D.—On the various contrivances by which British and Foreign Orchids are Fertilised by Insects.

CHAPTER XVII.

(1.) *Structure of an English Orchid.*

THIS work, the third of those to be considered among the publications on the Vegetable Kingdom by Charles Darwin, will for the future be denoted by the briefer title, "Fertilisation of Orchids." To its consideration we now pass. One object of the book is sufficiently indicated by its title. There is design to show the varying method and complex machinery whereby the many Orchids of Great Britain and of the tropical regions are fertilised. But a yet more important object is in view. There is design to show that these methods and this machinery are of such nature that the fertilisation of the ovules of any given flower by the pollen of the same flower is very rare, and that, therefore, as a rule, cross-fertilisation occurs. It will be remembered even by the non-botanical reader that in most flowers there is a female organ, the gynœcium, within whose swollen base (ovary or seed-case) are unripe seeds or ovules. These ovules can never become seeds unless they receive the influence of the pollen or yellow dust contained in the anthers or upper caps of the male organs or stamens. This pollen is carried to the stigma or receptive part of the female structure either by the wind or by insects. Many flowers have the pollen carried to their stigmas by the wind. The grasses or plaintains, for example, with their humble, dingily colored, unscented flowers, destitute of nectar, are not attractive to insects. But their clouds of yellow pollen lodged in anthers borne loosely on the top of long, weak, swaying filaments, and their hairy stigmas, fit them to be fertilised through the agency of the wind. Such plants as these are known as anemophilous or "wind-loving" plants.

On the other hand, many flowers have the pollen carried to their stigmas by insects. The roses or the violets, for example, with their gay, brightly colored, sweetly scented, flowers, nectar-laden, are attractive to insects. Such plants as these are known as "entomophilous," or "insect loving" plants.

Nobody who has seen an Orchid could ever be in doubt as to whether it were an anemophilous or an entomophilous plant. The book under discussion not only demonstrates this fact, but records all the minute and multitudinous adaptations to one end that are encountered in the large number of strange plants that constitute the order Orchidaceæ. Many of the facts known in relation to these plants were not originally discovered by Darwin. These he records together with his own innumerable and incomparable observations, and gives us as result a book, whereof it is inadequate praise to say that it is far more interesting than any novel.

Following the plan of the author, we will study the British Orchids first, and later some of the wonders of their tropical brethren. These notes, like the book itself, will be more intelligible to those who have seen, and far more intelligible to those who have dissected, the flowers to be studied than to the ordinary reader. Yet all will be quite able to follow the account and understand the mechanism of the Orchid who will patiently strive to master the details that follow.

The flowers best known to ordinary observers present outside the male and female organs two circles of protective leaves. The outer of these is the generally green calyx or cup, of sepals. The inner is the generally brightly colored corolla, of petals. Within these are the stamens constituting the male circle or andrœcium, and within these again, in the very heart of the flower, is the gynœcium or circle of female organs. The single female organ is called a carpel. And here may be remarked with great diffidence, as illustration of the height to which looseness of phraseology may reach, that even in "The Fertilisation of Orchids" there occurs confusion more than once between the terms gynœcium (or pistil) and carpels. It is as if a man confused the conduct and nature of a regiment with the nature and conduct of its individual soldiers. The account above given of the arrangement of parts in an ordinary flower, as a rose, will not exactly serve in the description of an Orchid. Let us study together an ordinary British member of the remarkable family, such as the Spotted Orchis that makes gay the face of Sussex Downs and the summits of many a sea-cliff in the south. From a curiously swollen root rises an erect, smooth, stem. On this are several smooth, parallel-veined, spotted leaves, and the summit is crowned with a nearly pyramidal head of many purple flowers. Carefully remove one of the flowers and hold it in the same position as that assumed by it when upon the stem. Apparently, it has a greenish, twisted stalk. Cut horizontally across this supposed stalk. It is full of ovules. This greenish, twisted part is no flower-stalk therefore. It is the lowermost part of the gynœcium. It is the ovary or seed-case. Observe now the structures placed upon the top of this ovary. Arranged in a sort of double circle upon its summit are six purple leaves. These represent the sepals and petals. Their color in itself would be for a lure to insects, but one of them is of such fantastic shape and huge size that it could hardly fail to attract the attention of an insect of the most unobservant nature. This notable leaf is, as you hold the flower now, on the side of the flower nearer to you. But we saw that the greenish ovary was twisted, and a little careful looking at young and old flowers teaches that in the early state this strange leaf is on the upper side of the flower, and that it only comes to be on the lower side through the twisting of the ovary. This odd leaf has received a special name, and considering upon what very small provocation structures are labelled with polysyllabic titles by scientific men, one can hardly wonder at this strange Orchid flower-leaf having a special designation. For, in the first place, it is so much larger than its fellows. Then it has a long spur running down from it, nearly parallel to the twisted ovary. This spur you may be sure contains honey for the visiting insect, and this spur we may call the nectary. Yet, again, the large leaf or labellum is partially lobed or roughly divided into three at its upper part, and this broad, three-lobed region looks a very likely landing-stage for an insect. Nay, in many more complex orchids than the spotted one, this labellum is much more modified, and assumes the very queerest shapes. When you hear in the future of bee, or spider, or fly, or butterfly, or man orchis you may remember that the names of all these are founded upon the odd shapes assumed by their labella.

Now holding the Orchid with its labellum turned towards you, look to the opposite side of the flower within the other flower-leaves. That is, you are to look across the wide three-lobed table-land of the labellum, across the open mouth, that is the opening of the nectary. If the nectary or spur were a precipice, upon your side of the precipice is the table-land of the labellum, and on the other side of the precipice are the structures I wish now to mention. First two shiny, sticky spaces. These are, as it were, on the remote wall of the precipice, not on the very summit. Second, a little shelf projecting out over the opening into the abyss like a ledge, and right in the way of anybody or of anything that might try to pass down into the nectary. Third, towering up from this ledge a large deep-purple two-lobed structure that is the anther, and behind that the flower leaves again. The shiny, sticky spaces you will see are at the top of the twisted ovary and are the stigma. *The pollen will have to be placed upon this ere the ovules in the ovary below will become ripe.* The little shelf or ledge is of the utmost importance. It is really a part of the stigma much altered, and is called the rostellum or little beak. It not only projects over the opening into the nectary, but covers also the base of the purple anther. The anther with its two purple lobes is the last of this strange series of structures. The orchid has only one stamen. If the flower is not very young each of the two purple lobes of the anther will be found to split open along a vertical line all down its front face. Try to find out what may be concealed within those purple anther lobes. The best way to do that is to press the fine point of a pencil against the rostellum, to hold it steadily there, and to wait patiently about twenty seconds. Then draw away the pencil slowly, and if your hand was steady the pencil will be adorned with two curious bodies that you have drawn out of the anther lobes, and that are pollen-masses. Each of them is broad above, where there are many packets of pollen-grains held together by little threads. In the middle part the grains are wanting, and only a thin stalk made of the threads is present. This stalk is the caudicle or little tail. Finally, at the very base is some sticky body, or how could the whole pollinium adhere to your pencil? It may seem strange that these two pollinia were removed by means of pressing the pencil point against the rostellum. But it was noted above that this same rostellum covered the base of the anther, and the pencil rested against and really displaced it and got at the sticky bases of the pollen-masses or pollinia inside the anther lobes. *These pollen-masses must be removed, and their upper portions rich in grains brought into contact with the stigma ere the ovules can be fertilised.*

