A HISTOPATHOLOGICAL STUDY OF THE BOVINE KIDNEY

THESIS FOR THE DEGREE OF M. S.

Otto Herbert Muth

1934

A HISTOPATHOLOGICAL STUDY

OF

THE BOVINE KIDNEY

A HISTOPATHOLOGICAL STUDY
OF
THE BOVINE KIDNEY

THESIS

Submitted to the faculty of the Michigan State College
in partial fulfillment of the requirements
for the degree of Master of Science
in Animal Pathology

by

Otto Herbert Muth

~~1934~~
1935

THESIS

CONTENTS

INTRODUCTION

This investigation was undertaken for the purpose of determining some of the histological detail of the bovine kidney and for the study of pathological alterations found in kidneys from cattle affected with streptococcic mastitis.

Since in the study of disease, knowledge of the histological structures of the organs involved is of cardinal importance, an attempt has been made to study these normal structures and to record the findings.

The effects of streptococci and their products, circulating in the blood stream, on the renal parenchyma of man and the common laboratory animals is well known. It would not be illogical to expect that in such a disease as streptococcic mastitis of cattle, in which there are undoubtedly great quantities of toxic substances from streptococci, if not the organisms themselves, in the blood stream for long periods, there might be considerable reaction on the part of the renal tissue.

LITERATURE

Although there is abundant literature on the histology of the renal mechanism of man and some of the common laboratory and lower animals, there seems to have been little written on the subject as regards the domestic animals. Nothing has been found in the available literature on the finer histological detail of the bovine kidney.

The same can be said in regard to the effects of streptococci and their toxins on the renal tissue. The problem has been recognized and studied in man, supplemented by the common laboratory animals, for years. In the case of the domestic animals the subject has apparently attracted little attention. Nothing has been found in the available literature relative to the reaction of the renal tissues of the bovine kidney to streptococci and their products.

MATERIALS AND METHODS

The tissues for this study were selected from two types of cases. Those selected for histological study were obtained from apparently normal animals. The others were obtained from animals with a history of streptococcic mastitis.

In some cases the tissues were collected prior to the beginning of this study and the identification of right and left kidneys was not kept. In three cases only a single block of tissue was obtained. In the remaining cases two or more blocks of tissue were obtained from each kidney.

The blocks of tissue were taken as soon after slaughter as possible and fixed in Zenker's solution, followed by the paraffin technique.

Sections 8 microns in thickness were made. Some were stained with eosin-hematoxylin. (Unless otherwise stated references will be made to this method of staining.) Others were stained with Mallory's aniline blue. In one case Gram's stain for bacteria was employed.

In two cases blocks from each kidney were also fixed in 10% formalin, frozen, sectioned at 15 microns thickness and stained for fat with Sudan IV.

In two cases a single block from one kidney was fixed in Zenker's solution, and another block from the adjacent area fixed in formalin for 24 hours, then fixed in Zenker's solution in the usual method. These were prepared by the

paraffin technique, sectioned at 8 microns and stained with eosin-hematoxylin.

In a single case the time between death and fixation in Zenker's solution was purposely delayed. The blocks were then fixed in the usual manner, followed by the paraffin technique, sectioned at 8 microns, and stained with eosin-hematoxylin.

In most cases, after microscopic study of the entire stained section, a representative portion of a block about 4 mm. square was selected. These 4 mm. portions were removed, reembeded in paraffin, and sectioned in serials at 8 microns thickness, ranging from 60 to 180 sections in number. Some were stained with eosin-hematoxylin, others with Mallory's aniline blue.

In one case an attempt to isolate organisms that might be present was made by stroking the freshly cut surface of the tissue on petri plates containing liver infusion agar, and incubating for 48 hours at 37 degrees C.

Studies from serial sections were made when practical. Measurements involving the maximum diameters of Malpighian bodies were also made from serial section.

Photo-micrographs were made by the use of the Leitz "Makam" photo-micrographic camera. Eastman's Wratten M plates and Super-sensitive Panchromatic cut film, with suitable filters were used.

HISTOLOGICAL STUDIES

The tissues for these studies were divided into two groups. Group I consisted of tissues from five apparently normal beef animals and were used for the study of normal histological structures. Group II consisted of two normal dairy heifers and a kidney obtained from a calf from the experimental dairy herd. The tissues from Group II were used in the study of the effect of different kinds of fixation and the effect of delayed fixation on the microscopic structure.

Group I

Study of Kidneys from Normal Animals

History - These animals were raised at the U.S.D.A. Experiment Station at Miles City, Montana. They were received by the Animal Husbandry Department of Michigan State College at the age of approximately 6-1/2 months, for study in an experiment on normal gains in weight. Their ration consisted of the following mixture:

Yellow corn	6 lbs.
Either cotton or linseed meal	1 "
Corn silage	3.5 "
Alfalfa hay	2 "

Cotton and linseed meal were alternated in the mixture at two week intervals. The animals were permitted all of the above feeds that they would consume twice daily. They were fasted 24 hours but permitted free access to water before slaughter.

The animals were between 14 and 15 months of age when killed. They were felled by a blow on the head, and slaughtered in the usual manner. The following data were obtained at that time.

Case Number	Sex	Live weight lbs.	Lower side at time of death	Loss of blood in %	Time killed A.M.	Time tissue fixed A.M.	Macroscopic Lesions
1398	Female	768	Left	3.7	6:30	7:45	One small scar on liver
1419	Male	881	Left	3.2	7:50	8:25	Small adhesion on spleen. Marked "fat necrosis" of peri-renal fat
1655	Female	716	Right	3.3	8:50	9:30	Three small scars on liver
1613	Male	763	Right	3.1	10:00	10:30	One small scar on liver
1617	Male	786	Right	3.2	11:00	11:30	None

RESUMÉ OF HISTOLOGICAL FINDINGS

Malpighian Body. Measurements in microns

Case Number	1398	1419	1655	1613	1617
Diameter minimum (inside of capsule)	150	162	135	156	144.1
" maximum " " "	192	186	162	186	174
" average* " " "	167.4	171.9	152.1	171.6	154.8
Average diameter for all animals, 163.5					
Variation in diameter, all animals, 135-192					
Diameter minimum (glomerulus)	138	141	120	144	126
" maximum "	168	175.5	153	174	162
" average* "	149.1	159.1	135.6	158.4	144.1
Average diameter for all animals, 149.2					
Variation in diameter, all animals, 120-175.5					
Average* depth of capsular space	9.15	8.87	8.25	6.6	5.35
Average, all animals, 7.64					

* Average found from measuring 10 Malpighian bodies from each case.

Exudate in Capsular Space. A small amount of granular and foamy material is found in the capsular spaces in each of the cases. This material stains similar to albumin with eosin-hematoxylin. In some cases there is differentiation of the substance when stained with Mallory's aniline blue, in that the granules take a light red stain, the foamy material blue.

Capsular Basement Membrane. The capsular basement membrane varies from 1 to 2 microns in thickness.

Glomerular and Capsular Epithelium. The interior of the capsule is lined, and the exterior of the capillary loops is covered with a flat epithelium. The nuclei appear large, oblong, flattened, and highly vesicular. They appear somewhat like the nuclei of vegetative fibroblasts. The chromatin is arranged in fine shreds and granules, and the nuclear membrane is very delicate. The nuclei of the mural and visceral epithelium cannot be differentiated. The cytoplasm of the visceral epithelium is so scant as to be inconspicuous except near the borders of the nuclei. It is somewhat more abundant in the mural epithelium and is seen as a thin sheet covering the space between the nuclei.

Glomerular Endothelium. The nuclei of the cells of the endothelium appear somewhat smaller and less vesicular than those of the epithelium, although there is some variation in their size and vesicularity. They usually appear largest and

most vesicular in the regions in which they appear most numerous. On cross-section through a capillary loop they bulge into the lumen and appear quite round. Their cytoplasm is very inconspicuous.

There is considerable variation in the distribution of the endothelial cells in the glomeruli. Some capillary loops appear to contain very few. Others contain so many that the direction of the capillary can be easily followed without reference to the basement membrane. It is estimated that there are about four or five times as many endothelial as epithelial cells in the average glomerulus.

Basement Membranes of the Capillary Loops. There is apparently considerable variation in the thickness of the basement membranes of the capillary loops. When stained with Mallory's aniline blue, some of them appear as thin blue lines. Others appear to be two to three times as thick.

Capillary Loops as a Whole. There are relatively few capillary loops which contain blood. Most of them appear somewhat contracted.

Proximal Convoluted Tubules. Measurements in Microns.

Case Number	1398	1419	1655	1613	1617
Outside diameter minimum	42	36	30	26	26
" " maximum	60	72	60	60	78
" " average	46.5	48.5	43.8	43.8	53
" " average all cases, 47.16					
Inside diameter minimum	13	18	15	15	20
" " maximum	36	42	36	24	54
" " average*	26	26.1	23	19.6	31
" " average all cases, 25.2					
Variations in number of epithelial nuclei observed on cross-section of proximal convoluted tubules.					
Minimum number observed	2	4	4	4	4
Maximum " "	8	9	8	8	8
Average** " "	5.5	6.8	5.8	6.1	6.2
Average number observed in all cases, 6.08					
Average* height of epithelium	10.2	11.3	10.2	12.1	11.2
" all cases, 11					

* Average found by measuring 10 tubules from each case.

** Average found by counting the epithelial niclei in cross sections of 10 tubules from each case.

Distal Convoluted Tubules. Measurements in Microns.

Case Number	1398	1419	1655	1613	1617
Outside diameter minimum	42	30	36	39	30
" " maximum	50	48	50	48	48
" " average*	47.5	39.8	44.4	43	39.8
" " average, all cases, 43.9					
Inside diameter minimum	13	21	20	17	15
" " maximum	36	36	30	26	33
" " average*	27.3	28.5	23	22.7	23.4
" " average, all animals, 24.9					
Variations in the number of epithelial nuclei observed on cross-section of proximal convoluted tubules					
Minimum number observed	8	6	7	5	6
Maximum " "	14	11	13	11	12
Average** " "	10.3	8	10.1	8.6	8.7
Average, all cases, 9.14					
Average* height of epithelium	10.1	8.2	10.7	10	8
" all cases, 9.4					

* Average found by measuring 10 tubules from each case.

** Average found by counting the epithelial nuclei in the cross sections of 10 tubules from each case.

Epithelium of the Convoluted Tubules. The epithelium of the proximal convoluted tubules bulges into the lumina over the nuclei, and with its brush border, which is easily seen, gives an irregular granular outline to the inner wall of the tubules. The cytoplasm appears granular and takes a light stain with eosin. The nuclei appear as typical, rather higher vesicular, epithelial nuclei.

