composed exclusively of male cells selected elsewhere, some living workers and their queen; all the bees produced in these cells were workers. I see nothing in this opposed to the theory of M. Landois; the eggs deposited in the drone-cells furnished workers because the bees had furnished them, *after deposition*, with worker food. We may add, in support of this opinion, that the queen had deposited two eggs which the workers destined to the production of males, as they closed the cells with convex lids. But they afterwards destroyed these eggs, because it was exactly at the season (very ill-chosen by MM. Sanson and Bastian) when they kill the drones.

Lastly, what, it seems to me, must give the cause to M. Landois, is that MM. Sanson and Bastian have seen deposited in worker-cells eggs which gave origin to males. These two naturalists, indeed, endeavour to explain the fact by means of Dzierzon's theory. The queen, they say, was old, and her spermatic reservoir no longer contained a sufficiency of spermatozoids, for it was semitransparent. Now, if the seminal receptacle is opaque when it is completely full, it is perfectly transparent when empty, and it seems to me that when we find it only semitransparent, it will still contain far too many spermatozoids to allow the observer to think that the eggs have not been fecundated.

XXX.—*On the manner of Fertilization of the Scarlet Runner and Blue Lobelia.* By T. H. Farrer, Esq.

To the Editors of the Annals and Magazine of Natural History.

Gentlemen,

The following notes of observations on the fertilizing-apparatus of the scarlet runner and the common blue lobelia, made by one who has not the slightest pretence to scientific knowledge, would never have been sent to the press, but for the kind suggestion of Mr. Charles Darwin, to whom they have been communicated. That these interesting facts, if not mentioned by previous observers, should have escaped his notice never occurred to me for a moment, although at the time this paper was written I had not seen his papers on the fertilization of the kidney bean in the 'Gardeners' Chronicle' of the 24th of October 1857 and the 14th November 1858, which he has kindly sent me. In these papers the structure and functions of the kidney bean are fully given, with his own interesting experiments; and though in them the details of the lobelia

are not given, there is a reference to that flower which shows clearly enough that they had not escaped him.

Whatever these facts are worth, they are the obvious results of Mr. Darwin's own most suggestive papers on *Primula*, *Linum*, and *Lythrum*, referred to in such high terms by Dr. Hooker in his Norwich address. To an amateur, dismayed by the difficulties of botanical classification, perplexed by his own incapacity for microscopical dissection, and disgusted by the mere cataloguing of species, Mr. Darwin's suggestion that the true account of the structure and functions of flowers is frequently to be found in their capacity for fertilization, and especially in their capacity for cross fertilization with the pollen of other flowers, is a ray of light which opens out an endless field of interesting observation. And to those who look in science for wider speculations, the grand generalization contained in these and other papers of Mr. Darwin's, to the effect that fertility in the animal and vegetable world requires the union of elements which are neither identical nor dissimilar, but different and yet similar, with all its consequences, affords endless matter for thought, whilst it receives life and reality from the minute observations of details in which his papers abound, and of which they set such wonderful and stimulating examples. I know of no writings which so well illustrate the axiom of the great German poet and observer—

"Was fruchtbar ist, allein ist wahr."

Sept. 17, 1868. T. H. Farrer.

Mechanism for transporting Pollen in the Scarlet Runner (Phaseolus coccineus).

The two wings are united to the back and outside of the keel some little distance above the base of both; their blades fold backwards from the centre towards the outside, and, by the bending of the spiral keel, with the pistil and stamens inside it, the wings are thrust a little to the right hand, so that the folded or bent blade of the left wing is opposite to the coil of the keel, and is the natural place on which any insect seeking to reach the bottom of the flower would alight. The lower parts or claws of the wings remain upright, and are firm and elastic.

The keel encloses the stamens and pistil from a point a little above the ovary, and at the upper end the margins are joined so as to form an imperfect tube: it makes together with them nearly two complete turns, of which the upper one and a half lie close above one another in the same plane. This plane is inclined at a small angle to the blade of the left wing, and is so placed that the mouth of the spiral tube points obliquely

downwards and towards the base of the left wing. To a spectator looking into the flower, the way, if any, to the base of the petals and of the ovary is obviously down the left wing and past the mouth of the spiral tube; but there is hardly room, in the quiescent state of the flower, even for the proboscis of an insect between the base of the wing and the keel.

On following the development of the flower in the bud, it appears that the peculiarity of the spiral coil of the keel, with its enclosed stamens and pistil, only appears at a late stage. In the earlier stage, though the anthers and the brush round the style are fully formed, the length of the style, filaments, and keel, and the form of the keel, are like those of other papilionaceous flowers.

