MR. DARWIN'S NEW WORK.*

Mr. Darwin's latest volume, on "The Formation of Vegetable Mould, through the Action of Worms," contains information which to the ordinary reader will be as interesting and surprising as that found in any of the works which the public have previously received from the same skilful pen. The story told by Mr. Darwin, of the silent but constant activities of the despised creatures which he brings under our notice, affords another striking illustration of the fact that the commonest and humblest objects in Nature, when attentively studied, are capable of yielding rich material for observation and reflection, and that in the great economy of the material world, the most important and valuable results are often brought about by the lowest agencies. The reader unaccustomed to the pursuit of natural science, and consequently unprepared for the marvellous revelations which are constantly being made to the humble and diligent student in every department of Nature, would scarcely expect to find that worms can repay any very close and attentive observation; and yet we venture to say that, after a perusal of this book, such a reader will be likely to conclude not only that a worm is by no means such a worthless, insignificant, and uninteresting creature as it has been commonly supposed to be, but also that we are only, even now, beginning to understand the perfection of that system of adaptation of means to ends, which prevails in the universe, and which comprehends the lowest as well as the highest things, and which is constantly bringing forth beneficent results from the most obscure and minute agencies.

The book before us is written with the direct simplicity and clearness which characterise Mr. Darwin's style, and which make it possible for one who knows nothing of the technical terminology of science to read his works with intelligence and zest; and every page is marked by evidences of that patience in investigation, that careful accuracy in detail, and that persistent regard for facts, which have gone far to secure for Mr. Darwin his high reputation as a man of science. Readers, indeed, who have a quick sense of humour, or, at any rate, a keen appreciation of the ludicrous, and are not wholly absorbed in considering scientific results, will sometimes feel a smile stealing over their faces as they picture to themselves some of the experiments of which Mr. Darwin gives so grave a narration in these pages. All but the strictest devotees of science will be prepared to forgive the irreverence of a quiet laugh at the idea of the great naturalist's attentions to the unhappy worms which, for the convenience of constant observation, he kept in pots of earth in his study. To think of Mr. Darwin approaching these creatures with light tread, and probably in his stockinged feet, lest he should disturb them by creating a vibration in the floor; of his covering them with a sheet of glass, and playing notes of the piano to them, to find out if they had any sense of hearing; of his turning bull's-eye lanterns upon them suddenly to find out if they had any perception of light; of his tasting their taste by supplying them with pieces of meat of various kinds, roast, boiled, and raw, and their intelligence by providing them with certain triangular pieces of paper, which they drew into their holes; all this, we confess, although the confession may prove our lack of the gravity which befits the consideration of a strictly scientific subject, has its amusing aspect to us, and touches our sense of the incongruous, besides, in its graver aspect, testifying to the indefatigable laboriousness and ingenuity and to the minute carefulness of the learned author.

Mr. Darwin's study of worms has extended, it appears, over a period of about half a century. As long ago as 1837, he read a paper before a learned society on the "Formation of Mould," in which he discussed the operations of worms, and mentioned some examples of their activity, and ever since then he appears to have kept the subject before him, and to have been accumulating information upon it. The results of such prolonged attention on the part of so competent an observer, may be regarded as practically all but exhaustive, and this book cannot fail to be regarded as the standard of appeal in this department of inquiry for a long time to come. The present volume consists of seven chapters, in addition to a brief introduction. The first two chapters treat of "The Habits of Worms"; the third chapter is upon "The Amount of Fine Earth brought up by Worms to the Surface"; the fourth chapter is on "The Part which Worms have played in the Burial of Ancient Buildings"; the fifth and sixth chapters are on "The Action of Worms in the Denudation of the Land"; and the concluding chapter gives a comprehensive and interesting summary of the information upon the entire subject.

In his Introduction Mr. Darwin, with characteristic succinctness, defines his subject as being "the share which worms have taken in the formation of the layer of vegetable mould which covers the entire surface of the land in every moderately humid country." The mould referred to, we are informed, "is generally of a blackish colour and a few inches in thickness." A series of observations led Mr. Darwin to the conclusion that by the persistent activity of the worm tribe this mould was constantly being turned over, triturated, and improved; that, in fact, "all the vegetable mould over the whole country has passed many times through, and will again pass many times through, the intestinal canals of worms," and that consequently "the term 'animal mould' would be in some respects more appropriate than that commonly used of 'vegetable mould.'" In reply to the remark which has been made that the work thus represented as having been accomplished is too stupendous to have been accomplished by creatures so small and weak as worms, Mr. Darwin instructively says, "Here we have an illustration of that inability to sum up the effects of a continually recurrent cause, which has often retarded the progress of science, as formerly in the case of geology, and more recently in that of the principle of evolution." The carefully collected facts in this volume sufficiently sustain and enforce the implied rebuke.

