

6. Wetterdal, B., *Acta Radiol.*, 1958, suppl. 156.
7. Gunn, S. A., Gould, T. C., Anderson, W. A. D., *Arch. Path.*, 1963, v75, 21.
8. Millar, M. J., Elcoate, P. V., Fischer, M. I., Mawson, C. A., *Canad. J. Biochem. Physiol.*, 1960, v38, 1457.
9. Vallee, B. L., *Physiol. Rev.*, 1959, v39, 443.
10. Rosenfeld, I., Beath, O. A., *Selenium. Geo-* botany, *Biochemistry, Toxicity and Nutrition*, Academic Press Inc., New York, 1964.
11. ———, *Proc. Soc. Exp. Biol. and Med.*, 1954, v87, 295.
12. Ganther, H. E., *World Rev. Nutrition & Diets*, 1965, v5, 338.

Received January 13, 1967. P.S.E.B.M., 1967, v124.

Electrolyte and Water Composition of Renal Tissue in Common Laboratory Animals.* (31982)

L. J. CIZEK AND M. R. NOCENTI

Department of Physiology, College of Physicians and Surgeons, Columbia University, New York City

While studying rabbit renal tissue slices under a variety of conditions(1), it was observed that the medulla consistently had a significantly higher water content than the cortex. Although no published comment pertaining to this difference can be found, it would appear from data scattered in the literature(2,3,4,5,6,7) that this difference is a very frequent, if not constant, finding. In order to substantiate this impression, the water and electrolyte contents of renal tissue were determined in several mammalian species. In addition, studies were made to ascertain what changes, if any, occurred in renal tissue water content during alterations in body hydration.

Methods. Renal tissue from the following species was used: male dogs, cats, rats (Sherman), rabbits (New Zealand) and male and female guinea pigs (English). Each group consisted of 3 normal adult animals. To study altered hydration, adult male rats were placed in the following groups: (1) normal control, (2) water deprived for 5 days (food *ad libitum*) and (3) hydrated with 5 ml water per 100 g body weight by gavage. In the latter group, the kidneys were removed 1 and 2 hours following the gavage; the fraction of the water load which had been excreted at these times was 55 and 72%, respectively.

The dogs, cats and rabbits were sacrificed

with an overdose of intravenous Nembutal, and the rats and guinea pigs by an overdose of ether. Both kidneys were quickly removed, stripped of their capsule, and each sliced longitudinally to obtain a median sagittal section. From this section, a small sample was obtained from the cortical area and from the apical papilla. The sample was placed in a weighed 10 ml volumetric flask, and the wet weight obtained. The samples were dried to constant weight at 100°C. The dried tissues were prepared for electrolyte analyses according to the method of Malvin and Wilde (8).

Results. In all species studied, the water content and the sodium concentration, expressed both as milliequivalents per gram of dry weight or of tissue water were significantly ($p < .01$) higher in the medulla than in the cortex (Table I). The medullary potassium concentration on a dry weight basis was significantly increased in the rabbit and rat. When expressed in terms of the tissue water, potassium concentration was decreased only in the cat and rabbit (Table I).

Regardless of the state of hydration, the medullary water content in the rat was significantly higher than that of the cortex (Table II). While a 5-day water deprivation period caused a reduction in the water content of both the cortex and medulla, the percentage of water in the medulla remained significantly greater than in the cortex.

Discussion. The present experiments dem-

* This investigation was supported by National Science Foundation Research Grant GB-780.

