MATERIALS AND METHODS

The specimen material was secured from one carcass each of chickens aged thirty-six hours (male), twenty days (sex unrecorded), five months (female), one and one-half years (male), and two years (female). Besides these, livers and some additional material were obtained from two groups of baby chicks. Several specimens of the bursa cloacae were obtained from other chickens. For the current revision, portions of several other specimens were utilized to check the original work and to verify the work of recent investigators.

The following methods were used: paraffin embedding with the exception of frozen sections of a specimen of each liver; Harris hematoxylin and eosin were used as a routine stain; Weigert's elastic tissue stain was used for elastic connective tissue; Van Gieson's picro-acid-fuchsin was used for white fibrous connective tissue; frozen sections of liver were stained with Scharlach R [alcohol-acetone method according to Mallory and Wright (1924)]; mucin was demonstrated by Mayer's mucicarmine method as given by Hoepke (1930); keratohyalin granules were stained by Pasini's (1930) method; reticulum, according to Foot and Menard (1927).

In the experiments with the baby chicks the chicks were killed at stated intervals and a section of the liver stained for fat to determine at what age the fat began to disappear and how long it persisted.

RESULTS

Observations were made on the digestive tract from the beak to the anus, including all appendages. No differences existed in the digestive tract of either sex, so the matter of sex will not be referred to again.

Beak

The beak, as shown in Plate IV, Figure A, consisted of three layers, bone (11), corium (6), and epidermis (1). The bone in the upper beak was the os incisivum and in the lower the os dentale. A layer of periosteum was observed outside the bone. (Pl. IV, Fig. A-10).

The corium (Pl. IV, Fig. A-6) extending from the periosteum to the epithelium was made up of connective tissue containing

Plate IV — Fig. A. Upper beak, cross section. Hematoxylin-eosin. 200 ×. 45 days.

1. Epidermis
2. Stratum corneum
3. Stratum lucidum
4. Stratum granulosum
5. Stratum germinativum
6. Corium
7. Blood vessels
8. Nerve
9. Taste corpuscle
10. Periosteum
11. Bone

blood vessels (7), nerves (8), and special nerve endings (9), as shown in Plate IV, Figure A.

The epidermis (Pl. IV, Fig. A-1) comprised four layers. The stratum germinativum (Pl. IV, Fig. A-5) was composed of three rows of tall cylindrical epithelial cells which changed abruptly to the stratum granulosum. (Pl. IV, Fig. A-4). This latter contained four to five layers of flattened cells, with their long axes parallel to the surface. They were distinctly granular. Intercellular bridges were very prominent in this layer. The stratum lucidum (Pl. IV, Fig. A-3) was less distinct than the corresponding layer in the skin of mammals. It comprised about one-eighth of the entire epidermis. The stratum corneum (Pl. IV, Fig. A-2) was a very thick layer of flat structureless cells.

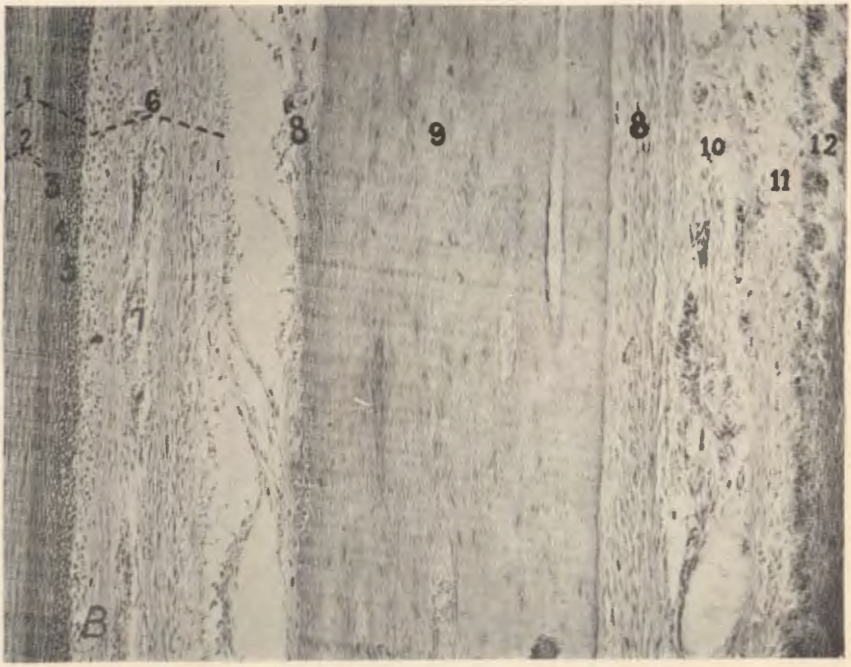

Plate IV — Fig. B. Lower beak, longitudinal section. Hematoxylin-eosin. 200 ×. 45 days.

1. Epidermis
2. Stratum corneum
3. Stratum lucidum
4. Stratum granulosum
5. Stratum germinativum
6. Corium
7. Blood vessels
8. Periosteum
9. Bone
10. Submucosa
11. Tunica propria
12. Epithelium of mouth

The general structure of the lower beak (Pl. IV, Fig. B) corresponded to the above. The cutis appeared more vascular. There were no taste corpuscles present. The epidermis was about one-third as wide as that of the upper beak. The stratum germinativum contained polyhedral cells, instead of cylindrical cells as in the upper beak.

Mouth Cavity

The mucous coat of the mouth cavity was lined throughout with stratified squamous epithelium. Papillae from the tunica propria extended into its basal layers, and projections from the epithelium protruded down between these papillae from the tunica propria. In the roof of the mouth (Pls. V-VII) the nuclei

Plate V — Fig. A. Anterior portion of the hard palate.

1. Epithelium
2. Tunica propria
3. Submucosa
4. Fat
5. Excretory duct
6. Maxillary salivary gland

Fig. B. Mid-portion of the hard palate.

1. Epithelium
2. Tunica propria
3. Submucosa
4. Fat
5. Medial palatine salivary gland
6. Papilla of hard palate

Fig. C. Region adjacent to the nares.

1. Epithelium
2. Tunica propria
3. Submucosa
4. Nasal mucous membrane
5. Medial palatine salivary gland
6. Papilla on hard palate

of the cells of the outer surface of the epithelium were flatter than those of the basal layer and took a deeper stain. In places they appeared to be in a small cavity which did not take any stain.

The division between the tunica propria (Pl. V, Fig. A-2) and the submucosa (Pl. V, Fig. A-3) was rather an arbitrary one since there was no muscularis mucosae present until the posterior part of the pharynx was reached. (Pl. VII, Fig. A-3). The tunica propria contained many macroscopic papillae (Pl. VI, Fig. A-3 and Fig. B-6) which extended posteriorly. The microscopic papillae extending into the epithelium seemed shorter near the lateral borders. Elastic and white fibrous connective tissue was present in the tunica propria. Diffuse lymphoid tissue was observed in the tunica propria of the 1½-year-old specimen and a lymph nodule in the 2-year-old specimen. These were not evident in young chickens.

The submucosa (Pl. V, Fig. A-3) was considered as that portion deeply to the tunica propria in which salivary glands lie. Since one gland was practically in continuity with another and these glands were paired, there were few areas in which no glandular tissue was present.

The submucosa contained elastic and white fibrous tissue, the latter forming a capsule about the glands. A fatty cushion was observed beneath the gland layers in many specimens (Pl. V, Fig. A-4). The muscular layer outside the submucosa was voluntary.

The floor of the mouth was very similar in structure to the roof of the mouth. Toward the lateral sides of the floor of the mouth the epithelium became less compact, the outer cells were more polyhedral, and the nuclei more spherical and pycnotic. The microscopic papillae of the tunica propria were more prominent.

Tongue

The general structure of the tongue (Pl. VIII, Figs. A and B and Pl. IX, Fig. A) was similar in its entire length. A thick stratified squamous epithelium (Pl. VIII, Fig. B-1) covered the dorsal surface. In some instances the surface was uneven, the projections resembling low blunt papillae.

Plates V-VII represent a longitudinal section through the roof of the mouth and rynx. The figures are a series from a section extending from the beak to the esophus. Hematoxylin-eosin. 50 ×. 2 weeks.

Plate VI — Fig. A. A longitudinal section through the mucosa lining the nares.

1. Epithelium
2. Tunica propria
3. Papillae separating the roof of the mouth from the pharynx

Fig. B. Anterior portion of the pharynx.

1. Epithelium
2. Tunica propria
3. Submucosa
4. Epithelium of nasal cavity
5. Medial palatine gland
6. Papillae of the roof of the pharynx

Fig. C. Mid-portion of the pharynx.

1. Epithelium
2. Tunica propria
3. Muscle arranged obliquely to the roof of the pharynx
4. Medial palatine gland
5. Sphenopterygoid salivary gland
6. Papillae of the roof of the pharynx

Plate VII — Fig. A. Region from pharynx to esophagus.

1. Epithelium
2. Tunica propria
3. Muscularis mucosae
4. Submucosa
5. Beginning lamina muscularis
6. Adventitia
7. Sphenopterygoid salivary gland
8. Papilla separating the pharynx from the esophagus

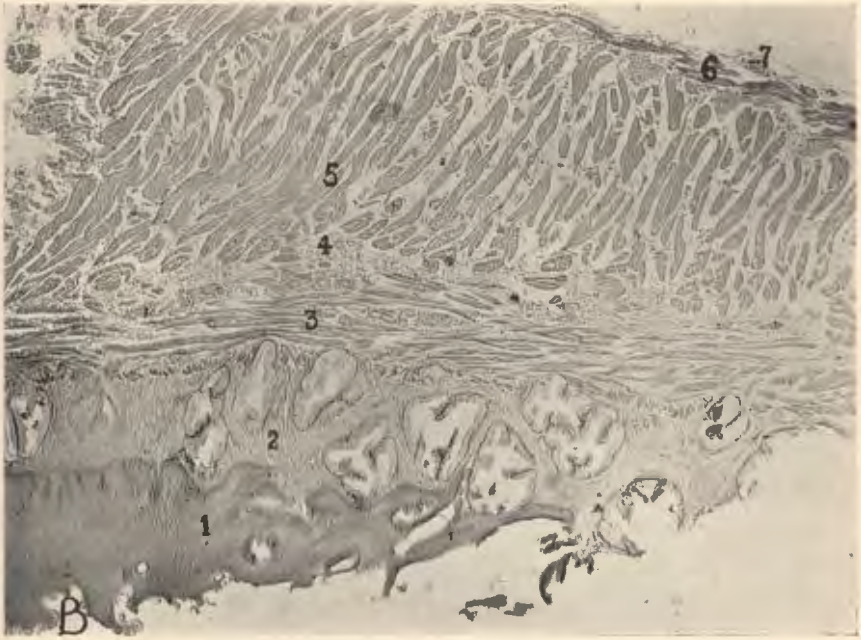

Fig. B. Esophagus.

1. Epithelium
2. Tunica propria with mucous glands
3. Muscularis mucosae
4. Submucosa
5. Circular layer of lamina muscularis
6. Longitudinal layer of lamina muscularis
7. Adventitia

Plate VIII — Fig. A. Cross section of tongue near tip. Hematoxylin-eosin. 50 ×. Baby chick.

1. Epithelium of dorsal surface
2. Tunica propria
3. Anterior lingual salivary glands
4. Cartilage (entoglossal bone)
5. Muscle
6. Epithelium of ventral surface showing cornification

Fig. B. Cross section of tongue, mid-portion. Hematoxylin-eosin. 50 ×. 1½ years.

1. Epithelium of dorsal surface
2. Tunica propria
3. Anterior lingual salivary glands
4. Entoglossal bone
5. Muscle
6. Epithelium af ventral surface

Plate IX — Fig. A. Base of tongue. Hematoxylin-eosin. 25 ×. Baby chick.

1. Epithelium
2. Papillae
3. Tunica propria
4. Submucosa
5. Cartilage (basihyal bone)
6. Cartilage (entoglossal bone)
7. Muscle
8. Lingual glands

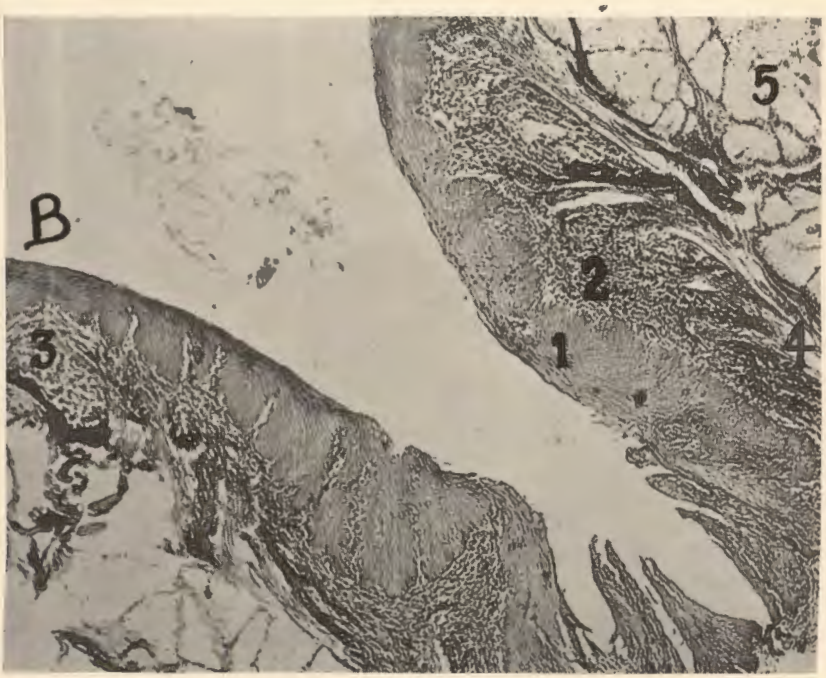

Fig. B. Cross section of Aditus laryngis. Hematoxylin-eosin. 50 ×. 1½ years.

1. Epithelium
2. Lymphoid tissue in tunica propria
3. Lymphoid nodule
4. Submucosa
5. Cricoarytenoid gland

The tunica propria (Pl. VIII, Fig. B-2) comprised the second layer, which contained the anterior lingual salivary glands on either side, (Pl. VIII, Fig. B-3), the entoglossal bone, (Pl. VIII, Fig. B-4) (cartilaginous in young birds) in the middle, with voluntary muscle (Pl. VIII, Fig. B-5) below the bone. The tunica propria was made up of white fibrous and areolar tissue containing blood and lymph vessels and nerves. Prominent microscopic papillae of tunica propria extended into the epithelium. In old birds the lower surface contained diffuse lymphoid tissue and an occasional lymphoid nodule. No lymphoid tissue was present in the tongue of a young specimen. The stratified squamous epithelium of the ventral surface of the tongue (Pl. VIII, Fig. B-6) was smooth. It was about one-third to one-fourth as thick as that of the dorsal surface. Toward the point of the tongue (Pl. VIII, Fig. A) the lower epithelium became cornified and took a stain similar to the stratum corneum of the beak. Toward the base of the tongue the entoglossal bone (Pl. IX, Fig. A-6) presented a different picture than in the mid-portion. Two wings of this bone extended laterocaudally just below the dorsal surface of the tongue. In the center the basihyal bone was observed. (Pl. IX, Fig. A-5).

The muscles presented different pictures at different levels. Near the tip the muscle was practically absent. (Pl. VIII, Fig. A). A cross section from the mid-portion of the tongue is shown in Plate VIII, Figure B, and a section from near the base is shown in Plate IX, Figure A.

Serial sections of the tongue failed to reveal any taste buds.

Salivary Glands

Schauder's (1923) description and terminology was used for the location and naming of the salivary glands. A translation of the outline, including only the parts pertaining to the chicken, follows:

a) Glands at the bottom of the oral cavity.
1. Anterior submaxillary: largely developed, paired glands in the angle between the lower rami of the maxilla.
2. Posterior submaxillary in group of 3:
a. anterior lateral, lying medial to the os dentale; *b*. intermediare, caudoventral to *a*; *c*. back mediale, postero-medial to and connecting with the intermediary group.

b) Glands of angle of the mouth.
   3. Angularis oris gland [Cholodkowsky (1892)]: lying in the angles of the beak, a small, three-cornered gland area.
c) Glands of the tongue.
   4. Anterior lingual; at the side of, in the middle of, and in the posterior part of the tongue.
   5. Posterior lingual: on the dorsal surface of the base of the tongue.
d) Glands of the roof of the mouth.
   6. Paired glands joining medially in the hard palate lying before the posterior nares [maxillary of Heidrich, (1905)].
   7. Medial and lateral palatine glands: extending longitudinally to the posterior nares.
   8. Sphenopterygoid: in the roof of the pharynx.
e) Glands of the pharyngeal canal.
   9. Cricoarytaenoideae: lying lateral to the larynx in the submucosa of the cutaneous mucous membrane.

The salivary glands all presented the same structure. They consisted of branched tubular glands with openings into a common cavity (Pl. X, Fig. A-3) from which an excretory duct (Pl. X, Fig. A-1) led to the mouth cavity. The angularis oris and the maxillary glands had a single opening for each gland. Others had many openings for a single gland. The cells were columnar in shape with small nuclei which lay close to their bases. Fine septa containing white fibrous and elastic fibers, capillaries, and some muscle fibers extended between the tubules from the capsule which surrounded the acini. Basket cells were not definitely identified. There were some large cells in the septa, but their nature was not determined. The glands were entirely composed of mucous cells, and in no case were serous cells observed.

The buccal epithelium extended into the duct a short distance and then changed to a low columnar type which continued into and lined the collecting cavity, becoming taller again in the latter.

Lymphoid tissue (Pl. XI, Fig. A-4 and Pl. XII, Fig. B-6) was found between the lobules of all glands of the adult specimens except in the anterior lingual. Only the third group of the posterior submaxillary and the cricoarytenoid contained lymphoid tissue in the 5-month-old specimen, and of the two younger specimens the only indication of lymphoid tissue was in the cricoarytenoid of the 36-hour chick.

A peculiar structure was observed in some of the glands. The cell outlines had disappeared, and the result was one conglomerate mass of secretion and cellular debris (Pl. XI, Fig. A-5). A similar area in another section (Pl. XI, Fig. B-2) took a mucous stain.

