

Histology

Small Intestine

It is the portion of the digestive tube which extends from the pyloric orifice to the ileocaecal junction (i.e between stomach & large intestine). The small intestine is the site of terminal food digestion, nutrient absorption & endocrine secretion. The processes of digestion are completed in the small intestine, where the products of digestion are absorbed by cells of the epithelial lining. The small intestine is relatively long (5 meters) & consists of 3 segments: Duodenum, Jejunum and Ileum.

The factors that increase the surface area for absorption are:-

1- Plicae circulares (valves of Kerckring):- are series of permanent folds, consisting of mucosa & submucosa, having a circular or spiral form. The plicae are most developed in ,and consequently a characteristic of, the jejunum. They increase the intestinal surface 3-fold.

2- Intestinal villi:- are 0.5 to 1.5 mm long outgrowths of the mucosa projecting into the lumen of the small intestine. They increase the surface 10-fold.

3- Microvilli of the intestinal absorptive cells:- increase the surface 20-fold. They are visible under light microscope as a striated free border. All the above three factors together, are thus responsible for 600-fold increase in the intestinal surface.

As in other parts of the digestive tube, the wall of the small intestine is made up of 4 layers:-

Mucous membrane:- the surface of the mucous membrane is

thrown up into minute projections called villi.

A **villus** consists of a core of lamina propria covered with epithelium. The C.T. core of each villus contains a lacteal (blind-ended lymphatic capillary), blood capillaries & strands of smooth m. In the duodenum, the villi are leaf-shaped, gradually assuming fingerlike shapes as they reach the ileum.

The intestinal epithelium is simple columnar, composed of intestinal absorptive cells (enterocytes), goblet cells & some enteroendocrine cells. In the ileum there is M-cell. The epithelium of the villi is continuous with that of the **intestinal glands** [or glands (crypts) of Lieberkuhn]. The intestinal glands are simple tubular glands, contain intestinal absorptive cells, goblet cells, Paneth cells, enteroendocrine cells & stem cells. Their secretions enter the lumen of intestine by means of small openings between the villi.

a) The intestinal absorptive cells(enterocytes):- are tall columnar cells, each with an oval nucleus in the basal half of the cell & striated brush border at the apex of each cell. When viewed with E.M., the striated border is seen to be a layer of densely packed microvilli. Each absorptive cell is estimated to have an average 3000 microvilli. Microvilli have the important physiologic function of increasing the area of contact between the intestinal surface & the nutrients. The function of the enterocytes is to absorb the nutrient molecules produced by the digestive process. Disaccharidases & peptidases secreted by absorptive cells & bound to microvilli in the brush border; hydrolyze the disaccharides & dipeptides into monosaccharides & amino acids that are easily absorbed. Lipid digestion occurs mainly as a result of the action of pancreatic lipase and bile. In humans, most of the lipid absorption takes place in the duodenum and upper jejunum. -

b) Goblet cells (unicellular mucous glands):- they are present on the villi & in the glands. They are irregularly scattered among the absorptive cells, and resemble wine glass in shape. Their apical region is distended with mucigen droplets, while the

base of the cell forms a slender stem or stalk. The nucleus tends to be flattened & the surrounding cytoplasm strongly basophilic. These cells produce mucus, whose main function is to protect & lubricate the lining of the intestine. The frequency of goblet cell increases as the contents of the gut become more solid towards the rectum.

c) **Enteroendocrine cells:-** they are small, pyramidal cells & have granules beneath the nucleus. Upon stimulation these cells release their secretory granules by exocytosis, and the hormones may exert paracrine(local) or endocrine(blood-borne) effects. They produce hormones such as secretin, cholecystokinin, gastric inhibitory polypeptide & motilin.

d) **Paneth cells:-** they are pyramidal in shape, with a round or oval nucleus situated near the base & secretory granules in the apical cytoplasm usually stain with acid dyes. They have the cytological characteristics, of cells actively secreting protein. Paneth cells are located at the base of the intestinal glands of the small intestine. Paneth cells produce lysozyme, an antibacterial enzyme whose function is to digest the cell walls of some bacteria & may play a role in controlling the intestinal flora. Lysozyme is present in the eosinophilic secretory granules.

e) **Stem cells (undifferentiated cells):-** are located in the lower half of the intestinal glands. In the small intestine the cells die by apoptosis in the tip of the villi & replaced with new ones formed through mitosis of stem cells (unidirectional cell flow).

