1. THE BOVINE KIDNEY IN HEALTH AND DISEASE

2. AN ETIOLOGICAL AND PATHOLOGICAL STUDY OF PNEUMONIA IN DOMESTIC ANIMALS

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Ronald T. Ingle

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by

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A THESIS

Submitted to the Graduate School of Michigan State College of Agriculture and Applied Science in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

Department of Animal Pathology

1939

Part One.

The Bovine Kidney in Health and Disease.

A. A Histological Study of the Bovine Renal Corpuscle.

B. The Number, Shape, Structures and Surface Area of the Glomeruli in the Bovine Kidney.

A. A Histological Study of the Bovine Renal Corpuscle.

Introduction

The renal corpuscle is one of the three most integral structures in the mammalian kidney.

If we are to study pathological changes in this body we must understand the normal architectural design. The main purpose is, therefore, to study the normal bovine renal corpuscle. We have also observed some cases thought to be suffering from early glomerulo-nephritis. This latter study is too limited to draw any definite conclusions.

Review of Literature

A review of literature reveals a complete lack of detailed studies of the histology of the bovine renal corpuscle.

Langham (34) has measured the renal corpuscle of the bovine and the average size for an adult animal would appear to be about 200 microns.

In observations on the human kidney Maximow (29) states the number of glomerular visceral epithelial cells is ten times as great as the glomerular endothelial cells.

In acute glomerulo-nephritis Bell (27) states the changes are all intracapillary. They consist of a massive proliferation of the endothelial cells and a splitting of the basement membrane to form intracapillary fibres.

Boyd (28) in describing the lesions of acute glomerulo-nephritis states that the epithelial cells swell and proliferate and finally become degenerate. He describes the endothelial cells as becoming much swollen, multiplying greatly and tending to block the lumen of the loop.

Materials and Methods

The kidneys for this study were from two types of cases. For histological studies, normal bovines of various age groups were selected. The cases for pathological studies were from animals which had died of pneumonia and which we believed were suffering from acute glomerulo-nephritis.

The majority of the material was obtained from the file cases in the Pathology Department, M.S.C.

All tissues were fixed in Zenker's solution. Paraffin embedded blocks were used and sections four microns thick were cut (or as close to four microns as possible) and stained. McGregor (19) in his studies has shown that the distinction between glomerular endothelial cells and glomerular visceral epithelial cells becomes much easier when the fine basement membrane of the loop which separates the two sets of cells is stained with Mallory's anilene blue. We used the Mallory-Heidenhain modification as given by Mallory (39).

The blocks for histological study were cut in serial section, four microns in thickness, and from forty to fifty sections were taken from the blocks which we thought showed early glomerulo-nephritis.

Each case was studied in the following manner. This description will explain the heading of the following charts.

1. The number of renal corpuscles in a microscopic field was counted, using a Bausch and Lomb binocular microscope, 10x ocular and 16 mm. objective.

2. One of the renal corpuscles in the above field was measured in its longest plane.

3. The number of glomerular endothelial nuclei were counted in the above renal corpuscle using the oil emersion lens. In each glomerulus the endothelial cells were counted three times and averaged. Approximately the largest endothelial nucleus was measured with the oil emersion lens and the size recorded.

4. The number of visceral epithelial nuclei were counted in the same renal corpuscle as three, using the oil emersion lens. These too were counted three times in each glomerulus. The largest epithelial nucleus, approximately, was measured and the size recorded.

5. The ratios of the glomerular endothelial cells to the glomerular visceral epithelial cells were recorded.

Accession: 3509

Age: Full term fetus

Species: Bovine

Remarks: Normal

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	31	58.5	4	4.1	26	7.8	1:6.5
	30	93.6	13	3.8	41	7.5	1:3.1
	25	78.0	6	4.1	43	8.1	1:7.1
	20	70.2	12	4.3	34	8.4	1:2.8
	18	68.4	7	4.2	26	8.2	1:3.7
	32	75.8	8	3.9	36	7.9	1:4.5
	27	78.0	9	4.0	32	8.1	1:3.5
	16	91.0	5	4.1	20	7.6	1:4.0
	12	84.2	7	3.9	43	7.8	1:6.1
	32	75.0	6	3.8	34	8.0	1:5.6
	19	80.0	5	4.1	27	7.0	1:5.4
	24	58.5	4	4.2	34	7.6	1:8.5
	28	82.1	6	4.2	43	7.8	1:7.1
	30	109.2	9	3.9	43	8.0	1:4.7
	31	74.1	10	3.8	42	6.8	1:4.2
	22	58.5	8	4.4	30	7.9	1:3.7
	26	81.9	6	4.6	27	8.2	1:4.5
	24	82.0	4	3.9	33	7.8	1:8.2
	20	70.2	7	4.0	38	7.9	1:5.4
	10	70.2	13	4.1	33	7.9	1:2.5
	16	78.4	11	4.1	27	8.2	1:2.4
	24	78.0	7	3.9	38	7.8	1:5.4
	19	72.3	11	3.6	28	7.9	1:2.5
	28	83.3	8	4.0	37	7.6	1:4.6
	22	95.3	5	3.9	32	7.2	1:6.4
Total	586	194.67	191	100.9	847	95.0	25:122.4
Max.	32	109.2	13	4.6	43	8.4	1:3.3
Min.	12	58.5	4	3.6	26	6.8	1:6.5
Av.	23	77.8	8	4.0	34	3.8	1:4.2

Accession: 3234

Age: 6 weeks

Species: Bovine

Remarks: Normal

No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
11	141	30	4.1	46	7.9	1:1.5
17	143	33	4.1	48	7.8	1:1.4
15	123	25	4.6	57	7.8	1:2.2
18	124	19	4.5	54	7.5	1:2.8
14	144	27	4.4	60	7.6	1:2.2
15	107	16	4.3	40	7.8	1:2.5
13	121	20	4.5	58	6.7	1:2.9
12	117	19	4.6	51	6.9	1:2.6
13	109	20	3.9	53	7.4	1:2.6
11	123	22	4.2	46	7.8	1:2.0
16	106	10	3.7	41	7.9	1:4.1
20	117	18	3.9	69	8.0	1:3.6
16	98	10	3.8	45	7.9	1:4.5
13	92	11	4.0	37	8.1	1:3.3
15	118	20	4.1	79	7.8	1:3.9
18	92	18	4.2	47	8.0	1:2.6
16	114	19	3.9	33	7.9	1:1.7
14	122	17	3.8	56	7.8	1:3.3
10	89	15	3.7	35	8.0	1:2.3
15	104	10	4.0	38	8.1	1:3.8
12	93	8	4.1	42	8.2	1:5.2
13	87	14	3.9	46	7.9	1:3.2
14	99	11	4.1	40	7.8	1:3.6
13	127	8	3.9	33	7.9	1:4.1
16	124	16	3.8	44	8.0	1:2.7
Total 360	2,834	436	102.1	1,198	194.5	25:74.6
Max. 18	144	33	4.6	69	8.2	1:2.0
Min. 12	87	8	3.7	33	6.7	1:4.1
Av. 14	113	17	4.1	48	7.8	1:2.8

Accession: 3221

Age: 7 weeks

Species: Bovine

Remarks: Animal slaughtered after a subacute bronchopneumonia of 3 weeks' duration.

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	18	140	27	5.5	36	7.8	1:1.0
	17	132	28	4.3	47	8.0	1:2.0
	18	124	18	4.2	23	6.4	1:1.0
	19	108	30	5.0	35	7.8	1:1.0
	14	107	27	5.4	56	7.7	1:2.0
	16	132	29	4.9	50	7.8	1:2.0
	17	129	28	5.3	43	6.8	1:1.0
	14	135	56	4.3	92	7.5	1:2.0
	17	116	37	5.8	69	7.6	1:2.0
	19	112	24	4.6	33	5.3	1:1.0
	16	108	28	5.3	48	7.2	1:2.0
	15	114	27	4.5	46	7.4	1:2.0
	18	119	24	4.6	43	7.6	1:2.0
	19	112	18	4.3	41	7.7	1:2.0
	10	123	29	4.2	43	7.5	1:1.0
	16	98	27	4.5	58	6.0	1:2.0
	12	114	28	4.5	41	6.7	1:1.0
	19	110	19	5.2	27	7.6	1:1.0
	18	96	30	5.6	59	6.9	1:2.0
	14	140	21	4.3	67	7.8	1:3.0
	16	109	13	5.8	28	6.9	1:2.0
	17	120	20	4.3	31	7.6	1:2.0
	19	118	26	4.7	37	7.8	1:1.0
	18	123	24	4.1	33	7.9	1:1.0
	18	112	29	4.6	36	7.4	1:1.0
Total	414	2,951	667	119.8	1,122	182.7	25:40.0
Max.	19	140	37	5.8	92	8.0	1:2.4
Min.	10	96	13	4.1	23	5.3	1:1.7
Av.	17	114	27	5.0	45	7.0	1:1.7

Accession: 3482

Age: 3 months

Species: Bovine

Remarks: Animal died of acute bronchopneumonia.

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus and Size of One Nucleus		No. of Epithelial Cells in One Section of Glomerulus and Size of One Nucleus		Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	10	132	12	4.0	25	7.9	1:2.0
	9	162	15	4.1	41	7.2	1:3.0
	11	157	16	4.0	27	8.0	1:2.0
	8	159	15	4.1	33	7.8	1:2.0
	8	162	22	4.0	28	7.9	1:1.0
	7	144	16	4.1	20	7.7	1:1.0
	9	126	17	4.1	25	7.8	1:1.0
	7	152	23	4.2	27	7.9	1:1.0
	12	128	13	3.9	24	7.6	1:2.0
	11	130	12	4.0	23	7.8	1:2.0
	8	146	14	4.1	24	7.9	1:2.0
	12	122	19	4.0	29	7.8	1:2.0
	10	136	20	4.1	36	7.9	1:2.0
	9	148	18	4.0	28	7.8	1:2.0
	10	139	24	4.1	31	7.9	1:1.0
	12	142	16	3.9	23	7.8	1:1.0
	11	134	17	4.0	26	7.9	1:2.0
	9	118	13	4.1	17	7.9	1:1.0
	9	146	19	4.0	30	7.8	1:2.0
	7	154	17	4.1	24	7.7	1:1.0
	6	139	16	4.0	21	7.8	1:1.0
	7	127	14	4.0	18	7.8	1:1.0
	9	124	15	4.1	19	7.1	1:1.0
	8	134	17	4.0	26	7.9	1:2.0
	7	123	16	4.1	23	7.8	1:1.0
Total	226	3,484	416	101.1	648	194.4	25:39.0
Max.	12	162	23	4.2	41	8.0	1:1.7
Min.	6	122	12	3.9	17	7.2	1:1.4
Av.	9	139	17	4.0	26	8.0	1:1.5

Accession: 3200

Age: 10 weeks

Species: Bovine

Remarks: Animal died of a subacute bronchopneumonia.

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	17	132	30	5.2	68	7.8	1:2.0
	16	114	20	4.6	39	7.4	1:2.0
	18	109	16	4.3	21	7.6	1:1.0
	25	118	18	4.5	23	7.4	1:1.0
	18	124	25	4.6	34	7.5	1:1.0
	23	126	27	4.3	34	7.8	1:1.0
	16	132	40	5.8	44	6.2	1:1.0
	24	144	27	6.0	41	6.7	1:2.0
	23	138	23	5.4	46	6.9	1:2.0
	17	133	19	4.6	40	7.5	1:2.0
	24	118	26	4.8	28	7.6	1:1.0
	18	104	29	5.2	30	7.9	1:1.0
	15	120	24	5.3	27	7.5	1:1.0
	16	138	23	6.0	45	6.9	1:2.0
	24	132	20	5.4	38	7.2	1:2.0
	17	104	14	5.5	26	7.3	1:2.0
	16	112	18	6.0	21	6.9	1:1.0
	25	118	20	5.4	29	6.8	1:1.0
	18	126	29	5.7	34	6.2	1:1.0
	17	120	26	6.0	27	6.8	1:1.0
	15	129	33	5.8	43	7.5	1:1.0
	24	132	27	5.2	34	7.2	1:1.0
	16	141	37	4.9	46	7.8	1:1.0
	16	139	32	4.6	39	7.1	1:1.0
	17	136	35	4.2	41	7.2	1:1.0
Total	475	3,139	638	129.3	898	180.7	25:32.0
Max.	25	144	40	5.8	68	7.8	1:1.7
Min.	15	104	14	4.2	21	6.2	1:1.5
Av.	19	125	26	5.0	36	7.0	1:1.3

Accession: 3372

Age: 3 months

Species: Bovine

Remarks: Normal

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscles	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	6	109	10	4.0	29	7.8	1:2.9
	7	124	13	4.4	36	7.6	1:2.7
	6	131	14	3.9	25	7.5	1:1.7
	8	118	19	4.2	37	8.0	1:1.9
	7	140	27	4.0	46	7.8	1:1.7
	10	128	32	4.0	59	8.0	1:1.8
	8	131	24	4.1	51	7.9	1:2.1
	8	123	15	4.1	42	7.8	1:2.8
	11	126	10	3.9	31	8.1	1:3.1
	8	134	22	3.8	50	8.0	1:2.2
	9	119	17	4.0	42	7.9	1:2.5
	12	114	15	3.8	44	8.0	1:2.9
	6	122	20	3.9	58	7.9	1:2.9
	4	118	15	3.7	47	8.0	1:3.1
	6	133	9	3.9	30	8.1	1:3.3
	10	127	12	4.0	31	8.0	1:2.5
	11	119	14	4.1	28	7.9	1:2.0
	13	141	21	4.1	48	7.8	1:2.2
	8	131	13	3.9	41	7.8	1:3.1
	9	119	16	4.2	52	7.9	1:3.2
	7	103	12	4.1	35	8.0	1:2.9
	5	97	11	4.2	31	8.1	1:2.8
	11	113	16	4.1	42	8.2	1:2.6
	12	116	19	4.0	58	8.1	1:3.0
	8	104	14	3.9	52	8.1	1:3.7
Total	210	3,040	410	96.7	1,045	198.3	25:65.6
Max.	13	141	32	4.4	59	8.2	1:1.8
Min.	4	97	9	3.7	28	7.5	1:3.1
Av.	8	121	16	3.9	42	7.9	1:2.6

Accession: 1458

Age: 11 months

Species: Bovine

Remarks: Normal

No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
6	156	21	3.9	49	7.9	1:2.3
5	140	20	3.7	53	7.8	1:2.6
5	148	26	4.0	61	7.9	1:2.3
2	172	32	3.8	63	7.6	1:1.9
4	175	25	4.0	76	7.9	1:3.0
5	140	15	3.9	51	8.0	1:3.4
4	148	17	3.6	39	7.9	1:2.2
5	147	23	4.1	69	8.2	1:3.0
4	148	27	3.8	64	8.0	1:2.3
5	156	25	4.0	72	8.1	1:2.8
5	172	30	3.8	50	7.9	1:1.6
7	140	20	3.7	42	8.2	1:2.1
5	136	14	3.5	39	8.1	1:2.7
8	158	17	3.9	54	7.6	1:3.1
7	162	21	4.1	41	7.9	1:1.9
5	110	14	3.8	42	8.0	1:3.0
5	120	8	4.0	32	7.8	1:4.0
5	141	17	3.8	53	7.9	1:3.1
5	174	31	3.7	83	7.8	1:2.6
5	161	25	4.0	57	7.6	1:2.2
7	130	16	3.7	40	7.8	1:2.5
3	140	19	3.9	59	8.0	1:3.1
5	131	21	4.1	48	8.1	1:2.2
7	140	24	3.8	42	7.9	1:1.7
Total 128	3,697	532	96.5	1,351	197.8	25:64.6
Max. 7	174	31	4.1	83	8.2	1:2.6
Min. 2	110	8	3.5	32	7.6	1:1.4
Av. 5	148	21	3.9	54	7.8	1:2.5

Accession: 1442

Age: 1 year

Species: Bovine

Remarks: Normal

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	9	176	35	4.0	43	8.1	1:1.2
	7	181	20	3.9	31	7.8	1:1.5
	10	167	22	4.2	25	9.7	1:1.1
	6	152	20	3.9	28	7.4	1:1.4
	77	164	26	4.1	40	7.6	1:1.5
	7	142	44	4.1	67	7.8	1:1.5
	8	191	39	4.0	61	8.0	1:1.5
	7	141	37	4.7	57	7.2	1:1.5
	9	168	34	4.0	59	8.0	1:1.7
	7	136	54	4.0	83	7.3	1:1.5
	8	163	24	3.9	44	7.7	1:1.8
	6	172	28	3.7	57	7.8	1:2.0
	9	169	30	3.4	73	7.6	1:2.4
	10	134	23	3.9	46	8.0	1:2.0
	7	152	19	3.8	48	7.8	1:2.5
	9	171	24	3.9	55	7.9	1:2.2
	8	162	21	4.0	54	7.9	1:2.5
	7	149	18	3.9	42	8.0	1:2.3
	10	152	27	3.8	61	8.1	1:2.2
	9	147	22	4.1	49	7.9	1:2.2
	7	156	26	4.0	49	7.8	1:1.8
	6	143	31	3.9	60	8.0	1:1.9
	7	162	26	3.9	61	8.1	1:2.3
	7	184	28	3.8	54	8.1	1:1.9
	6	171	22	4.0	63	8.1	1:2.8
Total	193	4,005	700	98.9	1,310	197.7	25:47.2
Max.	10	184	54	4.7	73	9.7	1:1.3
Min.	6	134	20	3.8	25	9.3	1:1.2
Av.	8	160	28	3.9	52	7.9	1:1.8

Accession: 1445

Age: 1 year

Species: Bovine

Remarks: Normal

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	7	157	41	4.0	72	7.8	1:1.7
	4	141	27	3.9	60	8.0	1:2.2
	3	137	19	3.8	44	7.9	1:2.3
	5	132	21	3.9	39	7.8	1:1.8
	4	173	35	3.7	83	8.1	1:2.3
	6	141	22	3.8	46	7.9	1:2.0
	7	137	20	3.7	40	8.0	1:2.0
	4	171	32	3.6	62	7.8	1:1.9
	4	162	36	3.9	66	7.9	1:1.8
	5	159	19	3.7	45	8.0	1:2.3
	6	172	15	3.6	38	7.9	1:2.5
	5	146	19	3.7	37	7.8	1:1.9
	5	139	29	4.0	47	8.0	1:1.6
	5	130	33	3.9	63	8.1	1:1.9
	5	147	22	3.7	46	8.0	1:2.0
	7	137	27	3.8	49	7.9	1:1.8
	5	171	18	3.9	34	7.9	1:1.8
	6	144	28	3.6	61	8.0	1:2.1
	5	136	22	3.7	40	7.9	1:1.8
	4	174	29	4.0	59	8.0	1:2.0
	7	138	31	4.1	63	8.0	1:2.0
	4	124	18	4.2	31	7.8	1:1.7
	6	179	24	4.0	42	7.9	1:1.7
	8	156	29	4.1	52	7.9	1:1.7
	4	139	20	3.9	39	8.0	1:1.9
Total	131	3,742	636	96.2	1,258	198.3	25:48.7
Max.	7	179	41	4.1	83	8.1	1:2.0
Min.	3	124	15	3.6	31	7.8	1:2.0
Av.	5	150	25	3.8	50	7.9	1:2.0

Accession: 1441

Age: 2 years

Species: Bovine

Remarks: Normal

No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
4	132	26	3.7	40	7.6	1:1.5
5	128	24	4.0	39	7.8	1:2.8
4	126	16	3.9	27	8.0	1:1.7
2	144	20	3.8	46	7.5	1:2.0
2	156	25	4.2	48	8.2	1:1.9
6	161	32	3.9	48	7.8	1:1.5
8	152	25	3.8	53	7.6	1:2.1
6	127	20	4.1	31	7.9	1:1.0
4	139	21	4.2	57	8.0	1:2.7
5	164	32	3.9	55	7.8	1:1.7
6	178	19	3.9	61	8.1	1:3.2
4	163	21	3.8	48	8.2	1:2.3
5	171	25	4.0	61	7.9	1:2.4
4	132	21	3.9	35	7.8	1:1.7
6	144	17	3.8	39	8.0	1:2.3
5	153	24	4.0	47	7.9	1:2.0
4	147	17	4.0	37	7.8	1:2.2
8	153	18	3.9	33	7.8	1:1.8
3	142	22	3.8	43	7.9	1:2.0
7	136	26	4.1	47	7.6	1:1.8
2	139	18	4.2	51	8.0	1:2.8
6	158	24	3.9	37	8.1	1:1.5
4	163	29	4.0	52	7.6	1:1.8
5	171	26	3.8	39	7.9	1:1.5
3	131	23	3.7	41	7.8	1:1.8
Total 118	3,710	571	98.3	1,115	196.6	25:50.0
Max. 8	178	32	4.2	61	8.2	1:1.9
Min. 2	126	16	3.7	27	7.5	1:1.6
Av. 5	148	23	3.9	45	7.8	1:1.9

Accession:	3441
Age:	**2 years**
Species:	**Bovine**
Remarks:	**Kidneys are normal in microscopic study although a pneumonia had apparently existed.**

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	8	112	8	4.1	17	8.0	1:2.0
	9	144	16	4.0	27	7.9	1:2.0
	10	122	15	4.1	24	7.8	1:2.0
	7	147	24	4.2	43	7.9	1:2.0
	8	131	17	4.0	23	7.9	1:1.0
	7	146	20	3.9	27	7.8	1:1.0
	15	137	17	4.1	29	8.0	1:2.0
	14	140	18	4.0	31	7.9	1:2.0
	9	136	15	3.9	25	7.8	1:2.0
	8	126	8	3.8	19	7.9	1:2.0
	9	108	10	4.2	25	7.7	1:2.0
	10	128	17	4.1	24	7.9	1:1.0
	6	138	19	4.2	38	7.9	1:2.0
	8	127	17	4.0	39	7.8	1:2.0
	9	136	12	4.1	24	7.9	1:2.0
	8	126	23	4.0	32	7.8	1:1.0
	12	132	18	4.1	18	7.9	1:1.0
	12	129	16	4.0	17	7.8	1:1.0
	9	141	29	3.9	49	7.9	1:2.0
	10	148	20	3.8	36	7.8	1:2.0
	14	122	21	3.9	24	7.8	1:1.0
	11	134	23	4.1	29	7.9	1:1.0
	9	129	24	4.0	28	8.1	1:1.0
	11	142	27	4.1	29	7.9	1:1.0
	12	137	23	4.1	28	7.7	1:1.0
Total	245	3,318	457	100.7	705	196.7	25:39.0
Max.	15	148	29	4.2	49	8.1	1:1.6
Min.	6	122	8	3.8	17	7.7	1:2.1
Av.	10	133	18	4.0	28	8.0	1:1.5

Accession: 1437

Age: 2 years

Species: Bovine

Remarks: Normal

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	4	172	20	3.9	60	7.9	1:3.0
	7	167	23	3.7	48	7.8	1:2.0
	5	154	26	3.7	42	8.0	1:1.6
	6	161	22	3.8	51	7.9	1:2.3
	7	142	26	3.9	60	7.8	1:2.3
	6	146	34	3.8	64	7.7	1:1.8
	7	153	37	3.9	51	8.0	1:1.3
	6	163	18	3.7	42	8.1	1:2.3
	5	142	19	4.0	43	7.9	1:2.2
	4	169	27	3.9	49	7.8	1:1.8
	8	134	21	3.7	41	7.9	1:1.9
	7	127	22	3.8	43	7.8	1:1.9
	7	147	23	3.9	47	8.1	1:2.0
	7	161	25	3.9	61	8.0	1:2.4
	5	136	24	4.0	45	8.1	1:1.8
	6	147	21	4.1	56	8.2	1:2.6
	4	149	18	3.9	39	7.9	1:2.1
	4	134	27	3.9	40	7.9	1:1.4
	6	146	16	3.7	29	7.8	1:1.8
	7	155	26	3.8	54	7.8	1:2.0
	5	163	21	3.9	63	7.9	1:3.0
	7	149	23	3.7	39	7.8	1:1.6
	6	136	26	3.6	62	7.6	1:2.0
	4	142	19	4.0	37	7.9	1:1.9
	5	138	17	3.9	39	7.9	1:2.2
Total	145	3,733	581	96.1	1,205	197.5	25:51.2
Max.	7	172	37	4.1	64	8.2	1:1.7
Min.	4	127	16	3.6	29	7.6	1:1.8
Av.	6	149	23	3.8	48	7.9	1:2.0

Accession: 1468

Age: 4 years

Species: Bovine

Remarks: Localised scar tissue
but normal on sectioning.

