BIOLOGY-GEOLOGY

Earthworms as Soil-Makers

"A Classic of Science"

"Vegetable Mould" is a Misnomer, According to Darwin, For the Pulverized Soil is Prepared by Earthworms

ON THE FORMATION OF MOULD. By Charles Darwin. In Transactions of the Geological Society of London, second series, vol. V. London: 1840. (*Read November* 1, 1837). *This is an exact reprint of the original publication.*

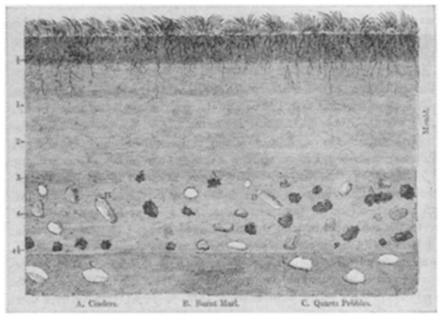
THE FORMATION of the superficial layer of earth, commonly called vegetable mould, offers some difficulties in being fully understood, which apparently have been overlooked. In old pasture lands, the mould, to the depth of a few inches, differs but slightly, although resting upon various kinds of sub-soil. The uniform fineness of its particles is one of its chief distinguishing characters; and this may be well observed in a gravelly country, where a recently ploughed field immediately adjoins another, which has long remained undisturbed for grazing. In the latter, not a pebble will be seen, either on the surface or immediately below it; although in the ploughed field, a large proportion of the soil may be composed of small stones. From the prevailing use of the expression "vegetable mould", it would appear that its origin is generally attributed to some effect of vegetation; yet it is scarcely conceivable that the turf, in the case of the two adjoining fields, can have produced so remarkable a difference as that alluded to.

My attention was called to this subject by Mr. Wedgwood, who showed me, whilst I was staying at Maer Hall, in Staffordshire, several fields, some of which a few years previously had been covered with lime, and others with burnt marl and cinders. These substances, in every case, were buried some inches beneath the turf. In several parts of three grazing fields, I dug square holes, and obtained the following results:—1st. In some good pasture land which had been limed, without having been ploughed, about ten years before, the turf, or the layer in which the roots of the grasses are closely woven together, was about half an inch thick. At two inches and a half beneath this, or about three from the surface, a layer of lime, or a row of small aggregated lumps of it, formed a well-marked white line around the holes. The soil beneath this layer of lime was gravelly, or of a coarse sandy nature, and differed considerably from the mould nearer the surface. About three years ago cinders also had been spread on this field; but when I examined it, they were buried at the depth of one inch. They were not sufficiently numerous to form a layer, though a line of black spots could clearly be traced parallel to and above the white one of lime. Some other cinders, which had been scattered in another part of this same field, only about half a year before, lay either on the surface or were entangled in the roots of the grass.

The second field, I mention only from the fact of the cinders being buried in such quantities, about three inches deep, as to form a stratum nearly one inch in thickness. The layer in some parts was so continuous, that the upper soil was united to the lower only by the longer roots of the grasses. The sub-soil was a red clay, and it occurred a little below the cinders.

The third case which I shall describe, is that of a field which, Mr. Wedgwood informed me, was waste land fifteen years ago. It was at that time drained, ploughed, harrowed, and well covered with burnt marl and cinders. It has not been disturbed since, and now supports a tolerably good but rather coarse pasture. The section in this field, as represented in the woodcut was turf half an inch; vegetable mould two inches and a half; a layer, one and a half inch thick, of fragments of burnt marl, (conspicuous from their bright red colour), of cinders, and a few quartz pebbles, mingled with earth. One of the angular fragments of burnt marl lying near the bottom, measured one inch in length by half an inch in breadth, and a quarter in thickness. Lastly, about four inches and a half below the surface, was the original black peaty soil. We thus find, beneath a layer, nearly four inches thick, composed of fine particles of earth mixed with decayed vegetable matter, those substances which had been spread on the *surface* fifteen years before.

The appearance in all the above cases was, as if (in the language of the farmers, who are acquainted with these facts) the fragments had worked themselves down. It is, however, scarcely possible that cinders or pebbles, and still less powdered quick-lime, could sink through compact earth and a layer of matted roots of vegetables, to a depth of some inches; nor is it at all probable that the decay of the grass, although adding to the surface some of the constituent parts of the mould, should separate in so short a time the fine from the coarse earth, and accumulate the former on those objects, which so lately had been on the surface. I may add, that I have repeatedly observed fragments of pottery and bones buried beneath the turf, in fields near towns, (on which such substances are often thrown with manure); and as these fields did not appear to have been ploughed, the circumstance often surprised me. On the contrary, I have noticed in gardens lately dug, that the rain, by washing away the finer particles, leaves stones and other hard bodies accumulated on the surface. (*Turn Page*)



SECTION OF SOIL

—in a field undisturbed for fifteen years. The cinders, marl and pebbles were at first on the surface of the soil. The mould was carried up and deposited on top of them during that time.

The subject of this paper was later elaborated by Charles Darwin into a book, "The Formation of Vegetable Mould, through the Action of Worms, with Observations on their Habits", published in London in 1881 and in New York by D. Appleton & Co. in 1890, with several later editions. Through the intervening half century, he had gathered many additional observations of the activity of worms, especially from a large number of Roman ruins discovered in England, whose foundations were excavated and examined.