M-cell (microfold cells, membranous epithelial cells):- are specialized epithelial cells overlying the lymphoid follicles of Peyer's patches. They are relatively flat cells whose apical surface is thrown into small folds rather than microvilli. These cells are characterized by the presence of numerous basal membrane invaginations that form pits containing many intraepithelial lymphocytes & antigen-presenting cells (macrophage). M cells can endocytose antigens & transport them to the underlying

macrophages & lymphoid cells, which then migrate to the lymph nodes, where immune response to foreign antigens are initiated. M cells represent an important link in the intestinal immunologic system. The basement membrane under M cells is discontinuous, facilitating transit between the lamina propria & M cells.

The lamina propria of the small intestine:- is composed of loose C.T. with blood & lymph vessels, nerve fibers & smooth m cells. The lamina propria constitutes the core of the intestinal villi & fills all the spaces between the glands. The smooth m. cells are responsible for rhythmic movements of the villi, which are important for absorption.

The muscularis mucosae of small intestine:- consists of an inner circular & an outer longitudinal layers of smooth muscle. The inner circular sends bundles up to lamina propria where they are attached to the lacteals.

The lamina propria & the submucosa of the ileum contain aggregates of lymphoid nodules known as Peyer's patches, an important component of the GALT(gut-associated lymphatic tissue). Each patch consists of 10-200 nodules & is visible to the naked eye as an oval area on the antimesentric side of the intestine. There are about 30 patches in the human, most of them in the ileum. Its covering epithelium contains M cells.

2) The submucosa:- contains in the initial portion of the duodenum, clusters of coiled tubular glands that open into the intestinal glands. These are the Brunner's glands. Their cells are of the mucous type, produce alkaline secretions. It acts to protect the duodenal mucous membrane against the effects of the acid gastric juice & to bring the intestinal contents to the optimum pH for pancreatic enzyme action. They also secrete urogastrone (a polypeptide hormone that enhances epithelial cell division & inhibits gastric HCl production).

3) Muscularis externa:- is composed of an inner circular & an outer

longitudinal layers of smooth m. The inner layer participates in the formation of the ileocaecal sphincter. Auerbach's plexus present between the 2 layers.

4) **Serosa:-** covers all of the jejunum & ileum & part of fee duodenum. **Adventitia** covers the remainder of the duodenum.

Large intestine:-

It is a tube about 5 feet (1.6 meters) in length. It extends from the ileo-caecal valve to the anus. It consists of the caecum, colon (ascending, transverse, descending & sigmoid), rectum, anal canal& appendix. It converts undigested material received from the small intestine into feces by removing water & adding mucus. The usual 4 layers are present in the wall of the large intestine. No villi are present in the large intestine .The intestinal glands are deeper (longer) than in the small intestine and characterized by a great abundance of goblet and absorptive cells. The intestinal glands of the large intestine also lack Paneth cells.

Appendix:- is a small, slender, blind diverticulum of the caecum. It has a narrow, stellate or irregular lumen. The villi are absent.

1.Mucosa of the appendix:-

a) **Epithelium:-** is simple columnar containing columnar absorptive. cells & goblet cells.

b) **Lamina propria:-** contains the intestinal glands(shorter & fewer) with some goblet cells, columnar absorptive cells, stem cells & numerous enteroendocrine cells. Lymphatic nodules with germinal centers are very numerous & highly characteristic of the appendix. These nodules originate in the lamina propria, because of their large size, the nodules may extend to the submucosa.

c) **Muscularis mucosae:-** is poorly developed.

2.Submucosa:- is relatively thick & highly vascular.

3.Muscularis externa:- is composed of an inner circular & an outer longitudinal layers of smooth m.

