Distribution of Lipids, Lipase and Alkaline Phosphatase in Renal Tubule of the Cat. (21230)

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A number of observers(1-5) have noted that unusually large amounts of lipids are found in the normal kidney tubules of the cat and Modell(3) reported the excretion of fat in the urine. Lipase and alkaline phosphatase have also been observed in the kidneys of various animals, *e.g.* Gomori(6) and Bourne(7). This investigation was undertaken to see if there was any correlation between the presence of these lipids and the distribution of lipase and alkaline phosphatase in the kidneys of young and old cats.

Material and Methods. Kidneys from 24 cats were used in these studies: 10 kittens or half grown cats up to 6 months of age and 34 cm in length from the occipital crest to the base of the tail; 14 adults of unknown ages and with lengths ranging from 37-47 cm. The kidneys were removed and weighed within 20 minutes of the beginning of anaesthesia by chloroform, Model(3,4). The average weight of the kidneys of the younger cats was 4.2 g and of the old cats, 11.2 g. Thin pieces were cut from radial sections of the left kidney. These were fixed in ice cold acetone for the tests for alkaline phosphatase and lipase(6,8, 9) and formal-calcium for the study of lipids (10). Frozen sections were cut for the study of lipids and also for the enzymes. Sudan black B was used generally to color the fats and oil red O and hematoxylin were used for comparison. The unsaturated triglycerides were demonstrated by the presence of rose colored droplets after treatment with Nile blue sulphate(11).

Observations. There was no significant difference in the distribution of lipids as colored by oil soluble dyes between the kidneys of the kittens and half grown cats so observations on them have been grouped under one heading (Table I). The kidneys of older cats were unlike the younger mainly in the increase in

TABLE I. Distribution of Lipids, Lipase and Alkaline Phosphatase in Renal Tubule of the Cat.

	Lipids		Unsaturated triglycerides	Lipase		Alkaline phosphatase
	Young	Older		Young	Older	
Renal corpuscle	——	Small sparse	——	——	——	Variable reaction
Protruded epithelium	Fine drops	Many	Present or not	+	+	Brush border positive
Proximal convoluted *a.*	Fine many	Coarse loaded	Loaded	+	+	*Idem*
Medullary segment *b.* proximal	Coarse more than *a*	"	"	+	+	"
c. terminal	"	Less or absent	Less or absent	+	Less or absent	Reduced
Descending limb	Scanty	Scanty	——	——	——	——
Ascending limb	> desc.	> desc.	——	——	Slight	Positive free surface, first part
Distal convoluted	Scanty	Scanty	——	——	"	——
Collecting duct	Scanty absent in medulla		——	——	——	——

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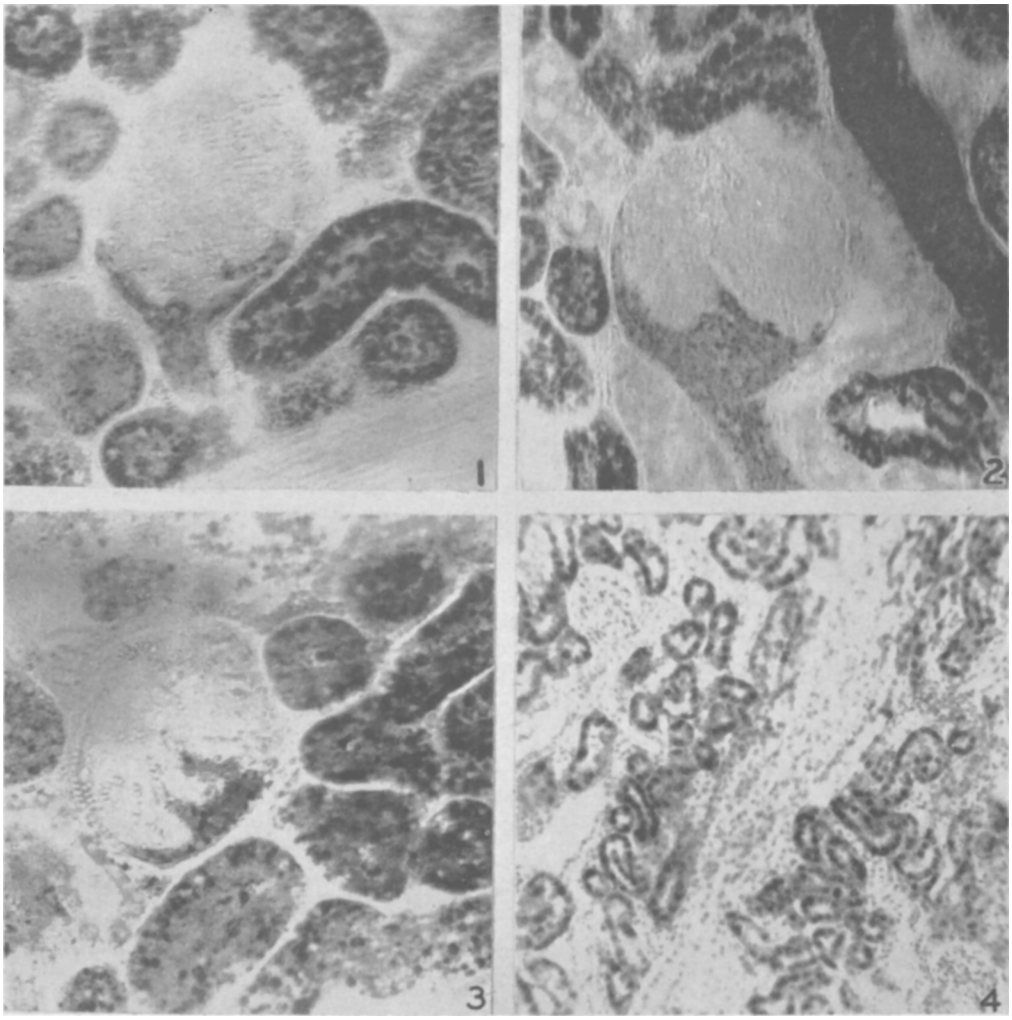