Even if you have never studied or even perhaps seen an Orchid, you may now be able to picture it to yourself in some degree. You can imagine the smooth, erect stem with the smooth parallel-veined leaves and the crown of purple flowers. You can imagine the flowers very attractive and irregular with the large, lobed, spurred labellum, the one anther with its two purple lobes, each harboring a pollinium. You can picture the pollinium with its broad upper end of packets of pollen grains, its narrow caudicle, its sticky base. There also is the rostellum covering those viscid bases and partly blocking up the entrance into the nectary, and on either side of the rostellum the viscid stigmatic surface, crowning the twisted ovary.

The working of all this complex mechanism will form our next object of study.

CHAPTER XVIII.

(2.) *Action of Parts.*

AS we study the action of the parts of the Orchid flower described in the last chapter, two things especially are to be kept in mind. Of these, one is that Charles Darwin desires to show that Orchids are entomophilous, or are aided by insects in the fertilisation of their flowers. The other is that cross-fertilisation occurs—*i.e.*, the pollen of a given flower is not placed upon the stigma of the same flower but upon that of another of the same kind.

The Orchids attract insects. The particular one selected as type attracts them by its color, its odd shape, and its nectar. Others of its fellows serve as yet more attractive lures to insects ; their strangely-shaped labella assuming the very forms of insect life. Yet others of the order that open in the night rather than in the day have a powerful odor that must be as attractive to night-flying insects as are the colors and shapes of their brethren to the sunlight-haunting butterflies and bees. An insect allured to the Orchid flower lands upon the labellum or specially modified leaf on the lower side of the flower. He passes his proboscis down into the nectary or spur of the labellum, down the "precipice" of the former chapter. It will be remembered that from the wall of that "precipice" opposite to that upon whose summit the insect stands juts out a ledge, the rostellum. The head of the insect must strike against that ledge. The ledge is really a trap-door, with hinges below. It is free at the top, and on the right side, and on the left side. Only attached along its lower edge, this rostellum is depressed by the pressure of the insect head, and the head now rests against whatever may be behind that ledge. But behind the rostellum, as the "pencil experiment" showed, are the bases of the purple anther-lobes and the sticky glands of the pollen-masses. The head of the insect, therefore, rests now against these last. The sticky glands, when exposed to the air as they now are, "set." Liquid at first, contact with the air makes them turn solid and set like a cement. It will be observed that they are setting on the head of the insect. This process requires time, requires many seconds. And this required time is gained by means of a device whose discovery is due to our author entirely. If the honey of the Orchid were free in its spur, so that the proboscis of the insect at once dipped into it and drank it, he would fly away so soon that there would be no time for the sticky parts of the pollen-masses to "set." But Charles Darwin has shown that in the spotted Orchid, and in all its fellows whose glands require time to set, the honey is not free in the tube, but is lodged in the very thickness of the walls of the nectary. To get at its food-supply, therefore, the insect has to bore, perhaps more than once or twice, into the walls of the spur, and all this takes time. It is "pretty to see" that all Orchids whose sticky glands take time to set have the honey in the thickness of the walls of the nectary, and on the other hand that Orchids whose glands adhere at once to any touching body have the honey placed as it is in most flowers, *i.e.*, free in the cavity of the nectary.

Our insect, then, standing upon the broad part of the labellum, pushing down his proboscis into the spur, eating into the wall of that spur, is resting his head against the two sticky glands of the pollen-masses, and these glands are setting on his head. And now, his meal finished, he flies away, and just as your pencil, when withdrawn from the Orchid, carried with it the two pollen-masses, so does the insect head or proboscis carry away the two pollen-masses. The insect flies away bearing, as it were, two new pairs of antennæ. This is no romance. Any student who will watch a bed of Orchids in the flowering time will see them visited by insects, and if he will catch some of the insects after they have left the plants, he will find affixed to their proboscides pollinia. In the "Fertilisation of Orchids" is figured a moth with seven pairs of pollinia attached to it, and reference is made to another insect that was encumbered with no less than thirteen pairs.

Now, however, a difficulty presents itself. The two pollen-masses within their anther-lobes are parallel to each other. When they are removed from the anther-lobes and are affixed to the insect they are still parallel. Suppose our insect goes to another flower, stands again upon the labellum, seeks for nectar in the spur. As his head rests against the rostellum of this new flower, the two pollen-masses will strike against the anther-lobes, and not upon the stigma. They would be placed in exactly the same position as that whence they were removed. No fertilisation could occur.

Try the pencil experiment again. After the pollinia have been removed, watch them carefully. They do not remain in the position that was theirs at first. A slow movement, so slow that it is almost imperceptible, takes place. The broad ends of the pollen-masses, those that are made of packets of pollen-grains, begin to move outwards, downwards, forwards. This mysterious movement—not perceptible in its details, very perceptible and momentous in its results—is due to a tiny piece of membrane attached to the sticky gland, and, in truth, like that, a part of the rostellum. Now gather the full consequences of this movement outwards, downwards, forwards. Had the pollen-masses remained in their original positions, they would have struck against the anther-lobes again as the insect visited the second flower. Now, however, as the insect lands upon the labellum, investigates with his proboscis the interior of the nectary, eats into the walls, his head resting placidly against the new adhesive glands behind the depressed rostellum, the tops of the pollen-masses strike not against the anther-lobes, but against those structures lower and more away from the middle line of the flower, the stigmas. Thus, then, the pollen has been removed by an insect from the anther-lobes of one flower and borne by an insect to the stigma of another flower. This Orchid, at least, is entomophilous and is cross-fertilised.