4. Serosa:- completely surrounds the appendix.

Caecum & Colon:-

1-Mucosa:- is thicker than in small intestine.

a) **Epithelium:-** is simple columnar epithelium, containing numerous goblet cells, absorptive cells & occasional enteroendocrine cells.

b) **Lamina propria:-** is similar to that of the small intestine. The intestinal glands are longer & more closely packed, containing many goblet cells, absorptive cells (have irregular short microvilli), stem cells (in the lower third of the gland) also few enteroendocrine cells. They lack Paneth cells.

c) **Muscularis mucosae:-** consists of an inner circular & an outer longitudinal layers of smooth m.

2-Submucosa:- contains blood & lymphatic vessels, nerves & Meissner's plexus. It has no glands.

3-Muscularis externa of the caecum & colon:- is composed of an inner circular & a modified outer longitudinal layer of smooth m. The outer longitudinal layer of the smooth m. is gathered into 3 thick longitudinal bands called taeniae coli. A thin layer of longitudinal smooth m. often exists between the bands. The parasympathetic ganglia of the Auerbach's plexus are present between the muscle layers.

In the living, the taeniae are in a state of partial contraction which causes the intervening portions of the wall to bulge outward, forming sacculations of the wall.

4-Serosa:- covers the transverse & sigmoid colon & caecum; however, the ascending & descending colon are retroperitoneal & the outer layer on their posterior surface is the adventitia. The serosa of colon is characterized by the presence of many

fat-filled outpocketings termed appendices epiploicae.

Rectum:- is usually divided into 2 parts. The upper part (rectum proper) measuring 5-7 inches in length, is structurally similar to colon. The intestinal glands are longer than in colon & are filled with goblet cells. There is no taeniae coli, the outer longitudinal muscle is complete layer (evenly distributed). The lower part is the upper part of the anal canal.

Anal canal:- in the upper part of the anal canal, there are permanent longitudinal folds of the mucous membrane, the rectal columns (anal columns) of Morgagni. The bases (distal ends) of these columns are connected by transverse folds of the mucosa, the anal valves (ano-rectal junction). Above the anal valves, the mucosa is lined by simple columnar epith., becomes stratified squamous non-keratinized distal to the anal valves, and changes to stratified squamous keratinized (epidermis) at the anus. The intestinal glands disappear at the ano-rectal junction (anal valves) & also the muscularis mucosae disappear.

Two prominent venous plexuses are associated with the anal canal, the internal & external hemorrhoidal plexuses located in the submucosa & the lamina propria of the upper & lower part of anal canal respectively. Hemorrhoids develop from chronic dilation of these vessels. In the lower end of the anal canal, there is the prominent circumanal glands(apocrine type of sweat gland) of the perianal skin.

Anal muscularis externa:- is composed of an inner circular & an outer longitudinal layer of smooth m. The inner circular layer forms the internal anal sphincter.

The diameter of the anal canal is controlled by two sphincters:

1. The internal anal sphincter: is composed of smooth muscle and is under

autonomic control.

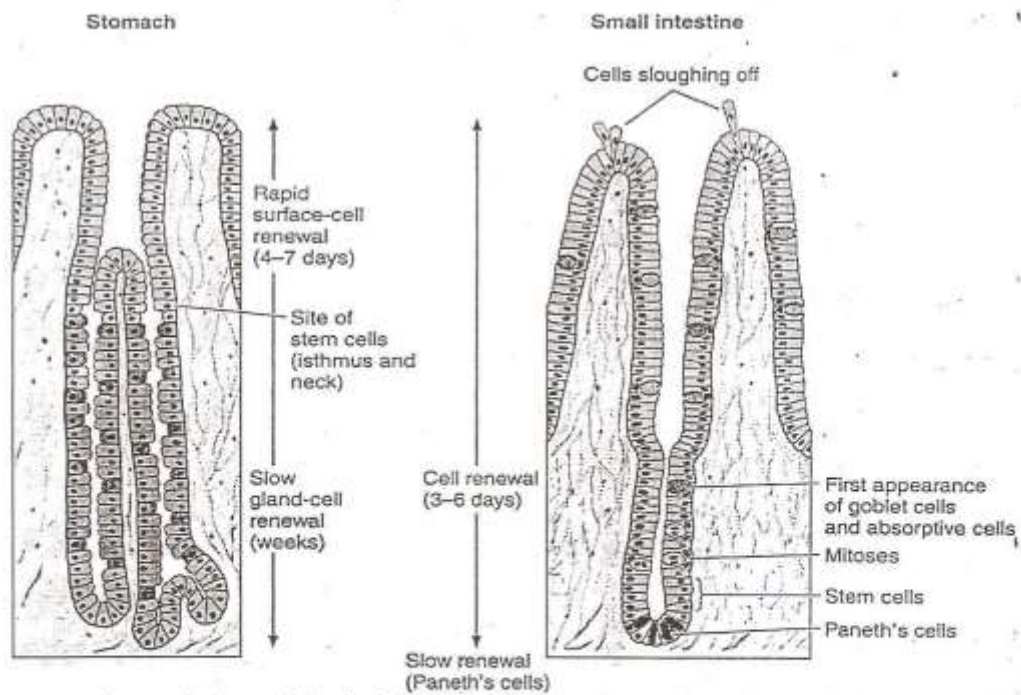
2. The external anal sphincter: is composed of skeletal muscle and is under voluntary control.

