MY STVDIO NEIGHBORS

W. HAMILTON GIBSON

"A Few Native Orchids
and
their Insect Sponsors"

EXCERPTED FROM

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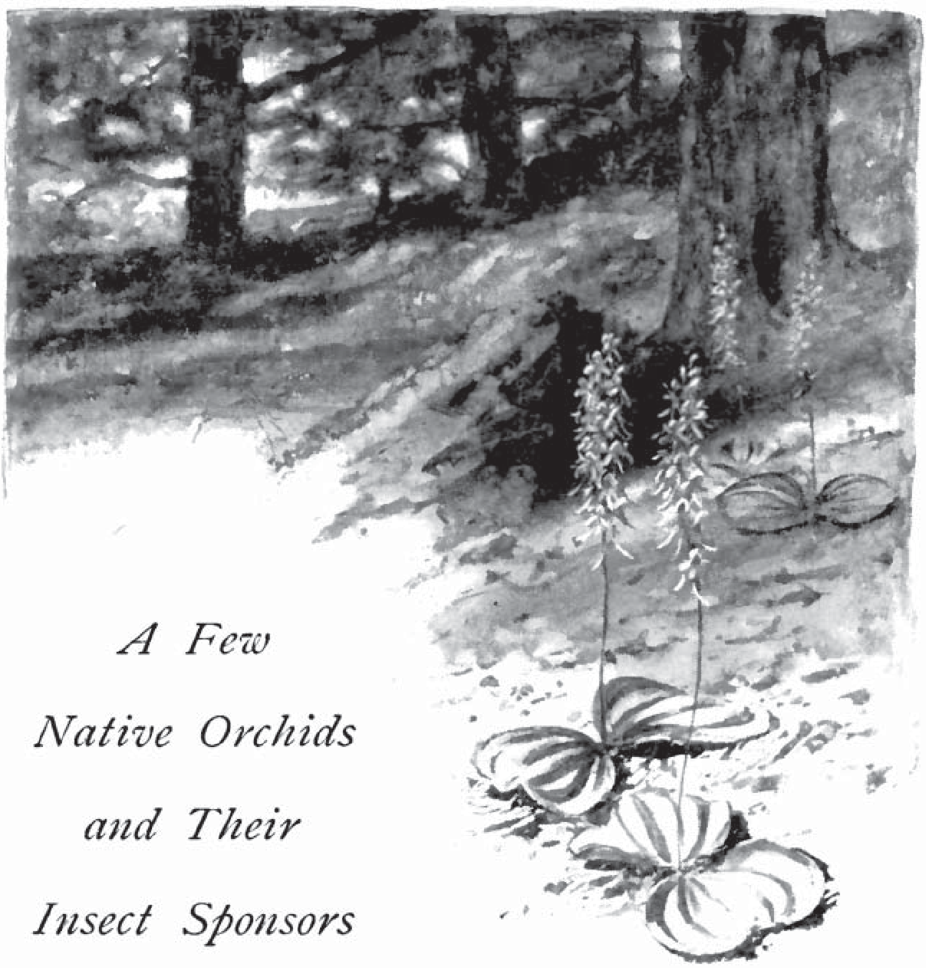


A Few Native Orchids and Their Insect Sponsors

IN a previous article I discussed the general subject of the fertilization of flowers, briefly outlining the several historical and chronological steps which ultimately led to Darwin's triumphant revelation of the divine plan of "cross-fertilization" as the mystery which had so long been hidden beneath the forms and faces of the flowers.

In the same paper I presented many illustrative examples among our common wild flowers possessing marvellous evolved devices, mechanisms, and peculiarities of form by which this necessary cross-fertilization was assured.

Prior to Darwin's time the flower was a voice in the wilderness, heard only in faintest whispers, and by the few. But since his day they have bloomed with fresher color and more convincing perfume. Science brought us their message. Demoralizing as it certainly was to humanity's past ideals, philosophic, theologic, and poetic, it bore the spirit of absolute conviction, and must be heard.

What a contrast this winged botany of to-day to that of a hundred years ago! The flower now no longer the mere non-committal, structural, botanical specimen. No longer the example of mere arbitrary, independent creation, reverently and solely referred to the orthodox "delight of man." The blossom whose unhappy fate was bemoaned by the poet because, forsooth, it must needs "blush unseen," or "waste its sweetness on the desert air," is found alone in that musty *hortus siccus* of a blind and deluded past. From the status of mere arbitrary creation, however "beautiful," "curious," "eccentric," hitherto accepted alone on faith — "it is thus because it is created thus: what need to ask the reason why?"—it has become a part of our inspiring heritage, a reasonable, logical, comprehensible *result,* a manifestation of a beautiful divine scheme, and is thus an ever-present witness and prophet of divine care and supervision.

The flower of to-day! What an inspiration to our reverential study! What a new revelation is borne upon its perfume! Its forms and hues, what invitations to our devotion! This spot upon the petal; this peculiar quality of perfume or odor; this fringe within the throat; this curving stamen; this slender tube! What a catechism to one who knows that each and all represent an affinity to some insect, towards whose vital companionship the flower has been adapting itself through the ages, looking to its own more certain perpetuation!

The great Linnæus would doubtless have claimed to "know" the "orchid," which perhaps he named. Indeed, did he not "know" it to the core of its physical, if not of its physiological, being? But could he have solved the riddle of the orchid's persistent refusal to set a pod in the conservatory? Could he have divined why the orchid blossom continues in bloom for weeks and weeks in this artificial glazed tropic—perhaps weeks longer than its more fortunate fellows left behind in their native haunts — and then only to wither and perish without requital? Know the orchid? — without the faintest idea of the veritable divorce which its kidnapping had involved!

Thanks to the new dispensation, we may indeed claim a deeper sympathy with the flower than is implied in a mere recognition of its pretty face. We know that this orchid is but the half of itself, as it were; that its color, its form, however eccentric and incomprehensible, its twisted inverted position on its individual stalk-like ovary, its slender nectary, its carefully concealed pollen — all are anticipations of an insect complement, a long-tongued night-moth perhaps, with whose life its own is mysteriously linked through the sweet bond of perfume and nectar, and in the sole hope of posterity.

And the flower had been stolen from its haunt while its consort slept, and had awakened in a glazed prison — doubtless sufficiently comfortable, save for the absence of that one indispensable counterpart, towards whom we behold in the blossom's very being the embodied expression of welcome.

Blooming day after day in anticipation of his coming, and week after week still hoping against hope, we see the flower fade upon its stalk, and with what one might verily believe to be evidences of disconsolation, were it not that the ultra-scientist objects to such a sentimental assumption with regard to a flower, which is unfortunate enough to show no sign of nerves or gray matter in its composition. Who shall claim to *know* his orchid who knows not its insect sponsor ?

To take one of our own wild species. Here is the *Arethusa bulbosa* of Linnæus, for instance. Its pollen must reach its stigma—so he supposed—in order for the flower to become fruitful. But this is clearly impossible, as the pollen never leaves its tightly closed box unless removed by outside aid, which aid must also be required to place it upon the stigma. This problem, which confronted him in practically every orchid he met, Linnæus, nor none of his contemporaries, nor indeed his followers for many years, ever solved.

Not until the time of Christian Conrad Sprengel (1735) did this and other similar riddles begin to be cleared up, that distinguished observer having been the first to discover in the honey-sipping insect the key to the omnipresent mystery. Many flowers, he discovered, were so constructed or so planned that their pollen could *not* reach their own stigmas, as previously believed. The insect, according to Sprengel, enjoyed the anomalous distinction of having been called in, in the emergency, to fulfil this apparent default in the plain intentions of nature, as shown in the flower. Attracted by the color and fragrance of the blossom, with their implied invitation to the assured feast of nectar, the insect visited the flower, and thus became dusted with the pollen, and in creeping or flying out from it conveyed the fecundating grains to the receptive stigma, which they could not otherwise reach. Such was Sprengel's belief, which he endeavored to substantiate in an exhaustive volume containing the result of his observations pursuant to this theory.

But Sprengel had divined but half the truth. The insect *was necessary,* it was true, but the Sprengel idea was concerned only with the *individual* flower, and the great botanist was soon perplexed and confounded by an opposing array of facts which completely destroyed the authority of his work — facts which showed conclusively that the insect could *not* thus convey the pollen as described, because the stigma in the flower was either not yet ready to receive it — perhaps tightly closed against it — or was past its receptive period, even decidedly withered.

This radical assumption of fertilization in the individual flower, which lay at the base of Sprengel's theory, thus so completely exposed as false, discredited his entire work. The good was condemned with the bad, and the noble volume was lost in comparative oblivion — only to be finally resurrected and its full value and significance revealed by the keen scientific insight of Darwin (1859). From the new stand-point of evolution through natural selection the *facts* in Sprengel's work took on a most important significance. Darwin now reaffirmed the Sprengel theory so far as the necessity of the insect was concerned, but showed that all those perplexing floral conditions which had disproved Sprengel's assumption, instead of having for their object the conveying of pollen to the stigma of the *same* flower, implied its *transfer* to the stigma of *another,* cross-fertilization being the evident design, or evolved and perpetuated advantage.

This solution was made logical and tenable only on the assumption that such evolved conditions, insuring cross-fertilization, were of distinct advantage to the flower in the competitive struggle for existence, and that all cross-fertilized flowers were thus the final result of natural selection.