One further minutia of arrangement. Suppose an insect juvenile, inexperienced, lands upon the labellum and investigates the interior of the nectary. Upon his proboscis, as he feeds, he feels the sticky glands setting. To the young the unusual is the terrific. The frightened insect quits feeding, and ere his repast is ended flies from the flower. He has not allowed the sticky glands sufficient time to set. He flies away pollinialess. The sticky glands of the pollen-masses have been exposed to the air and are setting uselessly? Not so. For the depressed rostellum, unlike most things when depressed, is elastic, and, springing into place again, keeps the glands of the pollen-masses from the air, and gives them the opportunity of retaining their moist condition The slimy stigma surface, moreover, is also viscid. Hence it detaches but a few pollen-grains from each pollen-mass, leaving the bulk of the grains still untouched and ready to fertilise the flower next visited.

And now, in all this exquisite adaptation of means to end, in this wondrous arrangement of atttractive flower leaves, of hidden nectar, of sticky bases of pollinia, of contractile pieces of membrane, of consequently moving pollen-masses, of elastic and depressable rostellum, and of viscid stigma, do we not see the marvellous power of nature and her no less marvellous patience? To think that all this has slowly evolved—not magically and at a word sprung into being—has, during the course of many centuries, been developed piece by piece, taking time in its growth by the side whereof man's little life is but a moment, fills us with awe and with heartfelt longing to understand more of these regular successions of events that we name "laws." These laws, that have been at work before man or god existed, and shall endure when gods are no more, perhaps for longer time than even life itself—aye, they are worth the study.

The arrangement of parts and the working of parts just described hold true in the main, not only for the *Orchis maculata* or Spotted Orchis, but in four other species of the same genus, and also for the Man Orchis, which is placed, probably unwisely, in a separate genus. Only in the Man Orchis the two sticky glands of the pollen-masses are very close together and present an interesting gradation towards the condition met with in yet another Orchid where the two become one. And, at the risk of wearying the reader, reference must be made to another series of gradations in the stigma structure. In the Spotted Orchis this organ is single, but slightly lobed. In the *Orchis mascula* it is clearly bi-lobed. In *Orchis ustulata* it is nearly double, and in the last Orchid to be studied it is quite double. That last Orchid is the pyramidal Orchid.

In this plant the general arrangement is as in those already described, but the following points of difference obtain. The labellum has two ridges that serve as guides to the proboscis of the insect and insist upon its going straight down the nectary, turning neither to the right hand nor to the left. The two pollen-masses are united at the base in a sort of saddle-shaped structure whose *under* side is adhesive. This sticking to a proboscis, the saddle so contracts as to make the pollen-masses sweep outwards and downwards only. Then later on a second movement forwards takes place and the two masses are aptly placed to hit the stigmas As we said above, the stigma is double.

The arrangements met with in the curiously modified fly, spider, bee, and frog orchids will next claim our attention.

CHAPTER XIX.

(3.) *Other British Orchids.*

IN the British orchids that are next to be studied we have to do with members of a genus other than that last considered. The genus now to be considered is the genus Ophrys. It must be quite understood that the plants to be described are of the order Orchidaceæ, and come under the general name of Orchids, but they belong botanically to a group different from that known as the genus Orchis. That group is the genus Ophrys.

All members of the genus Ophrys have two separate rostella. No longer have the anther-lobes one common trap-door covering their bases. Each anther-lobe with its included sticky gland forming the lowest point of the pollinium, has its own covering. A double ledge, therefore, projects out over the opening leading to the nectary.

(*a*) *Fly Orchis (Ophrys muscifera).*—This plant with its strange resemblance to the insect whose name it bears, has no nectary and apparently no nectar. Still its shape must be attractive to insects, and there is evidence and to spare that insects do visit the Fly-orchis. On the labellum, just where it joins the rest of the flower, are two shiny knobs. They contain no honey, but they may be attractive to and deceptive of insects. Sprengel, a great German Botanist, believes in "false nectaries," and these may be of that ilk. The caudicle or stalk of conjoined threads of the pollen-mass is in the Fly Orchis bent twice at nearly a right angle. As a consequence the remarkable movement of the pollen-masses described in Orchis is not required here, and moreover is not encountered. The double bend is of such nature that an insect crawling along the labellum and bending towards the shiny "false nectaries" must strike the pollen-grains that form the summit of the pollen-mass against the viscid stigma.

(*b*) *Spider Orchis (Ophrys aranifera).*—The caudicle of each pollen-mass is bent twice, but not nearly so much at right angles as in the last plant. The movement of depression does take place in this case, and is necessary to bring the pollen-grains ultimately into contact with the stigma. The anther-lobes in the "Spider" are widely open, and this is an interesting gradation towards the condition met with in the next plant.

(*c*) *Bee Orchis (Ophrys apifera).*—This lovely flower, that the dwellers in Cowes, Isle of Wight, can find growing out at "Egypt," has long, weak caudicles, and its anther-lobes, intensifying that which is seen in lesser degree in the Spider Orchis, open so widely that the heavy, upper pollen-masses fall out, and while the sticky glands remain in their places below, the pollen-heads are driven by the wind against the viscid stigma in front of which they are now dangling. Here, then, is an elaborate arrangement for self-fertilisation, and yet there are in the plant, despite all this, so many arrangements that in other flowers allied to it are clearly of use for cross-fertilisation, that it seems reasonable to suppose that at least occasionally cross-fertilisation may take place. Unless this be so, the bee-like aspect, the depressable rostellum, the viscid lower parts of the pollinia, the movement of depression that does occur if they are removed, the elastic threads, the viscid stigma are in the main incomprehensible. Charles Darwin asks : "Are we to believe that these contrivances in the Bee Orchis are absolutely purposeless, as would certainly be the case if the species is perpetually self-fertilised ?" Venturing to suggest for the words "contrivances" and "purposeless" the substitutes "structures" and "resultless," we may repeat the question, and the answer of those who believe in the gradual evolution of organs and organisms, and the survival only of that which is of value to the possessor, must be in the negative.

(*d*) *Musk Orchis (Herminium monorchis.)*—The name of this plant tells of its attraction to insects. The tiny flowers have a strong, musky odor. There is no nectar. The sticky gland is helmet-shaped. The head or body of the insect strikes into the hollow of the sticky gland, as the head of the warrior fits into the helmet, and removes the whole pollinium. The caudicle is fixed, not to the apex of the helmet, but to the hinder end, and there is a necessary movement of depression after removal from the anther-lobes.

