

## LITERATURE.

### MR. DARWIN ON EARTHWORMS.\*

The latest published of the series of monographs in which our great naturalist has given to the world the results of 50 years of bright, patient, minute observation of nature in special departments is, perhaps, the most remarkable of them all. It is in many respects more characteristic of the change which has within the space of a generation passed over the face and the spirit of modern science than any other that could be named. It used to be the fashion to talk a good deal about the "poetry of science," and very much musical but vague and sterile rhetoric was produced under the influence of this idea. The result was a large quantity of something that was not poetry and was not science—was not, indeed, anything useful for any purpose. This notion has given place to one far more productive, and that is the significance of every part of nature. Under the guidance of this idea Mr. Darwin has devoted an enormous amount of close observation to the habits and work of the common earthworm. This poor animal has hitherto served as the type of everything that is low, and mean, and sordid in nature. It can hardly do so henceforth. Mr. Darwin has shown that it is to the incessant action of earthworms that the layer of vegetable mould which covers the face of the country like a mantle is largely owing. Worms in almost countless numbers are ceaselessly at work, burrowing in the soil in all directions, passing it through their bodies, manuring it by dragging down leaves to serve as food and as lining to their burrows, undermining any object lying on the ground and bringing the earth to the surface, and gradually burying the object under the layer of vegetable soil. They aid in the disintegration of rocks. They assist to shape and alter the formation of the surface. They are important co-operators in the work of denudation which holds so high a place in the geological history of the world. All this is told to us with a minute and most interesting account of the observations on which it rests. That these results have an intimate bearing on the larger doctrines of modern biological science is, of course, apparent to every reader. They bring into prominence and vividly illustrate a great department of natural change, which is effected solely by the agency of small and little-headed causes

the agency of small and little-headed causes working insensibly through immensely long periods. This is the central teaching of the doctrine of evolution, and every fresh illustration of its truth is a gain to the demonstration of the theory.

It is characteristic of the wonderful foresight which has directed all of Mr. Darwin's researches, that he read a paper drawing attention to the action of worms in surface soil, in the year 1837. He pointed out that the sinking of small fragments of burnt marl, cinders, &c., spread over the surface of meadows, and afterwards found still in a layer some inches beneath the turf, was due—as he mentions, was first suggested to him by Mr. Wedgewood, of Maer-hall in Staffordshire—to the action of worms. He hence concluded that all the vegetable mould over the whole country had passed many times through, and would again pass many times through, the intestinal canals of worms. Since then Mr. Darwin has kept worms in pots filled with earth in his study, has observed them attentively, and, as he says, "became interested in them," has investigated their structure, their habits, their mental intelligence, their way of working. He has also studied them in their native soil, and by the assistance and co-operation of friends has brought together a vast quantity of information about them from all parts of the world. And the result is not only an interesting book, but also the elevation of the poor despised earthworm to a higher place in the scale of the forces and the creatures of nature than he before occupied.

Worms, Mr. Darwin tells us, have their bodies formed of from 100 to 200 almost cylindrical rings or segments. They have a well-developed muscular system, as might be inferred from the activity of their contortions. Behind their mouth, which is situated in what we may call the head, is a strong pharynx, and they excavate their burrows by inserting their head into any little crevice or hole in the soil, and then the pharynx is pushed forwards into this part, which consequently swells and pushes away the earth on all sides. The digestive system contains three pairs of glands, which separate a surprising amount of carbonate of lime from the food absorbed by the worm, and serve the purpose of excretion of the superabundance of lime its food contains. The trituration of food is performed

tains. The trituration of food is performed by means of a powerful gizzard, which, when we consider the work which the worm has to perform in the general economy of nature, may be regarded as its most important organ. They are destitute of eyes, but are sensitive to light, a circumstance proved by the familiar fact of their being nocturnal by habit. Our author found that the anterior extremity of the body is affected by light, which seems to pass through their skins and affect the cerebral ganglia. Here we have the very lowest stage of sensitiveness to light exhibited before any special optic organs are developed. They have no sense of hearing, but are extremely sensitive to vibrations in any solid object. That is to say, they are sensitive to vibrations in the earth in which they lie in something the same way that we are by means of our ears to the vibrations of the air. Their sense of smell is feeble, but their sense of taste is sufficiently acute to detect differences in the kinds of leaves on which they feed, and to exhibit marked preferences. Mr. Darwin is unable to say much of their mental qualities, but the result of a great number of experiments he made with them

\* *The Formation of Vegetable Mould through the action of Worms, with Observations on their Habits*, by Charles Darwin. London: John Murray. 1881.

in regard to the way in which they dragged leaves into their burrows for the purpose of lining them or plugging the orifice, satisfied him that they had much more intelligence than they are usually credited with. He minutely examined a large number of their burrows to see how this plugging was done, and with the same object he supplied his domesticated worms with small triangular pieces of paper to use instead of leaves. He noticed that the worm almost always seized the leaf or triangle near its apex and very seldom near the middle—that is to say, that it took the course which intelligence would dictate as the best for getting the leaf into the hole in the easiest way. It could hardly be by a specialised instinct that this was done, as the worms were tried not only with the paper, but also with leaves of exotic trees of which their progenitors could know nothing. Moreover, the operations were wanting in the unvarying certainty of a special instinct, and altogether looked much more like the result of a degree of intelligence adequate to the work of discriminating between the easiest and the hardest way of achieving the desired end. Finally, we may refer to the distribution of earthworms,

refer to the distribution of earthworms, which are found in all parts of the world and inhabit the most isolated islands, such as Iceland, St. Helena, the Falkland Islands, and even Kerguelen's Land, though how they can make their way to such remote islands is at present quite unknown.