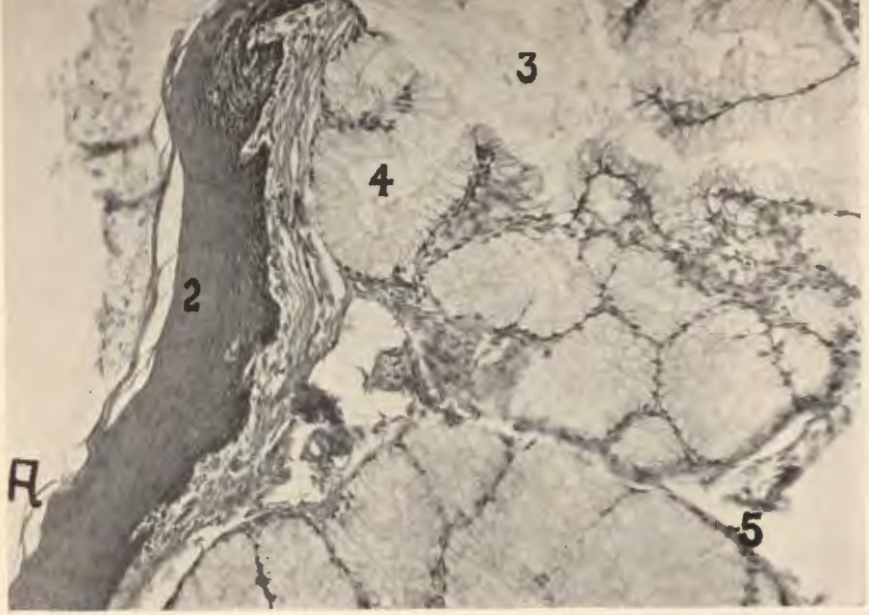

Plate X — Fig. A. Posterior lingual salivary gland (without lymphoid tissue). Hematoxylin-eosin. 200 ×. 20 days.

1. Duct with secretian pouring out
2. Epithelium of floor of pharynx
3. Central collecting cavity
4. Simple tubular gland
5. Gland capsule

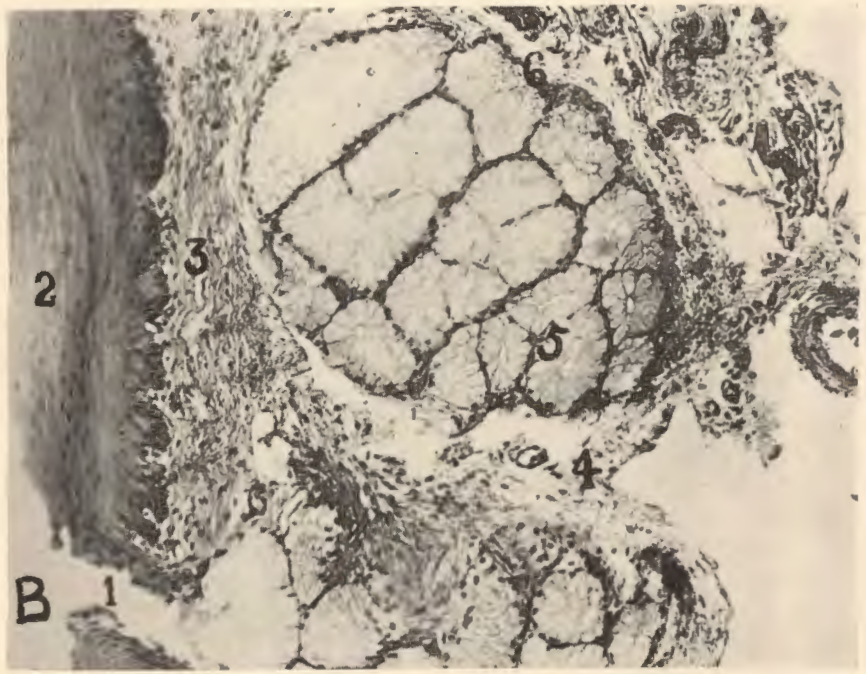

Fig. B. Sphenopterygoid salivary gland. Hematoxylin-eosin. 200 ×. 20 days.

1. Excretory duct
2. Epithelium of roof of pharynx
3. Tunica propria
4. Submucosa
5. Cross section of a gland tubule
6. Gland capsule

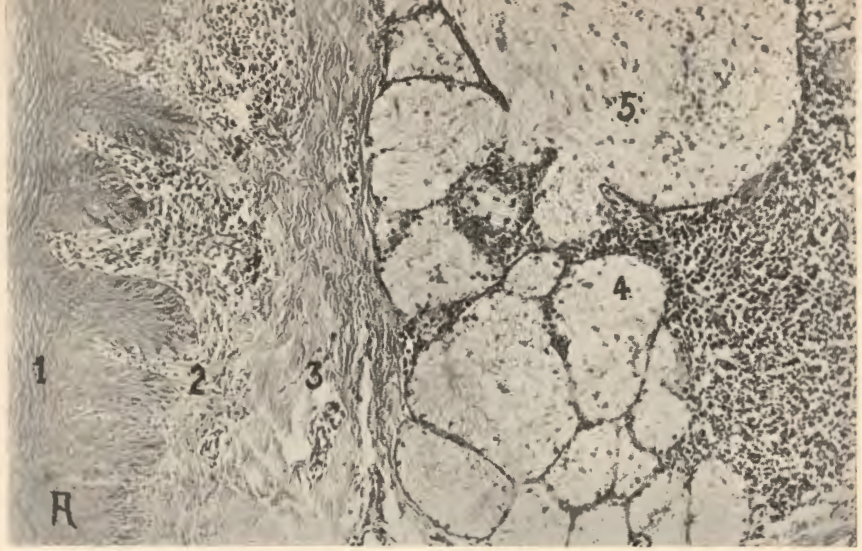

Plate XI — Fig. A. Sphenopterygoid salivary gland with lymphoid tissue. Hematoxylin-eosin. 200 ×. 2 years.

1. Epithelium of pharynx
2. Tunica propria
3. Submucosa
4. Gland showing infiltration with lymphoid tissue
5. Glandular orea with cell outlines absent

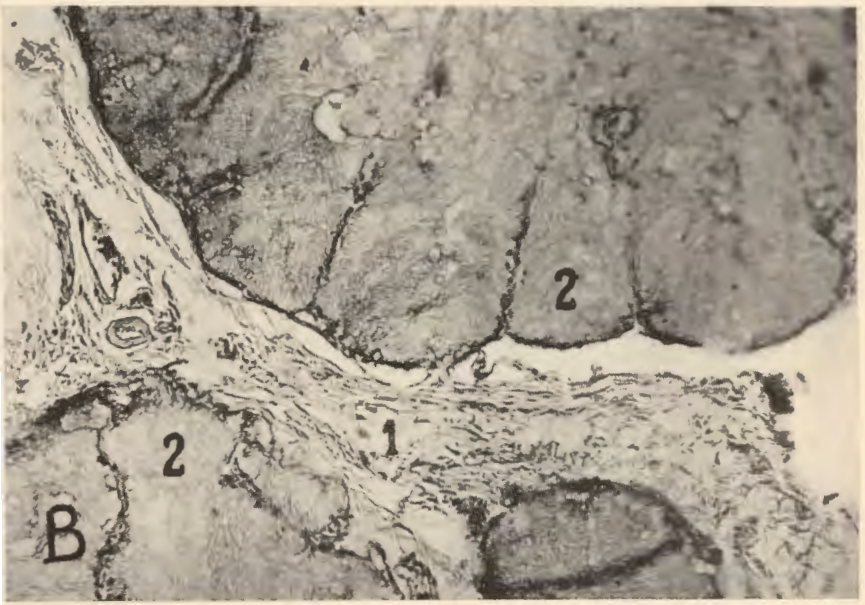

Fig. B. Posterior submaxillary salivary gland stained for mucin. 200 ×. 5 months.

1. Submucosa
2. Posterior submaxillary salivary gland

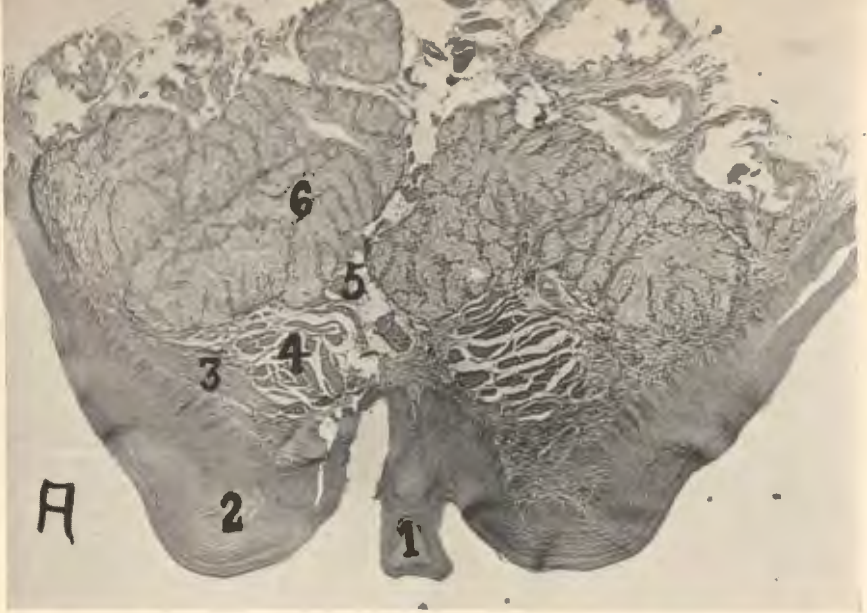

Plate XII — Fig. A. Maxillary salivary glond. Cross section from anterior portion of roof of mouth. Hematoxylin-eosin. 50 ×. 5 days.

1. Papilla of roof of mouth
2. Epithelium
3. Tunica propria
4. Muscle
5. Submucosa
6. Gland tissue

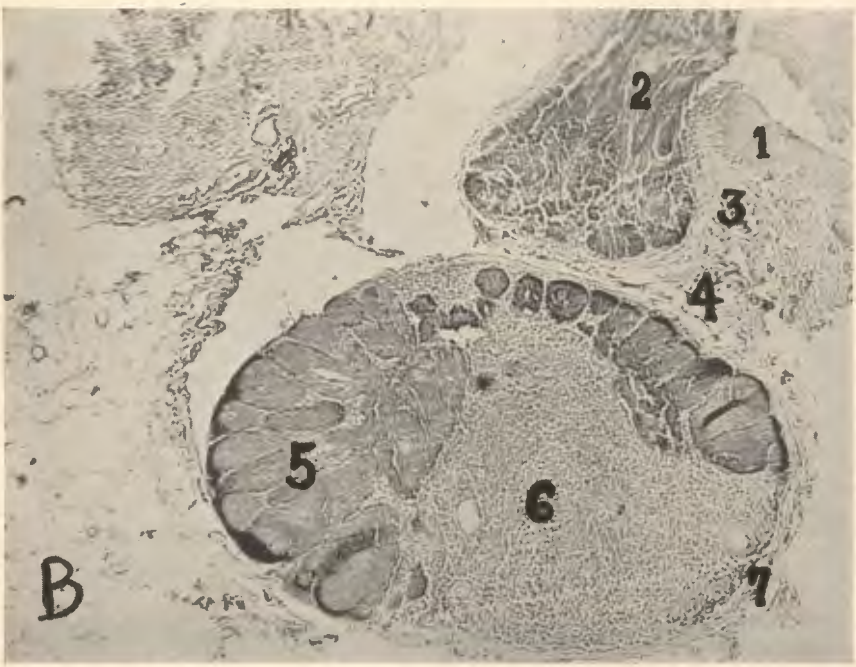

Fig. B. Lobule of submoxillary salivory gland. Mucous stain. 50 ×. 2 years.

1. Epithelium of roof of mouth
2. Excretory duct
3. Tunica propria
4. Submucosa
5. Gland tissue showing different densities of mucin
6. Lymphoid tissue
7. Gland capsule.

Pharynx

The pharynx extended from the row of papillae at the back of the hard palate (Pl. VI, Fig. A-3) to the row of papillae at the entrance of the esophagus. (Pl. VII, Fig. A-8). The roof of the pharynx was composed chiefly of the medial palatine (Pl. VI, Fig. C-4) and the sphenopterygoid glands (Pl. VI, Fig. C-5) between which lay a voluntary muscle making an oblique angle with the epithelium (Pl. VI, Fig. C-3). The microscopic structure resembled that of the mouth as did that of the floor of the pharynx. The latter contained the posterior lingual and the cricoarytenoid glands in its wall.

The structure regarded by some authors as a tonsil was observed as a lymphoid infiltration of the tunica propria in the region of the aditus laryngis (Pl. IX, Fig. B). Some lymph nodules were present under the stratified squamous epithelium.

As in the tongue, a study of serial sections of the pharynx did not reveal any taste corpuscles. If they are present in the domestic chicken, this author has not been able to locate them.

The wall of the digestive tube proper consisted essentially of a mucous membrane, comprised of an epithelial lining, tunica propria, and muscularis mucosae; a submucosa; a lamina muscularis; and an adventitia or serosa depending on the location of the organ.

Esophagus

The esophagus was similar in structure both anterior and posterior to the crop. It was characterized by a wide stratified squamous epithelial layer (Pl. XIII, Fig. A-1). The basal layer of the epithelium projected between prominent papillae of the tunica propria. The epithelium showed a loosening of the outer layers with a tendency to slough off. In the tunica propria (Pl. XIII, Fig. B-2) were contained large mucous glands (Pl. XIII, Fig. B-3). The tunica propria was made up of a network of fibrous tissue which contained many blood vessels, lymph vessels, and nerves. As the bird advanced in age the elastic tissue became more dense in the submucosa, (Pl. XIV, Fig. B) and was observed in the tunica propria. Lymphoid nodules were also observed. The mucous glands were lined by low cuboidal epithelium which decreased in height as it approached the surface, finally becoming flattened (Pl. XV, Fig. B-3).

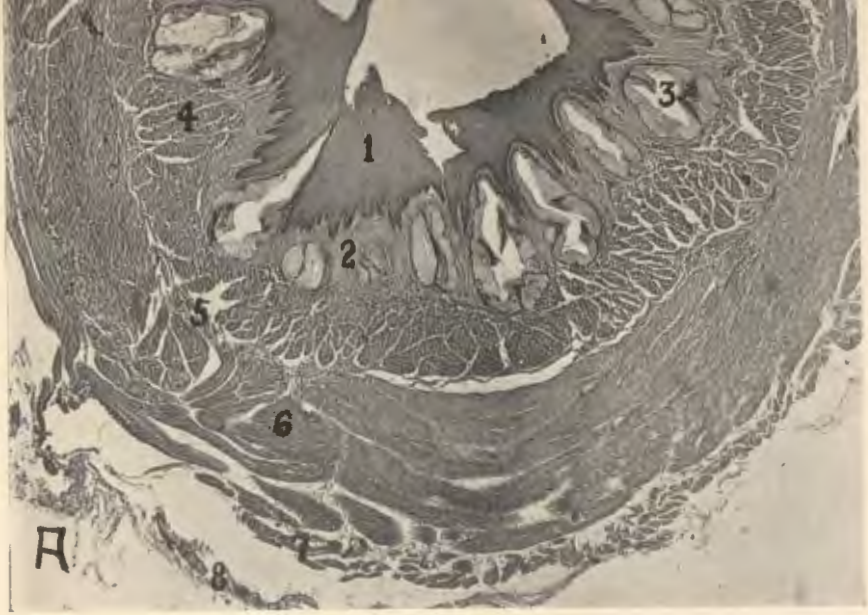

Plate XIII — Fig. A. Esophagus (near crop) cross section. Hematoxylin-eosin. 50 ×. 20 days.

1. Epithelium
2. Tunica propria
3. Mucous glands
4. Muscularis mucosae
5. Submucosa
6. Inner circular layer of the lamina muscularis
7. Outer longitudinal layer of the lamina muscularis
8. Adventitia

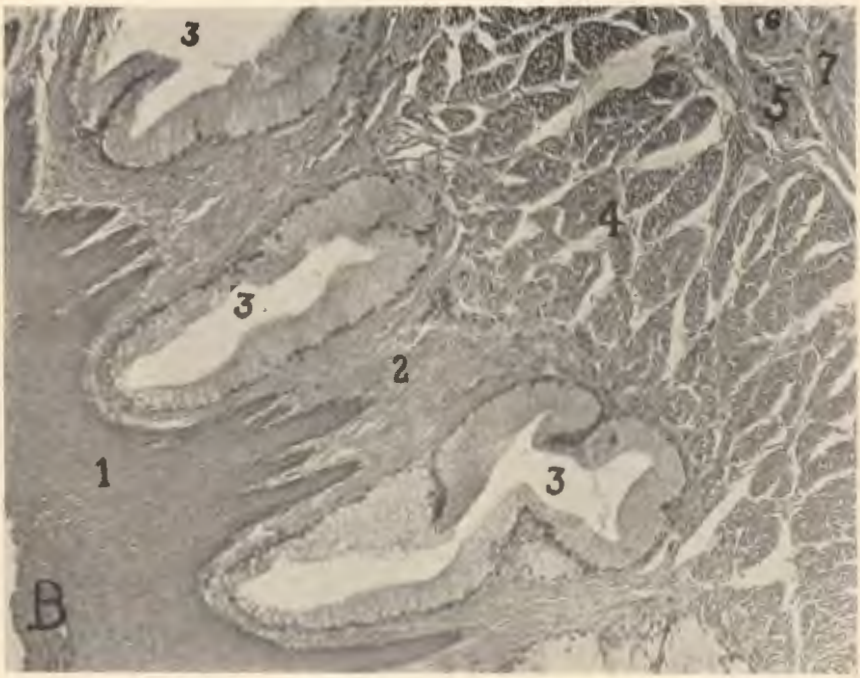

Fig. B. Esophagus (same as above). Hematoxylin-eosin. 200 ×. 30 days.