(*e*) *Frog Orchis (Peristylus viridis)*.—A very short nectary is seen in the Frog Orchis, and also two curious spots that secrete nectar. Now the opening into the nectary is very small, and is exactly in the middle line of the labellum. The two spots that form nectar drops are on the base of the labellum, one on each side of the middle line and immediately beneath the two rostella, behind which are the sticky glands. Further, running along the middle line of the labellum is a ridge that would be very uncomfortable for an insect. Hence the insect alights on the labellum to one side of this uncomfortable ridge, takes the nectar drop of that side, strikes against the rostellum of that side and removes the pollinium of that side. If, then, it goes to the opening of the short nectary in the middle line, it must strike the pollinium against the stigma, whose position is such that no movement of depression is needed. This would lead to self-fertilisation if both anther and stigma were ripe at the same time. But if the insect, disregarding any little inconvenience, went first to the richer supply of nectar in the median nectary and then to the side drops, he would carry away, whilst taking the latter, the pollen-mass of that flower to fertilise the stigma of the next one he visited.

(*f*) *Fragrant Orchid (Gymnadenia Conopsea)*.—Sweet-smelling, nectar-laden flowers, whose sticky glands are never covered by a rostellum at all. The caudicles and pollen-grains at the summits are covered by the anther-lobes and kept from air, but the sticky bases are exposed. A moth can carry away the pollinia, therefore, but as the sticky glands never "set," the first contact of the pollen-grains with a stigma, after the caudicles now exposed to the air have moved downwards, would result in the dragging away of the whole mass. This is obviated by the elastic threads that hold together the packets of pollen-grains being very weak. They allow the removal of some of those grains without the sticky non-setting gland being removed from the head of the insect.

(*g*) *Butterfly Orchis (Habenaria chlorantha)*.—White and of strong odor, with a long, richly laden nectary, this flower is very attractive to moths rather than to butterflies. The sticky gland in the Butterfly Orchis is not joined at once to the caudicle, as in all those hitherto studied, but has between it and the caudicle a little round stalk, shaped like a small side-drum. This serves to push the sticky part very prominently in the way of an investigating insect's head, and the necessary movement of the pollen-mass is effected, not by the caudicle, but by the drum-like stalk.

We now pass to a second tribe of the order Orchidaceæ Having considered the Ophreæ from the Spotted Orchis to the Butterfly, we turn to the Neotteæ. Here are no caudicles—*i.e.*, no little stalks of threads destitute of grains of pollen. The pollen grains of the uppermost part of the pollinia are no longer in large packets, but are held together, often in groups of four, by elastic threads. These threads finally project beyond the region of the pollen-grains, cohering with each other and generally becoming joined to the rostellum.

(*h*) *Marsh Epipactis (Epipactis palustris).*—The labellum is of two parts: (i.) the more prominent part that offers an excellent landing stage for insects and is joined on to (ii.) the basal part or nectary. In the normal position (i.) is partly enclosed within the edges of (ii.), and the entrance into the flower is minute. But even the weight of a fly will depress (i.), so delicate is the hinge between the two parts, and the insect can pass into the flower. As soon, however, as it has passed beyond the hinge the part (i.) springs up again, and our insect will have to force its way out of the flower backwards. Ere its entry, the elastic threads of the pollinia that project have become joined to the rostellum, and then the rostellum has undergone a curious movement forwards that serves to draw the pollen-masses out of their anther-lobes. Further, the front face of the rostellum has become exceedingly delicate, and at the lightest touch will rupture and present a sticky surface, whilst the very tiptop of the anther is destitute of pollen-grains and projects as a blunt point. How does all this act? An insect landing on the part (i.) of the labellum nearest to him depresses it by his weight. The entry into the flower is easy. He crawls in, and, feasting upon the nectar in part (ii.) of the labellum, the landing stage closes in behind him and he is a prisoner in the flower. When he has got all he can out of the flower he proceeds, man-fashion, to desert it. Struggling out backwards, his head strikes the rostellum for the first time, ruptures it, exposes the sticky part, draws that away, and with it the conjoined threads and the pollen-grains to which they are attached. As he thus struggles, part of his back presses against the projecting, blunt, grain-empty top of the anther and "eases" the anther-lobes. Thus the exit thence of the pollen masses already partly withdrawn by the forward movement of the rostellum is rendered much more easy. Visiting thereafter another flower, the part (i.) of its labellum is again depressed by his weight and an easy entrance is left for him and his attendant pollen-masses. This is of value, as the pollen is so friable that were it to strike against the leaves of the flower it would be scattered and lost. As the insect enters, these pollen-masses strike upon the stigma which projects further forwards than the anther-lobes or even than the rostellum, and, once again, cross-fertilisation by insect aid is effected.

(i) Helleborine (Epipactis latifolia).—As the last, save that the blunt tip of the anther does not appear to serve the same office of "easing" the anther-lobes, as the insect's back does not appear to press against it as he backs out of the flower.

(i) White Helleborine (Cephalanthera grandiflora.)—The part of the labellum nearest an approaching insect and furthest from the stamen is hinged on to the rest. At first it is erect and keeps the flower closed. As soon as the organs of reproduction are ripe, this hinged portion bends down and affords a landing-stage for insects. Then, later on, it rises into its former position and the flower is closed again. Further, the pollen-masses in this plant, standing immediately behind the stigmas, emit certain pollen-tubes from some of the grains, that penetrate into the substance of the stigma, and doubtless serve for self-fertilisation. After this penetration by some pollen-tubes the stigma moves forwards, partially withdrawing the pollen-masses from out the anther-lobes. The erect position of the petals of the flower guards these pollen-masses from the wind, that but for the petals would infallibly blow them out of the flower.

(k) Ladies' tresses (Spiranthes autumnalis).—The labellum in this plant is channelled down the middle, and thus the

insect is guided to the opening of the nectary. It has a fringed landing-stage, at first in such a position that there is but the very narrowest aperture into the flower. Later, the labellum moves further away and leaves a wider opening. This slight movement is essential for the fertilisation of the plant. Within the rostellum is a structure exactly like a boat standing erect on end. This boat has a cargo of sticky matter, and is about 1-25th of an inch long and 1-100th of an inch broad. The front face of the rostellum quite covers over the front of the boat, and is, as it were, a vertical deck to the viscid cargo. Now the front face of the rostellum is strangely sensitive, and on the slightest touch splits in such manner as to completely free the erect boat of its cargo. Below this complex rostellum lies the stigma, and from it runs on each side a membrane up to the anther above. These two membranes protect additionally the pollen-masses and form the clinandrum (from *κλίνη*, bed) or bed of the anther. The action of all these parts is as follows. A bee visiting a flower whose anther is ready for work finds the labellum in such position that only a very narrow channel is left leading into the flower. Even as the bee's proboscis passes down this channel the rostellum must be touched. That strange, sudden rupture occurs, and the boat is free. Its viscid matter sets upon the insect head, and the pollen-masses are withdrawn as the insect flies away. Journeying to a flower a little more advanced in hours, our bee finds the labellum has shifted further away from the rest of the flower. The entrance is now easy, and the pollen-masses from the younger blossom carried into the interior of the older, now strike against the stigma. The flower is cross-fertilised by the aid of insects. The Ladies' Tresses grows in spikes of flowers, and the bees always begin at the lowest flower and work steadily upwards. The result of this constant habit is of the greatest importance. I quote from our author:—"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 (for this is slowly and very gradually effected), the pollen-masses would be often 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 fertilised, 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 lower flowers on another plant and fertilise them; and thus, as she goes her rounds and adds to her store of honey, she will continually fertilise fresh flowers, and perpetuate the race of our autumnal Spiranthes, which will yield honey to future generations of bees."