The early ancestors of this flower were self-fertilized; a chance seedling at length, among other continual variations, showed the singular variation of ripening its stigma in advance of its pollen — or other condition insuring cross-fertilization — thus acquiring a strain of fresh vigor. The seedlings of this flower, coming now into competition with the existing weaker self-fertilized forms, by the increased vigor won in the struggle of their immediate surroundings, and inheriting the peculiarity of their parent, showed flowers possessing the same cross-fertilizing device. The seeds from these, again scattering, continued the unequal struggle in a larger and larger field and in increasing numbers, continually crowding out all their less vigorous competitors of the same species, at length to become entire masters of the field and the only representatives left to perpetuate the line of descent.

Thus we find in almost every flower we meet some astonishing development by which this cross-fertilization is effected, by which the transferrence of the pollen from one flower to the stigma of another is assured, largely through the agency of insects, frequently by the wind and water, occasionally by birds. In many cases this is assured by the pollen-bearing flowers and stigmatic flowers being entirely distinct, as in cucumbers and Indian-corn; perhaps on different plants, as in the palms and willows; again by the pollen maturing and disseminating before the stigma is mature, as already mentioned, and *vice versa*.

From these, the simplest forms, we pass on to more and more complicated conditions, anomalies of form and structure — devices, mechanisms, that are past belief did we not observe them in actuality with our own eyes, as well as the absolutely convincing demonstration of the intention embodied: exploding flowers, shooting flowers, flower-traps, stamen embraces, pollen showers, pollen plasters, pollen necklaces, and floral pyrotechnics — all demonstrations in the floral etiquette of welcome and *au revoir* to insects.

From the simplest and regular types of flowers, as in the buttercup, we pass on to more and more involved and unsymmetrical forms, as the columbine, monk's-hood, larkspur, aristolochia, and thus finally to the most highly specialized or involved forms of all, as seen in the orchid — the multifarious, multiversant orchid; the beautiful orchid; the ugly orchid; the fragrant orchid; the fetid orchid; the graceful, homely, grotesque, uncanny, mimetic, and, until the year 1859, the absolutely non-committal and inexplicable flower; the blossom which had waited through the ages for Darwin, its chosen interpreter, ere she yielded her secret to humanity.

And what is an orchid ? How are we to know that this blossom which we plucked is an orchid ? The average reader will exclaim, "Because it is an air-plant " — the essential requisite, it would seem, in the popular mind. Of over 3000 known species of orchids, it is true a great majority are air-plants, or epiphytes — growing upon trees and other plants, obtaining their sustenance from the air, and not truly parasitic ; but of the fifty-odd native species of the northeastern United States, not one is of this character, all growing in the ground, like other plants. It is only by the botanical structure of the flowers that the orchid may be readily distinguished, the epiphytic character being of little significance botanically.

A brief glance at this structural peculiarity may properly precede our more elaborate consideration of a few species of these remarkable flowers.

The orchids are usually very irregular, and six-parted. The ovary is one -celled, and becomes a pod containing an enormous yield of minute, almost spore-like, seeds (Fig. 3) in some species, as in the vanilla pod, to the number of a million, and in one species of the maxillaria, as has been carefully computed, 1,750,000.

The pollen, unlike ordinary flowers, is gathered together in waxy masses of varying consistency, variously formed and disposed in the blossom, its grains being connected with elastic cobwebby threads, which occasionally permit the entire mass to be stretched to four or five times its length, and recover its original shape when released. This is noticeable specially in the *O. spectabilis,* later described. The grains thus united are readily disentangled from their mass when brought into contact with a viscid object, as, for instance, the stigma.

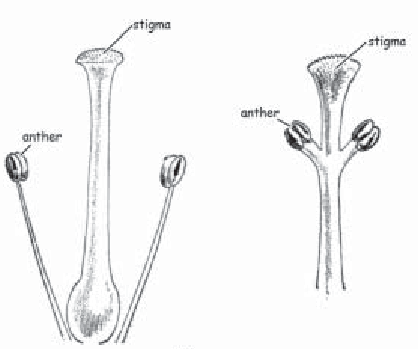
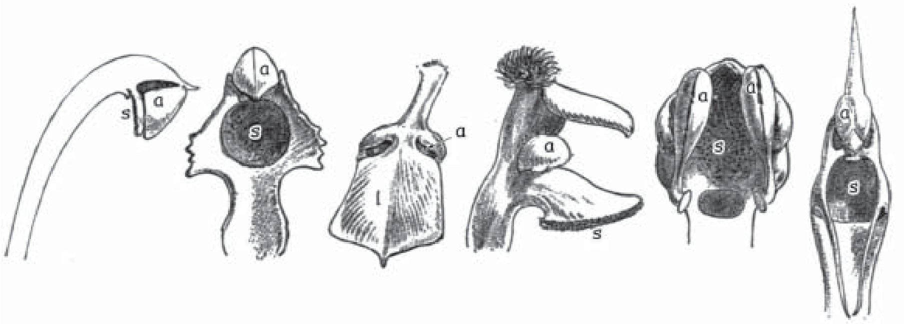


Fig. 1

But the most significant botanical contrast and distinction is found in the union of the style and stamens in one organ, called the column (Fig. 2), the stigma and the pollen being thus disposed upon a single common stalk. The contrast to the ordinary flower will be readily appreciated by comparison of the accompanying diagrams (Fig. 1).

When, therefore, we find a blossom with the anthers or pollen receptacle united to a stalk upon which the stigma is also placed, we have an orchid.

The order is further remarkable, as Darwin first demonstrated in his wonderful volume "The



a. Anther s. Stigma.

Fig. 2

Fertilization of Orchids," in that the entire group, with very few exceptions, are absolutely dependent upon insects for their perpetuation through seed. They possess no possible resource for self-fertilization in the neglect of these insect sponsors.

Many of our common wild flowers, as perfectly and effectually planned for cross-fertilization as the orchids, *do* retain the reserve power of final *self*-fertilization if unfertilized by foreign pollen.

But the orchid has lost such power, and in the progress of evolution has gradually adapted itself to the insect, often to a particular species of insect, its sole sponsor, which natural selection has again gradually modified in relation to the flower.

The above work by Darwin was mostly concerned with foreign species, generally under artificial cultivation, and so startling were the disclosures concerning these hitherto sphinx-like floral beings that a most extensive bibliography soon attested the widespread inspiration and interest awakened by its pages.

Fig. 3

But it is by no means necessary to visit the tropics or the conservatory for examples of these wonders. Our own Asa Gray, one of Darwin's instant proselytes, was prompt to demonstrate that the commonest of our native American species might afford revelations quite as astonishing as those exotic species which Darwin had described.

During a period of many years the writer has devoted much study to our native species of orchids from this evolutionary stand-point of their cross-fertilization tendencies. Of the following examples, selected from his list, some are elaborations of previous descriptions of Gray and others, though pictorially and descriptively the result of direct original study from nature; others are from actual observation of the insects at work on the flowers; and others still, original demonstrations based upon analogy and the obvious intention of the floral construction, the action of the insect — its head or tongue — having been artificially imitated by pins, bristles, or other probe-like bodies.

How many an enthusiastic flower-hunter has plucked his fragrant bouquet of the beautiful Arethusa, in its sedgy haunt, without a suspicion of the beautiful secret which lay beneath its singular form! Indeed, how many a learned botanist, long perfectly familiar with its peculiarities of shape and structure, has been entirely content with this simple fact, nor cared to seek further for its interpretation! But

> "All may have the flower now,
> For all have got the seed."

With Darwin as our guide and the insect as our key — an *open sesame* — the hidden treasure is revealed, It is now quite possible, as Darwin demonstrated, to look upon a flower for the first time and from its structure foretell the method of its intended cross-fertilization; nay, more, possibly the kind, or even the species, of insect to which this cross-fertilization is intrusted.

Let us look at our Arethusa. The writer has never happened to observe an insect at work upon this flower, but the intention of its structure is so plain that by a mere examination we may safely prophesy not only what must happen when the insect seeks its nectar, but with equal assurance the kind of insect thus invited and expected. I have indicated a group of the orchids in their usual marshy haunt, and in Fig. 4, separately, a series of diagrams presents sections of the flower, natural size and duly indexed, which renders detailed description hardly necessary. The column is here quite elongated, forked at the tip, the space between the forks occupied by the anther, which is hinged to the upper division. This anther lid is closed tightly, with the sticky mass of pollen hidden behind it in the cavity. The stigma is on the external inner side of the lower division, and thus distinctly separated from the pollen. The "lip" is extended forward as a hospitable threshold to the insect. And to what insect might we assume this invitation of color, fragrance, nectar, and threshold to be extended?

Let us consider the flower simply as a device to insure its own cross-fertilization. The insect is welcomed; it must alight and sip the nectar; in departing it must bear away this pollen upon its body, and convey it to the *next* Arethusa blossom which it visits, and leave it upon its stigma. These are the conditions expressed; and how admirably they are fulfilled we may observe when we examine flower after flower of a group, and find their nectaries drained, their anther cells empty, and pollen upon all their stigmas. The nectar is here secreted in a well — not very deep — and the depth of this nectar from the entrance is of great significance among all the flowers, having distinct reference to the length of the tongue which is expected to sip it. In the Arethusa, it is true, the butterfly or moth might sip at the throat of the flower, but the long tongues of these insects might permit the nectary to be drained without bringing their bodies in contact with the stigma. Smaller insects might creep into the nectary and sip without the intended fulfilment. It is clear that to neither of such visitors is the welcome extended. What, then, are the conditions embodied ? The insect must have a tongue of such a length that, when in the act of sipping, its head must pass beyond the anther well into the opening of the flower. Its body must be sufficiently large to come in contact with the anther. Such requisites are perfectly fulfilled by the humblebee, and we may well hazard the prophecy that the Bombus is the welcomed affinity of the flower.

