and the variations in muscle mass weight when expressed as a per cent of Wc. We take this to indicate that another factor entering into this "blood" item is the loss of muscle water by evaporation during the course of the 20-25 minutes required to remove the major portion of the muscle mass. The constancy of the "blood" weight is therefore of interest as an index of the repeatability of the dissection procedure.

Results. Each figure in Table I represents the mean of 16 ± 5 independent dissections. In the first column, these data are expressed as a per cent of the total body weight of the intact rat. As indicated above, a more repeatable and usable result can be obtained if tissue weights are expressed as a per cent of Wc (body weight minus the weights of the contents of the gastrointestinal tract and the depot fat) as is done in the second column. In the third column are given the corresponding standard deviations. These help to indicate the magnitude of change in tissue weight resulting from stress conditions that one might expect to detect with confidence by this dissection-chemical method. When tissue weight comparisons are made on a completely fat-free and fat-free dry-weight basis the results seen in columns 4 and 5 are obtained.

Summary. A combined dissection and chemical approach to the problem of determining tissue weights has been described. It allows the exact determination of total muscle mass and supportive tissue weight in a fraction of the time required by the complete dissection approach. It also provides estimates of the total marrow weight and the fresh weight of the connective tissue, which are difficult to obtain in any other manner.

We wish to thank Robert MacDonald, Lee and Kathleen D. Terrill, Malka Goodman, and Paul Finkelstein for their technical assistance with the dissection and analytical work, and Dr. Ellis Benson of the University of Minnesota Hospital for his helpful suggestions concerning the determination of actomyosin. This work was carried out under Contract AT(11-1)-106 between the University of Minnesota and the Atomic Energy Commission.

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Received December 5, 1955. P.S.E.B.M., 1956, v91.

Tissue Weights of the Rat. II. Changes Following 700 r Total Body X-Irradiation. (22187)

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In the first 4-6 days following total body x-irradiation with an LD_{50} dose of x-ray, the rat loses some 15% of its body weight. An exact description of this weight loss in terms of the weight changes of the individual tissues of the body is of considerable importance in providing a basis for any metabolic study of the nature of radiation damage.

Methods. Groups of 300-350 g male white rats (Holtzman Co., Madison, Wis.) were given 700 r of total body x-irradiation (140 kv, ¼ mm Cu, 1 mm Al) and sacrificed at one of a series of periods following irradiation. Unirradiated control animals for each of the different experimental periods were distributed within each group of experimental ani-

TABLE I. Tissue Weights following Total Body X-Irradiation with 700 r (Expressed as a % of Control(1)).

Tissue	Periods post x-ray 3 hr	12 hr	1 day	2 days	3 days	4 days	6 days	8 days	10 days
Muscle	96.7†	94.4†	96.2†	91.3†	88.3†	80.2†	85.3†	85.4†	87.6†
Supportive	99.2	103.1	103.4	113.1†	100.7	113.9†	105.8*	102.4	106.7*
Skin	97.0	97.4	101.4	93.8	86.4	91.1	87.7	94.3	98.2
Liver	101.3	95.8	96.4	90.8	97.2	94.7	94.6	96.1	106.5
Lung	110.8	90.2	101.9	99.4	99.4	112.6	97.0	94.7	97.3
Heart	101.5	105.4	104.8	103.0	97.3	98.8	98.8	97.3	106.6
Kidneys	106.2	104.6	99.0	100.9	86.4	92.1	98.5	94.2	103.3
Testes	99.7	115.0	105.6	108.3	103.1	107.3	88.4	90.2	101.5
Spleen	79.6†	64.2†	57.3†	47.5†	37.4†	36.7†	40.9†	43.1†	60.7†
Brain	103.8	101.6	105.7	107.4*	99.1	106.8*	104.0	97.2	102.1
Stomach	97.1	110.7*	107.5	103.0	106.4	101.1	104.4	86.4†	105.3
Small intestine	98.0	88.7*	83.9†	72.6†	90.1	121.0†	111.2*	86.4*	105.5
Large "	87.4	82.7*	90.0	86.5*	105.1	120.6*	116.0*	97.5	97.8
Thymus	101.8	86.4	42.2†	11.5†	22.2†	22.9†	23.5†	26.7†	43.4†
Depot fat‡	106.7	117.3	95.6	74.2	69.7	75.3	87.7	90.6	89.7
GI contents‡									
Chow	108.1	100.5	108.5	82.8	75.2	67.2	60.1	90.0	103.7
Synthetic	101.4	143.9	101.0	82.2	120.4	79.6	67.5	45.9	80.7

