LATE PUBLICATIONS.

THE FORMATION OF VEGETABLE MOULD THROUGH THE ACTION OF WORMS. By Charles Darwin. New York: D. Appleton & Co. 1882. San Francisco: Jas. T. White & Co.

The last contribution to natural science comes to us from that indefatigable worker, Charles Darwin, and is of much more vital importance to humanity, in relation to sanitary precautions in connection with epidemic diseases resulting from burials of both animals and man, than would appear from the perusal of this exquisite scientific treatise on the habits of worms. It is confirmatory of the results of the scientific investigations of the cause of epidemic diseases visiting animal and man, published from time to time, in 1880, by that great benefactor of humanity, Pasteur, of France.

All contagious or epidemic diseases are the *product* of *living germs*, which are *the parents* of each *distinct disease*—a *contagium vivum*, as it is termed.

The relations of diseases infecting man and animals are now known to be closer than was even suspected. Such as cow-pox and small-pox—malignant pustules—boils such as affect wool-sorters, are known to be a modification of splenic fever, communicated by the wool of infected sheep. Conclusions such as these are universally accepted by the scientific medical world, as witnessed by the congress in London of the leading medical men of civilization.

Pasteur's attention having been called to the terrible ravages of splenic fever (anthrax) raging among cattle in parts of France, in 1878, he took up the subject, and, as usual, was fundamental, and sought the *cause* as well as the *agents*. He examined the ground over the graves of cattle that had died of that disease the year previous, and found unquestioned germs of splenic fever. He then caused to be buried, six feet deep, three cows that had died of anthrax, fenced in the plot, and dug a trench around it. At intervals of some months, cylindrical particles of loose soil, the earth ejections of the worms on the surface of the grass, were examined, and in every instance the presence of thousands of germs of the disease was established, while beyond the ditch none were found. Further investigation and practical tests proved beyond doubt that the earth-worm was the messenger that conveyed the spores from the depths of the earth to the surface. Burial places are conservatories of epidemic diseases.

Mr. Darwin now informs us that there are about eight known species of worms, two of which rarely burrow in the ground, and one species which inhabits very wet places, and even lives under water. They

are destitute of eyes, but by experiments it was found that they were affected by light. The supposition is, "that the light passes through their skins, and excites their cerebral ganglia; . . . . their sensitiveness to light enables them to distinguish between night and day." They are "nocturnal in their habits, and at night may be seen crawling about in great numbers. . . . . They do not possess any sense of hearing, and possess but very feeble powers of smell. . . . . The sense of feeling is well developed." They are sensitive to temperature; they do not come out of their burrows during frost. "They exhibit some degree of intelligence, from the way they draw into their burrows withered leaves by their tips, as a more convenient way of drawing them into their narrow burrows. When the leaves of three species of foreign pine consisted of two needles of considerable length, united to a common base, it was by the base they were invariably drawn in. Again: when the leaves were narrower at the base than at the tip, sixty-six per cent. had been drawn in by the base, or foot-stalk, and thirty-four per cent. by the tip." The worms judged how best to draw the withered leaves of a foreign plant, lying exposed, into burrows; notwithstanding that "they had to depart from their usual habit of avoiding the foot-stalk." Instinct could not very well be "developed in reference to objects such as the leaves or petioles of foreign plants, wholly unknown to the progenitors of the worms, which act in the described manner." Their actions are not "so unvarying or inevitable as are most true instincts. . . . . The skill shown by these worms is noteworthy; and is the more remarkable, as the Scotch pine is not a native of this district." It is "surprising that they should apparently exhibit some degree of intelligence, instead of mere blind instinctive impulse, in their manner of plugging up the mouths of their burrows. They act in nearly the same manner "as would a man who had to close a cylindrical tube with different kinds of leaves, petioles, triangles of paper, etc."

They are omniverous, and feed on half-decayed leaves of all kinds, except a few tough ones. They also swallow a large amount of earth, and extract such digestible matter as it may contain.