The filaments of the stamens, which are, except one, united and stiff at the base, are in the upper part very thin and flexible, and follow the windings of the spiral keel. The anthers, which are small, lie in two rows entirely within the tube or hollow of the keel, a little within its mouth, and within and below the stigma.

The pollen is not very abundant, and is not dry and dusty, but moist and sticky.

The style is stout, strong, and very elastic; it is set firmly on the stiff upright ovary, so that its point of attachment to the ovary and base of the flower is at some distance from that of the attachment of the keel to the stiff claw of the wing. The stigma is at the extremity of the spiral coil, and on the lower or outer side, *i. e.* on the side next the wings; it is sticky, and is clothed with fine hairs. In the untouched flower it just protrudes out of the mouth of the tube of the keel, so that its tip is just visible on looking downwards into the flower. A little below it the style is clothed with stiffish hairs or bristles, which partly encircle the style like a circular brush, but which are considerably more in number on the upper or outer side of the coil than on the inner or under side. This brush is opposite to and in contact with the opening anthers.

Under these circumstances it is not obvious at first sight how the flower is fertilized. As regards self-fertilization, the arrangement does not seem a happy one; for the stigma is outside and below the tube of the keel, whilst the anthers and pollen are shut up within it.

The plants are frequented by, indeed they swarm with, bees. These are of various kinds, of which I do not know the names. But, so far as I could see, the smaller or hive-bees never succeeded in getting what they wanted through the mouth of the flower. They occasionally lighted on the petals, and looked in, but invariably went round to the back of the flower, and

there sometimes remained and sometimes went away disappointed. When they remained, they inserted their proboscides into a hole bored through the calyx, the petals, and the staminal tube. I never saw them bore these holes, though every flower where they remained had them. One humble-bee, however, (black, with two yellow bars on his back, and a light-coloured tail) certainly did bore or, rather, nip these holes; and this bee invariably adopted the same plan, and never looked at the mouth of the flower. But by far the greater number of the larger bees alighted on the wings, or, rather, generally on the left wing of the flower, and inserted their proboscides down the apparent natural channel towards the base of the flower. So far as I saw, the same bees always adopted the same course. In alighting on the wing of the flower, they weighed it down, and in so doing pressed outwards the stiff elastic lower part or claw. On doing the same thing with one's finger, it became obvious that the bee thus opened for its proboscis a clear path to the hollow between the claw and the staminal tube, and also to the base of the separate stamens, between which and the other stamens would be his access to the hollow surrounding the ovary. The tendency of pulling back the keel is to widen the openings between the separate stamen and the others; and there is a curious appendage outside the base of the separate stamen, which lies exactly in the path of the bee's proboscis, and which, when pressed, pulls the separate stamen back towards the vexillum, and leaves free access to the ovary. From the vigorous sidling struggles the bees constantly made, it looks as if they were trying in this way to get to the inside of the staminal tube, which I see is always penetrated by the bees which bore holes.

But, however this may be, it clearly appears that the same bending down of the wings of the flower which opens for the bees a way to its base, produces another and a very curious effect on the style. The lower part of the wings of the flower being attached to the lower and outer part of the keel, when the former is bent outwards, it pulls the base of the keel outwards too. The effect of this is to pull the upper spiral coil or tube of the keel backwards also, and at the same time to contract it. The style, which before had been exactly adjusted to the length of the keel, now becomes too long for it, and, in consequence of the stiffness of the lower part and the wiriness of the upper part of the style, the tube of the keel is pulled backwards on the style, or, which is the same thing, the coil of the style is pushed forwards through the tube, so as to thrust the upper end of the style quite out of the tube, and expose the whole of the stigma and the bristles below it. In

consequence of the direction and contraction of the spiral coil, this protrusion of the stigma is at first made in a direction rather outwards than upwards, towards the blade of the left wing of the flower; but as the thrust continues, the stigma turns more and more upwards. The anthers remain in their place within the tube, in consequence of the thin thread-like character of the filaments, which crumple up, and have not, like the stiff elastic style, the power to thrust themselves outwards. Consequently the anthers are passed over and swept by the brush of the style.