1. Epithelium
2. Tunica propria
3. Mucous glands
4. Muscularis mucosae
5. Submucosa
6. Blood vessel
7. Circular layer of lamina muscularis

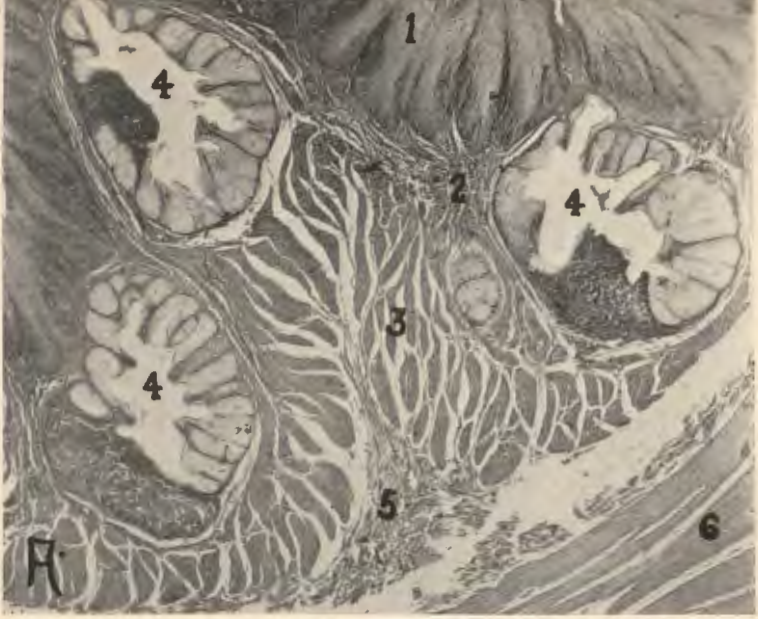

Plate XIV — Fig. A. Elastic tissue (fine black lines) in the tunica propria of the esophagus. Weigert's. 200 ×. 20 days.

1. Epithelium
2. Tunica propria
3. Muscularis mucosae

Fig. B. Elastic tissue in the submucosa of the esophagus. (Black in photograph.) Weigert's. 200 ×. 20 days.

1. Mucous gland
2. Muscularis mucosae
3. Submucosa (elastic tissue intense black)
4. Circular layer of lamina muscularis

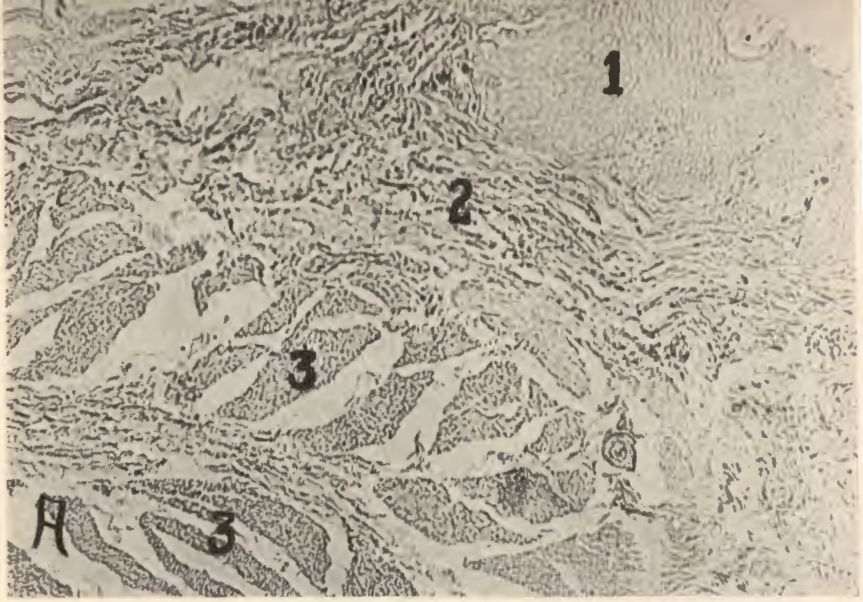

Plate XV — Fig. A. Esophagus showing leucocytic infiltration of the glands. Mid-portion, cross section. Hematoxylin-eosin. 50 ×. 1½ years.

1. Epithelium
2. Tunica propria
3. Muscularis mucosae
4. Mucous gland with lymphoid tissue
5. Submucosa
6. Circular muscle layer of lamina muscularis

Fig. B. Mucous gland opening into lumen of esophagus. Hematoxylin-eosin. 200 ×. 1½ years.

1. Epithelium
2. Tunica propria
3. Excretory duct
4. Gland with lymphoid tissue
5. Collecting cavity
6. Gland tubules

The muscularis mucosae (Pl. XIII, Fig. A-4) was of thick involuntary muscle arranged longitudinally. It was about three times as thick as the outer longitudinal layer of the lamina muscularis.

The submucosa (Pl. XIII, Fig. A-5) was thin, hardly discernible in places, while in others it widened out and a few blood vessels and nerves could be distinguished in it.

The lamina muscularis (Pl. XIII, Fig. A-6 and 7) consisted of a thick inner circular layer and a thin outer longitudinal layer of involuntary muscle. In specimens from birds aged 5 months, 1½ years, and 2 years, a heavy elastic tissue layer was in close contact with the outer longitudinal muscle layer.

The outer layer or adventitia (Pl. XIII, Fig. A-8) was thin, and served to unite the esophagus to adjacent structures. It contained elastic and white fibrous tissue and many plexuses of blood and lymph vessels and also nerves.

Crop

The lesser curvature of the crop (Pl. XVI, Fig. B) had essentially the same structure as the esophagus of which it was a part. The structure of the diverticulum of the crop (Pl. XVI, Fig. A) differed in some respects from the esophagus with which its walls were continuous. The glands of the crop (Pl. XVI, Fig. B-3) were confined to an area which was close to the junction with the esophagus. The epithelial projections between the papillae of the tunica propria were more rounded. The same sloughing of the epithelium was observed here. None of the specimens showed any lymphoid tissue in the diverticulum of the crop, but it was present in the esophageal wall of the crops of older birds. In three specimens the muscularis mucosae appeared to be arranged in an outer longitudinal and an inner circular layer (Pl. XVI, Fig. A-3). In the other two birds it was difficult to make out any circular layer. Elastic tissue was observed exteriorly to the outer longitudinal muscle layer of this organ in the baby chick, and it increased with age, spreading to the other layers of the wall. Many blood vessels were present in the adventitia, between the muscle bundles, and in the submucosa.

Junction of Proventriculus and Esophagus

The epithelium of the esophagus became narrower as it approached the proventriculus and changed at the junction into the

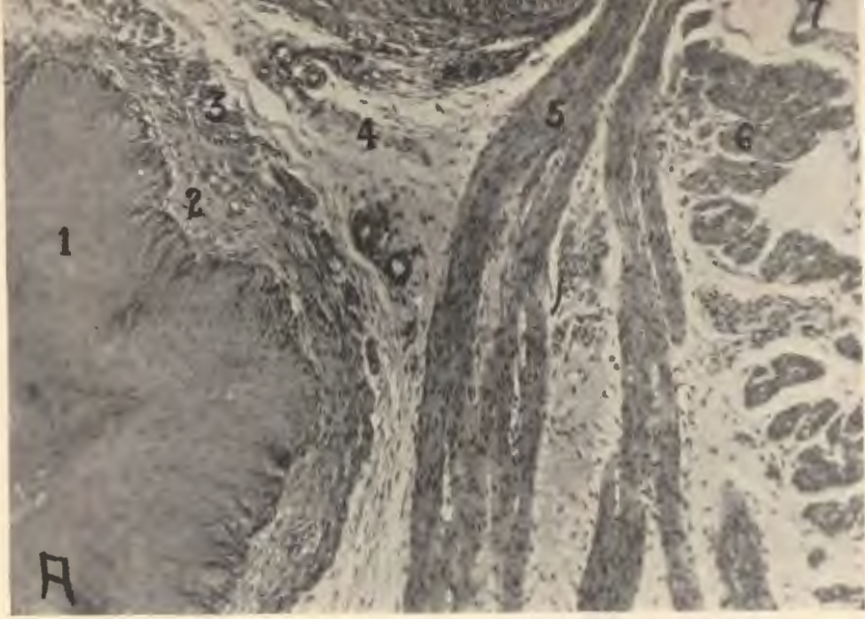

Plate XVI — Fig. A. Crop (diverticulum), cross section. Hematoxylin-eosin. 200 ×. 36 hours.

1. Epithelium
2. Tunica propria
3. Muscularis mucosae
4. Submucosa
5. Circular layer of the lamina muscularis
6. Longitudinal layer of the lamina muscularis
7. Adventitia

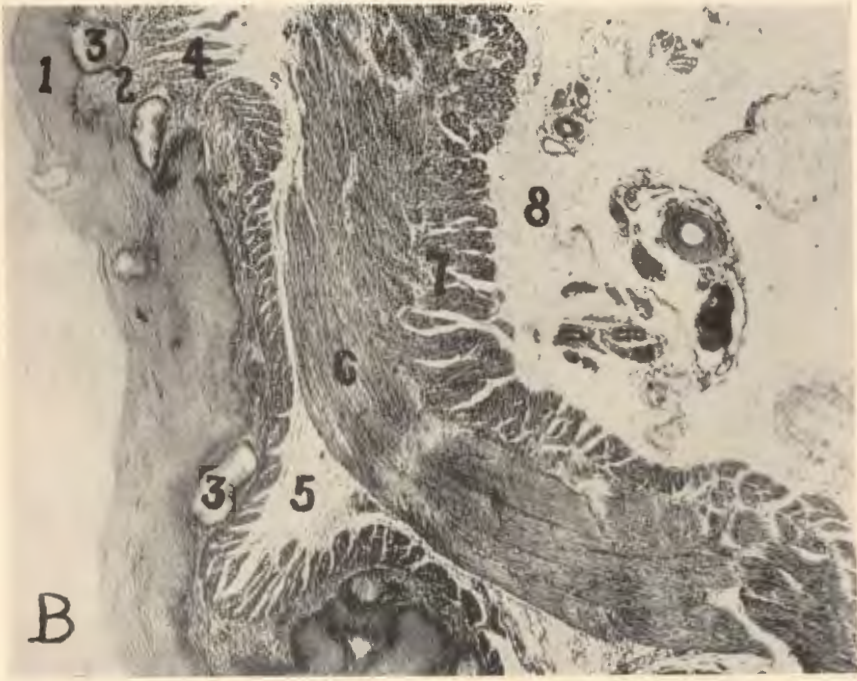

Fig. B. Crop (esophageal wall), cross sectian. Hematoxylin-eosin. 50 ×. 20 days.

1. Epithelium
2. Tunica propria
3. Mucous glands
4. Muscularis mucosae
5. Submucosa
6. Circular layer of the lamina muscularis
7. Longitudinal layer of the lamina muscularis
8. Adventitia (with many blood vessels)

one-layered simple columnar epithelium found in the remainder of the digestive tract except in the anus.

There was no abrupt change from one type of gland to the other. The mucous glands of the esophagus were found in the inner layer of the tunica propria, while in the deeper layer the anterior extremity of the glands of the proventriculus was observed.

Lymphoid tissue was found in the tunica propria of a section taken from a 3-day-old bird.

Proventriculus

The mucosal surface of the proventriculus presented several macroscopic papillae, each of which contained an opening from the proventricular glands (Pl. XVII).

The organ was lined by simple columnar epithelium covering plicae and lining sulci which were arranged concentrically around the gland openings (Pl. XVII and XVIII). On a cross section of the organ this arrangement gave the often misinterpreted appearance of surface tubular glands (Pl. XIX, Fig. B). They were so described by this author in the original article (Calhoun, 1933) and by Foust (1952). Recent research by Sjögren (1945) on the development of the proventriculus and gizzard in birds also refers to surface tubular glands. Plate XVIII shows these concentric plicae in a cross section of a papilla. The tunica propria extended into the plicae or laminae as shown in the same plate.

The muscularis mucosae (Pl. XIX, Fig. B-4) was observed below the surface glands, in the septa between the deeper glands, and in a longitudinal layer almost in contact with the lamina muscularis. The submucosa (Pl. XIX, Fig. A-8) was so thin as to appear absent in places. The lamina muscularis (Pl. XIX, Fig. A-9 and 10) showed the usual outer longitudinal and inner circular layers. The adventitia (Pl. XIX, Fig. A-11) appeared as a loose fascia containing few blood and lymph vessels and nerves.

Elastic tissue was demonstrable in the 36-hour chick and increased in amount as the bird aged. It predominated in the tunica propria and the septa between the deep glands. Lymphoid tissue was observed in the tunica propria in the three oldest specimens.

The deeper glands of the proventriculus presented two different pictures. On cross section the gland tubules (Pl. XX, Fig. A-1) showed a meshwork, the strands of which had a serrated appearance. On longitudinal section the glands (Pl. XX, Fig. A-2)

Plate XVII — Mucosal surface of the proventriculus of a 3-month-old chicken. Note the concentric arrangement of plicae around the openings from the glands and the irregular arrangement between the papillae. Gross. 10 ×.

Plate XVIII — Cross section of a single proventricular papilla showing the arrangement of the concentric plicae about the opening from the proventricular glands. Hematoxylin-eosin. 10 ×. 3 months.

1. Gland opening
2. Tunica propria of plicae
3. Sulci

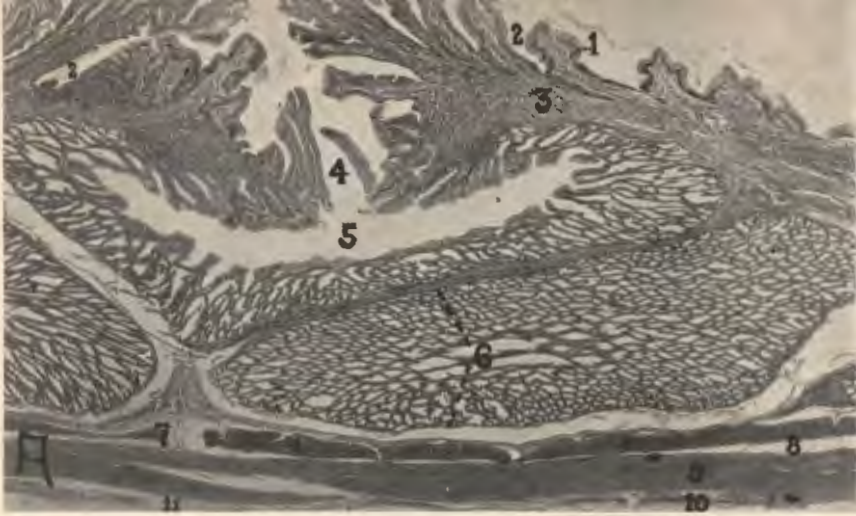

Plate XIX — Fig. A. Proventriculus showing opening of deep gland on the surface. (Organ inflated before fixation). Cross section. Hematoxylin-eosin. 50 ×. Age unknown (adult).

1. Epithelium
2. Tubular glands of the surface
3. Tunica propria
4. Opening of a deep gland on the surface
5. Collecting cavity
6. Gland lobule
7. Muscularis mucosae
8. Junction of muscularis mucosae and lamina muscularis (submucosa)
9. Circular layer of lamina muscularis
10. Longitudinal layer of lamina muscularis
11. Adventitia

Fig. B. Proventriculus (not inflated). Cross section. Hematoxylin-eosin. 50 ×. 36 hours.

1. Surface tubular glands lined with columnar epithelium
2. Tunica propria
3. Gland lobule
4. Muscularis mucosae
5. Circular layer of lamina muscularis
6. Longitudinal layer of lamina muscularis
7. Adventitia

showed long tubules, the cells (Pl. XX, Fig. A-4) of which were arranged obliquely to the axis of the tubule. The distal half or more of a single cell was not in contact with the neighboring cell thus giving the appearance of a serrated edge. A spherical nucleus was situated about the central part of the cell usually located toward the proximal half. The tubules opened into a central collecting cavity (Pl. XIX, Fig. A-5), which was lined with columnar epithelium. These collecting cavities opened on the inner surface of the proventricules as mentioned above.

The septa (Pl. XX, Fig. A-3) surrounding the lobules contained white fibrous and yellow elastic connective tissue, some muscle fibers, blood and lymph vessels, and nerves. The surface epithelium, the epithelium of the collecting canals, and that of the excretory ducts of the deeper glands took a mucous stain in its distal third.

Junction of Proventriculus and Gizzard

The deep glands of the proventriculus ended abruptly, as did the plicae on the surface. The cells lining the sulci soon took on the characteristic aspect of the gizzard glands and a keratinized layer was observed above them.

The white fibrous connective tissue of the tunica propria joined with that from the submucosa and continued into the gizzard as the submucosa.

The layer of the muscularis mucosae above the deep glands of the tunica propria apparently tapered off at the point where the tunica propria and submucosa joined. The deep portion of the muscularis mucosae widened out and was continued into the gizzard with the circular muscle layer of the proventriculus. These two continued as separate layers for a short distance and then became fused into a single layer of fibers which became a part of the musculari intermedii of the gizzard.

The outer longitudinal layer of the lamina muscularis ceased at the junction of the proventriculus and the gizzard.

Elastic tissue was particularly dense in this region in the 2-year-old specimen (Pl. XX, Fig. B).

Gizzard (Ventriculus)

The gizzard had as its innermost lining a horny layer (Pl. XXI, Fig. A-1) which was about three-fourths as thick as the glandular layer adjacent to it. This horny layer was an exudate

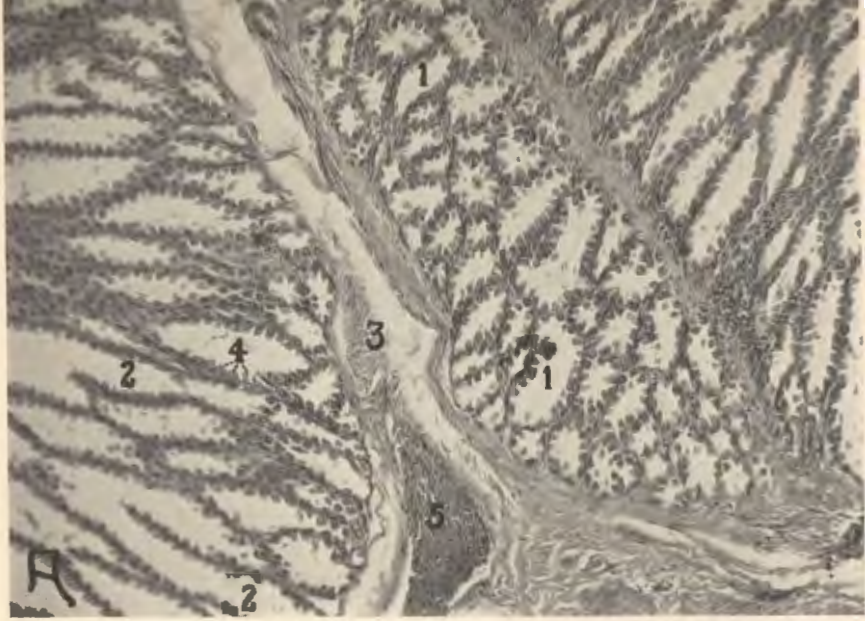

Plate XX — Fig. A. Proventriculus. Hematoxylin-eosin. 200 ×. 36 hours.