The diagrams (Fig. 4) sufficiently illustrate the efficacy of the beautiful plan involved. At A the bee is seen sipping the nectar. His forward

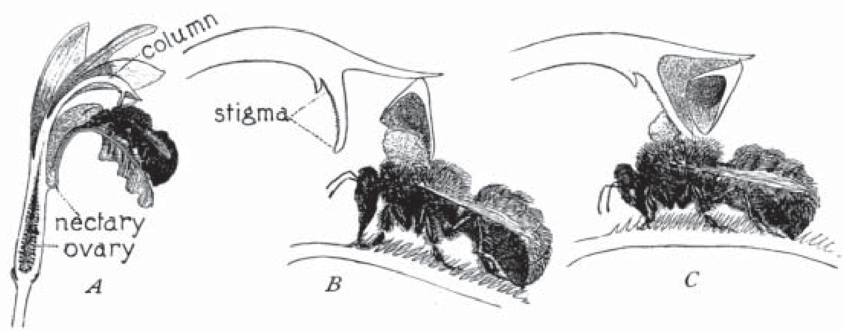


Fig. 4

movement thus far to this point has only seemed to press the edge of the anther inward, and thus keep it even more effectually closed. As the bee retires (B), the backward motion opens the lid, and the sticky pollen is thus brought against the insect's back, where it adheres in a solid mass. He now flies to the next Arethusa blossom, enters it as before, and in retiring slides his back against the receptive viscid stigma, which retains a portion of the pollen, and thus effects the cross-fertilization (C). Professor Gray surmised that the pollen was withdrawn on the insect's head, and it might be so withdrawn, but in other allied orchids of the tribe Arethusæ, however, in which the structure is very similar, the pollen is deposited on the thorax, and such is probably the fact in this species. In either case cross-fertilization would be effected. Nothing else is possible in the flower, and whether it is Bombus or not that effects it, the method is sufficiently evident.

Having thus had one initiation into this most enticing realm of riddles, each successive orchid whose structure we examine from this stand-point becomes a most interesting, perhaps a fresh, problem, whose assumed solution may often be verified by studying the insect in its haunts. Darwin thus foretold the precise manner of the cross-fertilization of *Habenaria mascula,* and also the insect agent, simply by the structural prophecy of the flower itself.

Suppose, for example, an unknown orchid blossom to be placed in our hands. Its nectary tube is five inches in length, and as slender as a knitting-needle. The nectar is secreted far within its lip. The evolution of the long nectary implies an adaptation to an insect's tongue of equal length. What insect has a tongue five inches long, and sufficiently slender to probe this nectary? The sphinx-moth only. Hence we infer the sphinx-moth to be the insect complement to the blossom, and we may correctly infer, moreover, that the flower is thus a night-bloomer.

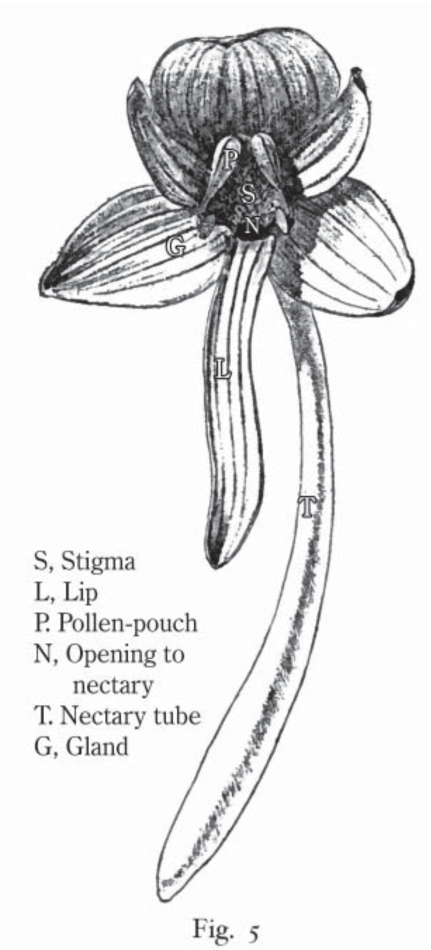


Fig. 5

Examination of the flower, with the form of this moth in mind, will show other adaptations to the insect's form in the position of pollen and stigma, looking to the flower's cross-fertilization. In some cases this is effected by the aid of the insect's tongue; in others, by its eyes.

In our own native orchids we have a remarkable example of the latter form in the *Habenaria orbiculata,* whose structure and mechanism have also been admirably described by Asa Gray.

All orchid-hunters know this most exceptional example of our local flora, and the thrill of delight experienced when one first encounters it in the mountain wilderness, its typical haunt, is an event to date from — its two great, glistening, fluted

leaves, sometimes as large as a dinner-plate, spreading flat upon the mould, and surmounted by the slender leafless stalk, with its terminal loose raceme of greenish-white bloom.

A single blossom of the species is shown in Fig. 5, the parts indexed. The opening to the nectary is seen just below the stigmatic surface, the nectary itself being nearly two inches in length. The pollen is in two club-like bodies, each hidden within a fissured pouch on either side of the stigma, and coming to the surface at the base in their opposing sticky discs as shown. Many of the group Habenaria or Platanthera, to which this flower belongs, are similarly planned. But mark the peculiarly logical association of the parts here exhibited. The nectary implies a welcome to a tongue two inches long, and will reward none other. This clearly shuts out the bees, butterflies, and smaller moths. What insect, then, is here implied? The sphinx-moth again, one of the lesser of the group. A larger individual might sip the nectar, it is true, but its longer tongue would reach the base of the tube without effecting the slightest contact with the pollen, which is of course the desideratum here embodied, and which has reference to a tongue corresponding to the length of the nectary. There are many of these smaller sphinxes. Let us suppose one to be hovering at the blossom's throat. Its slender capillary tongue enters the opening. Ere it can reach the sweets the insect's head must be forced well into the throat of the blossom, where we now observe a most remarkable special provision, the space between the two pollen discs being exactly adjusted to the diameter of the insect's head. What follows this entrance of the moth is plainly pictured in the progressive series of illustrations (Fig. 6). A represents the insect sipping; the sticky discs are brought in contact with the moth's eyes, to which they adhere, and by which they are withdrawn from their pouches

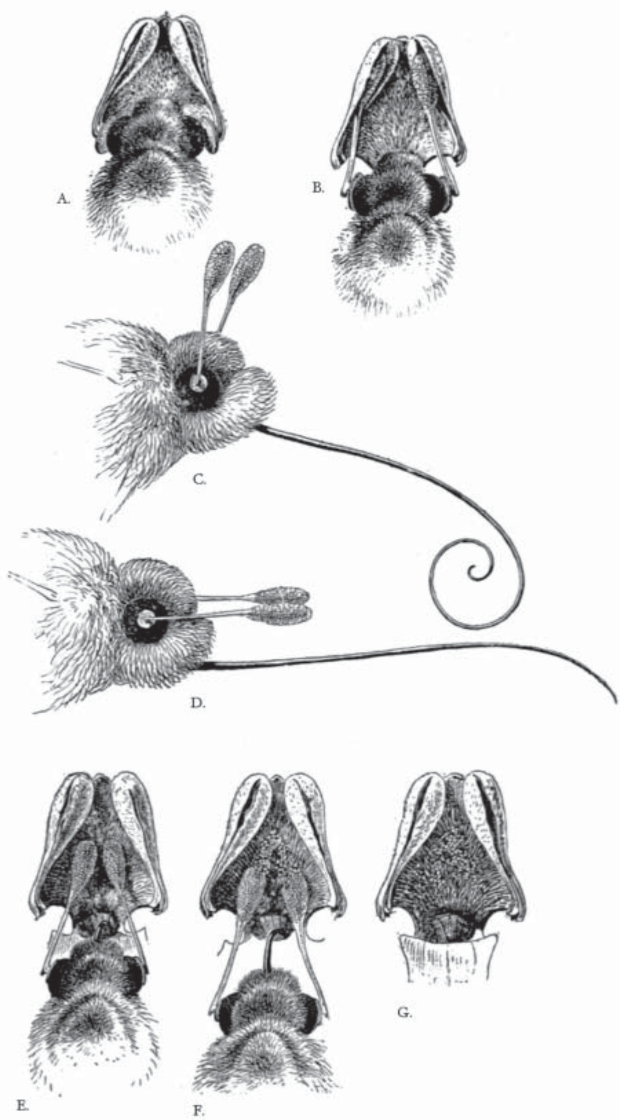


Fig. 6

as the moth departs (B). At this time they are in the upright position shown at C, but in a few seconds bend determinedly downward and slightly towards each other to the position D. This change takes place as the moth is flitting from flower to flower. At E we see the moth with its tongue entering the nectary of a subsequent blossom. By the new position of the pollen clubs they are now forced directly against the stigma (E). This surface is viscid, and as the insect leaves the blossom retains the grains in contact (F), which in turn withdraw others from the mass by means of the cobwebby threads by which the pollen grains are continuously attached. At G we see the orchid after the moth's visit — the stigma covered with pollen, and the flower thus cross-fertilized.

In effecting the cross-fertilization of one of the younger flowers its eyes are again brought into contact with this second pair of discs, and these, with their pollen clubs, are in turn withdrawn, at length perhaps resulting in such a plastering of the insect's eyes as might seriously impair its vision, were it not fortunately of the compound sort.

