs between Orchids and other plants. In most flowers the pollen consists of a fine powder, but in Orchids the grains cohere in masses; often borne upon a stalk or appendage, called the *caudicle*. The pollen-masses, with their appendages of all kinds, are known as *pollinia*. In the present species the anther (figs. 1 and 2 *a*) consists of two cells, separated from each other, each containing a pollen-mass. One of these pollinia removed from its cell, is shown at fig. 3, where *p* is the pollen-mass; *c* the caudicle or appendage; and *d* a *viscid disc*, to which the caudicle is firmly attached. Each pollinium has a similar disc, which is imbedded within the rostellum, as shown at fig. 4. A section through one of these discs, and the rostellum in which it is imbedded, would present the appearance of fig. 5. The two discs, at the base of the caudicles of the two pollen-masses, lie quite unattached within the cup of the rostellum, surrounded by fluid, except at the back, where the discs are each at first firmly adherent to a small portion of the membrane of the rostellum. How are these pollen-masses to be transferred to the viscid stigma lying beneath the projecting rostellum, and thus the ovules become fertilized? To answer this question was one of the aims of Mr. Darwin's work, and to explain it so satisfactorily as he has done, gives evidence of no small earnestness and perseverance, through years of close observation. Let us accept the labellum, or lower petal of the flower, as the landing place of an insect. The bee or butterfly alighting on this platform, thrusts its head into the chamber or cavity, at the back of which lies the stigma, in order to push its proboscis down into the nectary. As the rostellum projects above, it is almost impossible for the head of the insect to enter without touching the rostellum; as it is pushed further, the lip is depressed, and one or both of the viscid discs at the base of the pollinia is sure to become attached to the head of the insect; as this is withdrawn it bears with it one or both of the viscid discs attached to its forehead, together with their caudicles and pollen-masses. Let a pencil or any other object supply the place of the insect, and be thrust in at the mouth of the Orchis, in the direction of the nectary, and it will be found scarce possible to insert it without touching and bending down the lip of the rostellum, and bringing away one of the pollen-masses, attached by its viscid disc, as shown in fig. 6 *a*.

"Now, let us suppose," says Mr. Darwin, "our insect to fly to another flower, or insert the pencil, with the attached pollinium, into the same or into another nectary, by looking at fig. 6 *a*, it will be evident that the firmly attached pollinium will be simply pushed against or into its old position, namely into its anther cell. How, then, can the flower be fertilized? This is effected by a beautiful contrivance; though the viscid surface remains immoveably affixed, the apparently insignificant and minute disc of membrane to which the caudicle adheres, is endowed with a remarkable power of contraction, which causes the pollinium to sweep through about ninety degrees, always in one direction, viz., towards the apex of the proboscis or pencil, in the course, on an average, of thirty seconds. The position of the pollinium after the movement is shown at *b*, fig. 6. Now, after this movement, and interval of time (which would allow the insect to fly to another flower), it will be seen that if the pencil be inserted into the nectary, the thick end of the pollinium will exactly strike the stigmatic surface."

Another beautiful adaption then comes into operation. It has been said that the stigma is viscid. As soon as the mass of pollen touches this viscid surface, some portion adheres, whilst the viscidity is not sufficient to pull away the whole pollinium from the head of the insect, so that it may fly from flower to flower, and fertilize several in succession, until all the pollen is exhausted. The structure of the pouch of the rostellum in which the discs of the pollinia are inserted, is also worthy of observation. When in their natural position the discs are kept moist by the fluid surrounding them in this pouch; but when removed the discs dry rapidly, and lose their power of adhesion in a few minutes. So elastic is this pouch, that when depressed by the contact of a foreign object, it is bent forwards so that the pollinia are easily removed; but as soon as the pressure ceases, the pouch returns to its former position, and thereby economizes the moisture it contains, which would otherwise too speedily evaporate. As a whole, the mechanism by which this and many other orchids are fertilized, is so perfect and beautiful, that the account reads like a fairy tale, or rather, like a new Bridgewater Treatise, in which great theological truths are demonstrated without the aid of Theology.

