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XXIV.—*On a Bifid Earthworm* (*Lumbricus terrestris*). By
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[Plate X.]

THE *Lumbricus* described below belongs to Mr. Thomson Blackford, and was handed to me by Professor M'Intosh, to whom it had been courteously sent by Dr. Fulton, Superintendent of Scientific Investigations of the Fishery Board for Scotland.

The specimen is an earthworm in which the posterior half of the body is double. Each of the posterior portions has an anus. The recorded cases of bifurcation in the species of *Lumbricus* are few in number; and while that abnormality has been noticed not unfrequently in Polychæta, still comparatively few have been described. Professor E. A. Andrews, of Baltimore, U.S.A., published a list of the references made by different authors to bifurcation in Annelids in 'Nature,' vol. xlvii. no. 1214, Feb. 2nd, 1893. Mr. Robertson, of Oxford, gave the following description of a double earthworm in the 'Quarterly Microscopical Journal,' vol. vii. 1867:—

"The rings of the body presented the usual appearance from the first to the eighty-fifth, where the body divided into two symmetrical halves, each of which presented the usual appearance of the terminal part of an ordinary worm [Pl. X. figs. 8 and 9]. Each of these lateral appendages commenced

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by distinct and separate rings applied to the eighty-fifth [in this respect it differs from the earthworm which is the subject of this article], and not by its bifurcation into two parts. A small triangular membranous space was thus left on the dorsal and ventral surfaces, between the junction of the three rings. It was found that the large vessels, the digestive tract, and nerve-cord divided at the eighty-fifth ring, and were symmetrically arranged in each of the lateral appendages. The generative organs were fully developed and quite normal."

Two abnormal earthworms are recorded by Professor F. Jeffrey Bell in the *Ann. & Mag. Nat. Hist.* 1885, vol. xvi. pp. 475-477. "In the first specimen the left hind branch was shorter than the right. Though the left branch looked like a bud it was not really so, since as time wore on the difference in size increased, and the left then was not only much the smaller, but also much the less active. There were at first no signs of a clitellum, but after two months there were apparent indications of a clitellum. A short time after that date it lost its tails, and soon after was found dead.

"1. It makes it quite certain that, like lizards with their tails, earthworms may reproduce bilaterally what is ordinarily only produced terminally. But this is only another way of saying that earthworms are subject to a well-known and widely diffused law.

"2. The fact that the clitellum only became apparent a few days before the loss of the hinder end is positive; but the events may or may not have any relation to one another. If they have, they only show that when the earthworm is reproducing parts of its body it is, *pro tanto*, comparable to a form reproducing itself asexually, a phenomenon which, so high in the scale of organization, is, we know, not compatible or contemporaneous with sexual reproduction.

"The second specimen belonged to the species *Lumbricus foetidus*, and was dead when examined."

In 'The American Naturalist,' vol. xxvi. no. 309, 1892, a paper on "Bifurcated Annelids," by Professor Andrews, appeared. Prof. Andrews gives five instances of this abnormality in the species *Lumbricus terrestris*. Two of these are the specimens described by Robertson and Bell, the remaining three having been recorded by Dr. Horst, Asa Fitch, and Dwight Marsh. Prof. Andrews in this article says:—"Horst, in experimenting upon regeneration of lost parts in earthworms, found one, 100 millim. long, with two tails, each 25 millim. long and quite normally formed. This was alive when observed. Asa Fitch records finding in his garden in

New York State a live specimen about 3 inches long with the posterior end divided for nearly one fourth of its length. The appendages were equal, but each only about two thirds the normal thickness of the body anterior to them. Each appendage possessed a functional anus. The left appendage appears as a continuation of the body, three somites serving to form a gradual transition from the thicker trunk to the thinner appendage. The right appendage springs from the gaping suture between the trunk and the first of the three transitional left somites; where the origin of the right branch occurs there is a slight constriction not represented at all upon the left branch. The method of bifurcation seems thus similar to that recorded by Robertson.

"Dwight Marsh records a two-tailed earthworm found in Wisconsin. When alive both tails appear of equal importance, but in alcohol one division is markedly constricted where it joins the body and appears as a mere lateral branch. Each appendage has a branch of the intestine and of the nerve-trunk, as well as functional anus. In alcohol the specimen is only 34 millim. long, the tails each 12 millim."