In another allied example of the orchids — the Showy Orchid — we have, however, what would appear a clear adaptation to the head of a bee,

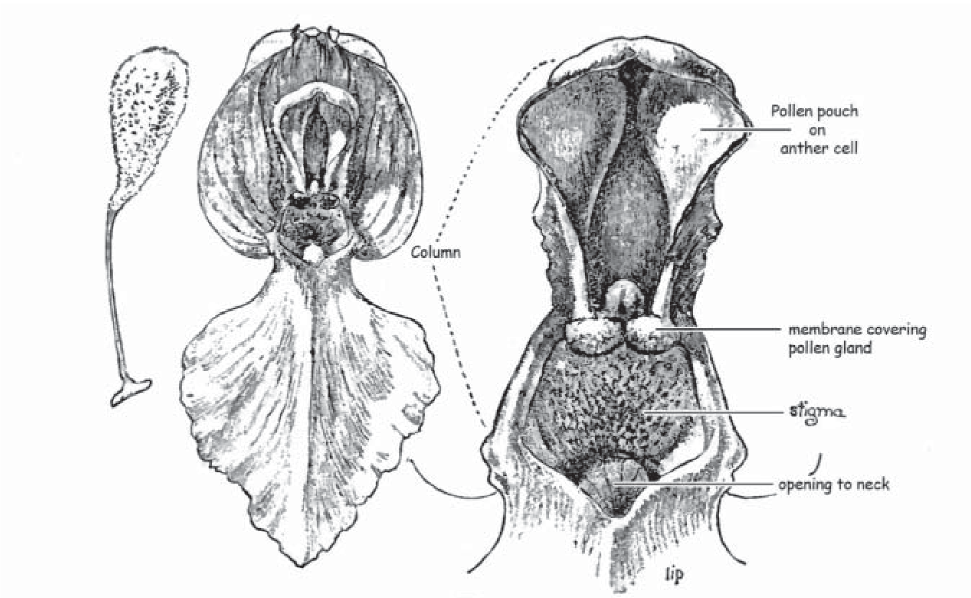
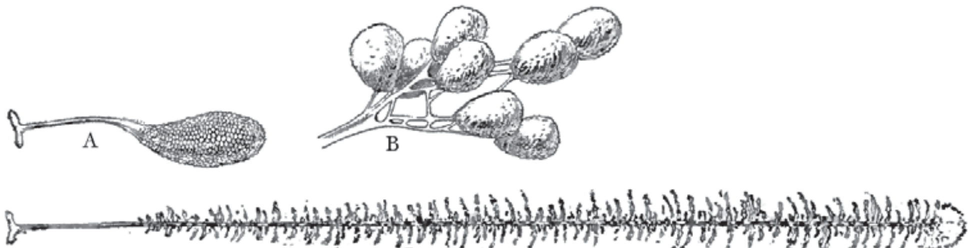


Fig. 7

though one which might also avail of the service of an occasional butterfly. A group of this beautiful species is shown in my illustration. A favored haunt is the dark damp woods, especially beneath hemlocks, and with its deep pink hood and pure white lip is quite showy enough to warrant its specific title, "spectabilis." An enlarged view of the blossom is seen in Fig. 7, and in Fig. 8 a still greater enlargement of the column.



A, Pollinium. B, Webby connection between grains C, Stretched to four times its length.

Fig. 8

I have seen many specimens with the pollen masses withdrawn, and others with their stigmas well covered with the grains. Though I have never seen an insect at work upon it in its haunt, the whole form of the opening of the flower would seem to imply a bee, particularly a bumblebee. If we insert the point of a lead-pencil into this opening, thus imitating the entrance of a bee, its bevelled surface comes in contact with the viscid discs by the rupture of a veil of membrane, which has hitherto protected them. The discs adhere to the pencil, and are withdrawn upon it (Fig. 9). At first in upright position, they soon assume the forward inclination, as previously described. The nectary is about the length of a bumblebee's tongue, and is, moreover, so amply expanded at the throat below the stigma as to comfortably admit its wedge-shaped head. The three progressive diagrams (Fig. 10) indicate the result in the event of such a visit.

The pollen discs are here very close together, and are protected within a membraneous cup, in which they sit as in a socket. As the insect inserts his head at the opening (A) it is brought against this tender membrane, which ruptures and exposes the viscid glands of the pollen masses, which become instantly attached to the face or head, perhaps the eyes, of the burly visitor. As the insect retreats from the flower, one or both of the pollinia are withdrawn, as at B. Then immediately follows a downward movement, which exactly anticipates the position of the stigma, and as the bee enters the next flower the pollen clubs are forced against it (C), as in the previous example.

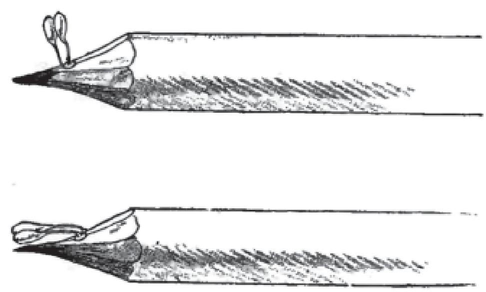


Fig. 9

In the case of a smaller bee visiting the flower, the insect would find it necessary to creep further into the opening, and thus might bring its thorax against the pollen-glands. In either case the change of position in the pollinia would insure the same result.

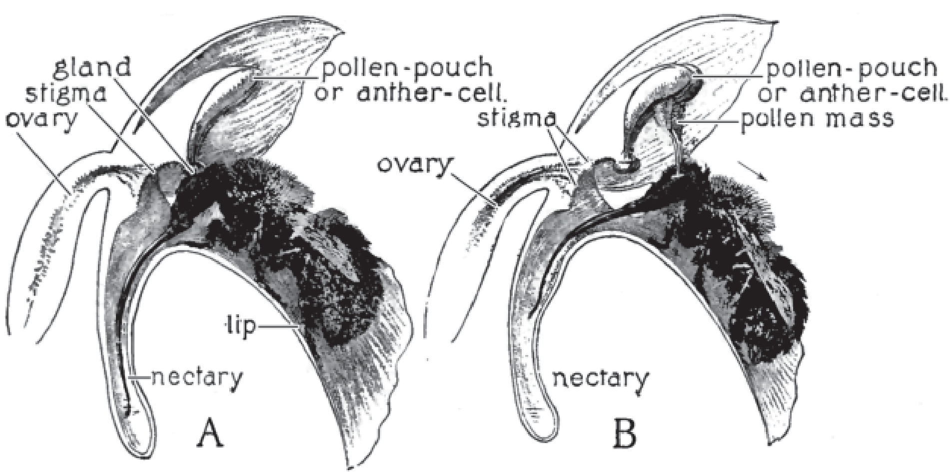


Fig. 10 A B

We have thus seen adaptation to the thorax, the eyes, and, the face in the three examples given. And the entrance of the flower in each instance is so formed as to insure the proper angle of approach for the insect for the accomplishment of the desired result. This direct approach, so necessary in many orchids, is insured by various devices — by the position of the lip upon which the insect must alight; by the narrowed entrance of the throat of the flower in front of the nectary; by a fissure in the centre of the lip, by which the tongue is conducted, etc.

Fig. 10 C

Many other species allied to the above possess similar devices, with slight variations; and there is still another group whose structure is distinctly adjusted to the *tongues* of insects — adaptations not merely of position of pollen masses, but even to the extent of a special modification in the entrance to the flower and the shape of the sticky gland, by which it may more securely adhere to that sipping member.

In the common pretty Purple-fringed Orchid, whose dense cylindrical spikes of plumy blossoms occasionally empurple whole marshes, we have an arrangement quite similar to the *H. orbicularis* just described, with the exception that the pollen-pouches are almost parallel, and not noticeably spread at the base (Fig. 11). In this case the eyes of sipping butterflies occasionally get their decoration of a tiny golden club, but more frequently their tongues.

If, however, the butterfly should approach directly in front of the flower, as in a larger blossom he would be most apt to do, he might sip the nectar indefinitely and withdraw his tongue without bringing it in contact with the viscid pollen discs. But in the dense crowding of the flowers, over which the insect flutters indiscriminately, the approach is oftenest made obliquely, and thus the

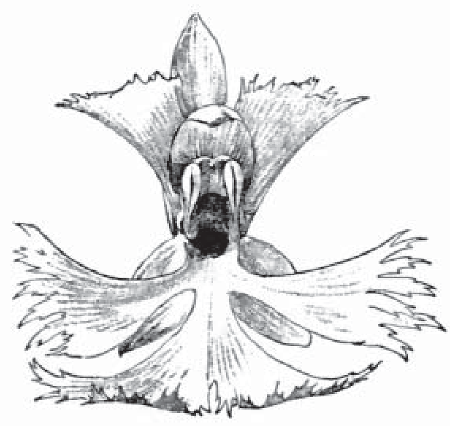


Fig. 11

tongue brushes the disc on the side approached, and the pollen mass is withdrawn. But an examination of this orchid affords no pronounced evidence of any specific intention. There is no unmistakable sign to demonstrate which approach is preferred or designed by the flower, and this dependence on the insect's tongue or eye would seem to be left to chance.

In another closely allied species, however, we have a distinct provision which insures the proper approach of the tongue — one of many similar devices by which the tongue is conducted directly to one or the other of the pollen discs.