The next species which offers any considerable variation in structure from the Early Orchis, is the Pyramidal Orchis (*Orchis pyramidalis*). In this species the stigmatic surfaces are two distinct rounded spots, one on each side of the rostellum. Then, again, the rostellum overhangs the entrance to the nectary. The pollinia are not separate, but both pollen-masses are attached by their caudicles to a single visid disc, which, in this instance, is saddle-shaped (fig. 7). Another modification of the mode of fertilization consequently takes place. If the proboscis of a moth, or a bristle, be thrust into the nectary, the pouch is depressed, and the saddle-shaped disc attaches itself to the object introduced; as soon as this object, with the adhering pollinia, is removed, by a rapid movement, consequent on drying, the flaps of the saddle curl around, and tightly embrace the object, so that in nine seconds it becomes firmly secured. As soon as this is accomplished, the pollinia, which, by the by, have necessarily diverged from each other in the movement, sweep downwards and forwards through nearly ninety degrees, as in the former instance. In this position the two ends of the pollinia will be found to have acquired such an adjustment that one of the pollen-masses will strike the surface of the stigma on one side at the same moment that the other pollen-mass touches the surface of the stigma on the other side of the rostellum, and the flower is completely fertilized.

In reference to this species Mr. Darwin remarks :—

As in no other plant, or indeed in hardly any animal, can adaptations of one part to another, and of the whole to other organized beings widely remote in the scale of nature, be named more perfect than those presented by this orchis, it may be worth while briefly to sum them up. As the flowers are visited both by day and night-flying Lepidoptera, I do not think that it is fanciful to believe that the bright purple tint attracts the day-fliers, and the strong foxy odour the night-fliers. The upper sepal and two upper petals form a hood protecting the anther and stigmatic surfaces from the weather. The labellum is developed into a long nectary in order to attract Lepidoptera, and we shall presently give reasons for suspecting that the nectar is purposely so lodged that it can be sucked only slowly in order to give time for the curious chemical quality of the viscid matter on the under side of the saddle setting hard and dry. He who will insert a fine and flexible bristle into the expanded mouth of the sloping ridges on the labellum will not doubt that they serve as guides, and that they effectually prevent the bristle or proboscis from being inserted obliquely into the nectary. This circumstance is of manifest importance ; for, if the proboscis were inserted obliquely, the saddle-formed disc would become attached obliquely, and, after the compounded movement of the pollinia, they could not strike the two lateral stigmatic surfaces.

Then we have the rostellum partially closing the mouth of the nectary, like a trap placed in a run for game ; and the trap so complete and perfect, with its symmetrical lines of rupture forming the saddle-shaped disc above, and the lip of the pouch below ; and, lastly, this lip so easily depressed that the proboscis of a moth could hardly fail to uncover the viscid disc and adhere to it. But if this did fail to occur, the elastic lip would rise again and re-cover and keep damp the viscid surface. We see the viscid matter within the rostellum attached to the saddle-shaped disc alone, and surrounded by fluid, so that the viscid matter does not set hard till the disc is withdrawn. Then we have the upper surface of the saddle, with its attached caudicles, also kept damp within the bases of the anther-cells, until withdrawn, when the curious clasping movement instantly commences, causing the pollinia to diverge, followed by the movements of depression, which compound movements together are exactly fitted to cause the ends of the two pollinia to strike the two stigmatic surfaces. These stigmatic surfaces are sticky enough not to tear off the whole pollinium from the proboscis of the moth ; but, by rupturing the elastic threads, to secure a few packets of pollen, leaving plenty for other flowers. But let it be observed that although the moth probably takes a considerable time to suck the nectar of any one flower, yet the movement of depression in the pollinia does not commence until the pollinia are fairly drawn out of their cells, nor will the movement be completed and the pollinia be fitted to strike the stigmatic surfaces until about half a minute has elapsed, which will give ample time for the moth to fly to another plant, and thus effect a union between two distinct individuals.