The epithelium of the distal convoluted tubules gives a more regular outline to the surface of the lumina. The cytoplasm appears granular, but there is considerable variation in the intensity to which the tubules stain with eosin. The nuclei appear less vesicular with larger chromatin granules than is seen in the proximal convoluted tubules. The chromatin often appears arranged in one, two, three, or more masses within the nucleus, there being a relatively clear zone between them and the nuclear membrane.

Content of the Tubules. Both proximal and distal convoluted tubules contain more or less of a granular and foamy material similar to that observed within the capsular space. There is very little of this material observed in the other portions of the nephron.

Blood Vessels

The nuclei of both the intima and media of the interlobular and afferent arteries appear quite vesicular, but there is no indication of abnormal proliferation observed.

Interstitial Tissue

The interstitial tissue consists of a delicate fibrous reticulum, and scattered connective tissue cells.

Lesions

The following lesions are recognized in the sections from the five cases:

Case 1398. A few interstitial lesions from 200 to 1500 microns in diameter are observed scattered throughout the deeper portions of the cortex. Macrophages predominate, but lymphocytes are also present in small numbers. There seems to be no involvement of the parenchyma.

Case 1419. One interstitial lesion about 1000 microns in diameter, adjacent to the renal capsule. Macrophages predominate, but a few lymphocytes are also present. There appears to be no involvement of the parenchyma.

Case 1655. One area 2000 microns in diameter infiltrated with lymphocytes. There appears to be slight thickening of the capsules of the corpuscles involved. One interstitial lesion about 500 microns in diameter adjacent to area cribosa in end of papillae. Lymphocytes predominate, but macrophages and vegetative fibroblasts are also present. A few lesions involving areas up to 200 microns in diameter are observed scattered throughout the cortex. Macrophages predominate, but lymphocytes are also quite numerous. An occasional adjacent corpuscle appears to have a slightly thickened capsule. There is no other apparent involvement of the parenchyma.

Case 1613. There are a few interstitial lesions up to 250 microns in diameter, (one reaching 1000 microns) scattered throughout the cortex. Fibroblasts predominate, but maccophages and lymphocytes are quite numerous. There appears to be no involvement of the parenchyma.

Case 1617. There are a few interstitial lesions up to 250 microns in diameter scattered throughout the cortex. Fibroblasts usually predominate, although macrophages predominate in one lesion observed. There appears to be no involvement of the parenchyma.

Group II

Study of the Effect of Variations in Technique on the Microscopic Structures of Kidney Tissue

Effect of Delayed Fixation on the Microscopic Structure of Kidney Tissue.

Case 238. History The kidney for this experiment was obtained from an animal from the experimental dairy herd of Michigan State College. The animal was slaughtered in the usual manner at 9 A.M.

Macroscopic Examination of Tissue. Three greyish white Foci, 1 to 2 mm. in diameter, are seen in the outer portion of the cortex. There are no other visible alterations.

Technique. Two blocks of tissue, each from opposite sides of the kidney were placed in Zenker's solution at 10:40 A.M. (one hour and forty minutes after death. The kidney was then placed in the ice box. Similar blocks were

placed in Zenker's solution at twenty four, forty eight, and seventy two hours after death. After fixation the tissues were prepared by the paraffin technique, sectioned at 8 microns and stained with eosin-hematoxylin.

Microscopic Examination. The tissues fixed at one hour and forty minutes after death present an appearance in structure similar to the tissues of Group I, which were fixed at approximately the same time after death. In the tissues fixed at 24, 48, and 72 hours respectively, there is an increasing appearance of cloudy swelling in the deeper parts of the cortex. The region adjacent to the renal capsule is characterized by shrinkage and complete loss of structure. This process includes a layer of tissue which is about 250 microns in thickness, in the block fixed at 24 hours after death, and which reaches a thickness of about 500 microns in the block fixed at 72 hours after death. The cytoplasm takes a deeper stain with eosin as the length of time between death and fixation increases. The nuclei show an increasing degree of pyknosis with delay in time of fixation. These conditions are very marked in the sections from blocks taken at 72 hours after death.

Effect of Fixing with Formalin followed, by Fixation in Zenker's Solution.

Cases A and B. History These were apparently normal heifers. They were slaughtered in the usual manner at about 9 P.M. August 7, 1934. Their approximate ages were

18 months each.

Macroscopic Examination of Kidneys. There are no gross alterations observed.

Technique. A single kidney was used from each animal. Two adjacent blocks of tissue were taken from each. One block from each organ was placed in Zenker's solution at 11:00 P.M. The remaining two blocks were placed in a 10% solution of formalin for 48 hours and were then fixed in Zenker's solution in the usual manner. After fixation in Zenker's solution the blocks were all prepared by the paraffin technique, sectioned at 8 microns and stained in eosin-hematoxylin.

Microscopic Examination. The histologic detail appears similar to that observed in the sections of Group I. A few interstitial lesions up to 250 microns in diameter are observed scattered throughout the cortices of both kidneys. The parenchyma does not appear to be involved in these lesions. There are no other apparent pathologic alterations. There appears to be less foamy and granular material within the lumina of the convoluted tubules near the renal capsule in the tissues prefixed in formalin, than in those fixed in Zenker's solution alone. In the deeper portions of the organ there is no significant difference however.

DISCUSSION OF HISTOLOGICAL FINDINGS IN KIDNEYS FROM GROUPS I AND II

The variation in size of the Malpighian bodies may be due in part to the amount of blood contained in the individual glomeruli. Since all of the animals used in this study were slaughtered for food, they were bled in the manner customary to that procedure. Animals thus bled lose varying amounts of blood. The amount retained in the different tissues no doubt depends upon the efficiency of the circulation during slaughter, the internal pressure of the organs, the rate of coagulation of the blood, and other factors. The distribution of the retained blood in the kidney does not seem to be uniform. Some glomeruli contain much more blood than others.

There appears to be a greater number of endothelial cells in the glomerulus of the bovine than has been reported in the human by McGregory.(1). This would not seem phenomenal considering the variations in glomerular structure of some of the lower animals (2) (3). The significance of the uneven distribution of the endothelial nuclei in the glomeruli of bovines can not be explained without further study. They might be most numerous in dormant capillaries.

The absence of blood in many capillary loops interferes somewhat with the study of their normal shape and structure. Their partial collapse no doubt causes a variation in the apparent thickness of their basement membranes, and in the

distribution of the epithelial and endothelial cells. If the tissues for study of glomerular histology were collected from animals which retained all of their blood upon death, one might see a different picture upon histological examination than has been seen in these.

The distribution of the chromatin in many of the nuceli of the distal convoluted tubules is not understood. This condition can not be regarded as evidence of mitosis because of the frequency with which it is observed, the irregular massing of the chromatin, and the absence of other mitotic figures. This condition was not altered by prefixing in formalin.

The granular and foamy material observed in the capsular spaces and convoluted tubules is confusing because of the fact that it stains quite similar to cytoplasm and renders the free surfaces of the cells indistinct in outline. Materials of this nature are considered artifacts by Maximow (4). The fact that it was only observed in the most functional parts of the nephron, and not in the collecting tubules tends to substantiate this belief. If some method of fixation and preparation of renal tissues was used which would eliminate this material, the tissues would be much more satisfactory for histologic study. Prefixing in formalin, a material employed by Bell (5) did not seem to materially alter the condition.

The vegetative appearance of the nuclei of the smaller

blood vessels can not be explained.

The interstitial lesions described compare favorably, except in extent, with those recorded by Smith (6) in his studies on "white spotted kidneys" in calves.His statement, "The relative infrequency of lesions in older animals - - -" (after 2-1/2 months), does not seem to apply in these cases. Although macroscopic white spots may not be common in such animals, there is no reason to believe that microscopic lesions of this nature might not occur any time during the life of the animal.

Group III

Studies of Kidneys from Cows Affected with Streptococcic Mastitis

The G animals of this series were contained in the experimental dairy herd, and the others were contained in the regular dairy herd of Michigan State College.

These animals were all inspected upon slaughter and considered fit for human consumption.

Case G 1. History Born November 13, 1925. Had 6 parturitions. One calf was aborted dead and the fetal membranes were retained. The condition was diagnosed as a B. coli infection of the fetus. Fetal membranes were retained at the time of two other parturitions, but there was no apparent illness. Examined and found affected with streptococcic mastitis in December 1932. There is a history

of infection until the time of slaughter, August 29,1933.

Microscopic Examination

Malpighian Bodies

Measurements. Many of the bodies have diameters greater than the average measurement for those of Group I, some reaching 240 microns.

Basement Membranes of Bowman's Capsules. Most basement membranes show considerable thickening, as compared with those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomerular Endothelium. There appear to be two or three times the number of endothelial nuclei as compared with the epithelial nuclei.

Basement Membranes of the Capillary Loops. Most glomeruli contain some loops, the basement membranes of which appear thickened.

Capillary Loops. Almost every glomerulus contains several loops distended with blood. Some are apparently distended but contain no blood cells.

Tubules

Proximal convoluted tubules. The variations in size, and the appearance of the epithelium, are within the range of those observed in Group I.

Distal Convoluted Tubules. Many of the distal convoluted tubules appear hypertropic, with outside and inside

diameters measuring up to 75 and 48 microns respectively. The epithelial nuclei of some tubules are too numerous to count accurately upon cross section. One hyalin cast 30 microns in diameter is observed in a degenerated convoluted tubule.

Blood Vessels

There are no apparent alterations in the blood vessels.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase to about 4 times the amount present in Group I, but there is little evidence of the replacement of the parenchyma.

Scattered throughout the cortex are a few interstitial foci of lymphocytes ranging up to 200 microns in diameter.

There are a few atrophic glomeruli scattered throughout the cortex. It is estimated that they do not exceed 1% of the total number.

Case G 3 History Born January 1, 1926. Had 6 parturitions. Affected with streptococcic mastitis from January 1933 until time of slaughter, October 24, 1933.

Microscopic Examination

Malpighian Bodies

Measurements. Many of the bodies have diameters greater than the average measurement for those of Group I. Some have diameters of about 240 microns.

Basement Membranes of Bowman's Capsules. All show considerable thickening, as compared with those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomerular Endothelium. As a whole there appear to be about the same number of endothelial nuclei as compared with epithelial nuclei. Some loops however, show about twice as many of the former as of the later.

Basement Membranes of the Capillary Loops. Most glomeruli contain some loops, the basement membranes of which appear thickened.

Capillary Loops. Only the loops of the glomeruli which lie within 1500 microns of the renal capsule, contain much blood. The remainder contains very little blood, but about 50% appear more or less distended.