This is the Ragged Orchid, a near relative of the foregoing, *H. psycodes,* but far less fortunate in its attributes of beauty, its long scattered spike of greenish-white flowers being so inconspicuous in its sedgy haunt as often to conceal the fact of its frequency. Its individual flower is shown enlarged at Fig. 12 — the lip here cut with a lacerated fringe (*H. lacera*). The pollen-pouches approach slightly at the base, directly opposite the nectary, where the two viscid pollen-glands stand on guard. Now were the opening of the nectary at this point unimpeded, the same condition

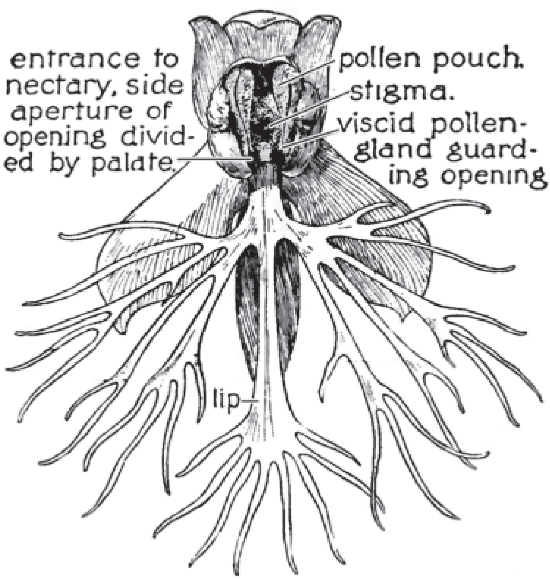


Fig. 12

would exist as in the *H. psycodes* — the tongue might be inserted between the pollen discs and withdrawn without touching them. But here comes the remarkable and very exceptional provision to make this contact a certainty — a suggestive structural feature of this flower of which I am surprised to find no mention either in our botanies or in the literature of cross-fertilization, so far as I am familiar with its bibliography. Even Dr. Gray's description of the fertilization device of this species makes no mention of this singular and very important feature. The nectary here, instead of being freely open, as in other orchids described, is abruptly closed at the central portion by a firm protuberance or palate, which projects downward from the base of the stigma, and closely meets the lip below.

The throat of the nectary, thus centrally divided, presents two small lateral openings, each of which, from the line of approach through the much-narrowed entrance of the flower, is thus brought directly beneath the waiting disc upon the same side. The structure is easily understood from the two diagrams Figs. 12 and 13, both of which are indexed.

The viscid pollen-gland is here very peculiarly formed, elongated and pointed at each end, and it is not until we witness the act of its removal on the tongue of the butterfly that we can fully appreciate its significance.

I have often seen butterflies at work upon this orchid, and have observed their tongues generously decorated with the glands and remnants of the pollen masses.

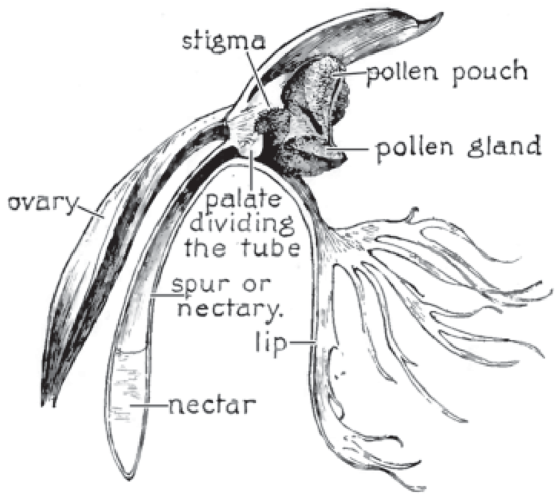


Fig. 13

The series of diagrams (Fig. 14) will, I think, fully demonstrate how this blossom utilizes the butterfly. At A we see the insect sipping, its tongue now in contact with the elongated disc, which adheres to and clasps it. The withdrawal of the tongue (B) removes the pollen from its pouch. At C it is seen entirely free and upright, from which position it quickly assumes the new attitude shown at D. As the tongue is now inserted into the subsequent blossom this pollen mass is thrust against the stigma (E), and a few of the pollen grains are thus withheld upon its viscid surface as the insect departs (F).

In this orchid we thus find a distinct adaptation to the tongue of a moth or butterfly.

Another similar device for assuring the necessary side approach is seen in *H. flava* (Fig. 15), a yellowish spiked species, more or less common in swamps and rich alluvial haunts.

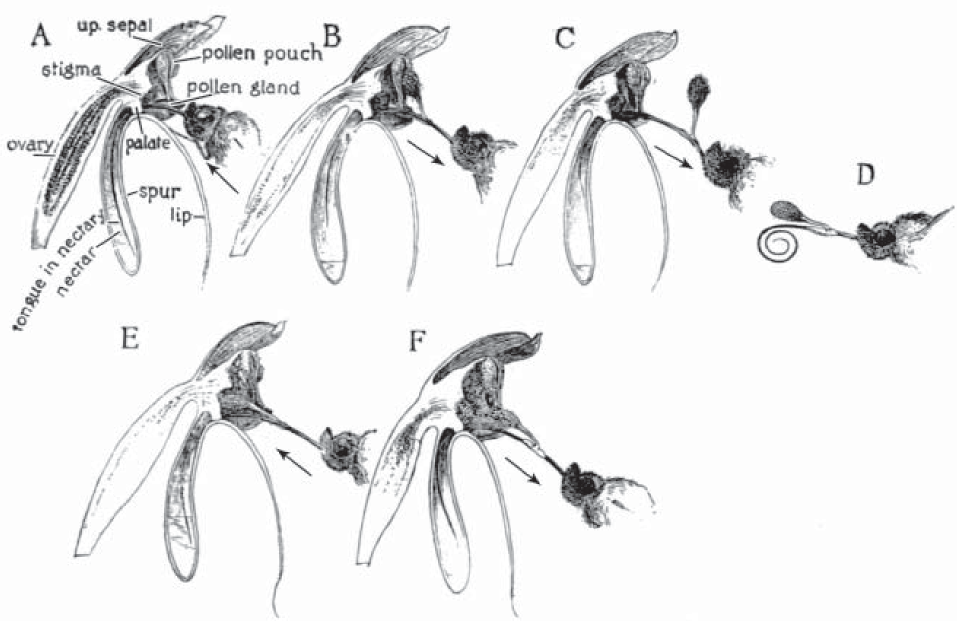


Fig. 14

Professor Wood remarks, botanically, "The tubercle (or palate) of the lip is a remarkable character." But he, too, has failed to note the equally remarkable palate of the ragged orchid, just described, both provisions having the same purpose, the insurance of an oblique approach to the nectary. In *H. flava* this "tubercle," instead of depending from the throat, grows *upward* from the lip, and, as we look at the flower directly from the front, completely hides the opening to the nectary, and an insect is compelled to insert its

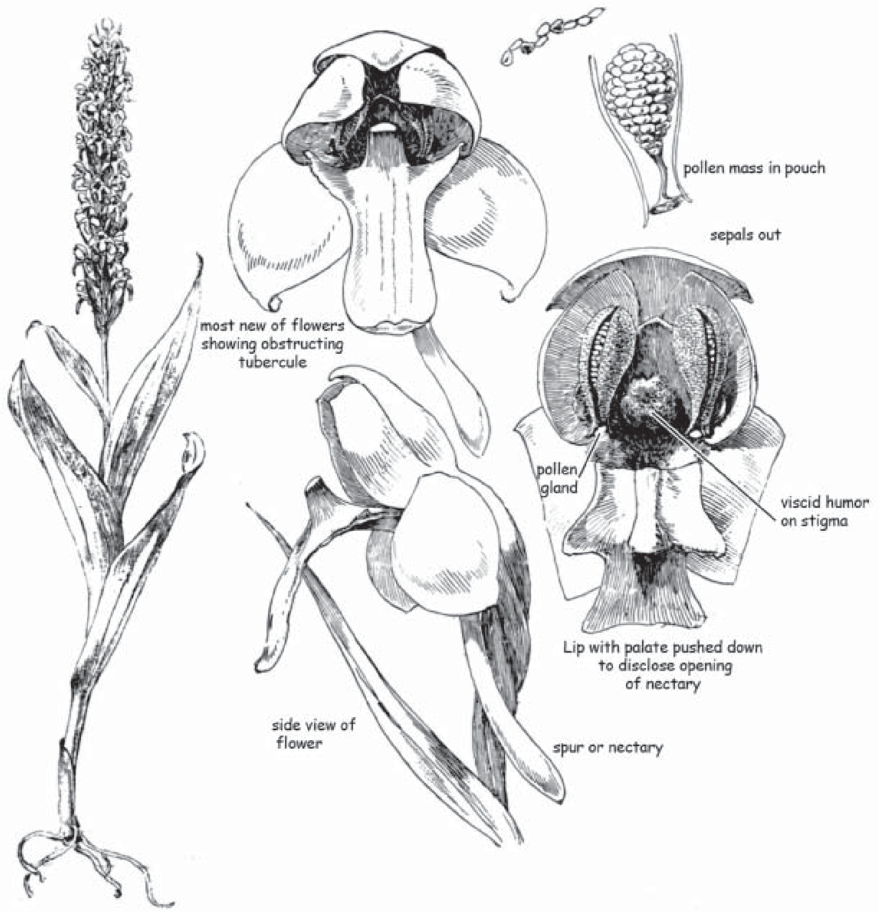


Fig. 15

tongue on one side, which direction causes it to pass directly beneath the pollen disc, as in *H. lacera,* and with the same result.

Of all our native orchids, at least in the northeastern United States, the Cypripedium, or Moccasin-Flower, is perhaps the general favorite, and certainly the most widely known. This is readily accounted for not only by its frequency, but by its conspicuousness. The term "moccasin-flower" is applied more or less indiscriminately to all species. The flower is also known as the ladies'-slipper, more specifically Venus's-slipper — as warranted by its generic botanical title — from a fancied resemblance in the form of the inflated lip, which is characteristic of the genus. We may readily infer that the fair goddess was not consulted at the christening.

