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SEGMENTATION IN EARTHWORMS, RESULTING FROM INABILITY TO REGENERATE A PORTION OF THE VENTRAL NERVE CORD

F. L. FITZPATRICK AND S. L. STOLBA

The first of the two following experiments was performed in 1927-1928. Thirty-five sexually mature earthworms (*Lumbricidae*) were put under the influence of ether. Anesthesia was resorted to so that the subjects would remain inactive during the subsequent operation. A tiny incision was made in the ventral body wall of each specimen, at a point just posterior to the clitellum. The ventral nerve cord was then severed with a fine pointed scissors. It will be noticed that the place of operation was posterior to the more important organs of the body. It was selected as such for the foregoing reason and also because the clitellum furnished the only available spot that might readily be identified at or after the time of operation.

After the operation the worms were placed in boxes of dirt, five worms in each container. The organic content of the dirt was renewed from time to time by the addition of leaf mould. The dirt was watered daily. The worms were removed for examination each day or every other day until the conclusion of the experiment. The incisions in the body walls healed within a few hours in all cases in which infections did not occur. A number of the subjects became infected and died, or died from other causes. Evidently the causes of death were attributable to the operations because thirty-five controls kept under circumstances as nearly identical as possible suffered no mortalities. Of the worms upon which the operation was performed, all thirty-five were surviving the fourth day after the operation, on the fifth day there were thirty-four survivors, on the sixth day thirty-three, on the seventh day thirty-one, on the seventeenth day thirty, on the thirtieth day twenty-eight, and on the sixtieth day twenty-five.

Until about three weeks subsequent to the time of operation most of the surviving subjects showed a pronounced lack of physiological dominance on the part of the anterior end of the body over the posterior end of the body. When the worms were stimulated

at the anterior end this end would frequently move off in one direction while the posterior end remained inactive. Or the posterior end might be stimulated and aroused to activity without any reaction on the part of the anterior end. Or when both ends were stimulated they might move off in different directions. There is nothing remarkable or surprising in these findings, they are approximately what we would expect under the circumstances. Obviously, during the period referred to, the cut ends of the nerve cords had not succeeded in establishing connections with each other or the regeneration had been only partial.

After about three weeks, however, the anterior ends began to recover their physiological dominance over the posterior ends and when the worms were stimulated they reacted in a manner approaching the normal. This seemed to indicate that after a three week period the nerve fibers of the ventral cords of the surviving subjects had re-established antero-posterior communication. This matter was investigated by making serial sections of the regions involved in several subjects. The serial sections seemed to indicate that the severed ends of the nerve cords had reunited.

The same experiment was repeated in 1928-1929 on a group of forty earthworms, with the exception that an entire segment (one to two millimeters in length) of the nerve cord was removed. In the first experiment the cut ends of the nerve cord were not separated; in this latter experiment, therefore, the physical obstacles to regeneration were much greater.

The worms were handled in two groups of twenty each. The rate of mortality in the first group was very high. On the second day there were nineteen survivors, on the fourth day fourteen, on the ninth day nine, on the fourteenth day six, on the forty-ninth day four, and on the one hundred and twentieth day only one survived. The mortality was probably due to injury sustained during the operation, and to the subsequent spread of infection. Segmentation at the point of operation occurred in three cases; in each case the posterior half died eventually while the anterior half lived.

Of the second twenty worms all were alive on the fifteenth day, on the sixteenth day there were nineteen survivors, on the thirty-fifth day eighteen, and at the conclusion of the experiment seventeen were still alive. The rate of segmentation was much higher than in the first group. On the second day two worms segmented, on the sixteenth day four segmented, and on the twenty-first,

thirty-fifth and forty-second days one each, on the sixty-seventh day two; so that at the end of the experiment fifteen worms out of the original twenty had segmented. All of these segmentations occurred in the middle of the body at the point where the nerve cord had been severed. Three of the worms also sloughed-off some ten segments at the posterior ends of their bodies.

All of the evidence in this experiment would seem to indicate that in the worms which did not segment the nerve cord had grown together or regenerated. When the nerve cord was unable to regenerate it seems that the continued loss of physiological dominance on the part of the anterior end over the posterior end furnished the stimulus which resulted in segmentation.

It might be noted, incidentally, that a good demonstration or laboratory experiment on physiological dominance may be provided by treating earthworms in the manner described above. This is particularly effective when the worms whose nerve cords have been severed are compared with normal specimens.

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