Tubules

Proximal Convoluted Tubules. The variations in size and appearance of the epithelium are within the range of those observed in Group I.

Distal Convoluted Tubules. Some distal convoluted tubules appear hypertrophic with outside and inside diameters up to 76 and 60 microns respectively. In some the epithelial nuclei are too numerous to count accurately on cross section.

There are occasional hyalin casts observed in degenerated convoluted tubules, and one such cast is observed in a collecting tubule.

Blood Vessels

Complete occlusion of one, and partial occlusion of several afferent arteries, due to proliferation of the cells of the intima is observed.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase to about 2 to 4 times the amount present in Group I.

Scattered throughout the cortex are a few interstitial foci ranging up to 100 microns in diameter, in which lymphocytes are the predominating cell. It is estimated that about 2% of the glomeruli have under-gone atrophy.

Case G 4 History. Born December 28, 1926. Had 5 parturitions. Examined and found affected with streptococcic mastitis December 1932. There is a history of infection until the time of slaughter, March 31, 1933.

Microscopic Examination

Malpighian Bodies

Measurements. Most of the bodies have diameters of between 240 and 250 microns.

Basement Membranes of Bowman's Capsules. There are no apparent alterations of the basement membranes.

Glomerular and Capsular Epithelium. There are no apparent alterations of the glomerular and capsular epithelium.

Glomerular Endothelium. There appear to be about twice the number of endothelial nuclei as compared with the

epithelial nuclei. The distribution throughout the glomeruli is not even however. Some loops contain apparently few endothelial nuclei, others many.

Basement Membranes of the Capillary Loops. Although most of the basement membranes appear normal, there is an apparent increase in the thickness of some.

Capillary Loops. Relatively few loops contain blood cells. Most of the loops appear moderately dilated however.

Tubules

Proximal Convoluted Tubules. The variations in size and the appearance of the proximal convoluted tubules, are within the range of those in Group I. Many have diameters greater than the average found in that group however, having outside and inside diameters of about 60 and 36 microns respectively. Six to ten epithelial nuclei are commonly seen in a cross section of a tubule. The epithelium appears otherwise normal.

Distal Convoluted Tubules. Many of the distal convoluted tubules appear hypertrophic, having outside and inside diameters up to 60 and 33 microns respectively. Some contain nuclei too numerous to count accurately on cross section.

There is an occasional hyalin cast observed in the convoluted and collecting tubules.

Blood Vessels

The cells of the media of many of the afferent and

interlobular arteries appear vegetative in that their nuclei are quite vesicular. There is no other evidence of proliferation however.

Interstitial Areas and Lesions.

Scattered throughout the cortex are several foci of macrophages having diameters ranging up to 100 microns. There are also several areas showing a local increase in connective tissue. No atrophic glomeruli are observed however.

Case G 6. History Born April 16, 1926. Had 6 parturitions. Was affected with streptococcic mastitis from May 1933 until time of slaughter, December 7, 1933.

Microscopic Examination

Malphighian Bodies

Measurements. Most of the bodies have diameters which are within the range of those measured in Group I. A very few have diameters as great as 200 microns.

Basement Membranes of Bowman's Capsules. Most of the basement membranes show thickness which ranges from slight increase to 4 times that observed in Group I.

Glomerular and Capsular Epithelium. The nuclei of the glomerular epithelium appear somewhat more numerous than has been seen in most cases. There is no other apparent alteration.

Glomerular Endothelium. As a whole the nuclei of the endothelium appear about as numerous as those of the epithe-

lium. Some few loops however show an increase over that ratio.

Basement membranes of the Capillary Loops. Most glomeruli contain some loops, the basement membranes of which appear somewhat thickened.

Capillary Loops. Relatively few loops are dilated because of the presence of blood cells in their lumina. Many appear moderately dilated but contain no blood cells.

Tubules

Proximal Convoluted Tubules. Many of the proximal convoluted tubules appear hypertrophic with outside and inside diameters up to 84 and 24 microns respectively. Some show as many as 14 nuclei on cross section, but the epithelium appears otherwise normal.

Distal Convoluted Tubules. Many of the distal convoluted tubules appear hypertrophic with outside and inside diameters up to 75 and 50 microns respectively. Some show as many as 22 nuclei on cross section.

Blood Vessels

The nuclei of both the intima and media of the afferent and interlobular arteries appear vegetative in that they are larger and more vesicular than is usually seen. The lumina of some appear partially, and of others completely obliterated.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase

to about 4 times the amount present in Group I. Scattered throughout the cortex are several foci of lymphocytes ranging up to 300 microns in diameter. There is one hemorrhagic area about 300 microns in diameter, located 3 mm. from the renal capsule. It is estimated that from .5 to 1% of the glomeruli show marked atrophy.

Case G 9 History. Born September 3, 1926. Had 4 parturitions. Was affected with streptococcic mastitis from December 1932 until slaughtered, October 18, 1933.

Microscopic Examination

Malpighian Bodies

Measurements. Many of the bodies have diameters greater than the average measurement for those of Group I, some reaching 245 microns.

Basement Membranes of Bowman's Capsules. The basement membranes of the capsules appear to be from 2 to 4 times as thick as those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomerular Endothelium. As a whole the nuclei of the endothelium appear about as numerous as those of the epithelium. Some loops however show an increase over that ratio.

Basement Membranes of the Capillary Loops. Most glomeruli contain capillary loops the basement membranes of which appear somewhat thickened.

Capillary Loops. Relatively few loops contain blood.

Most of the loops appear moderately dilated but contain no blood cells.

Tubules

Proximal Convoluted Tubules. Many tubules have outside and inside diameters of 60 to 80 and 24 to 36 microns respectively. As many as 12 epithelial nuclei are seen on cross section, but the epithelium appears otherwise normal.

Distal Convoluted Tubules. Many tubules appear hypertrophic with outside and inside diameters up to 77 and 57 microns respectively. In many instances the nuclei are too numerous to count accurately upon cross section.

At a distance of about 4 mm. from the renal capsule are seen a few distal convoluted tubules which appear necrotic in that their epithelium is shrunken from their basement membranes, the cytoplasm takes a more intense stain with eosin, and the nuclei appear pyknotic.

An occasional hyaline cast is seen in a degenerated convoluted tubule.

The cytoplasm of the cells of the epithelium of the thick part of the loops of Henle contains many vacuoles, and a few inclusion bodies which take a bile-like stain.

Blood Vessels

A few interlobular arteries contain an unusually large number of lymphocytes. The adventitia of some show a marked infiltration with the same type of sell. There appears to be no increase in the vesicularity of the cells of the small arterioles.

Interstitial Areas and Lesions

In some areas there is an apparent increase in the interstitial connective tissue to about 4 times the amount observed in Group I. This condition is not general however, other areas showing little if any increase.

Scattered throughout the cortex are a few interstitial foci of infiltrated cells ranging up to 200 microns in diameter. Macrophages predominate in some of these foci. In others lymphocytes predominate.

One cyst 250 microns in diameter is observed at the junction of the cortex and medulla.

Less than .5% of the glomeruli show marked atrophy.

Case G 10. History Born October 5, 1926. Had 5 parturitions. Affected with streptococcic mastitis from December 1932 until time of slaughter, December 11, 1933.

Microscopic Examination

Malpighian Bodies

Measurements. Most of the bodies have diameters which are within the range of those measured in Group I. There is a tendency, however, toward the greater measurements recorded. Relatively few have diameters of 200 microns or over. Those which have diameters as great as 200 microns contain considerable blood.

Basement Membranes of Bowman's Capsules. There is only slight if any thickening of the capsules as compared with those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomerular Endothelium. In some glomeruli, and in some loops of other glomeruli, the nuclei of the endothelium appear about as numerous as the nuclei of the epithelium. Most of the glomeruli, however, contain loops in which the endothelial nuclei exceed the epithelial nuclei in number. It is estimated that in some of these loops the ratio between the different types of nuclei is 6 to 1 or greater. The tufts which contain large numbers of endothelial nuclei do not appear atrophic.

Basement Membranes of Capillary Loops. Most glomeruli seem to contain some loops, the basement membranes of which appear thickened.

Capillary Loops. Relatively few loops contain blood. Those that do not contain blood, appear to be moderately dilated.

Tubules

Proximal Convoluted Tubules. Many of the proximal convoluted tubules have outside and inside diameters up to 78 and 38 microns respectively. Some show as many as 15 nuclei in a cross section. The epithelium appears otherwise normal.

Distal Convoluted Tubules. Many of the distal convoluted tubules appear hypertrophic, having outside and inside diameters up to 87 and 60 microns respectively. As many as 20 nuclei are observed in a cross section of a tubule.

Blood Vessels

There are no apparent alterations of the blood vessels.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase to about two times the amount observed in Group I.

Scattered throughout the cortex are numerous interstitial foci of macrophages. The greater number of them consist of only a few cells. Some reach 30 microns in diameter. As many as 6 foci are observed in a single high power field (.25 mm.).

It is estimated that less than .5% of the glomeruli show marked atrophy.

Case G 13 History. Born January 24, 1928. Had 4 parturitions. Was affected with streptococcic mastitis from December 1932 until the time of slaughter, January 20, 1934.

Microscopic Examination

Malpighian Bodies

Measurements. The bodies have measurements which are within the range of measurements for those of Group I.

Basement Membranes of Bowman's Capsules. Most of the basement membranes have a thickness that ranges from 2 to 4 times as great as those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomerular Endothelium. The nuclei of the endothelium appear to be about as numerous as the nuclei of the epithelium

in some glomeruli. In other glomeruli there appear to be about twice as many endothelial nuclei. The distribution of the endothelial nuclei seems to be quite uniform although some glomeruli contain loops in which they are more numerous than they are in others.

Basement Membranes of the Capillary Loops. Most of the glomeruli contain loops, the basement membranes of which appear somewhat thickened.

Capillary Loops. Relatively few loops contain blood. Most of the loops appear somewhat contracted.

Tubules

Proximal Convoluted Tubules. Many of the proximal convoluted tubules have outside and inside diameters which measure about 60 and 36 microns respectively. As many as 10 to 12 nuclei are commonly observed in a cross section of a tubule. The epithelium appears otherwise normal.

Distal Convoluted Tubules. Many of the distal convoluted tubules appear hypertrophic with outside and inside diameters measuring up to 66 and 54 microns respectively. As many as 20 nuclei are seen in a cross section of a tubule. The cytoplasm of the epithelial cells of the thick part of Henle's loops contains numerous large vacuoles.

Blood Vessels

A few afferent arteries are observed which show partial or total occulsion of their lumina, apparently due to the

proliferation of the cells of their intima and media.