	No. of Renal Corpuscles in Microscopic Field	Size of Renal Corpuscle	No. of Endothelial Cells in One Section of Glomerulus	and Size of One Nucleus	No. of Epithelial Cells in One Section of Glomerulus	and Size of One Nucleus	Ratio of Endothelial Cells to Epithelial Cells in Glomerulus
	6	192	30	4.0	39	7.8	1:1.3
	7	181	45	4.1	49	8.1	1:1.0
	7	163	30	3.9	37	11.7	1:1.3
	5	152	36	4.0	51	8.0	1:1.4
	5	114	35	4.2	46	7.8	1:1.3
	3	161	41	4.0	51	7.0	1:1.2
	5	158	50	4.2	61	7.9	1:1.2
	4	173	38	4.2	44	7.8	1:1.1
	3	172	35	4.0	39	7.8	1:1.1
	6	168	36	4.0	40	8.1	1:1.1
	5	173	42	3.9	59	7.8	1:1.4
	6	142	37	3.7	43	8.2	1:1.1
	5	157	36	4.1	54	8.0	1:1.5
	6	183	35	3.9	42	8.2	1:1.2
	4	176	32	4.0	36	8.1	1:1.1
	3	169	39	3.7	42	7.8	1:1.0
	4	142	32	3.9	37	8.0	1:1.0
	4	137	33	3.7	40	7.9	1:1.2
	8	181	40	4.0	51	8.3	1:1.2
	6	162	18	4.1	33	8.0	1:1.8
	6	134	39	3.7	47	8.1	1:1.2
	3	142	28	3.6	39	8.2	1:1.3
	4	153	43	3.8	52	7.9	1:1.2
	5	171	31	3.9	42	7.8	1:1.3
	5	136	29	3.9	37	8.0	1:1.2
Total	125	3,992	890	98.5	1,111	202.3	25:30.7
Max.	7	192	50	4.2	61	11.7	1:1.2
Min.	3	134	18	3.6	33	7.0	1:1.6
Av.	5	160	36	3.9	44	8.1	1:1.2

Discussion

It will be noted that as far as possible decimal figures have been avoided. This was felt advisable since these compilations can be at the best only approximations. The number of renal corpuscles in the microscopic field varies greatly. At birth the average number is near twenty-three, while in the adult animal there are approximately five. This would signify that one of three things has happened. 1. There has been a loss of glomeruli. 2. The interglomerular tissue has increased in amount. 3. The glomeruli have become much larger.

It is very unlikely that a significant loss of glomeruli could occur without noticeable lesions resulting. It must be considered true that the interglomerular tissue increases its volume when we note the increased weight of the kidneys with the little change in the medulla. Our figures would seem to indicate that there is an enlargement of the renal corpuscle from about 80 microns at birth to 200 microns at maturity. Thus, we may suppose the reason for the decrease in number of renal corpuscles in a standard microscopic field is due to two factors. 1. A great increase of interglomerular tissue. 2. A slight enlargement of the renal corpuscle itself.

The size of a normal vascular endothelial nucleus would appear to be about 4 microns. In the four cases of suspected nephritis, two of them revealed the vascular endothelial cells to be 5 microns. In the other two, there was no significant difference. The average size of the nuclei of the normal glomerular visceral epithelial cell would appear to be close to 8 microns. In two of the suspected nephritis cases, the same cases in which the endothelial nuclei were 5 microns,

the average epithelial nucleus was but 7 microns. These nuclei had a condensed, almost pyknotic appearance of the chromatin material, while the endothelial nuclei showed the exact opposite condition.

The bovine at birth apparently has fewer endothelial cells in comparison to epithelial cells; the ratio is about 1:3. This is apparently due to the two obvious factors; that is, both an increase of epithelial cells over the adult glomerulus, and a smaller number of endothelial cells. (Acc. 3509). As the animal becomes older, we find that these two cells become more equal in numbers, but this would appear mainly due to a propagation of the vascular endothelial cells.

In the four suspected pathological cases, we find the ratio low in each one except 3441 when we consider what the ratio would be in the normal animal.

Thus, in 3221 ratio is 1:1.7, normal would be 1:3

In 3200 " " 1:1.3, " " " 1:3

In 3482 " " 1:1.5, " " " 1:2

In 3441 " " 1:1.5, " " " 1:2

This appears to be due to a desquamation and loss of the epithelial cells. This observation is especially significant when we note epithelial cells in the subcapsular space. It is suggested that the significant lesion may be intercapillary.

Summary

1. Growth of interglomerular tissue is mainly responsible for the reduced number of the renal corpuscles in a constant section of a kidney from birth to maturity.

2. The size of a normal vascular endothelial nucleus is about 4 microns. The nuclei may enlarge to 5 microns in a nephritic condition.

3. The size of a normal glomerular visceral epithelial cell would appear to be 5 microns. In a nephritic condition they are on an average 7 microns.

4. The ratio of vascular endothelial cells to glomerular visceral epithelial cells becomes lower in a glomerulo-nephritis. This may be due to a desquamation of the epithelial cells.

THE NUMBER, SHAPE, STRUCTURES AND SURFACE AREA OF THE GLOMERULI IN THE KIDNEYS OF THE BOVINE

Introduction

As far as is known, there has been no estimate of the number of renal corpuscles in the kidney of the bovine using recent scientific technique as described by Moore (20). The number of renal corpuscles is of prime importance in determining the surface area of the filtering apparatus of the kidneys, which is necessary to estimate the physiological function of the kidney.

Review of Literature

In regard to the human kidney, the estimates given are indeed varied and show that until recently no work of an accurate nature has been accomplished.

Some of these results are as follows, as quoted from Vintrup (14):

Eysenhardt	(1815)	estimates there are	42,000,000 renal tubules
Huschke	(1828)	estimates there are	2,100,000 glomeruli
Sappey	(1886)	estimates there are	560,000 glomeruli
Putter	(1911)	estimates there are	1,900,000 for both kidneys
Kittelson	(1917)	estimates there are	1,040,000 for one kidney
Traut	(1923)	estimates there are	4,500,000 for one kidney

The number of glomeruli in the kidneys of different animals are given as follows for one kidney, as quoted from Vintrup (14):

Pig	Schweigger (1865)	500,000
	Putter (1911)	700,000
Cat	Miller and Carleton (1895)	16,000
	Peter (1909)	2,000,000 to 3,000,000

Rabbit	Putter	(1911)	230,000
	Conway and O'Connor	(1923)	55,000
Dog	Brodie and Thackrah	(1914)	142,000 and 125,000
Rat	Kittelson	(1917)	28,863
Sheep	Putter	(1911)	4,025,000
Ox	Putter	(1911)	4,025,000
Frog	Haymann	(1925)	3,650 and 6,460

Most of these figures are based upon counting the glomeruli in a small unit of cortex and then computing the number in the entire kidney.

A method has now been developed and is in use which is accurate to a high degree in determining the number of glomeruli in animals. This method is advocated by Traut (12), Vintrup (14) and Moore (20).

The results obtained by these authors correspond closely. Some of their counts are reproduced here (number of glomeruli in one kidney):

Man, child	887,399 (14)
Man, child	955,251 (14)
Man, adult	833,992 (14)
Man, adult	867,177 (14)
Man, adult	1,233,360 (14)
Cat, adult	171,165 (14)
Cat, adult	173,805 (14)
Cat, adult	202,813 (14)
Dog, 8 kg.	407,155 (14)
Dog,12 kg.	507,913 (14)

Rat, albino	33,826 (14)
Rabbit	200,000 (14)
Man, adult	557,619 (14)
Man, adult	1,005,483 (14)

Moore (20, Arataki (21) and Kittelson (4) are in agreement that there is an active postnatal nephrogenesis with the formation of new glomeruli in the kidney of the white rat up to 500 days of age. Moore (20) has shown that it does not exist in man, and my figures would indicate that no postnatal nephrogenesis takes place in the bovine. Moore (20), Arataki (21) and Moore and Hällman (16) show that there is a loss of glomeruli in man and rat during senility. This loss of glomeruli amounts to one-half to one-third of adult numbers. This has not been confirmed in my bovine cases, although in all probability the same condition exists.

Case 1623 has glomerular counts for both kidneys and the results are in agreement with the findings of Hayman and Starr (3), and Moore and Lukianoff (15), that the total number of glomeruli in each kidney as a rule approximate each other. The difference is close to ten per cent.

Method of Counting the Renal Corpuscles in the Bovine Kidney

1. The kidney is removed at autopsy with great care and the renal artery is cannulated and irrigated with physiological saline solution at 400 mm. mercury pressure. Air must not be permitted to enter the injection apparatus since it collects in the capillaries and cannot be voided. Irrigation is continued until the solution from the renal vein is clear and bloodless. This generally necessitates the

use of two litres of the solution.

2. The kidney is now placed in the refrigerator for 18 hours to allow rigor mortis of the blood vessels to pass off.

3. The renal artery is now cannulated again and a compound solution consisting of 15 per cent iron ammonium citrate and 1.5 per cent aqueous potassium ferrocyanide is injected at 600 mm. mercury pressure. Repeated temporary occlusion of the renal vein helps to raise the pressure within the kidney and insures more complete injection. Three litres should be used to give complete injection. After injection is completed the kidney is cut into 10-12 sagital sections and the cortex is removed from the medulla. Because of the lobation of the bovine kidney this is a delicate problem. It was found by careful manipulation that the cortex can be peeled off at the proper place. By this technique the arcuate vessels are exposed and are always adherent to the cortical material.

4. Weigh cortex and medulla and record.

5. Place in 20 per cent hydrochloric acid for 24 hours.

6. Dry on blotting paper for 15 minutes. Weigh the cortical material.

7. Three samples are now chosen for the computing. Each sample is composed of ten pieces of cortex taken at different points. The selections were made as follows:

a. Column of Bertini, close to medulla.

b. Midway between medulla and capsule along column of Bertini.

c. Close to capsule at column of Bertini.

d. Close to medulla at centre of lobe.

e. Midway between medulla and capsule at center of lobe.

f. Close to capsule at center lobe.

Each sample is carefully weighed.

8. Replace each sample in 20 per cent HCl and leave until it can be pulled apart with slight pressure, 1-10 days.

9. Several pieces of weighed medulla are also placed in 20 per cent HCl until partially digested.

10. Carefully wash samples and suspend in a mixture of three parts glycerol and one part of 10 per cent aqueous chloral hydrate. Macerate the samples further until an even suspension is obtained.

11. A pipette is used to obtain a small quantity of the suspension which is placed on a slide and a cover slip is applied without pressure on it.

12. An accurate stage is used and every glomerulus is counted in the sample.

13. The mathematics are simple and are explained by cases studied.

Discussion of Errors

It is seen that errors in using this method may be many, yet on close scrutiny it is apparent that these errors may be largely controlled.

1. Blood clotting in the vessels may be thought to cause obstruction to the injection of the chemical solution. These do not form, however, in the arterial side of the circulatory vessels, and they are completely washed out of the veins by the pre-injection of the saline solution.

2. The count may be materially lowered if some glomeruli have not been injected. This can be checked by fixing some of the discarded cortex in 10 per cent formalin and using the frozen section method,

cutting at 20 microns and carefully count several hundred glomeruli and determine how many were not injected.

My injections have been approximately 98 per cent perfect.

3. Separation of cortex and medulla is the most likely step for errors to creep in. This is also checked by making frozen sections of both medulla and cortex and determining how much of either tissue has been separated in the wrong place. As far as could be determined by this method, the technique employed is accurate to within a very small fraction.

The medulla has also been digested in two cases and the glomeruli counted. The results of this will be seen in the cases studied.

4. Prolonged emersion in the HCl may result in the digestion of the glomeruli. This must be carefully guarded against by close observation of the material. When the cortex can be easily separated with two needles, the digestion is sufficient and should be stopped.

5. Loss of samples by washing; sediment left in bottle or pipette. It may be necessary to use 20 cc. of glycerol-chloral hydrate to dislodge a small fragment of tissue in the bottle or pipette, but it may always be accomplished if time and care are taken.

Case 1.

Acc. 1618

History: Bovine, grade, one month old. Slaughtered for food purposes and kidneys saved. The before mentioned technique is used to inject the glomeruli.

Weight of right kidney after injection and separation of medulla and cortex 135.98 gm.

Weight of cortex 116.04 gm.

Weight of medulla 19.94 gm.

Ratio of medulla: cortex is approximately 1:5.

Weight of cortex after 24 hours' digestion with 20 per cent HCl is 84.5 gm.

Weight of medulla after 24 hours' digestion with 20 per cent HCl is 12.3 gm.

The following samples are chosen and remacerated. The number of glomeruli in each sample is as follows:

Sample 1.		1.65 gm.
202	412	133
205	186	384
394	206	264
314	249	351
218	328	263
341	314	322
297	293	316
283	368	408
323	257	365
445	263	422
346	408	380
297	376	354
412	351	403
385	297	367
337	309	300
426	236	125
394	245	418
263	294	361
324	411	227
208	263	402
193	362	384
309	291	20,484

Sample 2.		1.67 gm.
382	243	262
350	276	275
328	278	281
282	227	177
197	313	382
243	241	366
179	328	148
331	278	309
284	309	312
224	278	265
335	226	378
277	210	363
246	281	379
210	243	295
153	209	13,316
231	193	
391	348	

Case 1. Continued

Sample 3. 1.64 gm.	Sample 4. 1.52 gm.	
200	215	322
162	304	269
318	196	228
221	211	219
314	346	245
169	181	226
327	312	341
294	335	294
247	227	209
263	234	319
292	391	86
278	282	13,689
269	254	
307	246	
192	291	
141	187	
398	273	
221	301	
209	216	
215	342	
296	273	
283	254	
278	278	
255	226	
266	121	
362	251	In this case 640
320	265	glomeruli were
327	240	counted in the dis-
136	273	carded cortical
219	243	material for the
306	368	completeness of
213	335	staining. Only ten
268	299	were found to contain
239	304	no stain.
247	296	
348	226	
382	205	
364	216	
214	291	
327	354	
368	212	
329	385	
326	214	
476	256	
290	241	
12,476	210	

The total amount of medullary substance in this case has been macerated and counted after separation from the cortex. The number of glomeruli is as follows:

13	18	18	11	15
16	11	19	19	17
18	14	14	10	12
14	18	11	16	18
9	14	16	14	14
16	12	13	13	16
2	19	15	17	18
14	17	18	15	13
16	18	17	13	15
17	14	13	18	15
11	12	16	16	17
17	16	12	19	13
18	11	11	12	12
13	16	16	15	17
19	13	13	10	15
16	15	18	14	17
13	13	14	15	18
12	18	10	14	12
16	14	13	18	14
14	18	14	15	18
18	12	17	17	13
9	16	22	18	13
15	11	25	14	11
23	18	23	13	16
15	10	15	16	14
17	16	17	15	18
14	12	13	14	13
17	19	15	17	12
12	15	16	16	11
11	12	17	12	11
14	11	14	18	1
12	21	18	15	15
16	15	21	10	17
13	17	24	15	13
11	14	26	18	17
17	19	17	16	14
14	9	18	14	12
18	21	15	17	21
12	15	11	10	20
16	17	15	15	16
13	16	16	17	18
18	19	18	18	13
11	20	13	12	12
18	13	14	16	16
15	10	17	19	16
12	12	12	13	10
13	21	18	15	9

Medullary count of glomeruli. Continued.

15	15	6	11	17
21	18	16	15	15
13	12	12	12	18
18	14	15	18	25
16	13	10	19	27
14	7	18	14	28
14	15	19	12	15
18	12	7	15	17
19	8	5	17	26
13	12	24	11	23
12	13	24	14	18
17	14	16	17	16
18	12	18	18	20
12	16	23	14	16
16	10	18	15	21
12	16	16	10	24
18	20	27	24	15
13	13	14	15	12
17	11	16	15	26
16	14	28	17	14
18	13	23	18	9
13	15	25	12	27
19	16	16	14	12
14	17	22	17	8
13	13	18	17	11
11	16	17	18	16
18	12	26	12	7
13	17	24	17	15
18	10	17	18	16
15	16	12	13	23
19	14	9	16	21
10	10	13	12	25
14	12	25	17	27
16	21	10	18	14
12	17	17	14	18
12	18	8	12	21
15	17	16	17	25
14	11	23	18	28
11	20	26	12	13
18	13	20	17	12
8	17	14	13	7
6	11	17	12	24
19	7	17	14	28
13	3	8	16	11
16	9	14	11	14
5	15	10	18	23
18	5	16	19	21
17	13	13	13	28
12	17	18	25	16
14	15	13	23	13
18	8	19	21	15

Medullary count of glomeruli. Continued.

17	11	18	14	13
13	18	13	22	13
17	19	10	16	15
9	15	12	17	12
11	13	16	12	18
16	16	17	18	16
7	17	13	14	12
15	12	11	16	15
17	14	16	15	18
13	17	16	14	16
12	15	15	15	16
8	19	17	13	13
6	14	14	17	11
12	12	18	21	17
17	10	13	21	18
14	10	12	20	14
17	21	17	16	19
16	14	11	14	20
13	17	16	18	21
16	18	19	14	19
17	13	15	12	17
13	15	10	18	16
17	23	21	16	14
8	16	24	14	18
14	18	16	12	16
16	15	17	18	15
9	18	10	21	13
15	9	15	24	18
12	21	12	23	13
18	17	15	18	19
12	18	16	19	12
17	15	13	17	9
8	17	12	14	24
16	13	17	15	14
21	19	18	12	13
15	15	13	18	16
18	17	11	21	12
22	20	14	23	17
16	17	17	20	15
14	13	17	10	17
17	11	12	14	14
12	14	16	16	12
18	9	18	15	15
12	10	13	17	17
19	16	13	13	13
14	17	11	11	16
12	18	11	17	14
15	10	16	14	12
17	15	18	13	18
12	17	21	15	14
18	12	19	17	18

Medullary count of glomeruli. Continued.

13	21
12	18
17	23
18	17
12	18
18	15
14	23
17	22
14	17
12	15
16	17
13	18
18	14
11	21
17	18
18	19
13	15
18	23
14	15
17	17
15	13
17	17
14	14
18	18
12	19
16	12
11	18
18	12,777
15	
11	
13	
17	
15	
18	
19	
13	
15	
15	
21	
24	
10	
9	
16	
18	
14	
12	
12	
16	
18	

Case 1.

Acc. 1618

Sample 1.

1.65 gram of cortex contains 20,484 glomeruli

1 " " " " 12,414 "

Sample 2.

1.67 gram of cortex contains 13,316 glomeruli

1 " " " " 7,907 "

Sample 3.

1.64 gram of cortex contains 12,476 glomeruli

1 " " " " 7,607 "

Sample 4.

1.52 gram of cortex contains 13,689 glomeruli

1 " " " " 9,005 "

Average number of glomeruli per gram is:

$$\begin{array}{r} 12{,}414 \\ 7{,}907 \\ 7{,}607 \\ \underline{9{,}005} \\ 36{,}933 \end{array} \div 4 = 9{,}233$$

Weight of entire cortex is 84.5 grams. Therefore, the number of glomeruli in Case 1 is 84.5 x 9,233 = 780,189. But the medullary substance contains 12,777 glomeruli by actual count.

The percentage of error which resulted from the separation of cortex from the medulla was approximately one per cent.

Case 2.

Acc. 1624

History: Bovine, Aberdeen Angus, five years' old. Slaughtered for food purposes and kidneys saved.

Fresh weight: Right kidney 301 gm.

Left kidney 303 gm.

Weight of right kidney after injection of chemical but before separation of medulla and cortex 401 gm.

Weight of left kidney 425 gm.

Weight of cortex of left kidney before putting in 20 per cent HCl and after injection with chemical 358 gm.

Weight of medulla 55 gm.

Weight of cortex of right kidney after injection of chemical and before putting in 20 per cent HCl 325 cm.

Weight of medulla 60 cm.

Weight of cortex of left kidney after maceration for 24 hours and dried 15 minutes is 233 gm.

Sample No. 1 1.7 gm.

Sample No. 2 2.39 gm.

Sample No. 3 1.9 gm.

Weight of cortex of right kidney after maceration for 24 hours and dried 15 minutes is 238 gm.

Sample No. 1 1.72 gm.

Sample No. 2 1.37 gm.

Sample No. 3 2.1 gm.

Case 2.

Acc. 1624

Right Kidney

Sample 1. 1.72 gm.	Sample 2. 1.37 gm.	Sample 3. 2.1 gm.
212	316	147
202	274	446
294	255	492
361	304	386
247	342	346
196	253	366
278	169	313
227	207	372
273	251	441
286	197	329
241	276	260
280	284	360
305	319	288
210	164	436
285	235	162
346	338	379
233	261	265
314	4,445	347
188		284
233		316
247		296
126		412
277		97
318		7,540
390		
180		
73		
6,821		

In this case 718 glomeruli were counted in the discarded cortical material. Only nine glomeruli were found containing no dye.

Case 2.

Acc. 1624

Right Kidney

Sample 1.

1.72 gram cortex contains 6,821 glomeruli

1 " " " 3,965 "

Sample 2.

1.37 gram cortex contains 4,445 glomeruli

1 " " " 3,244 "

Sample 3.

2.1 gram cortex contains 7,540 glomeruli

1 " " " 3,590 "

Average number of glomeruli per gram is:

$$\begin{array}{r} 3,965 \\ 3,244 \\ \underline{3,590} \\ 10,799 \end{array} \div 3 = 3,599$$

Weight of entire cortex is 233 gm. Therefore, total number of glomeruli is 838,567.

Case 2.

Acc. 1624

Left Kidney

Sample 1. 1.7 gm.	Sample 2. 2.39 gm.	Sample 3. 1.9 gm.
245	376	244
229	289	281
94	345	267
183	303	324
175	314	198
277	410	273
243	408	246
258	343	269
220	335	291
197	361	247
350	267	256
157	342	312
273	281	309
233	109	279
454	294	283
251	193	294
141	342	318
238	312	262
280	214	239
217	329	253
323	261	314
347	253	281
369	324	244
242	284	268
301	247	309
250	269	280
298	319	266
215	286	214
284	270	231
240	309	220
362	262	206
249	9,251	210
8,195		227
		8,715

In this case 934 glomeruli were counted in the discarded cortical material. Only sixteen were found containing no dye.

Case 2.

Acc. 1624

Left Kidney

Sample 1.

1.7 gram cortex contains 8,195 glomeruli

1 " " " 4,820 "

Sample 2.

2.39 gram cortex contains 9,251 glomeruli

1 " " " 3,870 "

Sample 3.

1.9 gram cortex contains 8,751 glomeruli

1 " " " 4,586 "

Average number of glomeruli per gram is:

$$\begin{array}{r} 4,820 \\ 3,870 \\ \underline{4,586} \\ 13,276 \end{array} \div 3 = 4,425$$

Weight of entire cortex is 238 gm. Total number of glomeruli is $238 \times 4,425 = 1,053,150$.

Since the number of glomeruli in both kidneys of Acc. 1624 has been counted, we can determine the percentage difference of glomeruli in the kidneys of this case.

Number of glomeruli in left kidney 1,053,150

Number of glomeruli in right kidney 838,567

The percentage difference is 11 per cent.

Case 3.

Acc. 1623

History: Bovine, Aberdeen Angus, 11 years' old. Slaughtered for food purposes and kidneys saved.

Fresh weight: Right kidney 485 gm.

Left kidney 497 gm.

Weight of right kidney after injection with chemical but before separation of medulla and cortex is 669 gm.

Kidneys have been injected with potassium ferrocyanide and ferric ammonium citrate and the cortex has been separated from the medulla.

Weight of cortex 577.2 gm.

Weight of medulla 76.0 gm.

Weight of right cortex after maceration for 24 hours and dried 15 minutes is 393 gm.

Sample No. 1 1.68 gm.

Sample No. 2 2.12 gm.

Sample No. 3 1.97 gm.

Weight of medulla after maceration for 24 hours and dried 15 minutes is 56 gm.

Case 3.

