The intestine, consisting of the small and large intestines, is a very long tubular organ. The small intestine is divided, from oral to anal, duodenum, jejunum and ileum.

The duodenum continues with stomach at pylorus and is about 25 cm long and largely retroperitoneal, being closely attached to the dorsal wall of the abdomen. The jejunum and ileum are together about 7 m long and are suspended from the dorsal abdominal wall by the mesentery and freely movable.

The large intestine is also long and subdivided, from oral to anal, caecum, colon ascendens, colon transversum, colon descendens, colon sigmoideum and rectum, which opens at anus to outside. Except for the colon transversum, which is suspended by the mesocolon transversum from the dorsal wall of the abdomen, the rest segments of the large intestine are retroperitoneal and fixed to the dorsal wall of the abdomen.
• The wall of the digestive tube consists of concentrically arranged several layers; they are from inside to outside ① tunica mucosa, ② tela submucosa, ③ tunica muscularis and ④ tunica serosa.

• The tunica mucosa, mucous membrane, enclosing the lumen of the tube, consists of an epithelium, underlying loose connective tissue, lamina propria, and thin smooth muscle layer, lamina muscularis mucosae.

• The mucous membrane is enclosed by a layer of the loose connective tissue of coarse collagen fibers, tela submucosa, and then a thick smooth muscle layers, tunica muscularis, consisting of the inner circularly and outer longitudinally oriented smooth muscle layers. The outermost layer is the tunica serosa, peritoneum, which forms mesenterium at the posterior midline of the tube and connects the tube to the posterior midline of the posterior abdominal wall.
The pars pylorica of the stomach continues into the intestine, which is as a whole very long tubular organ. Digestion of food that is begun in the stomach is continued in the small intestine by enzymes produced in its mucosa and assisted by emulsifying agents and enzymes secreted into the lumen by the liver and pancreas. Little or no absorption of the nutrients takes place in the stomach. This is the principal function of the small intestine, which is 4 to 7 m in length and arbitrarily divided into three successive segments: the duodenum, the jejunum, and the ileum.

The luminal surface of the small intestine is greatly increased by the formation of grossly visible circular folds, plicae circulares, and by countless finger-like processes of microscopic dimensions, the intestinal villi.

The plicae circulares are permanent crescent folds involving both the mucosa and submucosa and extending half to two thirds of the way around the circumference of the lumen. They are very predominant in the duodenum and proximal half of the jejunum but in the distal half of the jejunum they gradually diminish in size and number and are seldom found beyond the middle of the ileum.

The villi are outgrowths of the mucous membrane and have a length of 0.5 to 1.5 mm. They cover the entire surface of the mucosa and give it a characteristic velvety appearance. In the duodenum they are broad, leaf-like structures arranged with their long dimension in the transverse direction. In the ileum they gradually become more finger-like.

Between the bases of the villi, there are the openings of innumerable intestinal glands or crypts of Lieberkühn. These are simple tubes, 320 to 450μm long, which penetrate the thickness of the mucous membrane and reach almost to the lamina muscularis mucosae. In the bottom of the glands of
Lieberkühn occur regularly the cells of Paneth. They are pyramidal or columnar in shape and contain numerous coarse apical granules stained deeply red with eosin.

- The epithelium covering the free surface of the mucous membrane consists of simple columnar cells. Three types of cells are distinguished: columnar absorptive cells, goblet cells and enteroendocrine cells.

- The absorptive cells are columnar or prismatic and of 20 to 26 μm in height with a centrally situated, vertically elongated nucleus. The luminal surface is specialized to form a striated border, microvilli. The bases of the cells rest upon a thin but conspicuous basement membrane, which is firmly attached to the connective tissue fibers of the lamina propria.

- The goblet cells are mucus-secreting unicellular glands scattered irregularly among the cylindrical absorptive cells.

