DEATH OF MR. HARDWICKE.

It is our painful duty to record the death of our publisher, Mr. Robert Hardwicke, which occurred on the morning of Monday, March 8, at the age of 52 years, after an illness which lasted but for ten short days. Thus was he cut off nearly in his prime, at a time too when his business relations were almost at their best. Of his friends it is not too much to say, that those who knew him longest knew him best, and have only to record their extreme sorrow for his loss. For assuredly there were none who were more thoroughly kind, genial, and considerate in all their dealings. Never before, in the course of our experience, have we met with one, with whom we have never within the period of ten long years had a single bitter word. All his dealings were kindly, none were severe. And though we feel that the fewest words are best when all are vain, we cannot help expressing our bitter sorrow at his death. For we have not the least hesitation in saying that we have lost a good, sincere, and earnest friend.

INSECTS AND FLOWERS.

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[PLATES CXIX and CXX.]

IN his charming little book on "British Wild Flowers in Relation to Insects," which ought to be in the hands of everyone interested in the subject, Sir John Lubbock makes a few observations on the form of pollen-grains, in relation to the fertilisation of flowers; but there is but little information at present to be found in botanical works on this point. The anatomical structure of the pollen-grain has been the subject of abundant research; but the feature of chief importance in connection with the means of transport is the external form of the grain, to which but little attention has been directed, at least in this country. With the exception of a few stray notes scattered through botanical and microscopical journals, the only publications bearing on the subject, illustrated by drawings (without which they are comparatively useless), are in German:—Schacht, in Pringsheim's "Jahrbuch," vol. ii. for 1860;

Fritzsche, "Beiträge zur Kenntniss des Pollen," 1832; and Mohl, "Beiträge zur Anatomie und Physiologie der Gewächse," 1834; the first of these being the only one bearing at all a recent date. There is, besides, a magnificent series of unpublished drawings by Bauer in the British Museum.

The size and form of the pollen-grain is, within very narrow limits, uniform in the same species; and an adaptation may frequently be observed to the normal mode of fertilisation of the species. In the pollen-grains of which drawings will be found on Plate CXIX., the size varies from less than $\frac{1}{2000}$ of an inch in diameter, in the case of *Hoteia japonica* (fig. 38), to nearly $\frac{1}{200}$ in that of *Cobœa scandens* (fig. 54). In relation to their mode of pollination, flowers may be divided into two classes, the "anemophilous," in which the wind, and the "entomophilous," in which insects are the main agent. The former are almost without exception flowers without beauty of form, colour, or scent; to the latter belong all plants with conspicuous, brightly-coloured, or sweetly-scented flowers, and, as Darwin has pointed out, all with irregular corolla. Between these two classes of flowers there is a marked difference in the external form of their pollen-grains. In the former case the object is to enable them to be carried easily by the wind to reach the female flowers (for they are very commonly unisexual), or the pistil in some other flower. To effect this purpose the pollen is always very dry and dusty, the grains not very large, usually nearly or quite spherical, and never spiny nor marked with conspicuous furrows or protuberances. The following pollen-grains drawn on Pl. CXIX. illustrate the appearance presented in the case of anemophilous plants. Fig. 1 is the pollen-grain of the hazel, fig. 2 of the birch, and fig. 3 of the balsam poplar (*Populus balsamifera*), all nearly perfectly spherical and quite smooth, with but very slight angularities or protuberances. It is true the pollen of the hazel has been described* and even drawn as "triangular;" but I suspect this must have arisen from the fact of its having been mounted in glycerine for the microscopic slide. Immersion in any thick fluid has the effect of altering the shape of the grain, by exciting the incipient growth of the pollen-tubes. I have in my collection a slide of the pollen of *Polygala myrtifolia* mounted in glycerine, in which the tubes are as long as the longer diameter of the grain. The proper way of observing the form of the pollen in its condition when escaping from the anther—which is of course the state in which it is carried by the wind or by insects—is to dust it off on to a glass slide, and observe it at once dry and without any covering-glass. Examined in this way, I have found the pollen of these three plants scarcely to deviate perceptibly from the spherical

* "Nature," vol. ix. p. 440.