(l) (Goodyera repens.)—A rare and deeply interesting little plant found in the Highlands: interesting as a link between many different kinds of Orchids. For, placed among the tribe known as the Neotteæ, whose members are destitute of caudicles, it has rudiments of those organs. Again, it only of its tribe has the pollen-grains in packets. The breadth of the filament of the stamen allies it to Cephalanthera: the structure of its rostellum and the shape of its labellum to Epipactis: the possession of a clinandrum to Spiranthes.

Of British Orchids only two of note remain for consideration. Neither of these has the rostellum attached permanently to the pollinia.

(*m*) *Bog Orchis* (*Malaxis paludosa.*)—This is the smallest of British Orchids and one of the rarest. It differs from other members of the order in having its labellum upturned and in other leaves of the flower being bent back as if to atone for the conduct of the labellum and allow room for the insect to visit the flower. The position of the labellum on the upperside of the flower is due to the twisted ovary having twisted just twice as much as it usually does. On the crest of the rostellum is to be seen a drop of viscid matter. As the anther-lobes behind the rostellum shrivel down and leave their contained pollen-masses free, the upper ends of these are caught by this sticky drop on the crest of the rostellum. They are thus held, and are sheltered from the wind by the two membranes running from stigma to anther, one on each side, and known as the clinandrum. An insect inserting its proboscis into the flower between the labellum and the rostellum must touch the sticky drop on the crest of the rostellum and remove it and the pollinia it has caught. These pollinia are loose, and naturally, drooping from the insect head, on its visiting another flower are deposited within the "waistcoat-pocket" structure at the base of the rostellum, that is the stigma. Once more the plant is cross-fertilised by insect aid.

(*n*) *Tway-blade* (*Listera ovata.*)—The labellum is very long and bent vertically downwards. It has a furrow whose borders secrete much honey. This furrow attracts and guides the insect straight up the middle of the long labellum. When he reaches its summit his head strikes the rostellum, which is in the Tway-blade greatly arched forwards. On the back of the rostellum lie the two pollinia. The position here of rostellum and pollinia, it will be observed, is very different from that to be seen in most Orchids. In those already studied the anther, with its contained pollen-masses, was erect, and the rostellum was vertically below the anther. In Listera the rostellum is nearly horizontal, and so is the anther. The pollinia escaping from the anther-lobes lie loosely on the rostellum. Now, when the insect head strikes the rostellum the latter explodes and gives forth two drops of sticky fluid, which catch at one and the same time the pollinia and the head of the insect. The insect flies away bearing the pollinia, and passing to an older flower fertilises that. Some remarkable movements backwards and forwards of the rostellum aid and are indeed essential to the cross fertilisation thus effected. Thus, when first the pollen-masses quitting the anther-lobes rest on the back of the rostellum, the latter slowly moves downwards and thus avoids the risk of its explosion of viscid drops catching the anther as well as the pollinia. This downward movement also brings the rostellum into admirable position for the insect head to strike it. Again, after the explosion the rostellum suddenly curves yet further downwards and covers the stigma below, so as to prevent self-fertilisation, and a little later it moves back again, further back, indeed, than its former position, and leaves the stigma quite uncovered and *now* viscid to be impregnated.

CHAPTER XX.

(4.) *Foreign Orchids.*

THE various Orchids that grow in Great Britain have now been studied under the guidance of the great teacher. He leads us next to the contemplation of those Orchids known to most of us as existent in hot-houses, but growing wild and abundant in tropical lands. These natives of climes far hence, where the temperature is higher and nature in all ways more prodigal, would not be likely to be inferior in wonder and in strange structures and devices to their brethren growing beneath a cooler sky.

To understand fully that which follows it will be necessary to remember that there are in the great natural order, Orchidaceæ, seven divisions or tribes. These are:—(*a*) Malaxeæ, whose pollinia have no caudicle; one member of this tribe, the Bog Malaxis, has already been studied. (*b*) Epidendreæ, whose pollinia have caudicles that are free below and not attached to any part of the rostellum: the well-known foreign Orchid, the Cattleya, is an example. (*c*) Vandeæ, whose caudicles are attached to the rostellum but not to the sticky part or "gland" directly: there is in this tribe a sticky gland, but interposed between the gland and the caudicle or stalk of the pollen-mass is a portion of the rostellum not viscid: example, Catasetum. (*d*) Ophreæ, with caudicles attached at once to the viscid gland, with no intervening non-viscid part: our own British Orchids are illustrations. (*e*) Arethuseæ, with hinged or opercular anthers; example, Vanilla, dear to the lovers of sweets. (*f*) Neotteæ, no caudicles, anthers dorsal: example, Spiranthes. (*g*) Cypripedieæ, including only one genus, Cypripedium, differing from all others in having two stamens instead of one. Our British Orchids belong for the most part to the divisions (*d*) and (*f*), the two great tribes Ophreæ and Neotteæ. The foreign Orchids come in the main under the other five groups.

Arranging these in tabular form we have:—

ORCHIDACEÆ—

			Tribe.	*Example.*
One stamen.	Pollen in waxy masses... ...	Without caudicles	Malaxeæ ...	Malaxis.
		With free caudicles	Epidendreæ.	Cattleya.
		Caudicles attached to rostellum ...	Vandeæ ...	Catasetum.
	Pollen powdery or with threads	Caudicles attached to glands... ...	Ophreæ ...	Orchis.
		With caudicles—anthers hinged .	Arethuseæ..	Vanilla.
		Without caudicles	Neotteæ ...	Spiranthes.
Two stamens			Cypripedieæ	Cypripedium

The two tribes Ophreæ and Neotteæ have been fully considered. Of the Arethuseæ Darwin had not up to the time of the issue of his book dissected any member. A brief account of each of the other tribes will finish the history of the individual plants of this remarkable order.