* Significant at 5% level (.05 $\geq$ P $>$ .01).
† " " 1% " (P $\leq$ .01).
‡ See text for discussion of significance.

mals in a manner designed to prevent intergroup variations from introducing a consistent bias into any portion of the data. Both the normal control data and the procedures for determining tissue weights have been discussed previously(1). All tissue weights are expressed as a per cent of Wc, the body weight minus the weights of the gastro-intestinal contents and body fat(1), and the post-irradiation tissue weights are then expressed as a per cent of the corresponding control tissue weights. This method of expressing the data overcomes artifacts resulting from the large changes in gastrointestinal content weights observed in the post-irradiation period(2). The actual calculation can best be demonstrated by using an example. The average control weight of the heart (after the blood had been expressed from the chambers) was 0.332 $\pm$ .030% of Wc(1). The weight of the heart of rat #88 (body wt = 350.2 g pre x-ray and 316.0 g at dissection) at 2 days post x-ray was 1.024 g. The average control body fat and gastrointestinal contents weights were 15.8 and 19.7 g, respectively, for this experiment. Thus, for rat #88, the heart was

$$\frac{1.024 \times 100}{350.2 - 15.8 - 19.7} = 0.325\% \text{ of control Wc.}$$

This figure averaged with similar data from 6 other rats yielded a mean of 0.342% of control Wc, which, as seen in Table I, was 103.0% of the normal control figure and did not differ significantly from it. The data in Table I represent the averages of over 1600 tissue weights from 193 different rats.

Results. The details of the tissue weight loss at each period following total body irradiation are shown in Table I. Each post-irradiation tissue value represents the mean of 7 $\pm$ 2 independent dissections, while the control values are the mean of 16 $\pm$ 5 independent determinations(1). The corresponding total body weights, expressed as a % of the pre-irradiation value, are 98.9, 98.2, 98.6, 92.2, 88.2, 87.0, 87.9, 90.5, and 94.5% respectively for 3 hrs, 12 hrs, and 1, 2, 3, 4, 6, 8, and 10 days following x-irradiation.

The loss of body weight following total body x-irradiation is primarily associated with a loss of muscle mass. The skeletal muscle is the only major tissue in which there is a prompt, progressive, and large loss of weight. The losses in liver and body fat weight are small and delayed. This pattern of loss constitutes a major difference between the weight loss characteristic of radiation and that seen in starvation(2). The tissues to lose the greatest amount of weight, on a relative basis, are the spleen and thymus. The thymus, in fact, comes so close to disappearing at 1 and 2 days following irradiation that its exact dissection and weighing become matters of considerable uncertainty. The total initial weight of both the spleen and thymus is so small, however, that this change has little significance in terms of body weight loss. The changes in the weight of the skin, kidneys and the liver roughly parallel that observed for total body weight. Thus, at each period these tissues represent a nearly constant per cent of the body weight at that time. The gastrointestinal tract shows alternate periods of increase and decrease in weight. The periods of decreased weight correspond roughly with the early and late irradiation death periods.

There are significant increases in the weight of supportive tissue following total body x-irradiation. This is due to the increased hydration of the connective tissue, rather than to any change in the weight of the mineral mass. Complete dissections demonstrated that there was no significant alteration in the ash, dry, or fresh weights of the skeleton or teeth at any of these periods. From the potassium and desoxyribonucleic acid data of Fig. 1, there appears to be a rapid loss of about 30% of the active marrow following x-irradiation. The near equivalence of these two curves indicates that a major part of the skeletal potassium is associated with marrow rather than bone mineral. The other curves in Fig. 1 show the increase in iron porphyrin content and then fat, associated with this destruction of marrow.

The weight of body fat(1) decreases significantly after the 2nd or 3rd day following irradiation. However, most of the body tissues, when carefully dissected, show no significant decrease in their fat content at any time, and marrow (Fig. 1) shows an increase. Thus, this decrease is confined to and characteristic of gross depot fat. The figures in Table I for body fat and gastrointestinal contents represent the means of several experiments which differed considerably in absolute terms. The same relative changes were present and statistically significant in each case,