form when magnified 250 diam. Fig. 4 is *Luzula campestris*, nearly spherical, but with a depressed band of lighter colour, dividing the grain into three nearly equal sections. Figs. 5 and 6 represent the pollen of plants the mode of fertilisation of which is doubtful; the former is that of the dog's mercury, *Mercurialis perennis*, elliptical but quite smooth, and covered with very fine reticulations; the latter of the box, spherical, but with a number of slight protuberances irregularly dispersed over the surface of the grain. *Plantago lanceolata* is described by Müller* as having three distinct forms of flower, and he suggests that it may be a species in a transitional state from anemophilous to entomophilous. It is probable that the form of the pollen may also vary. Fig. 7 represents that observed by myself, nearly spherical or with badly defined angles, and traversed by a single equatorial ridge, with several darker spots where the pollen-tubes are emitted. I find the colour described in my notes as nearly white, but some of the more perfect grains with a deep orange surface, very smooth and shining. In figs. 8 and 9 we have the grains of two grasses, the common *Poa annua*, and the "quaking-grass," *Briza media*. The spherical form is here somewhat departed from; but they are exceedingly light and smooth. The microscope shows various bright spots, which have the appearance of depressions or holes. Fig. 10 is the oval perfectly unfurrowed grain of *Dactylis glomerata*.

In flowers which are fertilised by the agency of insects the form and size of the pollen-grains vary to a much greater extent, and we find several distinct contrivances for the purpose of facilitating their attachment to the legs or bodies of bees, flies, and other insects. The most important of these are three:—longitudinal furrows varying in number from three to eight or nine or even more; the clothing of the surface of the grains with spines or other prominent projections; and the connecting them together by means of viscid threads. By far the most common form of pollen-grain is ellipsoidal, with three or more longitudinal furrows. Grains of this shape are obviously more calculated to cling to the hairs that clothe the legs and bodies of insects than perfectly spherical ones; while on the other hand they would not be so readily carried by the wind. Illustrations of such grains with three furrows are afforded by fig. 11, *Ranunculus Ficaria*; fig. 12, *Aubrietia deltoidea*; fig. 13, *Viola sylvatica*; fig. 14, *Aucuba japonica*, in which the anthers appear to be filled with an oily fluid; fig. 15, *Lamium album* (yellow); fig. 16, *L. purpureum* (red); fig. 17, *Nepeta Glechoma* (white); fig. 18, *Platanus orientalis*; fig. 19, *Convallaria Polygonatum*; and fig. 20, *Bryonia dioica*.

* "Befruchtung der Blumen durch Insekten," p. 342.

The pretty genus *Polygala* is characterised by a very remarkable form of pollen-grain. They are somewhat barrel-shaped, bulging in the middle, and with a considerable number (in *P. myrtifolia*, fig. 21, from twenty to twenty-four) of regular longitudinal alternate ridges and furrows. They are very beautiful objects under the microscope. In the various species of *Primula* characterised by "dimorphic" flowers, the grains are small, shortly cylindrical rather than ellipsoidal, and with a varying number of furrows. There is also this remarkable peculiarity, that as far as my observation goes, the pollen-grains of the long-styled form are invariably smaller than those of the short-styled form; at least this is the case in the primrose, cowslip, and polyanthus.*

In figs. 22 and 23 we have the long and short-styled forms of the primrose, figs. 24 and 25 of the cowslip, and figs. 26 and 27 of the polyanthus (transverse view). The explanation of this difference which has been suggested by Darwin and Lubbock, is a very ingenious and probable one. The long-styled form of *Primula* would of course require longer pollen-tubes to penetrate the style in order to reach the ovules than the short-styled form. It is fertilised normally by the short-styled form, and this latter form is therefore provided with pollen-grains of a larger size. In *Primula japonica* (in which I am not aware whether the two forms occur) the form of the pollen-grain is very different (fig. 28)—a triangular plate with three deep furrows. Occasionally in anemophilous flowers we have spherical furrowed grains, as in *Dicentra speciosa* (fig. 29), where there are also some irregularly disposed protuberances; or *Plantago media* (fig. 30), which approximates somewhat to the irregular form of *P. lanceolata.* Sometimes also we have ellipsoidal grains without any apparent furrow, as in *Anthriscus sylvestris* (fig. 31), *Adoxa Moschatellina* (fig. 32), which is somewhat lenticular, *Narcissus poeticus* (fig. 33), and the very large grains of *Fritillaria imperialis* (fig. 34) and *F. Meleagris* (fig. 35). Others again are characterised by being furnished with protuberances scattered irregularly over the grains, as *Ribes aureum* and *R. fruticosum* (figs. 36 and 37), the protuberances apparently causing the grains to adhere together in masses. In the very minute pollen-grain of *Hoteia japonica* (fig. 38), there is one such protuberance on each side, which is the case also with *Saxifraga crassifolia* (fig. 39). The section of the genus

* I have Mr. Darwin's authority for saying that his statement to the contrary effect, which will be found in his paper on the species of *Primula* in the "Journal of the Linnean Society," vol. x. p. 393, is an error, which will be found corrected elsewhere in his writings, and in those of Hildebrand and Lubbock. It has however been copied into several of our text-books.