(*a*) *Malaxeæ.*—(i.) *Masdevallia fenestrata.* A strange case of a flower completely closed, save for two tiny windows in the sides. These two windows show how essential are insects to the fertilisation of Orchids. That they enter at the windows there can be little doubt. As to what they do inside the dark room where the furrowed labellum, the rostellum and the caudicles wait for them, not even Charles Darwin can tell at present.

(ii.) *Bulbophyllum.*—The labellum is joined to the rest of the flower by a very narrow elastic strap, and thus, under the influence of the lightest breeze, performs a movement so eccentric that even our great philosopher uses the word "waggle" to describe it. As the flowers are dull in color, small, inodorous, the waggling is of use in attracting insects. The rostellum becomes viscid, and insects, in withdrawing from the flower, force the viscid matter up into the anther above and catch the pollinia. These are thus borne away, and on visiting another flower *one* only of the pollinia fits exactly into the oval opening of the stigmatic room.

(iii.) *Dendrobium.*—This flower has the parts arranged from above downwards as follows: (α) An anther with a long, elastic filament compressed like a spring and pressing the anther down against (β) the sloping clinandrum: (γ) the rostellum viscid and milky: (δ) the stigma. The labellum includes and faces all these, and the part of it opposite the stigma is curiously thickened. A retreating insect forces the viscid matter from the rostellum into the anther and *generally* carries away the two pollinia. If he fails to carry them off, the elastic filament, released during the retreat of the insect, flings the anther forward over the rostellum, flings the two pollinia out of the anther-lobes on to the thickened part of the labellum, whence they rebound on to the stigma, and self-fertilisation occurs.

(*b*) *Epidendreæ.*—(i.) *Cattleya.* The rostellum above the stigma and below the anther is broad, tongue-shaped, viscid. The pollinia have caudicles that lie outside the anther-lobes and on the upper part of the rostellum. A humble bee passing into the flower of Cattleya would depress the tongue-shaped rostellum, and as the bee withdrew, the rostellum would be upturned, its viscid matter forced over edges and sides and into the anther, glueing the free, protruding tips of the pollinia to the retreating humble bee. Thus the insect would carry away the pollinia, one whereof, on its visit to the next flower, would strike the sticky stigma below the rostellum, and once again an Orchid would be cross-fertilised through insect-agency.

(*c*) *Vandeæ.* (i.) Generally. In this tribe the caudicles within the anther-lobes are attached to the sticky gland or disc through the medium of a non-sticky part of the rostellum which, following Charles Darwin, we will call the pedicel. Three parts will be removed by insects, therefore; (*α*) the sticky part or disc (*β*) the non-sticky part of the rostellum or pedicel (*γ*) the caudicles carrying the pollen-masses.

(*α*) The disc is with one exception single and not enclosed.

(*β*) The pedicel. Its length in many cases is exquisitely related to the depth of the stigmatic room into which the pollen-masses are to be inserted. In a few cases, however, where the pedicel is long and the stigmatic room is shallow, compensating actions are encountered. These compensating actions take these forms. 1. Depression of the pollinium forwards like that which occurs in most of our British Orchids, and due to the contraction of the viscid disc. 2. Sudden bending backwards of the *pedicel* at about its middle point (*Maxillaria ornithorhynca*). 3. Elasticity of the pedicel, which originally fastened down in a straight line with disc at one end and anther at the other, springs up on removal into a position at right angles to the disc (*Oncidium*). 4. Curving of the pedicel whereby the originally straight pedicel presents a straight portion at each end with a curved intermediate part convex upwards. This curved median portion, resting on the ledge of the deep cavity of the stigma, enables the supported pollen-masses to be easily dropped into the depths of the cavity (*Phalænopsis*). 5. Reflexion of the pollinia from the sloping sides of the rostellum on to the stigmas. This occurs in Calanthe. In this Orchid the pedicel is wanting and the pollen-masses, eight in each anther-lobe, are attached at once to and radiate from the viscid disc. After removal by insect agency from one flower, and upon introduction into another flower of the same species, these radiating pollinia, striking against the sloping sides of the rostellum, glance off on to the lateral stigmas.

(γ) The strength of the caudicles and the length to which they can be stretched without rupturing is very remarkable in many of the Vandeæ. For some little time these facts were a puzzle to our investigator, for in the Vandeæ the pollen balls have to be detached and left on the surface of the stigma as wholes, not as parts. A few grains cannot in these plants be detached at a time as they can be in our British orchids. Many experiments in which the observer introduced the pollen-masses into the stigma room, allowed them to remain there, and then slowly withdrew the disc and the pedicel, all gave the same result. There was much stretching of the caudicles, but no rupture, and no fertilisation therefore by abandoned pollen-masses. At last it struck the naturalist that an insect in quitting the flower would not fly directly upwards and lift the pollinia out of the stigmatic room. He would be more likely to fly away in a nearly horizontal direction, and drag out the pollinia over the edge of the cavity. When the experiment was made after this fashion the stretched caudicles rubbing against the edge of the stigma room ruptured, and left the pollinia behind in the depths of the room.

One special genus and one special family of the Vandeæ remain for special consideration. The genus is Acropera, and the family Catasetidæ.

(ii.) *Acropera* was for long a subject of trouble. In the first place the mouth of the stigma room was so small in all the plants examined by Darwin that the pollen-masses could only with great difficulty be forced into the chamber. On the other hand, the small disc, the long, thin pedicel, the depression of the pollinia, all indicated relationships to a large stigma cavity low down. After much anxiety, it occurred to Charles Darwin that perhaps the Acroperæ he had studied were in function unisexual and not bisexual, *i.e.*, were in function only males, and not both male and female. Careful investigation confirmed this view. The surface of the stigma was found to be scarcely at all viscid: the cells making up the substance of the stigma were empty of protoplasm. The ovules or unripe seeds on the placenta-cords in the ovary or seed-case were replaced by rudimentary structures, quite useless in the reproduction of the plant.

(iii.) *Catasetidæ.*—The most remarkable of all the members of the remarkable order Orchidaceæ. With the genus Catasetum two other genera are very closely allied, Monachanthus and Myanthus: two other genera are less closely allied, Mormodes and Cycnoches.

