CHAPTER I.

EARTHWORMS AND LEECHES.

EARTHWORMS occur commonly in nearly all parts of England. Their body is roughly cylindrical, but tapers towards each extremity. It is divided into a number of similar rings or segments, about 140—180, by constricting furrows. The surface is moist and iridescent; this latter property is an optical effect produced by the fine striations with which the delicate cuticle is engraved, and is not due to the presence of any pigments. Earthworms inhabit burrows in the surface of the earth, and for the most part limit their operations to the top 12 or 18 inches (*i.e.* in the soil which is richest in decomposing vegetable and animal substances and in which decomposition occurs most rapidly), but during periods of prolonged drought or frost they descend to greater depths and undergo æstivation or hibernation, as the case may be, coiled up into a compact spiral and lying in a small excavated chamber. This is lined with small stones which prevent close contact with the surrounding earth and so permit free respiration.

The sides of the burrow are kept moist by slime discharged from the glandular cells of the skin, and perhaps by liquid discharged from the body-cavity through the dorsal pores which occur in the grooves that separate segment from segment. The slime is said to possess antiseptic properties, and thus to preserve the skin of the worm from harmful bacteria.

The mouth of the burrow is guarded by small stones or more frequently by one or more leaves pulled in to a greater or less distance. Fir-needles, stalks of horse-chestnut leaves and other similar things are often to be seen standing nearly erect upon the ground, their lower ends having been forcibly dragged into the mouth of a burrow by a worm. On still, warm nights in early autumn the rustling noise of fallen leaves being dragged along by worms is often plainly audible in favourable localities. Darwin has pointed out[1] that worms exhibit considerable intelligence in drawing the narrow end of leaves of various shapes foremost into the burrow: leaves with broad bases and narrow apices are generally pulled in tip first, whereas when the base is narrower than the apex the reverse position is usually found. There is no doubt that worms can judge which end of any leaf is the better to seize. The reason for thus pulling objects into the entrance of the burrow is probably to prevent the entry of foes, centipedes, parasitic flies, etc., to keep the burrow moist by preventing evaporation, to keep out the cold lower strata of air at night, to bring food supplies within safe reach, and also to enable the worm to lie near the mouth

[1] *Vegetable Mould and Earthworms.* London, 1881.

of the burrow unobserved. Here however they are not secure from all attack, for the quick ears of the thrush and other birds enable them to detect the slightest movement and, with a quick plunge of the beak, to seize and, after a brief tug-of-war, to extract the worm from its refuge. Frequently the well-known worm-castings are thrown up on the surface, and when this is so, leaves are not, as a rule, drawn into the burrows, the heap of castings serving the purpose.

The burrow is made partly by the awl-like tapering anterior end pushing aside the earth on all sides, and partly by the actual swallowing of the earth as the worm advances, so that the animal literally eats its way into the soil. The organic material in the swallowed soil serves as food, and the residue in a state of very fine division passes out at the anus, and is used either to form the above-mentioned castings or as a lining to the burrow, especially where this passes through hard, coarse earth.

Perfectly healthy worms seldom leave their burrows completely except perhaps after very heavy rain. The majority of those so frequently found travelling over the surface of roads and paths after rain are infected by the larvæ of parasitic flies and doomed to die. On warm, moist evenings, however, worms may be seen in hundreds lying stretched on the surface of the ground with only the broad flattened posterior end remaining in the burrow. Here we see one of the uses of this modification in the shape of the hinder segments of the body: their greater width enables them to obtain a firm purchase on both sides of the burrow, and thus the worm is provided with a sure anchor on which it can pull and at the slightest alarm shoot back like stretched elastic into the security of its burrow. At other times the flat tail is employed trowel-wise in smoothing the excrement against the walls of the burrow or in disposing the castings on this side and on that of the mouth of the burrow.

Locomotion is primarily effected by the alternate rhythmic contractions of the longitudinal and of the circular muscles of the body-wall which contract and elongate successive regions of the cylindrical body. The eight bristles (setæ or chætæ) with which each segment is furnished are however of scarcely less importance, inasmuch as they serve as so many little cogs to catch in irregularities of the surface and thus bring about movement in a definite direction. Muscles are attached to the inner parts of the setæ and can cause them to shift their positions; an arrangement that

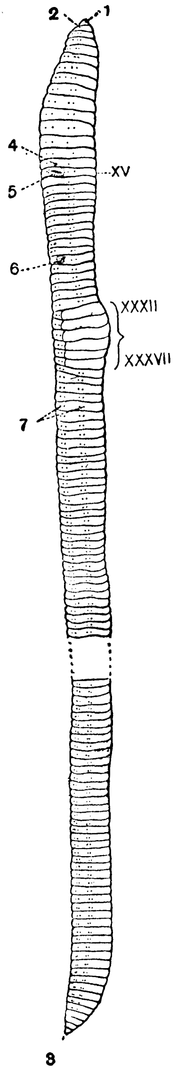

Fig. 1.