We need not advert to the experiments instituted to prove that the agency of insects was essential for the fertilization of all the British species of the genus *Orchis*. We cannot, however, entirely pass the subject of the production of nectar in the nectaries of Orchids, to which our author devoted considerable attention. Having examined several species, and found no signs of nectar either in the nectaries or labellum, although the plants must have existed for enormous periods of time, requiring for each generation insect agency, and possessing special contrivances for that purpose, he still pursued the investigation with faith that the nectaries could not be a sham, or that the plants existed by an organised species of deception.

As soon as many flowers were open [he says] I began to examine them. For twenty-three consecutive days I looked at them after hot sunshine, after rain, and at all hours. I kept the spikes in water, and examined them at midnight and early in the morning. I irritated the nectaries with a bristle, and exposed them to irritating vapours. I took flowers which had quite lately had their pollinia removed by insects (of which I had independent proof on one occasion by finding within the nectary grains of some foreign pollen), and I took other flowers which from their position on the spike would soon have had their pollinia removed ; but the nectary was invariably quite dry.

Convinced that the nectaries of these particular species of Orchids never contained nectar in this country, he next examined the membranes lining them, and was surprised to find that the outer and inner membranes were separated from each other, and contained a quantity of fluid between them ; moreover, that the inner membrane was exceedingly delicate ; and was led to adopt the hypothesis that here was the nectar of which he was in search, confined in a chamber between the two membranes of the nectary, and that the lax inner membrane might be penetrated by insects, and thus a supply of fluid obtained. Further, that the delay caused by the necessity of first puncturing the membrane, would detain the insect longer than otherwise, and thus unable the discs of the pollinia to become more securely attached to the head or back of the insect before leaving the flowers.

If this relation [he concludes] on the one hand between the viscid matter requiring some little time to set hard, and the nectar being so lodged that moths are delayed in getting it ; and, on the other hand, between the viscid matter being at first as viscid as ever it will become and the nectar lying all ready for rapid suction, be accidental, it is a fortunate accident for the plant. If not accidental, and I cannot believe it to be accidental, what a singular case of adaptation !

A singular exception to the general rule in the Orchids examined, was the Bee Orchis (*Ophrys apifera*), for, in this instance, self-fertilization appears to have been provided for. There are two pouched projections of the rostellum, as in many other species. The caudicles to which the pollen-masses are attached, are very long, thin, and flexible, and not possessed of sufficient rigidity to stand upright. The upper ends are curved forwards, and the masses of pollen directly overhang the stigmatic surface. When the flowers open, the pollen cells rupture, and the masses of pollen soon drop forwards suspended by the slight vibrating caudicle just opposite to the stigma, so that the slightest puff of wind sets them in motion ; and as they oscillate, the pollen touches against the viscid stigma, and some grains are left adhering, whereby impregnation is effected.

It is impossible to doubt that these points of structure and function, which occur in no other British orchid, are specially adapted for self-fertilization.

One other illustration from the British Orchids must be the last to which we can refer in detail. This species is the Ladies' Tresses (*Spiranthes autumnalis*). The long, thin, flat rostellum projects from the summit of the stigma (fig. 8 *r*). The disc is boat-shaped, standing vertically on its stem, imbedded in a fork of the rostellum (fig. 9). This little boat is filled with a thick adhesive fluid, which turns brown, and becomes hard on exposure to the air; the membrane of the rostellum folds over the boat, and covers it like a deck. A longitudinal furrow extends over the middle of the boat, which splits through its whole length on being touched gently with a needle, and a little adhesive fluid exudes. After this splitting, the boat becomes free, and attaching itself to whatever has caused the fissure of the membrane, is withdrawn with its adherent pollen-masses. The stigma lies beneath the rostellum, with a projecting sloping surface; its lower edge fringed with hairs.