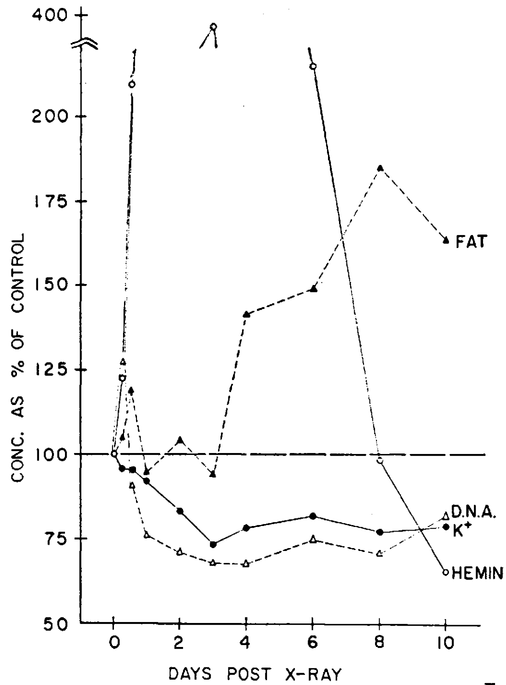

FIG. 1. Changes in composition of skeleton following total body x-irradiation.

however.

Three-hour weight loss. During the process of irradiation the rats were confined, 4 at a time, to a Lucite box whose surface was perforated with 1 cm holes for ventilation. We routinely found a loss of 7.4 $\pm$ 4.7 g of body weight during the 0.5-.8 hr required for the irradiation. The question naturally arises as to whether or not this weight loss is attributable to the irradiation or is a result of the manner in which the animals are handled.

The pertinent data are shown in Fig. 2. Here the per cent weight loss observed under each of 4 different sets of experimental conditions is plotted against time in hours. There was no significant difference between the weight losses observed in the groups of rats that were: (a) confined to the Lucite box for 2 hrs without food and water, (b) left in their cages without food and water for 2 hrs, and (c) sham irradiated, *i.e.*, placed in a carrying cage, transported to the x-ray room, placed into the Lucite box for ¾ hr, and returned to the animal room. The weight loss of the irradiated group was significantly (P = .05)

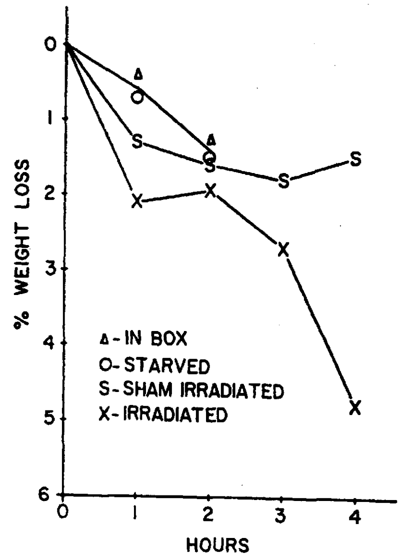

FIG. 2. Loss of body wt resulting from x-irradiation and from 3 control procedures.

greater than that observed for the sham-irradiated group during the first hour. During the next hour the animals were returned to their cages and they ingested some food and water. There was a slight weight gain, but this was promptly reversed, and after 3 hrs the weight of the irradiated group became progressively lower while the sham-irradiated animals recovered lost weight. As seen in Table I, much of the weight loss of the irradiated animal, even at this early period, can be explained in terms of a loss of muscle mass.

Summary. The weight changes observed in 15 tissues at 9 different periods following total body irradiation with an LD_{50} dose (700 r) of x-ray have been described and statistically evaluated. The loss of muscle mass explains the major portion of the body weight loss which is seen in the rat during the first 4-6 days following irradiation. Though the percentage weight loss was greater in spleen, thymus and marrow, these tissues are too small to have an appreciable effect upon total body weight change.

The authors wish to thank Judith Poncelet and Ada B. Simon for their technical assistance, and Drs. K. W. Stenstrom and J. F. Marvin of the Department of Radiology for x-irradiating the rats used in this study. This work was carried out under Contract AT(11-1)-106 between the University of Minnesota and the Atomic Energy Commission.

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Received December 5, 1955. P.S.E.B.M., 1956, v91.

Vit. B_{12} Distribution, Determined by Surface Body Counting Following Parenteral Administration of Co^{60} Vit. B_{12}.* (22188)

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In a preliminary report it was stated(1) that following intramuscular injection of 1 μg of Co^{60} vit. B_{12} maximal radioactivity was detected over the liver, spleen and left kidney, in the order named. Activity persisted over the hepatic area during periods of observation in all cases, and ranged up to 315 days. More recently, Glass and his co-workers reported studies in subjects who received Co^{60} vit. B_{12} parenterally(2). Their results showed essentially the same pattern of distribution as those previously described from our laboratory.

The present report is a detailed description of our findings on a large group of patients, and a comparison of these results with 6 persons receiving Co^{60} Cl_2.

Materials and methods. The first batch of Co^{60} vit. B_{12} had a specific activity of 0.240

* Co^{60} Vit. B_{12} and Co^{60} Cl_2 were supplied by Merck and Co., Rahway, N. J.