Fig. 1. Latero-ventral view of *Lumbricus terrestris*, slightly smaller than life-size. From Hatschek and Cori.

1. Prostomium. 2. Mouth. 3. Anus. 4. Opening of oviduct. 5. Opening of vas deferens. 6. Genital chætæ. 7. Lateral and ventral pairs of chætæ.

xv, xxxii and xxxvii are the 15th, 32nd and 37th segments. The 32nd to the 37th form the clitellum.

is very necessary in the rapid retrograde movement of a worm darting back into its burrow. If a worm is placed on a highly polished horizontal surface the contractions of its body do not result in any definite movement but merely in writhings. On the other hand, worms can climb along over nearly vertical surfaces provided these are rough. I have seen them moving at a good speed up a "dry wall" built of Bargate stone—a coarse-grained sandstone whose surface is admirably adapted to afford

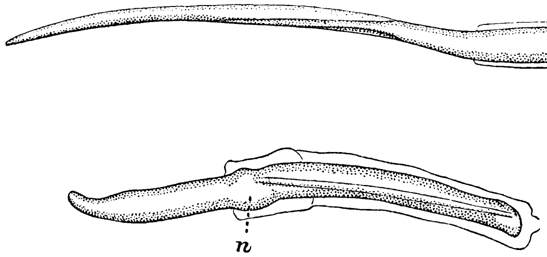

Fig. 2. A genital seta (grooved) from 26th segment of *L. terrestris*; actual length 1·75 mm.; and, below, an ordinary seta of the same individual; actual length 1·42 mm. The faintly indicated tube round the right-hand (inner) portion of the figures represents the seta sac.

hold for the numerous setæ. If a living worm be held in the hand the manner of using the setæ in ordinary locomotion is easily seen: as the body is elongated the setæ are retracted and disappear from sight, but directly the contraction of the longitudinal muscles of the body-wall begins the setæ shoot forth from their pits and can be seen plainly by the unaided eye and their points felt by the skin of the hand.

Digestion. In addition to the food obtained from the soil worms devour leaves, both fresh and decaying, and also animal substances, fat being especially attractive to them. By the sucking action of the muscular pharynx and the lips leaves are drawn to the burrow, and over the surface is discharged an alkaline fluid which softens and discolours the leaf-tissue, and appears to effect the partial digestion of both protoplasmic contents and starch granules. The fluid is derived from glandular cells in the skin of the anterior part of the body. Fragments of the softened leaf are sucked off by the worm, there being no teeth, and swallowed.

In passing along the œsophagus the food encounters the secretion from the calciferous glands. In *Lumbricus terrestris* there are two pairs of these glands in addition to a pair of œsophageal pouches; in *Helodrilus* (*Allolobophora*) *longus* the latter alone are present. It is probable that the primary function of these glands is to excrete calcareous matter derived from leaves. It is well known that such matter accumulates in the leaf-tissue and is not withdrawn with other substances when the leaf is detached from the parent tree, but is, as it were, excreted by the plant in the falling leaf. The majority of the leaves devoured by worms are such as have fallen in the natural order of things, and moreover all vegetable mould is very largely the product of decayed leaves. Hence worms are likely to take in a large amount of calcareous matter, and since they form neither shell nor bone there is no outlet for this substance and some special excretory apparatus seems necessary. At the same time it is probable that the calcareous fluid discharged into the œsophagus does play a part in digestion in serving to neutralise more or less the organic acids resulting from decay of vegetable substances in the soil, and thus assists the digestive action of the alkaline fluid which is poured over the leaves, and which continues its action subsequent to the act of swallowing. Nevertheless the contents of the gizzard and intestine are as a rule acid, probably as a result of fermentations occurring in the later stages of digestion. Harrington[1] finds that excess of acid in the food increases the amount of lime produced by the glands.

The crop serves as a temporary storage place in which the digestive processes continue prior to the passage of the food into the gizzard. Here the strong muscular walls and horny lining, aided by small particles of stone that are almost invariably to be found in this cavity, grind and triturate the food so that the contents of the intestine are always in a state of extremely fine division. Miss Greenwood[2] has described retractile cilia upon the epithelium of the intestine, and states that digestion is effected by the secretion of unicellular glands over the whole of the typhlosole and corresponding part of the intestine. The typhlosole, which forms so conspicuous a fold along the dorsal wall of the anterior portion of the intestine, is a contrivance for increasing the area of the internal absorbing surface without increasing the external bulk of the tube. The cylindrical body of a worm does not permit of enlarging the absorptive surface by augmenting the length of the intestine and throwing it into loops—an arrangement found in the convoluted intestines of most vertebrate

[1] *Journ. Morph.* vol. xv. suppl. 1900.
[2] *Journ. Physiol.* vol. XIII.

animals. A somewhat similar typhlosole is found in the intestine of fresh-water Mussels, though here it is accompanied by a few convolutions.