The most remarkable and powerful organs are the gizzards. "These are lined with so thick a chitinous membrane" that they are spoken of as "veritable armatures." "The gizzard is surrounded by powerful transverse muscles, which are about ten times as thick as the longitudinal ones, and were seen contracting energetically. One genus has two distinct gizzards." In another, "the second gizzard consists of four pouches, one succeeding the other, so that it almost may be said to have five gizzards." They "swallow stones to aid in the trituration of their food, so it appears to be with terricolous worms. The gizzards of thirty-eight of our common worms were opened, and in twenty-five of them small stones or grains of sand, together with hard calcarous concretions formed within the anterior calciferous glands, were found. Beads of glass, fragments of brick, and hard tiles were scattered over the surface of the earth pots in which worms were kept, and very many of these *beads* and fragments were found in the worm castings, intestines, and gizzards; . . . . this is to aid their gizzards in grinding the earth which they so largely consume."

As to sex: "The two sexes are united in the same individual, but two individuals pair together."

The habitat of the worm is the world over—the most isolated islands, Iceland, and the antarctic regions. "How they reach isolated islands is at present quite unknown. They are easily killed by salt water." It cannot be through the action of birds, in transporting the germs or the worms. For instance, "Kerguland is not *now* (?) inhabited by any land birds," yet worms are found there. Query: May it not be through floating logs, or wrecks of vessels? Logs are often found floating in fresh water, with earth and worms in the decayed heart of the log.

They live usually near the surface of the ground, but burrow very deeply according to climate. In very dry seasons and cold climates, they burrow from seven to eight feet; to the moisture, in dry seasons; and below the frost depth, in very cold climates. In England, worms were found at a depth of six and a half feet, at Silchester, Hampshire County. Several burrows were found terminating in a chamber at a depth of seven and eight feet from the surface. In Germany, they are found at depths—according to location—ranging from three to eight feet.

The natural cultivation of the soil goes on year after year by these active workers. In forests, the cultivation of the soil may be seen by removing the fallen leaves, when it is found that the surface is covered by the castings. Thus the earth, from three to seven feet, passes through their bodies in a very few years. Thus we have an enrichment of the soil by animal mold, and thereby chemical decomposition of vegetable mold. A low calculation of the number of worms to the acre amounts to about fifty thousand.

The castings were weighed. In England, the average was found to be 4 lbs. 3½ oz. per square yard; near Nice, in France, 5 lbs. 3½ oz. per square yard—per annum, or from 14.53 to 18.12 tons per acre, per annum, in England, forming a layer of from one and a half to two inches in ten years.

The apparent sinking of bodies on the surface of ground is thus accounted for by the worms' work. The action of worms protects and preserves, for indefinite periods, objects not liable to decay, by burying them beneath their castings. At Abinger, Surry, in 1876, in digging to a depth of two to two and a half feet in an old farm-yard and fields adjoining, were discovered old walls of Roman villas, fragments of pottery, and coins of Roman emperors, dating from 133–361 to 375, A. D. Mr. Darwin was present, and examined the trenches.

So at Brading, Isle of Wight, a Roman villa was discovered in 1880, and eighteen chambers cleared. A coin dated 337, A. D., was found.

At Silchester, Hampshire, the ruins of a Roman town have been better preserved than any other of the kind in England. A wall was traced fifteen to eighteen feet in hight, a mile and a half in compass, surrounding about one hundred acres of cultivated land. "In very dry weather, the wall could be traced by the appearance of the crops."

In one of the chambers, "evidence of two fires, separated by an interval of time, during which the six inches of mortar and concrete, with broken tiles," was accumulated. Under one of the layers of charred wood, a bronze eagle was found. An excavation made in the middle of the town showed the accumulation of worm-mold had a depth of twenty inches. In the middle of one of the walls, in the mortar, burrows were found, showing the great muscular power of the worms. One of the walls was found undermined at a depth of seven feet. Hence the subsiding of stone or brick walls.

Worms prepare the ground, and sift it, "like a gardener who prepares fine soil for his choicest plants." They add to the richness of the soil, by the introduction of vegetable matter into their burrows. "This earth forms the dark-colored, rich humus which almost everywhere covers the surface of the land."

The burrows which penetrate the ground five or six feet aid in its drainage, and allow the air to penetrate the ground, and assist the downward passage of the roots of trees, moistened by the humus of the lining of the burrows. And this accounts for the sprouting of seeds that have lain dormant, in turning up earth at great depths.

In the future, the geologist will have to take some note of the action of worms, as it presents certain facts which cannot be entirely ignored. Among many others may be mentioned the aid rendered in the decomposition of rocks by the humus acids, as well as the direct mechanical action on the smaller particles, by the continual exposure of new surfaces to the action of carbonic acid.

In the language of Mr. Darwin, "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 creatures."