GROSS AND HISTOLOGICAL STUDIES OF THE DIGESTIVE TRACT OF THE RABBIT

by

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TABLE OF CONTENTS

INTRODUCTION

This study was undertaken because of a need for a general gross and a more complete histological description of the digestive tract of the rabbit. Data were available concerning the various gross segments of the digestive tract but they were primarily of a quantitative or illustrative nature. Histological studies of the digestive tract have been of limited areas. The rabbit has been used as a laboratory animal for many years and has become increasingly important as a source of meat for human consumption.

MATERIALS AND METHODS

The animals used were average-sized, mature New Zealand and New Zealand Cross bred animals with a body length of 20 to 22 inches. They were made available by the pathology department, Kansas State College. All rabbits were in good health although they were not fat. Euthanasia was performed with pentobarbital sodium or chloroform. Fresh and embalmed (10 per cent formalin) specimens were used for the gross studies. The linear measurements of the various organs of the digestive tract were made on fresh specimens. Care was taken not to stretch the segments of the organs during measurement.

Sections for histological study were removed immediately after death and placed in 10 per cent buffered formalin, Bouin's or Zenker's solutions. Tissue specimens were taken from the cranial, middle and caudal portions of the esophagus.

Tissue specimens from the stomach were taken from the cardia, the blind left part, the fundus, and the pyloric regions. Tissue specimens were taken from the duodenum at one-inch intervals in the first four inches, then at four-inch intervals thereafter. The remainder of the intestines, jejunum, cecum, appendix, sacculated and smooth colon, and rectum was also sectioned at four-inch intervals. The routine specimens were dehydrated, infiltrated and embedded in paraffin then cut five to six microns in thickness with a microtome. The tissue sections were stained with Harris' hematoxylin and eosin Y (precipitated-acidified eosin Y). Special stains employed were the Fontana-Masson stain for argentaffin granules (Lillie, 1948) and Masson's silver method for argentaffin cells in blocks (Mallory, 1938).

REVIEW OF LITERATURE

Quantitative data were present in the literature on the various gross anatomical structures of the rabbit. Latimer and Sawin (1955), Brown, et al. (1926), Kibler, et al. (1942), and Crile and Quiring (1940) described the various organ sizes and weights. Latimer and Sawin (1957) described the lengths and weights of the various segments of the digestive tract. DeBruyn and Tornova-Svehlik (1954) reported on the quantitative determination of lymphatic tissue of the appendix. Similar reports on the weights and linear measurements of the digestive tract of the mink and cat were made by Kainer (1954) and Latimer (1937). Eaton (1938) reported on the weights and measurements

of various parts and organs of the guinea pig. Meek (1943) and Rowett (1957) gave gross illustrations of the digestive tract and Bensley (1918) briefly described the segments of the digestive tract of the rabbit. Jaffe (1951) reported on a quantitative study of the islets of Langerhans in rabbits.

Histological studies of special areas of the digestive tract have been made. Carleton (1935) described the distribution of Brunner's glands. Dawson (1945) and Dalton (1951) reported on the epithelial cells of the digestive tract and DeBruyn (1948) on the structure of the lymph nodes. Macklin and Macklin (1932) discussed the types of glands found at the pylorus. Sundberg and Downey (1942) compared the lymphoid cells of the bone marrow and lymph nodes of rabbits and guinea pigs. Ehrich and Cohn (1931) studied the nuclei of the heart muscle of the rabbit.

OBSERVATIONS

The Esophagus

The gross observations revealed the esophagus to be a musculo-membranous tube, approximately 15 centimeters in length and 1 centimeter in diameter, which extended from the pharynx to the stomach. Its position was similar to that described for the dog. Beginning at the caudal part of the pharynx, it lay dorsal to the larynx. From this position, it passed caudally just dorsal to the trachea to the fourth or fifth cervical vertebra where it inclined to the left of the trachea. At the

thoracic inlet, the esophagus passed along the dorso-lateral surface of the trachea to the base of the heart where it again reached the median plane dorsal to the trachea. It inclined slightly to the right before it passed through the hiatus esophageus of the diaphragm ventral to the 11th thoracic vertabra.

Microscopic observations of the esophagus revealed the mucous membrane to consist of stratified squamous epithelium that appeared to be slightly cornified (Plate I, Fig. 1).[1] The lamina propria was formed by fine interlacing connective tissue fibers and fibro-cytes. The muscularis mucosae was only one or two muscle fibers thick in the cranial part of the esophagus but near the cardia it was three or four muscle fibers thick. The smooth muscle fibers of the muscularis mucosae were arranged in a longitudinal direction. The submucosa was composed of loosely interwoven collagenous fibers and was relatively thick. The muscularis externa was composed of striated muscle fibers extending from the pharynx to the cardia. The striated muscle fibers were arranged in an inner longitudinal layer, a middle circular layer and an outer longitudinal layer. The inner longitudinal layer was three or four muscle fibers thick. The middle circular layer was five to ten muscle fibers thick. The outer longitudinal layer was one or two muscle fibers thick in the cranial part of the esophagus and three or four muscle fibers thick in the caudal part of the esophagus (Plate I,

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[1]All plates in Appendix

Fig. 2). A few smooth muscle fibers appeared in the outer muscle layer several millimeters cranial to the esophageal-cardiac junction. The striated muscle fibers were interwoven with the smooth muscle fibers around the cardia of the stomach. The extrathoracic part of the esophagus was attached to the surrounding structures by fibrous connective tissue while the thoracic part was surrounded by a serosa. No glands were present except at the esophageal-cardiac junction (Plate II, Fig. 1).