TABLE I. Water and Electrolyte Content of Renal Tissue Slices.*

Species	Sample size (mg)	Water (%)	Sodium		Potassium	
			mEq/g dry wt	mEq/g water	mEq/g dry wt	mEq/g water
Cortex:						
Male dogs	185 ± 24	77.1 ± .2	.264 ± .006	.079 ± .002	.240 ± .021	.071 ± .002
Male cats	169 ± 13	72.4 ± .5	.168 ± .010	.070 ± .002	.266 ± .008	.097 ± .003
Male rabbits	148 ± 19	77.1 ± .5	.268 ± .003	.078 ± .002	.303 ± .005	.089 ± .002
Male rats	62 ± 6	76.8 ± .3	.283 ± .015	.087 ± .005	.358 ± .021	.105 ± .008
Male g. pigs	56 ± 1	78.3 ± 1.5	.299 ± .021	.083 ± .006	.380 ± .014	.105 ± .004
Female g. pigs	63 ± 7	77.3 ± .6	.283 ± .008	.084 ± .005	.349 ± .020	.096 ± .013
Medulla:						
Male dogs	105 ± 13	83.1 ± 1.0†	1.253 ± .052†	.259 ± .027†	.270 ± .008	.056 ± .005
Male cats	84 ± 7	80.7 ± 1.1†	1.188 ± .041†	.290 ± .026†	.288 ± .013	.066 ± .004†
Male rabbits	109 ± 8	85.4 ± 1.0†	1.091 ± .083†	.182 ± .001†	.446 ± .028†	.074 ± .003†
Male rats	24 ± 2	82.9 ± .4†	.833 ± .082†	.169 ± .019†	.527 ± .040†	.104 ± .005
Male g. pigs	33 ± 0	83.0 ± 1.2†	.864 ± .104†	.176 ± .023†	.533 ± .067	.105 ± .009
Female g. pigs	38 ± 4	84.3 ± 1.5†	1.000 ± .064†	.187 ± .022†	.540 ± .073	.103 ± .011

* Each value is the mean of 6 samples ± standard error.

† p < .01.

TABLE II. Water Content of Rat Renal Tissue.

	Normal (%)	Dehydrated (%)	Hydrated (\bar{p} 2 hr) (%)	Hydrated (\bar{p} 1 hr) (%)
Cortex	76.7 ± .4	73.2 ± .4†	76.0 ± .1	77.5 ± .8
Medulla	84.6 ± .9*	81.9 ± 1.0*†	86.5 ± 1.5*	87.6 ± .9*‡

Each value is the mean of 6 samples ± standard error.

* p < .01 when compared with cortex of same group.

† p < .01; ‡ p < .05 when compared with same tissue of the normal group.

onstrate that the renal medulla consistently has a higher water content than the cortex in all of the common laboratory animals examined. Furthermore, it would appear that this relationship is sustained through varying states of body hydration. Inspection of data in the literature reveals that this relationship is also maintained under such differing conditions as reduced glomerular filtration rate, alterations in protein intake, altered hydration, elevated calcium plasma levels and potassium deficiency(2,3,4,7,9). Except for variations resulting from obvious differences in fat content, it is generally assumed that the water content of tissues is fairly uniform. It is therefore quite surprising that the considerable difference in water content between the renal cortex and medulla has not been previously commented upon. Only in one instance have we found a statement to the effect that the water content increased in the medulla(7).

Why there should be such a large variation in water content within the same organ, and

what is its physiological significance is unknown. It is well known that kidneys of most species show an increasing medullary sodium concentration gradient, while the medullary potassium concentrations in general remain unchanged from those found in the cortex. Although the electrolyte content of tissues is usually expressed as mEq/g tissue water, the presence of additional water in the medulla implies that the quantities of electrolyte in this area are even greater than ordinarily believed. Thus, when expressed in terms of dry weight, not only sodium, but in most instances, potassium is considerably increased. If potassium is essentially intracellular(10) and if we assume the potassium concentration of all cells to be essentially the same, then it might be reasoned that the additional water found in this region must be almost entirely intracellular. However, there is evidence(11) that the potassium concentration is high in all of the papillary fluids (loops of Henle, vasa recta plasma and collecting ducts). Unless excessively high, such extracellular potas-

sium in the presence of an overall normal medullary potassium concentration would indicate that a good portion of the "extra" water of the medulla could be located outside of cells. However, additional studies, both histological and microchemical, including the determination of the magnitude of papillary fluid concentrations, are necessary before the phenomenon of the renal water content difference can be resolved.