1. Cross sections of gland tubules
2. Longitudinal sections of gland tubules
3. Septa between lobules
4. Gland cells
5. A mass of blood cells in a blood vessel

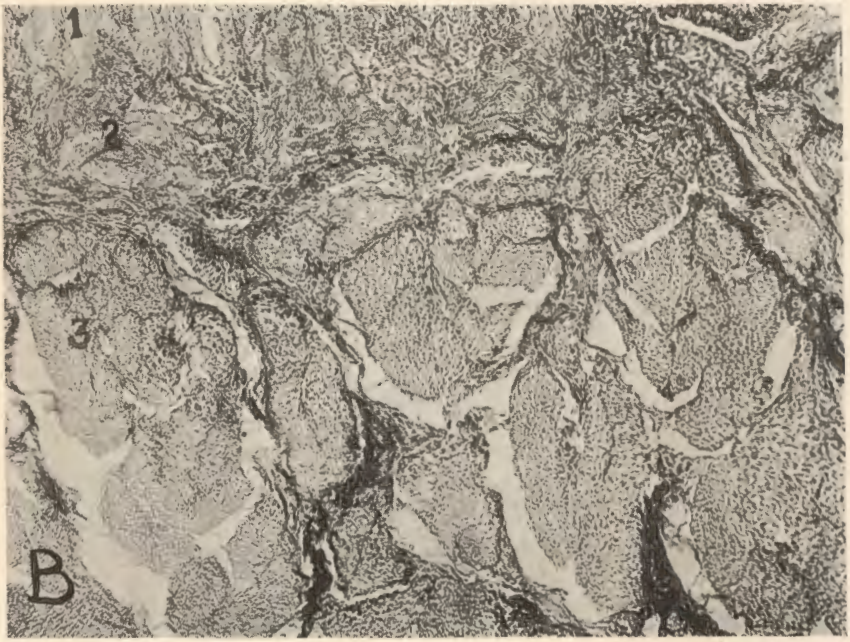

Fig. B. Elastic tissue in orea between proventriculus and gizzard. (Elastic tissue black.) Weigert's. 200 ×. 2 years.

1. Gland layer
2. Tunica propria
3. Muscularis mucosae

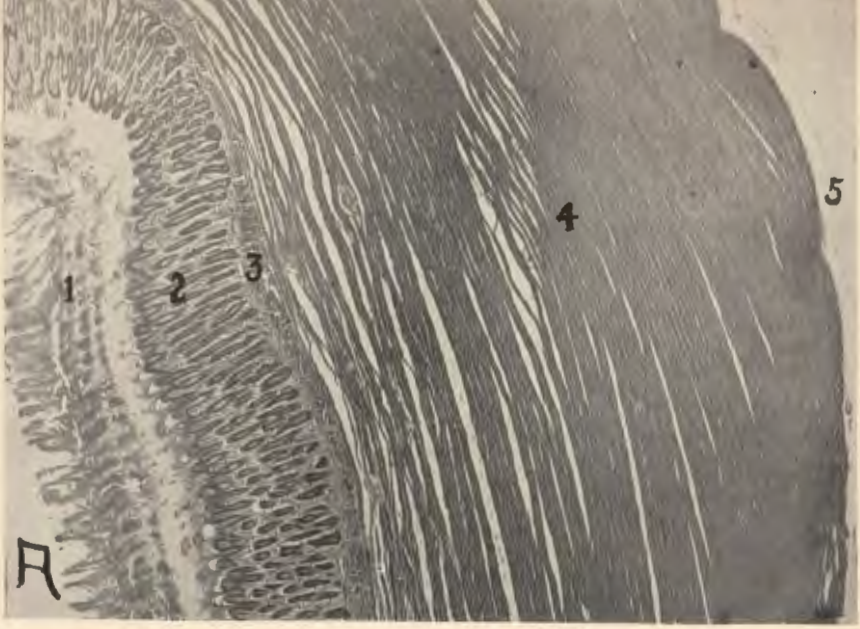

Plate XXI — Fig. A. Entire wall af gizzard. Hematoxylin-eosin. 50 ×. 3 days.

1. Horny layer
2. Glands in the tunica propria
3. Submucosa
4. Muscle
5. Serosa

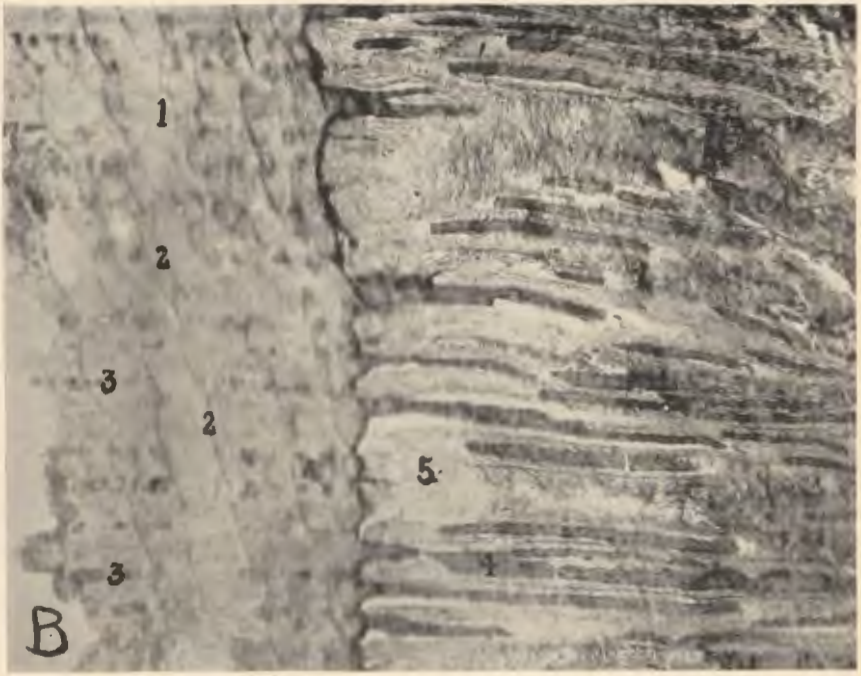

Fig. B. Gizzard showing horny layer in detail. Keratohyalin stain. 200 ×. 5 months.

1. Horny layer
2. Wavy line parallel to the surface
3. Lines perpendicular to the surface
4. Exudate in gland tubules
5. Glandular layer

from the glands and contained wavy lines (Pl. XXI, Fig. B-2) parallel to the surface, and colonnades or thickenings (Pl. XXI, Fig. B-3) perpendicular to the surface. The former apparently were formed by consecutive layers of the exudate and the latter by secretion being poured out at the same point; also, cellular debris was observed in this horny layer.

The epithelium of the mucous membrane was simple columnar and contained crypts, at the bottom of which opened the branched tubular glands of this organ. (Pl. XXI, Fig. A-2).

The glands of the gizzard were in the tunica propria and arranged in groups presenting in longitudinal section the arrangement shown in Plate XXII, Figure A-1. The gland tubules were lined with low cuboidal epithelium containing spherical nuclei which bulged into the lumen in places (Pl. XXII, Fig. B-3). The tubes were filled with an exudate which took a bright red stain with keratohyalin staining (Pl. XXIII, Fig. B-1). The gland cells themselves contained small granules of keratohyalin (Pl. XXIII, Fig. B-3). Elastic tissue was demonstrable in the tunica propria of the three oldest birds.

The muscularis mucosae was absent from the gizzard. The submucosa (Pl. XXI, Fig. A-3) was a dense layer of white fibrous and yellow elastic connective tissue, the former predominating. Blood vessels, lymphatics, and nerves were present.

The muscular mass (Pl. XXI, Fig. A-4) was comprised of a single thick layer of parallel fibers which extended from one aponeurosis to the other. It was criss-crossed by bands of white fibrous connective tissue which seemed to connect particularly to the fibrous submucosa (Pl. XXIV, Fig. B). At the junction of the smooth muscle and fibrous aponeurosis a white fibrocartilage was observed in many areas in specimens from several different ages (Pl. XXIV, Fig. A).

Near the center of the tendinous aponeurosis (Pl. I-11) the submucosa came in contact with the tendinous tissue of the aponeurosis and the muscular tissue was absent.

Exterior to the muscle a thin layer of connective tissue (Pl. XXI, Fig. A-5) containing nerves and blood and lymph vessels was present. Elastic tissue was present in this layer in all birds observed. Peritoneum covered the whole organ.

Lymphoid tissue was not observed in the gizzard wall in any of the five specimens originally studied nor in any of the six specimens observed for this revision.

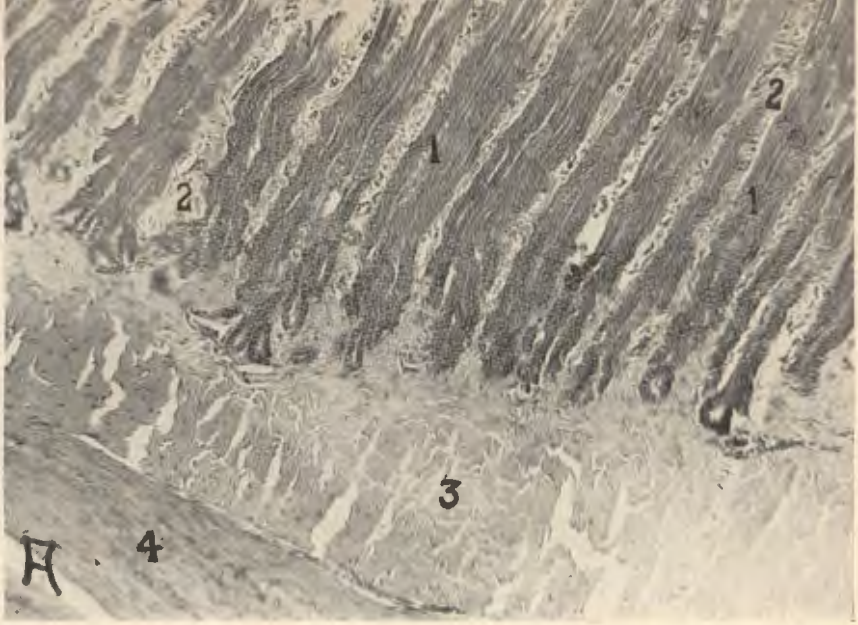

Plate XXII — Fig. A. Gizzard. Hematoxylin-eosin. 200 ×. 2 years.

1. Gland tubules in tunica propria (note arrangements in groups)
2. Septa of tunica propria
3. Submucosa
4. Muscle

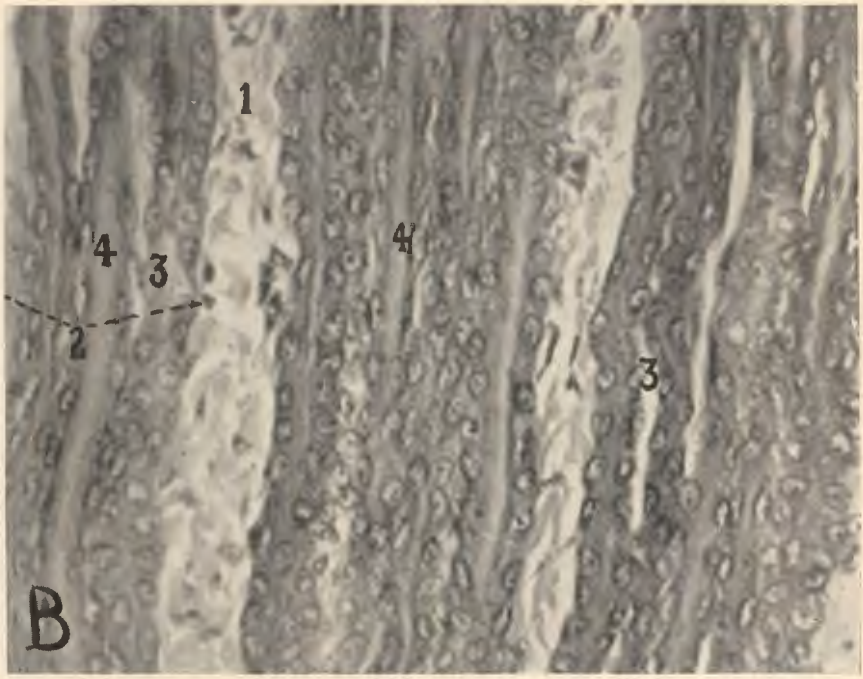

Fig. B. Gizzard. Hematoxylin-eosin. 800 ×. 2 years.

1. Tunica propria septa
2. Group of gland tubules
3. Flat cells with bulging nuclei
4. Lumen of a tubule

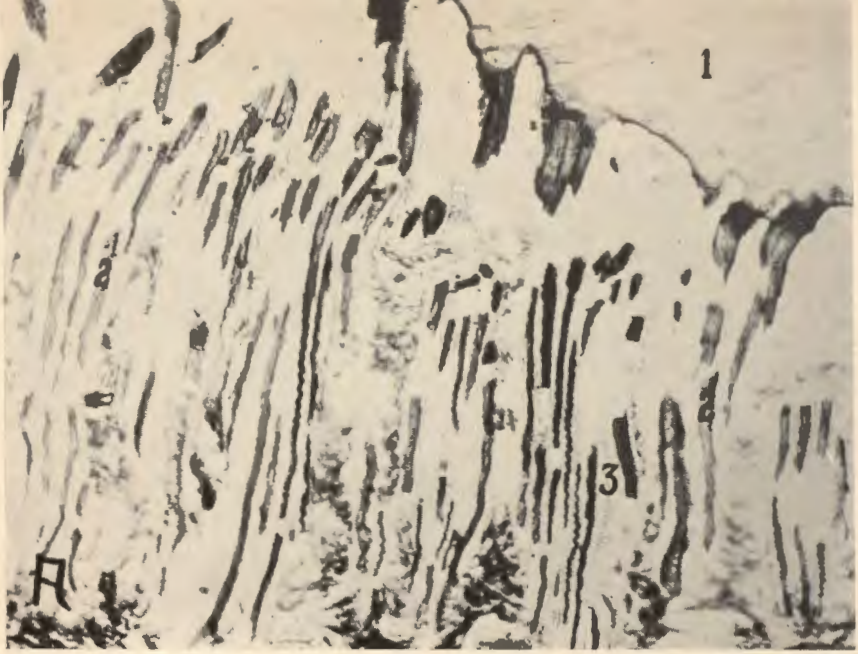

Plate XXIII — Fig. A. Gizzard showing keratohyalin stained in glandular layer. Keratohyalin stain. 200 ×. 5 months.

1. Horny layer
2. Exudate in tubule
3. Gland tubule

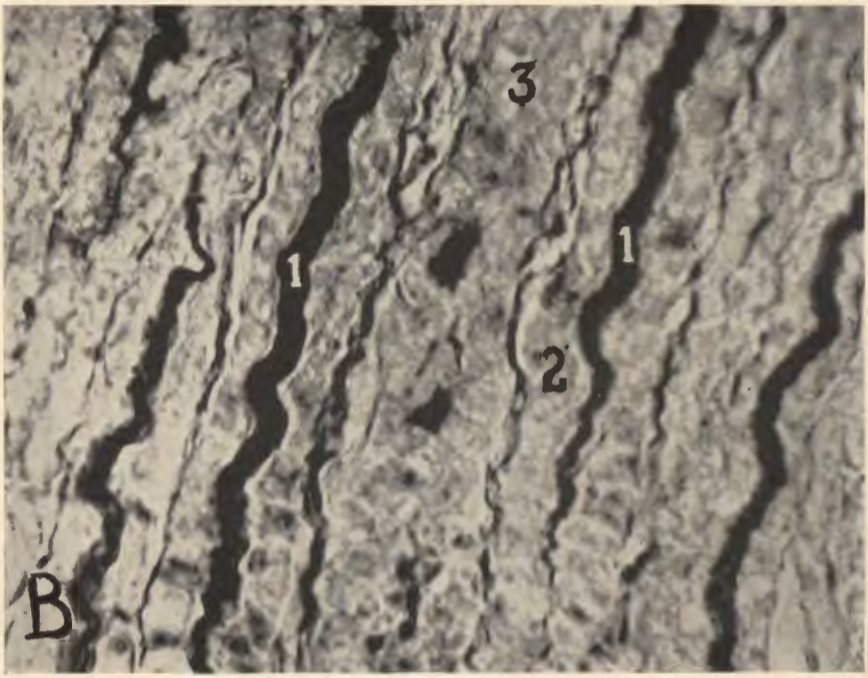

Fig. B. Gizzard showing keratohyalin granules. Keratohyalin stain. 800 ×. 36 hours.

1. Exudate in tubules
2. Tubule
3. Keratohyalin granules (fine black dots)

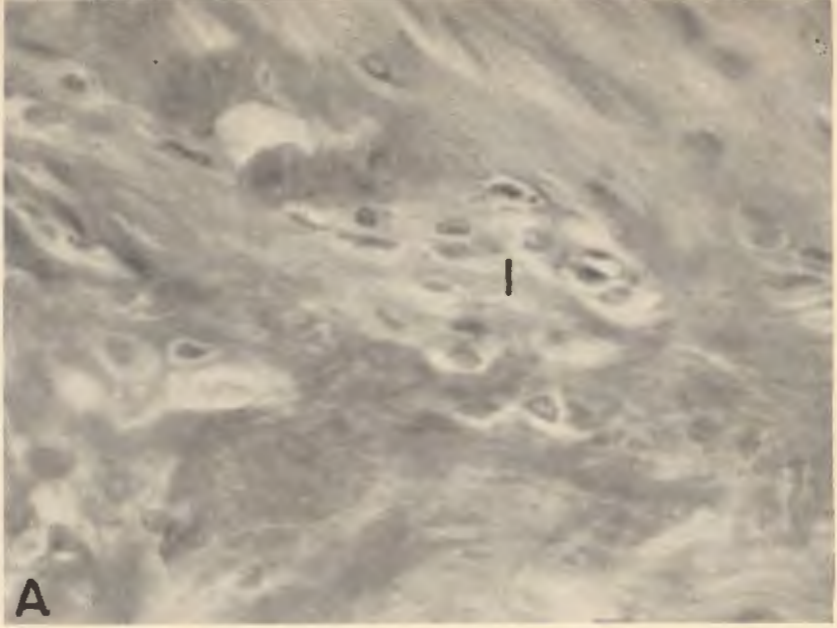

Plate XXIV — Fig. A. White fibrocartilage between the smooth muscle and white fibrous aponeurosis of the gizzard. Hematoxylin-eosin. 525 ×. 4 months. Note cartilage cells at 1.