(*a*) *Catasetum.*—The most reptilian in aspect of all known plants. The flowers are very large, of hue partly coppery, partly orange. The labellum is proportionately large and is fringed at the free end, whilst the attached end is scooped out into a chasm-like hollow, whose walls are thick, fleshy, sweet, nutritious. The rostellum is large and protuberant, and most remarkable of all, is prolonged below into two huge curved, tapering horns, free everywhere save at their points of attachment to the main body of the rostellum. These strange horns, called by Darwin antennæ, are tubular, and through the medium of two little fringes of membrane, are in direct structural continuity with the viscid discs of the pollinia above. The left-hand one of the two antennæ bends upwards at its free extremity, so that the tip is just in the middle line and guards the entrance into the chasm-like hollow of the labellum. The tip of the right-hand antenna is turned a little outwards. The pollinia have very large viscid discs, but these discs are so placed that they cannot possibly be touched by any part of the body of any animal visiting the flower. They are turned inwards into a chamber that is homologically the stigmatic room. The pedicel attached below to the enclosed viscid disc may be traced upwards over the front face of the curved protuberant rostellum into continuity with the pollen-mass enclosed in the anther-lobe. The pedicel is, therefore, fastened down in a curved position. Before considering the action of the various parts in this complex arrangement, the statement must be made that the three species of the genus Catasetum —viz., *C. saccatum*, *callosum*, *tridentatum*—are like the Acropera, males, that Monachanthus is the female form corresponding to these males, and finally, that Myanthus is the bisexual form corresponding in other respects with both these last. In reality, therefore, these three genera are different sexual forms of the same plant. The male form is Catasetum: the female form is Monachanthus: the bisexual form, wherein both male and female organs appear and function, is Myanthus.

Let us now see how Catasetum works. An insect attracted by the lurid aspect of its flowers makes for the thick, fleshy, sweet, nutritious walls of the chasm-like hollow of the labellum. The tip of the left-hand horn of the rostellum (the antenna) must be struck by the insect's head or body. The horn is marvellously sensitive, and the moment it is touched it transmits the stimulus up through the fringe of membrane to the pollinium above. The edges of the disc under this transmitted stimulus at once rupture. The disc is now free. The curved elastic pedicel fastened down originally over the protuberant rostellum is now freed below. It jerks the heavy disc forwards out of the functionless stigmatic room with such force, that the pollen-masses are dragged out of the anther-lobes, and the two whole pollinia, consisting of viscid disc, pedicel and pollen, are thrown with the viscid disc forward on to the insect's head or body. The insect flying from the male or the Catasetum visits sooner or later the female (Monachanthus), or the bisexual Myanthus. In either case the pollen will be left on the viscid surface of a functionally active stigma, and once again cross-fertilisation by insect agency will be effected.

(β) *Mormodes* has an arrangement of pollinia nearly identical with that of Catasetum. But no antennæ are present in Mormodes. The method in which its elastic pedicel is freed is as follows. The labellum, whose stalk is sweet to the taste, is turned upwards into an erect position, and is firmly pressed against the column formed of the stamen and gynœcium. The column is so arranged as to face the side of the flower, and not the front as in all other Orchids. Columns of successive flowers face alternately right and left. The position of parts is of great importance, as otherwise there would have been a want of space for the outthrowing of the pollinia. Lastly, there is near the top of the anther a little sensitive hinge. The action of the parts is on this wise. An insect lands on the top of the erect upturned labellum, and leans over to gnaw the sweet stalk and the equally sweet swollen bases of the other leaves of the flower. The weight and movements of the insect, and the actual pressure of his legs in his efforts after the edible, would indirectly or directly communicate pressure to the sensitive hinge of the anther, and the pollinia would be at once ejected, viscid disc foremost on to his body.

Divisions *d*, *e*, *f*, have already been considered.

(g) Cypripedieæ.—The labellum is in the Cypripedium strangely folded upon itself, and gives rise to the plant's common name of Ladies' Slipper. The one stamen of other Orchids is here rudimentary, and two others are developed. The pollen is, in this genus alone, glutinous. The rostellum is replaced by a third true stigma, and the three stigmas are rather convex and in this genus only not viscid. An insect entering the labellum by the median slit in its dorsal aspect, and seeking the more palatable parts in front, must crawl round by the side passages and over the two side anthers. In doing thus he will be smeared with the glutinous pollen. If he pursue his investigations yet further he will smear some of the pollen off upon the convex stigma, and if that organ be ripe self-fertilisation will occur. If, however, he make his exit without going the whole length of the labellum and visit another Cypripedium whose stigma is ripe, cross-fertilisation may take place.

We have now studied all the various forms of Orchids dealt with in the "Fertilisation of Orchids." One more chapter will be devoted to certain general matters in connexion with these remarkable plants, such as the honey secretion and the effect of the plants upon the insects, and then we shall pass to the consideration of yet another of the botanical works of Charles Darwin.

CHAPTER XXI.

(5.) *General facts.*

IN this, the last chapter on the Orchids, and the last, indeed, upon the most remarkable of the works on Botany that have come from the pen of Charles Darwin, it is proposed to take up one or two points of general interest in regard to the structure and actions of Orchids. We have studied all the chief plants of this wonderful order, perhaps in almost too great detail. It will be well now to conclude our account of them by taking up points that concern the whole series, not individuals only. The sepals and petals, the sources of attraction to insects, the rostellum, the movements of the pollen-masses, the homologies of the different parts of the flower, these call for a few words.

(*a*) *Sepals and Petals.*—These, generally highly colored, are attractive to insects possibly at considerable distance. They protect the parts within, and in many cases are so placed that they serve as a guide to the insect visiting the flower, and ensure the insertion of the proboscis into the nectar-place. Foremost in interest amongst these flower-leaves ranks the strangely modified petal called the labellum. Fantastic enough are the shapes it assumes, and far more attractive must it be than all the rest of the flower. Broad and lobed in most cases, it not only attracts. It affords a landing-stage for insects. Often it is grooved or ridged so as to guide the proboscis. Its elasticity in some cases as Epipactis, its odd folding upon itself in others as Cypripedium, its movements from and towards the rest of the flower, all help in the fertilisation and in the cross-fertilisation of the plants.

(*b*) *The Sources of Attraction to Insects.*—We have seen that the bright colors and odd shapes of these flowers serve to excite the curiosity and to determine the direction of the flight of insects. But there are other sources of attraction.