The result of these movements is that when the bee first inserts his proboscis into the flower, the stigma will exactly meet and sweep the base of it, and will brush off from it and keep a large part of any pollen it may have brought from other flowers. As the bee presses the wing of the flower further back, the style comes out further; the stigma turns upwards away from the insect, and that part of the style which is covered with hairs comes in contact with the base of the proboscis. In coming out of the tube or hollow of the keel this brush has been forced against and has swept the sticky pollen out of the anthers, and is covered with it; and, in consequence of the position of the hairs and the direction of the thrust, the pollen is especially thick on the side of the style which is next the bee. As he struggles and twists to get the nectar, abundance of the pollen is deposited on and clings to the base of his proboscis, as may be seen by thrusting any pointed object into the flower. When he quits the flower, its wing springs back to its original place: the keel of the flower does so also, and the end of the elastic style retreats to its own old position within the hollow of the keel. But it does not do this very quickly; and as the bee's motion, and especially that of his proboscis, is very rapid, his proboscis must be withdrawn before he ceases to weigh down the wing, and at any rate before the stigma retreats. It follows that his proboscis will not, in retreating, be touched or swept by the stigma; and the last thing it will touch in leaving the flower will be the pollen-covered brush of the style, from which it will carry off an abundant load of fresh pollen, to be deposited in its turn on the stigma of the next flower.

I found the base of the proboscides of some bees which I caught covered with the pollen. I also found the stigmas of flowers which had opened in a room, and were not visited by bees, quite free from pollen, although, on pressing down the wing of the flower, the brush of the style was seen to be covered by it. On the other hand, the stigmas of the flowers visited by bees were always covered with pollen.

If the above observations are correct, this looks like a very curious and elaborate mechanism in order to secure the fertilization of one flower by the pollen of another. The form and position of the wings, their partial cohesion with the keel, the spiral and partly tubular keel, the delicate flexible filaments of the stamens, the moist and sticky pollen, the strong elastic column of the style, its spiral form, the position and character of the stigma, the brush that sweeps out the anthers, the motion of the style on the bee's visit (which first brings the stigma into contact with his proboscis, and then, when it has swept him clear of the pollen of a former flower, brings the brush loaded with its own pollen into contact with the proboscis, and deposits its load with him, and finally allows him to withdraw without touching the stigma again) are surely a number of very remarkable and elaborate adaptations, all apparently tending to the transportation of pollen from one flower to another.

Mechanism for Fertilization of the common Blue Lobelia.

The *corolla* has a broad lip or lower side, so as to afford a standing-place to insects; the tube is slit on the upper side, so as to afford play to stamens and pistils.

The *stamens* have hard, syngenesious anthers, and separate, flexible filaments, which are attached to the calyx at some distance from the base of the style, so that they look like shrouds to a mast. The two on the lower side are the shortest when the flower opens, and look as if they pulled the anthers downwards.

The *anther-tube* is open at the top in the early bud, but closes before the flower opens, and then again opens by a very small aperture, which is at this stage, in consequence of the bending over of the upper anthers, pointed downwards at right angles to the mouth of the tube of the corolla. Out of the top of the connective of the two lowest anthers grows a cluster of short thick bristles in a downward direction across the mouth of the tube of the corolla. The anthers are very hard externally, and internally very soft; they open inwards when the flower opens. There is an abundance of dry powdery yellow pollen.

The style is surrounded immediately below the stigma by a ring of bristles, which are developed in the bud at an early stage, and point outwards and upwards until the stigma is fully developed. The stigma remains inside the anther-tube when the flower first

opens; after a time, it protrudes. It has two lobes, but they are folded or pressed together when the flower first opens, and then only expose their perfectly smooth outer or lower sides. When the stigma protrudes from the anther-tube, the lobes open, the smooth outer surface is turned back, the ring of bristles is reflexed on the style, and the upper or inner stigmatic surface of the lobes, covered with short hairs or papillæ, makes its appearance below the mouth of the anther-tube, where it faces outwards and downwards, so as to meet anything which is thrust into the tube of the corolla.

When the flower first opens, the length of the style, as compared with that of the stamens, is such that the closed stigma with its ring of spreading bristles is at the bottom of the anther-tube. The style grows rapidly, sweeping the pollen with its ring of bristles, and pressing it towards the mouth of the anther-tube. Towards the end of this stage of growth, the style becomes so long relatively to the stamens, that it presses towards or against the mouth of the anther-tube like a spring. If at this stage a bit of the top of the anther-cases is cut off, the compressed pollen is forced outwards with quite a spirt.

It is clear that the principal function of all this apparatus is not to fertilize the stigma with the pollen of its own flower. The back of the stigma, which is smooth and has no papillæ, alone comes in contact with that pollen, and the stigmatic surface is only displayed when the pollen of its own flower is nearly all expelled from the anthers, and when the stigma is beyond the place at which it would be found.

But all becomes clear if the function is to enable insects to carry pollen from one flower to another.