Andrews further says that he only knows "of about twenty recorded cases of Annelids with bifid ends. The period at which these monstrosities arise is not well known, whether they were formed in the embryo or were formed in the maturer period of the individual's existence. Yet there is little support for the former supposition, while for the latter we have in two cases good evidence and in many others considerable presumption towards this conclusion. Granting for the present that these monstrosities have arisen in late life after the removal of parts of the main axis, or after injuries, we may next inquire how far the two new ends are of equal value, whether the two new parts are equal in origin (as in Robertson's specimen), or whether the one is to be regarded as a subordinate part or lateral outgrowth from the main trunk."

Dr. Cori * describes a bifid *Lumbriculus variegatus* which, in the mode of bifurcation, agrees to some extent with the *Lumbricus* here described. In the *Lumbriculus*, however, each of the three nerve-cords of the trunk—the left, median, and right—gives rise to two nerves which become the corresponding nerves in the two appendages.

The *Lumbricus* described in this article had the posterior portion of the body doubled. The two appendages had

* Sonderabdruck aus 'Lotus,' 1894, Neue Folge, Bd. xiv. p. 1-6, fig. 3.

each an anus, and to all appearances were exactly similar. The trunk and appendages were of nearly equal diameter (Pl. X. fig. 1). Bell does not say whether the specimen described by him had two ani or not. The right-hand appendage was perhaps a shade less in diameter than the left. In this respect this specimen differs from that described by Fitch, in which the posterior appendages were of the same thickness, but of less diameter than the anterior portion. It differs also from that described by Robertson (fig. 8), which appears from his drawing in that respect to agree with Fitch's specimen. When the worm was placed with the dorsum upwards (fig. 1) it was found that the anterior part marked AD, stretching from the prostomium to the fifty-fourth segment, where the bifurcation commenced, was $1\frac{7}{8}$ inch long, the left appendage, DB, $1\frac{3}{8}$ inch long, and the right appendage, D'C, $1\frac{9}{16}$ inch long. In the portion AD there were 54 annuli, in DB 122 annuli, and in D'C 109 annuli. The specimen when examined was in spirit and to some extent contracted. The dorsal line was visible in the anterior portion, in which it could be traced up as far as the nineteenth segment. It ran in a perfectly continuous line down the trunk and the left appendage to the anus (fig. 1). No trace of it could be made out in the right appendage. This is the first important difference between the two appendages, and leads one to suppose that the trunk and the left appendage form the complete worm, and that the right appendage, in which there is no trace of the dorsal line, is the extra portion. Fitch was led to the same conclusion in his specimen.

On examining the junction of the three parts it was seen that the right appendage D'C arose from the right lateral portion of the fifty-fourth segment (fig. 2). The origin of this appendage differs from that of the corresponding one in Robertson's specimen (fig. 8), neither does it occur by the bifurcation of the fifty-fourth segment. At its junction with the fifty-fourth segment the right appendage is constricted. A similar constriction was noticed in the right appendage of Fitch's specimen and also in one of the appendages of the earthworm recorded by Marsh. On dissection it was found that the dorsal blood-vessel was bifurcated, as also were the gut (fig. 3), the supra-neural vessel (fig. 5), and the nerve-cord (fig. 4). The typical double nerve-cord was present in the anterior and both posterior portions. There was no appreciable difference in diameter between the two posterior portions of the dorsal blood-vessel; the intestine in the right appendage was, however, a little less in diameter than that

in the left. The typhlosole was present in both appendages, as well as in the trunk. The gut was empty at the junction, which was the only spot at which it was opened. The double nerve-cord in the right was of less diameter than that in the left appendage. No difference was noticed in the thickness of the two posterior portions of the supra-neural vessel. The constriction that was noticed externally on the right appendage at its junction with the body of the worm was not distinctly made out on the intestine of the same at its junction with the main alimentary tract formed by that of the trunk and left appendage. Two rows of nephridia were made out on each of the appendages, no difference being found between any of them.

The structure of the blood-vessels and gut gave no indication as to which appendage might have been secondarily formed.

As regards the nervous system, there is a normal double cord in the trunk (fig. 4). The left cord (*a*) is continuous with that of the left appendage (*e*), and in a similar manner the right cord (*b*) forms the outer cord of the right appendage (*f*). The inner cords of each appendage (*d* and *e*) are confluent at the bifurcation and have no connexion with the cords of the trunk.