Viola, known as *Melanium*, has a very remarkable form of pollen-grain. They are of a (comparatively) enormous size, the lateral aspect presenting nearly a rectangular parallelogram, the transverse aspect a nearly regular pentagon or hexagon. Fig. 40 represents the two views of the garden pansy, fig. 41 the side view of *Viola lutea*, and fig. 42 the transverse view of *V. cornuta*, offering a remarkable contrast to the size and form of the grains in the section *Nominium* of the same genus (see fig. 13). There is no doubt that this variation is connected with a difference in the mode of fertilisation in the two sections—a view which is confirmed by the great difference in the form of the stigma.

The form of pollen-grain covered with a number of distinct sharp spines, is characteristic of certain natural families, especially Malvaceæ, some sections of Compositæ, and some Cucurbitaceæ. They are usually, but not always, spherical. Fig. 43 is the very large and beautiful grain of the hollyhock (*Althæa rosea*). The grain of the garden *Cineraria* (fig. 44), presents about twenty-four of these spines round any diameter. Fig. 45 is the spherical grain of the dandelion (*Taraxacum officinale*); fig. 46 the ellipsoidal furrowed one of the groundsel (*Senecio vulgaris*).

Pollen-grains fastened together by viscid threads, so as to enable them to be carried about with greater facility in masses, are of various sizes and forms. One very familiar variety occurs in the various species of *Rhododendron* and *Azalea*; another is afforded by the well-known triangular grains of the Onagrarieæ, as illustrated by the *Fuchsia* (fig. 47), and another by the "touch-me-not," or *Impatiens*. The same occurs in Caryophyllaceæ, as *Stellaria Holostea* (fig. 48), and *Lychnis diurna* (fig. 49), where the grains are also covered with a great number of tooth-like or wart-like projections. The smooth oval furrowless grains of *Salix nitens* (fig. 50) are connected together in the same way. A different mode of adhesion is exhibited by the pollen of *Canna indica* (fig. 51). The grains are first of all hexagonal, and firmly attached together by their sides; but after they become separated from one another appear almost perfectly spherical; they are furnished with a number of minute spines. A very similar appearance is presented by the pollen of *Alpinia* (fig. 52). In the cultivated "white Arum" *Richardia africana* (fig. 53), the grains are variable in size, oval, without furrows, and connected together in long strings and masses. The pollen-grain of *Cobœa scandens* (fig. 54), is one of the most magnificent objects under the microscope. Perfectly spherical in outline, and nearly $\frac{1}{200}$ of an inch in diameter, its surface is cut up into minute hexagonal facets, reminding one of the eyes of a fly.

A very interesting illustration of the relation between the form of the pollen and the mode of pollination was brought out in a recent examination of perfect flowering specimens of the "Kerguelen's Land Cabbage" sent home from the *Challenger* expedition, who had used it largely as a vegetable while in those inhospitable regions. *Pringlea antiscorbutica* differs from the normal type of the order Cruciferæ, to which it belongs, in the entire absence of petals, the absence of honey-glands at the base of the flower, the long exserted style, and the stigma covered with long papillæ—all pointing, as suggested by Dr. Hooker, to the conclusion that the *Pringlea* is an anemophilous species in an order usually entomophilous. This inference is in harmony with the fact of the almost entire absence of winged insects in that country, which is constantly swept by the most furious winds. It is true that Mr. Moseley, the naturalist to the *Challenger* expedition, reports having found numbers of an apterous fly crawling over the foliage of the plant; but, singularly enough, he saw none on the inflorescence itself; whether they have any share in the fertilisation of the flower will remain for future explorers to discover. Having an opportunity of examining the pollen-grains under the microscope, I found them altogether in accordance with the hypothesis that the pollen is carried by the wind. While the usual form of the grains in Cruciferæ is ellipsoidal and three-furrowed, as illustrated in *Aubrietia* (fig. 12), or in the more nearly allied *Sisymbrium officinale* (fig. 55), those of *Pringlea* are, as exhibited in fig. 56, very minute and perfectly smooth and spherical.

