

Digestive System

University of Jordan
Faculty of Medicine
Batch of 2013-2019



Slide Sheet Handout Other

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Slide #: 2

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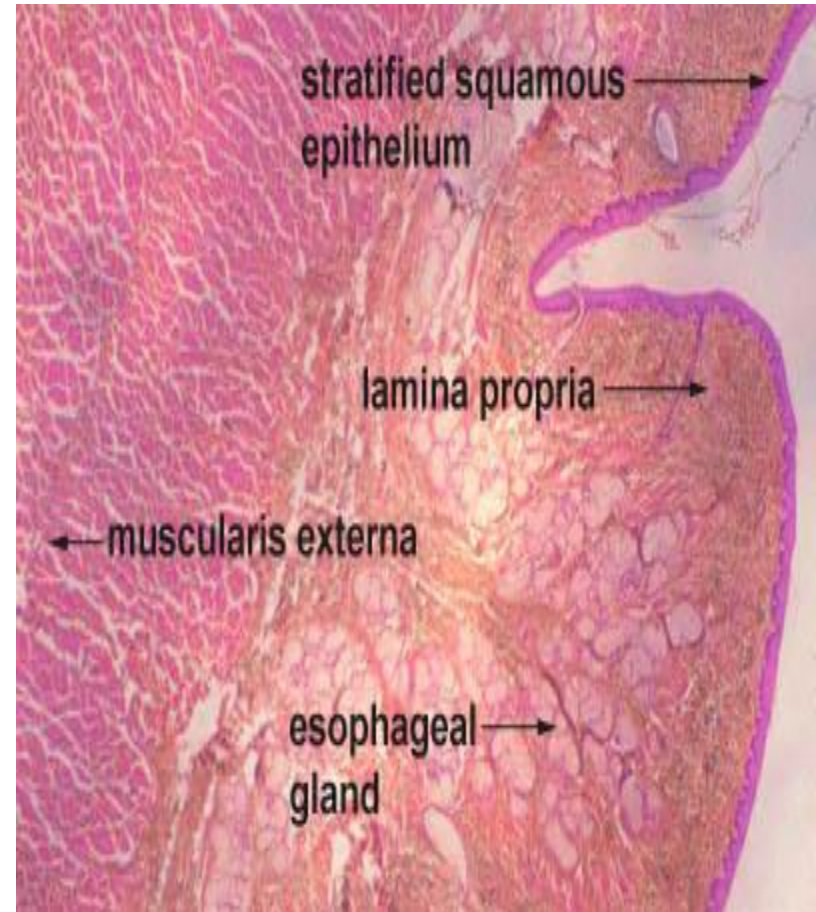
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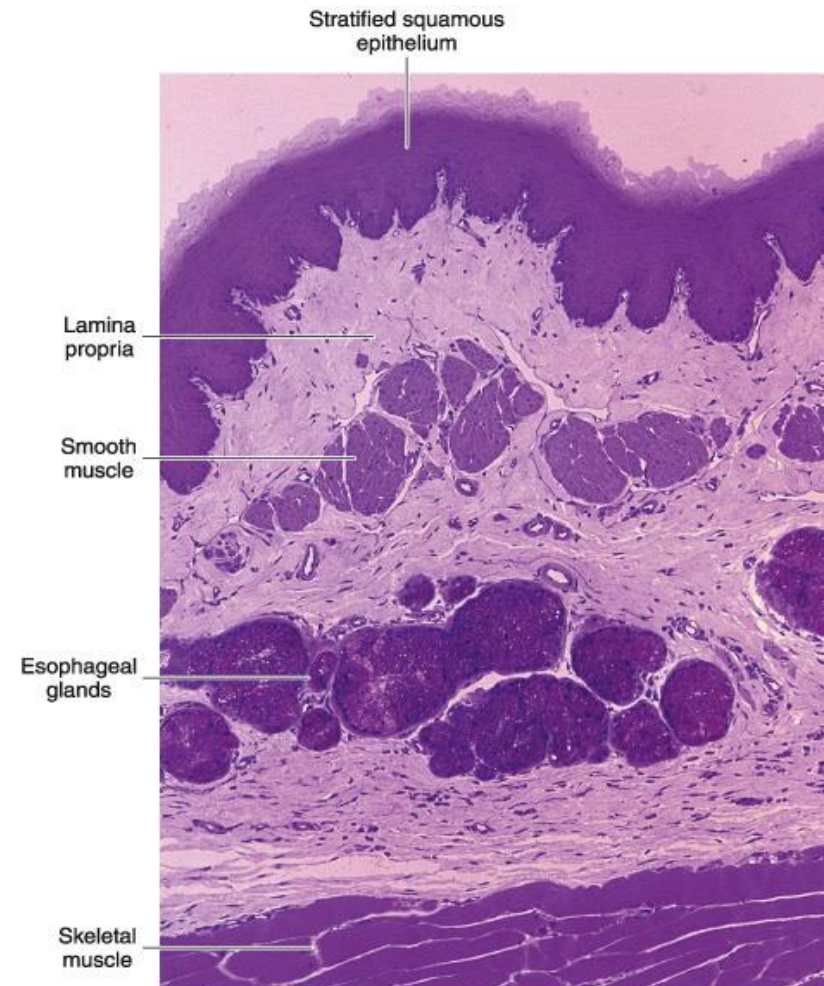
GI Histology 2

Esophagus

- is a muscular tube whose function is to transport foodstuffs from the mouth to the stomach and to prevent the retrograde flow of gastric contents
- Transport is achieved by peristaltic contractions and relaxation of the esophageal sphincters (upper and lower)
- usually controlled by reflexes and by the autonomic nervous system.
- In humans the esophagus is covered by nonkeratinized stratified squamous epithelium
- it has the same layers as the rest of the digestive tract.

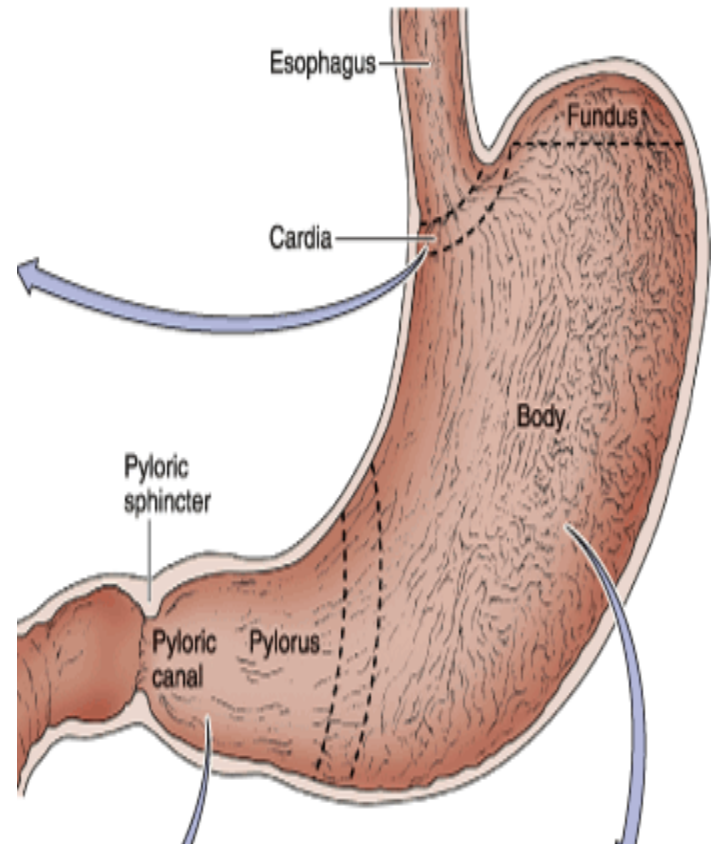


- In the submucosa are groups of small mucus-secreting glands, the **esophageal glands**, whose secretion facilitates the transport of foodstuffs and protects the mucosa
- In the lamina propria of the region near the stomach are groups of glands, the **esophageal cardiac glands**, that also secrete mucus
- At the distal end of the esophagus, the muscular layer consists of only smooth muscle cells that, close to the stomach, form the lower esophageal sphincter
- in the mid portion, a mixture of striated and smooth muscle cells; and at the proximal end, only striated muscle cells.
- Only that portion of the esophagus that is in the peritoneal cavity is covered by serosa.
- The rest is covered by a layer of connective tissue, the adventitia, that blends into the surrounding tissue.