The work of the worms which we have now to consider is that represented by their burrowing in the soil and bringing casts up to the surface. These casts represent earth swallowed in making the burrow, and also as food. The earth in passing through the body of the worm has undergone a process of grinding and digestion, and is ejected on the surface mixed with intestinal secretions. These worm-casts have been found on the Nilgiri Mountains—which we used in the pre-scientific spelling days, to call Neilgherries—weighing no less than 4½oz.—that is over a quarter of a pound. But those of the English species which have been made the subject of Mr. Darwin's observations, are on a much smaller scale. It is apparent that as the worms are incessantly burrowing in the soil and bringing fine earth to the surface, the burrows must in time collapse, and thus a constant process of renewing the surface soil of the country must go on. If there were no solid objects in or on the soil there would be little to draw attention to the extent or rate at which this process is carried on. But it is brought visibly and significantly before the eye and the attention when an undisturbed pasture receives a top-dressing of lime, or burned marl, or coal cinders, and a few years afterwards, on making a cut in the soil, these are found buried some inches beneath the surface, still preserving their parallelism with the surface, and all sinking at the same rate. As there is no agency but that of worms by which to account for their burial, and as the reality of the action of the worms is very apparent to every observer, we have here a measure of the rate at which the soil is brought to and deposited on the surface. Mr. Darwin quotes several cases the result of which is to show that an inch of soil is thus brought to the surface in about five years. The rate, of course, varies with the nature of the soil. He mentions one field which was ploughed in 1841 and was then so thickly covered with small and large flints, some of them half as large as a child's head, that it was always called by his sons the stony field." He remembers doubting whether he would live to see these larger flints covered with vegetable

see these larger flints covered with vegetable mould and turf. But after a few years the smaller stones disappeared, and next the larger ones, so that after 30 years a horse could gallop over the compact turf from one end of the field to the other, and not strike a single stone with his shoes. In this case the rate of accumulation was about one inch in 12 years. Our author quotes Professor von Haast, of New Zealand, to show that it would appear that a layer of aboriginal implements, flakes, chips, &c., of basaltic rock, had been slowly covered up by the castings of worms, thus showing that the action of which our author gives so many examples is equally in progress in the Southern Hemisphere. The action of worms in undermining large stones such as the monoliths of Stonehenge, and lowering them into the soil, at the same time bringing fine earth up by the sides of them, and thus partly burying them, is also described, and a curious chapter is devoted to the effect of their operations in aiding in the preservation of ancient remains by covering them with a concealing mantle of vegetable mould.

To appreciate the extent and the possibility of the action here ascribed to worms, it is necessary to form some estimate of their number and the amount of their individual work. It has been calculated that an acre of garden ground in England contains 53,767 worms, and an acre of corn-fields half as many. The calculation appears to Mr. Darwin, from his own observations, perfectly credible. A number of castings were collected and weighed, and the result of a number of observations gives us the amount of earth brought by this means to the surface, about 15 tons per acre. After taking his reader through a number of experiments and observations Mr. Darwin thinks that no one who considers the facts he has brought together "on the burying of small objects and on the sinking of great stones left on the surface—on the vast number of worms which live within a moderate extent of ground—on the weight of the castings ejected from the mouth of the same burrow—on the weight of all the castings ejected within a known time on a measured space—will hereafter doubt that worms play an important part in nature."

We have considered the worms as a fertiliser and renewer of the soil. We come next to regard his action in aiding in the superficial changes which are grouped by geologists

changes which are grouped by geologists under the comprehensive term denudation. Geologists have lately come to recognise that

this work of lowering, sometimes by an enormous thickness, the surface of the country, which they were formerly accustomed to ascribe to the operation of sea waves, is in reality effected much more largely by the more powerful agents of air and rain aided by streams and rivers. In what way, it may be asked, can worms take part in these enormous processes? The answer to this is given by the observations of Mr. Darwin on the way in which the castings of worms are affected by the natural slope of the ground. He first explains the action of the digestive fluids in the bodies of worms on the hard materials found in the earth they swallow. There is in their digestion at once a chemical and a mechanical action, which is ever reducing hard fragments to a more finely divided state, and is thus aiding in the disintegration of rocks. The small amount of humus acids they carry down in their burrows is regarded as acting on the underlying rocks. All the products of these actions are brought to the surface, and if that surface is a slope the larger proportion of them is deposited on the lower side of the burrow. The result is a steady movement of the surface of the ground down the slope, a movement which it will be seen combines with the action of winds, and rain, and streams to lower eminences, and to level the face of the country. The action of wind and rain on the loose, easily removed castings co-operates in the same direction, and a large number of instances are quoted to show that the effects supposed are real and extensive.

But we need not consider the subject further. By this time the worm has been vindicated from the position of contumely usually assigned to him. When it is once seen that he takes a place among the great natural forces by which the surface of the earth is shaped and chiselled to the form in which we now see it, it is impossible to look with scorn on the small and apparently helpless creatures which aid in bringing about this result. We may fitly conclude by quoting the final paragraph, in which Mr. Darwin sums up the results of his investigations:—

"When we behold a wide turf-covered expanse, we should remember that its smoothness, on which so much of its beauty depends, is mainly due to all the inequalities having been slowly levelled by worms. It is a marvellous reflection that the whole of the

marvellous reflection that the whole of the superficial mould over any such expanse has passed, and will again pass, every few years, through the bodies of worms. The plough is one of the most ancient and most valuable of man's inventions; but long before he existed the land was, in fact, regularly ploughed, and still continues to be thus ploughed, by earthworms. It may be doubted whether there are many other animals which have played so important a part in the history of the world as have these lowly organised creatures."