

Cardiac Glycogen in Diabetic Animals.

GERALD EVANS AND MORRIS A. BOWIE. (Introduced by C. N. H. Long.)

From the George S. Cox Medical Research Institute, University of Pennsylvania.

It has been shown previously¹ that cardiac glycogen is well maintained during fasting, exercise and epinephrine administration, in all of which liver and skeletal muscle glycogen is lowered. The present report gives the results of an examination of glycogen in the hearts of diabetic animals. In the literature there is evidence that cardiac glycogen is raised both in depancreatized animals^{2, 3, 4, 5} and in phloridzinized animals.^{6, 7, 8} However, in view of the wide range of values recorded and in view of the strict necessity for the avoidance of anoxemia in obtaining satisfactory values for cardiac glycogen,¹ it was considered not out of place to repeat the observations, particularly since the point is of importance to further work.

Depancreatized Cats. Three cats were depancreatized and maintained on insulin for from one to 2 weeks; food and insulin were then withdrawn, and after allowing 48 hours for the development of marked glycosuria, the animals were anesthetized with nembutal, artificial respiration established, and the chest and pericardium opened; the hearts were then secured by one rapid cut, immediately immersed in a roughly equivalent volume of cold 30% KOH and rapidly cut into approximately one-gram pieces. To obtain the weight of the sample, the vessel containing the KOH together with the scissors used in cutting the immersed heart was originally tared, and the whole reweighed after addition of the heart. After weighing, digestion was carried on for an hour on the steam bath and the analysis completed as previously described.¹ As controls, 3 hearts were similarly obtained from similarly fasted intact cats.

The values obtained for the 3 control hearts were 507, 410, 510 mg./100 gm., average 476 mg./100 gm.; those for the hearts of diabetic animals were 1345, 981, and 1496 mg./100 gm., average

¹ Evans, G., *J. Physiol.*, 1934, **82**, 468.

² Cruickshank, E. W. H., *J. Physiol.*, 1913, **47**, 1.

³ Fisher, N. F., and Lackey, R. W., *Am. J. Physiol.*, 1925, **72**, 43.

⁴ Cruickshank, E. W. H., and Shrivastava, D. L., *J. Physiol.*, 1930, **92**, 144.

⁵ Chambers, W. H., and Kennard, M. A., Pollack, H., and Dann, M., *J. Biol. Chem.*, 1932, **97**, 525.

⁶ Junkersdorf, P., *Arch. f. d. ges. Physiol.*, 1923, **200**, 443.

⁷ Geiger, E., and Schmidt, E., *Arch. f. exp. Path. u. Pharmacol.*, 1928, **134**, 173.

⁸ Lawrence, R. D., and McCance, R. A., *Biochem. J.*, 1931, **25**, 570.

TABLE I.
Effect of Phloridzin and Epinephrine on Cardiac Glycogen of Albino Rats.

Experiment	No. of Animals	Glycogen, mg./100 gm.		Blood glucose mg./100 cc.
		Heart	Gastrocnemius Liver	
Controls—24 hr. fasted. No phloridzin	16	542 ± 19	561	84
Phloridzin—24 hr. fasted	4	481	323	66
" " " "	4	538	367	57
" " " "	13	498 ± 24	291	55
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and 3 hr. after .02 mg./100 gm. epinephrine subcutaneously	4	539	111	71
As preceding except .04 mg./100 gm. epinephrine	4	528	105	64

1253 mg./100 gm. The difference was so clear cut that it was not thought necessary to enlarge the series.

Phloridzinized Rats. Albino rats of 150-200 gm. weight were given subcutaneously 50 mg. of phloridzin daily in 1 cc. of olive oil. Food was removed at the time of the first injection. At the end of the fasting periods noted in the table the animals were anesthetized with nembutal and the gastrocnemius, heart and liver samples taken and analyzed for glycogen as previously described.¹ Glucose was determined in femoral vein blood by the colorimetric copper method of Benedict.⁹ To one group of 8 rats, after 24 hours of phloridzination and fasting, epinephrine was given subcutaneously in the doses noted, and the animals sampled 3 hours later. The dilutions used were 1/50,000 and 1/25,000 and no delay was allowed to occur between the dilution of the stock Parke-Davis Adrenaline and its injection into the animals. The epinephrine was given because Geiger and Schmidt⁷ have reported that it raised cardiac glycogen in phloridzinized rats.

The table shows the results obtained and it appears from them that, although cardiac glycogen is well maintained during phloridzination both with and without an accompanying injection of epinephrine, it is not raised above the control level.

In agreement with the findings recorded in the literature, cardiac glycogen is found to be much increased in depancreatized animals. In disagreement with other recorded findings, cardiac glycogen is found not to be raised as a result of phloridzination either with or without injected epinephrine; a possible explanation is that an apparent increase may have been found as a result of the sluggish hearts of phloridzinized animals not suffering as great a loss of glycogen under brief anoxemic conditions as has been shown to occur with the more active hearts of normal animals.¹

In view of the importance that has been assigned to insulin for glycogen deposition in the muscles of eviscerate preparations,^{10, 11} it is a surprising finding that cardiac glycogen is found to be well raised in the hearts of depancreatized animals, from which insulin is presumed to be absent; a long maintained high blood sugar level is the most obvious factor in favor of the increased deposition. On the other hand, low blood sugar, as in the case of the phloridzinized animals, did not result in a significant lowering of cardiac glyco-

⁹ Benedict, S. R., *J. Biol. Chem.*, 1931, **92**, 141.

¹⁰ Best, C. H., Dale, H. H., Hoet, J. P., and Marks, H. P., *Proc. Roy. Soc. (London)*, 1926, **100B**, 55.

¹¹ Choi, Y. O., *Am. J. Physiol.*, 1928, **88**, 406.

gen, although at the same time there was a marked decrease in the glycogen of skeletal muscle.

These two findings seem to indicate that heart glycogen is under different control than that of skeletal muscle; the alternate conclusion would be that if cardiac and skeletal muscle glycogen are under essentially the same control, then some additional factor not readily recognized when dealing with skeletal muscle is entering more largely in the case of the heart.

Cardiac glycogen is therefore set aside as an interesting subject for study, not only because of the possible importance to the heart itself, but because such an investigation might also bring new light to the views regarding carbohydrate and muscle metabolism generally.

Summary. Cardiac glycogen is found to be raised in depancrea-
tized cats, and to be well maintained in fasting phloridzinized rats,
both with and without an accompanying injection of epinephrine.
Attention is drawn to the importance of these findings to current
views of carbohydrate change in the body.

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Effects of Chilling on Structure and Behavior of Embryos of *Amblystoma punctatum* Cope.

G. E. COGHILL.

Fallsington, Pa.

In my study of the development of the behavior of *Amblystoma* it became imperative to know whether or not eggs or embryos that had been subjected to a low temperature, in order to prolong the experimental season by retarding growth, followed the normal order of development of movements. To meet this requirement I conducted experiments in 1930. Regarding behavior the results were conclusively in the negative, but it seemed desirable to vary the conditions in further experiments before publishing the results, especially in consideration of the numerous and extreme structural defects that appeared in the experimental animals. But inasmuch as I have not been able, and probably shall not be, to repeat the experiments the most obvious results are here presented on account of their bearing on experimental morphology. The work was done in the biological laboratory of the Effingham B. Morris Biological