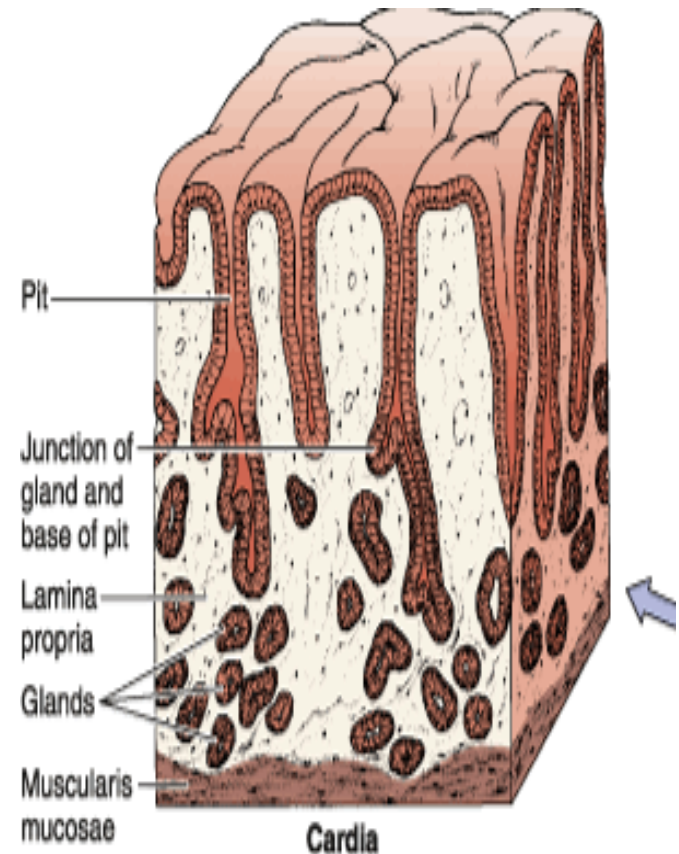
Stomach

- The stomach, like the small intestine, is a mixed exocrine– endocrine organ that digests food and secretes hormones.
- main functions are to continue the digestion of carbohydrates initiated in the mouth, add an acidic fluid to the ingested food, transform it by muscular activity into a viscous mass (**chyme**)
- and promote the initial digestion of proteins with the enzyme **pepsin**
- It also produces a gastric lipase that digests triglycerides with the help of lingual lipase.
- Gross inspection reveals four regions: **cardia**, **fundus**, **body**, and **pylorus**
- the fundus and body are identical in microscopic structure
- The mucosa and submucosa of the undistended stomach lie in longitudinally directed folds known as **rugae**. When the stomach is filled with food, these folds flatten out.



Mucosa

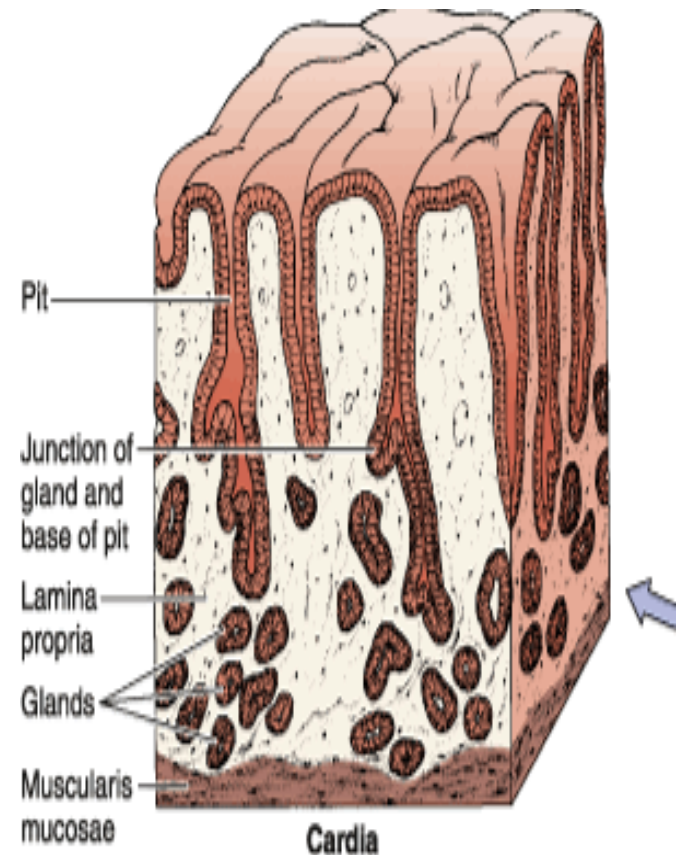
- The gastric mucosa consists of a **surface epithelium** that invaginates to various extents into the lamina propria, forming **gastric pits (can be seen by the magnifying glass)**.
- Emptying into the gastric pits are branched, tubular glands (cardiac, gastric, and pyloric) characteristic of each region of the stomach.
- The **lamina propria** of the stomach is composed of loose connective tissue interspersed with smooth muscle and lymphoid cells.
- Separating the mucosa from the underlying submucosa is a layer of smooth muscle, the **muscularis mucosae**.
- numerous small circular or ovoid invaginations of the epithelial lining are observed. These are the openings of the gastric pits \
- The epithelium covering the surface and lining the pits is a simple columnar epithelium, and all the cells secrete an alkaline mucus



- This mucus consists primarily of water (95%), lipids, and glycoproteins, which, in combination, form a hydrophobic protective gel
- Bicarbonate, secreted by the surface epithelial cells into the mucous gel, forms a pH gradient ranging from 1 at the gastric luminal surface to 7 along the epithelial cell surface
- Surface epithelial cells also form an important line of defense due to their function in mucus production, intracellular tight junctions, and the ionic transporters that maintain intracellular pH and bicarbonate production, important for gel alkalization.