Hermann Müller, who has devoted much attention to the reciprocal adaptations of flowers and insects to each others' needs, has described in his "Befruchtung der Blumen durch Insekten," and in greater detail in "Nature" (vol. viii. p. 433, *et seq.*), a remarkable kind of "dimorphism" exhibited by certain flowers. Our figs. 1 and 2 (Plate CXX.) are taken from the latter series of papers, and illustrate the phenomenon in the case of the common eye-bright, *Euphrasia officinalis*, so pretty an ornament to our hill-sides and heaths. If the specimens of this flower growing in different localities are observed, it will be found that those that inhabit more open sunny places have larger and more brightly-coloured flowers, while the flowers of those in more shady situations are smaller and paler—the relative sizes being represented by figs. 1 and 2 (both considerably magnified)—and that this difference in size is accompanied by other structural differences which favour cross-fertilisation in the one, self-fertilisation in the other case. If a flower of the larger form which has just opened (fig. 1 *a*) is examined, the stigma, *st*, already in a receptive condition, considerably overtops the anthers, *an*. Each of the two lower anthers is provided with two long hairs, *h*, which, in this stage of the flower, project into the opening of the corolla, so that an insect thrusting its head into the flower necessarily strikes against them, and in so doing shakes the pollen out of all the anthers on to its proboscis, and then carries it to the next flower it enters. At a later stage the parts occupy the relative position shown in *b*; and by this time the stigma is brown and withered, so that self-fertilisation is impossible. In the flower of the smaller form, (fig. 2), the anthers have completely discharged their pollen before the flower has fully opened (in the state shown in *a*); and the stigma, *st*, instead of overtopping the anthers, is slightly below and almost in contact with them. When the flower is fully open (*b*, *c*) the stigma is already withered up, so that cross-fertilisation is almost impossible. Dr. Müller has observed three species of Diptera and four of Hymenoptera visiting the larger form of the *Euphrasia*, but never any on the inconspicuous ones. The same dimorphism is found, under similar conditions, in several other plants—Müller mentions especially *Lysimachia vulgaris* and *Rhinanthus Crista-galli*—accompanied by similar contrivances for ensuring different modes of fertilisation. In the latter case the two forms have been described as distinct varieties, *R. Crista-galli*, *a*, and *β* Linn., and even as distinct species, *R. major* and *minor* Ehrh. In this last plant the small-flowered form appears to be frequently visited by insects, and to be self-fertilised only when by any chance it is left unvisited.

One of the most remarkable contrivances for ensuring cross-fertilisation is exhibited by the birth-wort (*Aristolochia Clematitis*) a rare wild flower in our southern counties. Fig. 3 *a* represents a flower cut through lengthwise when just opened. The stigmas, *st*, are in a receptive condition; but the anthers, *an*, are still closed. A small insect, *in*, which has brought on its back a mass of pollen from an older flower, has passed through the tube of the calyx, *t*, and reached the globular cavity below; the retrorse hairs which clothe the tube of the calyx effectually preventing its exit when once imprisoned. During its imprisonment the insect is sure to deposit some of the pollen on the stigma, the lobes of which then curve up, as represented in *b*. This curving up of the stigmatic lobes enables the anthers to open and discharge their pollen, some of which must adhere to the bodies of the still imprisoned insect. The hairs in the calyx-tube now die away, so as to allow the insect to escape and carry the fresh load of pollen to other flowers. But the flower has now altogether altered its position. As long as the stigma was still in a receptive condition, the pedicel was erect, and the calyx open (as represented in *a*), inviting the visits of insects. But as soon as the pollination of the stigma has been effected, the pedicel bends sharply downwards just beneath the ovary, so as to bring the flower into a pendent position; and by the time the insects have escaped, laden with pollen, the standard-like lip, *l*, of the calyx bends over so as to close up the orifice (as seen in *b*), and prevent any further incursions. The relative position of the reproductive organs would seem to render self-fertilisation impossible in this flower; and as many as six or eight flies have been found imprisoned at one time in the globular cavity of the calyx.

The position of a bee when sucking the honey from a flower with a tubular corolla is well shown in fig. 4, copied from Sprengel's "Entdeckte Geheimniss der Natur," representing a flower of *Stachys sylvatica* so visited. It was in fact the very instance here depicted which led Sprengel to the discovery that in "dichogamous" flowers, where the reproductive organs are not mature simultaneously, these organs occupy successively nearly the same position in the flower at the period of maturity of each, so that the very same part of an insect's body which rubs the pollen out of the anthers of one flower comes into contact with the stigma of another flower. Well might Sprengel exclaim, when the general truth of this law first began to dawn upon him, "Who must not admire the perfection of the structure, both of this flower and of this bee! Who cannot perceive that the Creator has adapted each one for the other, and has so constructed them that each supplies the need of the other!" Readers of Darwin's work on the Fertilisation of Orchids will recollect that from the extraordinary length of spur of that remarkable orchid *Angræcum sesquipedale* he draws the conclusion that Madagascar, its native country, must be the home of moths with a proboscis capable of extension to a length of between ten and eleven inches, for which purpose only could a spur be provided of such enormous length. A very short time since, Dr. Fritz Müller vindicated the sagacity of our great naturalist by sending home from Brazil the proboscis of a moth * captured in the province Sta. Catharina, of precisely that length.