Acc. 1623

Sample 1. 1.68 gm.	Sample 2. 2.12 gm.	Sample 3. 1.97 gm.
298	236	314
340	241	284
243	378	269
254	165	194
442	311	285
344	402	310
259	359	387
288	392	298
281	306	319
434	291	264
310	348	238
318	230	411
241	407	380
277	382	265
336	351	284
355	374	280
242	369	366
223	389	400
192	402	289
183	432	226
236	196	361
274	243	295
289	360	343
327	248	386
6,986	259	269
	281	278
	311	8,095
	372	
	351	
	408	
	359	
	299	
	10,452	

The total amount of medullary substance in this case has been macerated and counted after separation from the cortex. The number of glomeruli is as follows:

8	11	11	14	17
15	17	15	17	13
16	16	14	12	18
18	14	16	16	12
14	9	12	18	18
12	10	13	13	11
18	14	15	17	16
16	12	11	15	18
13	17	17	18	21
18	17	10	14	13
12	18	17	18	19
16	15	21	15	12
14	14	17	14	18
19	17	10	13	16
10	9	14	16	14
14	16	16	18	18
17	8	17	13	17
12	16	13	19	12
18	15	18	10	16
14	12	14	10	12
18	18	16	14	16
19	11	13	17	12
13	9	18	20	14
12	15	12	21	11
16	17	15	16	11
17	18	11	10	14
18	5	16	16	13
13	14	18	17	18
13	21	14	14	12
15	16	17	12	15
19	18	10	17	16
11	13	9	11	15
22	12	17	18	13
21	15	15	13	11
16	8	18	18	18
18	18	20	14	13
14	16	18	18	17
10	14	16	13	11
17	7	17	17	18
13	16	12	12	14
15	13	15	18	13
13	15	19	19	16
16	12	15	12	12
15	14	17	10	18
12	11	13	13	13
17	10	18	16	16
8	11	10	16	11

Medullary count of glomeruli. Continued.

18	8	18	14	16
10	16	12	19	13
10	23	16	16	18
14	17	13	20	11
13	18	19	21	19
12	15	15	11	20
16	16	17	14	13
11	12	12	18	15
13	18	11	16	17
18	13	15	19	19
13	17	18	13	10
18	13	16	18	12
10	16	10	15	15
21	11	18	18	17
14	18	22	13	14
8	12	18	12	18
14	16	10	12	12
11	14	14	10	17
13	18	17	25	19
7	9	15	17	14
14	15	13	15	16
16	18	16	19	21
18	22	13	9	11
13	17	15	16	15
16	15	17	21	16
15	17	16	16	18
12	12	13	18	21
18	15	17	13	17
16	15	12	16	19
14	11	18	11	14
15	14	16	18	17
12	9	17	14	12
17	15	14	16	16
11	17	16	13	24
1	15	12	15	17
9	17	17	14	15
16	13	14	18	14
15	8	16	13	16
19	15	14	19	18
15	17	17	10	12
13	14	10	16	12
17	18	18	23	15
15	19	12	16	17
18	14	15	18	15
13	19	11	19	18
12	16	15	16	13
16	14	13	17	19
18	12	17	13	16
14	16	13	12	18
13	19	11	13	12
13	17	18	11	15

Medullary count of glomeruli. Continued.

11	18
18	13
12	16
19	10
14	12
11	16
18	17
10	17
18	8,166
13	
15	
10	
16	
18	
13	
12	
16	
11	
11	
19	
17	
18	
14	
18	
12	
16	
11	
17	
19	
18	
14	
20	
23	
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17	
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17	
20	
23	
18	
15	
12	

Case 3.

Acc. 1623

Sample 1.

1.68 gram cortex contains 6,986 glomeruli

1 " " " 4,158 "

Sample 2.

2.12 gram cortex contains 10,452 glomeruli

1 " " " 4,953 "

Sample 3.

1.97 gram cortex contains 8,095 glomeruli

1 " " " 4,109 "

Average number of glomeruli per gram is:

$$\begin{array}{r} 4,158 \\ 4,953 \\ \underline{4,109} \\ 13,220 \end{array} \div 3 = 4,406$$

Weight of entire cortex is 393 gm. Therefore, total number of glomeruli is 1,731,558. But the medullary substance contains 8,166 by actual count. The total number of glomeruli is 1,731,558 + 8,166 = 1,739,724.

The Structure of the Glomerulus

When the results of eleven kidney injections have been reviewed, the internal structure is made considerably clearer. Often my specimens were not completely injected and thus had to be thrown out since a reliable count could not be obtained from these.

These specimens, however, afforded a fine chance to observe the capillaries of the glomerulus. In these cases it was often found that only a few capillaries were injected; in one instance two loops only were partially filled with the blue dye. In these instances there were never any branchings observed from one capillary loop to the other, nor did I see any of the blue dye in the efferent arteriole if the glomerular capillaries were not completely injected.

The afferent arteriole may be clearly seen to subdivide into 2-5 primary branches; this was seen especially well in one case where the capillaries did not seem to inject easily, but in which the afferent arterioles were well engorged. These branches seem to determine the number of lobules which the glomerulus will have. One lobule is formed by the capillaries from one primary branch of the afferent arteriole. The number of lobules varies from 2-5 and may even vary from 2-7.

The Size and Shape of the Glomerulus

The size of the glomerulus varies according to age. From the observations of Langham, and those of my own, the following measurements have been obtained from bovine kidneys:

Bovine at birth	80	microns
Bovine at one month	149	"
Bovine at one year	170	"
Cow at two years	200	"
Cow at five years	215	"
Cow at eleven years	220	"

The average would seem to be near 200 microns. The bovine glomerulus appears in my macerated specimens to be almost constantly ovoid in shape. This is the shape it assumes when the capsule is present and the capillaries are filled with fluid, which would simulate the normal physiological active period during life.

The Surface Area of the Bovine Glomerulus

There are about 50 capillary loops in a glomerulus and each loop is somewhat more than twice the diameter of the renal corpuscle, and may thus be taken to approximate 500 microns. The capillary length in a glomerulus will then be 25,000 microns or 25 mm. This will be a total length of 25 km. for the capillaries in a kidney, if we assume there are 1,000,000 glomeruli in the kidney. The diameter of a capillary is close to 10 microns. Therefore, circumference of capillary is

$$10 \times \frac{22}{7} = \frac{220}{7} \text{ u.}$$

Surface area of capillary in a kidney is

$$\frac{220}{7} \times 25{,}000{,}000{,}000 = .78 \text{ square metres}$$

Summary

1. The number of glomeruli in the normal bovine kidneys appears to vary to some degree. The lowest count of four was 800,000. The highest count was 1,700,000. The average would appear to approximate 1,000,000.

2. Each of the two kidneys from one animal contain approximately the same number of glomeruli.

3. There is probably no postnatal nephrogenesis of glomeruli in the bovine kidney.

4. The surface area of the capillaries in the bovine glomerulus approximates one square metre.

5. There appears to be no anastomosis of the capillaries of the normal glomerulus.

6. The glomerulus is divided into lobules corresponding to the primary branchings of the afferent arterioles. There are generally 2-5 lobules, but there may be as many as 7.

7. There is a postnatal enlargement of the renal corpuscle from 80 microns at birth to 220 microns at eleven years of age.

Table of Contents

Introduction

Pneumonia has in past years been a scourge of the live stock industry. It has become an accepted evil by our breeders. Its demoralizing effects have been felt by all those who have raised and cared for animals for any length of time. The purpose of this paper is to obtain some knowledge of the pathology and etiology of this dread condition and in this manner forward progress toward the extinction of pneumonia.

It is essential that we have a knowledge of the bacterial flora of the diseased lung. The prophylaxis and treatment of the condition is completely dependent upon this knowledge. It is also essential to be able to correlate the pathological changes with the bacteria present.

Review of Literature

Literature on the etiology of pneumonia in domestic animals is rather abundant. There is, however, paucity in regard to the morbid anatomical changes present in this condition. In particular, there is little correlation of the etiology and pathology of the diseased lungs.

Carpenter and Gilman (36) in 1921 have reported on calf pneumonia in New York state. They find that the lesions vary according to the chronicity of the condition. Their descriptions are that of a bronchopneumonia in its various stages. The bacteria found varied, but a streptococcus was the most consistent and predominating. Smith has reported on pneumonia in calves in three conditions. In 1925 (23) associated with scours and a bacteremia in young calves caused by Bacillus coli. In 1925 (35) he found Brucella abortus

infection to be the cause of fetal and new born calf pneumonia. In 1917 (24) an epidemic of pneumonia was found due to Bacillus actinoides. Fetal pneumonic lesions associated with Brucella infection have been described by Hallman, Sholl and Delez (25). Thorp (26) has studied calf pneumonia in a very complete and exhaustive manner and has shown that a characteristic bronchopneumonia is associated in many instances with a hemolytic streptococcus.

Pneumonia in sheep has been long recognized to occur in two forms. The more common is the acute condition, Kelser (7). The condition is often described as necrotic pneumonia and is due to Pasteurella ovisepticus. The chronic form of pneumonia has been found due to the Preisz-Nocard bacillus and has been known as pseudo-tuberculosis since 1887, Nocard (32), Preisz and Guinard (33). Spray (1) has reported exhaustively on pneumonia of sheep in Chicago packing houses. The majority of his cases were due to Pasteurella infection and were acute and subacute in duration. Rosenbusch (37) has studied cultures of Pasteurellae from pneumonia in hogs, sheep, and bovines. He divides the strains into two main groups. The one group is atypical on the basis that there is hemolysis on blood agar. The typical strains were subdivided into three strains on fermentation and serological differences. Newson and Cross (22) describe the Pasteurella from cases of pneumonia in sheep and divide them into three groups. They suggest Pasteurella hemolytica as a name for the atypical group which they isolated. Montgomerie, Bosworth and Glover (33) have studied an enzootic pneumonia of sheep probably due to Pasteurella and causing a typical bronchopneumonia. McBride (30) (31) has found B. coli and Sal. suipestifer the cause of pneumonia in hogs. The B. coli

infection was always of a septicemic nature when causing pneumonia. Benner (6) lists P. suisepticus as being of great importance in swine pneumonia. Literature on the virus pneumonias of hogs has not been reviewed in this work since it does not appear pertinent to this study. Kelser (7) states that the duration of pneumonia in hogs due to Pasteurella suiseptica may be acute or chronic.

Etiological and Pathological Study

The Specimens Studied.

The source of material has been from animals submitted for autopsy to the Pathology Department, M.S.C. No lungs were used for bacteriological or pathological examination if the animal had been dead for four hours or longer.

Method of Anatomical Studies.

Photographs were taken of many of the pneumonic lungs so as to give a clear view of the extent of the lesions and to eliminate detailed and often obscure descriptions of the involved areas.

The following method was used to identify the pieces of tissue taken for study.

R or L was sufficient to designate the right and left lung. Similarly, D and V were used to designate sections from the dorsal and ventral surfaces.

A signified the apical lobe

C signified the cardiac lobe

D signified the diaphragmatic lobe

I signified the intermediate lobe

All tissues taken for microscopic examination were immediately fixed in Zenker's solution and paraffin embedded for sectioning. The

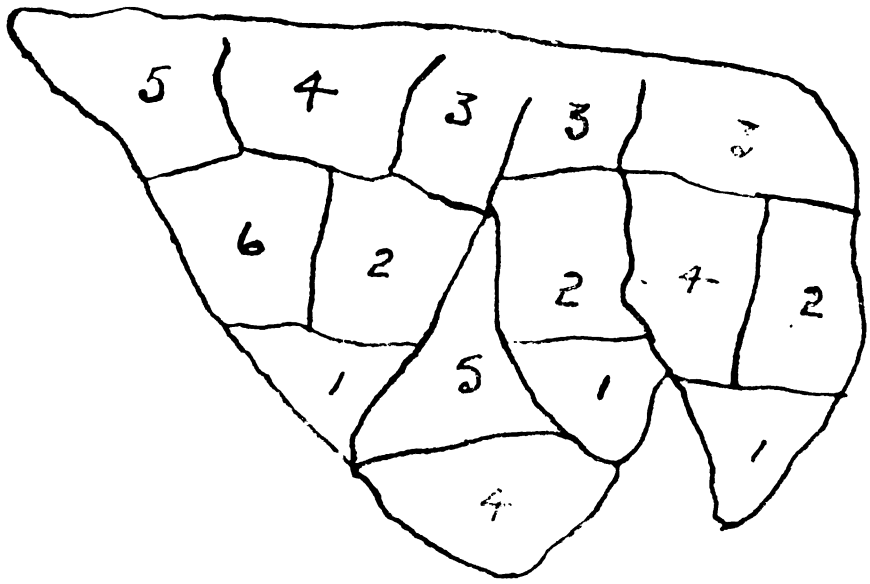
sections were cut at 8 microns and stained by the hemotoxylin and eosin method.

In some sections it was felt that a connective tissue stain would be valuable. The Mallory-Heidenhain triple stain was chosen and used.

Photomicrographs have been taken of representative portions of the sections.

A resumé and correlated account of the pneumonic process is given for each case as has been derived by the author from the sections studied.

DIAGRAM OF LUNG



Autopsy: 4116

Species: Ovine

Age: 6 years

History: The animal has been losing flesh for some time.

Gross Examination.

A bilateral pneumonia involving primarily the anterior extremities of the lungs. The involved areas are reddish-gray in color. The right lung is more massively affected than the left. On the right side there is involvement of the greater part of the apical and cardiac lobes with a small zone of consolidation extending along the periphery of the diaphragmatic for two inches and also extending up to the hilus along the anterior border. The right apical reveals some atelectasis and an emphysematous condition scattered along its surface.

The intermediate lobe is completely consolidated.

The left apical and cardiac lobes show a patchy pneumonic condition of the same duration as the right lung but involving much less area.

The pneumonic process appears to commence at the periphery of a lobe and extend to the hilus.

There were several lung worms in the bronchi of both lungs.

Microscopic Study.

A very characteristic lesion of this case is lymph-node like clusters of round cells which are peribronchial and perivascular in distribution. The cells composing these clusters resemble lymphocytes but they contain more cytoplasm than is usual. These clusters are found in lung tissue which does not show any other lesion, as well as

where there is a very active pneumonic process. There are many polymorphs in the lumen of the respiratory bronchioles in the active area, and some in the alveoli. Where the injury is very recent, the epithelium has been cast off the respiratory bronchioles and can be seen in the lumen. In other localities there is degeneration of the bronchiole epithelium and leucocytes to form a purulent exudate. The mononuclear phagocytes are in the majority in the alveoli while the polymorphs are dominant in the respiratory bronchioles. Here they can be seen accummulating in the mucosa and making their way toward the lumen. There is a peculiar bluish hyalinization of some of the alveolar walls. These appear thickened but there is no cellular proliferation. Some lungworms are noted in the bronchi but do not appear to be causing a marked inflammatory reaction. There is some atelectasis present throughout the anterior lobes.

This is an acute bronchopneumonia.

Organisms found:

1. P. ovisepticus.
2. E. coli.
3. Staph. aureus.

See Fig. I, XXVII, XL.

Autopsy: 4117

Species: Ovine

Age: 6 years

History: Similar to Autopsy 4116.

Gross Examination:

A bilateral pneumonia showing a reddish-gray involvement of the pneumonic area. Probably acute in duration. The right apical and cardiac lobes reveal an early progressing pneumonic condition. There is pronounced edema and a reddish consolidation of these lobes.

The right diaphragmatic has several small areas of consolidation on its dorsal surface.

The left apical and cardiac lobes reveal a patchy, reddish consolidation, intermingled with areas of emphysema and atelectasis. There is complete consolidation of the apex of the left cardiac lobe. The pneumonic areas are concentrated at the periphery of the lobes. The intermediate lobe has a complete consolidation of its peripheral half.

Microscopic Study.

This case shows the variety of lesions which one might say is characteristic of bronchopneumonia. There are areas showing edema and hemorrhage into the alveoli next to ones in which a purulent exudate has made the alveolar walls almost invisible. The first sign of cellular exudation appears to be in the respiratory and terminal bronchioles where the polymorphs invade the mucosa and the lumen. The mononuclear phagocytes, whose origin is probably the septum of the alveoli, next appear in the alveoli. Soon more polymorphs appear and fill the alveoli. Some of the respiratory bronchioles show an early productive tissue

reaction around them. Some rather active fibroblasts are seen in the alveolar walls where the pneumonic exudate is degenerating. There is atelectasis present, especially near the pleura. There are numerous lungworms present in the bronchi but no reaction is noted about them.

This may be termed a subacute bronchopneumonia with a recent flare-up.

Organisms found:

1. P. ovisepticus.
2. E. coli.
3. Strep. hemolyticus.

See Figs. II, III, XXVIII.

Autopsy: 4230

Species: Ovine

Age: 2 weeks

History: Animal's illness was undiagnosed until autopsy. The terminal stage of the disease ran a rapid and acute course.

Gross Examination.

A bilateral pneumonia in various stages which involves all lobes to some degree.

The right lung reveals almost complete consolidation of its anterior two lobes, while the diaphragmatic involvement is more patchy in nature. The apical and cardiac process is in the stage of gray hapatization while that of the diaphragmatic is mixed red and gray. The gray hepatized areas appear to be along the border while the red areas appear to be spreading toward the hilus. There are some small areas at the hilus which are normal.

The left apical and cardiac reveal the same massive involvement in the stage of gray hepatization as the right side did. The left diaphragmatic has a much earlier type of pneumonia than the right. There is edema and congestion present but little evidence of consolidation.

The intermediate lobe has a complete consolidation in the stage of gray hepatization.

Microscopic Study.

Within the apical lobes of this case the whole pathological process of the pneumonia may be studied. Here we find suppurative foci 15 mm. in diameter surrounded by a zone of fibrosis. Many of the respiratory bronchioles in these lobes reveal an early productive

reaction around them and there is desquamation of the epithelium and a marked exudation of polymorphs into the mucosa and lumen of these. This bronchiolitis is especially active and severe in the region of the abscesses. Mononuclear phagocytes are found diffusely scattered in the alveoli while the polymorphs are in clusters at the respiratory bronchioles. The other lobes show a recent extension of the chronic condition seen in the apical lobes.

This is a chronic suppurative condition of the lungs with a recent bronchopneumonia.

Organisms found:

1. Strep. hemolyticus.
2. P. ovisepticus.

See Figs. IV, V, XVIII, XIX.

Autopsy: 4236

Species: Ovine

Age: 3 days

History: The animal is from the college flock. There was difficult respiration indicative of pneumonia. The animal was extremely weak and was killed for examination.

Gross Examination.

The right apical is completely atelectatic and shows signs of a recent pneumonic condition. It is doubtful if this portion of the lung has ever functioned. At the apex of the right cardiac there is a similar small triangular area. There is congestion present in a diffuse manner in both lungs. The left cardiac has similar lesions as the right cardiac. The left diaphragmatic has an atelectatic and pneumonic area in the triangle formed by 6, 2, and 1.

Microscopic Study.

This case is similar in many respects to Autopsy 4237. There is, however, less endarteritis present, and a more typical broncho-pneumonia.

This is an acute bronchopneumonia with a slight endarteritis and phlebitis.

Organisms found:

1. P. ovisepticus.
2. Diplococcus of Spray.

See Figs. VIa, XXXIX.

Autopsy: 4237

Species: Ovine

Age: 2 weeks

History: The animal was progressing nicely until respiratory symptoms developed two days before death.

Gross Examination.

A bilateral pneumonia with massive consolidation.

The right apical lobe is completely consolidated. Most of the lobe is in the stage of red hepatization. The area of gray hepatization is at the apex. There is one small abscess at the apex 5 mm. in diameter. The right cardiac is completely consolidated with the same distribution as the apical lobe. Sectioning the lobe, we note four suppurative areas, the largest of which is 10 mm. in diameter. The right diaphragmatic has a few scattered areas of consolidation. These appear grayish-red in color.

The whole left lung is completely consolidated except for a narrow zone 10 mm. wide extending along the dorsal border of the cardiac into the diaphragmatic. There is hemorrhage here between the capsule and a zone of normal lung. Several suppurative areas are noted, for the main part they are distal to the hilus and appear to be in the tissue which is in the stage of gray hepatization.

The intermediate lobe is completely consolidated with gray hepatization.

Microscopic Study.

This case reveals a peculiar lesion. There are roughly circular areas varying in diameter from .75 mm. to 4.5 mm. The border of the circle is about 140 microns wide and is composed of a

necrotic mass of infiltrated polymorphs and lung tissue. The inner part is also necrotic but there is no cellular exudate here. The lesion is that of an infected infarct. Upon examining the arteries and veins of this case we find a very marked proliferation and thickening of the intima. This has resulted in a great narrowing of the lumen and apparently occlusion in some cases with the resultant infarcts.

The respiratory bronchioles in the non-infarcted area have a productive tissue reaction about them and an increase of mononuclear phagocytes in the mucosa. There is also some productive tissue in the alveolar walls themselves.

The pleura is thickened. The posterior lobes show an extreme congestion and some edema. It would seem that the chronic condition in this case has spread to the blood stream and has caused the endarteritis described. This has in turn destroyed the large areas by means of the infarcts formed which are now infected.

This is a chronic pneumonia with septic infarcts.

Organisms found:

1. P. ovisepticus.

See Figs. VIb, XXXVIII, XLVII.

Autopsy: 4346

Species: Ovine

Age: 4 weeks

History: Five animals have died and four others are sick in a flock which have previously been healthy with the same management. The diagnosis was pneumonia and "stiff lamb disease".

Gross Examination.

A bilateral pneumonia of chronic duration involving only the anterior lobes to any extent.

The right apical and the anterior portion of the right cardiac are completely consolidated. That of the apical lobe is gray hepatization while the cardiac is red. The right diaphragmatic and posterior portion of the cardiac are normal except for a few ecchymotic hemorrhages.

The left apical and left cardiac are completely consolidated and in the stage of gray hepatization. There is one small zone of normal tissue at the hilus. Only one small zone of consolidation is noted in the left diaphragmatic. It is in the stage of red hepatization.

Microscopic Study.

This is a very severe pneumonic condition. Areas of the lung are necrotic. These may be 6 mm. wide. From bronchi down there is complete destruction. The infection has been virulent enough to invade the arteries and veins and destroy them. We note that one side of an artery shows necrosis with invasion of polymorphs and monocytes in its wall. Within the lumen there is a thrombus composed of fibrin intermingled with polymorphs and monocytes. This condition has affected

mainly the anterior lobes. The posterior lobes reveal congestion and edema.

This is an acute pneumonia with arteritis and phlebitis resulting in thrombus formation and massive necrosis.

Organisms found:

1. P. ovisepticus.

2. Diplococcus of Spray.

See Fig. LII.

Autopsy: 4348

Species: Ovine

Age: 4 weeks

History: This animal is from the same flock as Autopsy 4346.

Gross Examination.

A bilateral pneumonia involving mainly the anterior lobes of the lungs. There is a fibrinous pleurisy over these lobes.

The right apical is completely consolidated. The stage is gray hepatization. The lobe is greatly swollen. The lobules stand out because the interlobular septa are depressed, and the lobules elevated. On the ventral surface at 2, there are four lobules which are apparently undergoing suppuration. The anterior division only of the right cardiac is affected. The pathology is similar to the apical but no suppurative areas can be detected.

The left apical is similar to the right and the suppurative areas are definitely along the border and especially near the apex.

The left cardiac contains more suppuration than any other lobe. Almost one-fourth of the lobe is abscessed. The remainder is in the stage of gray hepatization. The triangular area formed by 6, 2, and 1 is consolidated in the left diaphragmatic with red hepatization.

Microscopic Study.

This case is almost precisely similar to Autopsy 4346. The same large areas of necrosis exist, which is apparently due to the infection and blockage of the arteries and veins.

This is an acute pneumonia with arteritis and phlebitis resulting in thrombus formation and massive necrosis.

Organisms found:

1. Diplococcus of Spray.

2. Micrococcus catarrhalis.

Autopsy: 4133

Species: Porcine

Age: 5 months

Hisotyr: The animal was from a vaccinated piggery.

Gross Examination.

A bilateral extensive pneumonia with edema and reddish consolidation.

The right apical and cardiac lobes reveal primarily the same extent and duration of pneumonia, although there are more areas of involvement and of longer duration in the cardiac than in the apical. The apical lobe reveals scattered areas of emphysema and atelectasis.

There is also a generalized pneumonic condition of the right diaphragmatic. The duration on the whole is much shorter than the other lobes, although there are three or four small nodules of red hepatization close to the cardiac lobe.