The explanation of these facts, which occurred to Mr. Wedgwood, although it may appear trivial at first, I have not the least doubt is the correct one, namely, that the whole operation is due to the digestive process of the common earth-worm. On carefully examining between the blades of grass in the fields above described, I found scarcely a space of two inches square without a little heap of the cylindrical castings of worms. It is well known, that worms, in their excavations, swallow earthy matter, and that, having separated the portion which serves for their nutriment, they eject at the mouth of their burrows the remainder in little. intestine-shaped heaps. These partly retain their form until the rain and thaws of winter, as I have observed, spread the matter uniformly over the surface. The worm is unable to swallow coarse particles, and as it would naturally avoid pure or caustic lime, the finer earth lying beneath the cinders, burnt marl, or lime, would be removed, by a slow process, to the surface. This supposition is not imaginary; for in the field in which cinders had been spread out only half a year before, I actually saw the castings of the worms heaped on the smaller fragments. Nor, I repeat, is the agency so trivial as at first it might be thought: the great number of earth-worms, as every one must be aware who has ever dug in a grass field, making up for the insignificant quantity of the work which each performs. On the idea of the superficial mould having been thus prepared, the advantage of old pasture land, which it is well known farmers in England are particularly averse to break up, is explained; for the length of time required to form a thick stratum must be considerable. In the peaty field, in the course of fifteen years, about three inches and a half had been well prepared; but it is probable that the process is continued, though at a very slow rate, to a much greater depth. Every time a worm is driven, by dry weather or any other cause, to descend deep, it must bring to the surface, when it empties the contents of its body, a few particles of fresh earth. Thus, the manures added by man, as well as the original constituent parts of the soil, become thoroughly mingled, and a nearly homogeneous character is given to the whole.

Although the conclusion may appear at first startling, it will be difficult to deny the probability, that every particle of earth forming the bed from which the turf in old pasture land springs, has passed through the intestines of worms; and hence the term "animal mould" would in some respects be more appropriate than that of "vegetable mould".

I may conclude by remarking, that the agriculturist in ploughing the ground follows a method strictly natural; he only imitates in a rude manner, without being able either to bury the pebbles or to sift the fine from the coarse earth, the work which nature is daily performing by the agency of the earth-worm.

Note.—Since my communication on the "formation of mould", read on the 1st of November, I have received from Staffordshire an account which corroborates the statements then made, on the apparent sinking of objects placed on the surface of turf land. The first case I mention only because the substance is different from those previously described. In the spring of 1835 a boggy field, which had long remained as grass land, was so thickly covered with sand that the whole surface appeared of a red colour. At the present time, namely about two years and a half afterwards, the sand forms a layer three-fourths of an inch below the surface, that thickness consisting of peaty soil.

The second case is more interesting. It has been ascertained that a field, which has since been ploughed, was covered about eighty years ago with marl; an imperfect layer of it, but sufficiently distinct to be traced, is now found at a depth, very carefully measured from the surface, of twelve inches in some parts and fourteen in others: the difference corresponding to the top and hollow of the ridges produced by ploughing. It is certain, the marl must have sunk or been buried before the field was ploughed, for otherwise the fragments would have been scattered in the soil: this conclusion, moreover, explains the circumstance of the layer being horizontal, whilst the surface is undulating. At the present time no plough could possibly touch the marl, as the land in this country is never turned up to a greater depth than eight inches. In the preceding communication, I have shown, that in a field lately reclaimed from being waste land, three inches of mould had been prepared by the worms in the course of fifteen years. We now find, that within a period of less than eighty years, (but how much less cannot be told, unless the date when the field was first ploughed were known) the earth-worms have covered the marl, which was originally strewed on the surface, with a bed of earth of an average thickness of no less than twelve or thirteen inches.

November 14, 1837.

Science News Letter, January 28, 1933

PATHOLOGY

Cholesterol Makes Ready For Growth of Cancer

CHOLESTEROL, an important chemical compound found in animal tissue, "prepares the soil" for the growth of cancer. This new theory of a cause of cancer is suggested in a report by Dr. A. H. Roffo of Buenos Aires in the *American Journal of Cancer.*

Cholesterol is found in all animal fats and oils and in many organs.

In the case of skin cancers, Dr. Roffo believes that cholesterol is accumulated in the skin by the effects of exposure to light and in turn acts as a condition for the production of cancer. It prepares the soil, as he expresses it, probably because under the influence of light it itself becomes photoactive, emitting emanations which affect the surrounding tissue.

As evidence for these views he presents such facts as these:

Cancerous tissues show an increased cholesterol content compared with normal tissues, especially in the skin.

Tumor cells show a tendency to absorb and fixate cholesterol from the blood, or, in the case of cell cultures, from the surrounding medium.

In the skin a fixation of cholesterol in the tissues is favored by exposure to light. His analyses show that in the face and other parts of the skin exposed to light more cholesterol is present than in those parts protected from the light by clothing. He finds in this relationship an explanation of the fact that skin cancers are frequent on the face and rare where the skin is covered by clothing.

So far as skin cancers are concerned he sums up his views in the statement that "cholesterol prepares the soil for subsequent malignant growth by acting as an accumulator of light."

Science News Letter, January 28, 1933