

A NEW book * from the pen of the veteran naturalist Charles Darwin is always an event of interest, alike to the scientific and the literary world, as well as to the general reader. This year he has published two—one on the movements of plants, and the recent monograph on the worm.

The earth-worm, poor and insignificant as it may appear to the non-scientific mind, has always possessed an interest for the observers of nature, on account of the extent and activity of its labours in the soil.

* *The Formation of Vegetable Mould by the Action of Worms.* By Charles Darwin. London. 1881.

More than a hundred years ago Gilbert White, of Selborne, regretted there was no book devoted to the nature and habits of the worm. This accurate observer of the phenomena of nature, who is quoted by Darwin in confirmation of some observations of his own, was one of the first to vindicate the claim of the despised worm to be esteemed a useful member of the animal world. He writes:—“Earth worms, though in appearance a small and despicable link in the chain of nature, yet if lost would make a lamentable chasm. For, to say nothing of half the birds, and some quadrupeds, which are almost entirely supported by them, worms seem to be the great promoters of vegetation by boring, perforating, and loosening the soil, and rendering it pervious to rains and the fibres of plants, by drawing straws and stalks of leaves into it, and most of all, by throwing up numbers of lumps of earth, called worm-casts, which are a fine manure. Farmers and gardeners express their detestation of worms, but would soon find that the earth without worms would become cold, hard-bound, and devoid of fermentation.” The foregoing passage is from the “Natural History of Selborne,” and serves to show the different standpoint from which the lower types of animal life were regarded a century ago to that which modern science occupies. In those days all things were held to be subservient to the needs of mankind—the apex of creation. The different contributions to the comfort or welfare of the human race made by the lower animals formed their *raison d'être*, according to the egotistical philosophy of a few generations back. Gilbert White was too true a lover of all living things to adopt this tone himself; but we can see by his concessions to it that it was the tone of popular thought. The progress of scientific knowledge has taken some of this conceit out of us. We no longer believe that any form of life exists “but to subserve another's gain.”

Mr. Darwin, by his genuine zeal for knowledge, and the simplicity and lucidity of his descriptions, gives an interest to all things about which he writes, and his ardour as an observer invests them with an importance that makes us wonder we had not previously thought more about these subjects. In this book he gives us the results of observations carried on as one branch of his widespread investigations in the domain of natural science, through more than forty years, the first date being 1837, when he read a paper before the Geological Society of London on the “Formation of Mould.” In this paper he showed that fragments of burnt marl, cinders, and other hard substances freely scattered on the surface of grass land were,

after a few years, lying underneath the turf, at a depth of some inches, yet preserving the form of a layer. It was Mr. Wedgewood, the maker of the celebrated pottery that bears his name, and who was also Mr. Darwin's grandfather on the maternal side, who first suggested that this apparent sinking was due to the layer being covered by the fine earth brought to the surface by worms. So early in his investigations as the date of this paper Mr. Darwin appears to have come to the conclusion that "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."

Extended observations, not only in Europe, but, with the aid of correspondents, in America, India, New Zealand, New South Wales, and other parts of the world have since established this theory. Some objections to it were founded on the fact that, "considering their weakness and their size, the work the worms are represented to have accomplished is stupendous." But this objection, as Mr. Darwin points out, is only "an instance of that inability to sum up the effects of a continually recurrent cause which has often retarded the progress of science, formerly in the case of geology, more recently in that of the principle of evolution."

The present volume does not deal with the question of evolution, except in showing the great results of continuous small causes—a point that has a most important bearing on that principle.

Mr. Darwin kept several worms in pots, for the more close observation of their habits. The facts he obtained by this means may be considered more as proving what was previously known, than as accessions of fresh knowledge. Worms appear to possess certain senses in a very rudimentary state; or rather, we may say, they possess indications of what might, under favourable conditions, through long periods of time, develop into a sense. Thus, they have no eyes, yet are sensitive to light; they have no organ of hearing, yet are conscious of vibratory movements, either in the air, when near enough for the undulations to touch them, or in solid bodies on which they rested. That they have the sense of taste is evidenced by their preference for certain kinds of food. They have also the sense of smell, feebly developed. As they have no special respiratory organs, they breathe through the skin. The circulatory system is well developed, the nervous system fairly. Their strong points are the muscular system and the digestive apparatus. Anyone who has watched the movements of worms must have observed the

great muscular energy displayed in the lissom, gliding movement—equally rapid and easy whether it be backwards or forwards—and the rapidity with which they will dart into their burrows when alarmed. It is shown also in their swift and varied contortions when they are being worked on to the hook of the “gentle angler,” or in any other way put to pain. People who bait their fish-hooks with live worms may find their consciences soothed by the opinion expressed by Mr. Darwin that worms, though extremely sensitive to contact in every part of their bodies, do not suffer so much as their contortions would lead us to believe.