The Stomach

The stomach was a J-shaped dilatation of the digestive tract between the esophagus and the small intestine. The greater curvature was approximately 24 centimeters long and the lesser curvature was approximately 10 centimeters. The position was variable due to the variable distention of the organ. The stomach occupied the space in the abdominal cavity just caudal to the liver. The cranial surface was on a plane through the 12th thoracic vertebra while the caudal surface was on a plane through the second or third lumbar vertebra. The left extremity was to the left of the median plane against the dorsal wall of the abdominal cavity. The antrum pyloricum was near the right dorsal abdominal wall and the caudate lobe of the liver. There was a noticeable stricture in the region of the pylorus.

The epithelium was simple columnar. In the cardiac region, the gastric pits were deep. The mucous glands present in this

region extended for only one or two millimeters from the esophageal-cardiac junction of the mucous membranes. The gastric glands extended over the rest of the mucous membrane except in the pyloric region. The gastric glands were composed of parietal, chief and neck chief cells. The parietal cells were oval or polygonal in shape and were arranged around the outer area of the gland (Plate III, Fig. 1 and Fig. 2). The chief cells were most numerous and occupied the area of the gland adjacent to the lumen. The cells were cuboidal or pyramidal in shape. The neck chief cells were low columnar to cuboidal in shape and were not numerous. A few argentaffin cells were present in the deep part of the mucosa. The pyloric glands consisted of mucous cells. The pyloric pits were much deeper than the gastric pits. An intermediate zone existed where both gastric and pyloric glands were present. The muscularis mucosae was a thin layer of smooth muscle fibers some of which extended into the areas between the glands. The muscularis externa consisted of three incomplete layers, arranged in an inner oblique, middle circular and an outer longitudinal fashion. A serosa was present.

The Duodenum

The duodenum was a tubular organ approximately 60 centimeters in length and 1 centimeter in diameter. It left the pylorus in a dorsal direction and immediately curved to the right and caudally. It then progressed caudad medial to the

caudate lobe of the liver and the right lateral abdominal wall. The bile duct entered the duodenum one centimeter from the pylorus. Because of the comparatively loose mesoduodenum, the descending loop of the duodenum lay in the ventro-lateral region of the abdominal cavity. Near the pelvis, the duodenum turned craniad forming the pelvic flexure. Shortly after this flexure, the pancreatic duct entered the duodenum approximately 40 centimeters from the pylorus. The duct entrance was about eight centimeters from where the mesoduodenum attached to the descending part of the smooth colon. From this point of attachment, the duodenum progressed craniad in the dorsal abdominal area to the root of the common mesentery in apposition to the right side of the smooth colon to which it was attached. Here it turned left forming the duodeno-jejunal flexure and continued as the jejunum.

The villi were leaf shaped. No plicae circulares were present in the small intestine. The epithelium of the villi was of the columnar type with a striated free border (Plate IV, Fig. 2). Goblet cells were present. The intestinal glands extended down to the muscularis mucosae. The epithelium of the glandular crypt was low columnar and lacked a cuticular border. A few argentaffin cells were present in the glands. The muscularis mucosae was two to three smooth muscle fibers thick. Strands of smooth muscle extended up into the villi. The duodenal glands were present in the submucosa for 57 centimeters along the small intestine. They formed a thick layer at the origin of the duodenum but gradually became less numerous until

they completely disappeared. The muscular coat consisted of inner circular and outer longitudinal layers. The muscle layers were comparatively thinner than the mucosa. A serosa was present. The cells of the duodenal glands were of the mucous and serous types with mucous cells predominating. Individual duodenal glands appeared to have only one type of cell (serous or mucous) present. The serous type became numerous five centimeters from the origin of the duodenum and continued throughout the duodenal area (Plate IV, Fig. 1).

The Jejunum and Ileum

The jejunum and ileum were tubular organs about 250 centimeters in length and 1 centimeter in diameter. The jejunum arose from the duodenum ventral to the second lumbar vertebra at the root of the common mesentery in the median plane. Many coils were formed in the left mid-abdominal region and dorsal to the cecum. The ileum was considered to be that part of the small intestine where the arterial arches became small and the common mesentery blended in with the mesentery of the duodenum, colon, and cecum. The ileum then passed to the right in a plane ventral to the fifth lumbar vertebra crossing the midline ventral to the appendix and dorsal to the sacculated colon. It progressed in a large loop to the right and craniad near the right abdominal wall, then turned medially as it maintained its previously described relation to the cecum and colon. Ventral to the fifth lumbar vertebra, the organ turned caudally and entered the sacculus rotundus.

Five or six Peyer's patches were present in the wall of the jejunum and ileum opposite the mesenteric attachment. The external surface of the Peyer's patches presented a fine hexagonal appearance. They were elliptical in shape and approximately five by ten millimeters in size. Occasionally, one patch was found in the terminal part of the duodenum and accounted for the variation in number in the jejunum and ileum. The root of the common mesentery of the small intestine attached to the dorsal abdominal wall ventral to the first three lumbar vertebrae. From this attachment the mesentery fanned out to the jejunum and ileum. The lymph nodes were located at the base of the common mesentery.

The villi were rounded in the jejunum and club-shaped in the ileum. The epithelium consisted of simple columnar cells with a striated free border. A few scattered argentaffin (Plate VIII, Fig. 1) and goblet (Plate V, Fig. 2) cells were present. The intestinal glands extended down to the muscularis mucosa and were similar to the intestinal glands in the duodenal area (Plate V, Fig. 1). The submucosa contained no glands. The external muscular layers and the serosa were similar to that of the duodenum. The Peyer's patches were aggregates of lymph nodules and had a structure similar to the sacculus rotundus.

The Sacculus Rotundus

The sacculus rotundus was a thick-walled, cylindrical structure about two centimeters in diameter and three

centimeters long. The sacculus rotundus connected the ileum with the cecum. The wall was composed almost entirely of lymphoid tissue. An area of lymphoid tissue approximately two centimeters in diameter extended onto the cecum. There was a constricted valve-like structure (ileo-cecal valve) where the sacculus rotundus entered the cecum.