Table 15-1. Principal enteroendocrine cells in the gastrointestinal tract.

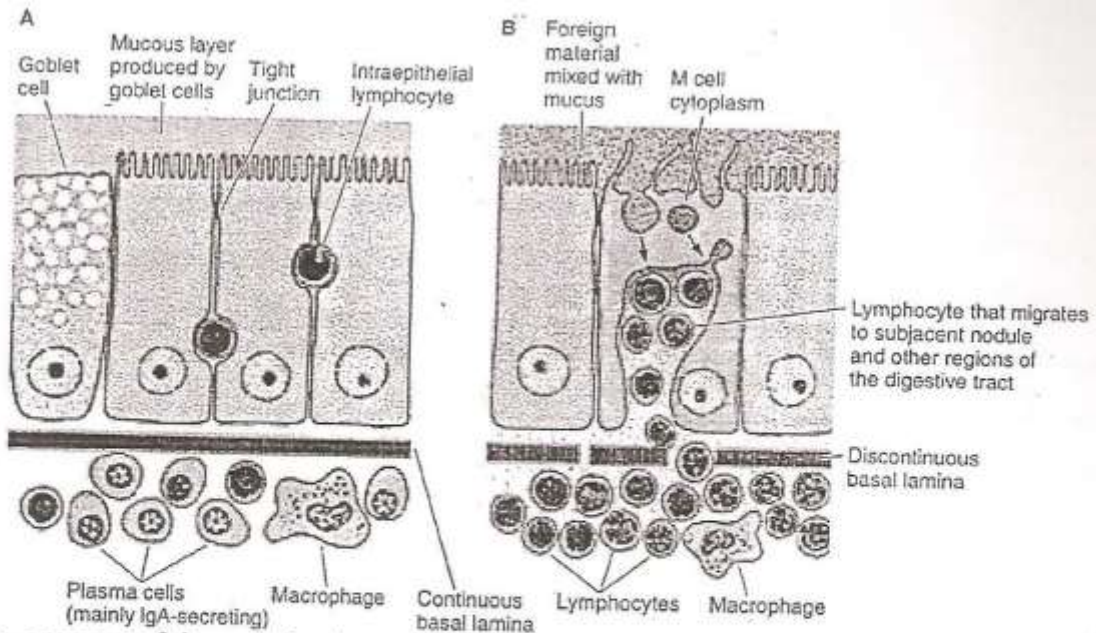
Cell Type and Location	Hormone Produced	Major Action
A—stomach	Glucagon	Hepatic glycogenolysis
G—pylorus	Gastrin	Stimulation of gastric acid secretion
S—small intestine	Secretin	Pancreatic and biliary bicarbonate and water secretion
K—small intestine	Gastric inhibitory polypeptide	Inhibition of gastric acid secretion
L—small intestine	Glucagon-like substance (glicentin)	Hepatic glycogenolysis
I—small intestine	Cholecystokinin	Pancreatic enzyme secretion, gallbladder contraction
D—pylorus, duodenum	Somatostatin	Local inhibition of other endocrine cells
Mo—small intestine	Motilin	Increased gut motility
EC—digestive tract	Serotonin, substance P	Increased gut motility
D ₁ —digestive tract	Vasoactive intestinal polypeptide	Ion and water secretion, increased gut motility