The authors express their gratitude to Mrs. A. Muda and Mr. J. Hegmann for technical assistance.

1. Nocenti, M. R., Cizek, L. J., Proc. Soc. Exp. Biol. & Med., 1967, v124, 767.

2. Levinsky, N. G., Davidson, D. G., Berliner, R. W., J. Clin. Invest., 1959, v38, 730.

3. Manitiuss, A., Levitin, H., Beck, D., Epstein,

F. H., *ibid.*, 1960, v39, 684.

4. ———, *ibid.*, 1960, v39, 693.

5. Levitin, H. Goodman, A., Pigeon, G., Epstein, F. H., *ibid.*, 1962, v41, 1145.

6. Kessler, E., Allen, R. L., Kirman, D., Strauss, H., Am. J. Physiol., 1964, v207, 109.

7. Ruiz-Guñazú, A. Arrizurieta, E. E., Yelinek, L., *ibid.*, 1964, v206, 725.

8. Malvin, R. L., Wilde, W. S., *ibid.*, 1959, v197, 177.

9. Levinsky, N. G., Berliner, R. W., J. Clin. Invest., 1959, v38, 741.

10. Moore, F. D., Olesen, K. H., McMurrey, J. D., Parker, H. V., Ball, M. R., Boyden, C. M., The Body Cell Mass and its Supporting Environment, W. B. Saunders Co., Philadelphia, 1963.

11. Berliner, R. W., personal communication.

Received January 18, 1967. P.S.E.B.M., 1967, v124.

Yellow Bone Marrow as Adipose Tissue. (31983)

ELIAHOU ZAKARIA AND ELEAZAR SHAFRIR

Department of Biochemistry, Hebrew University — Hadassah Medical School and Hadassah University Hospital, Jerusalem, Israel

The yellow variety of bone marrow (YBM) resembles in composition the homologous adipose tissue of other body sites. Marrow fat reflects the fatty acid composition of the diet, is prone to loss on fasting and its respiratory quotient indicates mainly fat oxidation(1). Experiments reported here were aimed to demonstrate that YBM is capable of metabolic responses characteristic of adipose tissue.

Materials and methods. Adipose tissues were obtained from *ad libitum* fed male guinea pigs weighing 500 to 700 g and male albino rats weighing about 200 g, anesthetized by intraperitoneal injection of sodium pentothal. The tibiae of the guinea pigs were exposed and opened by longitudinal incision. The YBM section, appearing as a yellowish solid cylinder, was carefully lifted out, weighed and incubated in a metabolic shaker at 37°C, as specified in the Tables. To compare the metabolic responses of the YBM with those of other adipose tissues, pieces of epididymal fat pad of similar weight (30 to 40 mg) were also cut out from the guinea pig

and from the rat. After incubation, the tissues were rinsed thoroughly in 0.9% NaCl and in 1% bovine albumin solution and extracted by grinding in Dole's heptane-isopropanol mixture(2). Separation of triglyceride (TG) and free fatty acid (FFA) components, hydrolysis of TG and titrations of FFA were done by previously applied methods(3,4), which were scaled down to fit the small amounts of tissue and medium. Radiochemicals were purchased from Amersham (Great Britain) and radioactivity was measured in a Packard Tri-Carb Scintillation Spectrometer. Fat content was estimated gravimetrically after evaporation of a washed chloroform-methanol extract of the tissue, prepared according to Folch *et al*(5). DNA and protein contents in the delipidated tissue residues were determined by the methods of Schneider(6) and Lowry *et al*(7).

Results. Table I shows the conversion of U-¹⁴C-glucose to CO₂ and TG in guinea pig tissues as compared with epididymal adipose tissue of the rat. The guinea pig YBM showed uptake and distribution of glucose radioactivity similar to the homologous epididymal