FIG. 1. Lipids; protruded and folded tubular epithelium in lumen of Bowman's capsule; proximal convoluted tubule. Sudan black B. × 250.

FIG. 2. Lipids; protruded tubular epithelium, tangential section; proximal and distal convoluted tubules, ascending limb. Sudan black B. × 250.

FIG. 3. Lipids; protruded epithelium outlining glomerular loops; proximal convoluted tubule, ascending limb. Sudan black B. × 250.

FIG. 4. Lipase; pars convoluta. × 100.

lipids in the proximal convoluted tubule and in the condition of the terminal portion of the medullary segment (Table I).

In 4 of the kidneys of the half grown cats and in all but one of the kidneys of the older cats, there were cells in the lumen of some of the Bowman's capsules characteristic of the proximal convoluted tubule. The folding of the epithelium within the capsular space is seen clearly in Fig. 1. Fig. 2 is a tangential section and Fig. 3 shows the characteristic finger-like processes extending among the glomerular tufts. In all the corpuscles the parietal layer of Bowman's capsule could be distinguished outside of the protruded epithelium, a criterion of Mayer and Ottolenghi(12) for its diagnosis. These protruded cells and the neck epithelium contained lipid droplets but not as many nor as large as in the coiled portion of the tubule (Fig. 1, 2, 3).

A positive reaction for lipase in the proximal convoluted tubules (Fig. 4), their medullary