There are six native species of the cypripedium in this Eastern region, varying in shape and in color — shades of white, yellow, crimson, and pink.

The mechanism of their cross-fertilization is the same in all, with only slight modifications.

The most common of the group, the *C. acaule,* most widely known as the moccasin-flower, whose large, nodding, pale crimson blooms we so irresistibly associate with the cool hemlock woods, will afford a good illustration.

The lip in all the cypripediums is more or less sac-like and inflated. In the present species, *C. acaule,* however, we see a unique variation, this portion of the flower being conspicuously bag-like, and cleft by a fissure down its entire anterior face. In Fig. 16 is shown a front view of the blossom, showing this fissure. The "column" (B) in the cypripedium is very distinctive, and from the front view is very non-committal. It is only as we see it in side section, or from beneath, that we fully comprehend the disposition of stigma and pollen. Upon the stalk of this column there appear from the front three lobes — two small ones at the sides, each of which hides an anther attached to its under face — the large terminal third lobe being in truth a barren rudiment of a former stamen, and which now overarches the stigma. The relative position of these parts may be seen in the under view.

The anthers in this genus, then, are two, instead

of the previous single anther with its two pollen-cells. The pollen is also quite different in its character, being here in the form of a pasty mass, whose entire exposed surface, as the anther opens, is coated with a very viscid gluten.

With the several figures illustrating the cross-fertilization, the reader will readily anticipate any description of the process, and only a brief commentary will be required in my text.

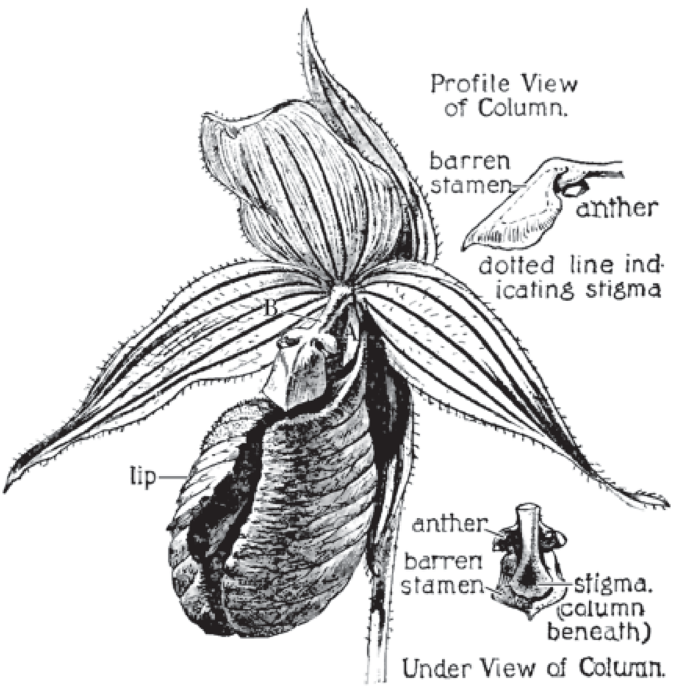


Fig. 16

I have repeatedly examined the flowers of *C. acaule* in their haunts, have observed groups wherein every flower still retained its pollen, others where one or both pollen masses had been withdrawn, and in several instances associated with them I have observed the inflated lip most outrageously bruised, torn, and battered, and occasionally perforated by a large hole. I had observed these facts in boyhood. The inference, of course, was that some insect had been guilty of the mutilation; but not until I read Darwin's description of the cross-fertilization of this species did I realize the full significance of these telltale evidences of the escape of the imprisoned insect. Since that time, many years ago, I have often sat long and patiently in the haunt of the cypripedium awaiting a natural demonstration of its cross-fertilization, but as yet no insect has rewarded my devotion.

At length, in hopelessness of reward by such means, I determined to see the process by more prosaic methods. Gathering a cluster of the freshly opened flowers, which still retained their pollen, I took them to my studio. I then captured a bumblebee, and forcibly persuaded him to enact the demonstration which I had so long waited for him peaceably to fulfil. Taking him by the wings, I pushed him into the fissure by which he is naturally supposed to enter without persuasion. He was soon within the sac, and the inflexed wings of the margin had closed above him, as shown in section, Fig. 17. He is now enclosed in a luminous prison, and his buzzing protests are audible and his vehemence visible from the outside of the sac. Let us suppose that he at length has become reconciled to his condition, and has determined to rationally fulfil the ideal of his environment, as he may perhaps have already done voluntarily before. The buzzing ceases, and our bee is now finding sweet solace for his incarceration in the copious nectar which he finds secreted among the fringy hairs in the upper narrowed portion of the flower, as shown at Fig. 18 A. Having satiated his appetite, he concludes to quit his close quarters. After a few moments of more vehement futile struggling and buzzing, he at length espies, through the passage above the nectary fringe, a gleaming light, as from two windows (A). Towards these he now approaches. As he advances the passage becomes narrower and narrower, until at length his back is brought against the overhanging stigma (Fig. 118 13). So narrow is the pass at this point that the efforts of the bee are distinctly manifest from the outside in the distension of the part and the consequent

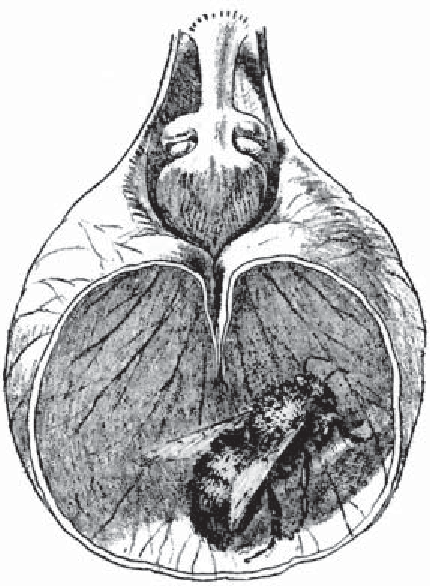


Fig. 17

slight change in the droop of the lip. In another moment he has passed this ordeal, and his head is seen protruding from the window-like opening (A) on one side of the column. But his struggles

Fig. 18 A

are not yet ended, for his egress is still slightly checked by the narrow dimensions of the opening, and also by the detention of the anther, which his thorax has now encountered. A strange etiquette this of the cypripedium, which speeds its parting guest with a sticky plaster smeared all over its back. As the insect works its way beneath the viscid contact, the anther is seen to be drawn outward upon its hinge, and its yellow contents are spread upon the insect's back (Fig. 18 C), verily like a plaster. Catching our bee before he has a chance to escape with his generous floral compliments, we unceremoniously introduce him into another cypripedium blossom, to which, if he were more obliging, he would naturally fly. He loses no time in profiting by his past experience, and is quickly creeping the gantlet, as it were, or braving the needle's eye of this narrow passage. His pollen-smeared thorax is soon crowding beneath the overhanging stigma again, whose forward-pointed papillæ scrape off a portion of it (Fig. 18 B), thus insuring the cross-fertilizing of the flower, the bee receiving a fresh effusion of cypripedium compliments piled upon the first as he says "good-bye." It is doubtful whether in his natural life he ever fully effaces the telltale effects of this demonstrative *au revoir.*

Such, with slight modifications, is the plan evolved by the whole cypripedium tribe. Darwin mentions bees as the implied fertilizers, and doubtless many of the smaller bees do effect cross-fertilization in the smaller species. But the more ample passage in acaule would suggest the medium-sized Bombus as better adapted—as the experiment herewith pictured from my own experience many times would seem to verify, while a honey-bee introduced into the flower failed to fulfil the demonstration, emerging at the little doorway above without a sign of the cordial parting token.

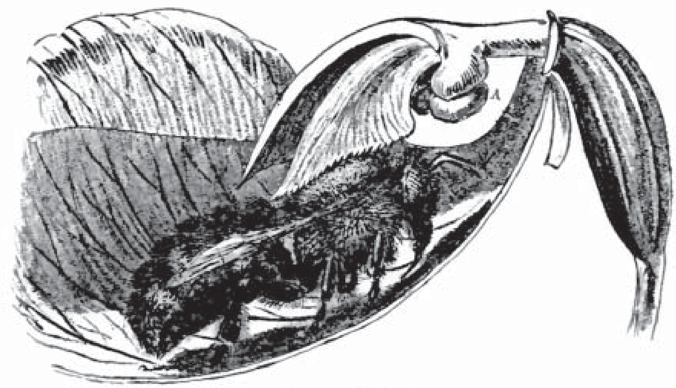


Fig. 18 B

Occasionally I suppose a fool bumblebee is entrapped within the petal bower and fails to find the proper exit, or it may be—much less a fool—having run the gantlet once too often, decides to escape the ordeal; hence the occasional mutilated blossom already described.

One of the most beautiful of our orchids, though its claims to admiration in this instance are chiefly confined to the foliage, is the common "Rattlesnake-Plantain," its prostrate rosettes of exquisitely white reticulated leaves carpeting many a nook in the shadows of the hemlocks, its dense spikes of yellowish-white blossoms signalling their welcome to the bees, and fully compensating in interest what they may lack in other attractive attributes.

The single flower is shown enlarged in Fig. 19—A, a young blossom, with analyses B and C, the latter indexed; D, an older blossom, with similar analyses (E and F). Both sorts are to be found upon every spike of bloom, as the inflorescence begins at the base and proceeds upward. As we look into the more open flower we observe a dark-colored speck, which, by analysis, proves to be the lid of the anther. This portion is further shown enlarged in Fig. 20, A. If we gently lift it with a pin, we disclose the pollen masses in the cavity (B) thus opened (C, profile section), the two pairs united to a common viscid gland at the base, this gland again secreted behind a veil of moist membrane, as also shown at B.