Numerous lymphocytes are observed in the lumina of some of the interlobular arteries and veins.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase of from 4 to 6 times the amount observed in Group I. The distribution is quite general, although there are some areas which show somewhat less interstitial connective tissue than others.

Scattered throughout the cortex are a few interstitial foci, ranging up to 300 microns in diameter, in which lymphocytes predominate, but in which macrophages are also quite numerous.

It is estimated that about 5% of the glomeruli show marked atrophy.

Case G 15 History. Born May 22, 1928. Had 4 parturitions. The fetal membranes were retained in one instance. Following one parturition, the uterus was everted. Recovery was uneventful in both instances. Was affected with streptococcic mastitis from January 1933 until the time of slaughter, January 23, 1934.

Microscopic Examination

Malpighian Bodies

Many of the bodies range from 200 to 220 microns in diameter.

Basement Membranes of Bowman's Capsules. Most of the basement membranes have a thickness that ranges from 2 to 4

times as great as those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomerular Endothelium. In some loops the nuclei of the endothelium appear to be about as numerous as those of the epithelium. In other loops there appear to be several times as many endothelial nuclei. All glomeruli observed show this uneven distribution of nuclei. It is estimated that as a whole there are 3 to 4 times as many endothelial nuclei as epithelial nuclei.

Basement Membranes of the Capillary Loops. Most glomeruli contain some loops, the basement membranes of which appear thickened.

Capillary Loops. Relatively few loops are filled with blood. Those which are not filled with blood appear moderately dilated.

Tubules

Proximal Convoluted Tubules. Many proximal convoluted tubules have outside and inside diameters of from 60 to 70 and 18 to 35 microns respectively. A few have outside and inside diameters as great as 80 and 42 microns respectively. As many as 15 nuclei are seen in a cross section of a tubule. The epithelium appears otherwise normal.

Distal Convoluted Tubules. Many distal convoluted tubules have outside and inside diameters of from 60 to 72 and 35 to 42 microns respectively. As many as 27 nuclei are

seen in a cross section of a tubule. In one section a few of the convoluted tubules which are in that region between 3 and 6 mm. from the renal cortex, are shrunken from the basement membrane and take a more intense stain with eosin than does the surrounding tissue. The nuclei show no evidence of necrosis however.

Much granular material which stains like bile, and a few vacuoles are observed in the cytoplasm of the epithelial cells of the thick portion of Henle's loops.

Blood Vessels

A few of the afferent arteries appear partially or totally occluded. The cells of these vessels do not appear vegetative however. The adventitia of some of the larger vessels show a marked infiltration with lymphocytes.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase of about 4 times the amount observed in Group I.

Scattered throughout the cortex are numerous foci of macrophages which range in size from a few cells to lesions 400 microns in diameter. These larger foci are usually associated with glomeruli which are apparently shrunken and appear to consist of a mass of pyknotic nuclei and collagen. The tubules are also reduced in size and have been replaced somewhat by the infiltrating cells. In some cases the tubules contain lymphocytes and polymorphonuclear cells. In some lesions fibroblasts also appear active, and in a few cases the replacement tissue is largely of this type.

It is estimated that about 5 or 6% of the glomeruli show some stage of atrophy.

Case G 16. History Born December 9, 1928. Had 3 parturitions. Was affected with streptococcic mastitis from January 1933 until the date of slaughter, October 4, 1933. At this time the mastitis had become suppurative.

Microscopic Examination

Malpighian Bodies

Measurements. Most of the bodies have diameters which are within the range of those of Group I. Relatively few have diameters as great as 200 microns.

Basement Membranes of Bowman's Capsules. Most of the capsules have basement membranes which have a thickness from 3 to 4 times as great as those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomerular Endothelium. In some loops the nuclei of the endothelium appear to be about as numerous as those of the epithelium. Other loops contain so many endothelial nuclei that it is impossible to count them. All glomeruli appear to have more endothelial nuclei in some loops than in others. No complete occlusion of capillaries by their endothelial cells is observed. It is estimated that as a whole the endothelial nuclei outnumber the epithelial nuclei 2 to 4 times.

Basement Membranes of the Capillary Loops. Most glomeruli contain some loops, the basement membranes of which

appear thickened.

Capillary Loops. Relatively few loops contain blood. Most of the loops appear moderately distended however.

Tubules

Proximal Convoluted Tubules. Many proximal convoluted tubules appear hypertrophic having outside and inside diameters up to 80 and 48 microns respectively. As many as 12 nuclei are seen on cross section of a tubule. The epithelium appears otherwise normal.

Distal Convoluted Tubules. Many distal convoluted tubules appear hypertrophic having outside and inside diameters of 75 and 48 microns respectively. In the cross sections of some tubules the nuclei are too numerous to count accurately.

Blood Vessels

The cells of both intima and media of some of the interlobular and afferent arteries appear vegetative, in that their nuclei are larger and more vesicular than is commonly seen. Several afferent arteries appear to be partially or totally occluded. Lymphocytes are numerous in some of the vessels. As many as 23 are seen in a cross section of an arciform artery.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase from 3 to 4 times the amount observed in Group I. It's distribution is not uniform, the greater amount being observed in the region of atrophic glomeruli.

Scattered throughout the cortex are numerous interstitial foci ranging up to 300 microns in diameter. In some foci lymphocytes predominate, while in others macrophages are the most numerous. Vegetative fibroblasts are also frequently seen in the lesions.

It is estimated that about 5 or 6% of the glomeruli show marked atrophy.

Case 130. History. Born November 3, 1929. Had 3 parturitions. Was affected with streptococcic mastitis from September 1933 to the time of slaughter, March 13, 1934.

Macroscopic Examination of Kidneys. The right kidney weighs 612 grams, the left 570 grams. There is no gross evidence of scarring. On section, the portion of the cortex over the pyramids varies from 5 to 8 mm. in thickness. The striations are fairly distinct, but the glomeruli appear to be more distinct. They appear as pin point dots. The pyramids appear to contain a little more blood than usual.

Microscopic Examination.

Malpighian Bodies

Measurements. Most of the bodies have diameters which are within the limits of those of Group I. There is a tendency however, toward the greater measurements recorded. Relatively few have diameters of 200 microns or over.

Basement Membranes of Bowman's Capsules. Most of the basement membranes have a thickness which ranges from 3 to 4 times as great as those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations in the epithelium.

Glomular Endothelium. In some loops the nuclei of the endothelium appear to be about as numerous as those of the epithelium. In other loops there appear to be several times as many endothelial nuclei. All glomeruli observed show this uneven distribution of nuclei. It is estimated that there are from two to four times as many endothelial as epithelial nuclei.

Basement Membranes of the Capillary Loops. Most glomeruli contain some loops, the basement membranes of which appear thickened.

Capillary Loops. In those glomeruli which are within 3 mm. of the renal capsule, the loops are more or less filled with blood. The other loops appear moderately dilated.

Tubules

Proximal Convoluted Tubules. Many of the proximal convoluted tubules have outside and inside diameters of from 60 to 70 and 24 to 36 microns respectively. As many as 15 nuclei are observed in a cross section of a tubule. The epithelium appears otherwise normal.

Distal Convoluted Tubules. Approximately 25% of the distal convoluted tubules appear hypertrophic, having outside and inside diameters up to 108 and 54 microns, respectively. In many instances the nuclei are too numerous to count accurately in a cross section of a tubule.

There is an occasional cast of cell debris, or hyalin, observed in a degenerated convoluted tubule.

Blood Vessels

The cells of both the intima and media of the afferent and interlobular arteries appear vegetative in that their nuclei are larger and more vesicular than usual. The appearance of some of the cross sections of these arteries suggests partial occlusion, although there are none observed that appear completely occluded.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase of about 3 to 4 times the amount observed in Group I. The distribution is quite general except in the region of a few atrophic units where the amount of connective tissue is greatly increased.

Scattered throughout the cortex are a few interstitial foci, ranging up to 150 microns in diameter, in which macrophages predominate, although lymphocytes are quite numerous.

It is estimated that less than 1% of the glomeruli show marked atrophy.

Case 86. History Born September 30, 1929. Had 3 parturitions. Affected with streptococcic mastitis from February 1933 until slaughtered May 17, 1934. At this time the mastitis was suppurative in nature.

Macroscopic Examination of Kidneys

The right kidney shows several pin point greyish-white spots on the surface of the cortex. Upon section there is slightly more blood seen in the right, than in the left kidney. The portion of the cortex over the pyramids is about 10 mm. in thickness. The striations are distinct. The left kidney shows one pin point hemmorrhagic spot in the medulla. The deeper 3 mm. of cortex is slightly lighter in color than the rest.

Microscopic Examination

Malpighian Bodies

Measurements. Most of the bodies have diameters which are within the range of those of Group I. There is a tendency however toward the greater measurements recorded. Relatively few have diameters of 200 microns or over, and these contain considerable blood.

Basement Membranes of Bowman's Capsules. There is only slight if any thickening of the basement membranes as compared with those of Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomular Endothelium. The nuclei of the endothelium appear to be about as numerous as the nuclei of the epithelium in a relatively few glomeruli. In most glomeruli there appear to be 6 to 8 times as many endothelial nuclei.

Basement Membranes of the Capillary Loops. There is not a marked variation in the thickness of the basement membranes

of the capillary loops.

Capillary Loops. In those glomeruli, which lie within 3 mm. of the renal capsule, the loops are well filled with blood. Deeper in the cortex relatively few loops contain blood. Those which contain little or no blood appear moderately dilated.

Tubules

Proximal Convoluted Tubules. Many of the proximal convoluted tubules have outside and inside diameters of from 60 to 70 and 24 to 36 microns respectively. As many as 12 nuclei are observed in a cross section of a tubule. The epithelium appears otherwise normal.

Distal Convoluted Tubules. A few of the distal convoluted tubules appear somewhat hypertrophic with outside and inside diameters of 60 to 70 and 45 to 54 microns respectively. The nuclei are too numerous to count accurately in a cross section of some of these tubules.

Blood Vessels

The cells of both intima and media of many of the afferent and interlobular arteries appear vegetative in that their nuclei are larger and more vesicular than usual. Several afferent arteries appear partially occluded. The adventitia of some of the larger vessels show a marked infiltration of lymphocytes.

Interstitial Areas and Lesions

There seems to be little if any increase in the interstitial connective tissue as compared with Group I. The cortex contains numerous interstitial foci which consist of from a few cells to lesions 200 microns in diameter. Although most of the lesions are quite discrete, some are more diffuse and partially or totally surround the corpuscles. Macrophages and lymphocytes are the predominating cell types, but a few polymorphs and vegetative fibroblasts are also seen in some of the larger lesions.