Fig. B. Fibrous connective tissue extending through the smooth muscle of the gizzard. Weigert-Van Gieson. 130 ×. Adult.

Section Between Gizzard and Duodenum

In the region between the gizzard and the duodenum, the mucous membrane became narrow only to widen again after it made an acute angle. It again made a slight turn, and at this point the horny layer ceased. Just posterior to this there was a short section resembling the portion of the mammalian duodenum in which Brunner's glands are present. Lymphoid tissue was observed in the area between the gizzard and duodenum in specimens as young as three days old.

Small Intestine

The structure of the small intestine, duodenum included, was similar throughout. The inner layer of the mucous membrane was lined with simple columnar epithelium with many goblet cells. These were mucous both on the lumen and in the glands of Lieberkühn (Pl. XXV, Fig. B-4). The inner surface showed villi (Pl. XXVI, Fig. A-10 and Pl. XXVIII) between which the crypts of Lieberkühn (Pl. XXVI, Fig. A-8) opened. The villi contained lacteals, blood vessels, muscle fibers, and lymphoid tissue, the latter varying with the age of the chicken. In the 36-hour chick there was much embryonic connective tissue in the tunica propria filling the villi and surrounding the glands of Lieberkühn. Practically no lymphocytes were observed at this age, but by the twentieth day they were scattered throughout the tunica propria. The villi branched, sometimes twice (Pl. XXVII, Fig. A). Elastic tissue was observed in the tunica propria of the three oldest chickens (Pl. XXVIII, Fig. B-1).

The muscularis mucosae was comprised of an outer circular and an inner longitudinal layer (Pl. XXVI, Fig. A-5). The latter sent fibers into the villi. In places the outer circular layer appeared to fuse with the circular layer of the lamina muscularis (Pl. XXVI, Fig. A-6).

The submucosa was apparent only in a few places and then was only a very thin layer (Pl. XXVI, Fig. A-4). There were a few blood and lymph vessels and nerves in addition to the connective tissue.

The lamina muscularis was made up of an inner circular and an outer longitudinal muscle layer with a connective tissue layer on each side, which contained plexuses of nerves, and blood and lymph vessels. (Pl. XXVI, Fig. A-2 and 3).

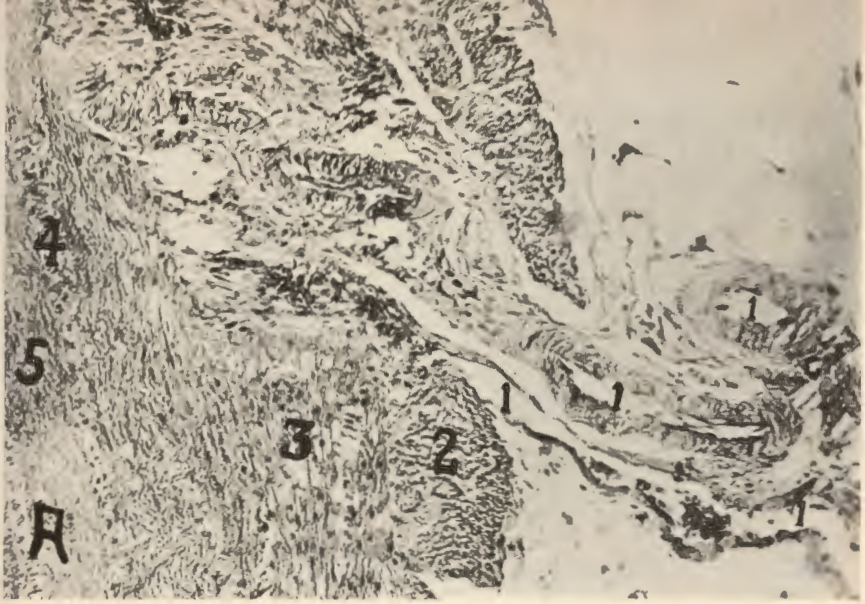

Plate XXV — Fig. A. Small intestine showing blood vessels entering the wall. Hematoxylin-eosin. 200 ×. 2 years.

1. Vessels in adventitia
2. Longitudinal muscle layer
3. Circular muscle layer
4. Submucosa
5. Muscularis mucosae

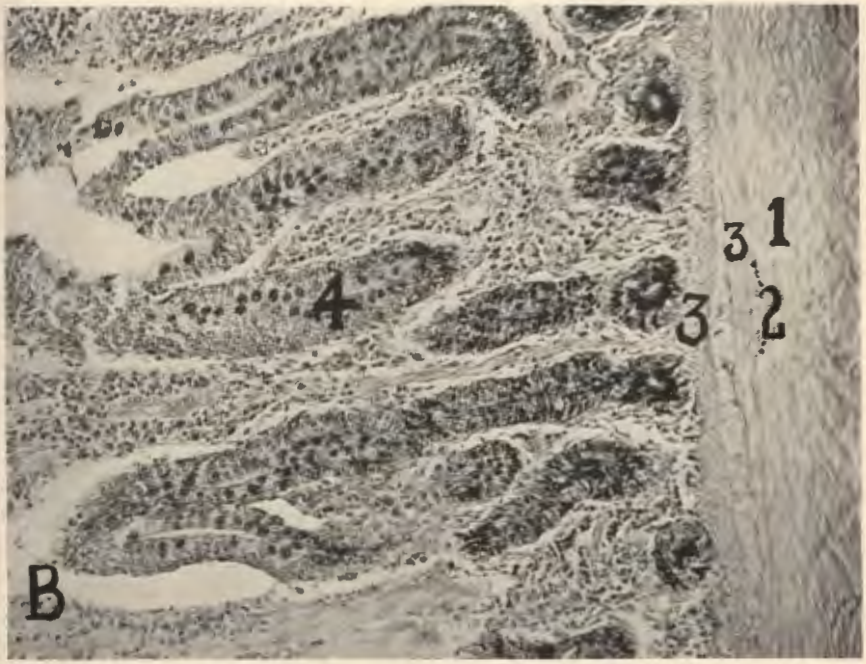

Fig. B. Duodenum stained for mucous glands. Mucous stain. 200 ×. 1½ years.

1. Circular layer of lamina muscularis
2. Junction of muscularis mucosae and the circular layer of the lamina muscularis (submucosa)
3. Muscularis mucosae
4. Glands of Lieberkühn with goblet cells showing mucin

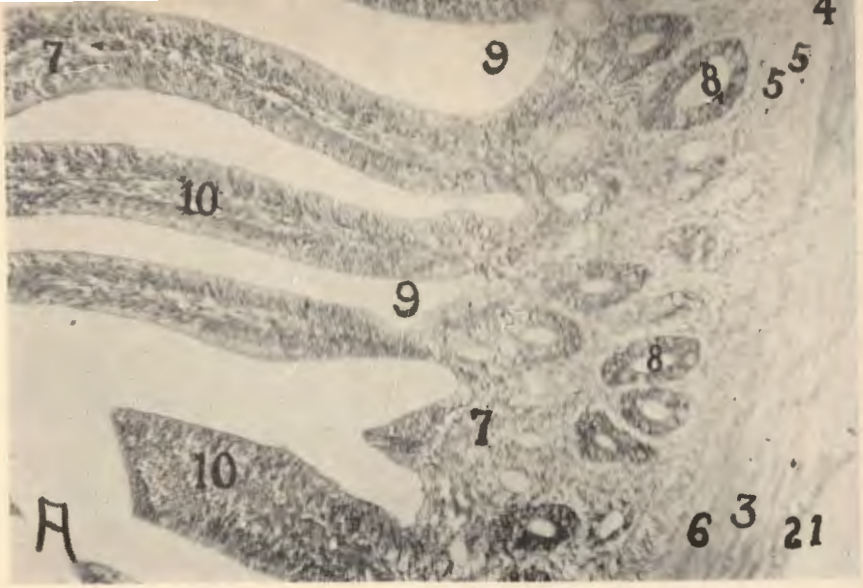

Plate XXVI — Fig. A. Small intestine cross section. Hematoxylin-eosin. 200 ×. 20 days.

1. Serosa
2. Longitudinal loyer of the lamina muscularis
3. Circular layer of the lamina muscu'aris
4. Submucosa
5. Muscularis mucosae
6. Apparent fusion of outer circular layer of muscularis mucosae and inner circular layer of the lamina muscularis
7. Tunica propria
8. Glands of Lieberkühn
9. Crypts of Lieberkühn
10. Villi

Fig. B. Longitudinal section of the sphincter between the small intestine and rectum. Hematoxylin-eosin. 25 ×. 1½ years.

1. Mucosa of the small intestine
2. Mucosa of the rectum
3. Muscle

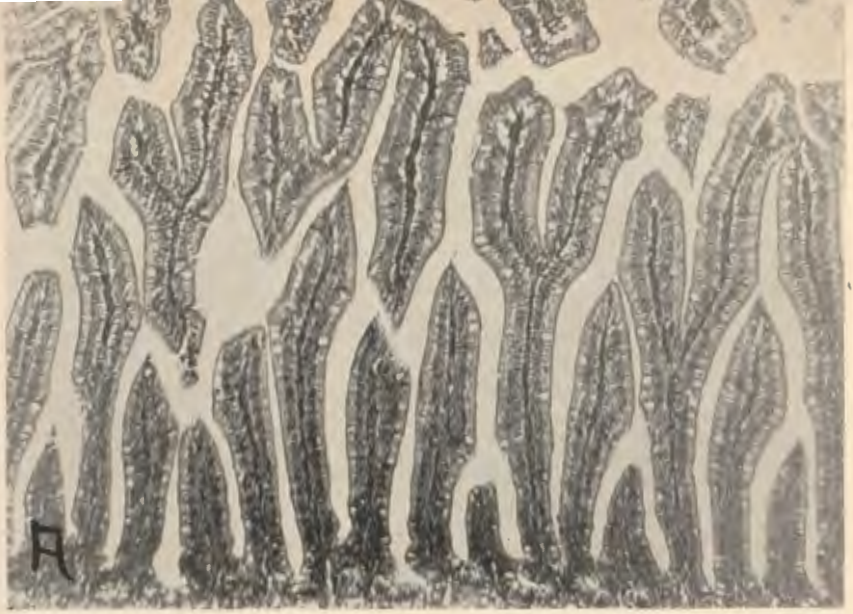

Plate XXVII — Fig. A. Types of duodenal villi. Hematoxylin-eosin. 200 ×. 36 hours.

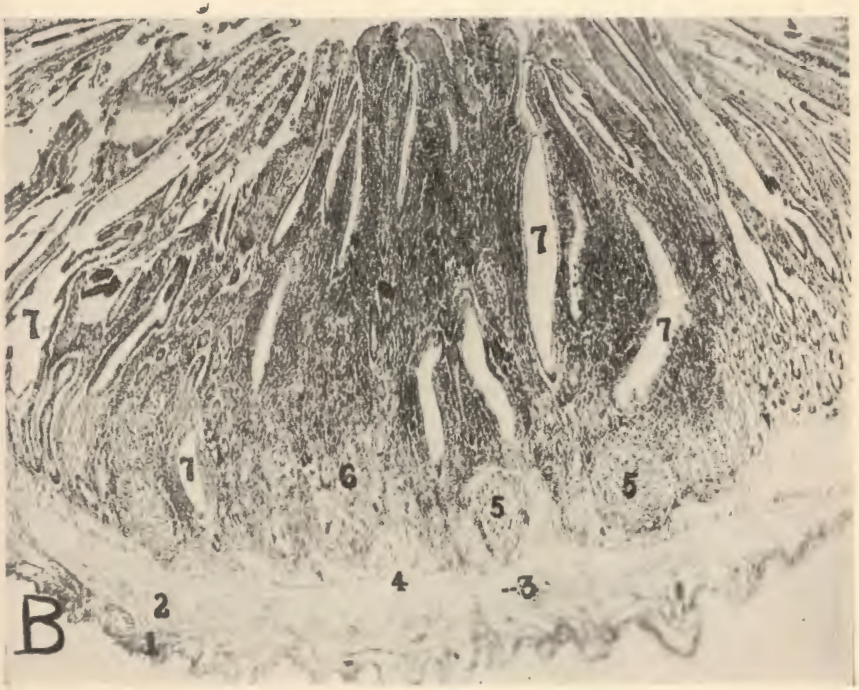

Fig. B. Lymphoid tissue in small intestine. Hematoxylin-eosin. 50 ×. 2 years.

1. Longitudinal muscle
2. Circular muscle
3. Submucosa
4. Muscularis mucosae
5. Lymph nodules
6. Diffuse lymphoid tissue
7. Crypts of Lieberkühn

Plate XXVIII — Fig. A. Villi in duodenum. Gross 7.5 ×. 4 months.

Fig. B. Elastic tissue in duodenum. Weigert's. 200 ×. 2 years.

1. Tunica propria with glands of Lieberkühn
2. Muscularis mucosae
3. Submucosa
4. Lamina muscularis
5. Serosa
6. Vessels crossing circular layer of the lamina muscularis

The subserous layer (Pl. XXVI, Fig. A-1) was very thin, consisting of both white fibrous and yellow elastic fibers. Blood vessels, lymph vessels, and nerves were contained in its meshes. It was limited outside by the peritoneum.

Diffuse lymphoid infiltration of the tunica propria and a few small lymph nodules were observed in the 5-month-old specimen, and in the 2-year-old bird the nodules were so numerous at one place in the small intestine as to appear almost like Peyer's patches (Pl. XXVII, Fig. B-5). A nodule was observed in the circular muscle layer of intestine in the 1½-year-old specimen.

At a point near the end of the duodenum the pancreatic and bile ducts entered (Pl. XXIX, Fig. A-2). There was an elevation in the mucous membrane of the duodenum at this point.

The villi of the duodenum were the longest in all cases. With the exception of the 36-hour chick, the diameter of the small intestine diminished from the duodenum to the rectum. In the 36-hour chick the diameter of the duodenum was not so large as the anterior half of the small intestine. In this portion the villi were wider and shorter, even appearing leaflike in some places. Toward the posterior portion the villi increased in length again, but the tube decreased in diameter becoming even smaller than the duodenum.

A circular sphincter muscle was observed at the entrance of the small intestine into the rectum (Pl. XXVI, Fig. B-3).

Caeca

The muscular coats of the caeca were continuous with those from the small intestine and rectum. The general structure of the caeca may be briefly summarized at this point. The structure of the different portions will be discussed later. A mucous membrane lined with columnar epithelium (Pl. XXX, Fig. A-1) containing goblet cells; villi in varying lengths depending on the region (Pl. XXXII, Fig. B-3 and Pl. XXX, Fig. A-2); a muscularis mucosae (Pl. XXX, Fig. A-4) absent in places; a submucosa (Pl. XXX, Fig. A-5) of white fibrous and yellow elastic tissue containing nerves, blood vessels, and lymph plexuses; a lamina muscularis (Pl. XXX, Fig. A-6 and 7) varying in thickness and arrangement; and a serosa (Pl. XXX, Fig. A-8) rich in nervous elements.

The caeca presented three different pictures depending on whether the proximal, middle, or distal portion was being considered. In Plate XXXII, Figure B-3, even the proximal portion

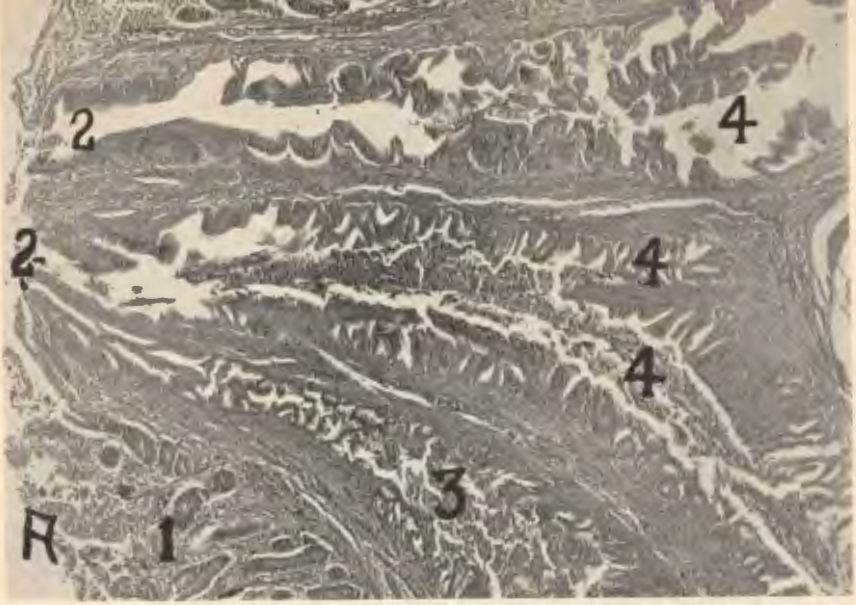

Plate XXIX — Fig. A. Longitudinal section of pancreatic and bile ducts entering the duodenum. Note the elevation in the mucous membrane of the duodenum. Hematoxylin-eosin. 50 ×. 1½ years.

1. Mucosa of the duodenum
2. Openings of ducts
3. Bile duct
4. Pancreatic ducts

Fig. B. Cross section of pancreatic and bile ducts near entrance into the duodenum. Hematoxylin-eosin. 50 ×. 5 months.