The mucosa formed mushroom-like structures over the lymph nodules. The stems of these structures were composed of simple columnar epithelium, smooth muscle fibers, blood vessels, lymphocytes and collagenous and elastic connective tissue. The mushroom top of the structures in addition contained mucous glands. The epithelium covering the lymph nodules was infiltrated with a large number of lymphocytes. The lymph nodules were composed of small and medium sized lymphocytes and a thin reticular network. Germinal centers were easily distinguished in most of the nodules. The muscularis mucosae was thin and in some areas appeared to be absent. Fibers from the muscularis mucosae passed up between the nodules to the mucosa above (Plate VII, Fig. 1). The external muscle layers and the serosa were similar to the jejunum and ileum.

The Cecum

The cecum was a tubular structure about 45 centimeters in length and from 1.2 to 3.2 centimeters in diameter. The cecum lay on the floor of the abdominal cavity arranged in a loose counter-clockwise coil as viewed from the ventral surface. The sacculated part of the colon lay between the cranial parts of

the cecal coil. The cecum covered the entire abdominal floor from a point ventral to the seventh lumbar vertebra cranially to the first lumbar vertebra. The free end of the cecum lay in the dorsal part of the abdominal cavity to the right of the median plane ventral to the fifth lumbar vertebra. The cecum was related ventrally to the abdominal wall, dorsally to part of the sacculated colon, duodenum, jejunum, ileum and part of the ascending and transverse colon, caudally to the bladder and cranially to the stomach and liver. A spiral fold extended into the lumen approximately seven millimeters from the wall of the cecum. The fold was apparent on the external surface by a spiral groove extending from the base of the cecum to the appendix.

The epithelium was simple columnar with a striated border. The goblet cells were numerous in the depressed areas between the small knob-like villi (Plate VI, Fig. 2). The lamina propria was infiltrated with a rather large number of lymphocytes and contained only a few mucous glands. The leaf-like structure (Plate VI, Fig. 1) that spiraled the length of the cecum was composed of the mucosa, submucosa and the inner layer of the muscularis externa. The muscularis mucosae was two to three cell layers thick. The external muscle layers and serosa were similar to that described for the small intestine.

The Appendix

The appendix was a small blind tube approximately 15 centimeters in length and 1.2 centimeters in diameter. The color was

lighter than the cecum because the ingesta was not visible through the highly lymphoid wall. The appendix began just ventral and caudal to the right kidney and extended caudomedially to just ventral to the sixth lumbar vertebra. It then turned cranio-laterally to a point about two centimeters to the left of the median plane.

The mucosa formed "tree-like" structures over the lymph nodules. The stems of these structures were composed of simple columnar epithelium, smooth muscle fibers, blood vessels, lymphocytes and collagenous and elastic connective tissue. The mushroom top contained mucous glands in addition to the structures in the stems. The epithelium covering the lymph nodules was continuous with the epithelium of the stem of the "tree-like" structure and was infiltrated with a large number of lymphocytes. The lymph nodules were composed mainly of small and medium sized lymphocytes and a thin reticular network. Germinal centers were easily distinguished in most of the nodules. The muscularis mucosae was thin and in some areas appeared to be absent. Fibers from the muscularis mucosae passed between the nodules to the mucosa above (Plate VIII, Fig. 1). The external muscle layers and the serosa were similar to the jejunum and ileum.

The Sacculated Colon

The sacculated colon was a tubular structure about 38 centimeters in length and varied in diameter from 2.5 centimeters at its origin to 1 centimeter at its distal end. It

originated from the base of the cecum to the left of the midline in a plane ventral to the fifth lumbar vertebra. It progressed to the right and slightly craniad (11 centimeters) between the two coils of the cecum. In the right flank region, it turned dorso-caudally then caudo-medially to an area ventral to the seventh lumbar vertebra. The colon then turned craniad to the right as far as the root of the cecal mesentery to which it was closely attached. At this point, the sacculations were absent. Three longitudinal muscle bands and three rows of sacculations were present on the external surface of the colon for the first 11 centimeters then two muscle bands blended with the mesenteric attachment while a broad band on the opposite side continued to the end of the sacculated colon. Throughout the area of one muscle band, there was only one row of sacculations.

The epithelium was composed of simple columnar cells with a striated border. Goblet cells were present. The intestinal glands extended deep into the lamina propria (Plate VIII, Fig. 2). Capillaries and smooth muscle fibers from the muscularis mucosae passed between the glands. Approximately 20 centimeters from the origin of the sacculated colon, the fibers of the muscularis mucosae became arranged in an inner circular and an outer longitudinal direction. The submucosa was a thin network of interlacing collagenous fibers and fibrocytes. The inner circular layer of the muscularis externa was thicker than in the cecum. The outer longitudinal muscle layer was arranged

in bands as described above but in some areas a very thin layer covered the inner circular layer and became greatly thickened in the longitudinal band areas. A serosa was present.

The Smooth Colon

The smooth colon was a tubular structure about 65 centimeters in length and 1.2 centimeters in diameter. This part of the colon originated ventral to the fourth lumbar vertebra. It formed a small S-shaped curve then progressed cranio-laterally to the ventral surface of the right kidney where it turned caudo-laterally. The smooth colon then passed caudad for a short distance (five centimeters), curved ventro-laterally and craniad (five centimeters) between the descending duodenum and the body of the cecum. At the caudal surface of the pyloric part of the stomach, it turned medially to pass transversely caudal to the stomach. The transverse segment was closely attached to the dorsal abdominal wall in a plane ventral to the first lumbar vertebra. In the region of the left kidney, the organ then turned caudad and progressed near the median plane to the pelvic cavity where it was continued as the rectum.