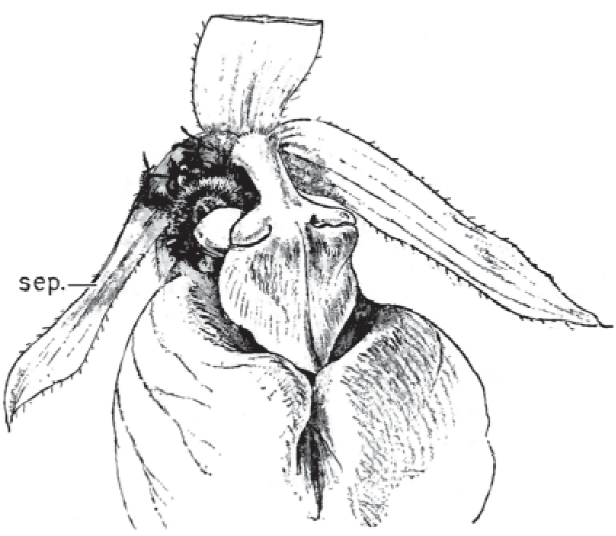


Fig. 18 C

This membrane is, moreover, very sensitive to the touch. Below the flattened tip of the column, and at a sharp inward angle, is the stigma. In the freshly opened flower (Fig. 19, A) the column inclines forward, bringing the anther low down, and its base directly opposite the V-shaped orifice in the lip, which also is quite firmly closed beneath the equally converging upper hood of the blossom.

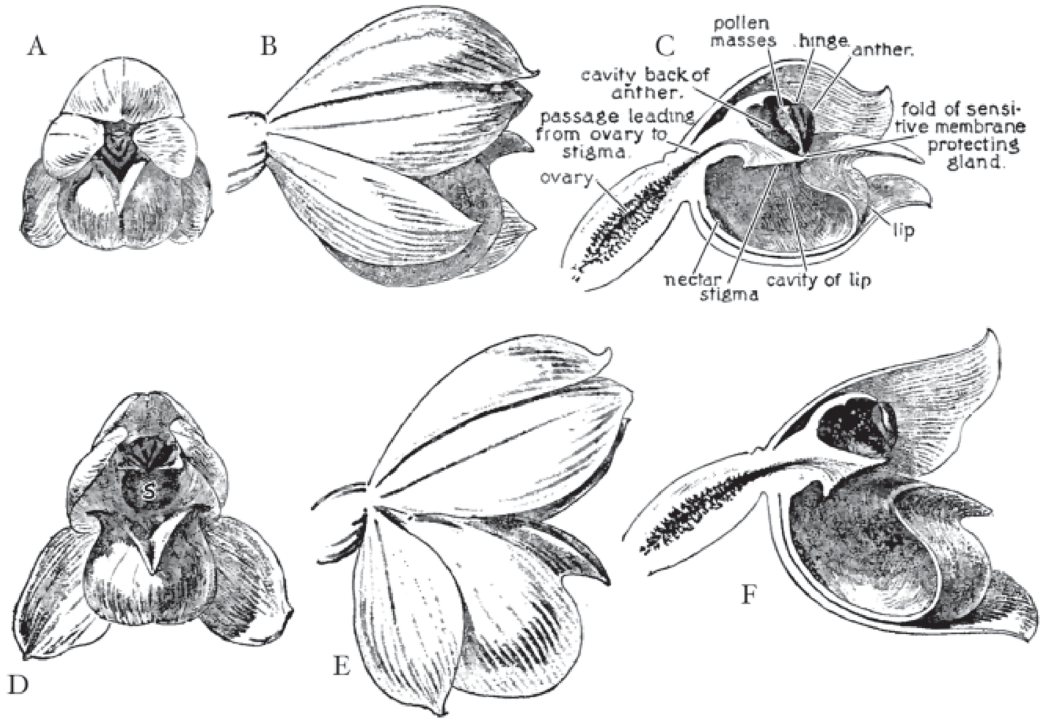


Fig. 19

The entrance is thus much narrowed. If we insert a pin in this V-shaped entrance it comes in contact with the sensitive membrane below the anther, and it is immediately ruptured, as shown at Fig. 20, D. The sticky gland is brought into immediate contact, and clasps the pin, which, now being withdrawn, brings away the pollen, as in E and F. Thus it is naturally removed on the tongue of its sipping bee.

The further demonstration will be better shown by profile sections (Fig. 21). Nectar is secreted

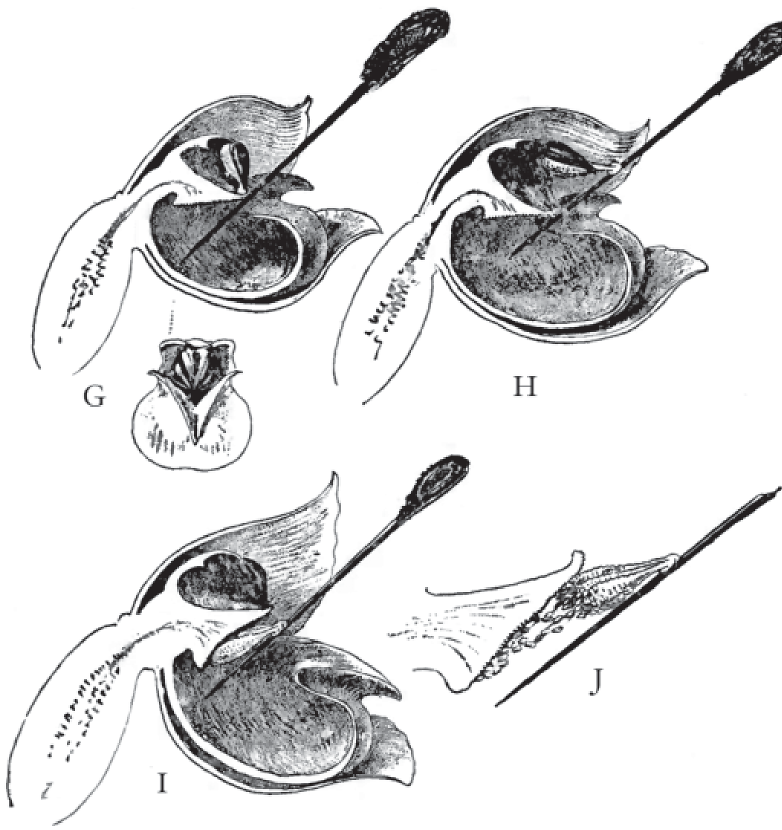


Fig. 21

in the hollow of the lip indicated, somewhat as in the cypripedium. If we now imitate with a probe the habit of the insect and the action of its tongue, we may witness a beautiful contrivance for cross-fertilization. We will suppose the bee to be working at the top of the spike. He thrusts his tongue into the narrow opening (G). The membrane protecting the pollen-gland, thus surely touched, ruptures as described, and the exposed gland attaches itself to the tongue, being withdrawn as at H, and located on the insect's

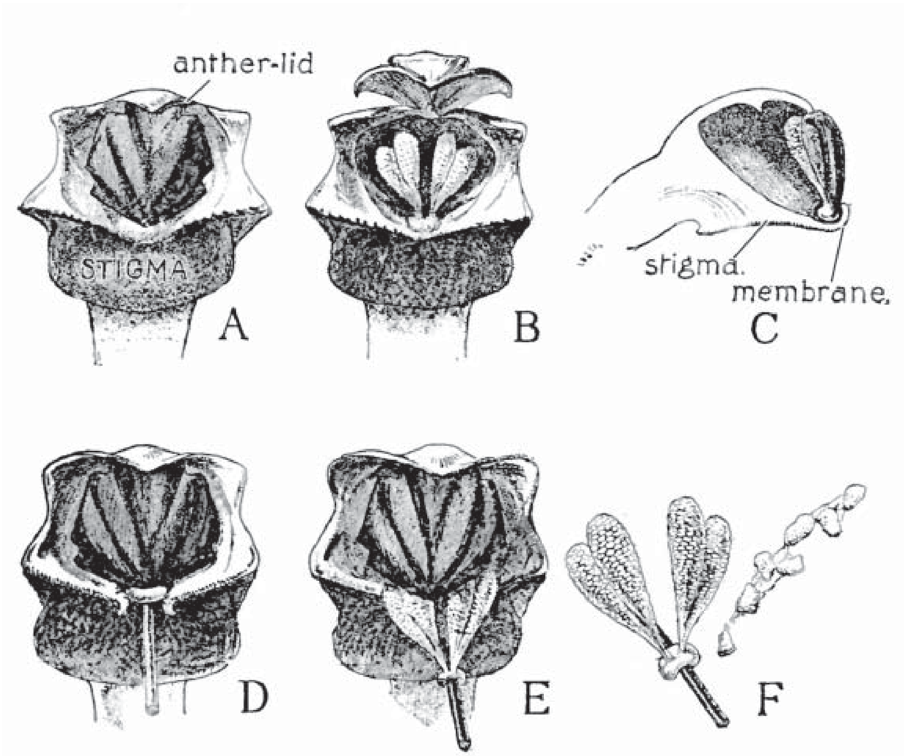
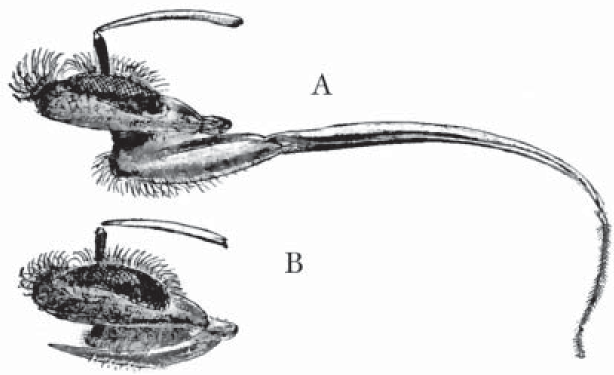


Fig. 20

tongue, as in F, Fig. 20. The bee leaves this flower cluster and flies to another, upon which it will usually begin operation at the bottom. The flower thus first encountered is an old bloom, as in Fig. 19, D. Its sepals are more spreading, the lip slightly lowered, and the column so changed as to present the plane of the stigma, before out of sight, in such a new position as to invariably receive the pollen. The tongue of a bee entering this flower conveys the pollen directly against the stigmatic surface (I), which retains its disentangled fecundating grains, as at J, and the flower's functional adaptations are fulfilled.