1. Mucosa of the duodenum
2. Bile duct
3. Pancreatic ducts

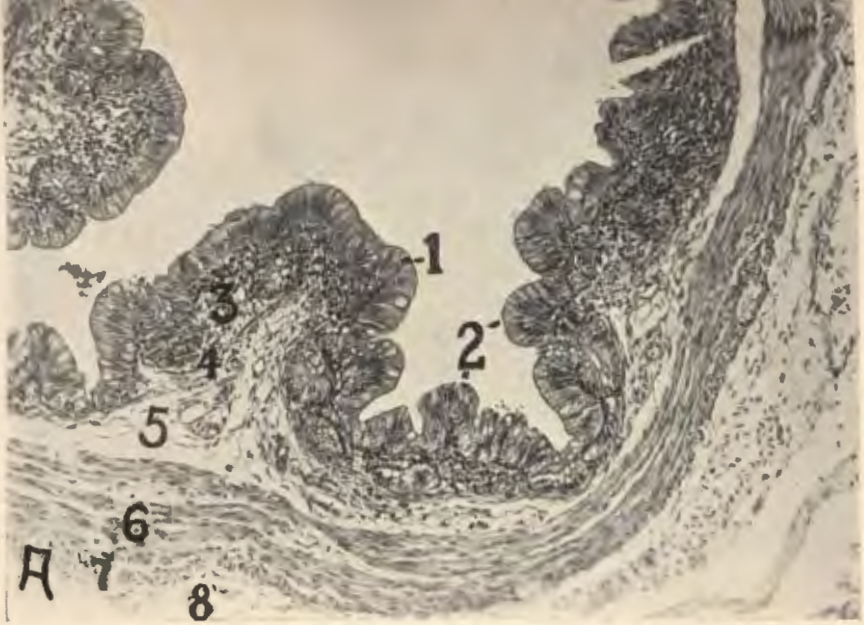

Plate XXX — Fig. A. Caecum, mid-partian, constricted. Hematoxylin-eosin. 200 ×. 36 hours.

1. Epithelium
2. Villi
3. Tunica propria
4. Muscularis mucosae
5. Submucosa
6. Circular layer of lamina muscularis
7. Longitudinal layer of lamina muscularis
8. Serosa

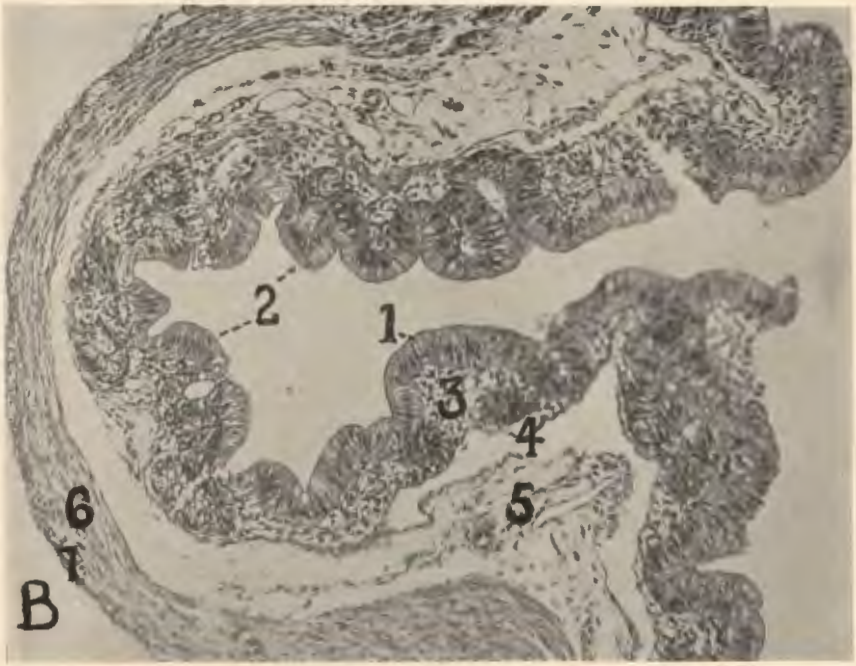

Fig. B. Caecum, mid-portion, dilated. Hematoxylin-eosin. 200 ×. 36 hours.

1. Epithelium
2. Villi
3. Tunica propria
4. Muscularis mucosae
5. Submucosa
6. Circular layer of lamina muscularis
7. Longitudinal layer of lamina muscularis

presented two slightly different views, because of a difference in contraction.

In the proximal portion were prominent villi. They had a structure similar to those of the small intestine. The muscularis mucosae and submucosa were both thin layers and crowded close to the base of the villi. The lamina muscularis was marked by a thick inner circular layer and a thin outer longitudinal layer. No lymphoid tissue was observed in the section of a 36-hour chick. In a section similarly cut, from a caecum of the 20-day-old chick, one small area of lymphoid tissue was seen. In a caecum of a 5-month-old specimen cut at the same proximal level, the tunica propria was a mass of lymphoid tissue with several nodules. A longitudinal section from the 1½-year-old specimen showed an extensive area just anterior to the origin of the caeca which was completely infiltrated with lymphoid tissue (Pl. XXXI, Fig. A-4) and contained numerous nodules (Pl. XXXI, Fig. A-5).

In the mid-portion the villi were shorter and broader (Pl. XXX, Fig. A-2 and Fig. B-2). Here again the constriction of the wall resulted in a slightly different picture. In a constricted part of the mid-portion the villi were longer, the muscle thicker, and the whole circumference smaller than in a dilated portion at the corresponding level. Plicae circulares were present at this level.

The muscularis mucosae contained a distinct inner circular and an outer longitudinal layer in the 36-hour specimen. No other showed this arrangement definitely. Lymphoid tissue became present with advanced age.

Near the blind end of the caeca of the 36-hour chick the inner circular and outer longitudinal muscular layers were nearly the same width. True villi were not present. Many eosinophils were present in the tunica propria. The muscularis mucosae was absent in places. Goblet cells were present in the epithelium. No lymphoid tissue was present.

In the distal portion of the caeca of a 20-day chick the inner circular muscle had increased to about three times the width of the longitudinal muscle. The surface of the mucous membrane approached a villi-like arrangement between the plicae circulares. On the plicae themselves the villi appeared as blunt projections. Eosinophils were numerous in the tunica propria. The muscularis mucosae comprised an inner circular and an outer longitudinal layer. It was present at all points. Goblet cells were observed in the epithelium. Much diffuse lymphoid tissue was present. The

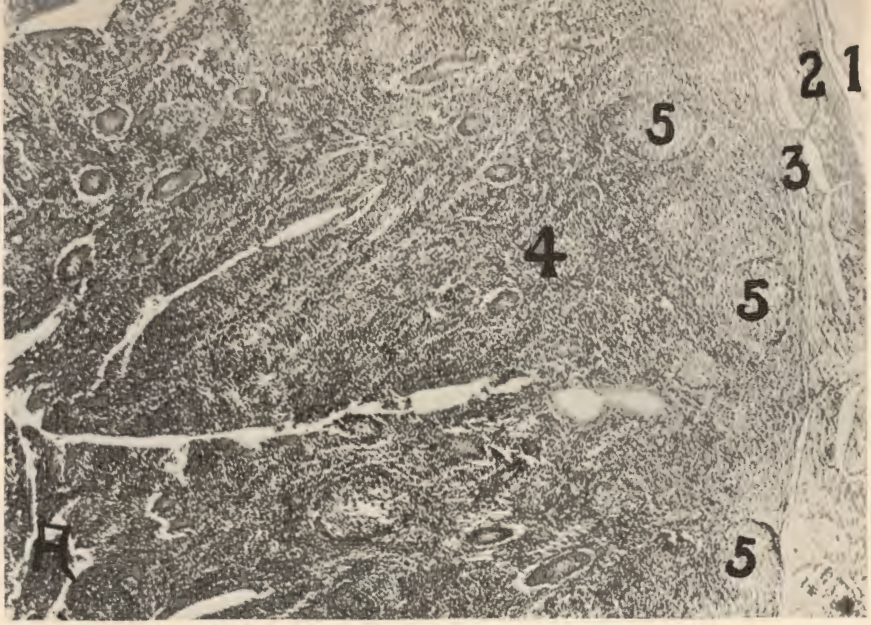

Plate XXXI — Fig. A. Lymphoid tissue in caecum (proximal portion). Longitudinal section. Hematoxylin-eosin. 50 ×. 1½ years.

1. Longitudinal layer of lamina muscularis
2. Circular layer of lamina muscularis
3. Muscularis mucosae
4. Lymphoid tissue
5. Lymph nodules

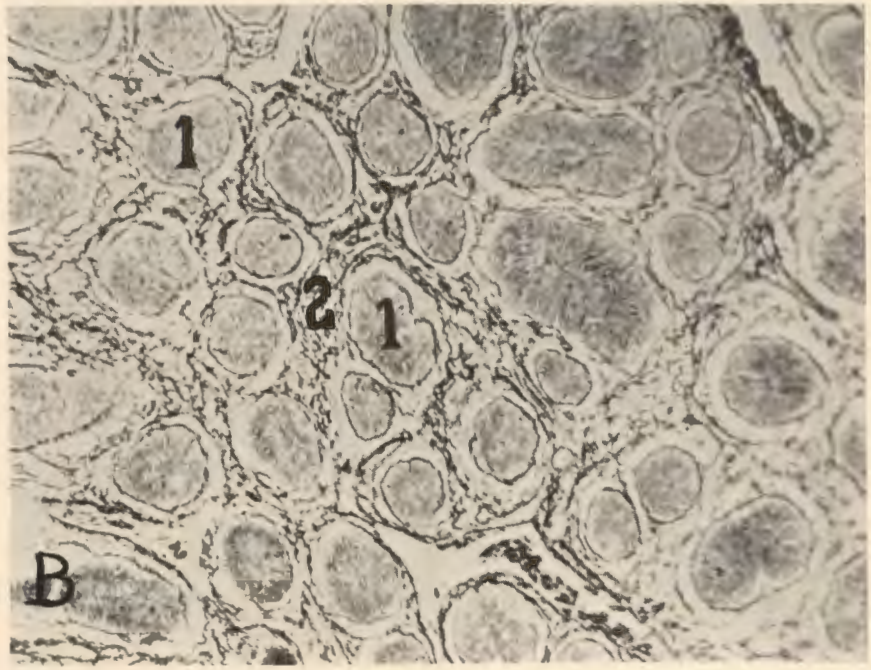

Fig. B. Reticulum in glandular area of caecum. (Reticulum fine black lines.) Reticular stain. 200 ×. 1½ years.

1. Glands of Lieberkühn
2. Reticulum in tunica propria

blind end of the caeca of the 5-month specimen was like the above with many lymph nodules in addition. The 1½- and 2-year-old specimens showed the same structure as the 5-month specimen.

Rectum

The rectum (Pl. XXXII, Fig. A) as a whole resembled the small intestine. Villi were present in all specimens. Scattered lymphocytes were observed in the tunica propria of the 36-hour and 20-day-old chicks, and lymph nodules in the older specimens.

Cloaca

The cloaca was separated from the rectum by a slight constriction (Pl. XXXIII, Fig. B-5) of the circular muscle forming a somewhat circular orifice. It was not visible from the exterior of the rectum. The cloaca was divided into three parts (Pl. XXXIII, Fig. B and Pl. XXXIV) — coprodaeum, urodaeum, and proctodaeum — by transverse folds. The dorsal fold (Pl. XXXIII, Fig. A-1) between the urodaeum and proctodaeum overhung the entrance to the bursa, which was in the dorsal wall of the proctodaeum (Pl. XXXIII, Fig. A-2). The ureters and genital tracts opened on the floor of the urodaeum.

All three parts had a similar structure. Villi were present. They were finger-like in the coprodaeum, but became more leaf-like and decreased in height in the urodaeum and proctodaeum.

The cloaca was lined with columnar epithelium which extended as far as the anus. There were plicae circulares present in addition to the folds between the compartments. Lymphoid elements in the tunica propria and elastic tissue throughout the wall increased with the age of the specimen.

Anus

The anal opening (Pl. XXXV, Fig. A-9) was lined with stratified squamous epithelium. The tunica propria at this point contained many papillae. After turning on the inside of the lip the epithelium became thinner; papillae of the tunica propria were absent; and, by the time it reached the fold, it had become the columnar epithelium of the proctodaeum (Pl. XXXV, Fig. B-4).

The muscularis mucosae was absent in the anus, and the tunica propria and submucosa were fused into a thin, loosely arranged connective tissue layer (Pl. XXXV, Fig. B-2).

Plate XXXII — Fig. A. Rectum. Hematoxylin-eosin. 200 ×. 36 hours.

1. Goblet cells in the simple columnar epithelium
2. Villi
3. Tunica propria
4. Glands of Lieberkühn
5. Crypts of Lieberkühn
6. Circular layer of lamina muscularis
7. Longitudinal layer of lamina muscularis

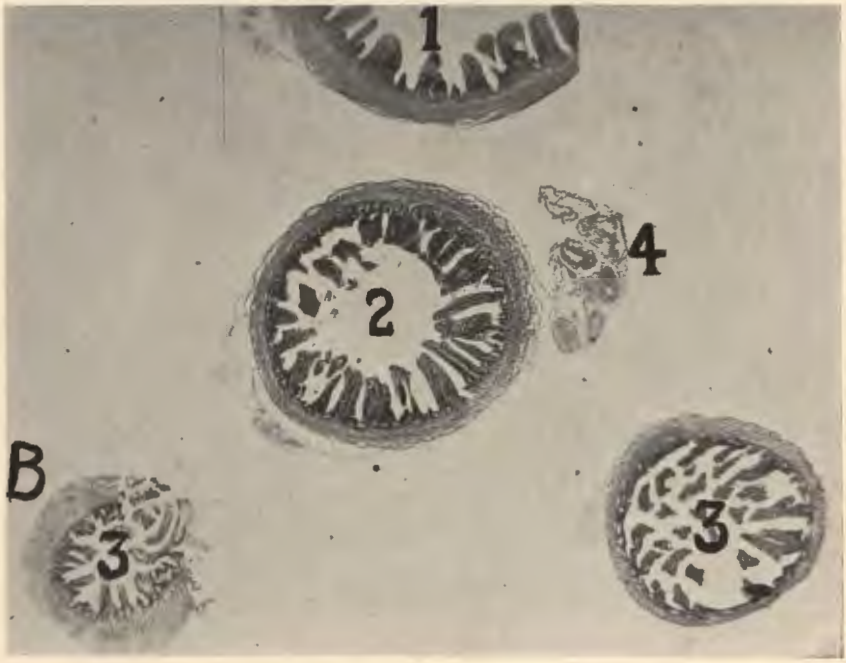

Fig. B. Small and large intestine and both caeca. Hematoxylin-eosin 25 ×. 1½ years.

1. Rectum
2. Small intestine
3. Caeca
4. Blood and lymph vessels and nerves

Plate XXXIII — Fig. A. Cloaca showing a fold covering the entrance to the bursa cloacae. Hematoxylin-eosin. 25 ×. 4 days.

1. Fold overhanging entrance to bursa cloacae
2. Dorsal wall of proctodaeum
3. Fold of wall of bursa cloacae
4. Dorsal wall of urodaeum
5. Ventral wall of urodaeum

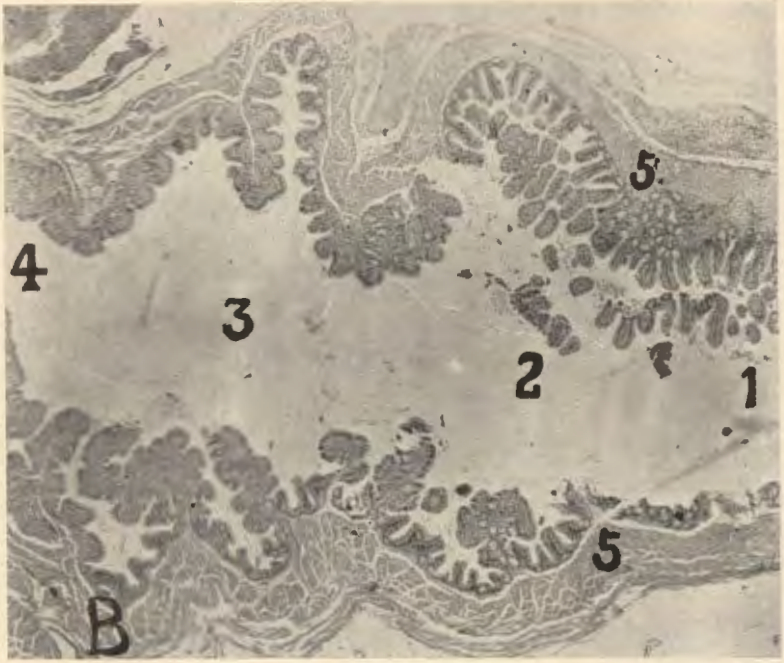

Fig. B. Longitudinal section of the two anterior chambers of the cloaca. Hematoxylin-eosin. 25 ×. 1 day.

1. Rectum
2. Coprodaeum
3. Urodaeum
4. Proctodaeum
5. Sphincter separating rectum from coprodaeum

Plate XXXIV — Gross view of open cloaca. Small metal rods show opening of ureters into the wall of the urodaeum. Larger probe indicates opening of the bursa Fabricii into the proctodaeum. 10 ×. 4 months.

1. Transverse folds of the rectum
2. Coprodaeum (Note blunt villi.)
3. Fold separating coprodaeum from urodaeum
4. Urodaeum
5. Proctodaeum
6. Dorsal lip of the anus

Plate XXXV — Fig. A. Anal opening, longitudinal section. Hematoxylin-eosin. 50 ×. 1 day.