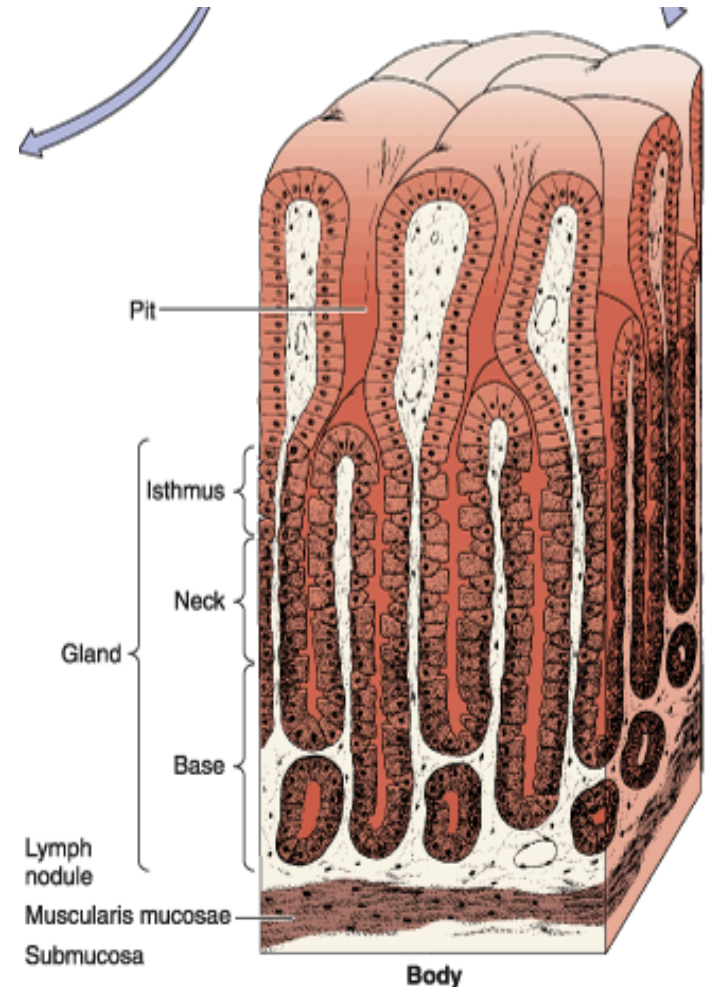
Cardia

- The cardia is a narrow circular band, 1.5–3 cm in width, at the transition between the esophagus and the stomach
- Its mucosa contains simple or branched tubular cardiac glands
- The terminal portions of these glands are frequently coiled, often with large lumens.
- Most of the secretory cells produce mucus and lysozyme (an enzyme that attacks bacterial walls), but a few parietal cells secreting H^+ and Cl^- (which will form HCl in the lumen) can be found
- These glands are similar in structure to the cardiac glands of the terminal portion of the esophagus.



Fundus & Body

- The lamina propria of the fundus and body is filled with branched, tubular **gastric (fundic) glands**, three to seven of which open into the bottom of each gastric pit
- Each gastric gland has three distinct regions: the isthmus, neck, and base
- The distribution of epithelial cells in gastric glands is not uniform
- The isthmus, close to the gastric pit, contains differentiating mucous cells that will migrate and replace superficial mucous cells, undifferentiated **stem cells**, and **oxyntic (parietal) cells**
- the **neck** of the glands consists of stem, mucous neck (different from the mucous cells in the isthmus), and parietal cells
- the **base** of the glands primarily contains parietal and chief (zymogenic) cells
- Enteroendocrine cells are dispersed in the neck and base of the glands.



Stem Cells

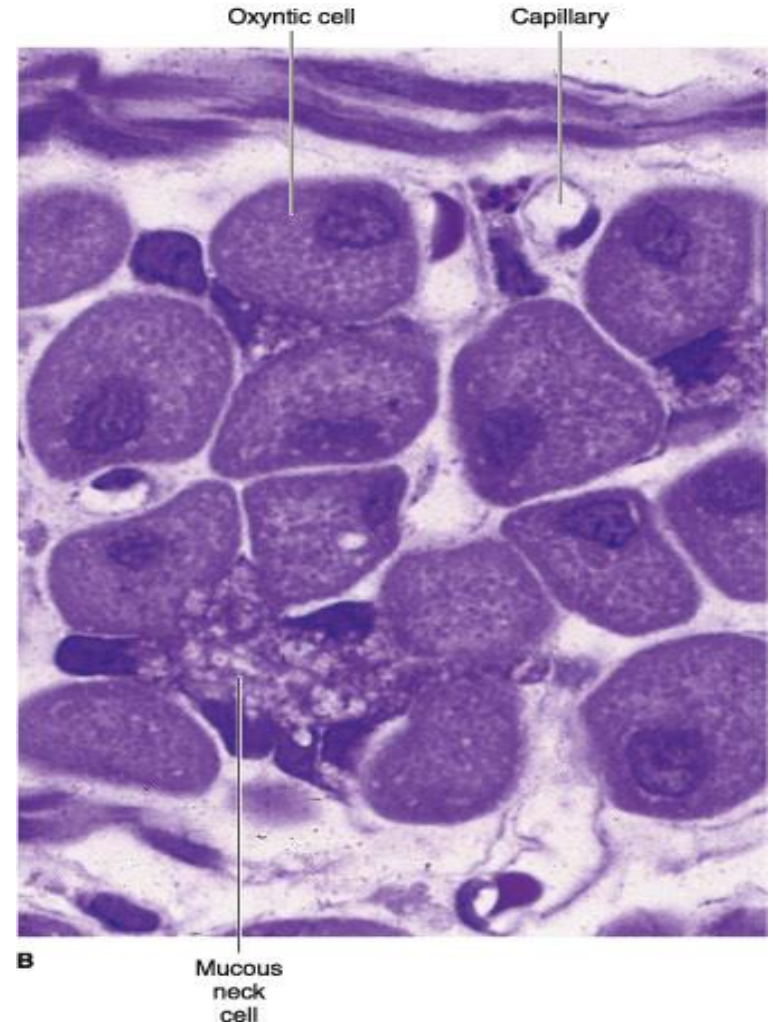
- Found in the isthmus and neck regions but few in number, stem cells are low columnar cells with oval nuclei near the bases of the cells
- These cells have a high rate of mitosis; some of them move upward to replace the pit and surface mucous cells, which have a turnover time of 4–7 days
- Other daughter cells migrate more deeply into the glands and differentiate into mucous neck cells and parietal, chief, and enteroendocrine cells

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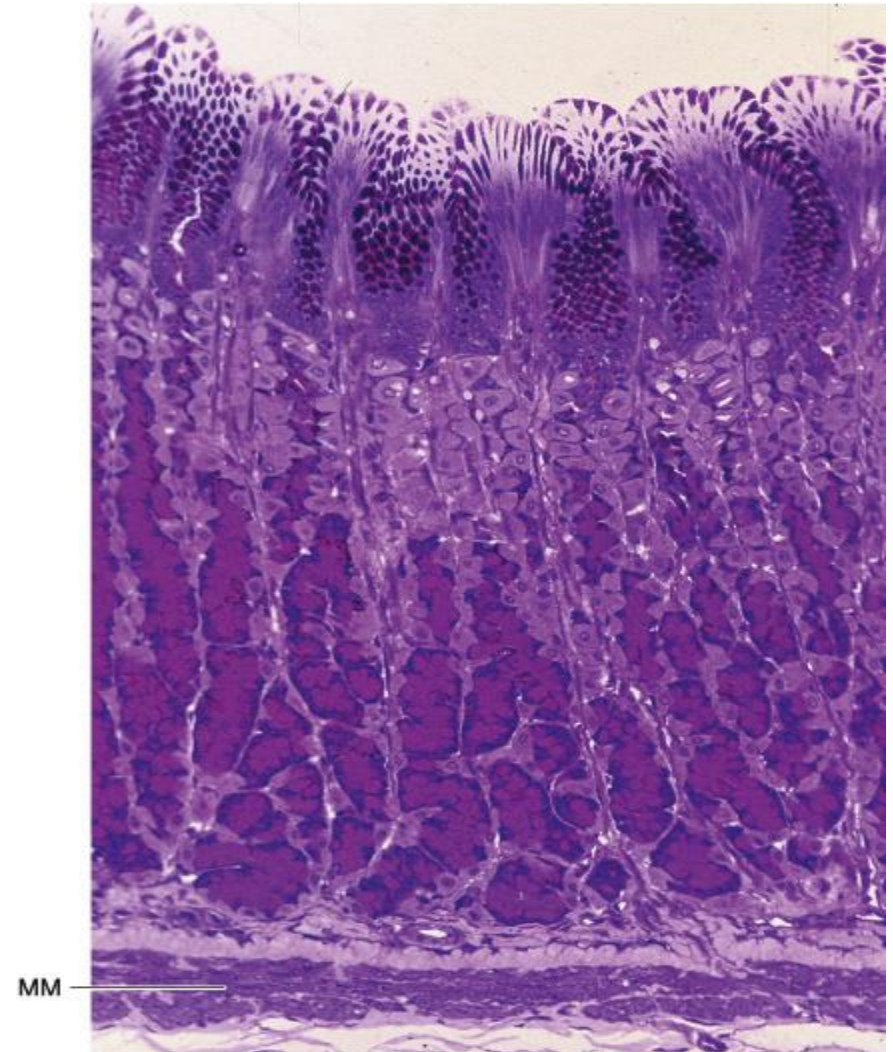
Mucous Neck Cells

- Mucous neck cells are present in clusters or as single cells between parietal cells in the necks of gastric glands
- Their mucus secretion is quite different from that of the surface epithelial mucous cells
- They are irregular in shape, with the nucleus at the base of the cell and the secretory granules near the apical surface.