The mode in which bees obtain the honey from flowers has been a subject of much controversy among naturalists. Swammerdamm, two centuries ago, erroneously described the tongue as a hollow tube, perforated at the extremity. This error was detected by subsequent observers, who taught—also erroneously—that the tongue of bees is merely a licking and not a sucking organ. This is indeed the teaching of most modern

* Drawn in "Nature," vol. viii. p. 223.

entomologists, even of so accomplished an observer as Milne-Edwards, who says that "honey-bees obtain their food not by sucking, but, as it were, by lapping, nearly in the same manner as a cat does." The same view is held by Carl Vogt and Gerstaecker. Hermann Müller, however, considers that he has proved that bees and other Hymenoptera really do suck honey. Fig. 5 (borrowed from him) represents the oral apparatus of a hive- or humble-bee stretched out to its fullest extent. The most prominent portion of this apparatus is the long tongue or *ligula, li*, at the end of which is a little membranous lobe, *w*, which was erroneously taken by Swammerdamm for a perforation. The ligula is composed of a number of rings, each provided with a whorl of hairs, which can be erected or pressed closely to the ligula at will. This ligula can be partially drawn back into the tubular *mentum, mt.* On each side of the ligula, and inserted into the mentum, are the *labial palpi, pl*, the two first joints of which are flattened and very slender, with a central rib, forming a sheath to the tongue, enclosing it from below, whilst the two small joints at the tips serve as feelers. The maxillæ terminate in two flat lanceolate horny pieces, the *laminæ, la*, each with a central rib, which also form a sheath to the tongue, enclosing it from above. The *maxillary palpi, pm*, occur in the mouth of typical bees only as atrophied useless organs. When a bee is obtaining honey from a flower, it may be seen to execute in succession a number of distinct acts of suction, sometimes as many as eight or ten, each act being accompanied by a protrusion of the tip of the tongue, followed by a retraction of it and of the whole sucking-tube. The mechanism of these movements is thus described by Müller :—In order to reach the bottom of a deep nectary, the bee stretches out the whole of the movable parts of the sucking apparatus, as shown in fig. 5, except that the two first joints of the labial palpi sheathe the tongue from beneath, while the laminæ closely embrace the mentum and the basal part of the tongue from above. When the terminal hairy whorls of the tongue, protruded as far as possible, are wetted with honey, the bee withdraws the mentum, together with the tongue and the labial palpi, so far that the laminæ are no longer overtopped by the latter, and that the laminæ and the palpi together, closely embracing the tongue, form a sucking-tube, of which only the upper part of the tongue above the labial palpi is prominent. The bee then withdraws the hairy whorls of the tongue, wetted with honey, into this sucking-tube; and the suction of the honey into the œsophagus is accomplished by the enlargement of the interior abdominal hollows connected with the œsophagus—which is visible from the outside by the swelling of the abdomen—and the simultaneous action of the whorl of hairs on the tip of the tongue gradually progressing downwards towards its base. These various movements Müller was able to follow by intoxicating bees with chloroform, and then immersing the tip of the tongue into a solution of sugar. When the bee is flying on a honey-seeking expedition, it carries its sucking apparatus stretched forwards, so as to be able to put it directly into the opening of the nectary; its tongue being perfectly enclosed between the labial palpi and the maxillæ, and the delicate whorls of hairs thus protected from injury. Bees frequently require to obtain the fluid from the cellular tissue itself of the petals, as in the hyacinth and some species of orchis, or from nectaries too deep to be reached by the proboscis, as in the heath or clover; for this purpose they sometimes bite the flowers by their mandibles, but more often pierce it by the extremities of the maxillæ or laminæ. Darwin states, in his "Origin of Species," that the common red clover, although containing abundance of honey, is perfectly useless, owing to the length of the corolla-tube, to the hive-bee, until the tube has first been bitten through by a humble-bee. The honey of *Trifolium incarnatum*, on the other hand, is perfectly accessible to the hive-bee.