The left lung is very similar to the right with the exception that the apical lobe has less consolidated areas and possibly a little more emphysema.

The intermediate lobe reveals scattered red hepatization and congestion.

Microscopic Study.

This case is very similar to Autopsy 4134 (which was studied first). There is, however, less damage and the pneumonic process is of longer duration, especially that of the anterior lobes. Hemorrhage is not prominent but there is a great deal of fibrinous exudate. The alveoli appear quite distended in many areas due to this fibrin and some edema. In the active areas, especially the apical lobes, there

is desquamation of the epithelium of the respiratory bronchioles. The mucosa is thickened due to mononuclear phagocytes and edema. There is an accumulation of monomuclear phagocytes in the alveoli and in the mucosae, which is marked but not massive. Congestion of alveolar capillaries is noted in the sections from the diaphragmatic lobes.

This is an acute bronchopneumonia.

Organisms found:

1. P. suisepticus.

See Figs. VII, VIII, XLI.

Autopsy: 4134

Species: Porcine

Age: 5 months

History: The animal was from a vaccinated piggery.

Gross Examination.

A bilateral pneumonia with red hepatization of approximately seven-eighths of the total lung tissue.

The two diaphragmatic lobes present the only non-pneumonic tissue and these areas reveal numerous petechial and ecchymotic hemorrhages. This normal tissue composes one-eighth to one-fourth of the lobe. It extends along the main bronchus towards the posterior border of the lobe but does not extend to either the lateral or dorsal periphery of the lobes. It appears slightly fan-shaped and extends through to the ventral border.

The remaining lobes show almost complete involvement, being in the stage of red hepatization.

Microscopic Study.

There is necrosis of the alveolar walls with massive hemorrhages in many parts of the lung. In other places a sero-fibrinous exudate has taken place in the alveoli. The respiratory bronchioles reveal a marked thickening of the mucosa due mainly to edema and partly to an increase of mononuclear phagocytes. The epithelium of the great majority of them has been completely desquamated. Cellular exudation other than red blood cells is not prevalent but a few mononuclear phagocytes are seen in the alveoli, especially where atelectasis is present, and in the mucosa of the respiratory bronchioles along with a few polymorphs. The interlobular lymphatics are greatly engorged with lymph.

This is a peracute bronchopneumonia.

Organisms found:

1. P. suisepticus.

2. Strep. hemolyticus.

3. B. coli.

See Figs. IX, X, XXIX, XLII.

Autopsy: 4154

Species: Porcine

Age: 5 months

History: The animal has had diarrhea and an anorexic condition for three weeks. Arriving at the autopsy room, his temperature was 102.6°F. and he was in a state of partial coma.

Gross Examination.

In the right cardiac lobe at 2, there is a zone of pneumonia extending from anterior to posterior border of the dorsal surface about one inch wide. When viewed from the ventral surface the zone appears to have started at the hilus and spread toward the apex. The consolidation is of a reddish-gray nature. The right diaphragmatic has a few scattered areas of consolidation. The largest one is at 6 and has a grayish discoloration.

The left cardiac lobe has a consolidated zone extending across and through the lobe at the hilus and down the posterior border almost to the apex. The lesion is in the stage of reddish-gray hepatization. Both diaphragmatic lobes show petechial and ecchymotic hemorrhages.

Microscopic Study.

In the recent areas of involvement there is a well marked fibrinous exudate. Many respiratory bronchioles of the anterior lobes show a productive tissue reaction around them. Many of the active fibroblasts can be seen in the alveolar walls which are showing some thickening due to these cells. This has apparently been a relatively long standing condition. The more recent attack has spread quickly and the congestion, sero-fibrinous exudate,

desquamation of respiratory bronchiolar epithelium has been due to it. There are some polymorphs in the mucosa of the respiratory bronchioles and in the lumen, but the number is not large. The mononuclear phagocytes are more uniformly spread and are in the alveoli.

This is a chronic bronchopneumonia.

Organisms found:

1. Sal. suipestifer.
2. Staph. albus.
3. Strep. hemolyticus.

See Figs. XI, LI.

Autopsy: 4176

Species: Porcine

Age: 4 months

History: The animal is undersized, has shown anorexia and is becoming emaciated.

Gross Examination.

A bilateral pneumonia showing congestion, red and gray hepatization.

The right apical lobe reveals an early involvement of a few small areas 5 to 10 mm. in diameter. The pneumonia is in the stage of congestion and red hepatization with most of the consolidation in the region of the hilus. Both ventral and dorsal surfaces show similar involvement. The right cardiac shows a uniform congestion, and on palpation there are three firm areas about 15 mm. in diameter which can be easily felt but cannot be seen. On cutting into the lobe, these areas are found to be in the stage of gray hepatization and the feel would suggest that there is productive tissue present.

The righr diaphragmatic shows scattered red and gray hepatization. The latter stage; that is, gray hepatization, appears to be more prevalent at 2 and 1. The consolidated portion extends three-fourths of the way along the border toward the posterior apex.

The left diaphragmatic is the only lobe in the left lung showing changes in gross. Here at 1, there is a triangular area consolidated and in the stage of gray hepatization.

Microscopic Study.

The anterior lobes,and in particular the apical lobes, reveal the oldest lesions. The respiratory bronchioles here are

surrounded by a node-like structure about 1 mm. in diameter. These nodes are composed of large numbers of monomuclear phagocytes and many fibroblasts. There are no distinguishable alveolar walls in these nodes. In many of them, only the remnants of the bronchiole can be discerned. Some immature eosinophils are present in many of the nodes, these are probably eosinophilic myelocytes.

The epithelium of the bronchi appear swollen, and cystic structures can be seen in them. This is considered to be due to blockage of the mucous duct. In the older areas of involvement, there is a thickening of many of the alveolar walls due to fibroblastic proliferation within them. A more recent process is seen at the hili of the anterior lobes and throughout the posterior lobes. This consists of a polymorph exudation into the lumen of the respiratory bronchioles, a desquamation of their epithelium and a serous and mononuclear phagocyte exudation into the alveoli with a few polymorphs also.

The pleura seems lined in the anterior lobes with a continual layer of cells of the lymphocyte and monocyte variety.

This is a chronic pneumonia with a recent extension.

Organisms found:

1. P. suisepticus.
2. Strep. hemolyticus.

See Figs. XII, XXXVII, XLVI.

Autopsy: 4179

Species: Porcine

Age: 4 months

History: This animal was the only sick one in the piggery. Before being killed, his temperature was 103°F. Marked prostration was noted. He had been ill for four days.

Gross Examination.

The right apical lobe is completely consolidated with a pneumonic process, with the exception of one small area 5 mm. in diameter near the apex. The stage is red hepatization. Near the hilus of the cardiac lobe there is an area in the stage of red hepatization. The anterior triangle of the right diaphragmatic lobe formed by 6, 2 and 1 is consolidated, being in the stage of red hepatization. Throughout the lobe there are scattered pneumonic areas but none greater than 5 mm. in diameter.

The left cardiac lobe has about two-fifths of its volume consolidated. This area is at the apex and is in the stage of reddish-gray hepatization. The left diaphragmatic has a few scattered pneumonic areas being of red hepatization in stage.

Microscopic Study.

There is a very marked atelectatic condition present, especially along the pleura. The respiratory bronchioles in the active areas have their lumen packed with polymorphonuclears which show no degeneration. There are many of these cells in the mucosa and they can be seen infiltrating the apparently uninjured epithelium. In the alveoli surrounding the infected respiratory bronchioles, there are a few polymorphs and many mononuclear phagocytes. In some of the

lymph nodes, a large number of eosinophils is noted. One of the apical lobes has a pronounced atelectatic condition in an area adjacent to a respiratory bronchiole, whose lumen is partially filled with a cellular exudate.

This is an acute bronchopneumonia.

Organisms found:

1. Strep. hemolyticus.
2. P. suisepticus.
3. Staph. aureus.
4. Diphtheroid organism.

See Figs. XIII, XIV.

Autopsy: 4188

Species: Porcine

Age: 3 months

History: This animal has been unthrifty for some time and finally has become quite ill. He was killed and autopsied.

Gross Examination.

A bilateral pneumonia in the stage of gray hepatization with involvement of over one-half of the lung tissue.

The right apical and cardiac lobes are almost completely consolidated with gray hepatization. Near the hilus of each, there are small scattered areas of red hepatization and some edematous lung tissue.

The right diaphragmatic lobe reveals consolidation of the anterior portion included in the triangle formed by 6, 2 and 1. This portion appears reddish-gray in color.

The left lung is almost identical to the right in duration and extent of pneumonic involvement. The left apical and cardiac appear, however, to contain several small yellow foci which apparently are suppurative in nature.

Microscopic Study.

The anterior lobes, and in particular the apical, reveal the oldest lesions. These lesions are most numerous at the apex of the lobes. The characteristic lesion is an early productive tissue reaction around the respiratory bronchioles. The lymph nodes of the bronchioles are more numerous and larger than in the normal lung. In one place there is a small abscess which has broken through the wall of the respiratory bronchiole. Surrounding it is a zone of

mononuclear phagocytes and further out a productive tissue reaction. This is an older lesion than the rapidly spreading process which has caused desquamation of the bronchioles and a great influx of polymorphs, both into the bronchioles and into the alveoli. The mucosa of the bronchioles and respiratory bronchioles is greatly thickened due to increased numbers of mononuclear phagocytes and lymphocytes. This lesion is common in the anterior lobes and is felt to be of a subacute nature.

This is an acute pneumonia which has been superimposed upon a moderate subacute condition of the lungs.

No bacteriological study.

See Fig. XLV.

Autopsy: 4071

Species: Bovine

Age: 10 days

History: The symptoms indicated pneumonia and scours.

Gross Examination.

A bilateral pneumonia for the most part in the stage of red hepatization.

The right apical is consolidated in a patchy manner. There is a narrow zone of consolidation which extends through the entire lobe close to the hilus. There are three other small areas of consolidation. Approximately one-third of the lobe is involved. The remainder of the lobe is markedly atelectatic.

The right cardiac has a patchy consolidation. It is in the stage of red hepatization. There is some evidence of an edematous condition.

The anterior tip of the right diaphragmatic is consolidated with an early red hepatization.

The left apical and cardiac lobes reveal some consolidated areas along the borders. The left diaphragmatic is similar to the right.

The intermediate lobe reveals congestion and edema.

Microscopic Study.

This is a moderate, typical, acute bronchopneumonia. There is a respiratory bronchiolitis present, showing a purulent exudate in the bronchioles and bronchi, but no evidence of destruction to any degree of the epithelium. The alveoli in the anterior lobes are packed with polymorphs and mononuclear phagocytes. In the diaphragmatic lobes

there is congestion and edema but very little cellular exudate.

This is a moderate acute bronchopneumonia.

No bacteriological study.

See Fig. L.

Autopsy: 4145

Species: Bovine

Age: 1 week

History: The animal became very emaciated and showed a very slight diarrhea.

Gross Examination.

The right apical has an irregular line of patchy pneumonia extending from its union with the cardiac across the lobe to position 2 on chart. Towards the periphery from this line which extends through to the ventral surface, there is a marked emphysematous condition. The right cardiac lobe reveals scattered areas of red hepatization and emphysema. The right diaphragmatic lobe has three areas of red hepatization close to the cardiac, on the dorsal and ventral surfaces.

The left apical and cardiac reveal involvement of over three-fourths of their surface with pneumonia in the stage of gray hepatization.

Microscopic Study.

The sections from the diaphragmatic lobes show early congestion and edema. The lesions of the longest duration are apparently at the apex of the apical and cardiac lobes. Here we find a pronounced cellular exudate, mainly polymorphs, in the alveoli, and in the lumen and mucosae of the respiratory bronchioles. The areas where the respiratory bronchioles are most severely affected, as judged by desquamation of the epithelium, appear markedly atelectatic. The exudate in the lumen of the bronchioles has degenerated and the purulent material may be seen even in the large bronchi. Sections

from near the hilus of a cardiac lobe reveal an emphysematous condition. The pleural capillaries are congested.

This is an acute bronchopneumonia.

Organisms found:

1. Strep. hemolyticus.
2. E. coli.
3. Staph. aureus.

See Figs. XV, XVI, XXIV, XXV.

Autopsy: 4173

Species: Bovine

Age: 1 week

History: The animal was being used for experimental hydrocephalus production by the Dairy Department. Injury to the spinal cord during the injection caused his death.

Gross Examination.

A bilateral pneumonia. The right cardiac lobe is almost completely consolidated with a pneumonic condition in the stages of red and gray hepatization. The apical lobe reveals some involvement at the hilus with emphysematous tissue at the border, a distribution which is rather unusual in this study.

There is a patchy involvement of the right diaphragmatic with pneumonia in the stage of red hepatization. The areas of involvement in this case also appear to approximate the main bronchi rather than the borders. The left apical and cardiac lobes are completely consolidated with gray and red hepatization. The left diaphragmatic has a triangular distribution of pneumonia at the anterior apex involving 6, 2 and 1. This consolidates two-thirds of the lobe. The duration is similar to the above lobes. The lung tissue approximating the cardiac has more area of involvement than that further back.

The intermediate shows almost complete consolidation, mainly of gray hepatization. There are small areas of red hepatization at the hilus.

Microscopic Study.

The sections from the diaphragmatic lobes reveal an early

congestion, with some edema and mononuclear phagocyte exudation. The sections from the anterior lobes reveal a different picture. The alveoli are filled with a purulent mass of cells, these are mainly polymorphs. Some areas show necrosis of the alveolar walls. The respiratory bronchioles near the apices are completely destroyed, many of these end as small suppurative foci and there is already signs of a productive tissue reaction about them. In this region the mucosae of the bronchi are infiltrated with polymorphs. There is much atelectasis present in the pneumonic areas. The interlobular lymphatics are engorged with lymph and polymorphs.

An acute bronchopneumonia with early suppurative lesions.

Organisms found:

1. Strep. hemolyticus.
2. Staph. aureus.
3. E. communior.

See Figs.XVII, XVIII, XXXIII.

Autopsy: 4232

Species: Bovine

Age: 3 months

History: The animal died of an acute pneumonia.

Gross Examination.

A bilateral acute pleuropneumonia.

The right apical is the only lobe showing any involvement on the right side. There is a patchy consolidation of this lobe in the stage of red hepatization with areas of emphysema surrounding them. Approximately one-eighth of the lobe is involved. The left apical and left cardiac are consolidated and greatly swollen. There is an edematous thickening of the interlobular tissue. The stage is red hepatization. Both of these lobes and most of the right apical are covered with a fibrinous membrane.

The left diaphragmatic lobe has a triangular area of pneumonia involving the area formed by 6, 2 and 1. This is in the stage of early red hepatization.

Microscopic Study.

The most recent involvement, which appears to have affected the diaphragmatic lobes and the hilus tissue of the other lobes, reveals the alveolar capillaries markedly congested and in some places there is profuse hemorrhage. The apices of the anterior lobes generally show a well developed cellular exudation. The lumen of the small respiratory bronchioles are filled with exuded polymorphs and desquamated epithelial cells - these are commencing to show a purulent state. The exudate within the alveoli, mainly polymorphs, does not appear degenerative as yet.

The pleura is greatly thickened by a fibrinous, cellular exudate

and reveals large areas of necrosis.

The most active and severe pneumonic process is seen adjacent to the pleura. At this point we find necrosis and early signs of suppuration of the respiratory bronchioles. The lymphatics are acutely engorged.

This is an acute bronchopneumonia and pleurisy.

Organisms found:

1. Strep. hemolyticus.

   (The only one which was isolated on lung puncture).

See Figs. XIX, XXXIV, XXXV.

Autopsy: 4281

Species: Bovine

Age: 3 months

History: This animal had been ill but before experiment was started had apparently recovered. The animal was injected with hemolytic streptococci Group C.

Gross Examination.

A bilateral acute pneumonia with a necrotic pleurisy.

The right apical is completely consolidated with a very early red hepatization. The right cardiac at the apex has also a very early consolidation. There is some edema and petechial hemorrhages in the non-consolidated portions of both lungs. The apex of the left cardiac lobe is the only portion of the left lung which is consolidated.

Microscopic Study.

This is an early pneumonia. The anterior lobes show the oldest type of lesion. Here the respiratory bronchioles contain a purulent exudate. There is complete loss of the bronchiolar epithelium and a great exudation of polymorphonuclear leucocytes through the mucosa into the lumen. The adjacent alveoli are also packed with a purulent debris. Farther away from the bronchioles there is congestion of the alveolar capillaries, some edema and hemorrhage, and a very noticeable infiltration of mononuclear phagocytes into the alveoli. The pleura shows a marked fibrinous exudate on its surface and a cellular exudate containing mainly polymorphs.

This is an acute experimental bronchopneumonia.

Organisms found:

1. Strep. hemolyticus.

See Fig. XLIX.

Technique for Bacteriological Examination.

The surface of the lung is seared over a pneumonic area with a red hot plate 1" x 2". Two small squares are cut out with sterile forceps and scissors. Each square of tissue is placed in a Bunsen burner flame for a few seconds. A blood agar plate is streaked with a cut surface of square and then incubated. The other square is placed in 5 cc. of tryptose broth and incubated eight to ten hours. A blood agar plate is then streaked from the tryptose broth and incubated for twenty-four hours. For the obtaining of infective material while the animal was still alive, the following two procedures were carried out.

1. Sterile swabs were used for obtaining throat swabs. Care was taken to exclude the flora of the mouth.

2. A lung puncture (10) was made over a consolidated portion of the lung using a sterile syringe and needle after carefully disinfecting the skin. The material obtained is incubated in the same manner as that above.

Since it is shown, Thorp (26), that streptococci probably play an important role in calf pneumonia we decided that particular attention should be paid to these bacteria. The bacteria were studied following principles set forth by Bergy's Manual (2).

The following cases are those studied bacteriologically by ordinary methods and are recorded in Table I.

Some Pasteurellae were studied in detail using fermentation reactions. Table III.

The streptococci were further studied serologically with the precipitation test and with fermentation reactions. Table II.

Upon communication with Dr. Lancefield, she very kindly sent us type cultures of streptococci groups and directions for producing the antisera, using rabbits. She included eight groups of streptococci and these were used to immunize the rabbits. Type A was the only one in which our results were poor. Two animals succumbed and the third animal has never developed high titre precipitating serum.

The method of extraction of the streptococcic polysaccharide first decided on was that of Brown (38). After some uncertain results we again corresponded with Dr. Lancefield who suggested using the method of Fuller (11). This procedure was used and found to be very satisfactory. The manner in which we applied it is as follows:

Five cc. of a 12-24 hour dextrose broth culture is spun down in the centrifuge and the supernatant fluid is removed as completely as possible. Tryptose broth does not seem to be satisfactory because it may cause some non-specific precipitation. One-tenth cc. of formamide is added to the residue and the tube shaken and placed in an oil bath at 150°C. for 15 minutes. The tube is allowed to cool and one-fourth cc. of acid alcohol is added, and the precipitate formed is removed by centrifuging.

The acid alcohol throws down bacterial debris and partially broken down proteins while keeping the group antigens in solution.

The supernatant fluid is drawn off by pipette, placed in a small tube and one-half cc. of acetone is added. The acetone precipitate is very small in amount but it contains practically all the group's antigen.

One cc. of saline and a drop of phenol red indicator are added to the latter precipitate and the whole neutralized with a trace of

sodium carbonate. This solution is used for the test.

In all fermentation reactions a one per cent solution of the fermentable substance was made in Dunham's solution, with added Andrade's indicator. Fermentation tubes were filled and the whole autoclaved at 15 pounds pressure for ten minutes.

A five day culture in Dunham's solution was used to demonstrate indol formation, and the reduction of nitrates to nitrites was ascertained in Dunham's nitrate broth.

Bacteriological Studies.

Since no reference could be found in available literature to the experimental production of pneumonia in calves, we attempted this, using a hemolytic streptococcus, Lancefield Group C, isolated from Autopsy 4145. The growth on a 12 hour tryptose slant culture was washed off with five cc. of physiological saline solution. Two cc. of the suspension was injected intratracheally into a three months old calf which on autopsy was given the number 4281. This calf had suffered from a peritonitis but was apparently well on the way to recovery when the injections of live streptococci were given. The temperature at this time was 100.8°F. Twelve hours later the temperature was 103.2°F. From this time until the sixth day after the injection, when animal was destroyed, the temperature varied from 102°F. to 105°F. Upon autopsy the pathology of this case was similar in many respects to that of the natural infection although it differed in that there was a marked necrotic pleurisy.

Five-tenths cc. of the streptococcic suspension from Autopsy 4145, prepared similarly to the above, was injected intratracheally into three rabbits. One animal was ill within twelve hours. On the fifth day it was dead. The autopsy revealed a streptococcic septicemia rather than a bronchopneumonia.

Six rats were injected with the same amount of suspension and two died, showing a septicemic condition.

A filtrate prepared with a Seitz filter, using approximately one gram of lung tissue, was injected intratracheally into two rabbits and four rats (.5 cc. each). None were sick and no lesions were found on autopsy four weeks later.

The sheep husbandry department at Michigan State College had been losing lambs from pneumonia in large numbers. From January to April, sixteen deaths had occurred. These lambs were from four to thirty days old when they first showed symptoms. The course of the disease was usually acute, three to four days in duration, although a few animals showed symptoms for thirty to forty days before succumbing. Recoveries were few.

Cultures isolated from the lungs of animals dead from the acute form of the disease revealed two prevalent organisms.