The epithelium was of the simple columnar type with some interspersed goblet cells. No villi were present. The columnar cells demonstrated a striated border. The glands were of a greater diameter and were shorter than in the sacculated colon. The fibers of the muscularis mucosae ran in two directions as in the distal part of the sacculated colon but were of greater thickness. Smooth muscle fibers passed up between the glands

of the lamina propria. The collagenous fibers of the submucosa, a comparatively thick layer, had a loose arrangement. The muscularis externa was composed of an inner circular layer and an outer longitudinal layer of smooth muscle. A serosa was present (Plate IX, Fig. 1).

The Rectum

The rectum was a tubular structure approximately 6 centimeters in length and 1.2 centimeters in diameter. It progressed caudad in the dorsal part of the pelvic cavity to the anus. The caudal four centimeters was retroperitoneal. Longitudinal folds of the mucous membrane were present. Just cranial to the anus, there were two or three circular folds in the mucous membrane.

The epithelium was simple columnar with a striated free border. The structure of the mucous glands was similar to those of the colon. The muscularis mucosae was several cell layers thick and consisted of circular and longitudinally arranged fibers. At the junction of the anal and rectal epithelium, the muscularis mucosae formed a column, five to eight smooth muscle fibers thick, that extended up to the stratified squamous epithelium of the anus (Plate IX, Fig. 2). Caudal to this, the muscularis mucosae gradually became indistinct. The submucosa was a dense network of collagenous fibers. The muscularis externa consisted of a thick circular layer and a thinner outer longitudinal layer. These smooth muscle layers extended about two millimeters caudal to the recto-anal junction.

Circularly arranged skeletal muscle fibers surrounded the muscularis externa of the caudal part (one centimeter) of the rectum and skeletal muscle formed most of the musculature of the anus. This skeletal muscle was part of the external anal sphincter muscle. The serosa on the retroperitoneal part of the rectum was replaced by a tunica adventitia consisting of a dense network of collagenous and elastic fibers (Plate IX, Fig. 2).

DISCUSSION

An important consideration in establishing an average length or weight of an organ was the size of the animals measured. The rabbits used were average sized mature New Zealand and New Zealand cross-bred animals, with a body length of 20 to 22 inches. The measurements found may not necessarily conform to measurements of other breeds.

The Esophagus

The length of the esophagus was slightly longer than Latimer and Sawin (1957) found in race X rabbits. Its course was similar to that described for the dog by Sisson and Grossman (1953). The mucous membrane was in longitudinal folds throughout the length of the esophagus, thus demonstrating the ability of the lumen to dialate. The mucous glands in the submucosa found in the dog and some domestic animals (Trautman and Fiebiger, 1952) were not present except at the esophageal-cardiac junction. Maximow and Bloom (1952) stated that no

esophageal glands were present in the rodent, horse and cat. Trautman and Fiebiger (1952) stated that glands occurred only at the pharyngoesophageal junction in the horse and cat. The muscularis externa (Plate I, Fig. 1) was composed entirely of striated muscle. It was formed of three layers arranged in an inner longitudinal, middle circular and an outer longitudinal layer. At the cardia, the striated muscle fibers intermingled with the smooth muscle fibers of the muscularis externa of the stomach for several millimeters before disappearing.

The Stomach

The size and position of the stomach varied with the amount of ingesta it contained. The cranial surface and pyloric region were fairly constant but the caudal surface of the body of the stomach was quite variable in position. However, the stomach of the rabbit did not appear to be as highly dialatable as that of the dog. The diaphragm of the rabbit had a more cranial position as compared to the mink (Kainer, 1954). Folds (rugae) were present on the mucosal surface of the stomach.

Only a few mucous type glands were present in the cardiac region. The gastric type glands became evident only one or two millimeters from the cardia and continued throughout the mucosa of the stomach until near the pylorus where the pyloric (mucous) type glands began to intermingle with them. Argentaffin cells were demonstrated in the gastric mucosa. Dawson (1945) found that they were most numerous in the cardiac region and least numerous in the pyloric region. At the pylorus, only mucous

type glands were present. Macklin and Macklin (1932) found that some of the glands at the pylorus were pyloric, some were duodenal and some consisted of cells from both duodenal and pyloric glands. The parietal cells of the gastric glands were numerous in the neck region of the glands (Plate III, Fig. 1). Dalton (1951) found that the parietal cells possessed a striated border. The muscularis mucosae passed into the rugae of the mucosa. The submucosa was a rather loose network of connective tissue. The muscularis externa was well developed and was thicker than in any other segment of the digestive tract.

The Small Intestine

The bile duct entered the duodenum through a small papillae shortly after the pylorus emptied into the lumen of the duodenum. The pancreas formed a loose thin mass of glandular tissue in the mesentery between the descending and ascending loops of the duodenum. Approximately 40 centimeters from the pylorus, the pancreatic duct passed from the caudo-medial border of the gland to enter the wall of the duodenum along its mesenteric attachment. Six Peyer's patches were noted on the wall of the small intestine. They were about evenly spaced between the pylorus and the ileocecal valve.

The epithelium of the mucosa of the small intestine was composed of simple columnar cells with a striated free border. Dalton (1951) found that the height of the striated border may change under varying conditions. Goblet cells were more

numerous near the base of the villi. A varying number of lymphocytes had infiltrated the epithelium. The duodenal glands first described in 1686 by Brunner, a Swiss physician, (Carleton, 1935) presented a special feature in the rabbit. Both serous and mucous cells were present although the mucous type predominated (Plate IV, Fig. 1). Carleton found this to be the only animal in which both types of cells were present. The extent of the duodenal glands in the various animals was determined to some degree by the point of entrance of the pancreatic duct into the duodenum (Carleton, 1935). The presence or absence of food changed the color of the intestine considerably because of the thin muscularis externa.