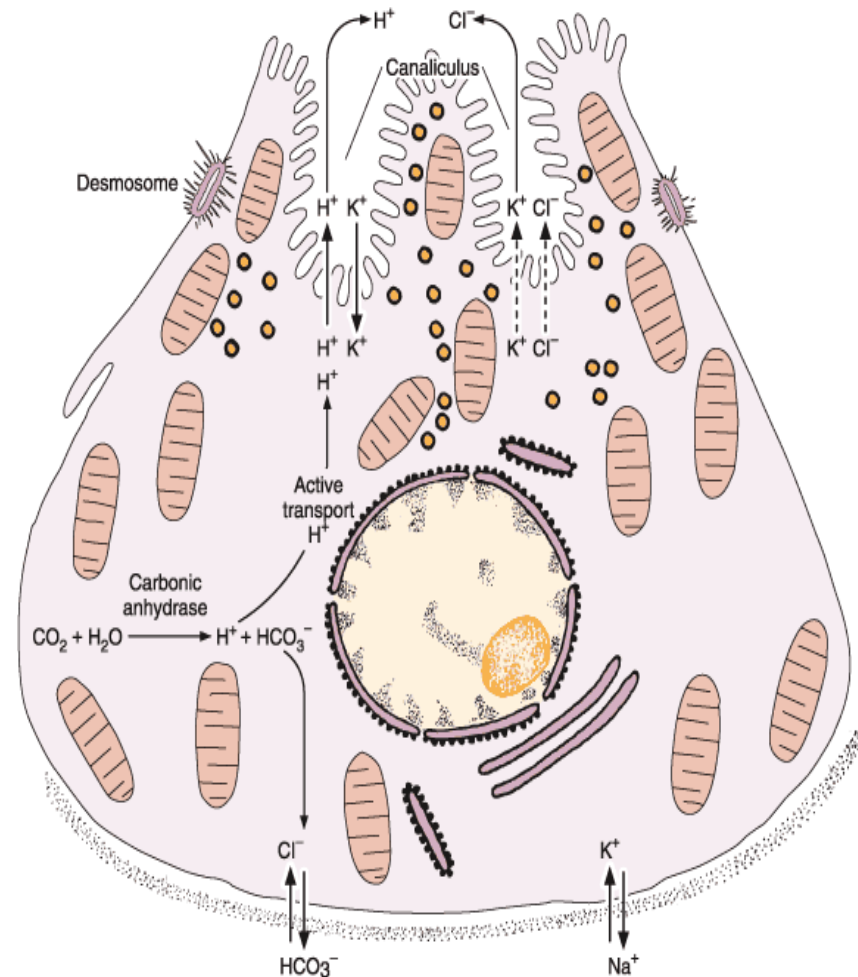
Oxyntic (Parietal) Cells

- Parietal cells are present mainly in the upper half of gastric glands; they are scarce in the base
- They are rounded or pyramidal cells, with one centrally placed spherical nucleus and intensely eosinophilic cytoplasm
- The most striking features of the active secreting cell seen in the electron microscope are an abundance of mitochondria and a deep, circular invagination of the apical plasma membrane, forming the **intracellular canaliculus**
- In the resting cell, a number of tubulovesicular structures can be seen in the apical region just below the plasmalemma, At this stage, the cell has few microvilli
- When stimulated to produce H^+ and Cl^- , tubulovesicles fuse with the cell membrane to form the canaliculus and more microvilli, thus providing a generous increase in the surface of the cell membrane



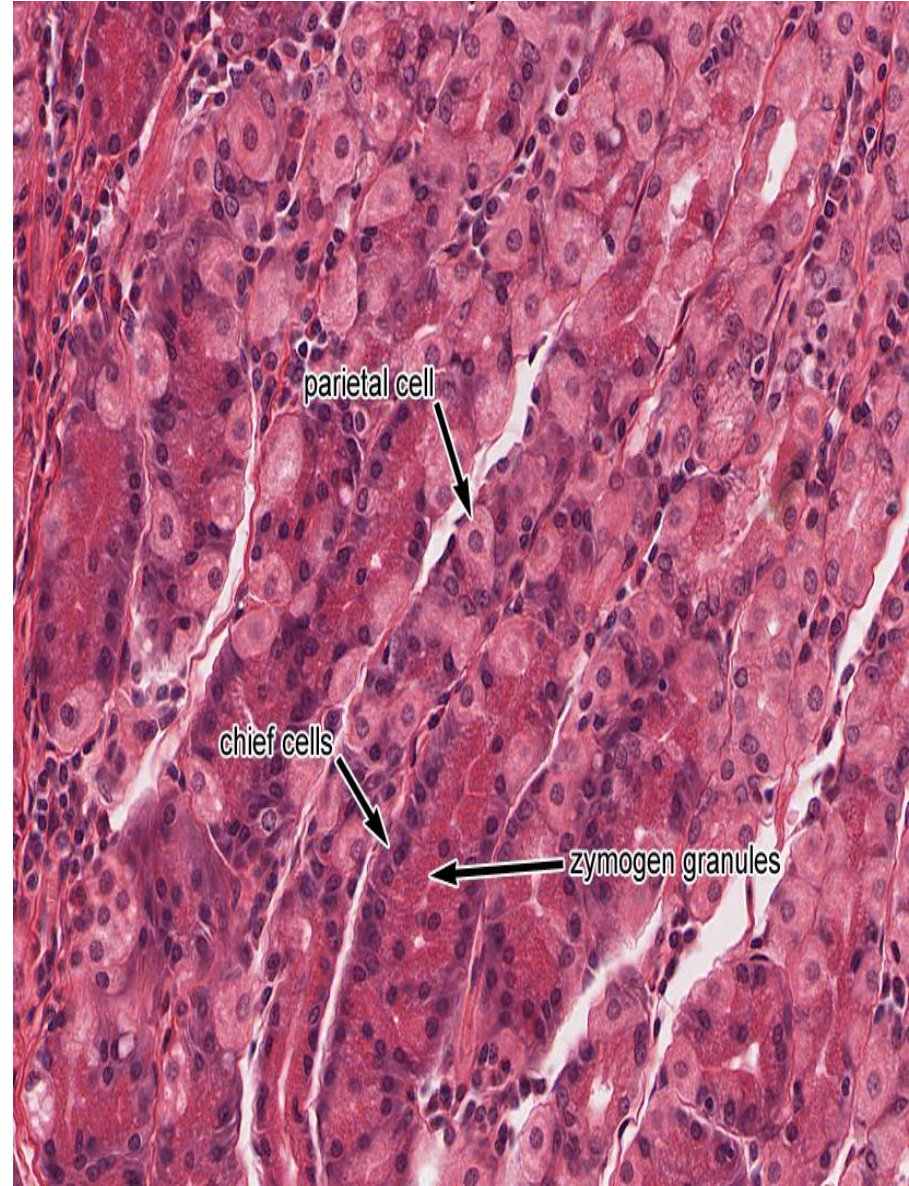
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- Parietal cells secrete hydrochloric acid
- The ion H^+ originates from the dissociation of the H_2CO_3 produced by the action of **carbonic anhydrase**, an enzyme abundant in oxyntic cells
- Once produced, H_2CO_3 dissociates in the cytoplasm into H^+ and HCO_3^-
- The active cell also secretes K^+ and Cl^- in the canaliculus; the K^+ is exchanged for H^+ by the action of the H^+/K^+ pump, while the Cl^- forms HCl .
- The presence of abundant mitochondria in the parietal cells indicates that their metabolic processes, particularly the pumping of H^+/K^+ , are highly energy consuming
- The secretory activity of parietal cells is initiated by various mechanisms. One mechanism is through the cholinergic nerve endings (parasympathetic stimulation).
- Histamine and a polypeptide called **gastrin**, both secreted in the gastric mucosa, act strongly to stimulate the production of hydrochloric acid
- Gastrin also has a trophic effect on the gastric mucosa, stimulating growth.