1. Pasteurella ovisepticus.
2. Diplococcus of Spray.

These organisms were grown in tryptose broth for twelve hours and centrifuged. The supernatant poured off, and the residue made up to approximately No. 1 McFarland's nephalometer with physiological saline. Equal amounts of the suspensions from the two organisms were mixed together. The suspension was immersed in a water bath at 100°C. for five minutes and then placed in the refrigerator at 2°C. and allowed to chill for four hours. It was then boiled again for three minutes. Cultures on blood agar were found sterile. This suspension was used for immunizing the lambs. The injections were commenced as soon after bith as possible. The procedure and results were as follows:

Lamb Numbers	No. of Injections	Interval In Days Between Injections	Dosages Given in cc's.	Pneumonic Symptoms	Mortality
A4	3	1	.5 .75 1.	0	0
A5	4	2	.5 1. 1. 1.	0	0
A6	3	2	.5 1. 1.	0	0
A7	4	1-	1. 1. 1. 1.	0	0
A8	4	2	.2 .5 1. 1.	0	0
A9	4	3	.5 1. 1. 1.	0	0
A10	1		,1·	Moderate	0
C7	1		,1·	0	0
C9	2	1·	,1· ,1·	0	0
B7	1		,1·	Slight	0

Host Origin and Autopsy No.	Col. No.	Colony Study	Morphology and Gram Stain Reaction	Mot.	Dex.	Lac.	Mal.	Man.	Suc.	Sal.	Lit. Milk	Gel.	Ind.	Nit.	Identification of Bacteria
4117 Ovine Pneumonia	1	2 mm. grayish-white, slight apex, regular	Gram - rod bipolar staining	Non	+	-	±	+	+	-	Acid	Non	Yes	Yes	Pasteurella ovisepticus
	2	1 mm. slimy, grayish-white colony	Gram - rod	Yes	+	+	+	+	-	+	Acid	Non	No	Yes	Escherichia coli
	3	Pinpoint, med. zone hemolysis	Gram - strep.	Non	+	+	+	-	+	+	Acid	Non	No	No	Streptococcus hemolyticus
4116 Ovine Pneumonia	1	1 mm. orange, hemolytic colony	Gram - coccus	Non	+	+	+	+	+	-	Acid and Coag.	Yes	No	Yes	Staphylococcus aureus
	2	1 mm. grayish-white, non-hemolytic col.	Gram - rod	Non	+	+	+	+	-	+	Acid	Non	Yes	No	Escherichia coli
	3	2 mm. regular, grayish-white colony. No hemolysis	Gram - rod bipolar staining	Non	+	-	-	+	+	-	Acid and Slight Reduc.	Non	Yes	Yes	Pasteurella ovisepticus
4124 Ovine Pneumonia	1	1 mm. orange hemolytic col.	Gram - coccus in irregular masses	Non	+	+	+	+	+	+	Acid and Coag.	Yes	No	Yes	Staphylococcus aureus
	2	1-2 mm. white colony, slight hemolysis	Gram - coccus in irregular masses	Non	+	+	-	+	+	-	Acid	Yes	No	Yes	Staphylococcus albus
	3	1 mm. slimy, grayish-white, hemolytic col.	Gram - rod	Yes	+	+	+	+	-	+	Acid	Non	Yes	No	Escherichia coli
	4	1 mm. grayish-white colony. No hemolysis	Gram - rod bipolar staining	Non	+	-	±	+	+	-	Acid	Non	Yes	Yes	Pasteurella ovisepticus
	5	Pinpoint, hemolytic col.	Gram - strep.	Non	+	+	+	-	+	±	Acid	Non	No	No	Streptococcus hemolyticus

Host Origin and Autopsy No.	Col. No.	Colony Study	Morphology and Gram Stain Reaction	Mot.	Dex.	Lac.	Mal.	Man.	Suc.	Sal.	Lit. Milk	Gel.	Ind.	Nit.	Identification of Bacteria
4230 Ovine Pneumonia	1	.5 mm. pearly gray col. Zone of hemolysis is 1 mm.	Gram - strep.	Non	+	±	+	-	±	±	Acid	Non	No	No	Streptococcus hemolyticus
	2	2 mm. grayish-white col.	Gram - rod pleomorphic	Non	+	-	-		+	-	Acid and Reduc.	Non	Yes	No	Pasteurella ovisepticus
	3	Pinpoint, gray, non-hemolytic colony	Gram - rod	Yes	●	●	●	●	●	●	Pepton	Com.			Probably Saphrophyte
4236 Ovine Pneumonia	1	Grayish-white, 1 mm., in pure culture, peculiar odor	Gram - rod pleomorphic bipolar stain	Non	+	-	-		+	-	Acid	Non	Yes	No	Pasteurella ovisepticus
4237 Ovine Pneumonia	1	1 mm. pearly gray, smooth colony	Gram - rod, bipolar pleomorphic	Non	+	-	-	+	+	-	Acid	Non	Yes	Yes	Pasteurella ovisepticus
	2	.5 mm. col. Hemolytic zone shows very faintly green	Gram - diplococcus in chains (short)	Non	+	-	+	-	+	-	Acid and Pepton	Yes	No	No	Diplococcus of Spray

Host Origin and Autopsy No.	Col. No.	Colony Study	Morphology and Gram Stain Reaction	Mot.	Dex.	Lac.	Mal.	Man.	Suc.	Sal.	Lit. Milk	Gel.	Ind.	Nit.	Identification of Bacteria
4345 Lamb Pneumonia	1	1 mm. grayish-white colony. Shiny, small zone of hemolysis, almost in pure culture	Gram + diplococcus, pleomorphic	Non	+	+	+	-	+	-	Pepton	Yes	No	No	Diplococcus of spray
	2	Pinpoint, transparent, non-hemolytic colony	Gram - diplococcus	Non	-	-	-	-	-	-	Decol.	Non	No	No	Micrococcus catarrhalis
4346 Lamb Pneumonia	1	1 mm. grayish-white colony, slight hemolysis	Gram + diplococcus	Non	+	+	±	-	+	-	Sl. Pepton	Yes	No	No	Diplococcus of spray
	2	1 mm. grayish-white col. No hemolysis	Gram - rod, pleomorphic with bipolar stain	Non	+	-	-		+	-	Acid	Non	Yes	Yes	Pasteurella ovisepticus
4282 Lamb Pneumonia	1	Pinpoint, non-hemolytic	Gram - diplococcus	Non	-	-	-	-	-	-	Decol.	Non	No	No	Micrococcus catarrhalis
	2	.5-1 mm. col. Slight hemolysis	Gram + diplococcus	Non	+	+	+	-	+	-	Pepton	Yes	No	No	Diplococcus of spray
	3	.5-1 mm. gray col. No hemolysis	Gram - rod bipolar staining	Non	+	-	-	+	±	-	Acid	Non	Yes	Yes	Pasteurella ovisepticus

Host Origin and Autopsy No.	Col. No.	Colony Study	Morphology and Gram Stain Reaction	Mot.	Dex.	Lac.	Mal.	Man.	Suc.	Sal.	Lit. Milk	Gel.	Ind.	Nit.	Identification of Bacteria
4154 Pig Pneumonia	1	Gray, moist and irregular. Non-hemolytic	Gram - rod	Yes	⊕	-	⊕	⊕	-	-	Acid then Alkal.	Non	No	No	Salmonella suipestifer
	2	1-2 mm. white col. Slight hemolysis	Gram + coccus in irregular groups	Non	+	+	±	+	+	-	Acid and Coag.	Yes	No	Yes	Staphylococcus albus
	3	Pinpoint, wide zone of hemolysis	Gram + strep.	Non	+	±	±	-	+	±	Acid	Non	No	No	Streptococcus hemolyticus
4176 Pig Pneumonia	1	1-2 mm. grayish col., regular, no hemolysis	Short gram - rod. Bipolar staining	Non	+	-	-		+	-	Acid	Non	Yes	No	Pasteurella suisepticus
	2	Pinpoint, wide zone of hemolysis	Gram + strep.	Non	+	+	+	-	±	+	Acid	Non	No	No	Streptococcus hemolyticus
4133 Pig Pneumonia	1	2 mm. grayish-white col., regular, non-hemolytic	Short gram - rod. Bipolar staining found in long chains; some are long rods	Non	+	+	-	+	-	-	Acid	No Growth		±	Pasteurella suisepticus
4134 Pig Pneumonia	1	2 mm. grayish white, viscous, slight hemolysis	Short gram - rod	Yes	⊕	⊕	⊕	⊕	-	⊕	Acid	Non	No	Yes	Escherichia coli
	2	1-2 mm. grayish-white, regular non-hemolytic	Short gram - rod. Bipolar staining	Non	+	-	-	+	+	-	Reduced to Acid	Non	Yes	No	Pasteurella suisepticus
	3	Very small col., pinpoint zone of hemolysis	Gram + strep.	Non	+	+	±	-	+	+	Acid	Non	No	No	Streptococcus hemolyticus
	4	Double zone hemolysis, inner zone is wide and green, outer zone is narrow and clear	Gram + strep. or diplococcus	Culture not viable											

Host Origin and Autopsy No.	Col. No.	Colony Study	Morphology and Gram Stain Reaction	Mot.	Dex.	Lac.	Mal.	Man.	Suc.	Sal.	Lit. Milk	Gel.	Ind.	Nit.	Identification of Bacteria
4179 Pig Pneumonia	1	Pinpoint, medium zone of hemolysis	Gram + strep.	Non	+	+	+	-	+	+	Acid	Non	No	No	Streptococcus hemolyticus
	2	1 mm. grayish-white, regular, no hemolysis	Gram - rod short chains bipolar staining	Non	+	-	-		+	-	Acid	Non	Yes	Yes	Pasteurella suisepticus
	3	Gray, wrinkled colony	Gram + diphtheroid	Culture not viable											Diphtheroid organism
	4	2 mm. orange col. Hemolytic	Gram + coccus in groups	Non	+	+	+	+	+	-	Acid and Coag.	Yes	No	Yes	Staphylococcus aureus

Host Origin and Autopsy No.	Col. No.	Colony Study	Morphology and Gram Stain Reaction	Mot.	Dex.	Lac.	Mal.	Man.	Suc.	Sal.	Lit. Milk	Gel.	Ind.	Nit.	Identification of Bacteria
4127 Calf Pneumonia	1	Pinpoint hemolytic colony	Gram + strep.	Non	+	+	+	-	+	+	Acid	Non	No	No	Streptococcus hemolyticus
	2	1 mm. white, regular col.	Gram + coccus	Non	+	+	+	+	+	+	Acid and Coag.	Yes	No	Yes	Staphylococcus albus
	3	1 mm. grayish-white col. Slight hemolysis	Gram - rod	Yes	⊖	⊖	⊖	⊖	⊖	⊖	Acid and Coag.	Non	Yes	Yes	Escherichia communior
4145 Calf Pneumonia	1	3 mm. white, extremely hemolytic col.	Gram - rod	Probably saphrophytic											
	2	1 mm. orange col., regular	Gram + coccus	Non	+	+	+	+	+	+	Acid and Coag.	Yes	No	Yes	Staphylococcus aureus
	3	1-2 mm. opaque, non-hemolytic col.	Gram - rod	Yes	⊖	⊖	⊖	⊖	-	+	Acid and Coag.	Non	Yes	Yes	Escherichia coli
	4	Pinpoint hemolytic col.	Gram + strep.	Non	+	±	±	-	+	+	Acid	Non	No	No	Streptococcus hemolyticus
4173 Calf Pneumonia	1	Pinpoint, hemolytic opaque col.	Gram + strep.	Non	+	+	+	-	+	±	Acid	Non	No	No	Streptococcus hemolyticus
	2	2 mm. lemon-white hemolytic colony	Gram + coccus	Non	+	+	+	+	+	+	Acid and Coag.	Yes	No	Yes	Staphylococcus aureus
	3	1 mm. opaque col. Slight hemolysis	Gram - rod	Yes	⊖	⊖	⊖	⊖	⊖	⊖	Acid	No	Yes	No	Escherichia communior
4171 Calf Pneumonia	1	Pinpoint, hemolytic colony	Gram + strep.	Non	+	+	+	-	+	±	Acid	Non	No	No	Streptococcus hemolyticus
	2	1 mm. orange hemolytic col.	Gram + coccus	Non	+	+	+	+	+	+	Acid	Yes	No	Yes	Staphylococcus aureus
295	1	Pinpoint, hemolytic col.	Gram + strep.	Non	+	+	+	-	+		Acid	Non	No	No	Streptococcus hemolyticus
298	2	Pinpoint hemolytic col.	Gram + strep.	Non	+	+	+	+	+		Acid	Non	No	No	Streptococcus hemolyticus

Table 2.

Source	Host Origin	Lancefield Group	Dextrose	Lactose	Sucrose	Maltose	Salicin	Mannitol	Sodium Hippurate	Trehalose	Sorbitol	Gelatin	Arabinose	Raffinose	Glycerol	Milk Curdled
4127	Bovine	C	+	+	+	+	+	-	-	-	+	-	-	-	-	-
4145	Bovine	C	+	±	+	±	+	-	-	-	+	-	-	-	-	-
4173	Bovine	C(b)	+	+	+	+	±	-	-	-	±	-	-	-	-	-
4171	Bovine	C	+	+	+	+	±	-	-	-	+	-	-	-	-	-
295	Bovine	C	+	+	+	+	+	-	-	-	+	-	-	-	-	-
298	Bovine	B	+	+	±	+	+	-	+	+	+	-	-	-	-	-
4134	Porcine	C	+	+	+	±	+	-	-	-	±	-	-	-	-	Slight
4154	Porcine	C	+	±	+	±	±	-	-	-	+	-	-	-	-	-
4176	Porcine	C(d)	+	+	±	±	+	-	-	-	+	-	-	-	-	-
4179	Porcine	C(f)	+	+	+	+	+	-	-	-	+	-	-	-	-	-
4117	Ovine	C	+	±	+	+	+	-	-	-	+	-	-	-	-	-
4230	Ovine	C	+	±	±	+	±	-	-	-	±	-	-	-	-	-
4232	Bovine	C	+	+	±	+	+	-	-	-	+	-	-	-	-	-

Source	Host Origin	Pleomorphism	Bipolar Staining	Hemolysis	Indol	Mouse Pathogenesis	Dextrose	Lactose	Sucrose	Maltose	Salicin	Mannitol	Trehalose	Surbitol	Glycerol	Milk	Dulcitol	Arabinose
4133 Pure Culture	Porcine	Chains and Long Rods	Yes Tissue Only	-	±	++	+	-	+	-	-	+	-	+	-	Acid	+	+
4134	Porcine	Long and Short Rods	Very Poor	-	+	+	+	-	+	-	-		-	+	±		-	-
4179	Porcine	Chains	Yes	-	+	++	+	-	+	-	-		±	-	-	Acid	+	+
4117	Ovine	Great Variance in Size of Rods	Yes	-	+	+	+	-	+	±	-	+	-	+	±		-	-
4116	Ovine	Chains	Poor	-	+	+	+	-	+	-	-	+	-	+	-		-	-
4230	Ovine	Variance in Size	Yes	-	+	+	+	-	+	-	-		-	+	±	Acid and Reduction	+	+
4237	Ovine	Yes	Diplococcus	Yes Colonies Less Than 1 mm.	-	Died in Less Than 4 days (2 mice)	+	±	+	+	-	-	-	-	-	Acid and Peptonized	-	-
4348	Ovine	Yes	Diplococcus	Yes Slight	-		+	+	+	+	-	-	-	-	±	Peptonized	-	-
4282	Ovine	Yes	Diplococcus	Yes	-		+	+	+	+	-	-	-	-	-	Peptonized	-	-

Host Origin	No. of Cases Studied	No. of Bacterial Species Isolated	Colon Group	Streptococci Group C	Staphylococci	Pasteurellae	Salmonellae	Diptheroid Organism	Gram - Diplococci	Gram + Diplococci
Bovine	6	3	3	6	4	0	0	0	0	0
Porcine	5	6	1	4	2	4	1	1	0	0
Ovine	9	6	3	2	2	8	0	0	2	3

Discussion

The first point of involvement in a lung is usually the apices of the anterior lobes. The diaphragmatic lobes are generally last affected and the anterior apex of these is also affected first. The pneumonic process appears to spread from the borders toward the hilus of the anterior lobes and then involves the bulk of the diaphragmatic lobes, if the animal survives long enough. Atelectasis is common enough, to be seen in every case where there is any degree of consolidation. Emphysema would appear to be most prevalent in the apical lobe, especially where a band of consolidated tissue is distal to the apex. A well marked pleurisy has been noted in only two cases and both were calf pneumonias. (Fig. XXXVI).

The histological pathology varied. By far the greatest number of cases were of an acute nature, as the description will indicate. There were eighteen cases studied, and twelve might well be considered acute in nature. The remainder fall into the subacute and chronic class. The dividing line has here been difficult to dogmatically define. Four of the sheep pneumonias, Autopsies 4236, 4237, 4346 and 4348 would well warrant further study but at present it would seem that an infected infarct was the cause of death. There are some indications that a pneumonic condition has been present before the large destruction of tissue has occurred, due to the infected vessels.

The prevalent lesion of a chronic bronchopneumonia is a productive tissue reaction about the terminal and respiratory bronchioles. In no case was there noted any bronchitis.

In six cases of bovine pneumonia, six beta hemolytic streptococci were isolated which all proved to be Lancefield group C organisms. The

same organism was almost as important in porcine pneumonia since in five cases there were four Lancefield Group C streptococci found. But there were four Pasteurellae isolated from these same five cases. In ovine pneumonia the Pasteurellae are apparently most significant, although in the later cases, the diplococcus of Spray may be significant. A bacterin composed of P. ovisepticus and diplococcus of Spray, broken down almost to a solution by thermal methods, has immunizing powers against pneumonia when used on young sheep.

Summary

1. Five cases of calf pneumonia have been studied in gross and microscopically for pathological alteration. Four of these and two other cases were studied bacteriologically. Six porcine cases were anatomically studied in a similar manner to the above and five were studied bacteriologically. Seven ovine pneumonias were also studied anatomically and all these bacteriologically. In addition, two others were studied for the bacterial etiological factor.

2. All cases were bronchopneumonias.

3. There is bilateral involvement with the earliest lesions in the apical and cardiac lobes.

4. The apex and border of a lobe is the first affected.

5. The respiratory bronchioles show the first inflammatory reaction of a cellular nature.

6. A causative agent of calf pneumonia is a beta hemolytic streptococcus, Lancefield Group C.

7. The same Group C streptococcus is found in porcine and ovine pneumonia but is generally associated with another organism, the Pasteurellae being most prevalent.

8. Pasteurellae are the most significant organism in ovine pneumonia although the diplococcus of Spray may be more significant in lamb pneumonia.

9. A properly prepared bacterin composed of P. ovisepticus and the diplococcus of Spray may have some value for immunizing young sheep against pneumonia.

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All photographs of the lung in gross are approximately one-third of the natural size.

Fig. I. Autopsy 4116.

Ventral view. Note the emphysematous condition in the right apical distal to the narrow zone of consolidation.

Fig. II. Autopsy 4117.

Dorsal view. Note the very early type of pneumonia, especially of the right apical and cardiac lobes.

Fig. III. Autopsy 4117.

Ventral view. Note the intermediate lobe has probably the oldest lesion.

Fig. IV. Autopsy 4230.

Ventral view. Note complete consolidation of anterior lobes.

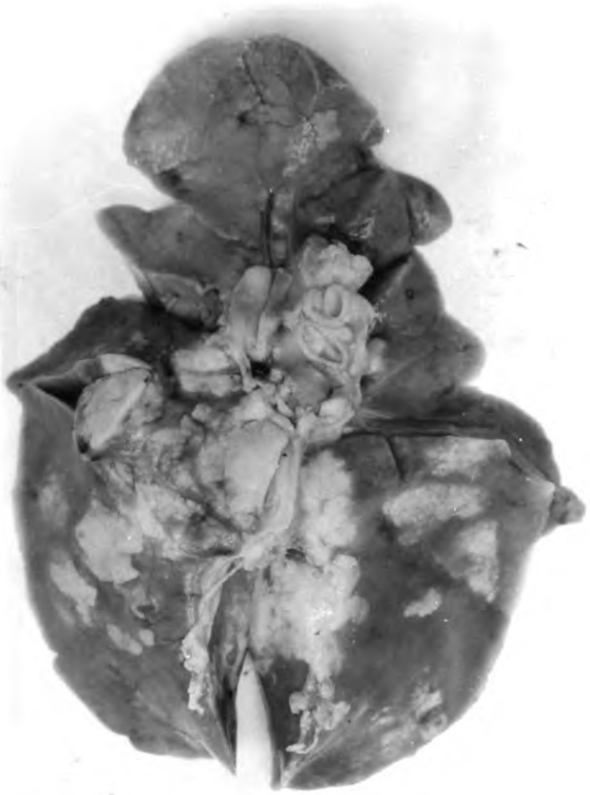

Fig. V. Autopsy 4230.

Dorsal view. Note patchy distribution of pneumonia in posterior lobes.

Fig. VIa. Autopsy 4236.
Dorsal view. Note the early generalised pneumonia.

Fig. VIb. Autopsy 4237.
Dorsal view. Note the massive consolidation and the suppurative lesions.

Fig. VII. Autopsy 4133.

Dorsal view. Note edematous condition throughout both lungs.

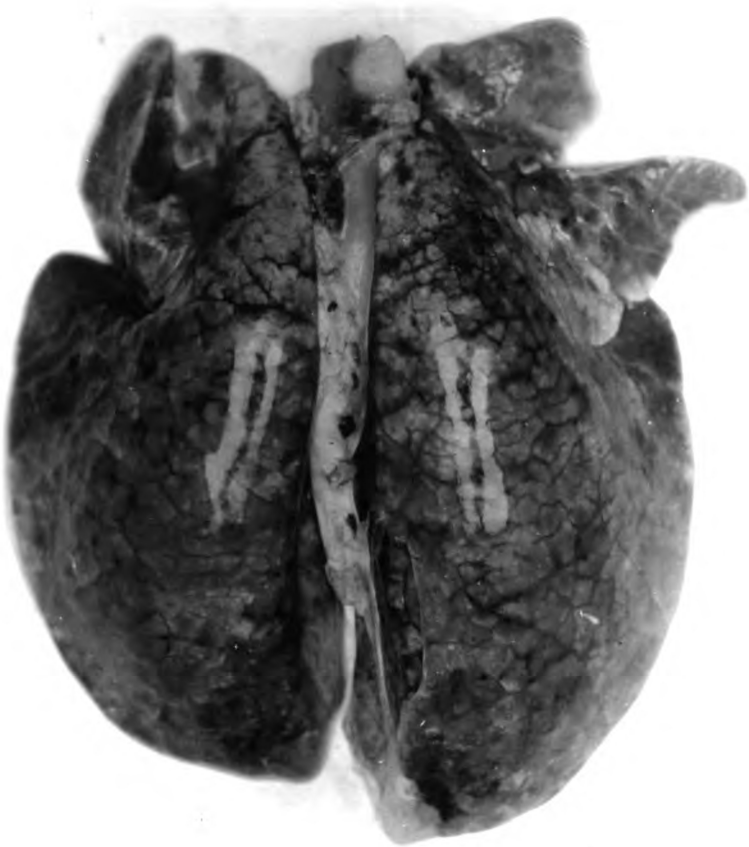

Fig. VIII. Autopsy 4133.

Ventral view. Note that many adjacent lobules are in different stages of pneumonia.

Fig. IX. Autopsy 4134.

Dorsal view. Note massive consolidation with the oldest lesions apparently at the apices of the apical lobes.

Fig. X. Autopsy 4134.

Ventral view. Note massive consolidation.

Fig. XI. Autopsy 4154.

Dorsal view. Note the narrow zone of consolidation across the right cardiac lobe.

Fig. XII. Autopsy 4176.

Dorsal view. Note the distribution of pneumonia in the right lung.

Fig. XIII. Autopsy 4179.

Dorsal view. Note the scattered type of pneumonia in the diaphragmatic lobes.

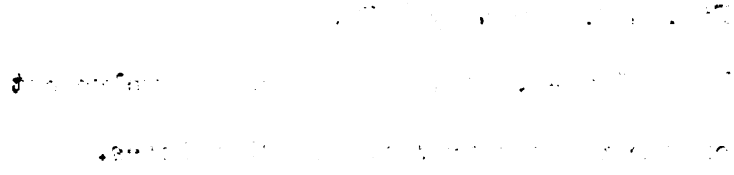

Fig. XIV. Autopsy 4179.

Ventral view. Note the massive involvement of the right apical and cardiac lobes.

Fig. XV. Autopsy 4145.

Dorsal view. Note patchy type of pneumonia.

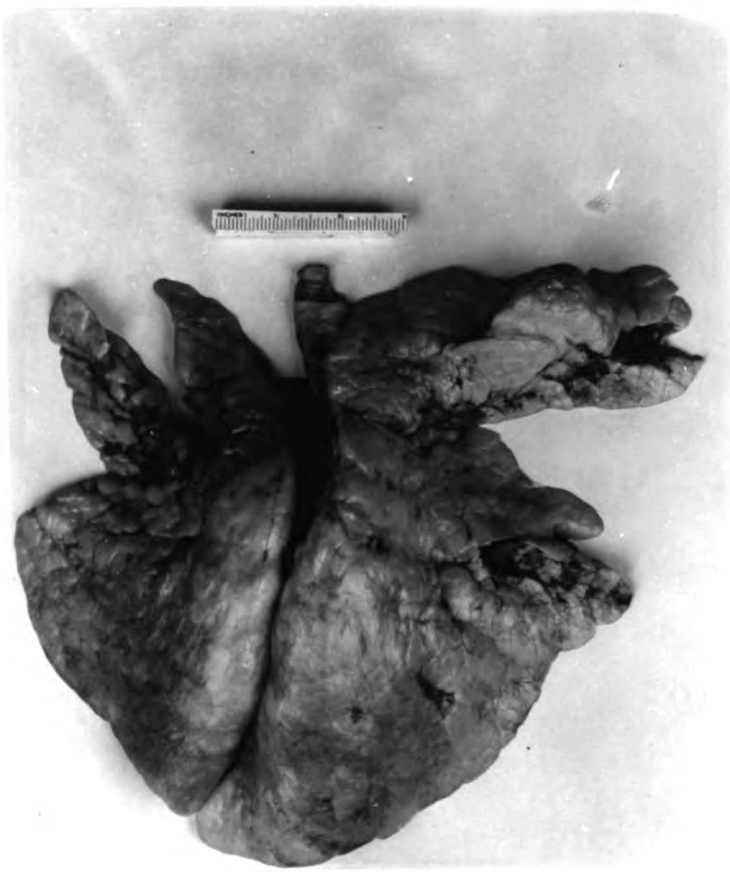

Fig. XVI. Autopsy 4145.

Ventral view. Note patchy type of pneumonia.

Fig. XVII. Autopsy 4173.

Dorsal view. Note the emphysematous condition of the right apical.

Fig. XVIII. Autopsy 4173.

Ventral view. Note most of the consolidated portion is in the stage of red hepatization.

Fig. XIX. Autopsy 4232.

Ventral view. Note the greatly swollen left apical and left cardiac. Interlobular edema is conspicuous.

Fig. XX. Autopsy 4124.

Dorsal view. Sheep pneumonia. Note the consolidated portion in the stage of red and early red hepatization.