The sacculus rotundus (Bensley, 1918) was a structure composed almost entirely of lymphoid tissue. The serosal surface of Peyer's patches and the sacculus rotundus presented a fine hexagonal appearance. The wall was composed almost entirely of lymphoid tissue. The mucous membrane was arranged in "tree-like" structures which more or less covered the lymph nodules (Plate VII, Fig. 2). The free surface of the nodules was covered by columnar epithelium with a heavy infiltration of lymphocytes.

Murray (1930) found that when an extract of the duodenal mucosa was injected into the blood stream, the amounts of HCl and pepsin secreted in the stomach were significantly less when Brunner's glands were not present.

The Large Intestine

The cecum was a large thin-walled structure which may be considered to have a base, a body and an appendix. The sacculus rotundus attached to the cecum at the junction of the base and body. The external surface presented a spiral groove extending from the base to the appendix. Opposite this groove on the internal surface, there was a fold extending into the lumen of the cecum.

The mucosa of the cecum was thin compared to the rest of the intestinal tract and contained relatively few glands (Plate VI, Fig. 2). The spiral leaf was composed of the mucosa, submucosa and the inner layer of the muscularis externa. Peristalsis would probably affect the depth of the leaf.

The appendix presented the same external appearance and general structure as the sacculus rotundus. DeBruyn (1948) believed the lymph nodules to be composed of a fairly definite head, neck, and body. This was demonstrated in the section of the appendix (Plate VII, Fig. 1). DeBruyn and Tornova-Svehlik (1954) found that the depletion of the lymphocytes only reduced the size of the nodules and did not result in an empty network of widely spaced reticular cells as occurred in the lymph node. Germinal centers were present with large numbers of small lymphocytes around the periphery of the nodules. Sundberg and Downey (1942) found the undifferentiated reticular cells in the lymph nodule to be 30 microns in diameter.

For convenience of description, the colon was divided into a sacculated colon and a smooth colon. The smooth colon may be further divided into ascending, transverse and descending parts. This did not agree with Rowett (1957) who termed the smooth part the rectum. Bensley (1918) described the colon as consisting of ascending, transverse and descending parts. The ascending part included the sacculated colon and the ascending part of the smooth colon as described above.

The sacculated colon decreased greatly in diameter from its origin to its termination. It lay between the coils of the cecum. The mesenteric attachment of the sacculated colon blended with that of the cecum. The material in the gut changed from a semifluid to a semisolid state in this part of the intestine. The absorption of a large amount of water in the area could possibly be explained by the large number of capillaries present in the mucosa. The crypts of the glands were separated by capillaries and their prominence was easily noted. The wall of the gut presented sacculations which were separated by longitudinal muscle bands. These bands were composed of the external layer of the muscularis externa.

The smooth colon was a direct continuation of the sacculated colon. The ingesta present in the lumen of the distal end of the sacculated colon was formed into round balls about one centimeter in diameter. In the proximal end of the smooth colon, the balls became more firm and slightly separated. They were present in the colon in single file with a constriction of

the gut between each ball. This gave the smooth colon a sacculated appearance when examined grossly. When empty, the smooth colon presented a smooth appearance.

The rectum was considered to be that part of the large intestine between the pelvic inlet and the anus. No gross differences were noted between it and the colon. In some of the animals examined, it was noted that in the region of the rectum the fecal balls became packed against each other. The mucosa of the smooth colon and the rectum was similar and the mucous secreting glands quite large and numerous, while in the sacculated colon the mucosa was relatively thicker, the glands deeper, and the large type mucous cell not present.

It became apparent that the muscularis mucosae was composed of circular and longitudinally arranged fibers about 20 centimeters from the origin of the sacculated colon. The arrangement continued to the anus with the layers becoming thicker as the rectum was approached. The muscularis externa of the smooth colon appeared to be similar with an outer longitudinal layer and an inner circular layer. Near the caudal part of the anus, skeletal muscle fibers of the external anal sphincter were present around the outer layer of the muscularis externa. The epithelial lining of the mucosa changed abruptly at the rectoanal junction from the simple columnar to stratified squamous. The mucous glands were not present from this point caudally (Plate IX, Fig. 2).

SUMMARY

A gross and microscopic description of the digestive tract of the rabbit was presented.

The esophagus of the rabbit was found to contain no glands except at the esophageal-cardiac junction. The muscularis externa was striated throughout. The striated muscle fibers were arranged in an inner longitudinal layer, a middle circular layer and an outer longitudinal layer. The esophagus was approximately 15 centimeters in length and 5 millimeters in diameter.

Gastric glands were present in all of the mucosa of the stomach except for a few millimeters around the cardia and a short distance proximal to the pylorus.

The duodenum was approximately 60 centimeters in length and 1 centimeter in diameter. The duodenal glands contained both mucous and serous cells. The glands extended approximately 57 centimeters along the small intestine. The bile duct entered the duodenum one centimeter and the pancreatic duct approximately 40 centimeters from the pylorus.

The jejunum and ileum were approximately 250 centimeters in length and 1 centimeter in diameter. The musculature of the intestinal tract was thin, allowing the ingesta to influence the color of the various segments.

Peyer's patches, six in number, were small elliptical areas of lymphoid tissue about five millimeters by ten millimeters. They were evenly spaced throughout the small intestine and were plainly visible from the external surface of the gut.

The sacculus rotundus was a lymphoid sac-like structure approximately two centimeters in diameter and three centimeters in length at the terminal end of the ileum connecting it to the cecum.

The histological structure of Peyer's patches, sacculus rotundus, and the appendix was similar. The lymph nodules were covered by simple columnar epithelium. The mucosa formed "tree-like" structures over the lumen surface of the nodules.

The cecum was large, being approximately 45 centimeters in length and 1.2 to 3.2 centimeters in diameter. It occupied most of the abdominal floor. A spiral groove on its surface indicated the location of a spiral leaf which extended into the lumen about seven millimeters. The leaf was composed of the mucosa, submucosa and the internal muscle layer of the muscularis externa. The intestinal glands were relatively sparse in the cecum.