Chief (Zymogenic) Cells

- Chief cells predominate in the lower region of the tubular glands
- characteristics of protein-synthesizing and -exporting cells
- Their basophilia is due to the abundant rough endoplasmic reticulum. The granules in their cytoplasm contain the inactive enzyme **pepsinogen**
- The precursor pepsinogen is rapidly converted into the highly active proteolytic enzyme **pepsin** after being released into the acid environment of the stomach
- There are seven different pepsins in the human gastric juice, which are aspartate endoproteinases of relatively broad specificity active at pH <5
- In humans, chief cells also produce the enzyme **lipase**.



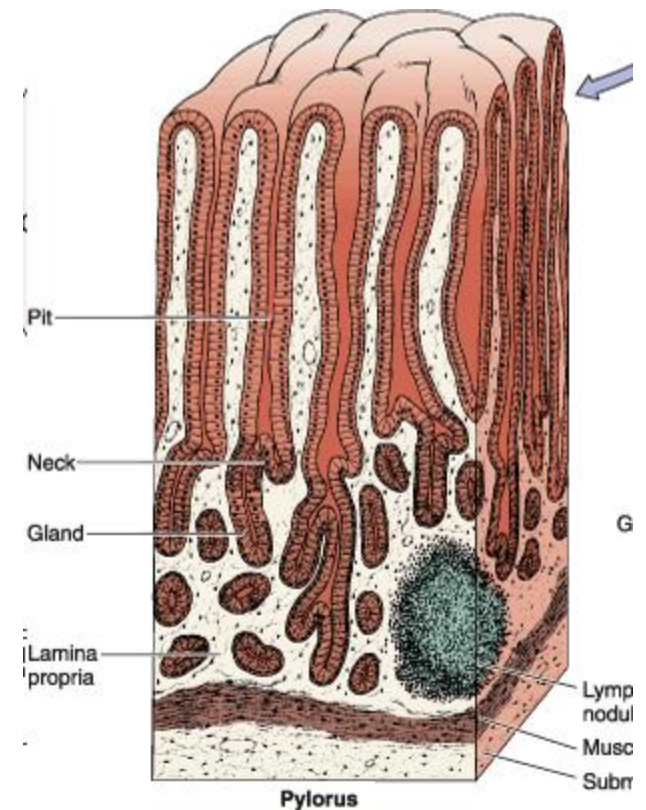
Enteroendocrine Cells

- are found in the neck and bases of gastric glands
- In the fundus of the stomach, **5-hydroxytryptamine** (serotonin) is one of the principal secretory products
- In the stomach the G—pylorus cells produces Gastrin that lead to the Stimulation of gastric acid secretion and Gastric mucosal growth

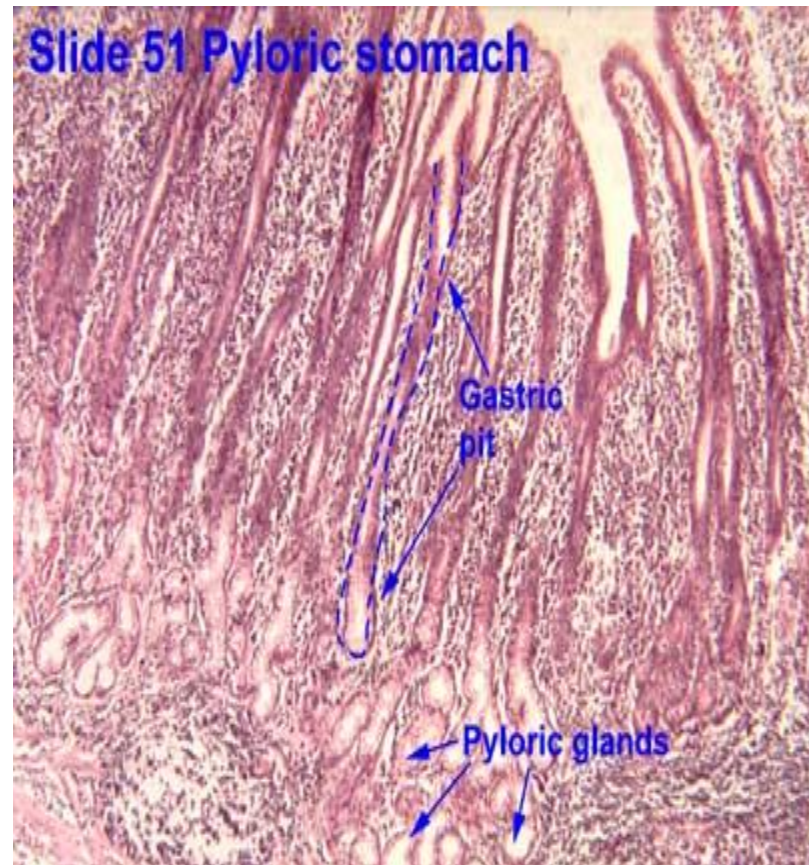


Pylorus

- has deep gastric pits into which the branched, tubular **pyloric glands** open.
- Compared with the glands in the cardiac region, pyloric glands have longer pits and shorter coiled secretory portions
- These glands secrete mucus as well as appreciable amounts of the enzyme lysozyme
- **Gastrin (G) cells** (which release **gastrin**) are enteroendocrine cells intercalated among the mucous cells of pyloric glands