Fig. XXI. Autopsy 4124.

Ventral view. Sheep pneumonia. Note that the involvement is more extensive on the ventral surface.


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Fig. XXII. Autopsy 4127.

Dorsal view. Calf pneumonia. Note extensive consolidation.

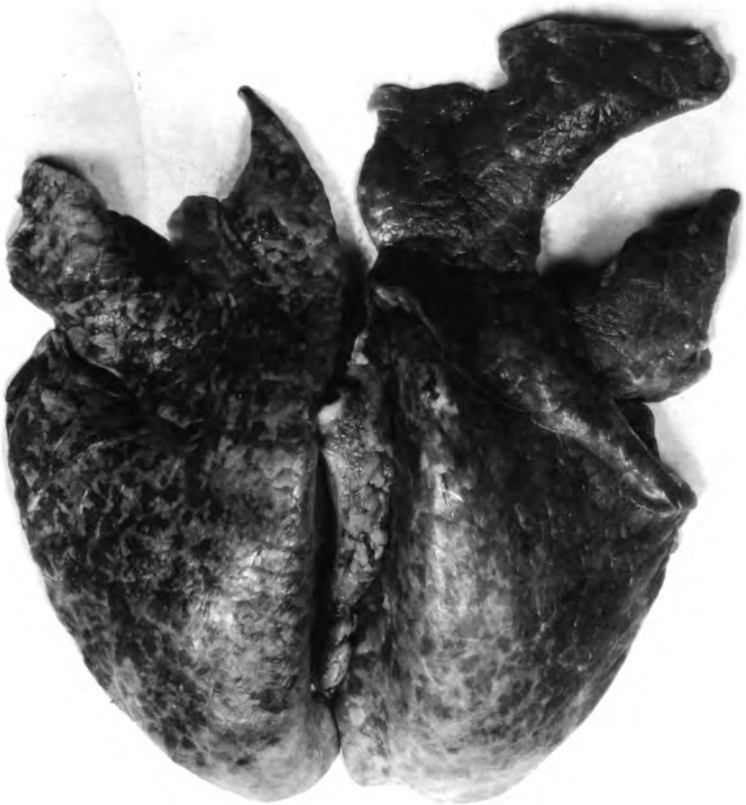


Fig. XXIII. Autopsy 1127.

Ventral view. Calf pneumonia. Note that the condition is more patchy here than that of dorsal view.

Fig. XXIII. Autopsy 4127.

Ventral view. Calf pneumonia. Note that the condition is more patchy here than that of dorsal view.

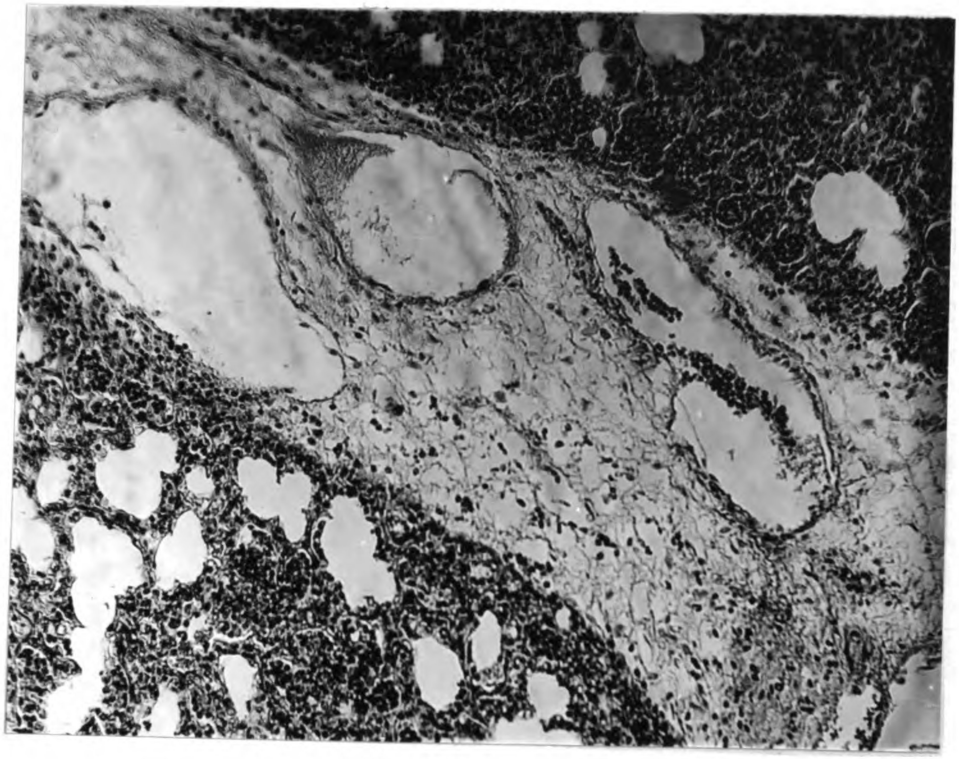
Figs. XXIV to XXXIX have a magnification of approximately 140X.

Fig. XXIV. Autopsy 4145.

Note the distended lymphatics in the interlobular septum.

Fig. XXV. Autopsy 4145.

Note emphysema and the lowering of the bronchiole epithelium.



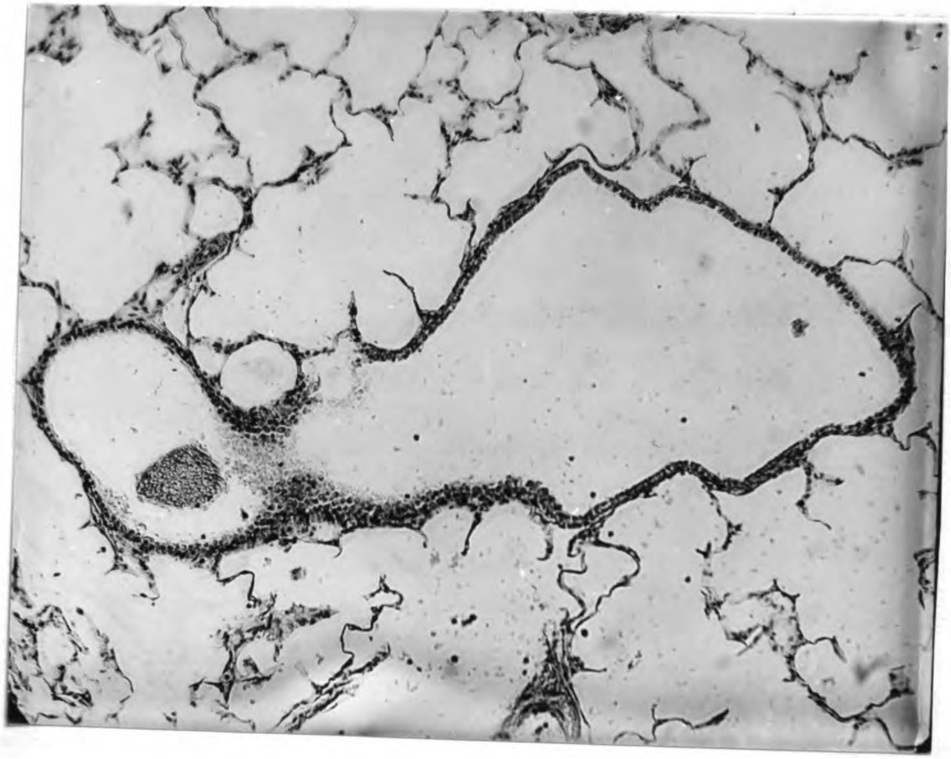
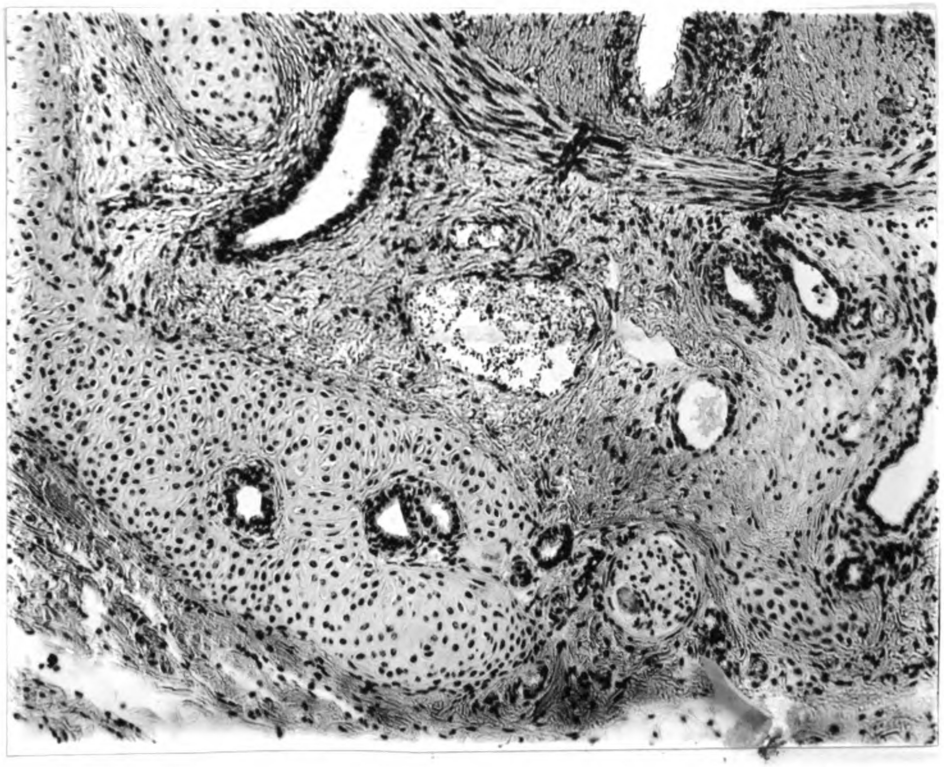


Fig. XXVI. Autopsy 4145.

An interesting anomaly in that mucous glands are seen in the cartilage plates of a bronchus.

Fig. XXVII. Autopsy 4116.

Note round celled node which is perivascular in distribution.



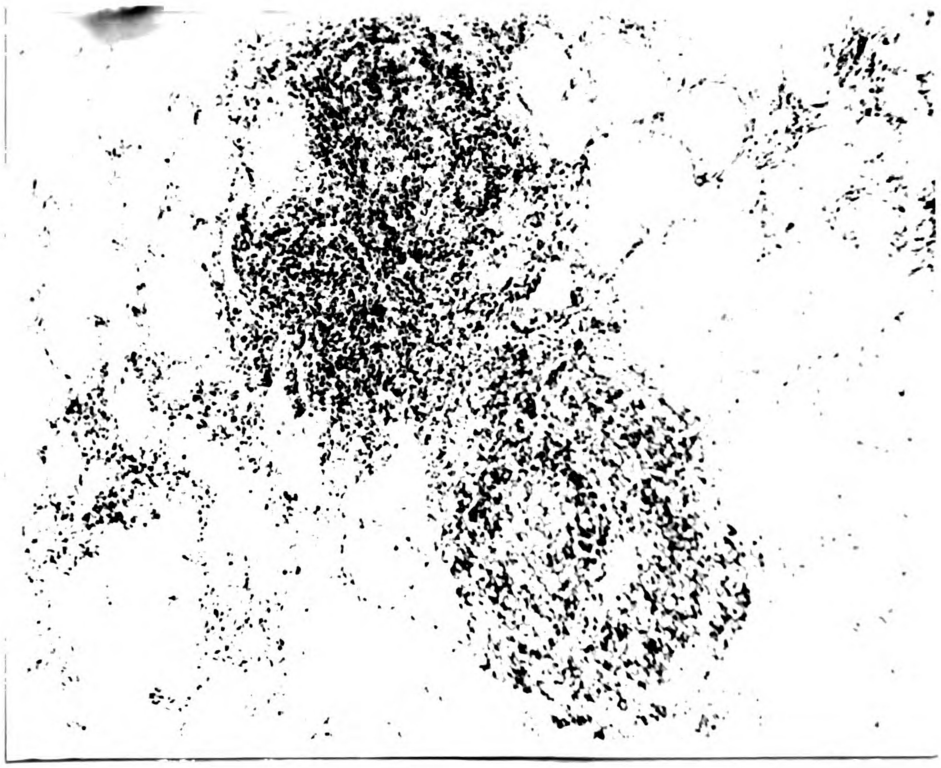
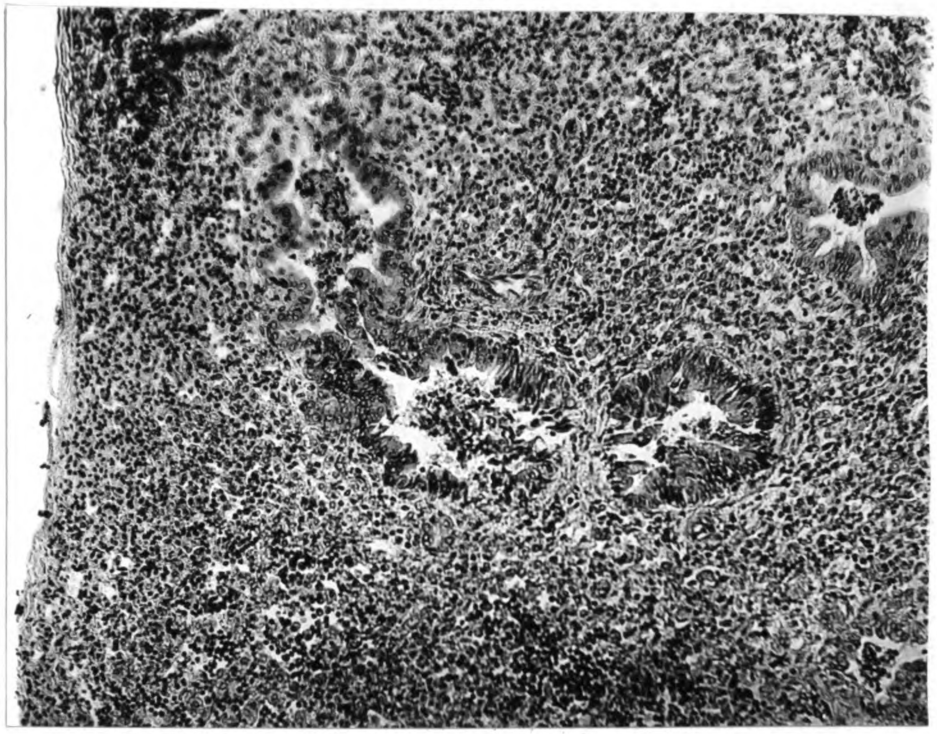


Fig. XXVIII. Autopsy 4117.

Note atelectasis and desquamation of bronchiole epithelium.

Fig. XXIX. Autopsy 4134.

Note complete loss of bronchiole epithelium and great thickening of the mucosa with mononuclear phagocytes and an edematous fluid.



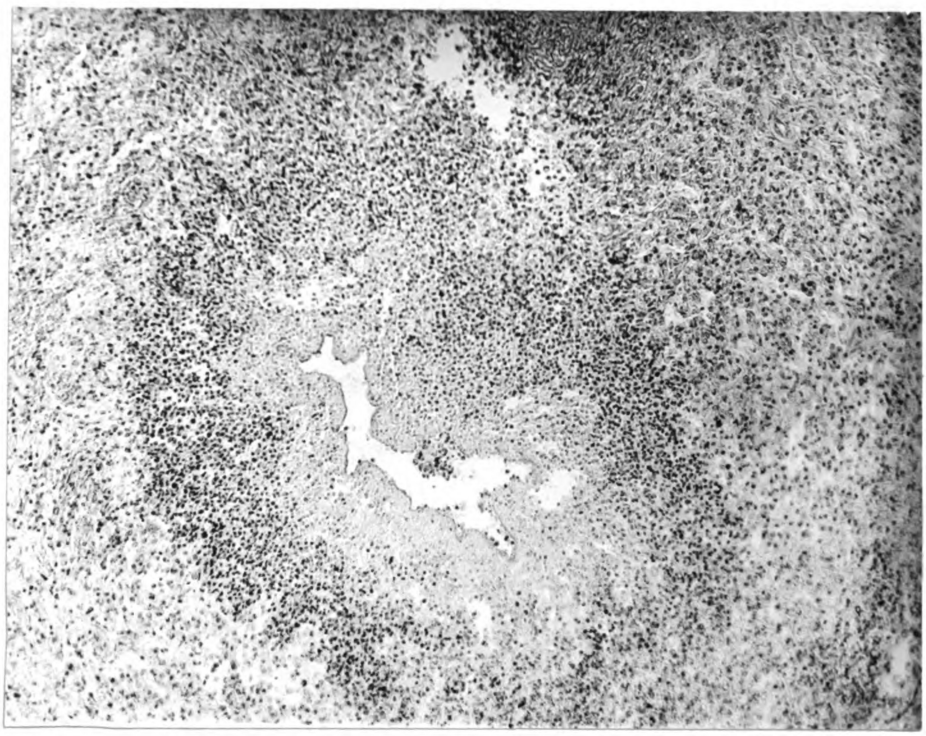


Fig. XXX. Autopsy 1870.

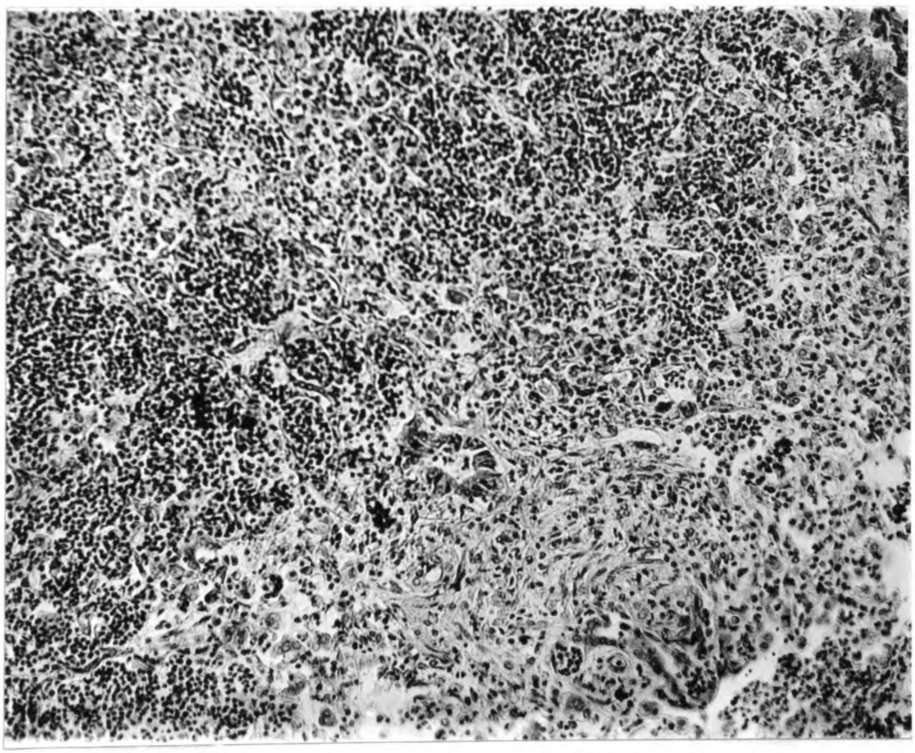
Note the large numbers of infiltrating polymorphs and the early productive transection.

Fig. XXXI. Autopsy 1872.

Note the chronic fibroblastic proliferation and also the marked vascular endothelial proliferation.

Fig. XXX. Autopsy 4230.
Note the large numbers of infiltrating polymorphs and the early productive tissue reaction.

Fig. XXXI. Autopsy 4232.
Note the chronic fibroblast proliferation and also the marked vascular endothelial proliferation.



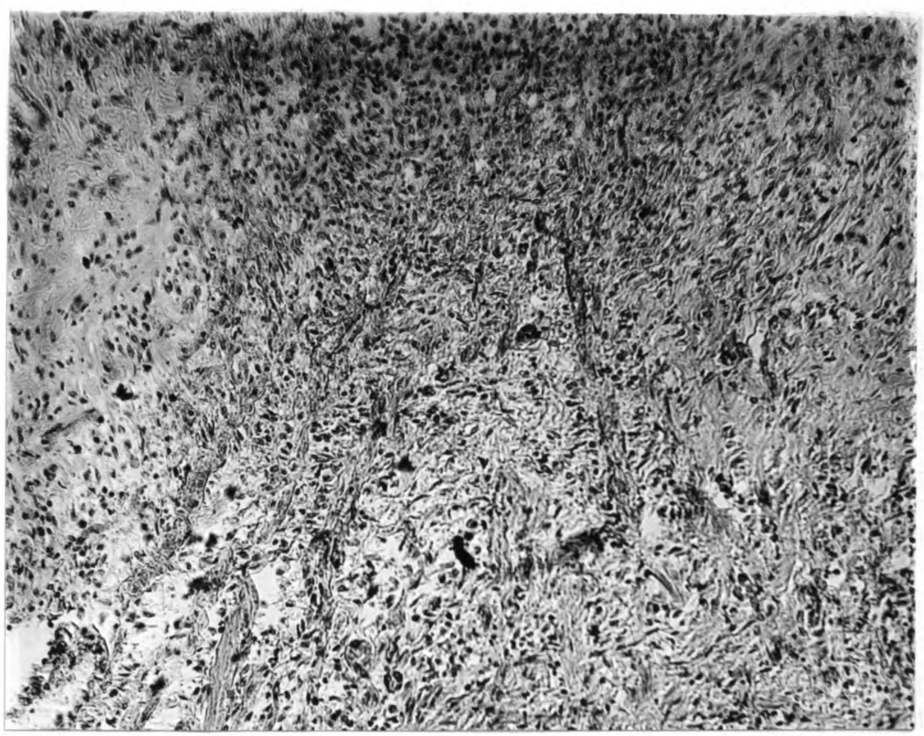


Fig. XXXII. Autopsy 4232.

Chronic abscess in lung.

Fig. XXXIII. Autopsy 4173.

Note congestion of alveolar walls and small areas of necrosis in them.

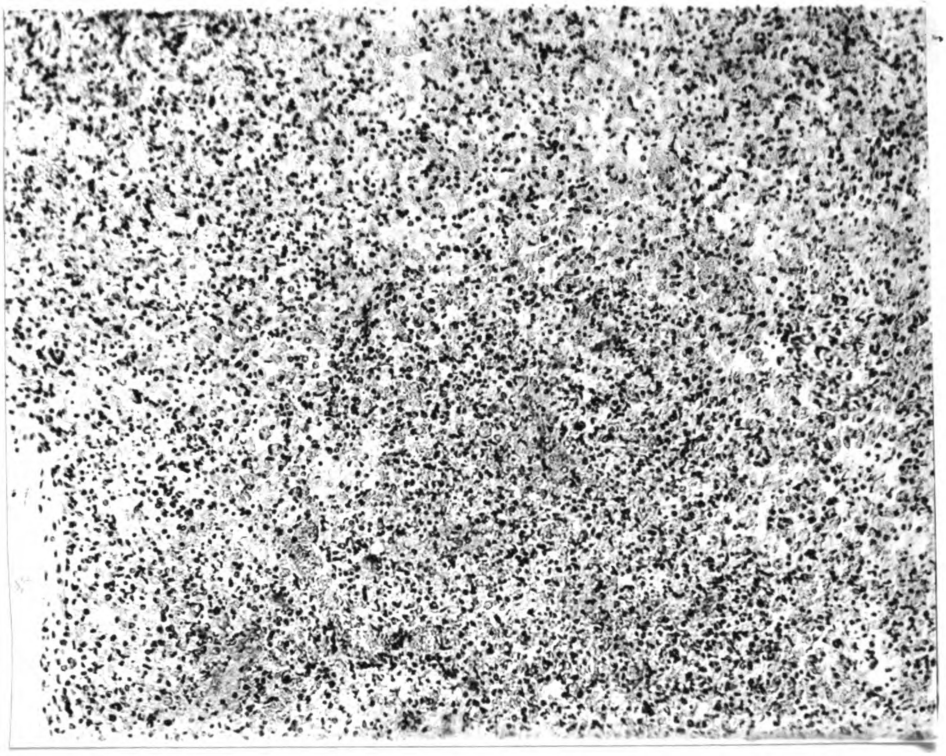


Fig. XXXIV. Autopsy 4232.

Necrotic pleurisy with a fibrinous exudate.

Fig. XXXV. Autopsy 4232.