Some of the macrophages contained in the larger lesions are peculiar in that they are larger in size and have a more abundant and granular cytoplasm which takes a more intense stain with eosin than do the usual macrophages.

Although practically all units show some infiltration, only those involved in the larger lesions show marked morphological change. These changes are characterized by the thickening of Bowman's capsules and atrophy and degeneration of the convoluted tubules. In some of these tubules the nuclei appear large and highly vesicular, not unlike the nuclei of vegetative fibroblasts. The tubules are reduced in size, have lost their regular shape and the cytoplasm of their epithelium stains very faintly with eosin. Some of these tubules contain hyaline casts.

It is estimated that about 5% of the units show some of the above morphological changes, but there are very few that show marked atrophy and fibrosis.

Sections stained by Gram's method for bacteria are negative.

Sections stained with Sudan IV show only a trace of fat in the epithelial cells of the thick portion of Henle's loops.

Case 230 History. Born September 3, 1925. Had 6 parturitions. Salpingectomy was performed on the left side December 22, 1933, because the structure was enlarged. Recovery was uneventful. The animal was affected with streptococcic mastitis from November 1933 until slaughtered, June 15, 1934.

Macroscopic Examination of Kidneys. The right kidney weighs 922 grams, the left 907 grams. On stripping the capsule the surface is somewhat mottled, showing numerous grayish, somewhat translucent foci varying in size from pin point to 2 mm. in diameter. These are sufficiently numerous to give the kidney a mottled appearance. Two or three dozen or more are on each lobule. Some of these are shrunken below the surface, giving a pitted appearance. Occasionally a focus is seen in which the small areas are coalesced to form an area 5 mm. in diameter. Over the greater portion of the surface, however, they appear as rather sharply circumscribed small foci. On section the cortex averages about 9 mm. in thickness. The inner 1/3 to 1/2 of the cortex is somewhat lighter in color than the rest. The striations are distinct.

On gross examination the glomeruli are largely indiscernible although in some cases they appear as small, grayish foci. The color of the cortex is fairly uniform. Only on occasional narrow, grayish streak 1 mm. in width extends into the medulla. What appear to be foci of productive processes are not discernible except occasionally near the surface. The medulla shows no gross alterations.

Microscopic Examination

Malpighian Bodies

Measurements. Many of the bodies have diameters of 200 microns or over. Some have diameters as great as 240 microns.

Basement Membranes of Bowman's Capsules. The basement membranes appear to be 4 to 5 times as thick as those seen in Group I.

Glomerular and Capsular Epithelium. There are no apparent alterations of the epithelium.

Glomerular Endothelium. In some loops the endothelial nuclei appear about as numerous as the epithelial nuclei. All glomeruli appear to contain some loops with a greater number of endothelial nuclei however. It is estimated that in the average glomerulus the endothelial nuclei out number the epithelial nuclei from 3 to 6 times.

Basement Membranes of the Capillary Loops. All glomeruli contain some loops the basement membranes of which appear thickened.

Capillary Loops. Relatively few loops contain blood, and as a whole they appear somewhat contracted.

Tubules

Proximal Convoluted Tubules. Most of the proximal convoluted tubules have outside and inside diameters of from 66 to 80 and 48 to 56 microns respectively. A few have outside and inside diameters as great as 90 and 60 microns respectively. As many as 11 nuclei are seen in a cross section of a tubule. In some extensive areas of degeneration the outside diameters are similar, but an epithelium of only about 6 microns in height contributes to relatively greater lumina.

Distal Convoluted Tubules. The measurements of the distal convoluted tubules are within the range of those of Group I, but in some cross sections the nuclei are too numerous to count accurately.

There is an occasional hyalin or cell debris cast in a degenerated convoluted tubule.

A few inclusions, staining like bile, are observed in the epithelial cytoplasm of the thick portion of Henle's loop.

Blood Vessels

The nuclei of the cells of both the intima and media of the afferent and interlobular arteries appear vegetative in that they are larger and more vesicular than usual.

Many of the afferent arteries appear partially or totally occluded due to these productive changes. The larger vessels show a perivascular infiltration with macrophages and lymphocytes as well as productive changes in the surrounding connective tissue.

The vessels which contain blood show numerous lymphocytes and lucocytes within their lumina.

Interstitial Areas and Lesions

The interstitial connective tissue shows an increase of from 2 to 4 times the amount observed in Group I, exclusive of those areas altered by marked pathological change.

Scattered throughout the cortex are a few more or less discrete foci, ranging in size from a few cells to lesions 100 microns in diameter, in which macrophages predominate, but in which lymphocytes are also numerous.

The principal lesions consist of areas up to about 1 mm. in width extending from the renal capsule to the medulla. The alterations consist of infiltration and proliferation, with degeneration of the units present. Macrophages are the predominating infiltrating cell type, although polymorphs and lymphocytes are also numerous. The fibroblasts in these lesions appear vegetative and there is a marked increase of connective tissue.

The units present show different stages of atrophy and degeneration. The glomeruli present a picture of simple atrophy, even the visceral and parietal epithelium being

retained in a shrunken condition. The tubules are filled with cell debris, containing many polymorphs, and hyalin casts. A few casts staining like calcium deposits are also observed.

Several lesions which suggest a more chronic process are also present. These consist of areas 3 to 4 mm. in width extending from the renal capsule to the medulla. The epithelium of the convoluted tubules in these areas is very low, measuring about 6 microns in height. There is a pronounced increase in the interstitial connective tissue and a slight infiltration of macrophages and lymphocytes.

There is some hyalinization of the stroma of the medulla.

It is estimated that 20 to 25 per cent of the cortical substance is involved in the above lesions.

Sections stained with Sudan IV are negative for fat.

Agar plates smeared with fresh tissue remained sterile after incubation at 37°C for 72 hours.

DISCUSSION OF FINDINGS IN KIDNEYS FROM MASTITIS AFFECTED ANIMALS

Although the histological structures of this group of kidneys has been compared with those of a much younger group, the variations within the different structures of this group are such that all of them can not be explained on a basis of maturity.

There is apparent enlargement of one or more portions

of the nephron in most of these cases. The amount of nonfunctional tissue is not sufficient to warrant the assumption that this is of the nature of compensatory hypertrophy. In all but Case 230, in which approximately one fourth of the parenchyma is affected, the amount of tissue rendered nonfunctional by pathologic change would appear to have little or no influence on the excretory load of the remaining tissue. The fact that all portions of the nephron do not show relative alterations in size also indicates that the changes are not due to compensatory hypertrophy.

The greatest and most constant change observed in any portion of the nephron appears to be in the distal convoluted tubules. This consists of an increase in the size of the tubule and in the number of epithelial cells. There seems to be no relation between this and any other alteration observed in the kidney.

That some of the smaller arterioles show partial or total occlusion might be expected since some of the glomeruli appear incapable of function. Whether the former condition is primary or secondary to a disturbed glomerular circulation has not been ascertained by this study, but certainly no glomerulitis, such as recorded by Bell (5) and McGregory (7) in the human kidney, has been encountered in these cases. The glomerular changes of a degenerative nature, in these kidneys appear as a purely atrophic process, and are not characterized by proliferation or less of the glomerular epithelium, cresent formation of cells in the

capsule, capillary thrombosis, and necrosis of the tuft. Although there is an apparent proliferation of endothelial nuclei in some glomeruli, it does not seem to be associated with pathological alterations.

Neither can the condition found in these kidneys be likened to the eclamptic kidney of Bell, (8) in that there is no uniform thickening of the basement membranes of the capillary loops. Except for a thickening of the capsular basement membrane, and of the shrinking of the body as a whole, there are no conspicuous changes in the atrophic corpuscles.

With one exception there is a decided increase in the interstitial connective tissue in this group of kidneys. The case showing little increase in interstitial connective tissue was one of the younger animals of the group. This may account for the lack of induration as compared with some of the others.

The interstitial lesions of this group, for the greater part, differ from those observed in Group I, only in extent. In some kidneys they are frequently seen partially or totally surrounding Malpighian bodies, some of which show atrophy and thickening of the capsules. In other kidneys the lesions are only occasionally seen adjacent to a Malpighian body. The relation of these lesions to the bodies is not understood.

There seems to be no correlation between the length of time the animals were affected with streptococcic mastitis, any other affliction that they have suffered, or the age,

and the kidney changes observed in this group, although it is recognized that the number of cases studied is too limited to justify the drawing of any definite conclusions.

SUMMARY AND CONCLUSIONS

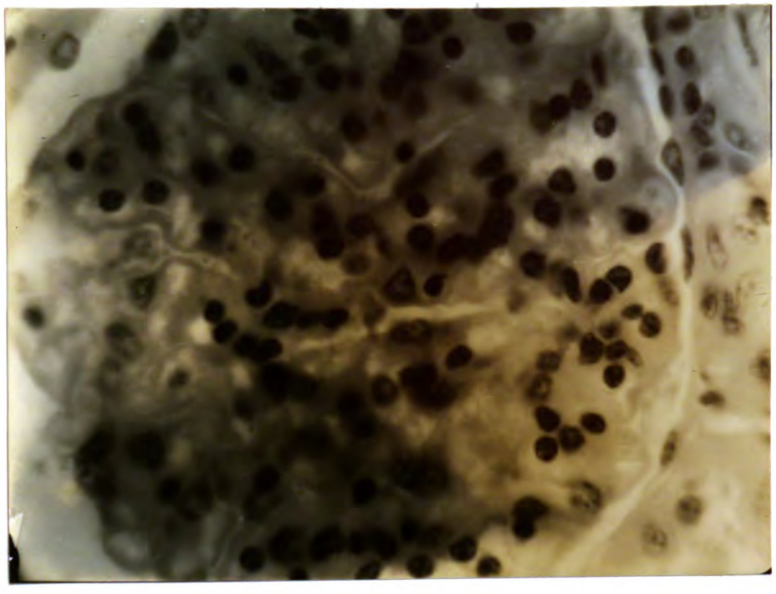
The kidneys of 5 apparently normal beef animals have been studied microscopically and a description of some of their histological structures recorded.

The effect of delayed fixation of kidney tissue has been studied. It was found that delay in fixation gave rise to loss of microscopic structure, apparent cloudy swelling of the cytoplasm of the epithelium, and pyknosis of the nuclei.

The effect of prefixing in formalin on the epithelium of the kidney has been studied. Prefixing in 10% formalin for 24 hours followed by regular fixation in Zenker's solution did not materially improve the preserving of the epithelial structure, as compared with fixing in Zenker's solution alone.