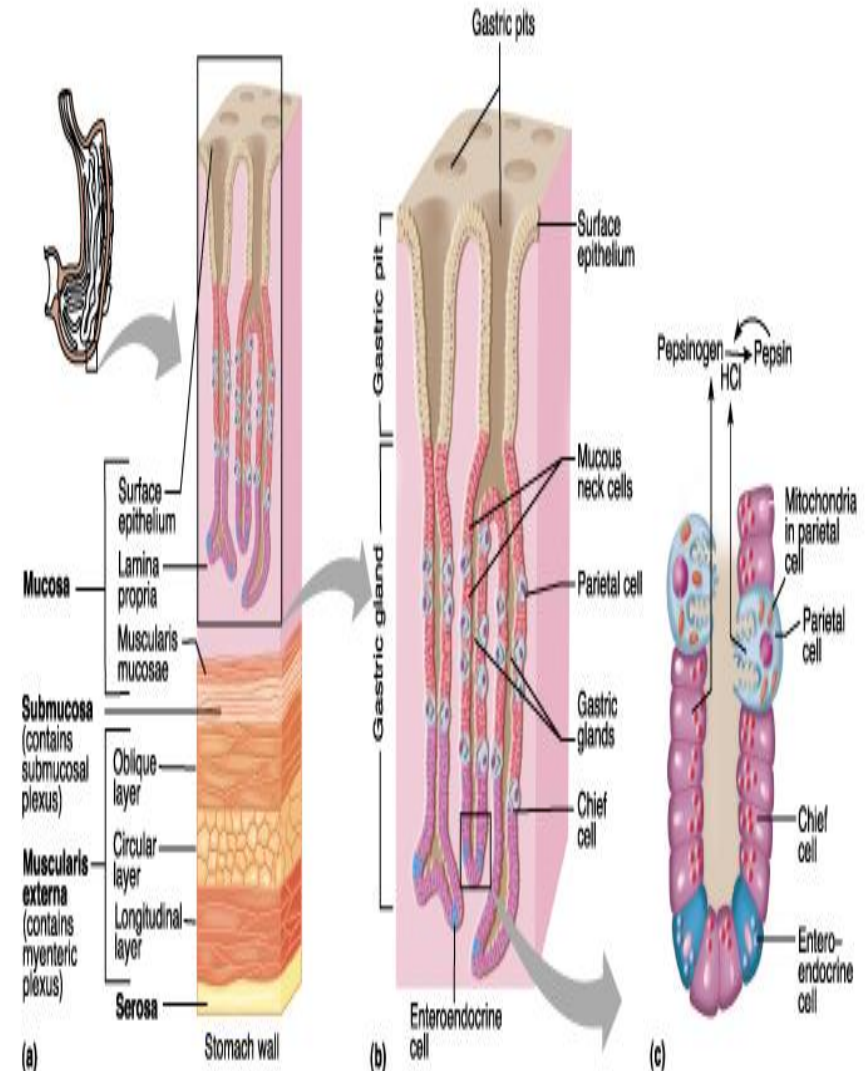


- Parasympathetic stimulation, the presence of nutrients such as amino acids and amines in the stomach, and distention of the stomach wall directly stimulate the G cell to release gastrin,
- which in turn activates the parietal cell, increasing acid secretion
- Other enteroendocrine cells (**D cells**) secrete **somatostatin**, which inhibits the release of some other hormones, including gastrin
- Secretion of somatostatin is stimulated by HCl, counterbalancing the acid secretion.



Other layers

- The **submucosa** is composed of dense connective tissue containing blood and lymph vessels; it is infiltrated by lymphoid cells, macrophages, and mast cells.
- The **muscularis** is composed of smooth muscle fibers oriented in three main directions.
- The external layer is longitudinal, the middle layer is circular, and the internal layer is oblique
- At the pylorus, the middle layer is greatly thickened to form the **pyloric sphincter**.
- The stomach is covered by a thin **serosa**.

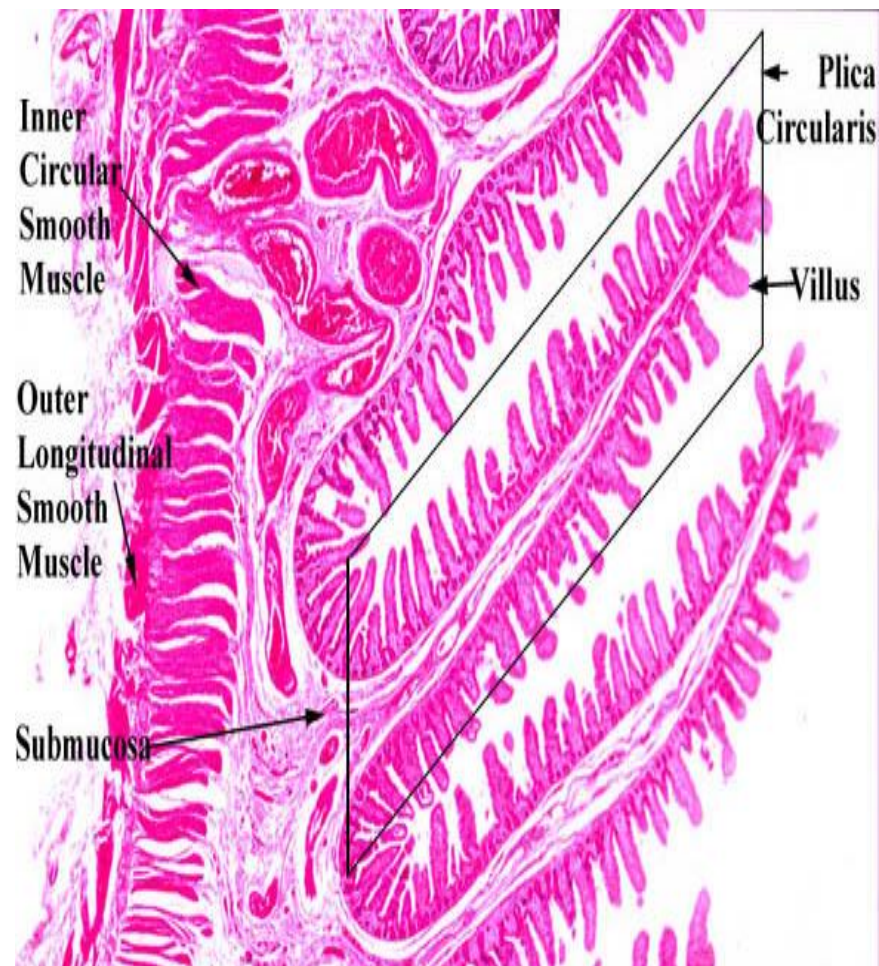


Small Intestine

- The small intestine is the site of terminal food digestion, nutrient absorption, and endocrine secretion
- processes of digestion are completed in the small intestine, where the nutrients (products of digestion) are absorbed by cells of the epithelial lining
- The small intestine is relatively long—approximately 5 m—and consists of three segments: the **duodenum**, **jejunum**, and **ileum**.