An early inflammation of a respiratory bronchiole.

Note the edema in the alveoli.

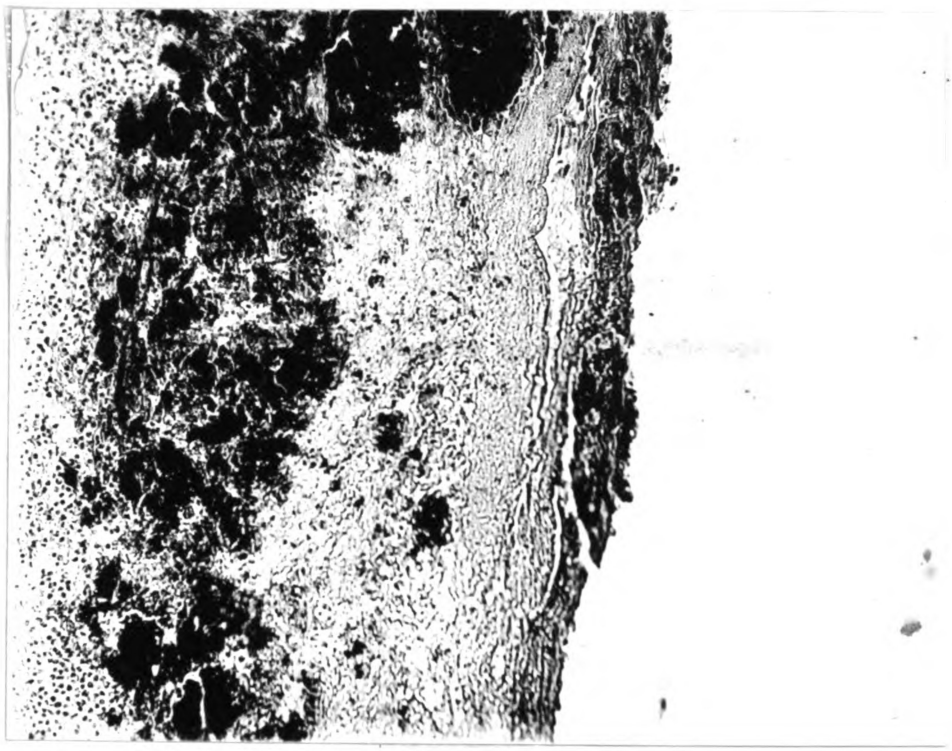
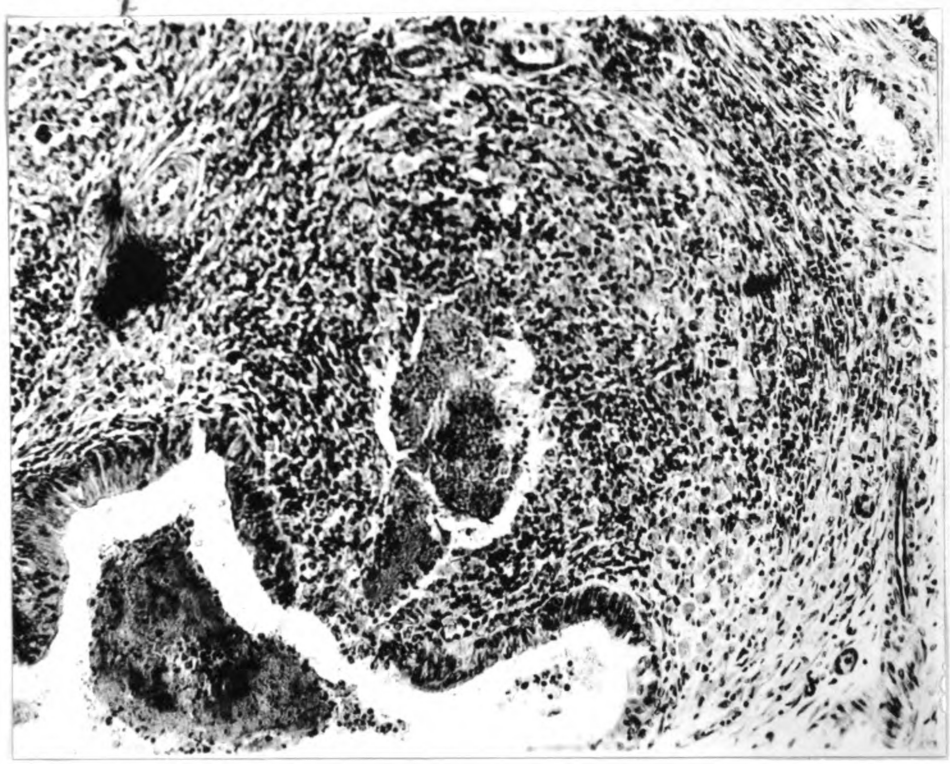


Fig. XXXVI. Autopsy 4188.

Note the small chronic abscess communicating with the bronchiole.

Fig. XXXVII. Autopsy 4176.

Note the enlarged lymph node like structures surrounding the bronchiole. There is also thickening of the mucosa due to an increased number of mononuclear phagocytes.



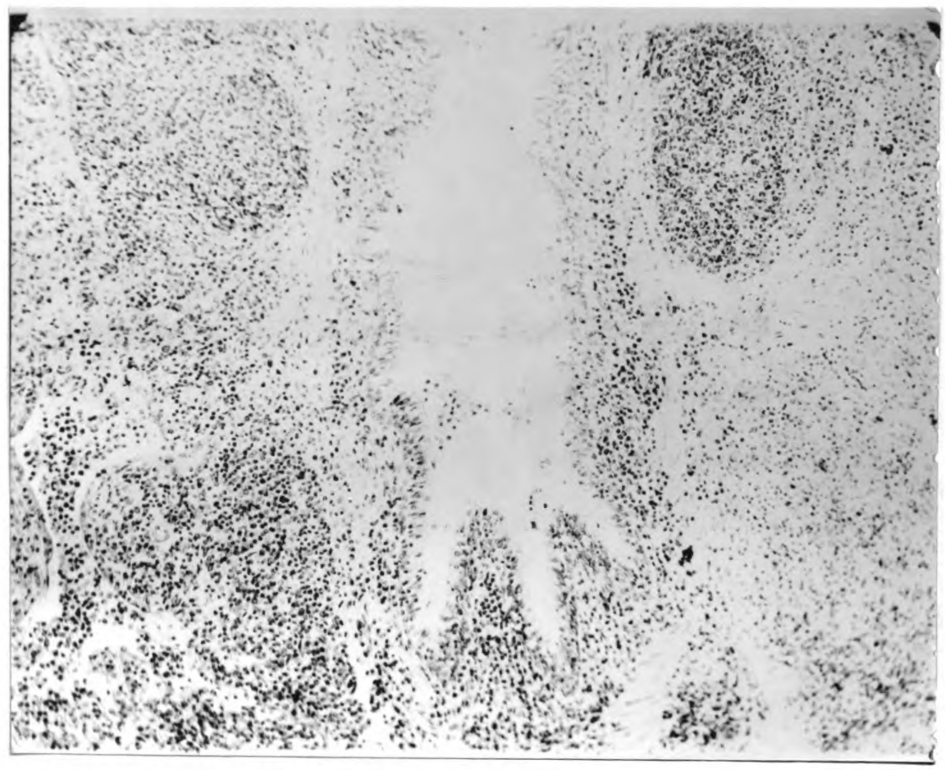
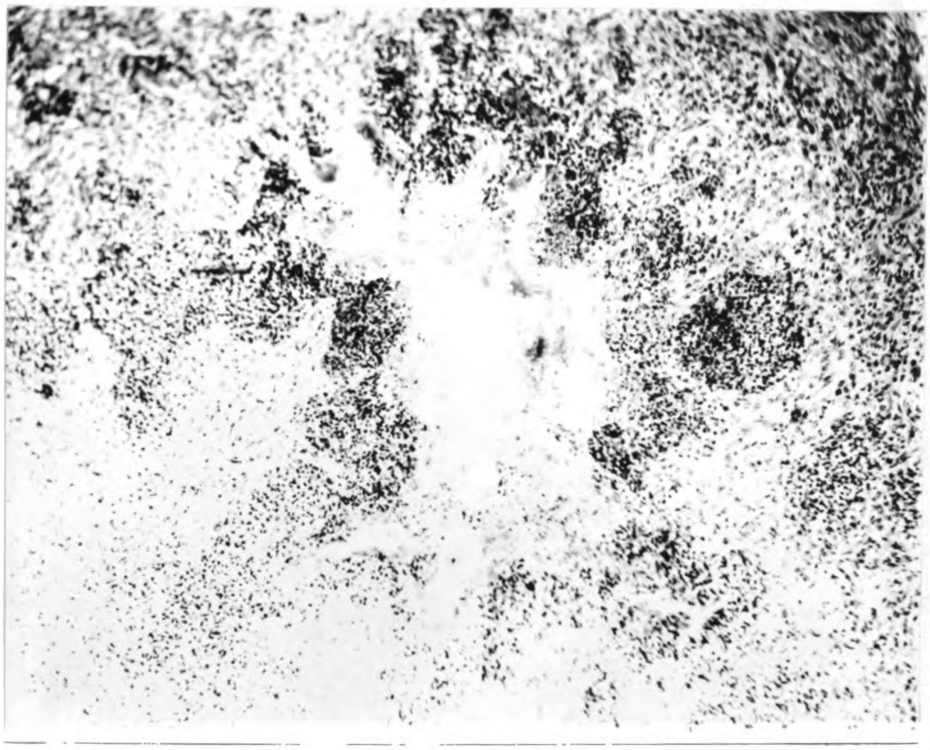


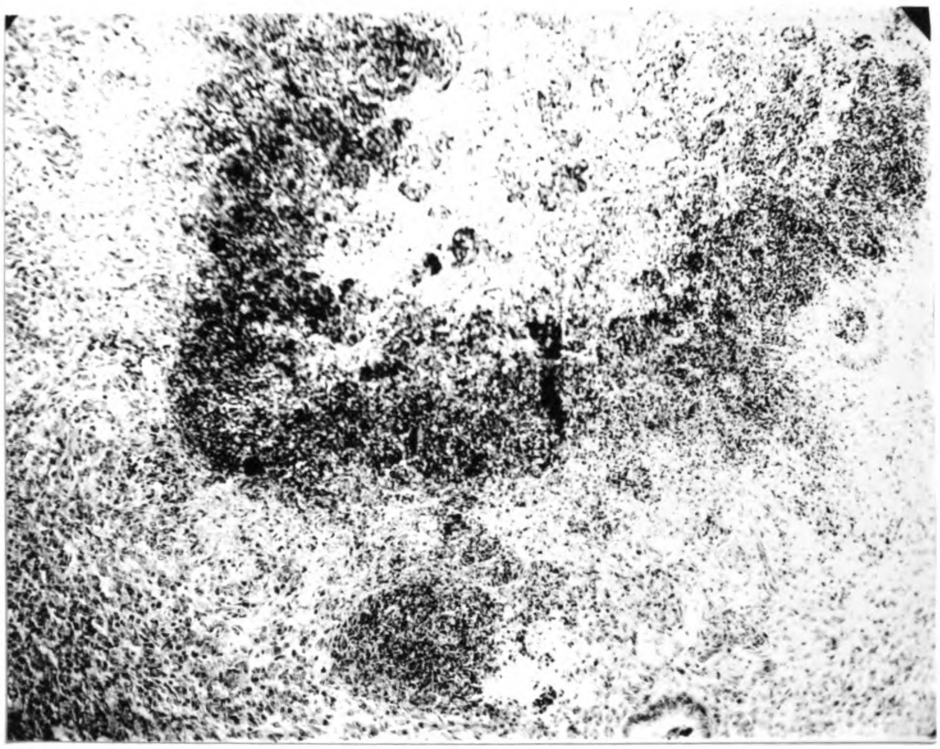
Fig. XXXVIII. Autopsy 4236.

Infarct.

Fig. XXXIX. Autopsy 4237.

Infarct.





Figs. XL to XLV and Figs. XLVII, XLIX, L, LI, LII and LIII have an approximate magnification of 900X.

Fig. XLVI has an approximate magnification of 1100X.

Fig. XLVIII has an approximate magnification of 1000X.

Fig. XL. Autopsy #116.

Note atelectasis and large numbers of mononuclear phagocytes.

Fig. XLI. Autopsy #117.

Note hemorrhage and necrosis of alveolar walls.

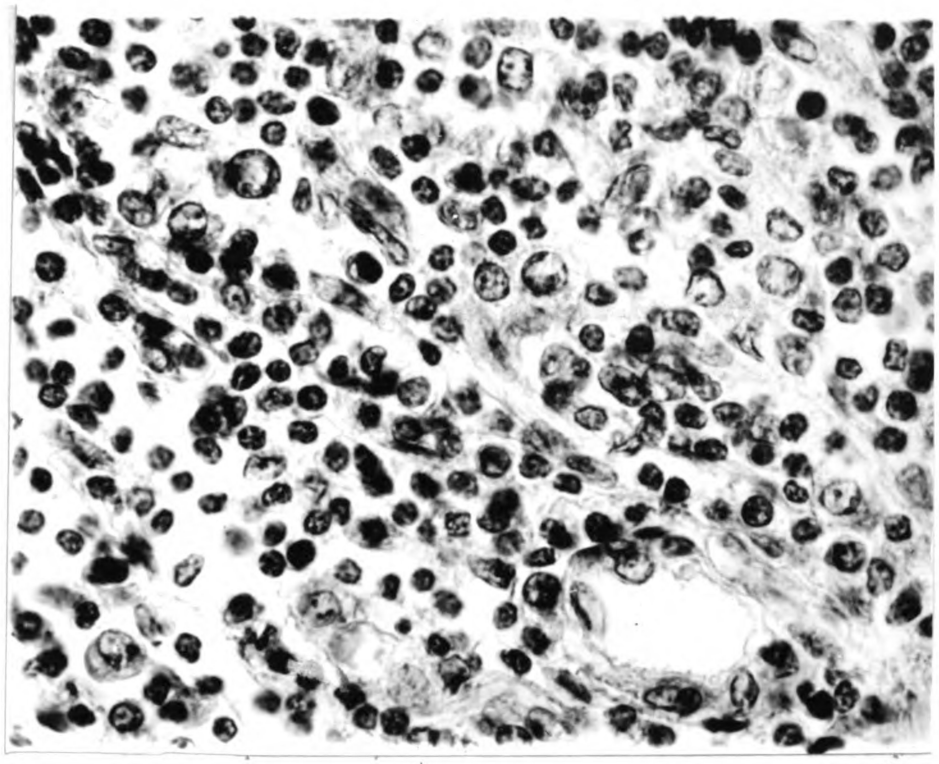
Fig. XL. Autopsy 4116.

Note atelectasis and large numbers of

mononuclear phagocytes.

Fig. XLI. Autopsy 4133.

Note hemorrhage and necrosis of alveolar walls.



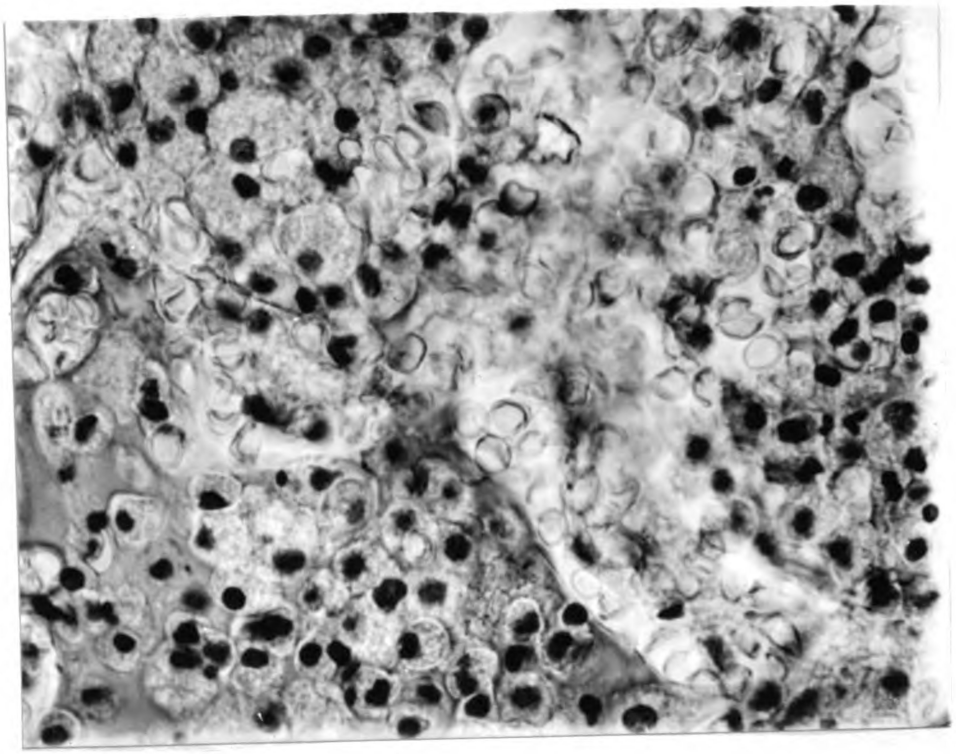


Fig. XLII. Autopsy #134.

Note hemorrhage, necrosis and mononuclear phagocytes.

Fig. XLIII. Autopsy #230.

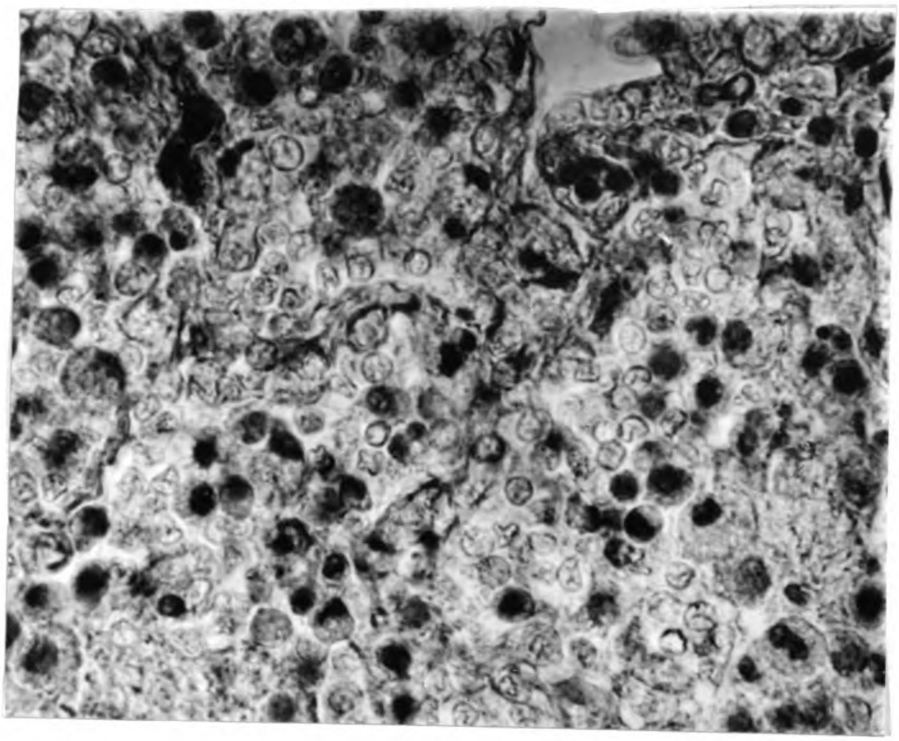
Chronic productive tissue.

Fig. XLII. Autopsy 4134.

Note hemorrhage, necrosis and mononuclear phagocytes.

Fig. XLIII. Autopsy 4230.

Chronic productive tissue.



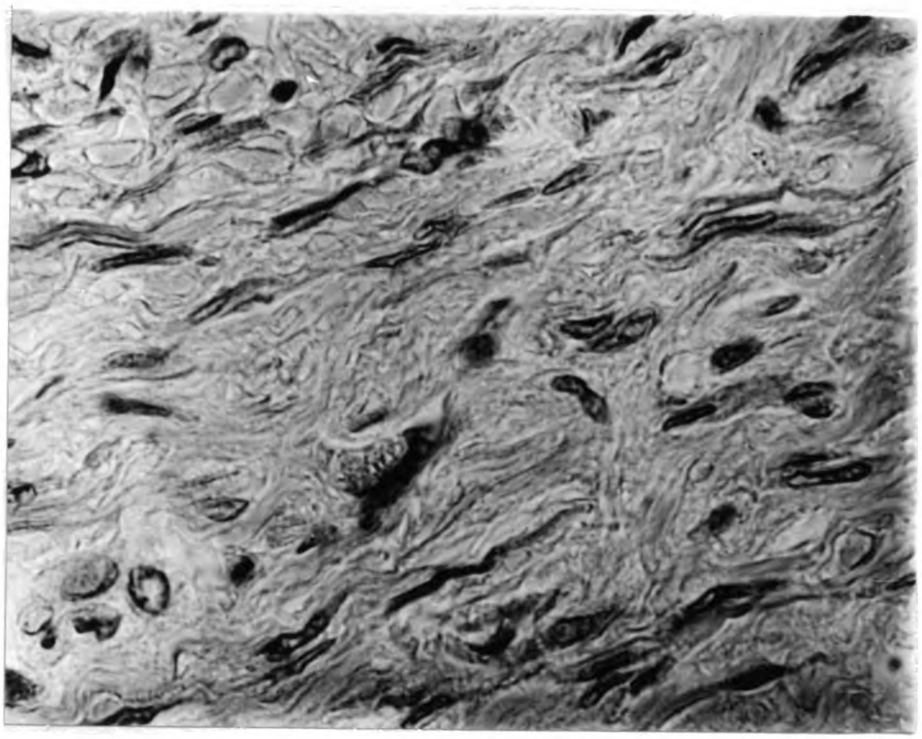
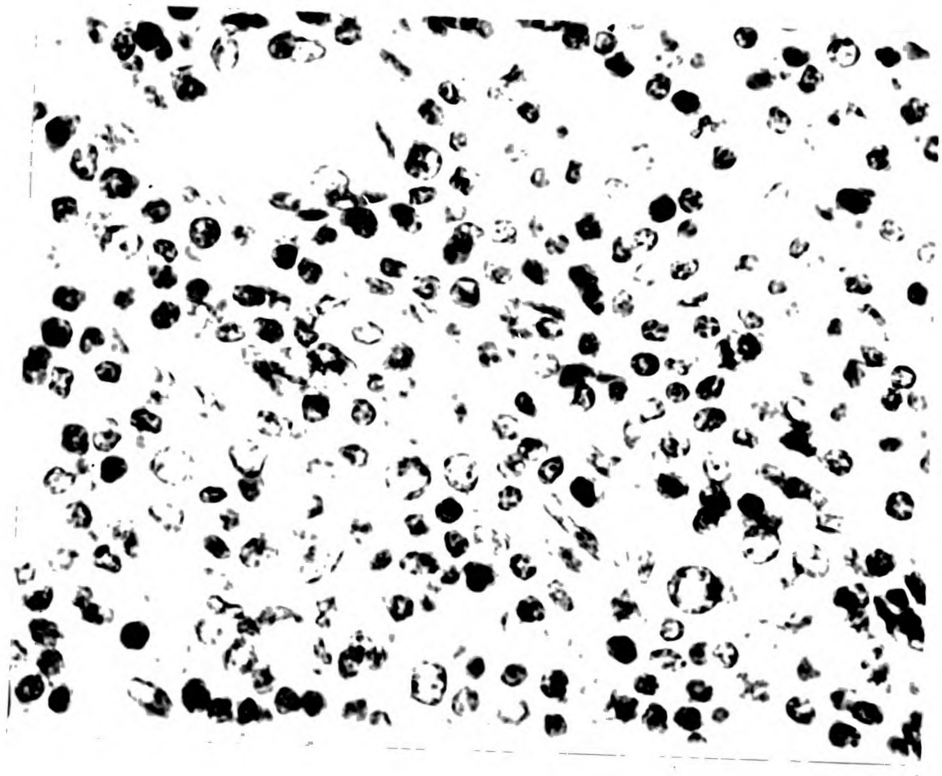


Fig. XLIV. Autopsy 4173.

Note the mononuclear phagocytes and early productive tissue in the mucosa of a bronchiole.

Fig. XLV. Autopsy 4168.

Small abscess communicating with a bronchiole.