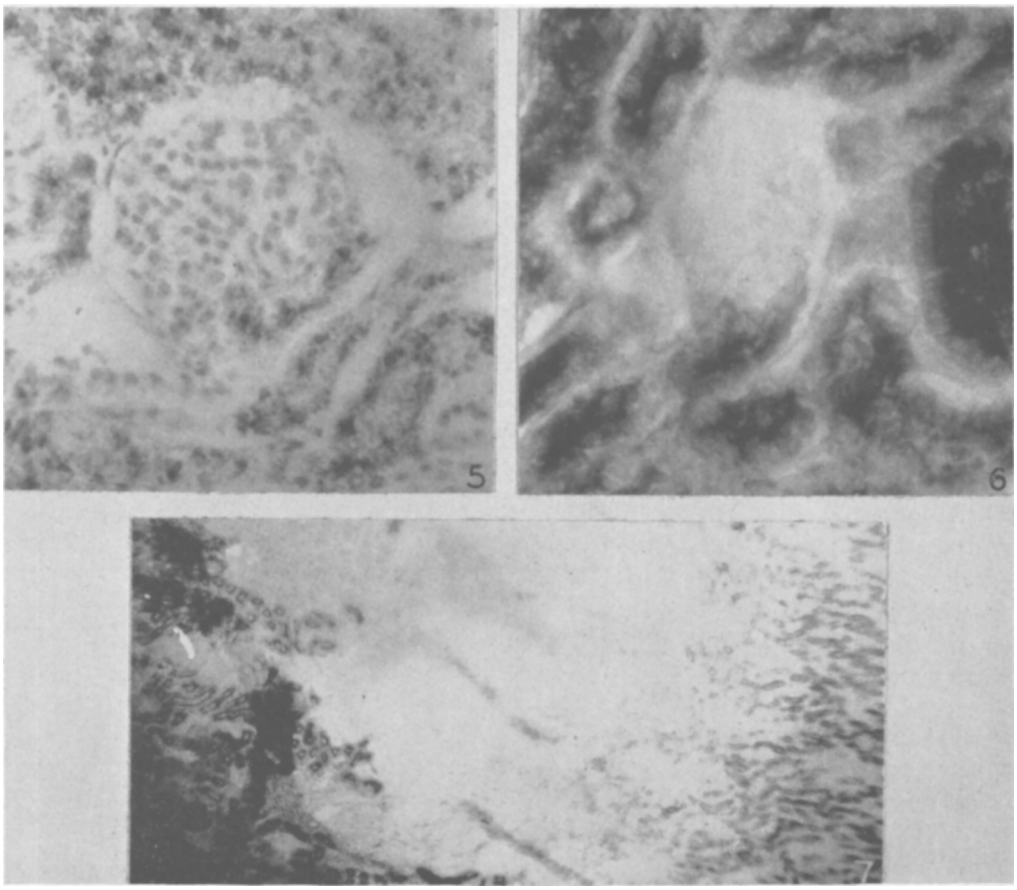

FIG. 5. Lipase; protruded epithelium, proximal convoluted tubule. × 250.

FIG. 6. Alkaline phosphatase; brush border of protruded epithelium, neck and proximal convoluted tubule. × 250.

FIG. 7. Alkaline phosphatase; brush border of proximal convoluted tubules on the left and free surface of cells of the first portion of the ascending limb on the right. × 35.

segments and in the tubular epithelium within the capsular space (Fig. 5) correlated with the presence of fats in these regions (Table I).

The brush border of the cells of the proximal convoluted tubule, its medullary segment and the protruded epithelium gave a positive reaction for alkaline phosphatase in all of the kidneys (Fig. 6). In some sections it was the only positively reacting part of the cell. In others the nuclei were colored where the luminal surface gave a positive reaction. Besides the brush border there was a positive reaction of the free surface of the first part of the ascending limb of Henle's loop which formed a dark band across the medulla (Fig. 7).

Discussion. According to Modell(3), the amount and distribution of lipids in the renal tubule of the cat do not vary with the state of nutrition, diet, or amount of intracellular fat present in other organs.

The most notable change in the distribution of lipids occurs with increasing age with a shift from fine droplets in the proximal convoluted tubules in young animals to much coarser and more numerous ones in the older cats, Smith(2). These droplets not only were colored in the oil soluble dyes but also gave a positive reaction for unsaturated triglycerides with the Nile blue sulphate method. There were no significant differences due to aging noted in the reactions for lipase and alkaline phosphatase. End portions of the medullary segments with some fat up to the descending

limb as well as those with none were present in all but one of the old kidneys. Because of the difference in fat content and also in cell contour in the terminal part, Foote and Grafflin(5,13) described 2 histologically different segments of the proximal convoluted tubule. The cells in the piece with no lipids were often edematous. In this condition of the medullary segment, triglycerides were not visible, there was little or no indication of lipase and the alkaline phosphatase reaction was often reduced to a fine, hardly discernible line. From this picture the assumption might be made that the terminal region of the proximal convoluted tubule is a vulnerable part of the kidney of the cat.

A discussion of the presence of epithelium protruded into the capsular space and a review of the literature can be found in the paper of Mayer and Ottolenghi(12), who concluded that the protrusions were found in mature renal corpuscles of 70% of the kidneys of young and adult dogs; there was no correlation with race, sex, age or history; the cause was unknown. In the present study these protrusions were found in 13 of the 14 kidneys of the older cats and in 4 of the 10 younger animals. Lehmann and Treuter quoted by Mayer and Ottolenghi(12) observed protrusions in 50% of the kidneys of cats. This tubular epithelium in the capsular space was found not only to contain lipids but also to react positively in the techniques for the demonstration of lipase and alkaline phosphatase. These observations confirm the view of Mayer and Ottolenghi(12) that the protruded epithelium probably has a metabolism similar to that of the proximal convoluted tubule.

Summary. In the proximal convoluted tubule (its neck protruded epithelium and medullary segment) the presence of large amounts of lipids including triglycerides correlated with the positive reactions for lipase and alkaline phosphatase. If the terminal part of the medullary segment contained little or no fat, there was little or no indication of the presence of lipase or alkaline phosphatase. In those other regions of the tubule where lipids were scant or absent, there were slight or no reactions for lipase and none for alkaline phosphatase with the exception of the free surface of the first part of the ascending limb of the loop of Henle which gave a positive reaction. Protrusions of tubular epithelium into the capsular space were common in the kidneys of old cats.

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