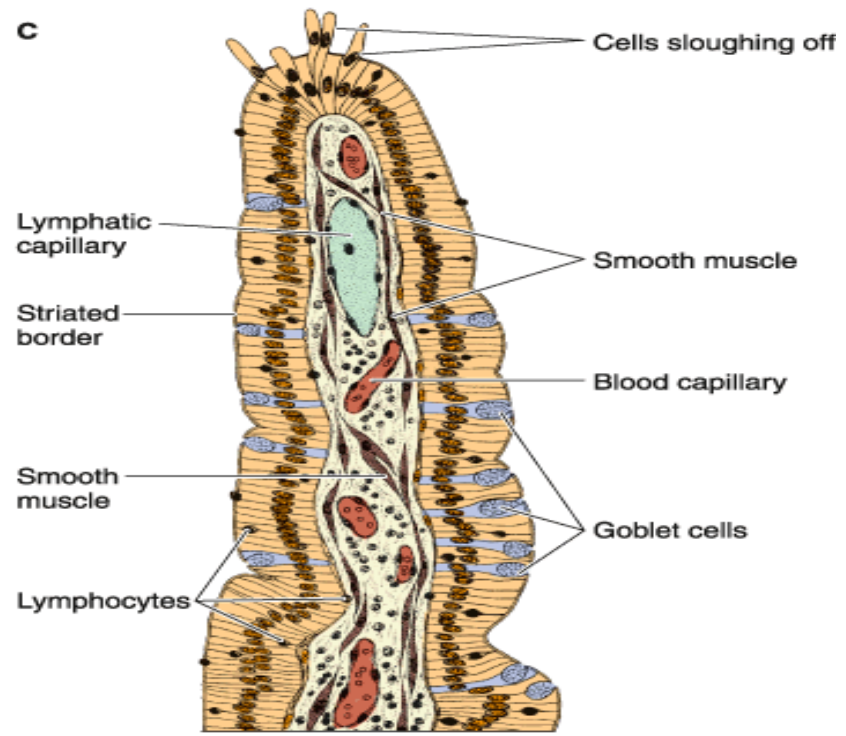
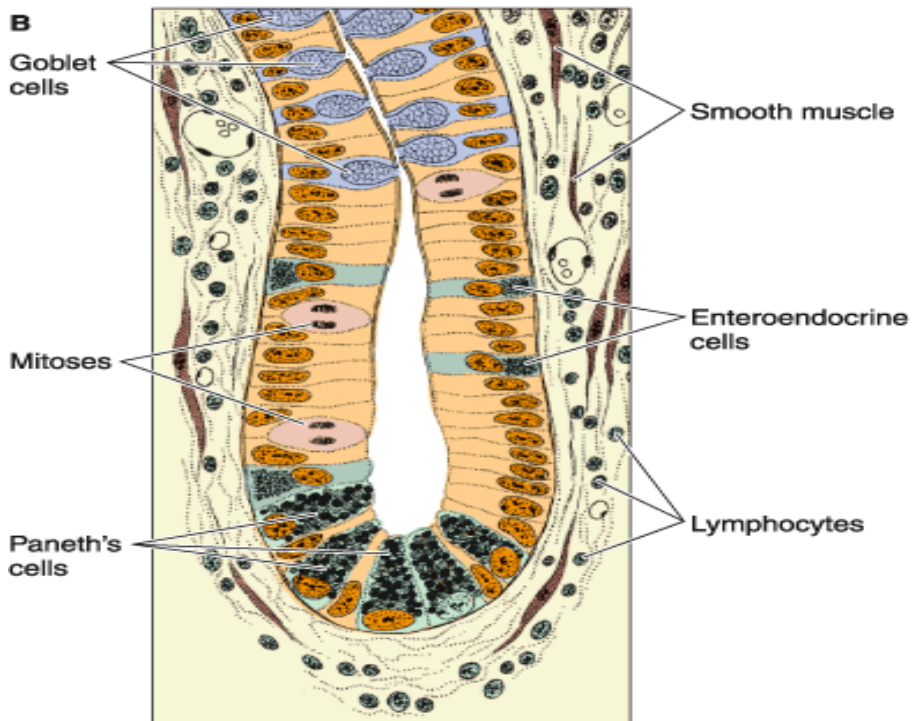
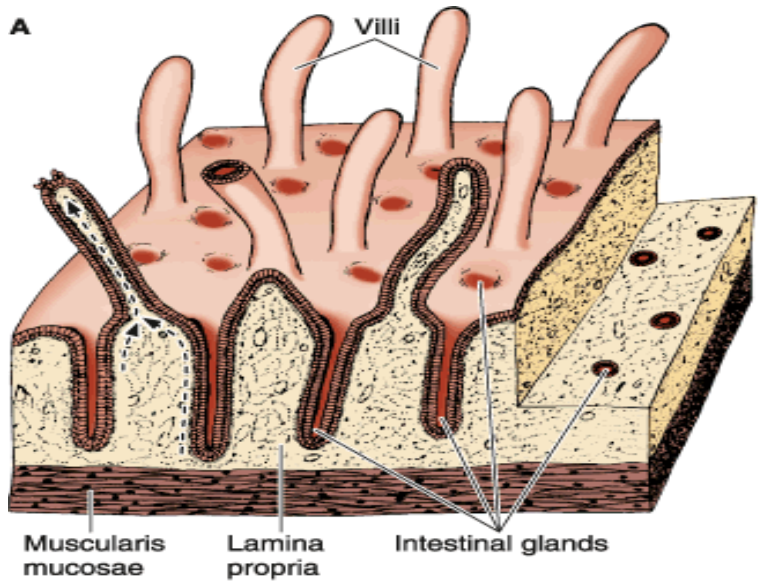
Mucous Membrane

- the lining of the small intestine shows a series of permanent folds, **plicae circulares (Kerckring's valves)**,
- consisting of mucosa and submucosa and having a semilunar, circular, or spiral form
- The plicae are most developed in, and consequently a characteristic of, the jejunum.
- They do not constitute a significant feature of the duodenum and ileum, although they are frequently present.
- **Intestinal villi** are 0.5- to 1.5-mm-long outgrowths of the mucosa (epithelium plus lamina propria) projecting into the lumen of the small intestine
- In the duodenum they are leaf shaped, gradually assuming fingerlike shapes as they reach the ileum

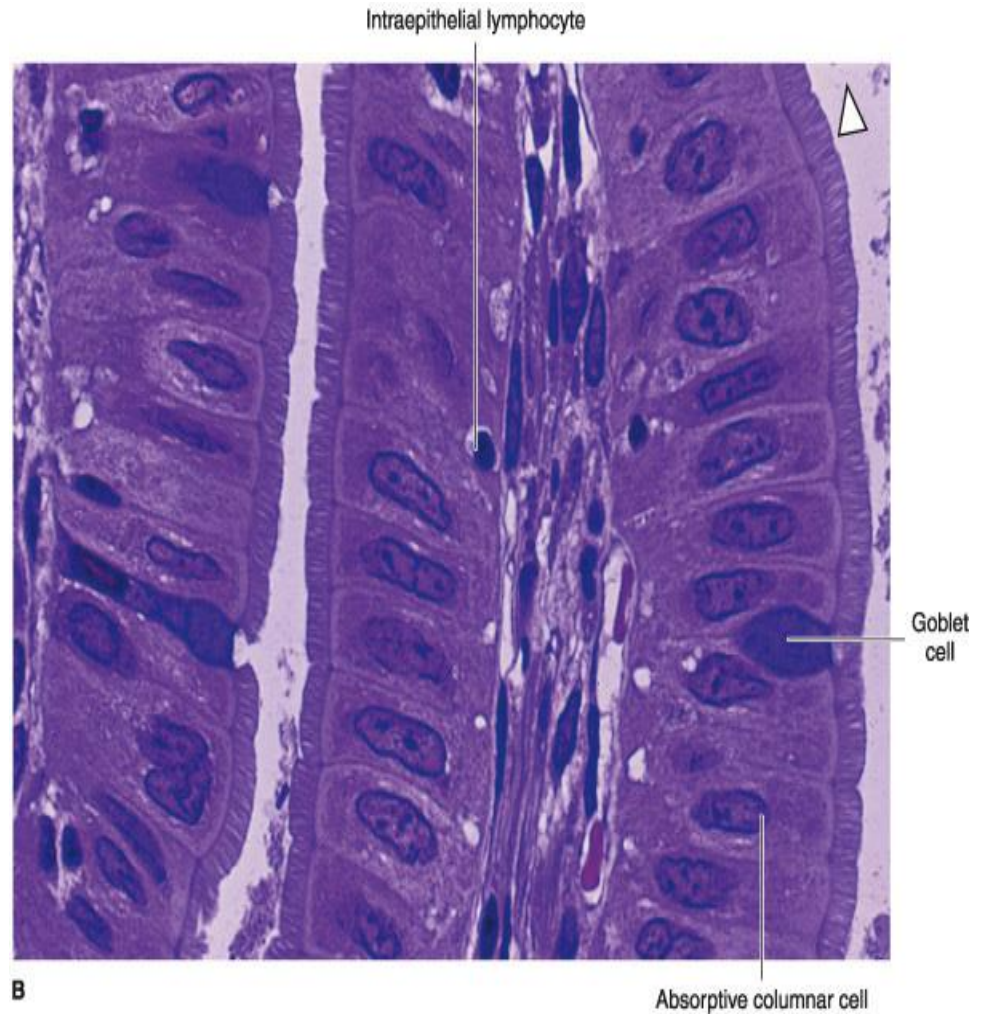


- Between the villi are small openings of simple tubular glands called **intestinal glands** (also called **crypts**), or **glands of Lieberkühn**
- The epithelium of the villi is continuous with that of the glands
- The intestinal glands contain stem cells, some absorptive cells, goblet cells, Paneth's cells, and enteroendocrine cells.