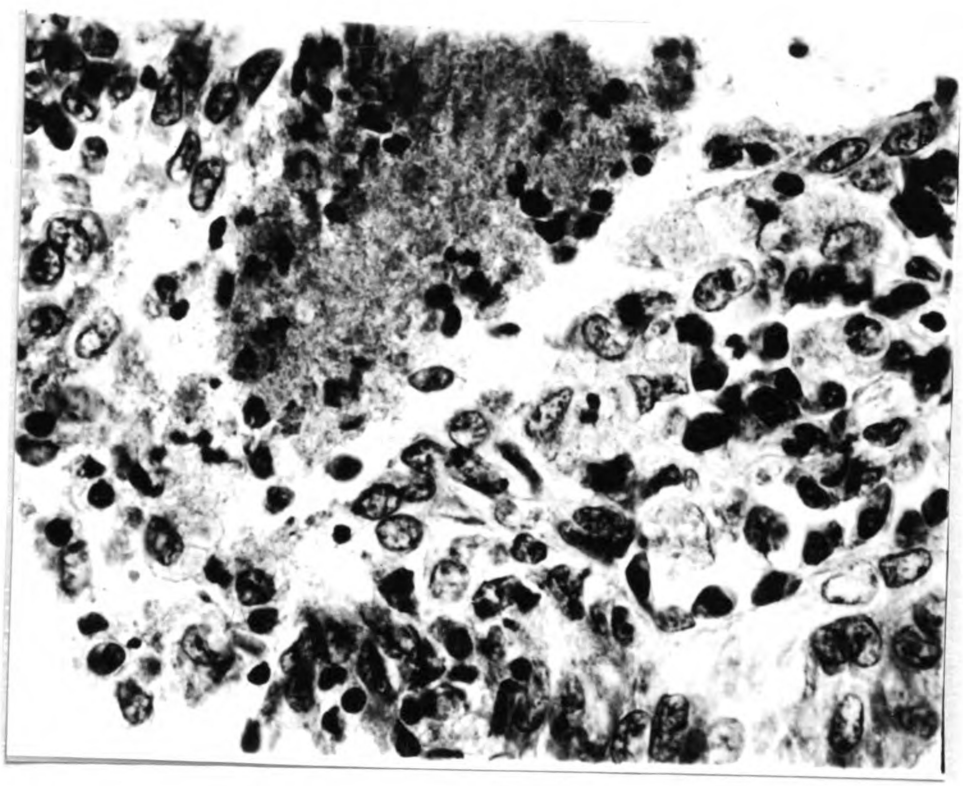
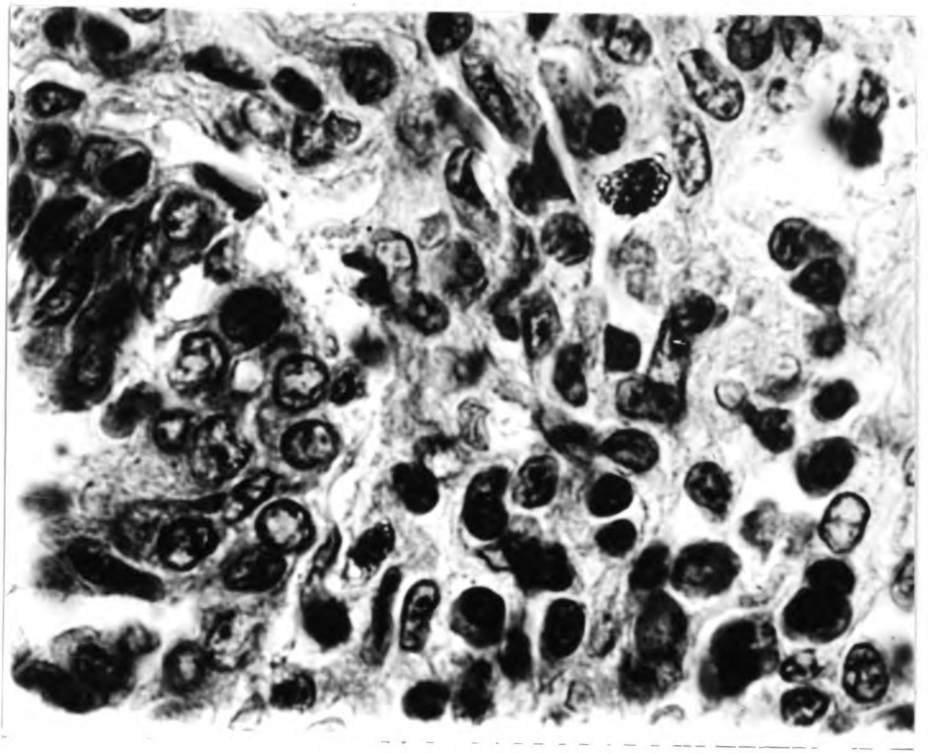


Fig. XLVI. Autopsy 4176.

Note the fibroblasts and the eosinophilic myelocyte.

Fig. XLVII. Autopsy 4236.

Note the great thickening of the intima of this artery with a narrowing of the lumen.



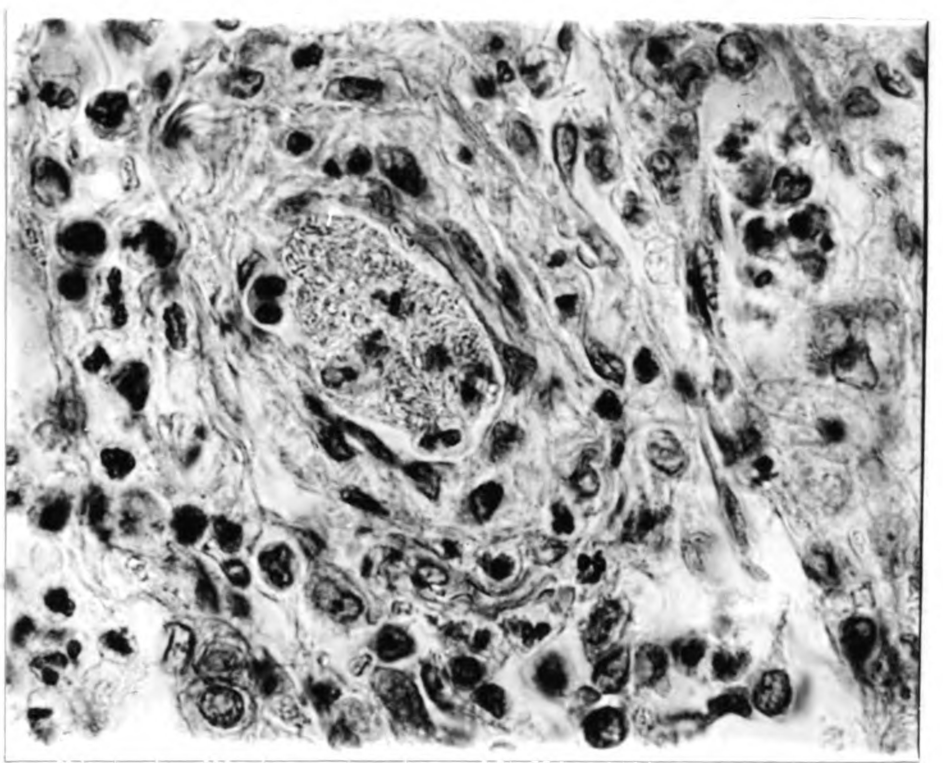


Fig. XLVIII. Autopsy #281.

Note congestion of alveolar capillaries with hemorrhage and mononuclear phagocytes in the alveoli.

Fig. XLIX. Autopsy #281.

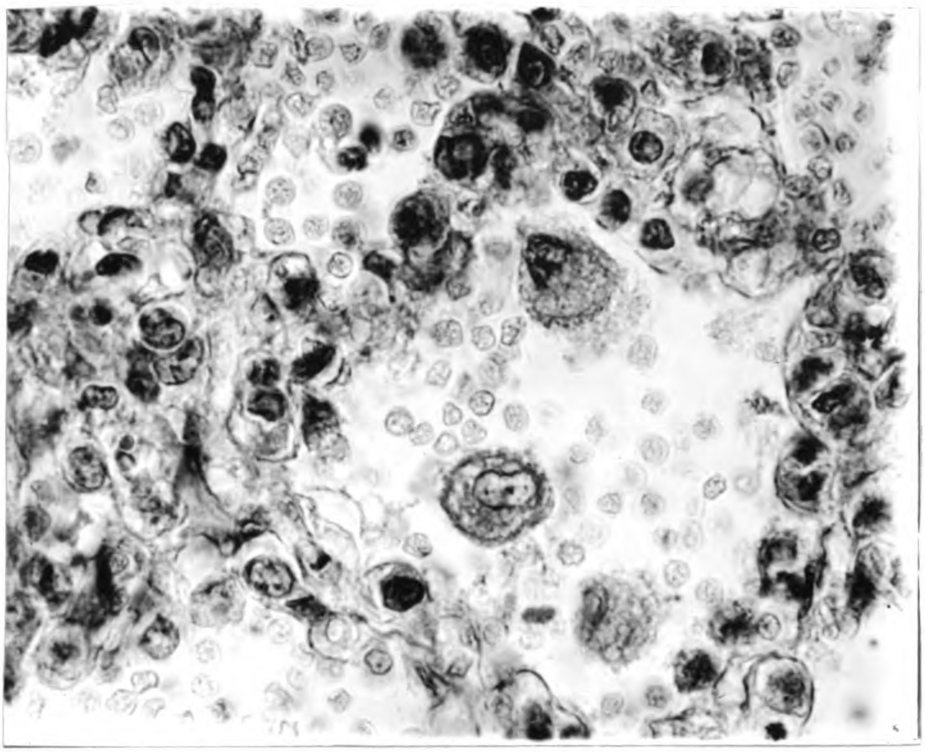
Note desquamation of bronchiolar epithelium with purulent exudate in the lumen and edema of the mucosa.

Fig. XLVIII. Autopsy 4281.

Note congestion of alveolar capillaries with hemorrhage and mononuclear phagocytes in the alveoli.

Fig. XLIX. Autopsy 4281.

Note desquamation of bronchiolar epithelium with a purulent exudate in the lumen and edema of the mucosa.



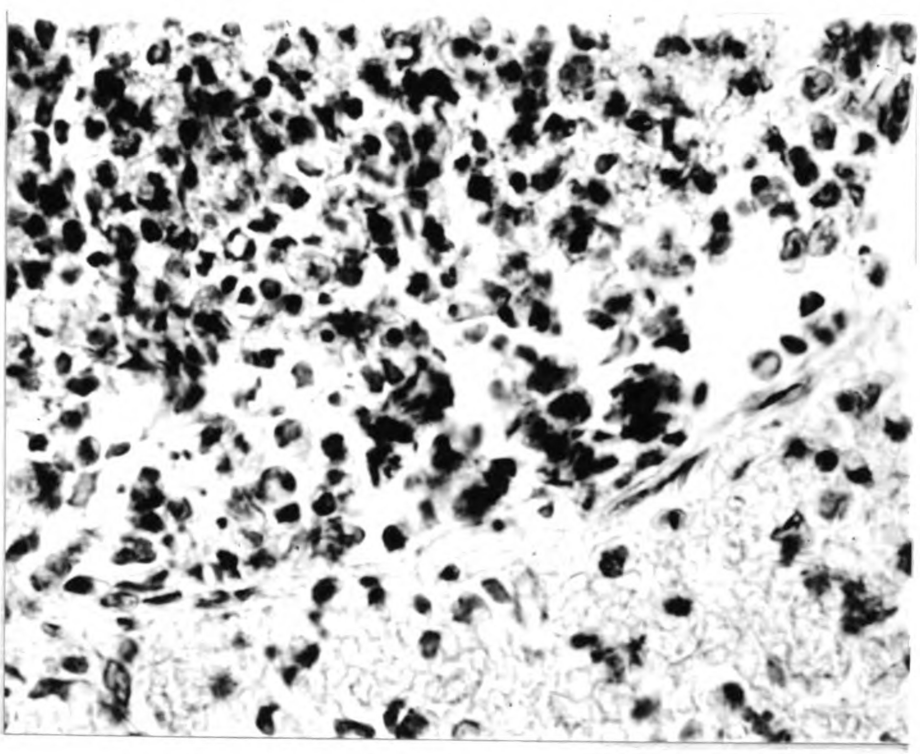


Fig. I. Autopsy #071.

A respiratory bronchiole showing infection and an early suppurative condition of the mucosa.

Fig. II. Autopsy #1534.

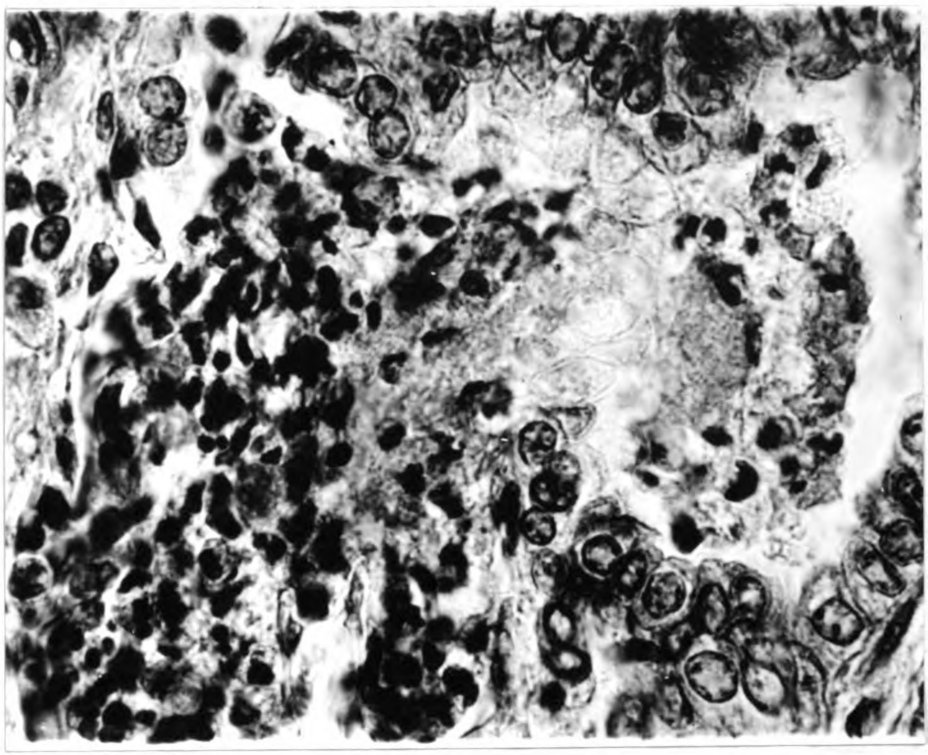
Note sero-fibrinous exudate in the lumen.

Fig. L. Autopsy 4071.

A respiratory bronchiole showing infection and an early suppurative condition of the mucosa.

Fig. LI. Autopsy 4154.

Note sero-fibrinous exudate in the lungs.



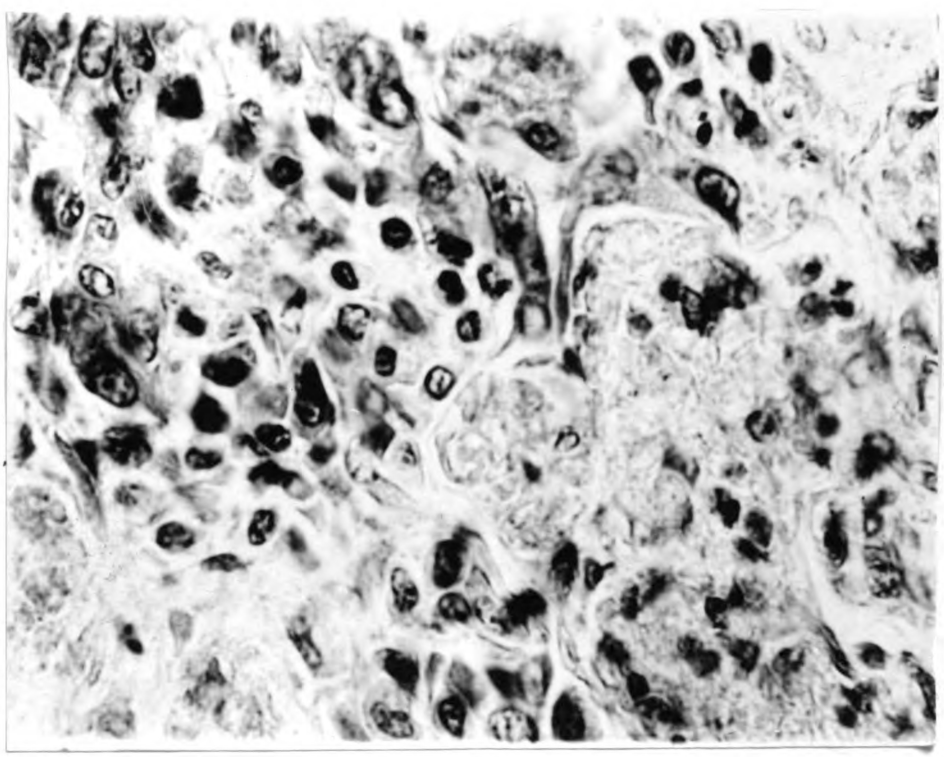
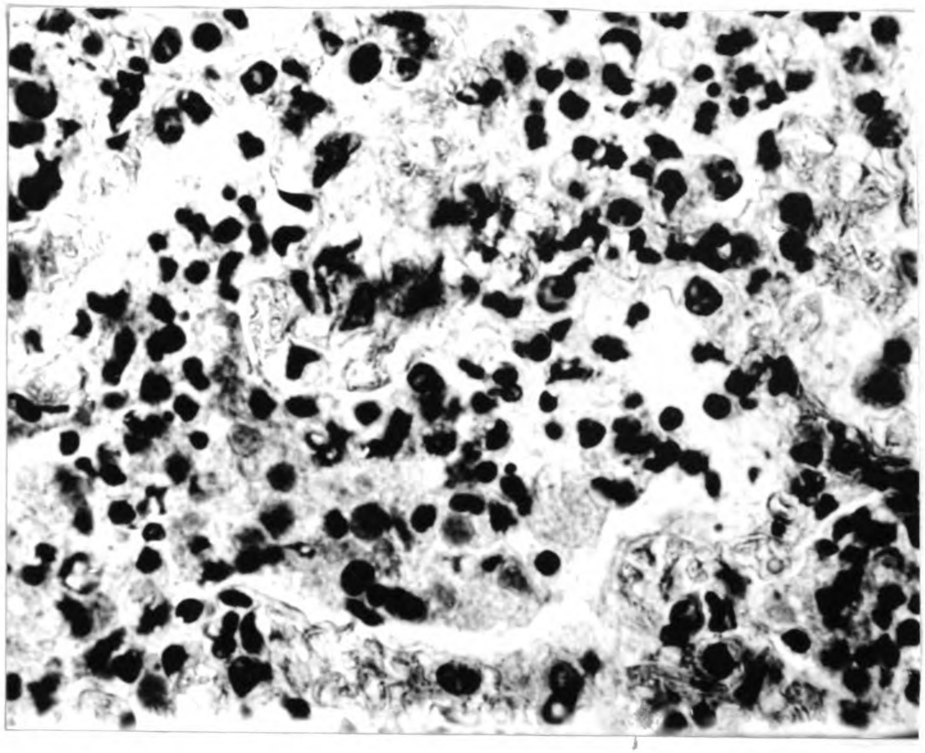


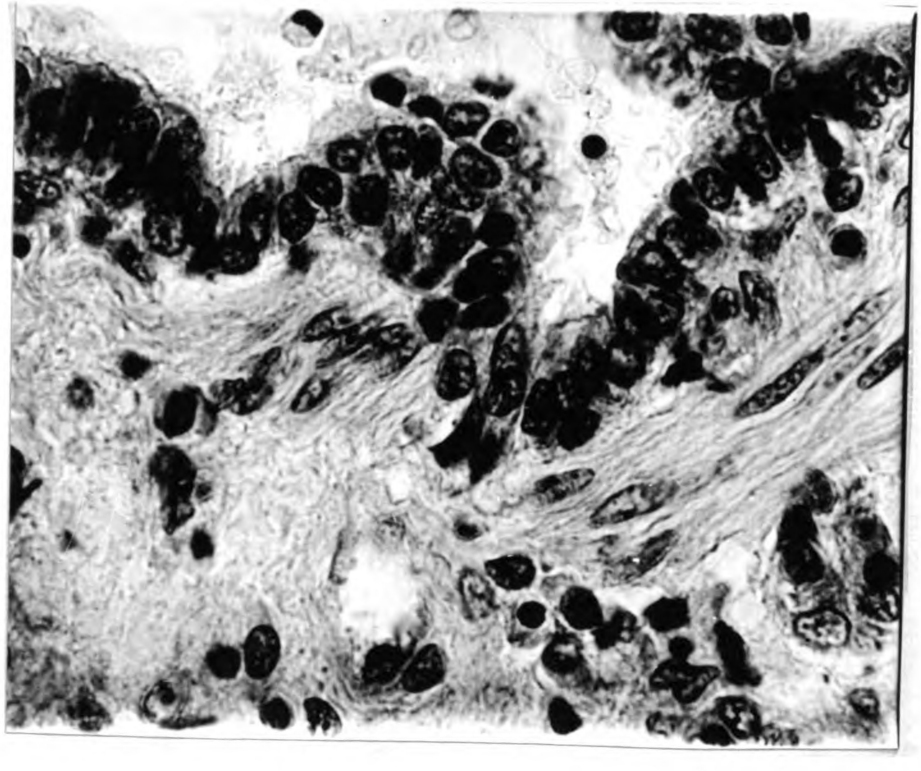
Fig. LII. Autopsy 4346.

Necrosis of infiltrating cells. They show pyknosis.

Fig. LIII. Autopsy 4236.

Note productive reaction about this respiratory bronchiole.





VASCULAR INJECTIONS

The study of the vascular tree in whole organs has been attempted many times. Most methods have consisted of the injection of gelatinous substances colored with dyes and then cutting the organ in serial sections along the course of main arteries. Used X-ray plates have been dissolved and injected in a warm state, when the solution cooled off it solidified and the tissue was then digested off. The viscosity of these fluids were such that the smaller vessels could not be injected and results have therefore been quite unsatisfactory.

A solution of resin in acetone was obtained and injections were commenced using this solution. The resin used is insoluble in HCl and a perfect cast of the circulatory system is obtained upon injection with the acetone-resin solution and digestion of the remaining tissue with the HCl.

Since my method has proven satisfactory and has not previously been used for this purpose, I will outline the procedure used.

1. The organ is removed from a freshly killed animal, leaving the main arteries and veins intact.

2. The main artery is cannulated and the organ is washed out with water until the flow from the veins is perfectly clear. The injection pressure should be about 400 mm. Hg.

3. The organ is now placed in a refrigerator for 24 hours to allow rigor mortis to pass off and to allow the water to drain away.

4. The artery is cannulated again and the acetone-resin solution is injected at 500 mm. Hg. pressure. No air is allowed to enter the injection apparatus. The pressure is held at 500 mm. for

two hours and is then allowed to drop to 100 mm. Hg. pressure. The artery is then tied off to prevent the solution from flowing out when the cannula is removed.

5. The vein is next cannulated and the injection mass is forced into the venous system at 300 mm. Hg. pressure. The pressure is maintained for two hours, the vein then tied off, the cannula removed and the organ is immersed in concentrated HCl until the tissue is completely dissolved. Upon removing the organ, we find that the arteries and veins are present in a perfect cast of their normal condition and location.

Notes on the Gross Angiology of the Bovine Kidney

The renal artery enters at the hilus and breaks up into four main branches - the first branch supplies the posterior three to four lobes. The second branch supplies the adjacent four to five lobes. The third branch is distributed to the next four to five lobes. The anterior branch, which is the largest, supplies the greater amount of kidney tissue which is apparently five large lobes. The primary branch divides into three to five secondary branches which correspond to the interlobar and the arcuate vessels of text book descriptions. These arcuate vessels do not have the curved appearance which they are supposed to assume. The branching of the interlobar vessel into interlobular resembles very closely that of a tree or plant which is pedicle in nature. Only in a few instances can the vessel be seen transversing the outer medulla, and even in these cases it ends up with bushy-like branchings of the interlobulars. The afferent arterioles are not completely injected. They are extremely numerous. The glomerular capillaries are not injected in any of my cases. The veins follow closely the course of the arteries.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