In treating of the habits of the worms, Mr. Darwin begins by saying something of their distribution, especially in this country. They abound on chalk downs and commons where the soil is poor, and the grass short and thin; but "they are almost or quite as numerous in some of the London parks, where the grass grows well and the soil appears rich." They have a great liking for paved courtyards near houses. But it would appear that they distribute themselves sometimes in the same field in a capricious manner; and the safest generalisation upon this point perhaps is, that they prefer a moderate amount of damp. During the heat of summer and the extreme cold of winter, they bury themselves in the earth at some
distance and cease to work. The night is their period of activity, and then they issue forth from their burrows. They generally, however, keep their tails in their burrows, and arerapper of expanding them tails and of making use of some "short, slightly reflexed bristles, with which their bodies are armed," in such a way that they cannot be dragged out of the ground without pulling them in pieces. Mr. Darwin doubts whether a worm can find its way back to a burrow which it has once left; although, he says, they apparently leave their burrows on a voyage of discovery, and thus they find new sites to inhabit." They have a way of lying near the mouths of their burrows for hours together, and, of course, readily fall victims to the blackbirds and other enemies, on the look out for them. Their persistence in what, from a worm’s point of view, must be regarded as a foolish habit, is due to the suggestion of a love of warmth; and it will surprise many people to learn that worms, especially the more luxurious of them, we presume, "often coat the mouths of their burrows with leaves, apparently to prevent their bodies from coming into contact with the cold damp earth."

Of the structure of worms Mr. Darwin gives an elaborate description. A worm of good-size consists of from one to two hundred almost cylindrical rings, each surrounded by bristles; its muscular system is well developed; it has a mouth and something which corresponds to the proboscis or trunk in other animals; it has some "calciferous glands," in this respect being unique in the animal kingdom, and these perform an important part in its process of digestion; and it has a gizzard. Worms have no jaws or teeth, and they breathe through the skin. Their nervous system is "fairly developed." By a series of observations and experiments Mr. Darwin was led to the conclusion that worms, although they have no eyes, are sensitive to light, and are capable of perceiving the distinction between night and day. They have no faculty of hearing, but they are "extremely sensitive to vibrations among solid objects." They have, it would seem, but a feeble sense of smell, and can only perceive certain odours. "Of all their senses, that of touch, including in this term the perception of a vibration, seems to be the most highly developed; Mr. Darwin compares them in this respect to a blind man, who forms an idea of objects by the touch, and he thinks that there is some reason to believe that worms by means of touch are "enabled to gain a general notion of the form of an object." In the sense of taste worms appear to be also fairly well endowed, and, like superior creatures, they have their decided preferences with regard to food. They are, indeed, omnivorous, and they live chiefly on half-decayed leaves, but they are very fond of cabbage leaves, and make nice distinctions between the different sorts; they have a decided weakness for onions; they prefer raw fat to any other kind of meat, and they are fond of fresh fish and shell-fish—"and this is the chief operation for which they seem to exist—they swallow an enormous quantity of earth, out of which they extract any digestible matter which it may contain, casting it forth afterwards in a triturated and much improved condition. Mr. Darwin describes a protracted series of experiments carefully adapted under the circumstances to determining whether worms were to be credited with intelligence, and he came to the conclusion that they were. Referring our readers to the volume for the account of the experiments, which, by the way, may serve as a valuable lesson in the art of observing for scientific purposes, we may quote a brief passage in which the conclusions are summed up:

The Intelligence of Worms.

If worms are able to judge, either before drawing or after having drawn an object close to the mouths of their burrows, how best to drag it in, they must acquire some notion of its shape; else, of course, they would probably acquire it by touching it in many places with the anterior extremity of their bodies, which serves as a tactile organ. It may be well to remember how perfect the sense of touch is in a worm, and how it comes in a man when born blind and deaf, as are worms. If worms have the power of acquiring some notion, however rude, of the shape of an object and of their burrows, as seems to be the case, they deserve to be called intelligent; for they then act in nearly the same manner as would a man under similar circumstances.