The gourmand who wished he had a throat a mile long, with palate all the way down, might have been well content to be a worm. Not only is the business of their lives eating, but the beneficial work they effect on the earth is due to their voracity. They swallow enormous quantities of earth, extract the nutriment it contains, and then eject it on the surface, returning to their burrows to repeat the process. It is by means of these castings that worms cover the surface of the ground with fine earth, thoroughly triturated, mixed with the juices of their own bodies, and with all the small particles of stone, rock, or other hard substance contained in it pulverized by the action of their gizzards. Several instances are given of the rate at which the land is covered with this fine mould.

A grass field had been covered with marl and then left for several years as pasture; twenty-eight years afterwards a layer of the marl could be traced at a depth of twelve inches in some parts and fourteen inches in others. Another field of good pasture land, having been covered with quicklime, was left undisturbed for ten years, at the end of which period some holes were dug and the lime discovered at a depth of three inches from the surface, under a layer of vegetable mould and turf.

The disappearance of substances thrown on the surface of grass land is a familiar fact to farmers, who say that they work themselves downwards. “How,” Mr. Darwin remarks, “powdered lime, cinders and heavy stones, can work down, and at the same rate, through the matted roots of a grass-covered surface, is a question which has probably never occurred to them.”

Mr. Darwin has made numerous investigations with a view to ascertain the amount of earth thrown up by worms, and also the number of worms per acre on different kinds of land. The narration of the carefully made observations brings vividly before

the mind the patient pursuit of accuracy that distinguishes modern scientific research. Its superiority in this respect to former methods is very striking when we contrast its cautiously advanced conjectures with a statement so loose and wild as that of Réaumar, who is said to have computed "that the number of worms lodged in the bosom of the earth exceeds that of the grains of all kinds of corn collected by man!" It is difficult to imagine the kind of data on which this conjecture was founded.

Archæologists are, it appears, specially indebted to worms for the preservation of ancient remains. Relics of ancient battle-fields have been disinterred, after being covered for centuries by the gradually accumulating mould, thrown up by these busy little animals. A notable instance was that of the iron arrow-heads used at the battle of Shrewsbury in 1403. In the same way the remains of old Roman towns and buildings in many parts of England have been covered up, largely by the action of worms, and thus preserved till accidentally discovered.

A far more important work effected by worms, to which our author directs attention, is the share they take in the denudation of the surface of the earth. The removal of the disintegrated substances of rocks and mountains to lower levels, by the action of air and water, is called denudation. The process has a very important part in the history of the earth's surface. As an instance of what denudation is, and what results it may bring about, Mr. Darwin cites the instance of the Mississippi:—

"The amount of sediment brought down by this great river has been investigated with special care by order of the United States Government. The result is, that the mean level of its enormous area of drainage must be lowered one foot in 4,566 years. Consequently, estimating the mean height of the North American Continent at 748 feet, and looking to the future, the whole of the great Mississippi basin will be washed away, and brought down to the sea level in less than 4,500,000 years, if no elevation of the land takes place."

This may seem a very long look into the future, and a prospect that scarcely concerns us; but it is well to remember how great a stumbling-block in the way of the advancement of science has been the want of the habit of mind that contemplates immense periods of time in connection with the history and changes of our earth. Sir Charles Lyell used to tell a story of a rich man who put down his name for a very small sum in a charitable subscription. Upon being remonstrated with by a friend, he at once increased the sum, and explained his apparent parsimony by saying that in his early life

he had been very poor, and he had never been able to get the chill of poverty out of his bones. Lyell applied it to the difficulty of getting people to entertain any adequate idea of the immense periods required in the formation of the earth's crust. They had been accustomed to think of a rapid creation and a brief history, and they could not get the chill of poverty out of their bones sufficiently to make grants of millions of years.