A. Extended B. Folded beneath the head

In the allied Spiranthes, or "Lady's-Tresses," a somewhat similar mechanism prevails, by which fertilization is largely effected by the changed position or angle of the stigma plane.

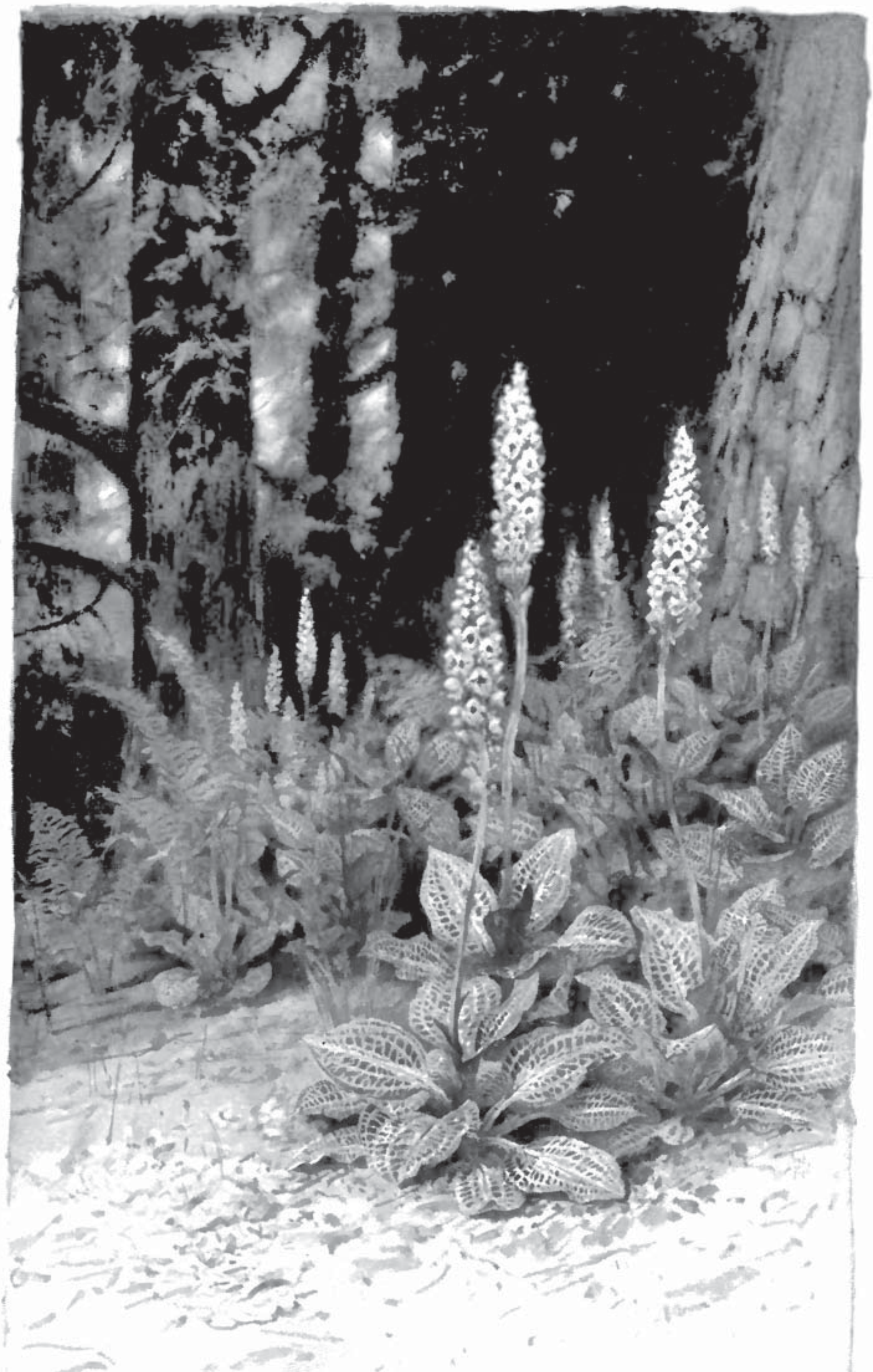
And thus we might proceed through all the orchid genera, each new device, though based upon one of the foregoing plans, affording its new surprise in its special modification in adaptation to its insect sponsor — all these various shapes, folds of petals, positions, colors, the size, length, and thickness of nectary, the relative positions of pollen and stigma, embodying an expression of welcome to the insect with which its life is so marvellously linked. Occasionally this astounding affinity is faithful to a single species of insect, which thus becomes the sole sponsor of the blossom, without whose association the orchid would become extinct. A remarkable instance of this special adaptation is seen in the great Angræcum orchid of Madagascar, described by Darwin; and inasmuch as this species glorifies Darwin's faith in the truth of his theory, and marks a notable victory in the long battle for its supremacy, it affords an inspiring theme for my closing paragraphs.

Among the host of sceptics — and were they not legion? — who met this evolutionary and revolutionary theory with incredulity, not to say ridicule or worse, was one who thus challenged its author shortly after the appearance of his "Fertilization of Orchids," addressing Darwin from Madagascar substantially as follows: "Upon your theory of evolution through natural selection all the various contrasting structural features of the orchids have direct reference to some insect which shall best cross-fertilize them. If an orchid has a nectary one inch long, an insect's tongue of equivalent length is implied; a nectary six inches in length likewise implies a tongue six inches long. What have you to say in regard to an orchid which flourishes here in Madagascar possessing a long nectary as slender as a knitting-needle and eleven inches in length ? On your hypothesis there must be a moth with a tongue eleven inches long, or this nectary would never have been elaborated."

Darwin's reply was magnificent in its proof of the sublime conviction of the truth of his belief : "The existence of an orchid with a slender nectary eleven inches in length, and with nectar secreted at its tip, is a conclusive demonstration of the existence of a moth with a tongue eleven inches in length, *even though no such moth is known."*

Many of us remember the ridicule which was heaped upon him for this apparently blind adherence to an untenable theory. But victory complete and demoralizing to his opponents awaited this oracular utterance when later a disciple of Darwin, led by the same spirit of faith and conviction, visited Madagascar, and was soon able to affirm that he had caught the moth, a huge sphinx-moth, and that its tongue measured eleven inches in length.

Here we see the prophecy of the existence of an unknown moth, founded on the form of a blossom. At that time the moth had not been actually seen at work on the orchid, but who shall



question for a moment that had the flower been visited in its twilight or moonlight haunt the murmur of humming wings about the blossom's throat would have attested the presence of the flower's affinity, for without the kiss of this identical moth the Angræcum must become extinct. No other moth can fulfil the conditions necessary to its perpetuation. The floral adaptation is such that the moth must force its large head far into the opening of the blossom in order to reach the sweets in the long nectary. In so doing the pollen becomes attached to the base of the tongue, and is withdrawn as the insect leaves the flower, and is thrust against the stigma in the next blossom visited. This was clearly demonstrated by Darwin in specimens sent to him, by means of a probe of the presumable length and diameter of the moth's tongue. Shorter-tongued moths would fail to remove the pollen, and also to reach the nectar, and would thus soon learn to realize that they were not welcome.

The Angræcum also affords in this long pendent nectary a most lucid illustration of the present workings of natural selection. The normal length of that nectary should be about eleven inches, but in fact this length varies considerably in the flowers of different plants, this tendency to variation in all organic life being an essential and amply demonstrated postulate of the entire theory of natural selection. Let us suppose a flower whose nectary chances to be only six inches in length. The moth visits this flower, but the tip of its tongue reaches the nectar long before it can bring its head into the opening of the tube. This being a vital condition, the moth fails to withdraw the pollen; and inasmuch as the pollen is usually deposited close to the head of the moth, this flower would *receive* no pollen upon its stigma. This particular blossom would thus be both barren and sterile. None of its pollen would be carried to other stigmas, nor would it set a seed to perpetuate by inheritance its shorter nectary.

Again, let us suppose the variation of an extra long nectary, and the writer recently saw a number of these orchids with nectaries thirteen inches in length. The moth comes, and now must needs insert its head to the utmost into the opening of the flower. This would insure its fertilization by the pollen on the insect's tongue; and even though the sipper *failed* to reach the nectar, the pollen would be withdrawn upon the tongue, to be carried to other flowers, which might thus be expected to inherit from the paternal side the tendency to the *longer* nectary. The tendency towards the perpetuation of the short nectary is therefore stopped, while that of the longer nectary is insured.

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