- The enteroendocrine cells are visualized by the fixatives containing potassium dichromate as yellowish orange cells locating at the bottom of the intestinal glands or crypts of Lieberkühn. These reactions are similar to those of the adrenal medulla. Some of these cells precipitate silver salts in the absence of a reducing agent and are called argentaffin cells. They occur as rather widely scattered individual cells and appear to be minor component of the epithelium, but their number in the human intestine is estimated to be innumerable.

- The epithelium covering the villi continues into the glands. The wall of the crypts is lined with low columnar epithelial cells with basophil cytoplasm and round nuclei in their basal portion. Among them there are numerous mitotic figures. Here regeneration takes place, and the new cells moving upward differentiate into goblet cells and into the columnar cells with striated borders.

- The epithelial lining of the intestinal tract is continuously being renewed by proliferation of cells in the crypts, their movement up onto the villi, and exfoliation of effete or dying cells at the villus tips. This process of renewal is referred to as the cell turnover of the epithelium and its duration is the cell turnover time.
This figure shows a longitudinal section through the pylorus; the right half of the figure is the pars pylorica of the stomach and the left half, the duodenum. The abrupt transition is indicated by an arrow. In the pars pylorica the mighty musculature, transversely sectioned, in the tela submucosa is the M. sphincter pylori. In the area of the pars pylorica no gland is seen in the tela submucosa whereas in the duodenum there are the duodenal glands occupying the tela submucosa.
• Higher magnification of 11-02.

In the right half, in the pars pylorica, gastric pits and pyloric glands are seen; and in the left half, in the duodenum, intestinal villi and intestinal glands in the mucosa and duodenal glands in the submucosa are seen.

• The abrupt transition from the pars pylorica into the duodenum is indicated by three arrows.
• This specimen was taken from a man who had committed suicide by drinking formalin. According to this peculiar condition the mucous membrane is unusually well preserved.

• In this figure three plicae circulares are seen, on the surface of that countless intestinal villi protrude into the lumen. In the tela submucosa, beneath the lamina muscularis mucosae, numerous groups of the duodenal glands are seen.

• About the tunica muscularis, the musculature of the inner circular layer shows considerable shrinkage.
This figure shows two longitudinally sectioned intestinal villi. The surface covering epithelial cells, irregularly intermingled with the goblet cells, and the connective tissue core containing numerous free cells are perfectly preserved. In the axial portion of each villus the central lacteal is perceived.
• Higher magnification of the left villus in 11-05. The tall columnar epithelial cells, with distinct striated border on the free surface, attach to the basement membrane firmly with their basal surface. The basal portion of the epithelial cells becomes slender so that a narrow gap is evident between each cell. Directly beneath the basement membrane there are numerous capillaries. At bottom center of this figure a portion of the central lacteal is seen. In the connective tissue, lamina propria, there are numerous free cells.
• This is a transverse section of an intestinal villus. The epithelial cells provide the evident striated border and their basal portion becomes slender so that a narrow gap between each cells is conspicuous. Their basal surface attaches firmly to the basement membrane, directly beneath of which there are numerous capillaries containing erythrocytes. At center a transverse section of the central lacteal is seen. In the lamina propria there are numerous free cells.
This is to show the intestinal glands in the lamina propria and duodenal glands in the tela submucosa. The intestinal glands or crypts of Lieberkühn are simple tube beginning at the bases of the hollow between two villi and penetrating into the lamina propria. They consist of simple columnar epithelial cells with basophilic cytoplasm. In the bottom of the glands there are conspicuous cells containing numerous coarse granules staining deep red with eosin, the Paneth cells.

