Works by Mr. Darwin.

The Effects of Cross- and Self-Fertilisation in the Vegetable Kingdom. By Charles Darwin, M.A., F.R.S., &c. London: Jno. Murray. 1876.

The Various Contrivances by which Orchids are Fertilised by Insects. By Charles Darwin, M.A., F.R.S., &c. Second Edition. London: Jno. Murray. 1877.

Both these books are not only of remarkable value, but full of what must be of the highest interest to thoughtful minds. The former is the formal statement of what has been repeatedly and with great force asserted by Mr. Darwin, which is, that there is a great repugnance in nature to the fertilisation of plants by means of their own pollen. That cross-fertilisation is essential to the successful preservation of a species or variety. The pollen of a given plant must not be suffered to become the fertilising agent of its own seeds.

It is well known now that the equivalent of a sexual method

of fecundation is found throughout the entire realm of biology—from the base to the apex of the whole organic series. The most lowly organised of nature's life-forms, as well as the most complex and gorgeous, depend for their continuity upon this. But amongst plants a thousand contrivances are found, exquisite in their adaptations, which are merely to avoid the evil arising from the pollen of a flower falling on its own stigmatic surface, and so effecting self-fertilisation. Thus it frequently happens that the pollen is borne upon one flower, and the "pistil," or seed-casket, is in another. A common example of this is the willow. More striking still, the flowers bearing the pollen may grow on one plant, and the flowers bearing the stigmatic surface, and the seed to be fertilised, are borne upon another and wholly separate plant. This is the case with the hop. Now, it is manifest that the pollen, if it reach the stigmatic surfaces, must do so by some agency outside the plant itself. This is accomplished in nature on a large scale by the agency of wind. The common hazel is a good example. It flowers from January to March, that is, at a time when few insects are on the wing, and when the winds are strong and gusty, and before the foliage leaves have opened to prevent their action. The flowers are of two kinds—catkins, which are simply pollen-bearing flowers, and seed-bearing flowers crowned with tinted filaments, moistened with a viscid fluid, which, as the air rushes past, laden with the exquisitely delicate pollen grains, catches by its viscidity many of these, and fertilisation is secured.

The quantity of pollen thus discharged is one of the comparatively few extravagances of nature. But if a yew tree in a pollen-bearing state be shaken, the pollen rises like a dense smoke; and the American lakes, which adjoin the vast pine woods, are, at the pollen-yielding season, covered with a rich yellow layer of simply wasted pollen.

But in the majority of plants, the structure of the pollen, or the relative arrangement of stamens and pistils, with many other conditions, renders fertilisation by wind impossible; and it is here that insect agency becomes so indispensable and fraught with adaptation. Every one has observed how assiduously flowers are visited by insects. They are attracted by two things—scent and colour; and these are both guides to the honey or nectar of which the insect is in search. This honey is so placed in an immense proportion of the flowers of the globe, that, by a thousand entrancing adaptations, the insect in reaching it must carry away the pollen from one flower, and from its exquisitely-arranged position deposit it on the stigmatic surface of another of the same species. This explains how it is that in the majority of cases richly-scented flowers are not highly coloured or gorgeously decorated—either scent *or* colour may be a guide to

the hungry insect. And, for the same reason, flowers that bloom at night are very pale, or white.

Now, one of the means by which flowers are prevented from effecting their own fertilisation is, that when the pollen is ripe and ejected, the stigmatic surface of the same flower is *not* ripe; that is, is not covered with its viscid secretion, and therefore the pollen will not adhere, and no result can follow. Clearly, therefore, unless such a flower receive pollen in some way when its stigmatic surface is ripe, its seed will never be fertilised.

A beautiful instance of how this is effected is seen in the southern English wild flower known as the Birthwort. It is a trumpet-shaped flower, with its smaller end fastened to a small hollow ball. Within this latter are to be found the anthers with their pollen and the stigmatic surfaces of the pistils. The tube of the flowers is small, and will only admit small insects. The nectar is in the ball at the bottom. The tube is lined with *stiff hairs*, set at an angle with the sides of the tube, and pointing downwards. They are quite stiff, but leave just opening enough for the passage *downwards* of a small insect. It enters, let us suppose, laden with pollen from another flower. The stigmatic surface, when the flower is in this condition, is ripe; its viscid surface consequently receives the pollen which adheres to it as the insect creeps over it in search of nectar. But, having satisfied itself, on seeking exit from the flower the insect finds itself a prisoner! The bristle-like points directed downwards admitted of its ingress, but their position makes egress impossible! Hence, the tiny prisoner must content itself with the honey which it finds in this particular flower. Meanwhile, the pollen brought by the insect has done its work; the stigma dries and withers, and the anthers open and discharge their pollen, with which of necessity the insect is at once charged. At the same time the needle-like hairs *dry up* and wither away, and the insect can escape to bear the pollen of this flower to another. To complete the whole, a sort of flap at the top of the tube of this flower falls down and closes the entrance from future ingress.