The appendix was approximately 15 centimeters in length and 1.2 centimeters in diameter. The structure was similar to the sacculus rotundus.

The large intestine was divided into the cecum, sacculated colon, smooth colon, and rectum. The smooth colon was divided into ascending, transverse and descending parts. The rectum was that part of the large intestine from the pelvic inlet extending caudally to the anus.

The sacculated colon was approximately 38 centimeters in length and 1 to 2.5 centimeters in diameter. Three rows of sacculations extended 11 centimeters from the proximal end of

the sacculated colon. Throughout the remainder of the sacculated colon, one row of sacculations was present. The external layer of the muscularis externa was arranged in longitudinal bands corresponding to the number of rows of sacculations. The gland crypts were deep in the mucosa. Definite longitudinal and circular layers of the muscularis mucosae first appeared 20 centimeters from the origin of this section of the intestine.

The smooth colon was approximately 65 centimeters in length and 1.2 centimeters in diameter.

The rectum was approximately 6 centimeters in length and 1.2 centimeters in diameter.

The mucous glands in the smooth colon and rectum were large and numerous. The muscularis mucosae gradually thickened toward the anus. There was an abrupt change in the type of epithelium of the mucosa at the recto-anal junction from simple columnar to stratified squamous cells.

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APPENDIX

EXPLANATION OF PLATE I

Fig. 1. A transverse section of the esophagus. (100X)

Fig. 2. A longitudinal section of the esophagus. (100X)

PLATE I

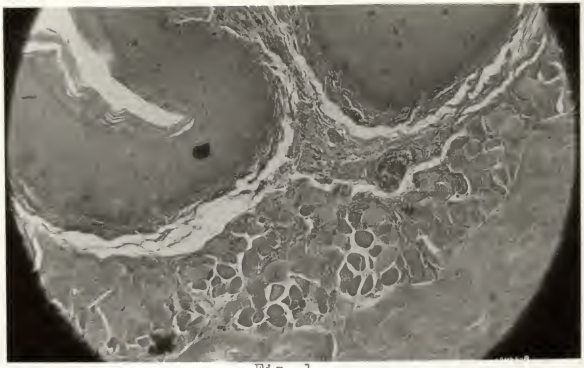

Fig. 1

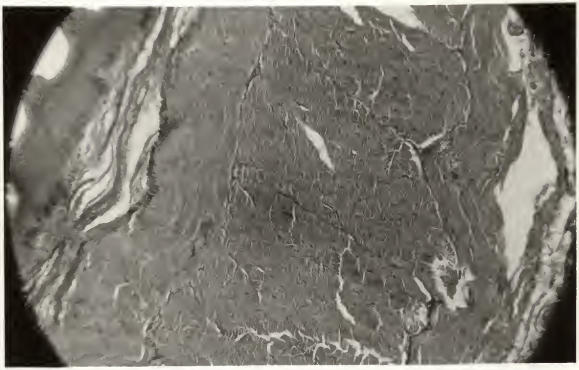

Fig. 2

EXPLANATION OF PLATE II

Fig. 1. Junction of the mucosa of the esophagus with the mucosa of the stomach. (100X)

Fig. 2. Smooth and skeletal muscle fibers at the cardia of the stomach. (100X)

PLATE II

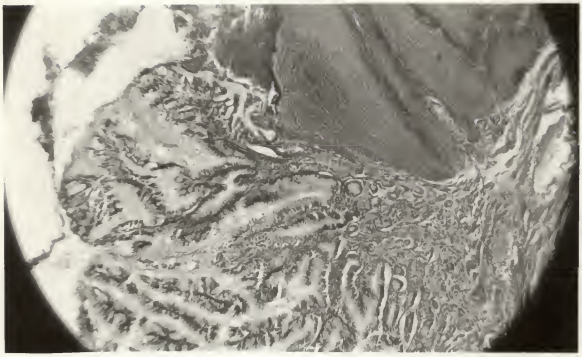

Fig. 1

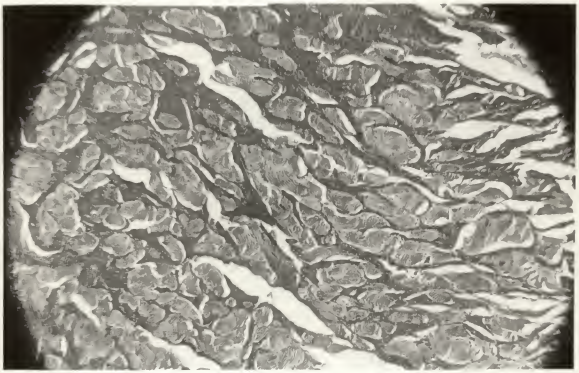

Fig. 2

EXPLANATION OF PLATE III

Fig. 1. Mucosa of the body of the stomach. (100X)

Fig. 2. Gastric glands of the body region of the stomach. (430X)

PLATE III

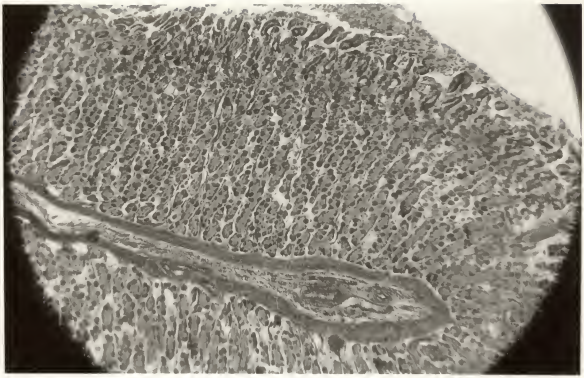

Fig. 1

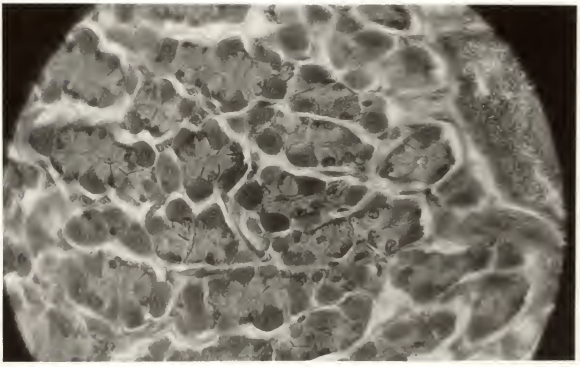

Fig. 2

EXPLANATION OF PLATE IV

Fig. 1. A transverse section of the duodenum, showing the duodenal glands. (100X)