1. Villi of proctodaeum
2. Dorsal lip of the anus
3. Ventral lip of the anus
4. Point at which the inner layer of muscle in the upper lip begins to change direction
5. Muscle of upper lip ending in a longitudinal arrangement
6. Muscle of lower lip arranged in an inner longitudinal and outer circular direction
7. All the muscle in the lower lip arranged in a longitudinal direction
8. Muscle of lower lip ending in a circular arrangement
9. Anal opening

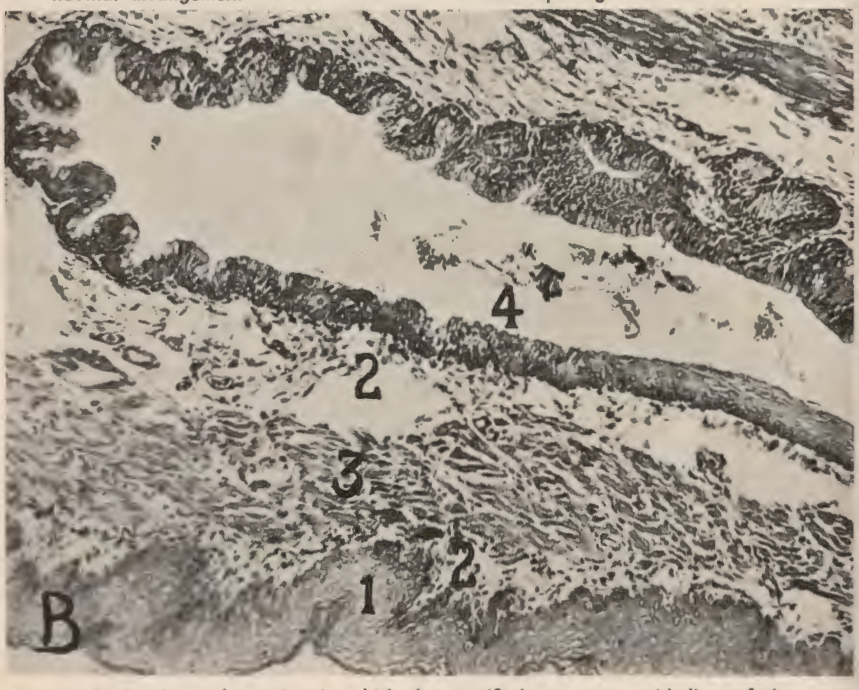

Fig. B. Region in anal opening in which the stratified squamous epithelium of the anus changes to the simple columnar epithelium of the proctodaeum. Hematoxylin-eosin. 200 ×. 1 day.

1. Epithelium of anal opening
2. Tunica propria and submucosa
3. Muscle
4. Point at which stratified squamous epithelium changes to simple columnar type.

Just anterior to the bursa cloacae a voluntary muscle began. It extended as a circular muscle to a point in the wall of the proctodaeum just above the ventral lip of the anus (Pl. XXXV, Fig. A-4). Here the inside portion of the circular layer began to arrange itself in a longitudinal direction. The two portions were continued thus for a short distance. By the time the lamina had reached the furthermost point of the dorsal lip of the anus, its few fibers were all arranged longitudinally (Pl. XXXV, Fig. A-5).

The muscular arrangement of the ventral lip was a little different. The fibers were circular as above; then a few fibers of the inside portion changed to a longitudinal direction (Pl. XXXV, Fig. A-6) only to change back to a circular arrangement at the extremity of the ventral lip (Pl. XXXV, Fig. A-8).

Liver

The livers of the five specimens presented one variation – the fat spaces in the liver cells of the baby chicks. This variation will be discussed later. The liver of the chicken differed little from that of the mammal. The interlobular septa were probably less apparent than those of the domesticated animals. The portal canal (Pl. XXXVI, Fig. B) contained the portal vein (1), lymph vessel (4), hepatic artery (3), and bile ducts (2). The interlobular veins were not prominent.

The central veins (Pl. XXXVI, Fig. A-1) were distinguished by the prominent sinusoids which entered them. They were lined with a thin endothelial membrane (Pl. XXXVI, Fig. A-2). The sinusoids were also lined with endothelial cells. The Kupffer cells were definitely marked.

The liver epithelium was arranged in a tubule of four to seven cells about an intralobular bile capillary. This tubular arrangement was well marked in a cross section. In longitudinal section these tubules looked like a plate or lamina two cells thick, as Elias and Bengelsdorf (1952) described them (Pl. XXXVI, Fig. A). The liver cell was a pyramidal cell with its apex bordering the lumen of the tubule. A large spherical nucleus was in the distal half of the cell.

Elastic tissue was confined to the walls of the blood vessels, to the connective tissue septa surrounding them, and to the capsule of Glisson surrounding the liver. White fibrous tissue was distributed similarly.

The liver cells (Pl. XXXVI, Fig. A-3) were supported by a meshwork of reticular tissue (Pl. XXXVII, Fig. A-2).

Baby chicks were sacrificed daily in an age series from one to 45 days, and the livers were examined microscopically for fat. Grossly these livers appeared yellowish or ochre-colored until about the fifteenth day at which time they began to take on the typical color of the normal adult liver. Microscopically a slight decrease in the amount of fat was observed by the twelfth day (Pl. XXXVIII, Fig. B). By the fifteenth day a considerable decrease was noticeable in the amount of fat (Pl. XXXVIII, Fig. C), and it continued to decrease until on the twenty-first day (Pl. XXXVIII, Fig. E) the fat globules were confined to a small area about the central veins. This condition persisted until about the twenty-fifth day. After this time occasional fat droplets were found scattered throughout the liver. The oldest specimen observed was 45 days old. The adult hematoxylin-eosin-stained specimens showed an occasional vacuole in the liver cells which may have been fat. There were indications that the type of feed and the relation of time of feeding to time of slaughter would change this picture. This phase was considered beyond the scope of this study.

Bile Duct

The wall of the bile duct consisted of the following layers: an outer adventitial layer; a lamina muscularis with scant outer longitudinal bundles, a prominent middle circular layer, and a somewhat irregular inner layer varying from longitudinal to oblique; a tunica propria extending into longitudinal folds which were covered with villi-like projections; and a simple columnar epithelial lining (Pl. XXXIX, Fig. B).

Gall Bladder

The gall bladder had a serosal covering which was quite thick and vascular in some areas but thin and avascular in others. Between the serosa and the mucous membrane there were two thin layers of muscle, an inner longitudinal and an outer oblique or circular. The longitudinal layer was quite constant, but the outer layer was occasionally absent. The mucous membrane was a loose connective tissue layer thrown into villi-like folds covered with columnar epithelium. When the organ was distended, these folds were not apparent (Pl. XL).

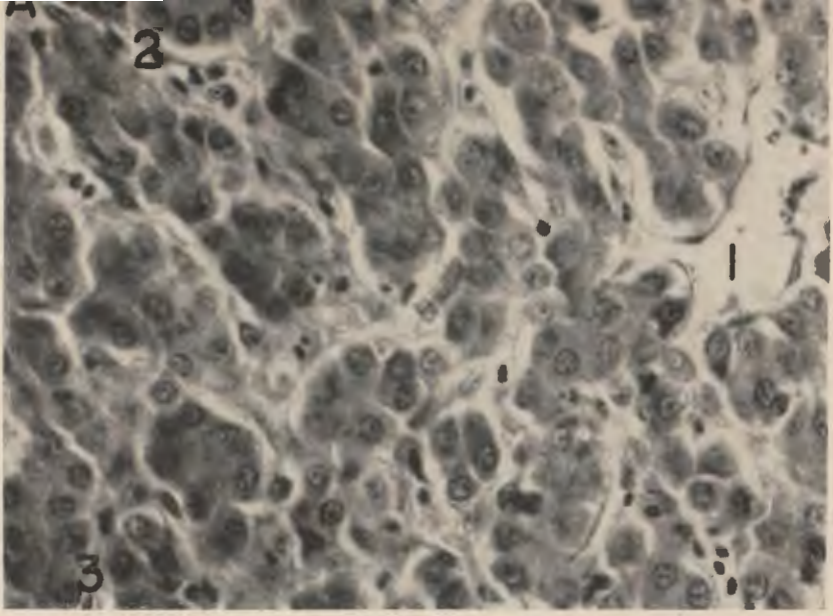

Plate XXXVI — Fig. A. Liver. Hematoxylin-eosin. 710 ×. 2 years.

1. Central vein with sinusoids opening into it
2. Cross section of liver cord or tubule
3. Tubule of liver cells cut longitudinally

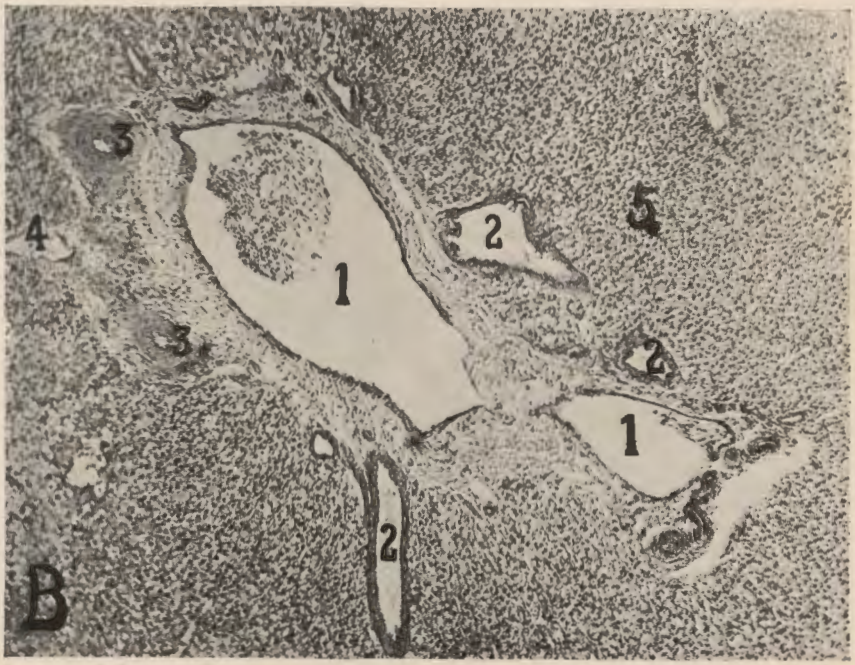

Fig. B. Liver showing portal canal. Note fat spaces in the liver parenchyma. Hematoxylin-eosin. 200 ×. 8 days.

1. Portal vein
2. Bile ducts
3. Hepatic arteries
4. Lymph vessel
5. Liver parenchyma

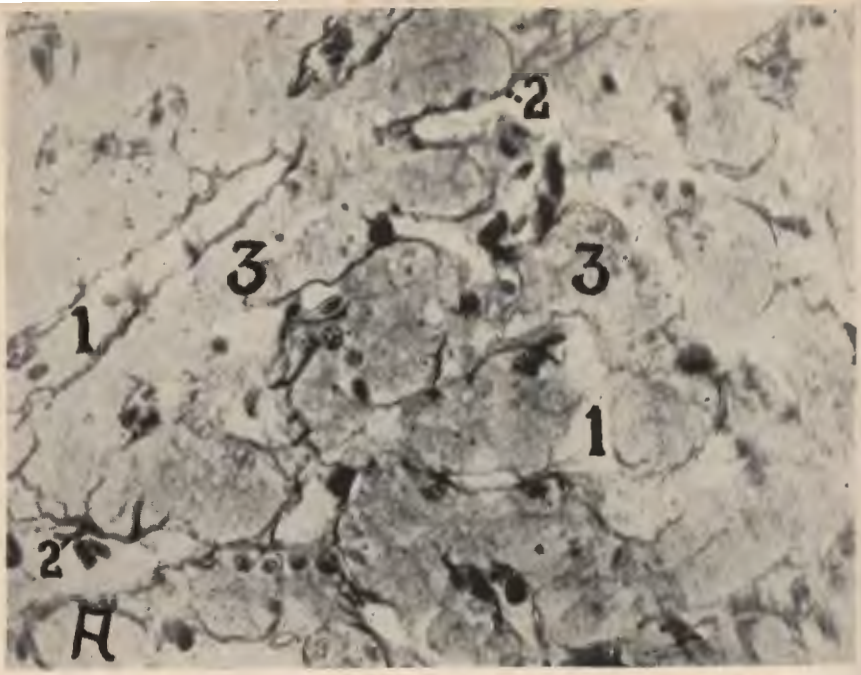

Plate XXXVII — Fig. A. Liver stained for reticulum. Reticular stain. 800 ×. 1½ years.

1. Sinusoids
2. Reticulum (black lines)
3. Tubules of liver cells

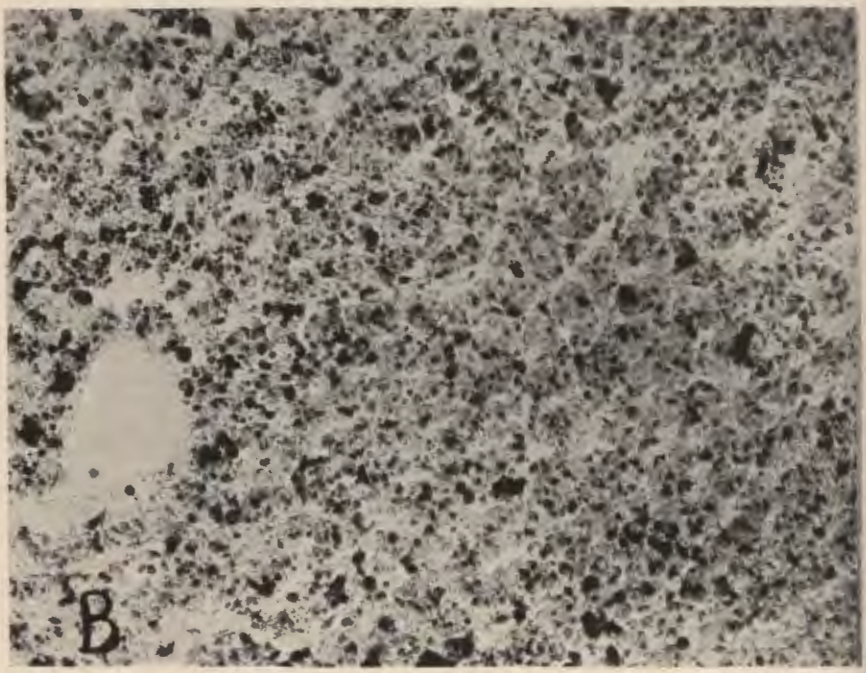

Fig. B. Liver stained for fat. Droplets appear dark. Scharlach R. 200 ×. 10 days.

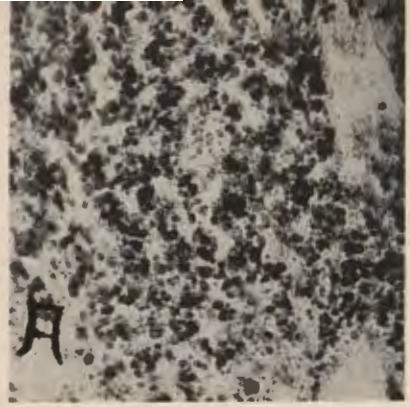

Fig. A—9 days

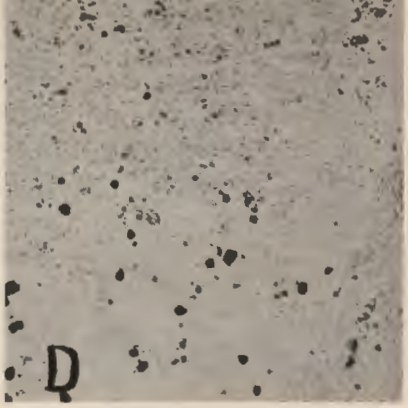

Fig. D—18 days

Fig. B—12 days

Fig. E—21 days

Fig. C—15 days

Fig. F—25 days

Plate XXXVIII — Figs. A—F. Liver stained for fat at 9, 12, 15, 18, 21, and 25 days. Scharlach R. 200 ×. Nate gradual lessening of fat until on the 21st and 25th days it is confined to an area around the vessels.

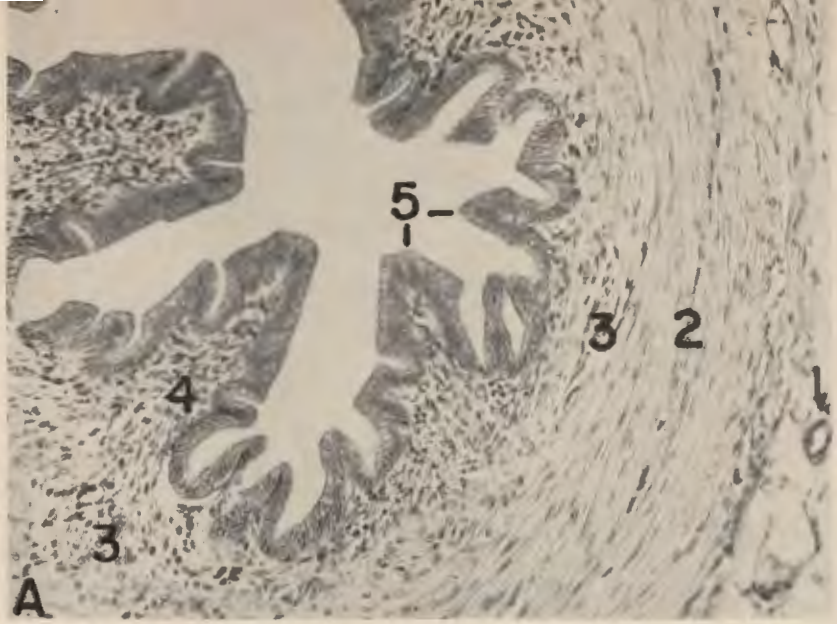

Plate XXXIX — Fig. A. Pancreatic duct. Hematoxylin-eosin. 200 ×. 4 months.

1. Tunica adventitia
2. Circular layer of the lamina muscularis
3. Inner longitudinal layer of the lamina muscularis
4. Tunica propria
5. Villi-like projections covered with simple columnar epithelium

Fig. B. Bile duct. Hematoxylin-eosin. 200 ×. 5 months.

1. Longitudinal layer of the lamina muscularis
2. Circular layer of the lamina muscularis
3. Connective tissue between muscle strands
4. Inner oblique muscle layer
5. Tunica propria
6. Villi covered with simple columnar epithelium

Plate XL — Gall bladder. Longitudinol section. Hematoxylin-eosin. 710 ×. 4 months.

1. Fibrous serosa
2. Outer circular layer of the lamina muscularis
3. Inner longitudinal layer of the lamina muscularis
4. Tunica propria
5. Simple columnar epithelium

Pancreas

The pancreas was a lobulated tubulo-acinar gland, the interlobular septa being very indistinct. The pancreas consisted of many tubular acini (Pl. XLI) which emptied into small collecting ducts lined with flattened epithelium. These ducts in turn emptied into larger ones lined by cuboidal epithelium and so on until the large collecting ducts (Pl. XXXIX, Fig. A) with columnar epithelium were reached.

The collecting ducts were seldom seen in the sections, and the exact pattern of the duct system is not understood. Many elongated branching tubulo-acini were observed. As in the duct system, the extent of the tubule and the manner of branching is not entirely clear. It certainly does not present the typical spherical acinus of the mammalian pancreas and salivary glands.