H. Müller has described, in a very interesting manner,* the mode in which hive- and honey-bees collect pollen. They first moisten it with honey before stripping it off with the brushes of their feet from the anthers. During this process the maxillæ and the labium are commonly bent beneath the breast as when at rest; the jaws are opened, and a drop of honey is spit out upon the pollen. The dry pollen of *Plantago lanceolata* (fig. 7, Pl. CXIX.) Müller saw collected by a bee in the following manner:—The bee maintains itself in the same place, immediately before the anthers, by very rapid vibrations of its wings; its sucking-apparatus is stretched forwards, but the tongue quite enclosed between the laminæ and the labial palpi; and a drop of honey is spit out from the tube on to the anthers. It then suddenly grasps the anthers with the brushes of its anterior legs, and strips off the moistened pollen on them; the dry pollen from the neighbouring anthers being also shaken out in a dense cloud. In *Plantago lanceolata* there is no honey; when pollen is to be collected from nectariferous flowers, bees retract their sucking-organs, while these organs have to be stretched out when the honey is collected. They can never therefore suck honey and collect pollen at the same time, but perform these actions alternately. There are, however, some bees, like *Andrena*, *Osmia*, and *Megachile*,

* "Nature," vol. viii. p. 206.

which collect pollen without moistening it; and these may be observed to perform both operations simultaneously.

The mode of fertilisation of the Orchideæ and Asclepiadeæ has been made so familiar by the writings of Darwin and others, that no detailed description will be necessary. With the exception of the Bee-orchis, orchids are almost invariably entomophilous; and the parts of the flowers are so arranged that in obtaining the honey from the nectary (the spur or labellum) the visiting insect — mostly some species of Hymenoptera or Lepidoptera—must necessarily strike its head or proboscis, in the first flower which it visits, against the viscid disc, so as to detach the pollinia or pollen-masses; while on entering another flower these pollen-masses are made to strike against the stigmatic surface. Fig. 6 shows at *a* a drawing of the common tway-blade, *Listera ovata*, copied from the frontispiece of Sprengel's "Entdeckte Geheimniss der Natur;" and at *b* another flower, in which the honey is being sucked from the spur by a species of ichneumon, illustrating how admirably the two long arms into which the labellum is divided are fitted for affording a standing-place to the insect while obtaining the honey.

A plant which it is difficult to place in any class in relation to the mode of its fecundation is the *Vallisneria spiralis*, of the South of France, so commonly grown in fresh-water aquaria. The pollination of the pistil is effected in this instance neither by the agency of insects nor by that of the wind, but as it were spontaneously through the medium of water. The plant is diœcious, the male and female flowers (fig. 7, *m* and *f*) being both of very simple structure and borne on different plants, often growing in close proximity to one another. The male flowers are borne on very short stalks, the female flowers on much longer spiral stalks, which have the power of coiling and uncoiling. When mature the male flowers break off from their pedicels, and, rising to the top of the water, scatter the pollen abroad on its surface, as if waiting the arrival of the female flowers, which, about the same time, also rise to the surface by the uncoiling of their pedicels. In this position some of the floating pollen reaches them and fertilises the pistil; and when this has been accomplished the pedicel again coils up and brings the female flower again below the surface of the water, where it ripens its fruit.

These examples will serve only as a few illustrations of the vast field still left for observers of the phenomena connected with the contrivances supplied by nature to favour the cross-fertilisation of flowers.

EXPLANATION OF PLATES.

PLATE CXIX.

Pollen-grains (*all* × 250).