The *vesiculæ seminales*, the only portions of the reproductive organs present, were poorly developed. Three only of these were found, where normally there should be four pairs; one (*vs*₁, fig. 6), which was very small, on the left side of the tenth segment, and one on each side (*vs*₂ and *vs*₃, fig. 6) of the twelfth segment. Of the latter the left-hand one (*vs*₂) was much the larger. The fact that on the right side of the body the *vesiculæ seminales* were practically undeveloped gives ground for the supposition that the right appendage is the result of asexual reproduction. There is an entire absence of any clitellum; in this respect the specimen resembles that described by Bell. Robertson found in the worm described by him that the reproductive organs were well developed and normal. It would thus appear probable that asexual reproduction does not account for *all* cases of bifurcation in earthworms.

The method of bifurcation in this earthworm differs from that in the specimens recorded by Robertson and Fitch. As already mentioned, in Robertson's specimen each of the lateral appendages commenced by distinct and separate rings applied to the eighty-fifth segment. In the worm described by Fitch the right appendage arose from the gaping suture between the trunk and the first of the three transitional left

somites which are interposed between the trunk and its thin connexion. This specimen (Fitch's) differs from the one described here in that in the latter the left appendage is of the same diameter as the trunk, and the right appendage arises from the fifty-fourth segment, not from the suture between two segments. Fitch considered that in his specimen the left appendage was the continuation of the trunk, and this appears to be the case in the *Lumbricus* here described. The right appendage arises from the right side of the fifty-fourth segment (fig. 2). Segment 54 differs very much from the other segments both in shape and size. It is triangular in shape, the base being represented by the right side, where the right appendage joins the segment (fig. 2). The somite is of normal length on the left side, but on the right it has grown antero-posteriorly and is very much longer. The increase in length on the right side has caused the left appendage to be pushed to the left, so that the anterior and left posterior portions are not in the same straight line as they probably ought to be.

At what time in the life of the worm the extra tail was developed it is very difficult to tell. If it originated in the embryo we should expect that the two tails would be similar in every respect. They are not, however, identically equal. The mode of connexion between the trunk and the right appendage differs from that of the trunk and the left appendage. The right-hand appendage, moreover, is constricted at its junction with the anterior portion, while the left is not so. The dorsal line is not present in the right appendage. It is difficult to imagine how such an abnormality could have originated in the embryo. In such a case a division of each of the mesoblasts, neuroblasts, nephridio-blasts, &c. must have been effected. It might appear possible that the two appendages had been formed by a median vertical longitudinal fission of the original worm. The division may be supposed to have extended from the anus forward to about the middle of the body dividing the gut, vessels, &c. equally and passing between the two nerve-cords. But the completeness of every organ in each appendage does not countenance that supposition; but, assuming that such a fission had taken place, it might probably have been going on at the time of the death of the earthworm. In this case there would have been at the fork a mass of embryonic cells, by their division giving rise to the left wall of the gut in the right appendage and the right wall of the gut in the left appendage, and similarly with the blood-vessels, nerves, and body-walls. The outer gut-walls of the two appendages

would in that case be the right and left walls of the original intestine. Two new rows of nephridia would be produced, one on the inner side of each appendage. The secondarily formed organs would probably differ slightly in structure from the corresponding original organs. No difference was noticed between the nephridia of one row and the nephridia of any of the other three rows in the appendages. Again, it would naturally be expected that the appendages would be symmetrically joined to the anterior trunk. This, however, is not the case. Lastly, the dorsal line, which is absent in the right appendage, would probably have been present in both appendages had this been a case of median fission. If the fission were supposed to have taken place a little to one side of the median line greater difficulties would be encountered. This is, then, apparently a case of budding, not of bifurcation. The right-hand appendage is a bud of segment 54, probably formed subsequently to the complete development of the original worm. The original worm is represented by ADB (fig. 1), and the right-hand appendage D'C (fig. 1) is an outgrowth from the right side of the somite and away from the middle line. The growth in diameter of the bud has caused the increase in size of the right side of the somite.

The third view is that the bifurcation may be the result of lateral budding. In many annelids longitudinal budding is common, and in the Syllidæ lateral budding also regularly takes place. These buds give rise to new individuals. It is impossible to tell whether the bud under consideration might have given rise to a new individual, or whether, like the bud described by Bell, it might have been absorbed if the *Lumbricus* had lived. Bell does not mention whether or not the bud was provided with an anus. If it had no anus, the two buds are not comparable. Claparède was of opinion that the budding in a *Serpula* examined by him might have been caused by a lesion, and M'Intosh, in reference to *Syllis ramosa*, considered that budding may take place at any point in consequence of lesion at that point. If it is taken for granted that at one time this earthworm existed in a normal condition, viz. that the anterior trunk and the left appendage made up the normal *Lumbricus*, and that the right appendage was developed some time after, the origin of the right-hand appendage might be explained thus:—Assuming that segment 54 had in some manner been cut or pierced (the wound extending into the interior of the intestine), some of the earth passing through the intestine during the process of alimentation may have been diverted through this opening