The tubular flowers of this species are arranged in a spike, each flower standing out horizontally. The labellum is furnished at the base with two globular processes, in which an abundance of nectar is secreted, which falls into a receptacle beneath. The entrance to the nectary beneath the lower margin of the stigma is very contracted. When the flower first opens, there is nectar in the receptacle, but the rostellum and labellum approximate so closely, and so narrow a channel is left, that only a fine bristle could be passed down into the nectary. In a day or two, the labellum retreats further from the rostellum, and a wider channel is opened. This circumstance is important to the fertilization of the species.

Most Orchids have their flowers open for some time before being visited by insects, but, in this instance, the boat-shaped disc, with its pollinia, has been found to be removed soon after the expansion of the flower. At this period, the passage to the nectary is so small, that an insect could not thrust down its proboscis, without touching the furrow along the middle of the membrane covering the disc. This touch causes the membrane to split, and the boat-shaped disc is freed; its viscid fluid causes it to adhere longitudinally to the proboscis, and, as the insect flies away, it bears the pollinia with it. Here arises a difficulty:—Since the labellum lies so close to the rostellum, how could the pollinia possibly be conveyed to the stigma? It has been observed, that, after a day or two, the channel is enlarged, and *then* there is no difficulty in the pollen-masses being placed in contiguity with the viscid stigma. From these circumstances, it must be concluded, that the pollen collected from an early-opened flower cannot be transferred to its own stigma, but to the stigma of another flower, which has been open for two or three days. We will again leave Mr. Darwin to explain in his own words:—

Hence not only the pollen must be carried from one flower to another, as in most Orchids, but a lately expanded flower which has its pollinia in the best state for removal cannot then be fertilized. Generally, old flowers will be fertilized by the pollen of younger flowers, borne, as we shall see, on a separate plant. In conformity with this I observed that the stigmatic surfaces of the older flowers were far more viscid than those of the younger flowers. Nevertheless, a flower which in its early state had not been visited by insects would not necessarily, in its later and more expanded condition, have its pollen wasted; for insects, in inserting and withdrawing their probosces, bow them forwards, and would thus often strike the furrow of the rostellum.

Writing on the faith of other observations, he adds :—

The bees always alighted at the bottom of the spike, and, crawling spirally up it, sucked one flower after another. I believe humble-bees generally act thus when visiting a dense spike of flowers, as it is most convenient for them —in the same manner as a woodpecker always climbs up a tree in search of insects. This seems a most insignificant observation ; but see the result. In the early morning, when the bee starts on her rounds, let us suppose that she alighted on the summit of the spike : she would surely extract the pollinia from the uppermost and last opened flowers ; but when visiting the next succeeding flower, of which the labellum in all probability would not as yet have moved from the column, the pollen masses would often be brushed off her proboscis and be wasted. But Nature suffers no such waste. The bee goes first to the lowest flower ; and, crawling spirally up the spike, effects nothing on the first spike which she visits till she reaches the upper flowers, then she withdraws the pollinia. She soon flies to another plant, and alighting on the lowest and oldest flower, into which there will be a wide passage from the greater reflexion of the labellum, the pollinia will strike the protuberant stigma. If the stigma of the lowest flower has already been fully fertilized, little or no pollen will be left on its dried surface ; but on the next succeeding flower, of which the stigma is viscid, large sheets of pollen will be left. Then, as soon as the bee arrives near the summit of the spike, she will again withdraw fresh pollinia ; will fly to the low flowers on another plant, and fertilize them ; and thus, as she goes her round and adds to her store of honey, she will continually fertilize fresh flowers and perpetuate the race of our autumnal spiranthes, which will yield honey to future generations of bees.