A histopathologic study has been made of the kidneys of 12 dairy cows affected with streptococcic mastitis. The changes observed were largely hypertropy of the distal convoluted tubules, increase in interstitial connective tissue, and interstitial nephritis attended by degenerative and atrophic changes in some of the excretory units. No typical "glomerulo-nephritis", such as is reported in the human kidney has been observed.

Interstitial lesions ranging in size from only a few cells to foci several hundred microns in diameter, and consisting for the greater part of macrophages and lymphocytes, have been observed in all of the kidneys studied. These lesions are frequently seen unassociated with apparent alterations in the contiguous parenchyma.



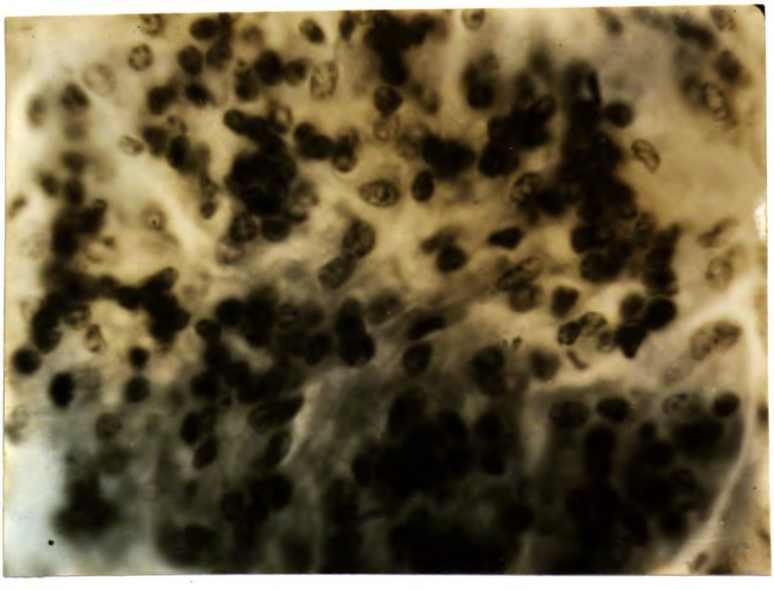
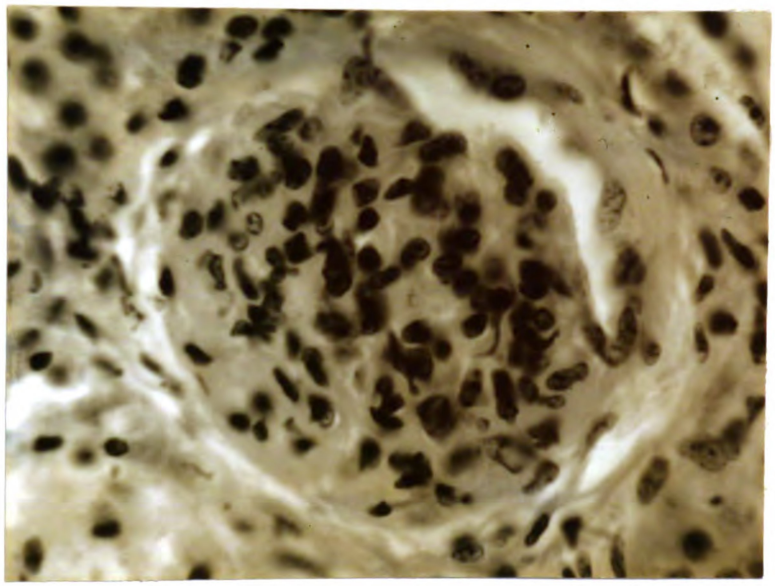


Figure 1. (Above) Case G 10

Figure 2. (Below) Case 1613
Sections through presumably normal glomeruli showing variations in number of endothelial nuclei in different glomeruli, Eosin-hematoxylin 620X.



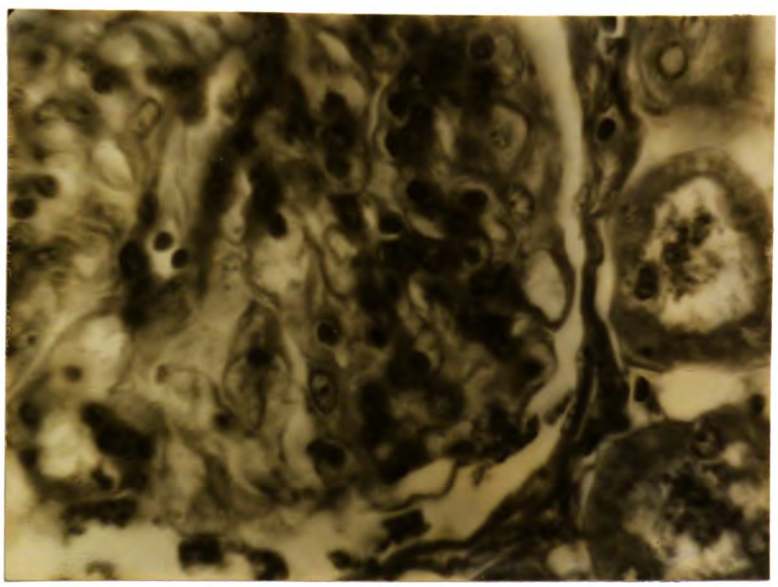
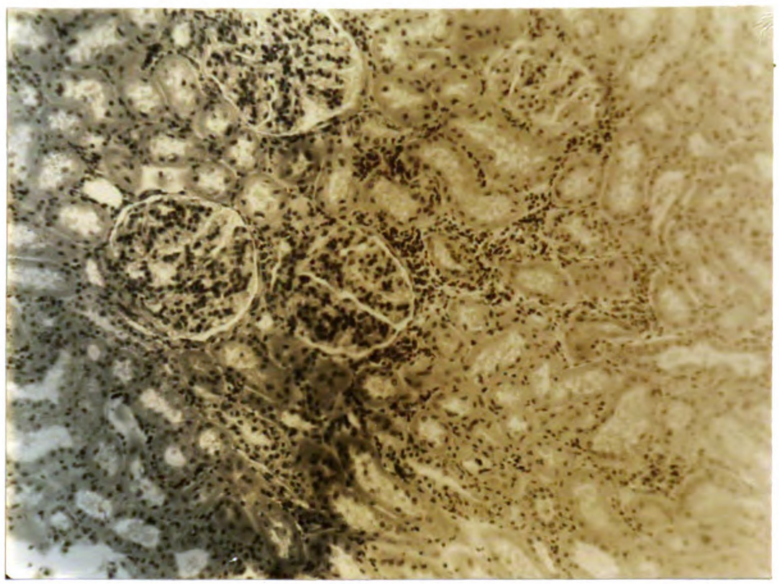


Figure 3. (Above) Case G 13. Section through atrophic Malpighian body showing contraction of glomerular capillaries and thickening of the capsule. The epithelial cells are still present. Eosin-hematoxylin. 620X.

Figure 4. (Below) Case G 9. Section through glomerulus showing thickened basement membrane of loops. Mallory's aniline blue 620X.



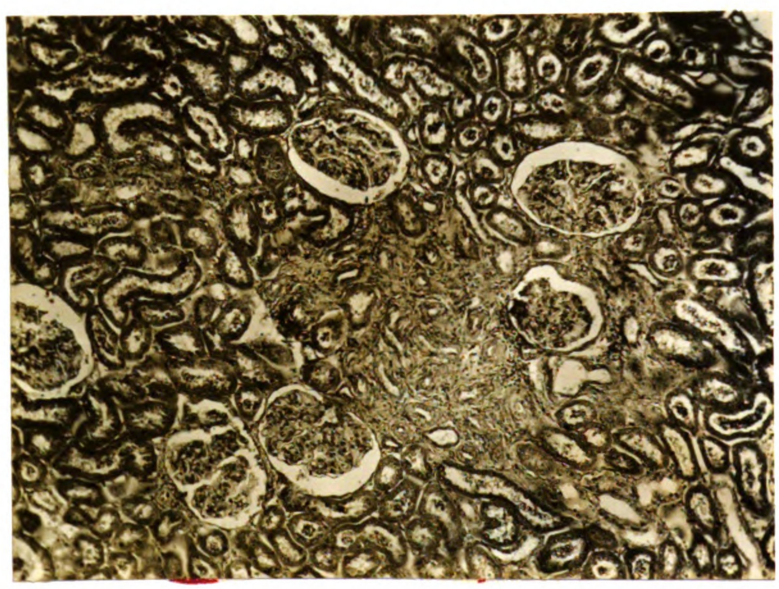
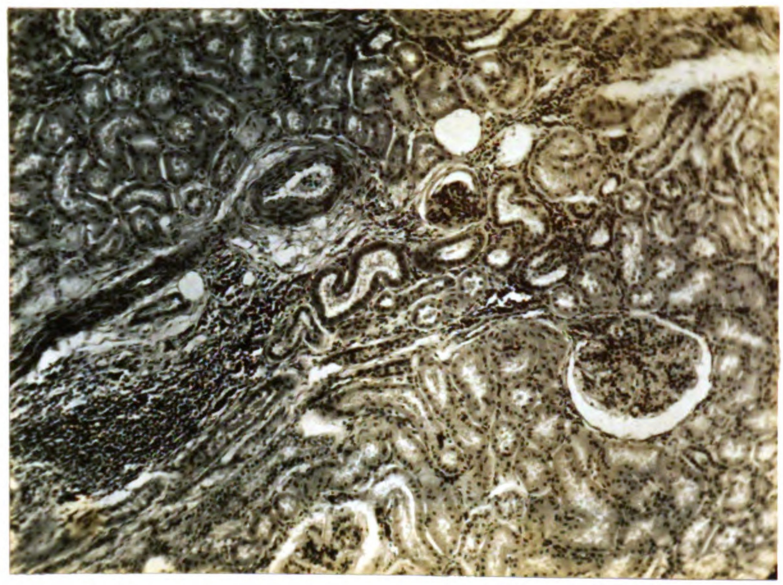


Figure 5. (Above) Case 86. Section through cortex showing periglomerular and intertubular infiltration with macrophages. Eosin-hematoxylin 100X.

Figure 6. (Below) Case G 6. Section through cortex showing atrophic glomerulus and replacement of tubules by connective tissue. Mallory's aniline blue 80X.