To sum up, as chance does not determine the manner in which objects are drawn into the burrows, and as the existence of specialized instincts for each particular case cannot be admitted, the first and most natural supposition is that worms acquire the method of dragging the object by trial and error, and that they thus possess some degree of intelligence. This will strike every one as very improbable; but it may be doubted whether we know enough about the habits of worms to justify our natural distrust of such a conclusion. With respect to the small size of the cerebral ganglia, we should remember what a mass of inherited knowledge, with some power of adapting means to an end, is crowded into the minute brain of a worker-ant.

In the construction of their holes, or burrows, worms display an amount of skill which may well entitle them to be compared with creatures of a higher order, whose labours have more frequently been held up to admiration. As indicative of a fine instinct, nearly approaching the faculty of intelligence, we extract the following from amongst many interesting pages on the same subject.

The Habitations of Worms.

The burrows run perpendicularly, or more commonly a little obliquely. They are excavated with surprising rapidity. I have seen a long line of earth thrown out of the burrow, and the worm, by the sudden contraction of the muscles of the body, draws itself along the line of earth. The worm, when it has once distended its body, and has acquired the form of a long cylinder, resists a great weight of earth, and is not easily dislodged. The walls of the burrows are often dotted with little globular pellets of voided earth, still soft and viscid to the touch, and some distance by the sides of the worm as it travels up or down its burrow. The lining thus formed becomes very compact and smooth when nearly dry, and it is the viscid nature of the reflexed bristles which project in rows on all sides from the body, thus have excellent points of support; and the burrow is rendered well adapted for the purpose for which it is used.

The lining appears also to strengthen the walls, and perhaps saves the worm’s body from being actually squeezed out, because several burrows which passed through a layer of sifted coal-cinders, spread over the turf to a thickness of 3 inches, had been thus lined to an unusual thickness. In this case the earth from the castings, had pushed the cinders away on all sides, and had not swallowed any of them. In another place, burrows similarly lined, passed through a layer of course-sifted coal-cinders, 3 inches in thickness. We thus see that the burrows are not mere excavations, but may rather be compared with tunnels lined with cement. The mouths of the burrow are, in addition often lined with leaves; and this is an instinctive habit, for Mr. Darwin does not appear to have been hitherto noticed. Many leaves of the Scotch fir or pine (Pinus sylvestris) were given to worms kept in confinement, and these, a few days after spread out on the surface of the soil, were stuck into the interstices between the pine-leaves; and these interstices were likewise plastered with the viscid castings voided by the worms. The structure, in this form colored so well, that I succeeded in removing one only with a little earth adhering to it. It consisted of a slightly curved cylinder, which appeared to have been spread out through holes in the sides of the burrows and at either end. The pine-leaves had all been drawn in by their bases; and the sharp points of the needles had been drawn into the burrows. Had this not been effectually done, the sharp points would have prevented the retreat of the worms into their burrows; and these structures are thus not only used for the conveyance of the converging lines of points, which renders the ingress of an animal easy and its egress difficult or impossible. The skill shown by these worms is noteworthy, and is the more remarkable, since the Scotch pine is not a native of this district.

We must not linger over the interesting particulars contained in the chapter on the quantity of the mould annually accumulated by the process of the passing of earth through the bodies of worms; but we may mention that calculation, founded on careful tests, are given, showing that in an acre of land, the weight of earth turned over every year was found to range, in four cases, from 756 tons to 18,12 tons. We must content ourselves with one or two more quotations, and they shall be from the concluding chapter, in which, as we have remarked, the results are summarised. Take the following, which points out the services which worms render in the fertilization of the earth.
THE LITERARY WORLD.

October 11, 1851.

Effects of Worm-activity on the Soil.