In pursuing his investigations on the mode of fertilization in Orchids, collateral subjects, of course, received their due share of Mr. Darwin's attention, and the "why and wherefore" of all the eccentricities of Orchid-life were boldly faced with the resolution of penetrating to the depth of the mystery. As might have been expected from such an inquirer, much curious investigation and some ingenious theories resulted, and the latter portion of the volume to which we have alluded deals with the following supplementary topics : The ideal type of structure in Orchids, or, as he terms it, "The Homologies of Orchids," on the gradation of organs, and, finally, the deductions to be made from his observations. Briefly, it may be stated, that he regards the typical Orchis flower as consisting of fifteen parts, arranged in five series of three parts in each, three to the sepals ; three to the petals ; six to the stamens, in two series of three in each ; and three to the pistil. In no Orchis are all these parts developed.

Can we (he says) feel satisfied by saying that each Orchid was created exactly as we now see it, on a certain "ideal type ;" that the omnipotent Creator, having fixed on one plan for the whole order, did not please to depart from this plan; that He therefore made the same organ to perform diverse functions (often of trifling importance compared with their proper function), converted other organs into mere purposeless rudiments, and arranged all as if they had to stand separate, and then made them cohere? Is it not a more simple and intelligible view that all Orchids owe what they have in common to descent from some mono-cotyledonous plant, which, like so many other plants of the same division, possessed fifteen organs, arranged alternately, three within three, in five whorls, and that the now wonderfully changed structure of the flower is due to a long course of slow modification; each modification having been preserved which was useful to each plant during the incessant changes to which the organic and the inorganic world has been exposed?

Our space will only permit us to indicate that whilst deductions are made in favour of the theory of "natural selection," the culminating and special deduction of the work is—that throughout this vast order, containing, probably, about six thousand species, the act of fertilization is almost entirely left to insects; that self-fertilization is a rare event; and that, herein, "Nature tells us, in the most emphatic manner, that she abhors perpetual self-fertilization."

Finally, we must briefly allude to Mr. Darwin's discoveries on the fertilization of the Purple Loosestrife. Until recently it was supposed that the relative lengths and characters of the stamens and pistils were approximately permanent in each vegetable species; that, in a certain plant which had the pistil extending beyond the stamens, it might be predicated that in all the flowers of the same species the pistil would be found longer than the stamens and similar in all other respects. Such, however, is not the case. Plants with two forms were discovered, and, at length, Mr. Darwin announced to the Linnean Society that he had found a plant in which three forms existed; this was the common purple loosestrife, *Lythrum Salicaria*. This, however, is only part of the truth, the whole being still more marvellous. In the three forms, all of which contain male and female organs, there are three distinct female and three sets of male organs or stamens, all differing from each other as much as in ordinarily distinct species; and all three forms must necessarily co-exist for the organization of the species to be perfect.

In the accompanying figures (fig. 10) *a* represents the long-styled, *b* the mid-styled, and *c* the short-styled forms. In the long-styled form the pistil is one-third longer than in the mid-styled form and three times as long as that in the short-styled form. The stamens are twelve in each form, in two sets, of six in each set. In the long-styled form the six longer stamens are shorter than the pistil, but extend beyond the mouth of the corolla; the six shorter stamens do not reach to the mouth of the corolla, but are concealed within it. The pollen, in both sets of stamens, is yellow, and the grains are a little larger in the long than in the short stamens. In size, the seeds of this form were larger than in either of the others, so that five seeds of the long-styled form were equal to six of the mid-styled form and seven of the short-styled form.

In the mid-styled form (*b*), the pistil was shorter than the six long stamens and longer than the six short stamens, but it extended beyond the mouth of the corolla. The six short stamens, as in the long-styled form, did not extend beyond the corolla. The six longer stamens had pink filaments, and corresponded in length with the pistil in the long-styled form, whilst the six long stamens, in the long-styled form, corresponded with the pistil in the mid-styled form. The pollen grains of the long stamens in this form were greenish, whilst those of the short stamens were yellow.