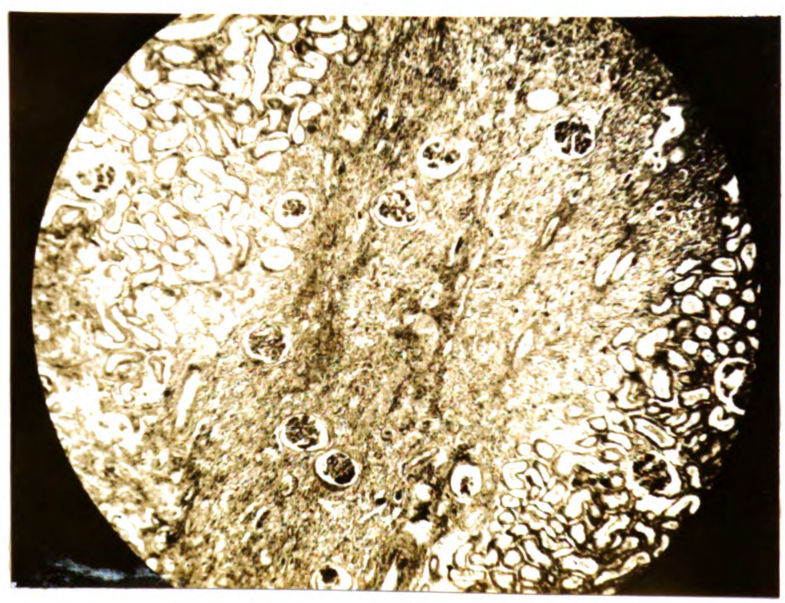
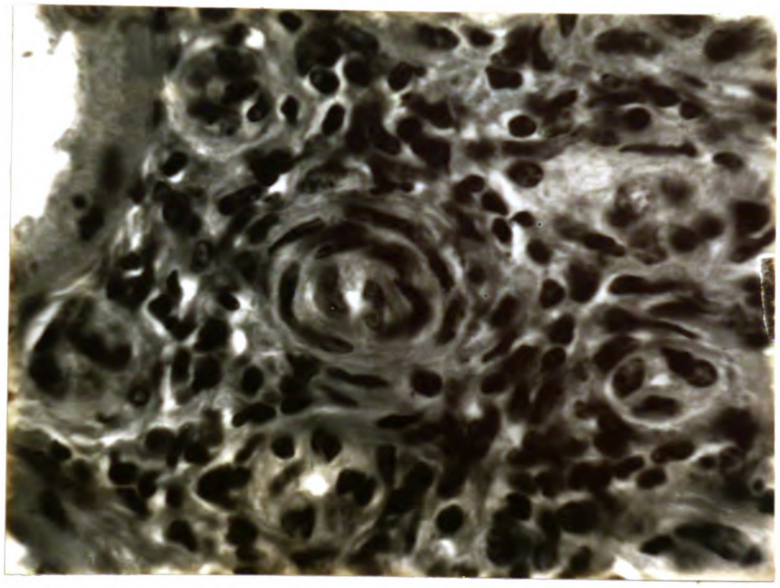


Figure 7. (Above) Case G 15. Section through cortex showing an atrophic glomerulus, infiltration of macrophages, and hypertrophic distal convoluted tubule at "a". Eosin-hematoxylin 80X.

Figure 8. (Below) Case 86. Section through lesion showing replacement of tubules with connective tissue and atrophy of the involved glomeruli. Mallory's aniline blue 40X.



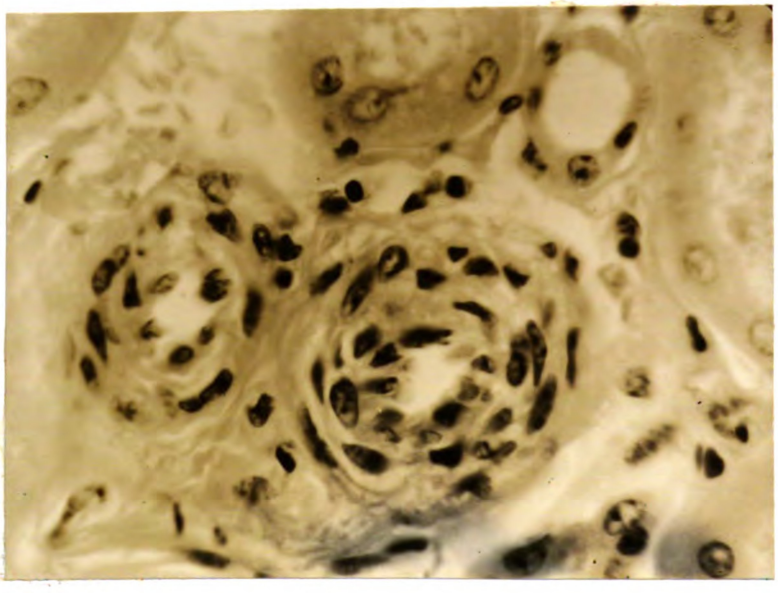
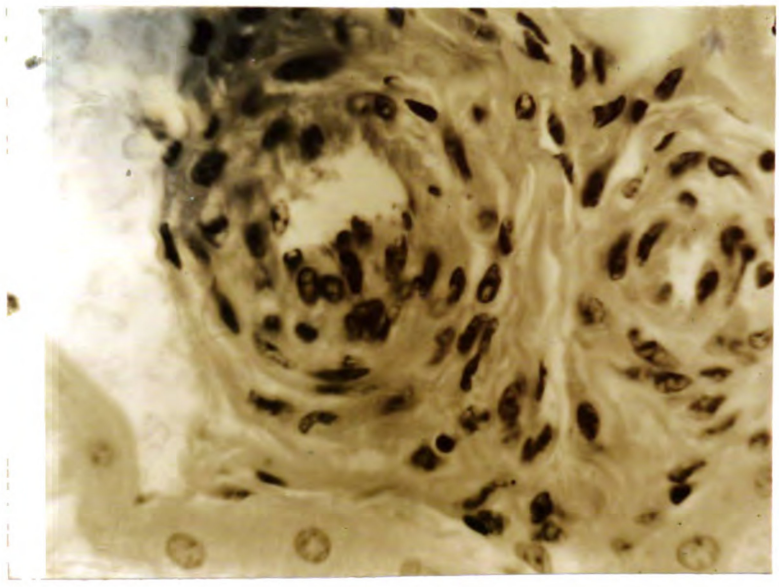


Figure 9. (Above) Case 230. Section through a small lesion showing partial occlusion of an interlobular or afferent artery and atrophy of the convoluted tubules. Eosin-hematoxylin 620X.

Figure 10. (Below) Case G 6. Section through two interlobular arteries showing large vesicular nuclei in the intima and media. Eosin-hematoxylin 620X.



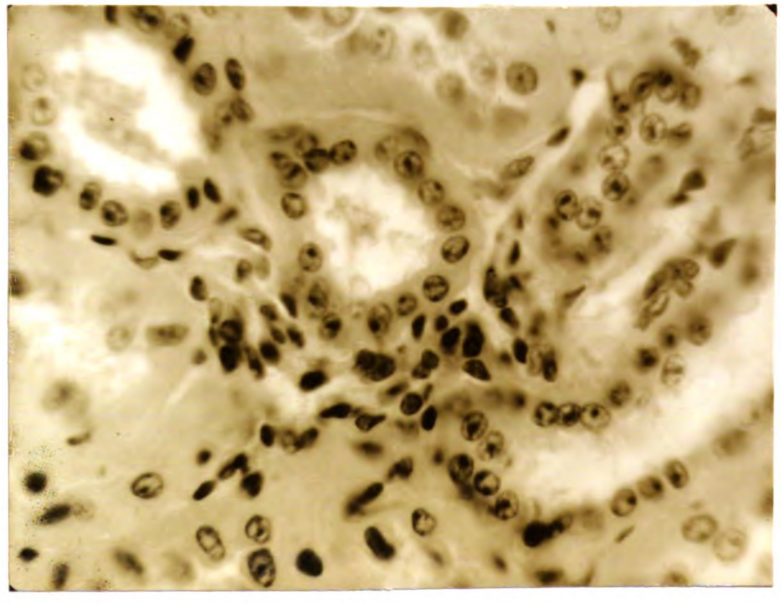


Figure 11. (Above) Case G 6. Section through an interlobular artery showing partial occlusion due to proliferation of the intima. Eosin-hematoxylin 620X.

Figure 12. (Below) Case 130. Section through a distal convoluted tubule showing an increase in the number of epithelial cells. Eosin-hematoxylin 620X.

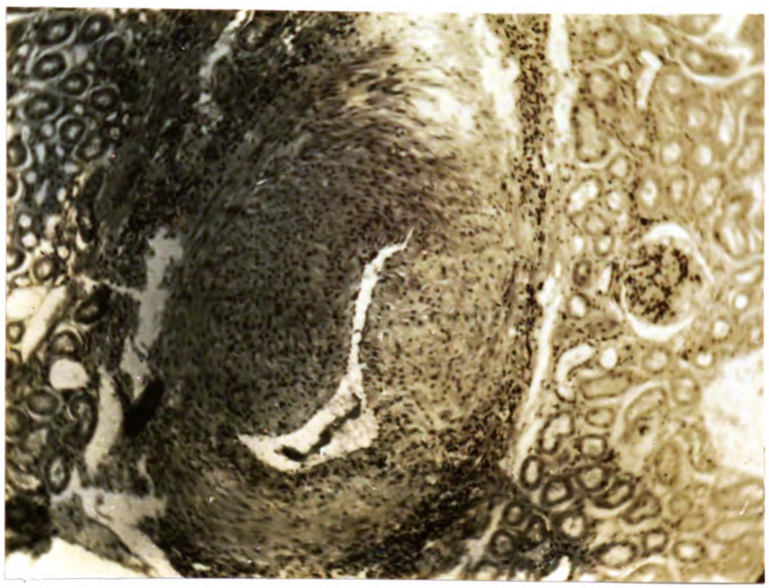
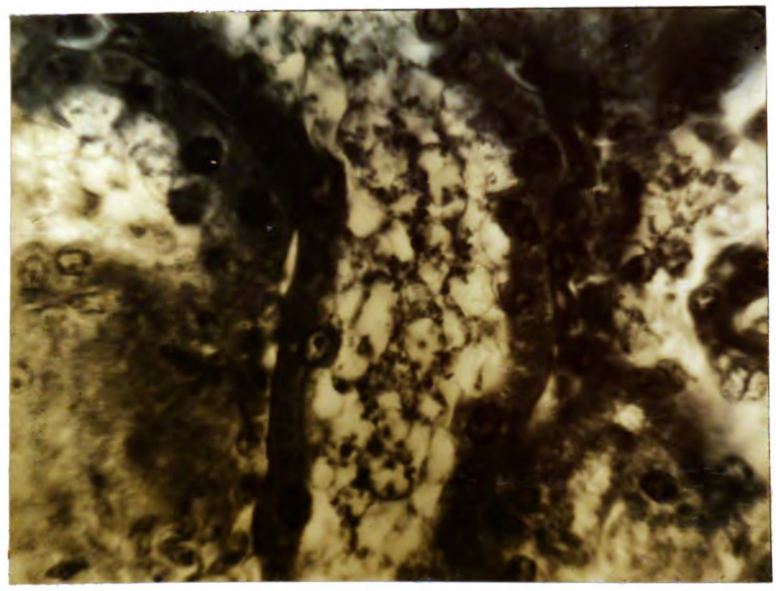


Figure 13. (Above) Case 86. Section through an arciform artery. The advential layer shows a marked infiltration with lymphocytes. 80X.