The long processes of nature, unfasting yet unfasting, the ages that must elapse before any noticeable result is obtained, are made apparent to us in Mr. Darwin's account of the action of worms in denudation. It is by means of the humus acids, generated in the bodies of worms during the digestive process that they act upon rocks, and aid in their disintegration. The following will give some idea of the method :—

“The combination of any acid with a base is much facilitated by agitation, as fresh surfaces are thus continually brought into contact. This will be thoroughly effected with the particles of stone and earth in the intestines of worms during the digestive process ; and it should be remembered that the entire mass of the mould over every field passes, in the course of a few years, through their alimentary canals. Moreover, as the old burrows slowly collapse, and as fresh castings are continually brought to the surface, the whole superficial layer of mould slowly revolves or circulates, and the friction of the particles one with another will rub off the finest films of disintegrated matter as soon as they are formed. Through these several means, minute fragments of rocks of many kinds, and mere particles in the soil will be continually exposed to chemical decomposition, and thus the amount of soil will tend to increase. As worms line their burrows with their castings, and as the burrows penetrate to a depth of five or six, or even more feet, some small amount of the humus acids will be carried far down, and will there act on the underlying rocks.”

The important work carried on by worms in the fertilization of the soil is thus summarized by Mr. Darwin :—

“Worms prepare the ground in an excellent manner for the growth of fibrous-rooted plants and for seedlings of all kinds. They periodically expose the mould to the air, and sift it so that no stones larger than the particles which they can swallow are left in it. They mingle the whole intimately together, like a gardener who prepares fine soil for his choicest plants. In this state it is well fitted to retain moisture, and to absorb all soluble substances, as well as for the process of nitrification. The bones of dead animals, the harder parts of insects, the shells of land molluscs, leaves, twigs, &c., are before long all buried beneath the accumulated castings of worms, and are thus brought, in a more or less decayed state, within reach of the roots of plants. Worms also drag an infinite number of dead leaves and other parts of plants into their burrows, partly for the sake of plugging them up and partly as food.”

These leaves, after being torn to pieces and saturated with the intestinal secretions, are mingled with earth, and become an

important constituent of the rich, dark loam which covers the surface of the land. The worm-burrows also allow the air to penetrate deeply into the ground, and they facilitate the downward passage of the roots of plants.

After describing the important functions of the worm in the economy of nature, it is gratifying to find Mr. Darwin ascribing to them something more than a mere mechanical instinct or inherited memory. Lowly organized as they are in regard to the senses, their actions in some respects justify us in ascribing to them a degree of intelligence. After treating, at a great length, on the way in which worms plug the mouths of their burrows with leaves, and their adaptation of means to end in this work, Mr. Darwin finds that they display intelligence—if we may “infer intelligence when we see an individual profiting by its own experience.” This is what worms with which he experimented obviously did, when supplied with leaves of a kind that must have been unfamiliar to them, and with triangles of paper, which were drawn into the burrows in the way most convenient for plugging the orifice.

“If,” says Mr. Darwin, “worms are able to judge how best to drag an object into their burrows, so as to close the mouth, they must acquire some knowledge of its shape; this they can only acquire by touching it with the anterior extremity of their bodies. It may be well to remember how perfect the sense of touch becomes in a man born blind and deaf, as worms are. 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 act in nearly the same manner as a man would under similar circumstances.”

It is the best proof of the ability shown in Mr. Darwin's book, that one rises from the perusal of it with an enhanced perception of the interest that attaches to lower forms of life—the dignity inherent in any order of existence, however lowly, not merely because it subserves general ends, but as having a beauty and completeness of its own.

M. W.

MR. DE LISSA * is entitled to all the praise that may be bestowed upon a professional man who, instead of devoting all his thoughts and energies to the details of business, employs a portion of his time in philosophical speculation upon the best modes of ameliorating

* *Proposal of a New System of Bankruptcy and Insolvency Law.* By Alfred De Lissa, Attorney-at-Law, Sydney. George Robertson, Melbourne, Sydney and Adelaide. 1881.