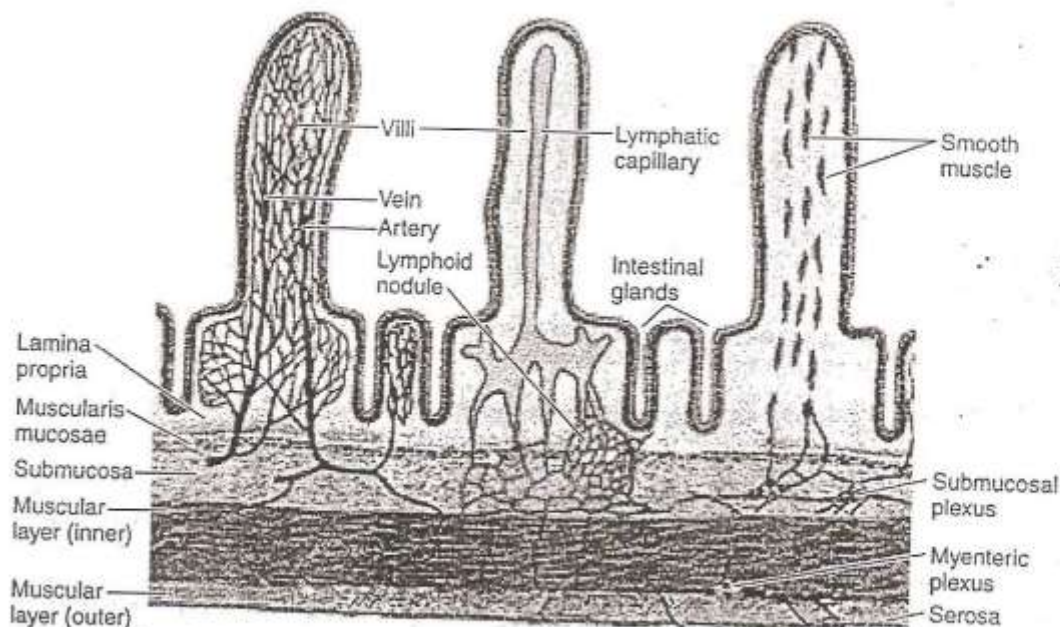
Electron micrograph of an enteroendocrine cell (open type) of the human duodenum. Note the microvilli in its apex. x6900. (Courtesy of AGE Pearse.)