In the common pink, thyme, and many others, the same method, with less complex or varying details, is adopted. In the cross-leaved heath, the most delicate mechanical contrivance is adopted to compel the bee, in getting at the nectar, to open the pollen box, that the dust may fall where of necessity it must come into contact with the stigma of the next flower. While in instances in which self-fertilisation is adopted—quite the exception—the method by which this is effected only intensifies the meaning, and gives additional meaning to the delicate contrivances by which it is sought to be avoided.

In the common sage, again, the mechanical adaptations by which the visiting bee is made to secure the cross-fertilisation of

the plant, whilst it obtains the honey which it seeks, are simply mechanical refinements of the highest order.

To the development of the wonders which this subject discloses the former of these books is devoted; and we need scarcely say that the work is done as no other could have done it.

The second book, by the same gifted author, is written to explain in special detail the absolute perfection which the agency of insects in the fertilisation of *orchids* has reached. The mutual adaptations are simply entrancing. Even in the common purple orchis of our meadows this is abundantly seen. Like the whole family, it has a "spur," in which the honey is secreted; at the entrance of this spur the pollen masses are fixed. They are set in a very delicate membrane, which breaks on the slightest touch. When it is broken, the bases of these pollen masses are exposed, and these are covered with a viscid fluid. The result is, that the insect, alighting on the lip of the flower, pushes its proboscis down the spur, breaks the delicate membrane, and exposes the viscid discs of the pollen masses, which immediately stick to the trunk, and in a few seconds harden—firmly fixed to this part of the insect. But, if they were to harden, and become glued at right angles to the trunk or proboscis, the insect could not get the trunk into the next flower. The result is, that in hardening the pollen masses *bend down*, so as to be nearly horizontal with the trunk. Now, in going to the next flower, the laden proboscis has to push its way down past the stigmatic surfaces, and the result is that the pollen is wiped off and the flower fertilised.

It is impossible in the space at our disposal to do justice to this beautiful subject: the contrivances are so manifold; the adaptions so refined and palpable. But we may note that in the Catasetums—a group of foreign orchids—the complexity of contrivance is only rivalled by the precision with which the end is secured. The insect creeps into the flower and seeks the nectar. In doing so it must touch a spur: this is sensitive in so high a degree that when it is touched it causes the rupture of a delicate membrane, which restrains an elastic pollen mass: this at once springs out with immense force, and strikes the insect with a gummy surface or disc. The result is that it adheres; and the insect flies away, startled, to seek another flower; and in doing so wipes the pollen off on to the surface that requires it.

But few things are more marvellous than the fact that there is a wonderful orchid known as *Angraecum sesquipedale*, which has a spur,—not three-quarters of an inch, but actually from eleven to twelve inches in length. At the base of these wonderful spurs there is an inch and a half of honey. This could only be for the attraction and access of insects. But no insect could be found at the time with so enormous a proboscis as to reach down to this nectar. But, said Mr. Darwin, in effect, there must *be* such an

insect, or the plant must speedily perish. And the result is that careful search has brought it to light. Herr Fritz Müller has found the very insect—sent home its proboscis, which is no less than eleven inches long, and a drawing of which appeared some time since in *Nature*, taken from an original photograph.

Now it is impossible for the student of Theology to be unmoved by such wonderful evidences of *present adaptation* as are disclosed by these researches. Paley would indeed have found them to be priceless treasures—irresistible witnesses. But we may query much if Paley's argument *as it now stands* would ever have been given to the world, if these and kindred facts had been known to him. To affirm that any set of adaptations, any group of adjustments, leading up to a well-defined and exquisitely accomplished end, was *the* purpose for which it was all devised, is now known to be an unwarrantable assumption. The facts of nature forbid it. Variation is a primal law of nature. There was a time when, in the vast majority of cases, it could be affirmed that *present* adaptations did not exist. There may be, in the future, a time when again they shall be succeeded by others. There is no "final cause" within *our* ken. But there *is* a sublime capacity in nature to adjust itself to varying conditions, and amidst all variations to preserve concurrent adaptation—to balance the details of design to the end to be accomplished throughout all vicissitudes. And thus, instead of the device of an artificer, conceived and completed—destined to be that and nothing else—the great Creator has vested vital forms not only with a rigid precision of adjustment and adaptation to present circumstances, but with an elastic power of gradual *readaptation* to new and varying conditions, which makes design in nature not merely a thing that *has been*, but a thing that is; and thus indicates the presence and constant action of a great and unsearchable, but benevolent Spirit.