Mr. Darwin, in his book, alluded to the way in which worms are employed by the gardener to prepare the ground in an excellent manner for the growth of firm-rooted plants and for seedlings of all kinds. They periodically penetrate the air, moisten it, and soft it so that at no seasons larger than to a breath, which they can swallow left in it. They may be said to be the surface which is the most thoroughly taken over by the gardener who prepares fine soil for his choicest plants. In this state it is well fitter to retain moisture and absorb all soluble substances, as well as for the process of nitrification. The bones of many animals, the harder parts of insects, the stumps of land-molluscs, leaves of twigs, etc., are before long all buried beneath the worm-contaminated castings of worms, and are thus brought in a more or less decayed state within reach of the roots of plants. Worms likewise drag an infinite number of decayed leaves and other parts of plants into their burrows, partly for the sake of digging them up and partly as food. The larvae which are dragged into the burrows as food, after being torn into the finest shreds, partially digested, and attorned with the intestinal and urinary secretions, are converted into earth. This earth forms the dark coloured, rich humus which almost everywhere covers the surface of the land with a fairly well-defined layer or mantle. Von Heesen placed two worms in a vessel eighteen inches in diameter, which was filled with earth, on which fallow could not grow. He allowed soft water, and J. B. de Vries allowed fresh water, and these were soon driven into their burrows to a depth of 6 or 8 inches. About six feet from the almost uniform layer of soil, a centimeter (4 in.) in thickness, was converted into humus by having passed through the alimentary canal of the two worms. It is believed by some persons that worm-burrows, which often penetrate the ground almost perpendicularly to a depth of five or six feet, materially aid in its drainage; notwithstanding that the visible channels through which the water of the burrows prevent or check the run- water directly entering them. They allow the air to penetrate deeply into the ground and they also greatly facilitate the downward passage of roots of moderate size; and these will be nourished by the humus with which the burrows are lined. Many seeds owe their germination to having been covered by castings; and others are buried, to a considerable depth beneath accumulated castings lie dormant until, at some future time they are accidently managed or planted.

The concluding passage of the volume contains a suggestive allusion to an almost inexpressible source of interest to the thoughtful observer—that, namely, of the organism. We find agencies in the material world by means of which beneficial and beautiful results are so often secured.

Lowly Agencies in Nature.

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 being slowly levelled by worms. It is a marvellous reflection that the whole of the superficial movements of our expasion has passed, and will again pass, every few years through the bodies of worms. The plough is one of the most useful and at the same time the most important parts of the world’s inventions; but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed, by innumerable species. It is incredible whether there are many other animals which have played so important a part in the history of the world as these lowly-organised creatures.

Next to the agriculturist the archæologist should be thankful to these creatures which aforesight were thought to be serviceable only to themselves. They protect and preserve for an indefinitely long period every object, not liable to decay, which is dropped on the surface of the land, by burying it beneath their castings. Thus, and often in gardens and curious terracotta pavements and other remains are thus preserved, though, no doubt the worms in these cases have been largely aided by earth washed and blown from the adjoining land, especially when cultivated.

But they may work harm, as when they undermine such pavements and cause unequal subsides.

Even old massy walls may be undermined and subsided; and no-building is in this present state, unsafe on the foundations if but 7 feet beneath the surface, at a depth at which worms cannot work. It is probable that many monolithic stones and some old walls have fallen down from having been undermined by worms.

As to how these effects are produced, and how it is proved that such feeble creatures are capable of bringing to pass such great results, we must leave the book itself, which is easy and interesting reading and—thanks to large type—of no formidable extent. In short, earthworms largely swallow earth in making their burrows, and also for the sake of extracting any nutritious matter it may contain; and this is voided over the surface of several thousand square yards after a few years lying at the depth of some feet beneath the turf, but still forming a layer.

The suggestion that this apparent sinking of superficial bodies is due to the large quantity of fine earth thrown through the air, and that in the form of castings was made by Mr. Darwin’s own direct observations, and this he at that time proceeded to verify, by ascertaining that at which objects left on the surface of the soil were afterwards found, this sinkings of the earth, it is best to conclude that all the vegetable mould over the whole country has passed many times through, and will still pass many times through the intestinal canal of worms, and therefore that it should rather be called “animal” than “vegetable” mould. Returning to the subject now in later days, Mr. Darwin confirms his conclusions by another and more indirect line of evidence, namely, by weighing all the worms thrown up on a measured space within a given time, as also by sedulous and protracted observation of the habits and actions of these animals. There is also an interesting chapter on the part which worms have played in the formation of ancient buildings, as at the old Roman remains at Pons Aelius and Wroxeter, and at Beaulieu Abbey, described by Henry VIII; and two others on their action in the denudation of the land.

A large part of the chapter on the habits of worms is devoted to the question of their intelligence, and to an account of the researches made by Mr. Darwin and his son Francis in this regard, founded mainly on observations of their management in closing and opening their burrows, and in dragging them various kinds of leaves and other articles of food. Adopting the idea that in-