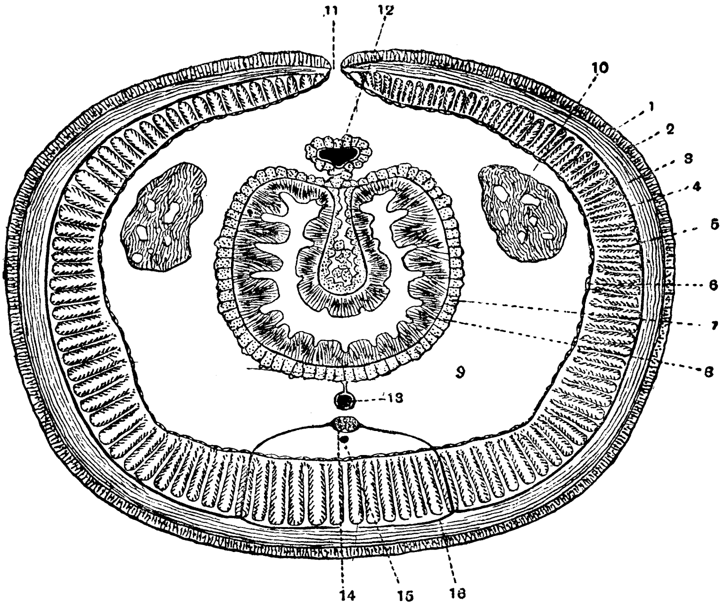

Fig. 3. Transverse section through *Lumbricus terrestris* in the region of the intestine, and of a dorsal pore. Magnified.

1. Cuticle. 2. Ectoderm or epidermis. 3. Circular muscles. 4. Dorsal nerve. 5. Longitudinal muscles. 6. Somatic epithelium. 7. Splanchnic epithelium or yellow cells. 8. Epithelium lining the intestine. 9. Cœlom. 10. Nephridium cut in section. 11. Dorsal pore. 12. Dorsal blood vessel lying along the typhlosole or the groove in the wall of the intestine. 13. Subintestinal blood vessel. 14. Ventral nerve cord. 15. Subneural blood vessel. 16. Ventral nerve.

The dorsal and ventral nerves are added diagrammatically. The other structures are drawn from nature.

The spiral valve that occurs in the intestine of the

Dogfish, and other Elasmobranch fishes, and the somewhat similar structure in the intestine of the medicinal leech and again the radial "mesenteries" of Sea-anemones and their allies are mechanisms adapted to securing the same end as the typhlosole, viz. that a tube whose internal surface shall greatly exceed its external in superficial extent.

Respiration and Circulation. In the absence of special organs of respiration this function is in the worm performed by the outer surface of the body. In each segment of the body a pair of blood vessels is given off from the subintestinal longitudinal trunk to the body-wall and skin, where the interchange of oxygen and carbon dioxide is effected through the moist surface of the integument. The oxygenated blood is then returned either to the subneural trunk or to the vessels which run in the walls of the anterior portions of the digestive system, the blood being kept in motion by the pairs of contractile "hearts" in segments 6 or 7—11. These hearts run from the longitudinal dorsal vessel round the œsophagus to the subintestinal vessel. Astonishment is sometimes expressed that worms can breathe underground. But the soil is seldom so closely packed that there is not a fair supply of air entangled in the spaces between the particles of earth, and doubtless the aëration of the soil is substantially enhanced by the very burrowing of the worms themselves. At the same time it is noteworthy that their blood is provided with a special vehicle of oxygen —hæmoglobin—not indeed contained in corpuscles as in the blood of vertebrate animals, but dissolved in the liquid itself; and, speaking generally, it is the case that such oxygen-carriers are found either in animals whose bulk is considerable in proportion to their respiratory surfaces, or in animals which though small live in an environment poor in oxygen, *e.g.* *Tubifex* living in mud, and the aquatic larvæ of some species of *Chironomus* (Gnat). It is very probable that the worms so often seen on the surface of the ground after heavy rain have come up to avoid the suffocation to which they assuredly are exposed when the soil becomes saturated and much of the included air expelled by the water. Many worms, however, normally live in very moist places and can withstand prolonged immersion in water. In order to test their powers of endurance in the absence of oxygen I placed one worm in a flask full of water that had been boiled to expel all gases and then allowed to cool in an atmosphere of carbon dioxide: in 3 minutes the worm was asphyxiated and to all appearance dead. A second worm was placed in ordinary tap-water that had not been boiled and though it made strenuous efforts to get out it was still alive and vigorous after $1\frac{1}{2}$ hours' immersion; on transferring it to the other flask it too in a couple of minutes lay motionless. I then poured off the water and filled the flask with oxygen gas: the second worm recovered in ten minutes, and the first, which had been drowned for nearly $1\frac{3}{4}$ hours, in about double that time.

Excretion. The chief excretory organs of the body are the nephridia. These are fine, much convoluted tubes, opening internally by ciliated funnel-shaped mouths into the body-cavity and externally on the ventral surface.