Fig. 2. A transverse section of the duodenum. Note the striated border of the epithelium. Fontana Masson silver stain. (430X)

PLATE IV

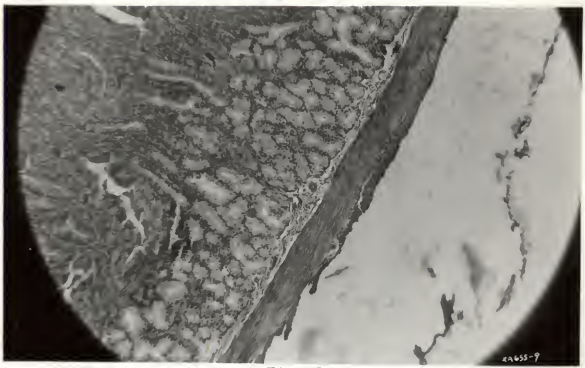

Fig. 1

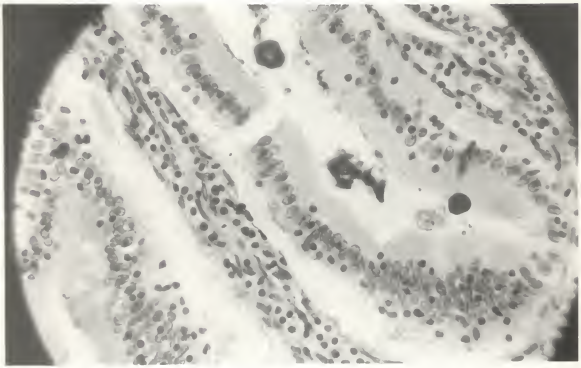

Fig. 2

EXPLANATION OF PLATE V

Fig. 1. A slightly stretched transverse section of the jejunum. (100X)

Fig. 2. An enlargement of a villus in Fig. 1. (430X)

PLATE V

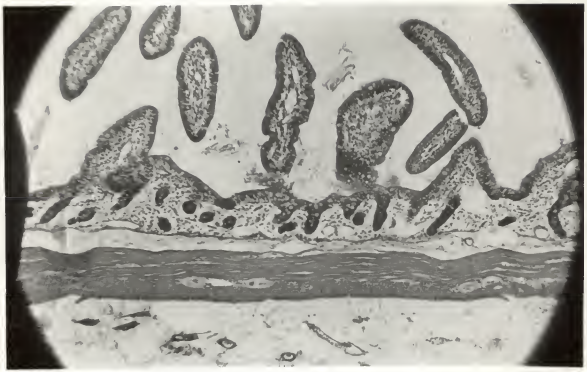

Fig. 1

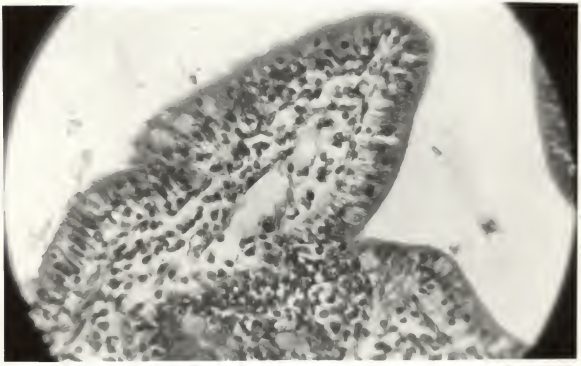

Fig. 2

EXPLANATION OF PLATE VI

Fig. 1. A transverse section of the spiral leaf of the cecum. (100X)

Fig. 2. A transverse section of the mucosa of the cecum. (430X)

PLATE VI

Fig. 1

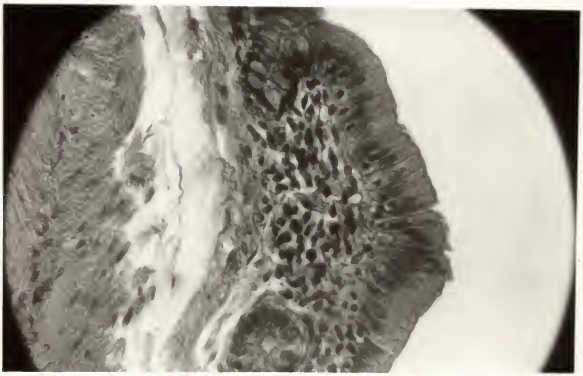

Fig. 2

EXPLANATION OF PLATE VII

Fig. 1. A transverse section of the appendix. (100X)

Fig. 2. A lymph nodule of the sacculus rotundus. (100X)