The duodenal glands locate in the submucosa and consist of richly branched and coiled tubules arranged in lobules 0.5 to 1.0 mm in diameter. The ducts penetrate the lamina muscularis mucosae to open into a crypt of Lieberkühn. The terminal portions consist of lightly pink staining cuboidal or columnar epithelial cells enclosing a wide lumen, so that the glands appear very alike with mucous glands. The secretion is a clear, viscous, and distinctly alkaline fluid. Its principal function is thought to protect the duodenal mucosa against the erosive effects of the acid gastric juice.
• In the middle of this figure traverses the lamina muscularis mucosae; upper to it densely packed are intestinal glands, at the bottom of that the Paneth cells containing deeply red stained coarse granules are evident; lower to it, tela submucosa is filled by the duodenal glands. At middle right two ducts of the duodenal glands penetrate the lamina muscularis mucosae.
This is a high power magnification of the basal portion of an intestinal gland. The high columnar epithelial cells enclose the narrow lumen; long elliptic nuclei, locating in the basal portion, arrange perpendicular to the basement membrane. The cytoplasm shows distinct basophilia. Four Paneth cells containing red stained coarse granules are evident. Along the outer surface of the gland five enteroendocrine cells are recognized (arrows). Their granules are fine, locate basal than the nucleus and show the orange hue. At top center a mitotic figure is seen.
• In this figure, transverse sections of the bottom of the intestinal gland are densely packed. The coarse granules of the Paneth cells are conspicuous. The enteroendocrine cells are also evidently perceived. The space separating each gland is filled by free cells (lamina propria).
• This is the same specimen as 11-04. The duodenal glands locate in the tela submucosa and consist of richly branched and coiled tubules arranged in lobules 0.5 to 1.0 mm in diameter. The ducts penetrate the lamina muscularis mucosae to open into a crypt of Lieberkühn. The terminal portions consist of lightly pink staining cuboidal or columnar epithelial cells enclosing a wide lumen, so that the glands appear very alike with mucous glands. In this figure at top center is a duct which branches repeatedly constituting the whole lobule.
• This is a transverse section of the macaque duodenum through the papilla duodeni major.

• At lower middle, the ductus choledocus causes an elevation on the back wall of the pars descendens of the duodenum, that is papilla duodeni major (arrow) and the ductus choledocus opens at the top of its undermost portion. In this figure opening of this duct is clearly seen (arrow).
• This is a whole view of the transverse section of human jejunum. This specimen was taken from a man who had committed suicide by drinking formalin. According to this peculiar condition the mucous membrane is unusually well preserved.

• The numerous plicae circulares protrude highly into the lumen and from their surface innumerable intestinal villi project into the lumen. The free space of the intestinal lumen appears narrow, through which flows the foods, digested by the enzymes and became liquid. During this the nutrients are absorbed via epithelium into the blood.

• At the left side attaches the mesenterium.
• Three plicae circulares containing tela submucosa as a core protrude highly into the lumen. From the surface of them innumerable intestinal villi project into the lumen.

• Tunica muscularis consists of inner circular and outer longitudinal smooth muscle layers. The outermost layer is tunica serosa, that is the peritoneum but hardly perceivable.
• At the lower one fourth traverses the lamina muscularis mucosae, upper to that is the mucous membrane. There are innumerable intestinal villi and intestinal glands.

• The intestinal villi are finger-like outgrowths of the mucous membrane, having the epithelial covering and a core of loose connective tissue, lamina propria, containing numerous capillaries beneath the epithelium and a straight blind lymphatic tubule, central lacteal, at the axial portion. In the lamina propria a lot of free cells are seen.

• Between the bases of the villi there are openings of the intestinal glands or crypts of Lieberkühn. These are simple tubes, which penetrate the thickness of the mucous membrane and reach almost to the lamina muscularis mucosae. At the bottom they contain the Paneth cells.