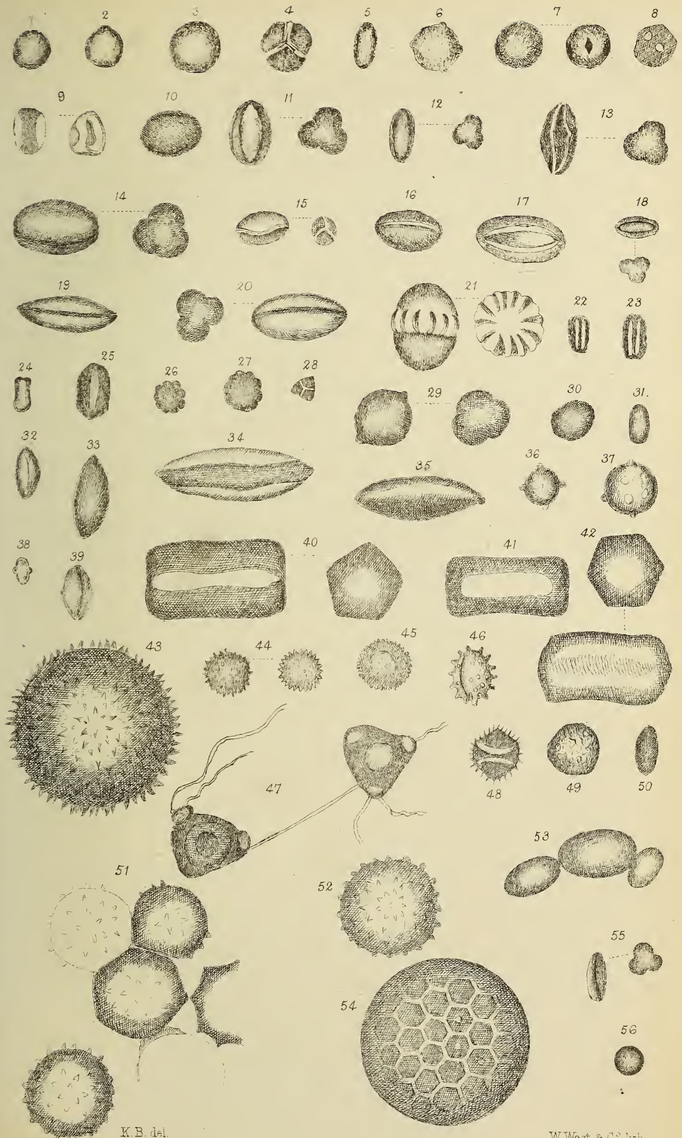
(N.B.—1‴ = $\frac{1}{1000}$ in.)

Fig. 1. *Corylus Avellana*, 1‴; 2, *Betula alba*, 1‴; 3, *Populus balsamifera*, 1·5‴; 4, *Luzula campestris*, 1·3‴; 5, *Mercurialis perennis*, 1·3‴ × 0·7‴; 6, *Buxus sempervirens*, 1·25‴; 7, *Plantago lanceolata*, 1·25‴; 8, *Poa annua*, 1·2‴; 9, *Briza media*, 1·2‴ × 1‴; 10, *Dactylis glomerata*, 1·6‴ × 1·25‴; 11, *Ranunculus Ficaria*, 1·7‴ × 1·25‴; 12, *Aubrietia deltoidea*, 1·4‴ × 1‴; 13, *Viola sylvatica*, 1·9‴ × 1·3‴; 14, *Aucuba japonica*, 2·3‴ × 1·6‴; 15, *Lamium album*, 1·5‴ × 0·7‴; 16, *Lamium purpureum*, 1·8‴ × 1·1‴; 17, *Nepeta Glechoma*, 2·4‴ × 1·4‴; 18, *Platanus orientalis*, 1·2‴ × 0·9‴; 19, *Convallaria Polygonatum*, 2·8‴ × 1‴; 20, *Bryonia dioica*, 2·7‴ × 1·4‴; 21, *Polygala myrtifolia*, 2·4‴ × 1·9‴; 22, *Primula vulgaris* (long-styled), 0·9‴ × 0·5‴; 23, *Primula vulgaris* (short-styled), 1·2‴ × 0·75‴; 24, *Primula veris* (long-styled), 1‴ × 0·5‴; 25, *Primula veris* (short-styled), 1·4‴ × 1‴; 26, *Primula vulgaris* (var. hort., Polyanthus, long-styled), 1·3‴ × 0·9‴; 27, *Polyanthus* (short-styled), 1·6‴ × 1·1‴; 28, *Primula japonica*, 0·6‴; 29, *Dicentra speciosa*, 1·5‴; 30, *Plantago media*, 1·2‴; 31, *Anthriscus sylvestris*, 1‴ × 0·6‴; 32, *Adoxa Moschatellina*, 1·4‴ × 0·7‴ × 0·5‴; 33, *Narcissus poeticus*, 2·2‴ × 1·1‴; 34, *Fritillaria imperialis*, 4‴ × 1·75‴; 35, *Fritillaria Meleagris*, 3·5‴ × 1·3‴; 36, *Ribes aureum*, 1‴; 37, *Ribes fruticosum*, 1·4‴; 38, *Hoteia japonica*, 0·7‴ × 0 4‴; 39, *Saxifraga crassifolia*, 1·4‴ × 0·8‴; 40, *Viola tricolor* (var. hort.), 3·75‴ × 2‴; 41, *Viola lutea*, 3·3‴ × 1·7‴; 42, *Viola cornuta*, 3·5‴ × 1·9‴; 43, *Althæa rosea*, 4·4‴; 44, *Cineraria*, sp., 1‴; 45, *Taraxacum officinale*, 1·25‴; 46, *Senecio vulgaris*, 1·3‴ × 1·1‴; 47, *Fuchsia*, sp., 2‴; 48, *Stellaria Holostea*, 1·25‴; 49, *Lychnis diurna*, 1·25‴; 50, *Salix nitens*, 1·2‴ × 0·7‴; 51, *Canna indica*, 2·3‴; 52, *Alpinia* sp., 2·6‴; 53, *Richardia africana*, 2‴ × 1·4‴; 54, *Cobæa scandens*, 4·6‴; 55, *Sisymbrium officinale*, 1·3‴ × 0·75‴; 54, *Pringlea antiscorbutica*, 0·75‴.