PLATE VII

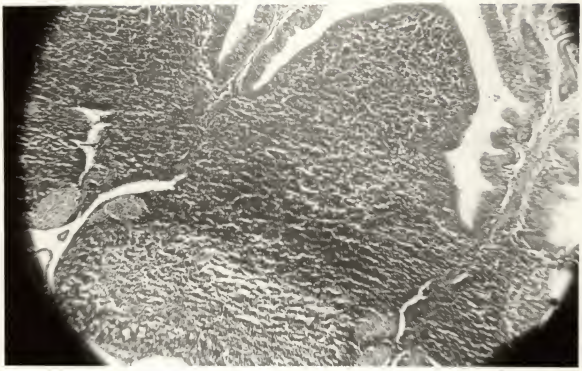

Fig. 1

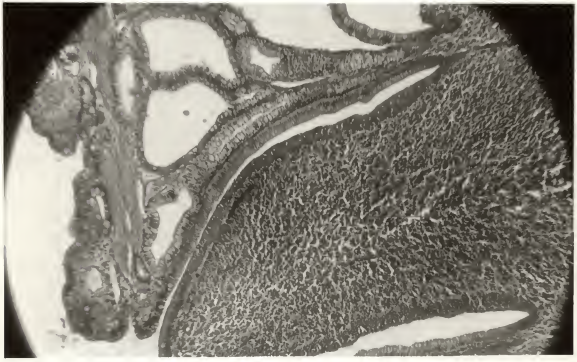

Fig. 2

EXPLANATION OF PLATE VIII

Fig. 1. A transverse section of the duodenum showing argentaffin cells (black granular cells). (430X)

Fig. 2. A transverse section of the sacculated colon. (100X)

PLATE VIII

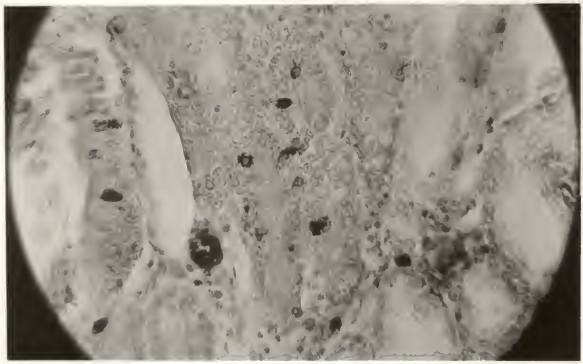

Fig. 1

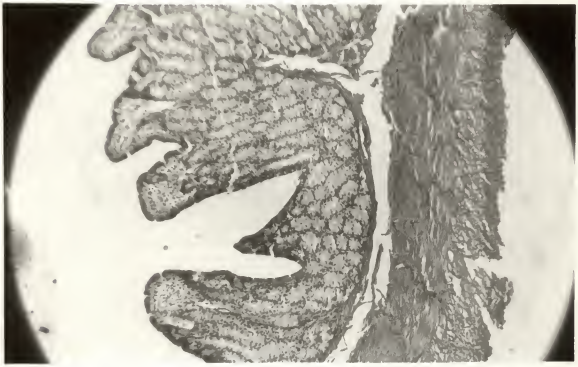

Fig. 2

EXPLANATION OF PLATE IX

Fig. 1. A transverse section of the smooth colon. (100X)

Fig. 2. Junction of the rectoanal mucosa. (100X)

PLATE IX

Fig. 1

Fig. 2

EXPLANATION OF PLATE X

Superficial view of the abdominal cavity. A, Liver; B, stomach; C, duodenum; D, jejunum; E, cecum; F, sacculated colon; G, uterus.

PLATE X

EXPLANATION OF PLATE XI

Deep view of the abdominal cavity. A, Liver; B, stomach; C, duodenum; D, jejunum; E, cecum; F, sacculated colon; G, smooth colon; H, uterus; I, appendix; J, sacculus rotundus.

PLATE XI

EXPLANATION OF PLATE XII

Digestive tract of the rabbit. A, Esophagus; B, stomach; C, duodenum; D, jejunum; E, ileum; F, sacculus rotundus; G, cecum; H, sacculated colon; I, smooth colon; J, appendix.

PLATE XII

GROSS AND HISTOLOGICAL STUDIES OF THE DIGESTIVE TRACT OF THE RABBIT

by

KENNETH WINFERD HUFFMAN

D. V. M., Oklahoma State University
of Agriculture and Applied Science, 1953

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

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OF AGRICULTURE AND APPLIED SCIENCE

1958

Extensive research on diseases of the rabbit has been done because it has been an important laboratory animal for many years. Research on the gross and microscopic anatomy of the digestive tract has been of special areas. This study was undertaken because of the need for a general gross and a more complete histological description of the digestive tract of the rabbit.

Tissue specimens were taken from segments of the digestive tract from the esophagus to the rectum inclusive. The specimens were fixed, embedded, sectioned and stained. Gross examinations were made on fresh and embalmed specimens.

Gross examinations revealed the stomach of the rabbit to be comparable in size to that of the dog. The rabbit had an exceedingly thin walled digestive tube caudal to the stomach thus allowing the ingesta to influence the color of the fresh intestinal specimens. The cecum was large, covering most of the abdominal floor. A spiral groove was present on the external surface of the cecum from the base to the appendix. This groove indicated the location of a spiral leaf which extended into the lumen of the cecum.

Several lymphoid areas peculiar to the rabbit were present in the intestine. Peyer's patches were well defined elliptical areas visible from the external surface of the small intestine. The sacculus rotundus was a lymphoid sac-like structure between the ileum and cecum. The appendix was a large cylindrical lymphoid structure similar in external appearance to the Peyer's patches and the sacculus rotundus.

The general histological structure of the digestive tract of the rabbit was similar to other animals commonly studied but a few special features were present. The esophagus of the rabbit contained no glands except at the esophageal-cardiac junction. The muscularis externa was striated muscle and was arranged in an inner longitudinal layer, a middle circular layer and an outer longitudinal layer. The gastric glands of the stomach were present in all of the mucosa except for a few millimeters at the cardia and a short distance proximal to the pylorus. The duodenal glands contained both mucous and serous cells.

The lymph nodules of the Peyer's patches, the sacculus rotundus and the appendix were covered with simple columnar epithelium which was continuous with the "tree-like" structures between and over the nodules.

The muscularis mucosae appeared to be arranged in longitudinal and circular layers in the caudal half (18 centimeters) of the sacculated colon and these layers continued to the anus.