Figure 14. (Below) Case 230. Section through an Arciform vein showing infiltration of perivascular area with lymphocytes. Polymorphs and lymphocytes are seen in the lumen. Eosin-hematoxylin 80X.



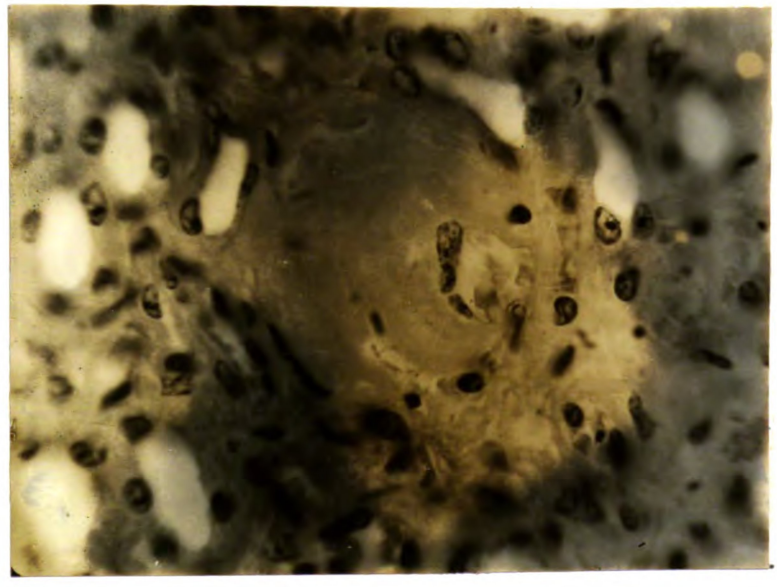


Figure 15. (Above) Case G 9. Section through convoluted tubule showing foamy and granular material in the lumen. Mallory's aniline blue 620X.

Figure 16. (Below) Case 230. Section through the medulla showing hyalinization of the stroma. Eosin-hematoxylin 620X.

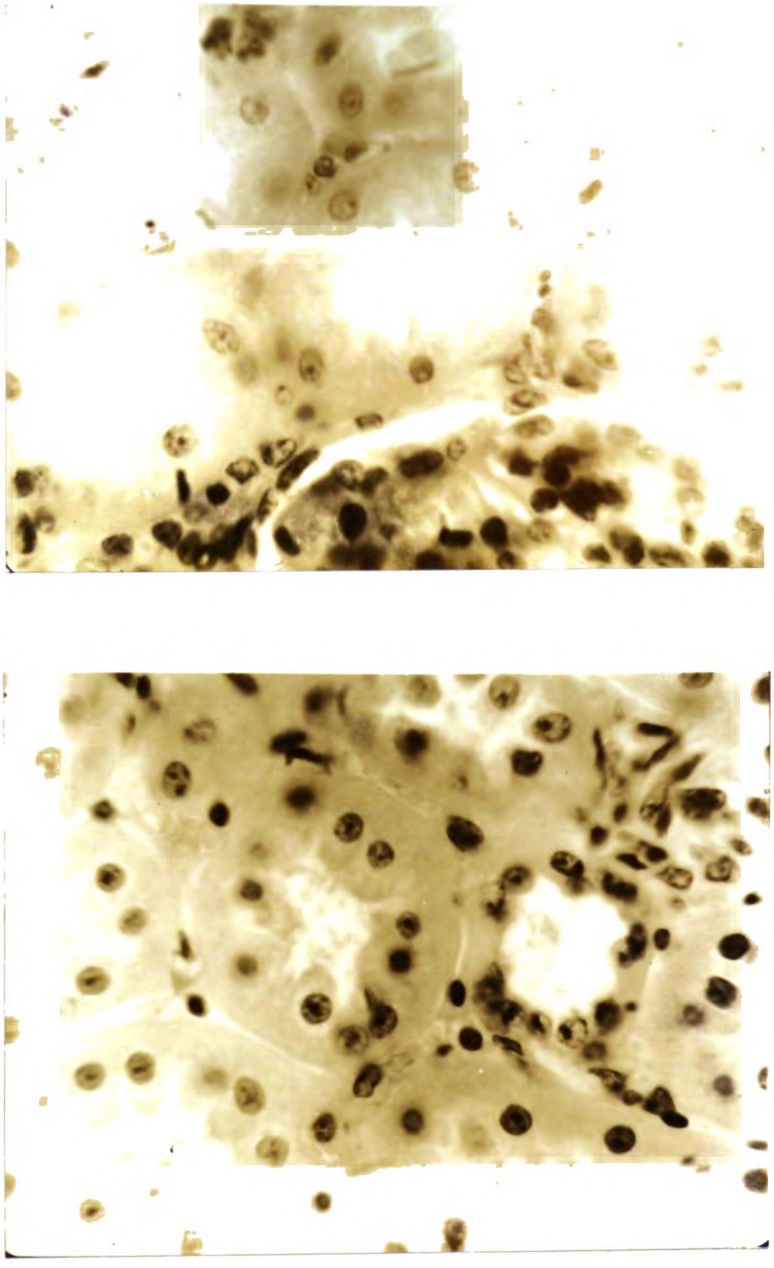
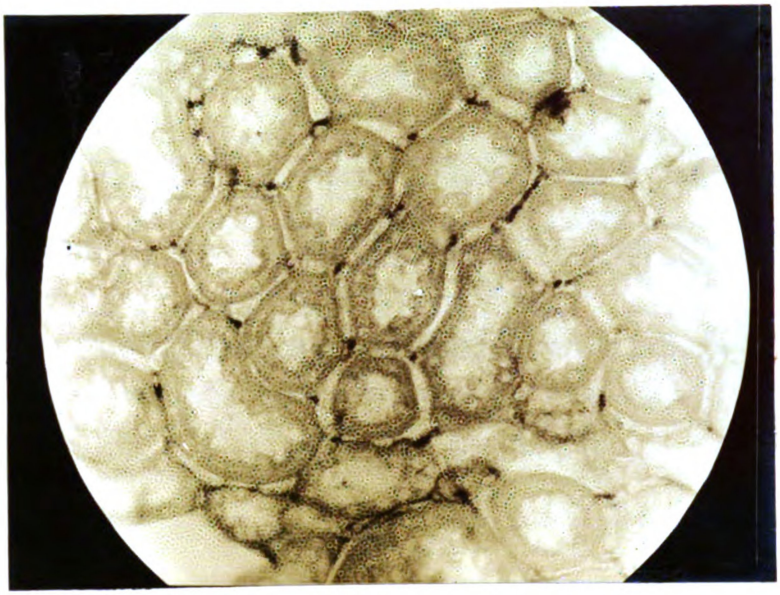


Figure 17. (Above) Case 1613

Figure 18. (Below) Case 130. Sections through proximal convoluted tubules showing variation in number of epithelial nuclei observed on cross section. Eosin-hematoxylin 620X.



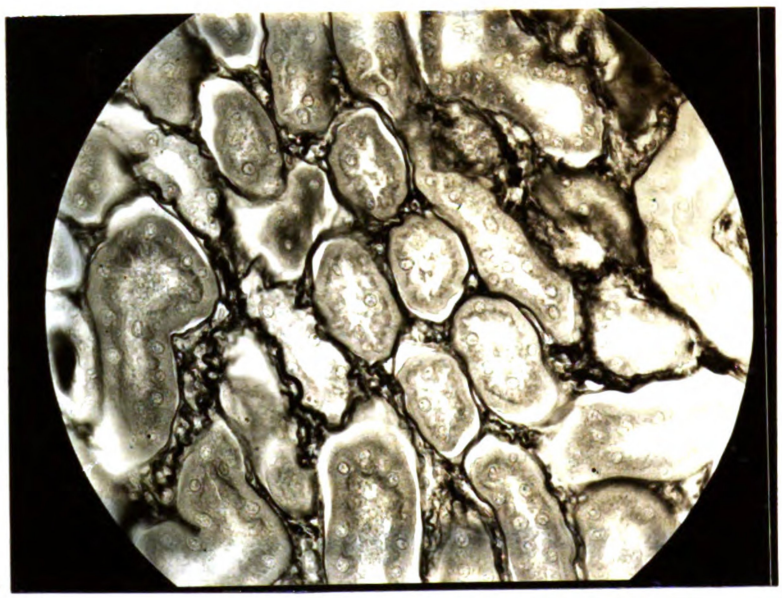


Figure 19. (Above) Case 1613. Section through the cortex of a presumably normal kidney. The imperfect definition is due to a defect of the negative. Mallory's aniline blue 288X.

Figure 20. (Below) Case 130. Section through the cortex. There is considerable increase in the interstitial tissue compared with Fig. 19.

ACKNOWLEDGMENT

It is with pleasure that I wish to express my appreciation to Dr. E. T. Hallman of the Department of Animal Pathology for his helpful suggestions and assistance given in this study, and to Mr. L. A. Moore of the Department of Dairy Husbandry for furnishing some of the materials used.

REFERENCES

1. McGregory, Leon. The Finer Histology of the Normal Glomerulus.
   Am. Jour. Path. 5:545, 1929.

2. Smith, H. W., The Functional and Structural Evolution of the Vertebrate Kidney.
   Sigma XI Quarterly 21:141, December, 1933.

3. Marshall, E.K., The Comparative Physiology of the Kidney in Relation to Theories of Renal Secretion.
   Physiological Reviews 14:133, January 1934.

4. Maximow, A. A., Text book of Histology (Saunders) p. 565.

5. Bell, E. T., Glomerular Lesions Associated with Endocartitis.
   Am. Jour. Path., 8:639, November 1932.

6. Smith, Theobold, Focal Interstitial Nephritis in Calves.
   Jour. Exp. Med. 41:413, 1925.

7. McGregory, Leon, The Cytological Changes Occurring in the Glomerulus in Clinical Glomerulorephritis.
   Am. Jour. Path., 5:557, 1929.

8. Bell, E. T., Renal Lesions in Toxemia of Pregnancy.
   Am. Jour. Path., 8:1, January 1932.