

mucin. If our previous hypothesis is correct, that the efficiency of glucuronic acid excretion is dependent upon the total amount of glucuronic acid available, then the progressive rise in glucuronic acid excretion during starvation when 10 gm. of mucin is fed indicates that glucuronic acid can be stored during fasting in some form and hence is not oxidized in the body for energy.

The autopsies on these dogs were made by Dr. S. J. Fogelson. With few exceptions all dogs that had excreted a large amount of glucuronic acid, showed a gastritis more marked in the pyloric area than in the fundus, and a marked duodenitis. The gastric mucosa was slimy, indicating that some mucin was still present. In one case, where a female was fasted for 2 weeks, one prepyloric, 2 duodenal ulcers, and multiple ulcers of the pylorus were found. We think that the gastritis and duodenitis result from the interference in the normal mucin metabolism of the mucosa incident to the loss of glucuronic acid. While it is possible that borneol may have an irritating action directly upon the mucosa and produce the gastritis and duodenitis, it seems that the feeding of borneol to dogs for over 100 days, during which time massive doses were fed for 40 days, would produce more ill effects than were noticed. Investigations on Pavlov pouch dogs bear out our conclusion.

Many more animal experiments must be performed before any final conclusions can be formed on the metabolism of glucuronic acid. We submit our findings and our tentative conclusions.

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Glucuronic Acid as a Growth Factor in Guinea Pigs.

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(Introduced by C. J. Farmer.)

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It is generally considered that the animal body can synthesize glucuronic acid either from carbohydrates or from amino acid metabolites. Miller and Conner have reported results previously which indicate that either the rabbit cannot synthesize glucuronic acid or that the rate of synthesis is low. A similar investigation on dogs did not give such definite indications. In comparing the chemical properties of glucuronic acid with the chemical properties of Vitamin

C, we were struck with the close similarity existing between them. Svirbely and Szent-Györgyi¹ have reported evidence indicating that Vitamin C is an hexuronic acid. Glucuronic acid is an hexuronic acid and we decided to compare its biochemical properties with those of Vitamin C, even though Hirst and Reynolds² state that the hexuronic acid isolated by Svirbely and Szent-Györgyi is not glucuronic acid. We were interested also in the importance of glucuronic acid in growth.

If glucuronic acid cannot be synthesized by the growing animal, it would then be an essential carbohydrate acid for growth, for it is a constituent of the glycoproteins in cartilage, connective tissue and mucin. If glucuronic acid can be synthesized by the growing animal, then they should experience no difficulty in growth on a diet deficient in glucuronic acid.

Eighteen guinea pigs weighing 280-320 gm. were fed the basal Vitamin C deficient diet of Sherman, LaMer, and Campbell,³ *ad lib.* Of these, 6 were fed, by dropper, a water solution containing 2 mg. of an equilibrium mixture of glucuronic acid* and its lactone, for 9 days, and thereafter 10 mg. per day. Six were fed $\frac{1}{4}$ gm. of gastric mucin per day, mixed with dry feed, and 6 were kept as controls. The control animals began to lose weight after the second day. The group receiving mucin gained an average of $2\frac{1}{2}$ gm. during a period of 5 days, when they started to lose. The group receiving glucuronic acid gained 12 gm. during a period of 8 days, after which they began to lose weight. By the 14th day, all of the animals had developed symptoms of scurvy. No differences between the groups as to severity were noticeable. The rate of loss of weight of the groups from the 10th to 14th day was practically the same. On the 14th day, each was given 1.7 cc. of orange juice and $\frac{1}{6}$ of a medium-sized orange. The glucuronic acid and mucin groups started to gain weight immediately, but the control group continued to lose weight for another day. One of the control group died on the 14th day and 2 more on the 16th. Autopsy showed symptoms of scurvy. The cortex of the adrenals of the animal that died on the 14th day did not reduce silver nitrate. On the 16th day 1 glucuronic acid pig died.

¹ Svirbely, J. L., and Szent-Györgyi, A., *Nature*, 1931, **129**, 576.

² Hirst, E. L., and Reynolds, R. J. W., *Nature*, 1931, **129**, 576.

³ Sherman, H. C., LaMer, H. L., and Campbell, H. L., *J. Am. Chem. Soc.*, 1922, **44**, 165.

* The glucuronic acid was prepared by the method of Quick, *J. Biol. Chem.*, 1927, **74**, 331.

On the 30th day, the control group were 10 gm. below their original weight whereas the mucin group had gained 7 gm. and the pigs receiving glucuronic acid had gained 36 gm. There were no external symptoms of scurvy. One animal was killed from each group. Autopsy showed slight hemorrhagic areas around the joints. The cortices of the adrenals reduced silver nitrate. Orange juice was removed from the diet with the exception of one pig of the glucuronic acid group. On the 31st day, the weight of the control group reached its original level, but they started to lose weight rapidly. The mucin group started to lose weight slowly on the 32nd day, and the pigs receiving glucuronic acid started to lose weight rapidly on the 34th. Again, mucin and glucuronic acid delayed the onset of scurvy on a Vitamin C deficient diet.

We conclude from our experiments that Vitamin C is not glucuronic acid since it does not protect guinea pigs on a scorbutic diet from developing scurvy nor alter the severity of the condition of scurvy. Our data indicate that the addition of glucuronic acid to the diet we fed was beneficial to the guinea pig, since it postponed the period of loss of weight in the onset of scurvy and facilitated weight recovery when orange juice was added to the diet. Since there are no data in the glucuronic acid content of foods, we do not know how much may be present in the food.

Since the guinea pigs which were fed glucuronic acid gained weight faster than the control group, we consider this as evidence indicating that the guinea pig either cannot synthesize glucuronic acid or that the synthesis proceeds slowly. Also we have observed that the adrenals of a guinea pig which has died as a result of scurvy do not reduce silver nitrate solution.

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Electrical Currents Associated with Sound Reception by the Ear.

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The remarkable phenomenon of the reproduction of voice sounds and musical tones entering the cat's ear, by amplification of electrical currents from the eighth nerve and neighboring structures,