

TABLE I.

Fluid injected 25 cc. per kilo	Per cent injected fluid leaving blood in 30 min.	Percentage of fluid leaving blood entering				
		Muscle	Skin	Liver	Intestine	Spleen
*1. Distilled water	97.8	36.0	8.0	12.0	6.0	0.25
2. 0.45% NaCl	96.0	40.0	7.6	23.0	9.6	0.40
3. 0.6% CaCl ₂	93.7	37.8	12.0	25.2	13.2	0.30
4. 0.9% NaCl	58.0	0.0	30.0	19.0	8.0	0.50
5. 1.8% NaCl	46.0	0.0	27.0	Samples lost	10.0	0.20

*1 is average of 10 experiments; 2, of 5; 3, of 5; 4, of 8; 5, of 6.

The table shows that with hypotonic solutions the fluid passes into all tissues; with isotonic solutions, however, little seems to enter muscle. In a few experiments not recorded in the table, stronger solutions of CaCl₂ were injected. It was found the fluid went chiefly into the intestine and the skin, the muscle actually losing fluid.

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Storage of water in various parts of the earthworm at different stages of exsiccation.

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This study was made last December on 12 specimens of *Lumbricus terrestris*, recently obtained from Pennsylvania. When brought into the laboratory, the earthworms were kept 1 or 2 days barely covered with tap water until weight equilibrium was reached. The laboratory temperature during the experiment was nearly constant at 18° to 19° C., the extreme range being 16° to 20°.

Changes in body weight. Eight worms were exposed on dry filter paper, and weighed at frequent intervals. At various stages of exsiccation, they were replaced in tap water, to determine the rate of recovery in body weight. Two of the worms, after losing

42 or 43 per cent of their original weight in 4 or 5 hours, respectively, revived and nearly regained their original weight within 24 hours after replacement in water. The other 6 worms, in which the loss was 50 to 60 per cent after 5 to 9 hours of exsiccation, became stiff and failed to revive upon replacement in water. Nevertheless they absorbed water at about the same rate and to nearly the same extent as the 2 survivors. The dry weights (dried in oven to constant weight at 100° C.) of these 6 worms averaged 11.935 per cent (range 11.21 to 12.67) of the original fresh weight. The normal water content under the conditions stated was therefore about 88 per cent.

The individual weight curves of these 8 worms appear somewhat variable but roughly logarithmic in form, decreasing rapidly at first and then more slowly. The curves are reversed in form upon reabsorption of water, but the process is slower. It is remarkable that within the first 24 hour period, the weight curves showing loss and gain of the survivors do not differ appreciably from those of the worms killed by the more severe exsiccation. Evidently the limit of tolerance (under the conditions stated) for *Lumbricus terrestris* is a loss of somewhere between 43 and 50 per cent of body weight. For another species of earthworm, *Allolobophora chloroticus*, Hall¹ reported survival after loss of 69.6 per cent of the body weight in 105 minutes of exsiccation. Adolph and Adolph² noted in *Lumbricus terrestris* a loss of body weight up to 50 per cent on placing the worms in salt solutions; also smaller variations in weight according to temperature.

Changes in cross-sectional areas. The remaining 4 earthworms (see Table I) at various stages of exsiccation were anesthetized by chloroform vapor, to obtain uniform relaxation. They were then fixed in 10 per cent formalin solution and embedded in celloidin. The shrinkage by this process is relatively slight. Cross sections of the body just behind the clitellum were stained and mounted. The areas of the entire body and of the constituent layers were enlarged by 2 methods: (1) by photography (x 38), and (2) by outline drawings of the enlarged sections projected on paper (x 103). The various layers were then cut out and weighed, and the corresponding areas calculated. The

¹ Hall, F. G., *Biol. Bull.*, 1922, xlii, 31.

² Adolph, E. F., and Adolph, P. E., *J. Exp. Zool.*, 1925, xliii, 105; *Anat. Rec.*, 1925, xxxi, 340.

two methods give similar results, but the latter appears more accurate.

TABLE I.
Body Weights and Cross-sectional Areas.