In the night-flowering Orchids the dull, musky odor aids. Nectar and edible portions of the flower do their work in yet other members of the order. These attractive causes may be grouped thus: (i.) Shape, (ii.) Color, (iii.) Odor, (iv.) Food. The food may be liquid, as in the nectar flowers, or solid. Hence our fourth division falls again into two groups: (a) Liquid food or nectar. On the whole this honey is secreted by the labellum, and generally by some part of its base. In one genus, Coryanthes, the base of the labellum is provided with two small horns, from whose tips the secreted nectar drips down into a sort of bucket formed for its reception by the rest of the labellum. In Vanilla, the base of the ovary where it joins the stalk of the plant is sweet. In Cypripedium the honey is formed by the hairs that are on the surface of the labellum. In some of our British Orchids the fluid is loose in the tube of this remarkable organ, and can at once be devoured, and in these the "setting" of the sticky glands takes place at once. In others the nectar is in the very thickness of the walls of the tube or spur, and can only be obtained by the insect gnawing into those walls. This process takes time, and the "setting" of the sticky glands in these particular Orchids and in these alone requires time. Lastly, in Sarcanthus both these two last conditions are encountered, and nectar is found free in the spur, and also imprisoned in the substance of the walls of the spur. (β) Solid food. This is seen in the form of certain edible portions of the flower, and generally of the labellum. On the labellum of the reptilian lurid-looking Catasetum are excrescences that are sweet to the taste. On that of Calanthe is a cluster of round little warts, and in Eulophia are fringed ridges, and these warts and ridges would seem to be edible and attractive.

(c) *The rostellum.*—This organ plays a very important part in the life-history of almost all Orchids. It is the middle one of the three stigmas. The two side stigmas remain normal and receptive of pollen. The median stigma becomes modified to form the rostellum. In no other known plants is there a structure akin to the rostellum of Orchids. It secretes viscid or sticky matter. So in less degree do the two side stigmas. But whilst the two side stigmas are thus enabled to attach to themselves the pollen grains brought by insects, the sticky part of the rostellum causes the pollen masses to adhere to the body of the insect. Very various as are the aspects under which this organ presents itself, they are all connected by many minute gradations. From the tiny oval piece of membrane to which the caudicle of Orchis adheres up to the gigantic disk and pedicel and antennæ of Catasetum every gradation can be traced.

(*d*) *The movements of the pollinia.*—It will be remembered that in many cases when pollen masses have been withdrawn from the anther of a particular flower by the insect, they are in such a position as to render fertilisation of that or of any other flower out of the question. In those cases a slow movement of the pollen-masses is observed that at last places them in such a position that on the next visit to an Orchid of the same species as that whence the pollinia were taken the pollen grains are brought into contact with the viscid surface of the stigmas. The movement is always due to the contraction of a piece of the rostellum. Sometimes as in the Orchis, the piece is very minute. Sometimes, as with the huge "pedicel," drum-like in shape, of the Butterfly-Orchis a large portion undergoes contraction. The movement is in the main hygrometric (from ὑγρος, moisture, and μετρον, a measure), that is, it is due to drying up and consequent contraction of certain moist parts.

(*e*) *The homologies of the different parts of the flower.*—Homology is likeness in structure, not necessarily in function. Parts that are built upon the same model are homologous. Parts that perform similar functions are analogous. Arm and leg in man are instances of homologues. Bones, muscles, arteries, veins, nerves are alike in each. But arm and leg are not analogues. Their functions are not similar. The lungs of a man and the gills of a fish are analogues, for they perform the same office, that of respiration. They are not, however, alike in structure. The extraordinary flower of the Orchid, with its labellum and single stamen and clinandrum, presents a curious problem to the student. How to reconcile all these queer parts and arrangements with the ordinary type of flowers that belong to the same great class as the Orchidaceæ? Lilies and Irises are normal enough with their six flower-leaves, six stamens, and three carpels. Where are these parts or their homologues in the Orchid? By most patient dissection and observation Charles Darwin has answered this enquiry. To account for the six flower-leaves is not difficult. They are there, the whole six. Truly one of them is very much modified into the middle part of the labellum, but they are all to be seen. Only the middle part of this curious landing place is true petal. The two side pieces will be accounted for directly.

Let us see what has become of the six stamens that are typically present in the great class Monocotyledones. The six stamens in the Lily, the Iris and other plants are in two sets of three, an outer and an inner. Of the outer three, in Orchids one only develops into a pollen-bearing stamen. The single stamen so often mentioned belongs to this outer set of three. Its two companions are modified to form the two side-pieces of the labellum. So that the labellum really is made of one petal forming the central part of that oddly-shaped organ and of two stamens belonging to the outer trio and forming the two side-pieces of the labellum. What is the fate of the three inner stamens? Two of them are present as actual pollen-carrying stamens in Cypripedium. In other Orchids these two form the membranous sides of the clinandrum or anther-bed. In this "bed" the anther lies protected from the wind by the two membranous modified stamens. Lastly, the third stamen of this inner or second circle is represented by a little ridge that runs down the front of and strengthens the column. The three carpels are easily recognised on making a transverse section of the ovary or seed-case. Three sets of seeds are observable, attached to the inner walls of that ovary. The three stigmas are represented by the two viscid side spaces and the central rostellum.

(*f*) *Conclusions.* And now what are the conclusions arrived at by the illustrious author of this book? After all his laborious investigation of multitudinous Orchids, three great principles force themselves upon him and upon us. (i.) That insects are necessary for the fertilisation of Orchids. Pollen from anther cannot get to stigma and thence to unripe seed or ovule and impregnate that ovule save through the agency of insects. Arrangement upon arrangement is met with demonstrating the remarkable adaptation of flower to insect, and of insect to flower.

(ii.) That self-fertilisation is rare, and cross-fertilisation almost universal. Very rarely is the pollen of a given Orchid used to fertilise the ovules of the same plant. Far more generally is the pollen of a particular flower borne to the stigma and thence to the ovule of another individual of the same species. And this cross-fertilisation, not confined, as will hereafter be shown, to Orchids only, but almost universal in plants, by bringing together in the reproduction of the new being cells from two slightly different parents and not cells from the same plant, gives far more opportunity for the variation of that new individual in ever new directions.

(iii.) That these wonderful adaptations of structure are not the result of special creative acts. It is, after careful review of all the evidence, impossible to believe that each species of Orchid sprang into existence at the word of an almighty being. All these marvellous flowers, with all their minute and curious structure-modifications, and all their complex relationships of parts to one another and to insects, are the result of slow modification of parts through century upon century. By gradual evolution from simpler forms the Orchids have come into being. Every slight variation that has rendered them more fitted for the great struggle for existence, that has given them a better chance in the life-battle, has been transmitted and strengthened until we find such a wondrous arrangement as the sensitive antennæ of Catasetum, and the heavy pedicel flung out to strike with unerring aim the head of the insect. Let us end this our study of the Fertilisation of Orchids with quotation of the master's own words: "The more I study nature, the more I become impressed with ever-increasing force with the conclusion that the contrivances and beautiful adaptations slowly acquired through each part occasionally varying in a slight degree but in many ways, with the preservation or natural selection of those variations which are beneficial to the organism under the complex and ever-varying conditions of life, transcend in an incomparable degree the contrivances and adaptations which the most fertile imagination of the most imaginative man could suggest with unlimited time at his disposal."