The secretory cells of the pancreas were low columnar and wider at their base than near the lumen. They had a granular cytoplasm, denser near the lumen. The granules were probably similar to the zymogen granules of the mammalian pancreas, although the eosin staining was more uniform throughout the cell. The spherical nucleus was in the basal half of the cell. Centro-acinar cells were demonstrable (Pl. XLII).

Two types of islets of Langerhans were observed. One was the beta islet similar in appearance to those of the mammalian pancreas, containing a few delta cells in addition to the beta cells. The other type was an islet consisting mostly of alpha cells plus a few delta cells. The islet tissue was not separated from the rest of the pancreas by a connective tissue layer. There were small amounts of reticular tissue present in the islets. Elastic and fibrous tissue was confined to the blood vessels and ducts and vicinity, and to the peritoneal covering.

Pancreatic Duct

The structure of the pancreatic duct was identical to that of the bile duct. Its wall was slightly thicker (Pl. XXXIX, Fig. A).

Bursa Cloacae

The wall of the bursa cloacae consisted of a thin serosa comprised chiefly of white fibrous connective tissue, an outer circular

Plate XLI — Pancreas. Note somewhat concentric arrangement of the tubulo-acinar units about the islets. Hematoxylin-eosin. 130 ×. 4 months.

1. Alpha islets
2. Small beta islets
3. Elongated tubular acini
4. Note appearance of branching
5. Lymphoid tissue
6. Blood and lymph vessels

Plate XLII — Fig. A. Pancreas. Hematoxylin-eosin. 1000 ×. 4 months.

1. Alpha islet
2. Lumina
3. Acinus showing a centro-acinar cell
4. Beginning of pancreatic duct
5. Lymphoid tissue

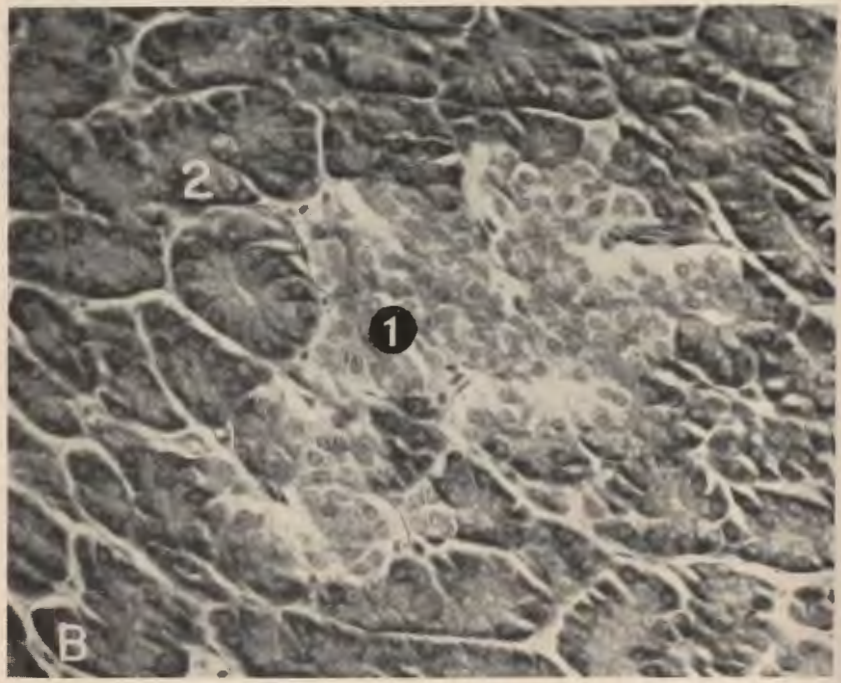

Fig. B. Pancreas. Hematoxylin-eosin. 1000 ×. 4 months.

1. Beta islet
2. Acinus showing centro-acinar cells

and an inner longitudinal involuntary muscle layer, and a mucosa thrown into longitudinal folds with a structure characteristic of this organ alone (Pl. XLIII).

Some of the muscle fibers joined with white fibrous connective tissue and elastic fibers to form a trabecula (Pl. XLIV, Fig. A-1), which extended the length of the fold and sent septa in between the lymph follicles (Pl. XLIV, Fig. A-2). This trabecula was rich in blood vessels.

There were many follicles in a fold. The follicle was a dense lymphocytic structure which was divided into a cortical (Pl. XLIV, Fig. B-4) and a medullary (Pl. XLIV, Fig. B-3) portion, the latter being less dense, comparable to the germ center of a lymph node. This medullary portion was in contact with the columnar epithelial lining. This epithelium was pseudostratified columnar on and near the tips of the folds. In between the folds it appeared as simple tall columnar, although there were areas in which it appeared cuboidal. Goblet cells were present. The medullary portion extended out through the cortical portion to join with an indipping in the epithelium (Pl. XLIV, Fig. B-2). The cortical portion was set off from the medullary portion by a reticular network (Pl. XLV, Figs. A and B) and by a row of cells which appeared similar to a columnar epithelium in places. No blood vessels were observed in the medullary portion but were present in the cortical part.

Yolk Sac

The wall of the yolk sac consisted of a fibrous connective tissue layer (Pl. XLVI, Fig. B-4) upon which were located many longitudinal folds of columnar epithelium containing many vacuoles (Pl. XLVI, Fig. B-2). The whole was surrounded by a serous membrane (Pl. XLVI, Fig. B-5).

Yolk Stalk

The wall of the yolk stalk was similar to that of the intestine with which it was continuous. A lamina muscularis, comprised of an outer longitudinal and an inner circular muscle (Pl. XLVI, Fig. A-2), and a muscularis mucosae with both longitudinal and circular fibers (Pl. XLVI, Fig. A-4) made up its muscle. The submucosa was thin (Pl. XLVI, Fig. A-3). The tunica propria (Pl. XLVI, Fig. A-5) was a dense connective tissue layer arranged in villi-like projections which were covered with a simple colum-

Plate XLIII — Bursa cloaca. The blind end was cut and the organ everted. Note the shape and extent of the folds and the gross appearance of the lymph follicles. Gross. 3 ×. 4 months.

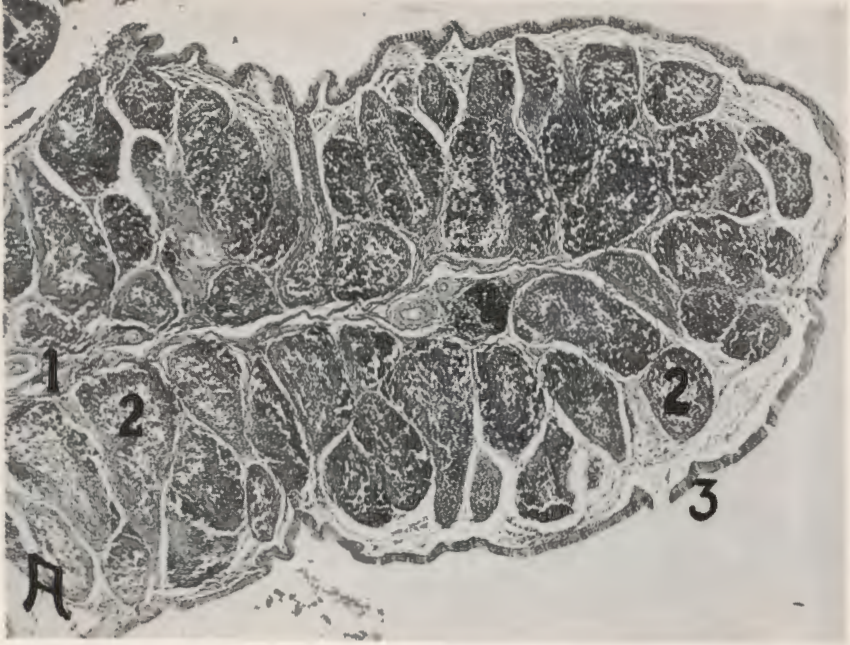

Plate XLIV — Fig. A. Fold in wall of the bursa cloacae. Hematoxylin-eosin. 50 ×. 7 months.

1. Trabeculae
2. Lymph follicles
3. Epithelium

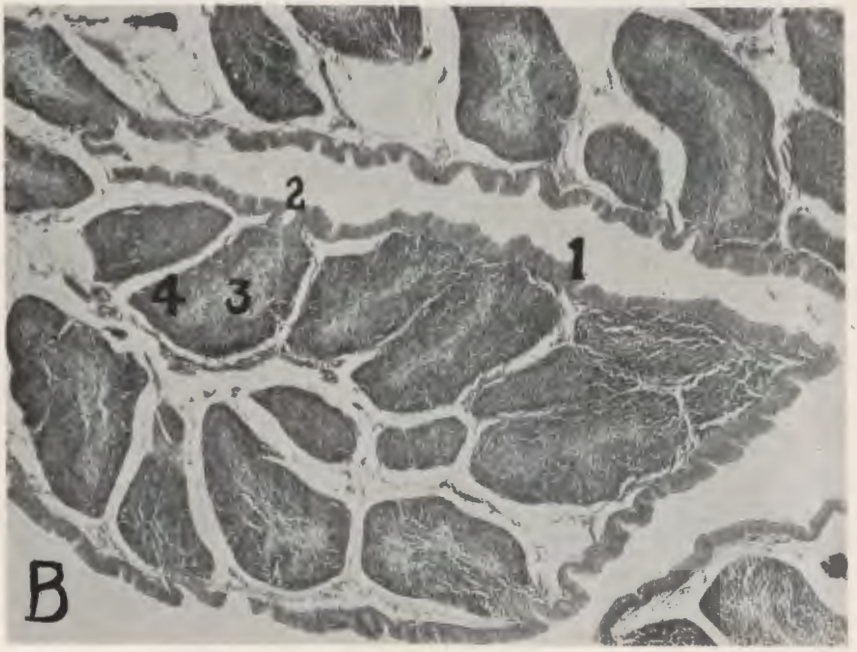

Fig. B. Fold of the bursa cloacae. Hematoxylin-eosin. 50 ×. 5½ months.

1. Epithelium
2. Epithelium joining the medullary portion
3. Medullary portion of a nodule
4. Cortical portion of a nodule

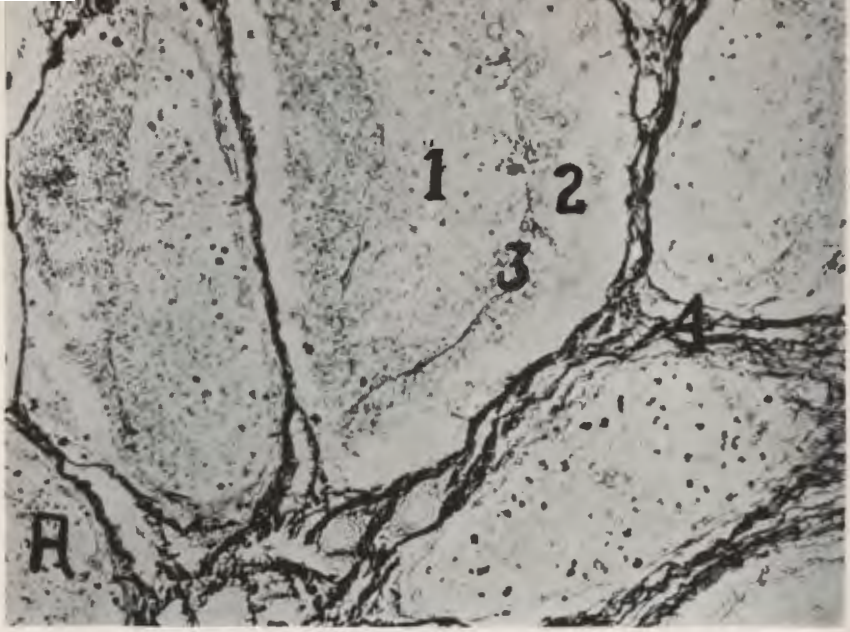

Plate XLV—Fig. A. Fold of the bursa cloacae showing reticulum. Reticular stain. 200 ×. 7 months.

1. Medullary portion of lymph follicle
2. Cortical portion of lymph follicle
3. Reticular tissue at junction of medullary and cortical portions
4. Interfollicular septa

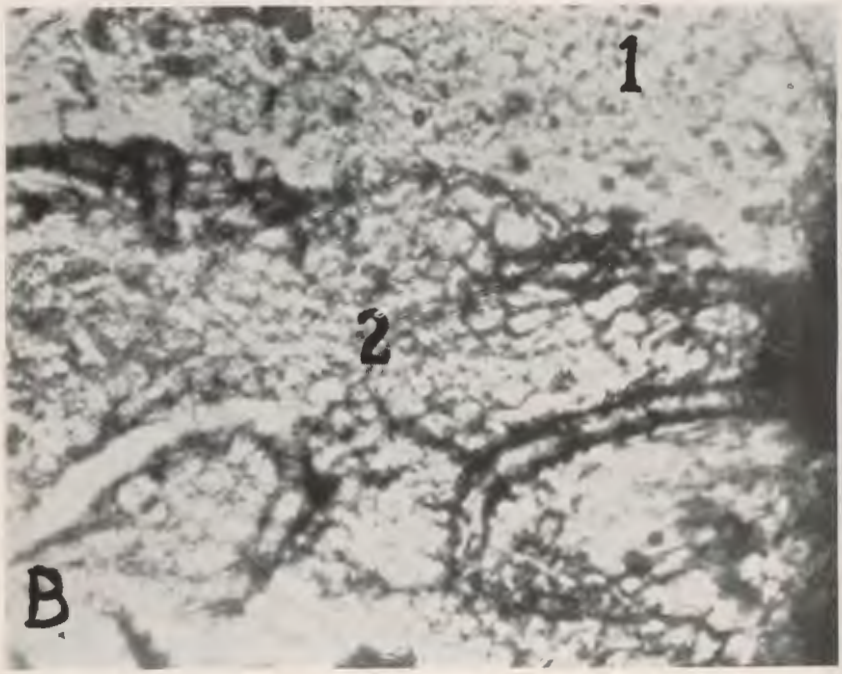

Fig. B. Reticulum separating cortical from medullary portions in a follicle of the bursa cloacae. Reticular stain. 800 ×. 7 months.

1. Cortical portion
2. Medullary portion

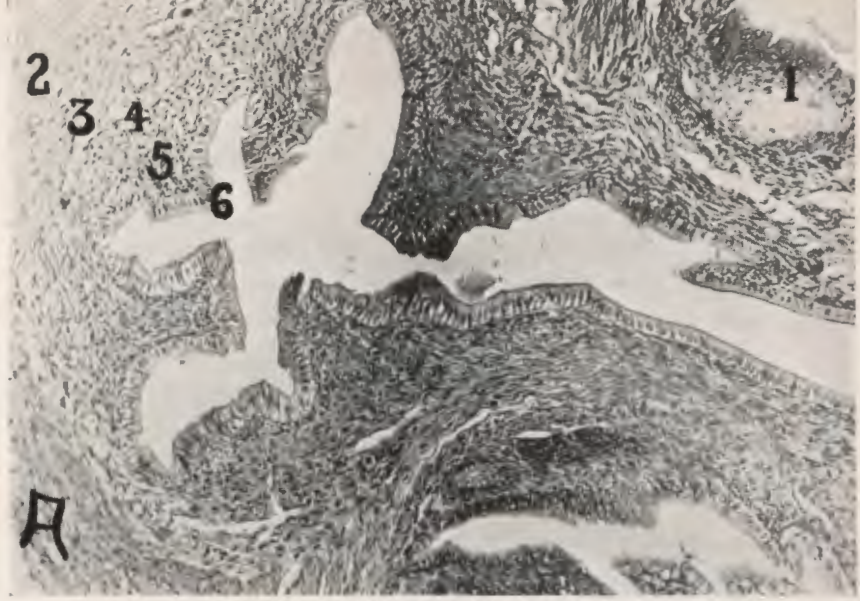

Plate XLVI — Fig. A. Yolk stalk. Hematoxylin-eosin. 200 ×. 36 hours.

1. Intestinal mucosa
2. Lamina muscularis
3. Submucosa
4. Muscularis mucosae
5. Tunica propria
6. Columnar epithelium

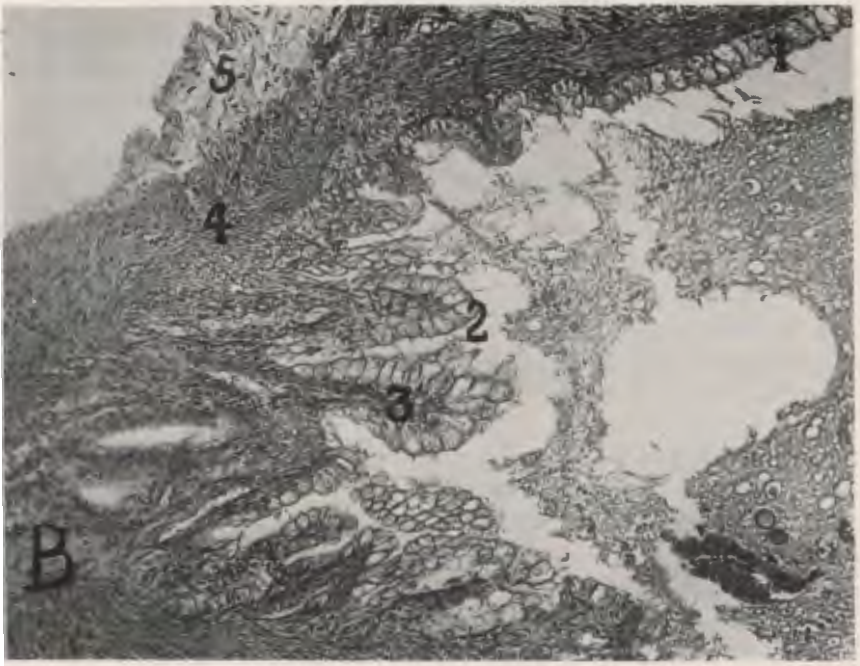

Fig. B. Yolk sac. Hematoxylin-eosin. 200 ×. 1 day.

1. Cuboidal epithelium of yolk stalk
2. Columnar epithelium of yolk sac
3. Folds in the mucaus membrane
4. Fibrous connective tissue layer
5. Serosa