Earthworm No.	Original body weight	Final body weight	Length of exsiccation	Loss of body weight	Area of body in cross section
	grams	grams	hours	per cent	mm. ²
12	7.023	7.023	0	0	18.99
10	8.853	6.118	2	30.9	15.08
9	6.742	3.775	4	44.0	13.15
11	7.362	3.885	5	47.2	11.81

As shown in Table 1, the areas (reduced to actual size) for the entire cross sections varied from 18.99 mm.² for the normal control (No. 12) to 11.81 mm.² for extreme exsiccation (No. 11), with loss of 47.2 per cent in body weight. Table II shows the percentages of the total cross-sectional area formed by the areas of the various parts in each of the 4 worms. The *epidermis* appears slightly variable, but in the last case forms a slightly higher percentage of the total area than in the normal. This indicates that the loss in actual area (or volume) for the epidermis is in general nearly proportional to that for the whole body, assuming the cross sections to be typical and the shrinkage uniform in all directions. The same is true for both *circular* and *longitudinal muscle*, excepting the last case, in which the percentages indicate that the muscles have lost relatively less, and therefore appear relatively larger in area. The *intestinal wall*, including typhlosole, large blood vessels and ventral nerve cord, shows similar relations. The *celomic cavity*, including the septa and nephridial tubules, and the *intestinal lumen* remain nearly uniform in relative size (with an exceptional increase in the intestinal lumen of No. 9), up to the extreme case. This is somewhat remarkable, since one might expect the water to be lost from the larger cavities more readily than from the smaller tissue spaces. This appears to occur only in the extreme exsiccation (No. 11), in which the two large cavities are reduced to about half their original relative size.

The individual tissue cells of the various layers cannot be measured with accuracy. In general, however, the cells show surprisingly little change in size or structure. The greatest change is in the epidermis cells, which appear slightly shrunken.

Losses in volume of the various layers. In calculating the volumes of the various layers, the cross-sectional areas were multiplied by the body length. This length was obtained by dividing the body weight by the cross-sectional area of the body (assuming the specific gravity as 1). The losses in volume were calculated for the extreme case, No. 11, in comparison with the normal, No. 12. The volumes in No. 12 were assumed to be the initial values for No. 11, making slight correction for the difference in initial body weight. In this case, with a loss of 47.2 per cent in body weight (or volume), the various layers have apparently decreased in volume by the following percentages: epidermis, -41.0; circular muscle, -35.6; longitudinal muscle, -24.9; intestinal wall, -37.8; celomic cavity, -70.9; intestinal lumen, -76.1.

From the data for the volumes, another calculation was made to show what proportion of the total water loss was derived from each of the various layers, in the extreme case (No. 11). On this basis, the percentages contributed by the various layers appear as follows: epidermis, 5.4; circular muscle, 8.3; longitudinal muscle, 14.0; intestinal wall, 16.3; celomic cavity, 31.5; intestinal lumen, 24.5. Thus the two large cavities apparently contribute 56 per cent, and the muscles 22.3 per cent, of the total water loss in extreme exsiccation. These figures would not be correct for the cases of smaller total loss, however, since in the earlier stages of exsiccation the relative losses are more nearly equal in the various layers, as shown in Table II.

TABLE II.
Percentage of total body area made by each part in cross section.

Earth-worm No.	Epidermis	Circular muscle	Longitudinal muscle	Intestinal wall	Celomic cavity	Intestinal lumen
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
12	6.2	11.0	26.4	20.3	20.9	15.2
10	5.3	11.0	27.0	20.2	22.1	14.4
9	4.8	9.7	27.0	17.5	19.5	21.5
11	6.9	13.3	37.5	23.8	11.6	6.9

SUMMARY.

Lumbricus terrestris, under the conditions stated, survived a loss of 43 per cent in body weight during 5 hours of exsiccation, but did not survive longer periods with losses of 50 to 60 per cent. Nevertheless, the curves of body weight during exsiccation and after replacement in water appear similar in all cases (up to

24 hours). Measurements of cross-sectional areas indicate that during exsiccation in the earlier stages the epidermis, body muscles, celomic cavity, intestinal wall and lumen lose roughly in proportion to their size. But in extreme exsiccation a relatively larger proportion is contributed by the celomic cavity and the intestinal lumen. The loss in the tissues appears chiefly from the intercellular spaces, as the cells (excepting the epidermis) show but slight changes in size and structure.