• At lower right corner there is an infiltration of the lymphocytes.
• At the lower one fourth traverses a connective tissue layer between two thin muscle layers. This is the core of a plica circularis. Upper to this muscle layer three intestinal villi and transverse sections of the intestinal glands are seen, in the bottom of that the Paneth cells containing red stained granules are conspicuous. In the middle locating villus a longitudinally sectioned central lacteal is evident. Around the intestinal glands and in the core of villi a lot of free cells are seen. In the young animals intestinal villi show foliated form.
Higher magnification of the villus locating at center in 11-17. Throughout the whole length of axial portion of this villus penetrates a blind lymphatic tube, the central lacteal, which is attended by a few smooth muscle fibers. Beneath the epithelium a large number of free cells are seen; especially at the tip of the villus groups of the macrophages are evident. Higher magnification of this portion will be shown in 11-19.
• These are macrophages crowding in the lamina propria at the tip of an intestinal villus. Macrophages take in extrinsic alien substances and also intrinsic residues to eliminate from the body. They transform them with enzymes, lysosomes, to harmless substances and keep within the cytoplasm. The macrophages loaded such substances migrate and finally arrive at the tip of the intestinal villi. At the tips of the intestinal villi exfoliation of the effete and dying epithelial cells takes place continuously. With such exfoliation above macrophages are also dropped down into the intestinal cavity and eliminated as a part of feces.
• In this figure macrophages are large and contain much dark brownish substance, some of them contain even erythrocytes and leucocytes.
This figure shows the intestinal glands and tela submucosa of monkey jejunum. The intestinal glands consist of tall columnar cells enclosing a narrow lumen. Among the epithelial cells numerous mitotic figures are scattered. At the bottom of the glands the Paneth cells containing red granules are evident. Between the glands there are a lot of free cells. Beneath the bottoms of the glands traverses a thin muscular layer, lamina muscularis mucosae, lower to which is the tela submucosa containing two small plexus of Meissner (arrows). The lowermost layer is a part of tunica muscularis, circular muscle layer.
• This figure shows a whole view of a transverse section of the ileum. At the right side attaches the mesenterium and at the opposite side the aggregated lymphatic nodules are seen. In the ileum diminish the plicae circulares in size and in number; in this figure only four of them are present. The intestinal villi are also less numerous.
• Here two intestinal villi are longitudinally sectioned, both of that the central lacteal penetrates the axial portion. Among the epithelial cells a number of goblet cells are scattered. As the villi are less numerous, the intestinal glands are also scanty so that the lamina propria is wide and contains numerous free cells.
11-23.
Intestinal villus,
longitudinal section.
Monkey,
H-E stain,
x 130.

- Higher magnification of 11-22. The central lacteal is here widely dilated and its lining endothelial cells are evident. In the lamina propria at the tip of the villus numerous large macrophages are seen. Among the covering tall columnar epithelial cells a lot of goblet cells are scattered.
• In the tela submucosa small groups of nerve cells and nerve fibers are scattered. They are called Meissner’s plexus. They control the functions of the mucous membrane, especially the functions of the glands. Here a small group of three nerve cells and nerve fibers in the connective tissue is shown.
In the tunica muscularis, between the circular and the longitudinal muscle layers there are groups of nerve cells which control the motion of the intestine. They are called Auerbach’s plexus. Here a large one consisting of numerous nerve cells is shown.

• The lamina propria of the small intestine contains great number of isolated lymphatic nodules, solitary nodules. This figure shows a solitary lymphatic nodule in the human jejunum consisting of a large germinal center and densely surrounding small lymphocytes.
In the ileum, on the wall opposite to the attachment line of the mesentery, there are aggregated lymphatic nodules, Payer’s patch. They are grossly recognizable as elongated, oval, slightly thickened areas, 12 to 20 mm long and 8 to 12 mm wide.