by the resistance offered by the earth in the posterior portion of the intestine, that is, the portion of the intestine lying between the opening and the anus. The cells surrounding the wound would become active, and a healing process would be set up. It is probable that the earth would tend to find its way through this opening in preference to passing through the rest of the intestine, and so the wound would not readily be closed. From the continued activity of the cells in the attempt to heal the wound, a process would gradually be formed. The main mass of the earth would probably continue to pass through this opening until the process became almost as long as the portion of the body between the point of lesion and the original anus, that is, until an equal resistance was offered at the fork to the passage of the earth along both branches of the intestine. The quantity of earth would then be equally divided between the two appendages, half of it passing along each. From the fact that the right-hand appendage is the shorter of the two, it might be supposed that a greater proportion of the earth would still pass along it, owing to its offering less resistance; but the greater length of the left appendage is compensated by the fact that its inclination to the trunk is less than the inclination of the new appendage to the same. The new appendage having now much less work to do than previously, the active cells at its posterior end would be enabled to narrow the opening and form an anus.

None of the explanations offered above are really satisfactory. It is probable that this earthworm existed as a normal *Lumbricus*, before the right-hand appendage was developed. The cause of the budding must be left undecided. There is doubtless some connexion between the fact that the reproductive organs are so undeveloped and the presence of the lateral bud. Whether the reproductive organs were from the first undeveloped, and the bud represents an attempt at asexual reproduction, or the reproductive organs atrophied in later life owing to the budding process, can only be a matter for conjecture. An interesting question suggests itself. How did this worm manage to move through the earth? It was alive when dug up. It would have no difficulty in moving about on the surface, but it certainly could not have readily burrowed in the ground. It therefore probably lived on the surface or amongst soft soil and decaying vegetable-matter close to the surface.

My best thanks are due to Professor M'Intosh, Dr. Fulton of Edinburgh, and Mr. A. T. Masterman, B.A. Cantab., University of St. Andrews, for valuable assistance and advice.

EXPLANATION OF PLATE X.

- Fig. 1.* Bifid earthworm, natural size, in spirit.
Fig. 2. Enlarged drawing of segments 54 &c., showing the bifurcation.
Fig. 3 shows the bifid condition of the dorsal vessel and gut.
Fig. 4. Drawing showing the relation of the nerve-cords in the two appendages and anterior trunk to each other.
Fig. 5. Bifid supraneural vessel lying above the nerve-cords.
Fig. 6. Drawing showing position of the vesiculæ seminales.
Fig. 7 shows bifid nature of dorsal vessel, gut, supraneural vessel, and nerve-cord. The gut has been drawn to one side to expose the nerve-cord.
Figs. 8 & 9. Copies of Robertson's drawings of earthworm described by him.

Explanation of letters used.

<i>a.</i> Left nerve-cord in anterior trunk.	<i>at.</i> Anterior trunk.
<i>b.</i> Right nerve-cord in anterior trunk.	<i>dv.</i> Dorsal vessel.
<i>c.</i> Left nerve-cord in left appendage.	<i>g.</i> Gut.
<i>d.</i> Right nerve-cord in left appendage.	<i>h.</i> Heart.
<i>e.</i> Left nerve-cord in right appendage.	<i>la.</i> Left appendage.
<i>f.</i> Right nerve-cord in right appendage.	<i>nc.</i> Nerve-cord.
	<i>ra.</i> Right appendage.
	<i>s.</i> Septum.
	<i>sn.</i> Supraneural vessel.
	<i>vs.</i> Vesicula seminalis.

XXV.—*Natural History Notes from H.M. Indian Marine Survey Steamer 'Investigator,' Commander R. F. Hoskyn, R.N., commanding.*—Series II., No. 1. *On the Results of Deep-sea Dredging during the Season 1890-91 (continued).* By A. ALCOCK, M.B., Surgeon-Captain I.M.S., Superintendent of the Indian Museum.

[Continued from vol. xi. p. 172.]

OF the species to be described in the sequel some have already been figured in the "Illustrations of the Zoology of H.M. I.M.S. 'Investigator,' Crustaceans," part i., published in 1892, and some in part ii. of the same publication, which I hope will be issued early this year. All the new species not yet figured will, I hope, appear in part iii. of the 'Illustrations,' which is now in preparation and may be expected early next year (1895).