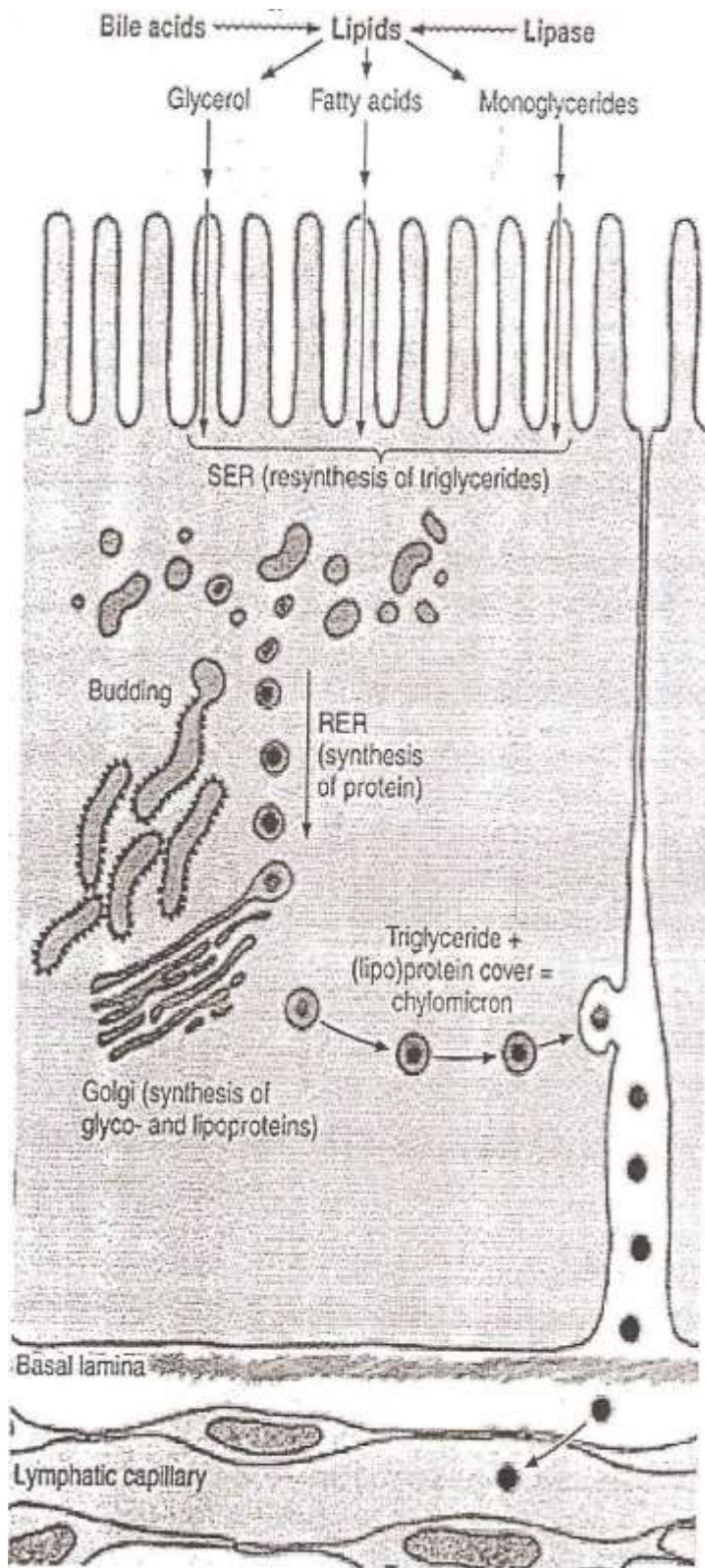
Regeneration of the epithelial lining of the stomach and small intestine. Note differences in the location of stem cells.



Some aspects of immunologic protection of the intestine. A: A condition that is more frequent in the upper tract, such as in the jejunum. There are many IgA-secreting plasma cells, scattered lymphocytes, and some macrophages. Note that the lymphocytes in the epithelial lining are located outside the epithelial cells, and below the tight junctions. B: A condition that is more frequent in the ileum, where aggregates of lymphocytes are located under M cells. The M cells transfer foreign material (microorganisms and macromolecules) to lymphocytes located deep in the cavities of the M cells. Lymphocytes spread the information received from this foreign material to other regions of the digestive tract, and probably to other organs, through blood and lymph.



Blood circulation (left), lymphatic circulation (center), and innervation (right) of the small intestine. The smooth muscle system for contracting the villi is illustrated in the villus on the right.



Lipid absorption in the small intestine. Lipase promotes the hydrolysis of lipids to monoglycerides and fatty acids in the intestinal lumen. These compounds are stabilized in an emulsion by the action of bile acids. The products of hydrolysis cross the microvilli membranes passively and are collected in the cisternae of the smooth endoplasmic reticulum (SER), where they are resynthesized to triglycerides. These triglycerides are surrounded by a thin layer of proteins that form particles called chylomicrons (0.2–1 micrometers in diameter). Chylomicrons are transferred to the Golgi complex and then migrate to the lateral membrane, cross it by a process of membrane fusion (exocytosis), and flow into the extracellular space in the direction of the blood and lymphatic vessels. Most chylomicrons go to the lymph; a few go to the blood vessels. The long-chain lipids (>C12) go mainly to the lymphatic vessels. Fatty acids of fewer than 10–12 carbon atoms are not reesterified to triglycerides but leave the cell directly and enter the blood vessels. RER, rough endoplasmic reticulum. (Based on results of Friedman HI, Cardell RR Jr: Anat Rec 1977;188:77.)