If—a short time after the flower has opened, when the anther-cells have burst, when the anther-tube has opened slightly at the top, when the mouth of the anther-tube is turned downwards, and when the style is growing and is pushing the stigma and its brush towards the mouth of the anther-tube—any pointed object is thrust into the tube, it touches and rubs and pushes a little backwards the stiff bristles attached to the connective of the lower anthers. This motion, combined with the thrust of the style and of its brush, forces the pollen through the small opening of the anther-tube downwards in a gentle stream or shower on the back or upper side of the object inserted. A pencil will become covered for some length by it. The aperture or slit in the tube of the corolla affords free play to the anther-tube under this treatment.

Bees frequent this lobelia, and get well dusted on the back

with the pollen. When an insect leaves one flower and goes to another, possibly a flower lower in position and in a later stage of development, on another stem or plant, he will very likely find the stigma of that flower expanded and protruded. If so, it will just sweep his back dusted with the pollen of the previous flower; and if he then mounts to a flower higher in position and in an earlier stage of development on the second stem or plant, he will probably find the anthers in a state to give up their pollen to him, and so on.

The flowers are very commonly out two at once on one stem, the lower one with the stigma protruded and unfolded, and the upper one with the stigma still within the anther-tube, and the anther-tube ready to discharge its pollen at a touch. The number of flowers visited by a humble-bee in a few minutes is very remarkable.

It is interesting to watch the gradations of this curious structure in *Campanula*, *Jasione*, and *Lobelia*. All have the stamens set upon the calyx; all have the brush on the style for sweeping out the anthers; in all the stigmatic surface remains closed until the pollen has been swept out; and in all, when the stigma opens it turns its back on its own pollen, if, indeed, any is then left on the style. But there are great differences.

In *Campanula* the brush is long and the three-lobed stigma large; the pressure of the growing style with its brush against the anthers is effected by means of the edges of the lobes of the valvate corolla, which are folded deeply inwards, and, being opposite to the stamens, press against their backs as the flower opens; and the transportation of pollen must be effected by the moving about of the insect within the bell and against the pollen-covered style. There must be a profuse expenditure of pollen; but even here there seems to be a wonderful economy in the bristles, which are not scattered on the style promiscuously, but are set on in ten rows apparently opposite the ten anther-cells.

In *Jasione* the brush is shorter, and the two-lobed stigmatic surface quite small; the long thin lobes of the corolla do not press the anthers against the brush, but, instead, the anthers in the opened flower are syngenesious. Their attachment to one another, however, is slight, is at the base only, and does not exist in the early bud. The transport of pollen must be effected by the insect walking over the numerous flower-heads, and amongst and against the long protruding styles, of which some in each head are generally pollen-covered, with closed stigmas, and others pollen-stripped, with opened stigmas.

In *Lobelia* the anthers are short, the brush on the style is

reduced to a ring of bristles, and the stigma is also small; but by the remarkable arrangements above noticed in the hard and completely syngenesious anthers (syngenesious from an early stage in the bud) and in the style, the pollen is ejected in small quantities at a time on the exact spot in the insect on which it should be placed for transportation to the stigma of another flower, and is swept with equal precision from that spot by the stigma of the next flower he visits.

XXXI.—*Note on a new Japanese Coral* (Isis Gregorii), *and on* Hyalonema. By Dr. J. E. Gray, F.R.S. &c.

Mr. Bradley Gregory, the Surgeon of H.M.S. 'Rattler,' has sent to Mr. Carruthers, for the British Museum, a fragment of a coral which appears to be new to science. Mr. Gregory observes:—"The man who was sent to procure specimens of the *Hyalonema* from Inosima brought back in addition a large branch of what at first appeared like the plant that grows in the marshes, called *Equisetum*; but on close inspection it was found solid and smooth like glass, with joints and secondary branches coming from it. The gentleman who was kind enough to show me this thing tore off a small branch, which I have sent to you lashed on to a piece of bamboo."

The specimen sent indicates a new species of *Isidinæ*. The branch is very long, slender, of nearly equal thickness almost throughout the whole of its length, only very slightly and gradually tapering just at the tip. It is formed of about fifty or fifty-one elongated slender joints united by a short but distinct pale brown articulation. The joints are very similar in length, being rather more than half an inch long; but sometimes there is a shorter one interjected in various parts of the series. The branch is about 27 inches long, and $\frac{1}{8}$ inch in diameter; the horny internodes are very much shorter than the joint, and about the same diameter.

Unfortunately the specimen does not show what was the general distribution of the branches. This may be verticillate, as Mr. Gregory compares the coral to an *Equisetum*; and the elongated branches are like the slender ones of some of the species of that genus. The specimen does not afford any means of determining if the branches arise from the calcareous joints, or from the horny internodes of the stem, which distinguishes the two genera *Isis* and *Mopsea*.

Waiting the receipt of more perfect specimens, I propose to call the coral, provisionally, *Isis Gregorii*, after the gentleman who so liberally sent it to the British Museum.