PLATE CXX.

Fig. 1. *Euphrasia officinalis*, larger-flowered form; *a*, flower just opened; *b*, position of stigma and anthers in a more advanced stage; *c*, two anthers seen from the inner side; *st*, stigma; *an*, anthers; *h*, hairs attached to the two lower anthers.

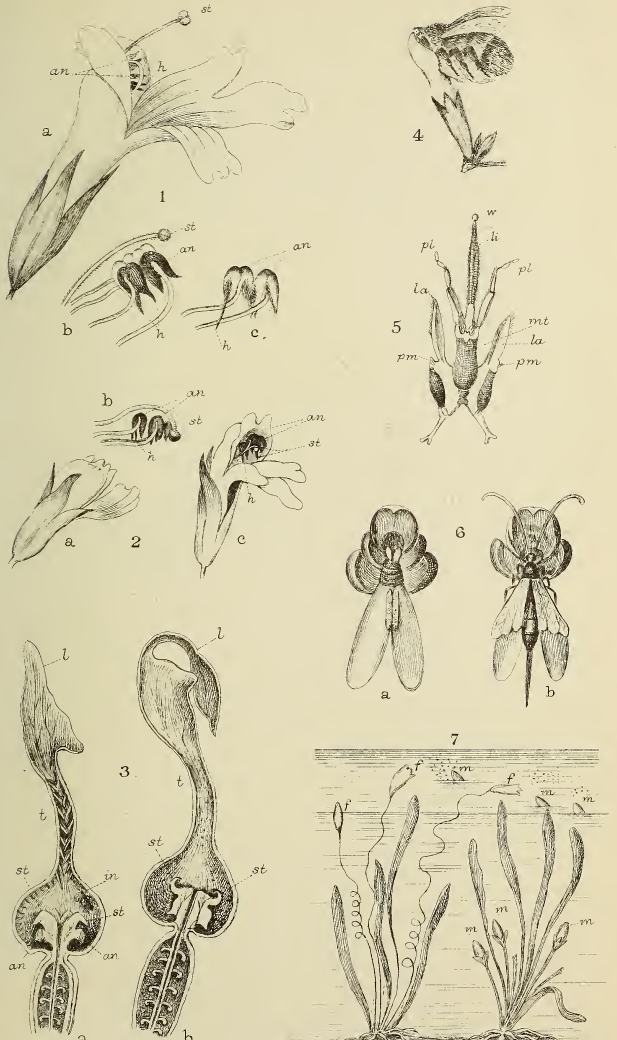
Fig. 2. *Euphrasia officinalis*, smaller-flowered form; *a*, flower just opening; *b*, position of stigma and anthers in this flower; *c*, flower in a more advanced stage; the letters as in fig. 1.



K. B. del.

W. West & Co. lith.

Pollen-grains, × 250.



K. B. del.

W. West & C° lith.

Insects & Flowers.

FIG. 3. *Aristolochia Clematitis*; *a*, flower in an earlier, *b*, in a later stage; *st*, stigmas; *an*, anthers; *t*, tube of calyx; *l*, standard-like lip of calyx; *in*, insect imprisoned in globular cavity.

FIG. 4. Bee sucking honey from flower of *Stachys sylvatica*.

FIG. 5. Head of humble-bee, *Bombus agrorum*; *li*, ligula; *w*, membranous lobe at tip of ligula; *pl*, labial palpi; *la*, lamina; *pm*, maxillary palpi; *mt*, mentum.

FIG. 6. Flower of tway-blade, *Listera ovata*; *b*, showing an insect (ichneumon) seated on the labellum, and sucking the honey.

FIG. 7. *Vallisneria spiralis*; *m*, male; *f*, female flowers.

FIGS. 1, 2, and 5 after H. Müller; figs. 4 and 6 after Sprengel.