In the short-styled form (*c*), the pistil was very short, not extending to the mouth of the corolla, and in length equalling the set of short stamens in each of the preceding forms. The long stamens were of equal length to the long stamens in the mid-styled form and the pistil in the long-styled form, whilst the short stamens were equal to the long stamens in the long-styled form and the pistil in the mid-styled form. In this form all the stamens extended beyond the mouth of the corolla. The filaments of the longer stamens were pink and the pollen greenish, as in the long stamens of the mid-styled form, whilst in their uncoloured filaments and yellow pollen as well as in length, the six shorter stamens corresponded with the long stamens in the long-styled form. All the pistils and stamens, in all three forms, were bent upwards towards their extremities, in a manner corresponding with their length. Hence it will be observed, that there are three distinct female organs, differing in length, curvature, and in the size of the seed. That there are three kinds of stamens: *short*—with white filaments and yellow pollen; *medium*—with white filaments and yellow pollen; *long*—with pink filaments and greenish pollen.

We cannot enter into the more minute particulars of Mr. Darwin's communication, suffice it to say, that from careful experiment he ascertained what the greatest amount of fertility was produced by the union of pollen borne on filaments of an equal length with the pistils fertilized; that is, from the shortest stamens with the shortest pistil, from the longest stamens with the longest pistil, and from the medium stamens with the medium pistil. In all three forms the female organ was but feebly, if at all, influenced by the two kinds of pollen produced in the same flower. So that of eighteen possible unions or crossings between stamens and pistils in the three forms, six were fertile, and twelve, more or less, barren. It is clear, therefore, that for a flower to produce its maximum of good seed it is absolutely essential that the pistil of one flower should be fertilized by the pollen from another, and that unless so crossed little or no good seed is produced. By what agency is this intercrossing effected ? The same reply which Mr. Darwin has furnished in respect to Orchids he again gives for the purple loosestrife, namely, the intervention of insects.

Insects are necessary for the fertilization of this Lythrum. During two years I kept two plants of each form protected, and in the autumn they presented a remarkable contrast in appearance with the adjoining uncovered plants, which were densely covered with capsules. In 1863 a protected long-styled plant produced only five poor capsules ; two mid-styled plants produced the same number ; and two short-styled plants between them produced only one. These capsules contained very few seed ; yet the plants were fully productive when artificially fertilized under the net. In a state of nature the flowers are incessantly visited for their nectar by hive- and humble-bees, and various diptera.

We cannot enter into the details of the mode by which this fertilization is conducted, or how the different points in structure are adapted for the perfect fertilization of the plant, whence our author justifies himself in the conclusion that—

insects, and chiefly bees, act both as general carriers of pollen, and as special carriers of the right kind.

A brief sketch, like the present, cannot do justice to the claims of any author like Mr. Darwin to be regarded as the great stimulator of inquiry and research in a given direction; but we think it will be admitted that no one has done so much of late years for vegetable physiology, and certainly no one has exercised so great an influence upon the current of thought and investigation on the mysteries of species and variation.

EXPLANATION OF PLATE.

Fig. 1. Section of flower of *Orchis mascula*, with floral leaves removed—*l*, labellum ; *n*, nectary ; *s*, stigma ; *r*, rostellum ; *a*, anther.

Fig. 2. Front view of the same flower—letters answering to the same parts.

Fig. 3. Pollinium, removed from its cell—*p*, pollen mass ; *c*, caudicle ; *d*, viscid disc.

Fig. 4. Rostellum, with discs embedded therein and lip depressed—*c*, caudicles ; *r*, rostellum ; *d*, viscid discs.

Fig. 5. Section of Rostellum and enclosed discs—*r*, rostellum ; *d*, disc ; *c*, caudicle.

Fig. 6. Pencil, with Pollinium attached—*a*, when first removed ; *b*, after depression.

Fig. 7. Saddle-shaped Disc of *Orchis pyramidalis*, with pollinia.

Fig. 8. Section of flower of *Spiranthes autumnalis*—the dotted lines indicate the position of the labellum and upper petal.

Fig. 9. Front view of the Stigma and of the Rostellum with embedded disc—*d*.

Fig. 10. Sections of flowers of *Lythrum salicaria*—*a*, long-styled form ; *b*, mid-styled form ; *c*, short-styled form.