This figure shows a longitudinal section of aggregated lymphatic nodules. The surface epithelium is almost entirely destroyed by the post mortem autolysis, whereas the aggregated nodules are relatively well preserved.
• This is a higher magnification of a part of 11-27. Two nodules have each a large germinal center. The surrounding infiltration of small lymphocytes is limited within the lamina propria. Beneath the nodules numerous lymphatics are perceived as fissures. Surface epithelium is almost entirely destroyed.
This figure shows the longitudinal section of the lower lip of the ileocaecal valve; the upper side is the ileum and the lower, cecum. On the upper side, numerous intestinal villi cover the surface, whereas on the lower side none of them are seen and the surface is smooth. In this figure, the mucous membrane of the ileum covering the upper surface of the valve turns beyond the tip of the valve to the lower surface and abruptly shifts to that of the caecum. The muscle layers of each part are separated in the left half of this figure and unite together in the right half.
The large intestine includes several successive segments: the caecum, the ascending, transverse, and descending colon, the sigmoid colon and the rectum which opens at the anus to the outside. At the junction of the caecum and the ascending colon, the ileum joins it on its medial side and the orifice between the two is closed by the ileocaecal valve. Projecting from the caecum, posteromedial to the ileocaecal valve is the vermiform appendix.
The appendix is a blindly ending tubular evagination of the caecum. Its wall is thickened by an extensive development of lymphatic tissue, which forms an continuous layer with many large and small lymphatic nodules. The small lumen often contains masses of dead cells and detritus. The lymphatic tissue of the appendix is similar to that of the tonsils and often shows chronic inflammatory changes.

Here is shown the transverse section of a human appendix.
The mucous membrane of the large intestine does not form folds nor villi so that it has a smooth surface, which is lined by simple columnar epithelium with a thin striated border.

The glands of Lieberkühn are straight tubules and their length are larger than in the small intestine. They differ from the glands in the small intestine in their greater abundance of goblet cells. At the bottom of the crypts are usually proliferating, undifferentiated epithelial cells and occasionally enterochromaffin cells. No Paneth’s cells occur in the large intestine.

The structure of the lamina propria is essentially the same as in the small intestine; eosinophil leucocytes are abundant.

The tunica muscularis is well developed and consists of inner circular and outer longitudinal layers. The external longitudinal layer differs from the corresponding coat of the small intestine in that, longitudinally oriented muscle fibers are localized in three thick bands to form the teniae colli.

This figure shows the general features of the large intestine, colon transversum. At top middle tenia mesenterica is evident. But in monkey no omentum majus is present, so that differentiation of the tenia omentalis and tenia libera is unable. The tela submucosa is wide and consists of coarse collagen fibers.
The lowermost edge is the lamina muscularis mucosae consisting of the smooth muscle fibers. Above this the field is occupied by the crypts of Lieberkühn, densely parallel arranged one another and perpendicular to the lamina muscularis mucosae. Each crypt is lined by tall columnar epithelial cells, intermingled by a lot of goblet cells. The lamina propria is filled by innumerable free cells.
• At about upper one third of the figure traverses the lamina muscularis mucosae, and lower to this is the tela submucosa, where two small groups of nerve cells, the Meissner’s plexus, are seen (arrows).
At about the lower one third of the figure traverses the lamina muscularis mucosae and upper to this is the mucous membrane. Here the arrangement of the intestinal crypts is not dense and lamina propria between them is wide and loosely filled by free cells. At the bottom of the crypts yellowish orange hue is perceived, caused by the presence of the enterochromaffin cells. Lower to the lamina muscularis mucosae is tela submucosa, where a group of nerve cells, Meissner’s plexus, is evident (arrow).
• This is a higher magnification of 11-34.
• As this specimen was treated with fixative containing the potassium dichromate, the enterochromaffin cells are visualized (arrows). In these cells chromaffin fine granules are found basal to the nucleus. At bottom of this gland a mitotic figure is conspicuous.
The left two thirds of this figure is the mucous membrane of the rectum and the right one third, the skin of the anus. The rectum opens into the anus; the portion of rectum just before the opening is called the anal canal and here shifts abruptly the simple columnar epithelium into the stratified squamous epithelium; here beneath the epithelium appears the meshwork of veins of large caliber, plexus hemoroidalis. The circular muscle layer becomes thick and called M. sphincter ani internus; the longitudinal muscle layer joins with M. levator ani.

The mucous membrane of the anal canal shifts into the skin of anus and begins the cornification of the epithelium and hairs and sebaceous glands appear.

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