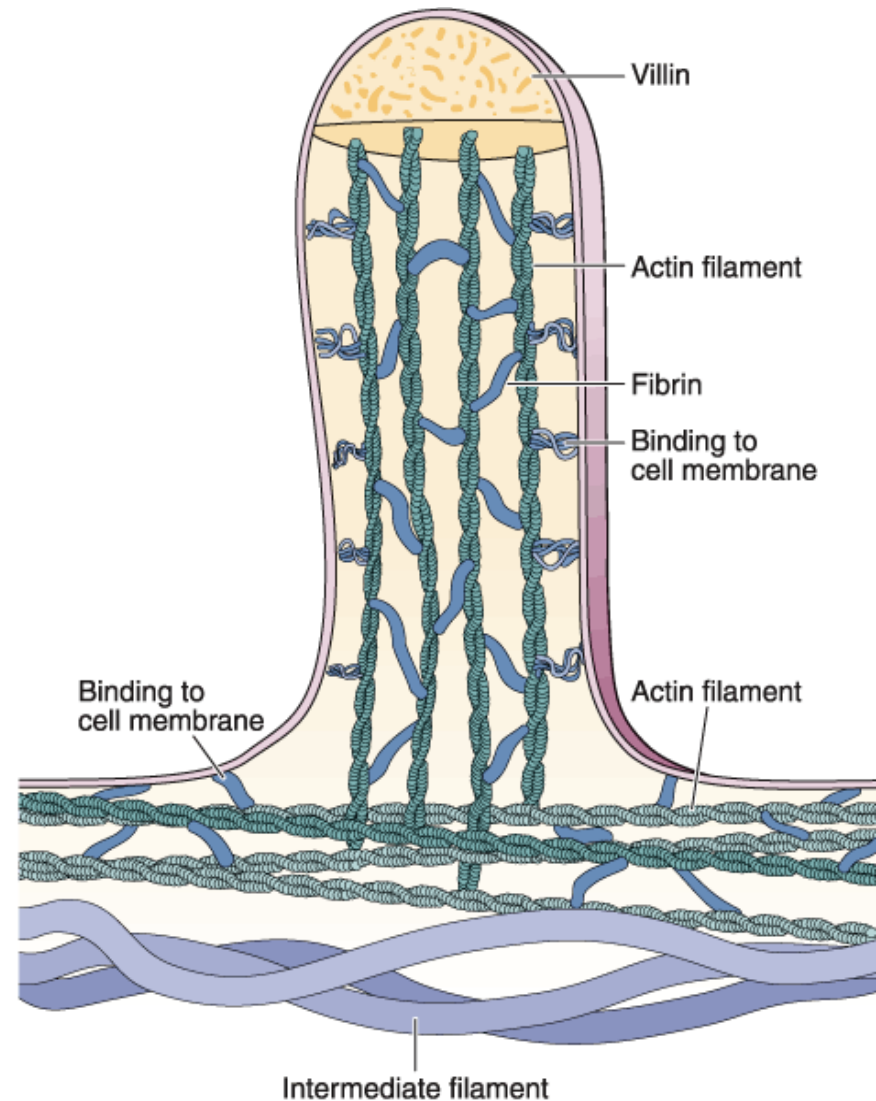




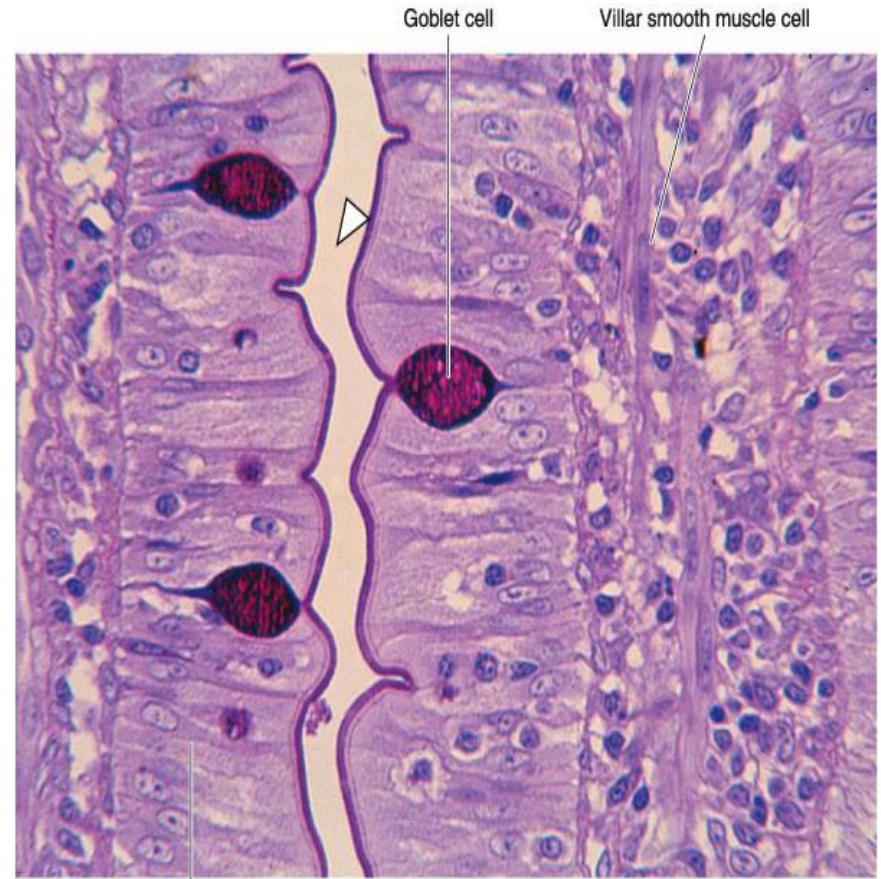
- **Absorptive cells** or **enterocytes** are tall columnar cells, each with an oval nucleus in the basal half of the cell
- At the apex of each cell is a homogeneous layer called the **striated (brush) border**
- When viewed with the electron microscope, the striated border is seen to be a layer of densely packed **microvilli**
- Each absorptive cell is estimated to have an average of 3000 microvilli, and 1 mm² of mucosa contains about 200 million of these structures



- Each microvillus is a cylindrical protrusion of the apical cytoplasm that is approximately 1 μm tall by 0.1 μm in diameter
- consists of the cell membrane enclosing a core of actin microfilaments associated with other cytoskeletal proteins
- Microvilli have the important physiological function of increasing the area of contact between the intestinal surface and the nutrients.
- The presence of plicae, villi, and microvilli greatly increases the surface of the intestinal lining
- It has been calculated that plicae increase the intestinal surface 3-fold, the villi increase it 10-fold, and the microvilli increase it 20-fold.
- Together, these processes are responsible for a 600-fold increase in the intestinal surface, resulting in a total area of 200 m^2



- **Goblet cells** are interspersed between the absorptive cells
- They are less abundant in the duodenum and increase in number as they approach the ileum
- These cells produce acid glycoproteins of the mucin type to form mucus, whose main function is to protect and lubricate the lining of the intestine.

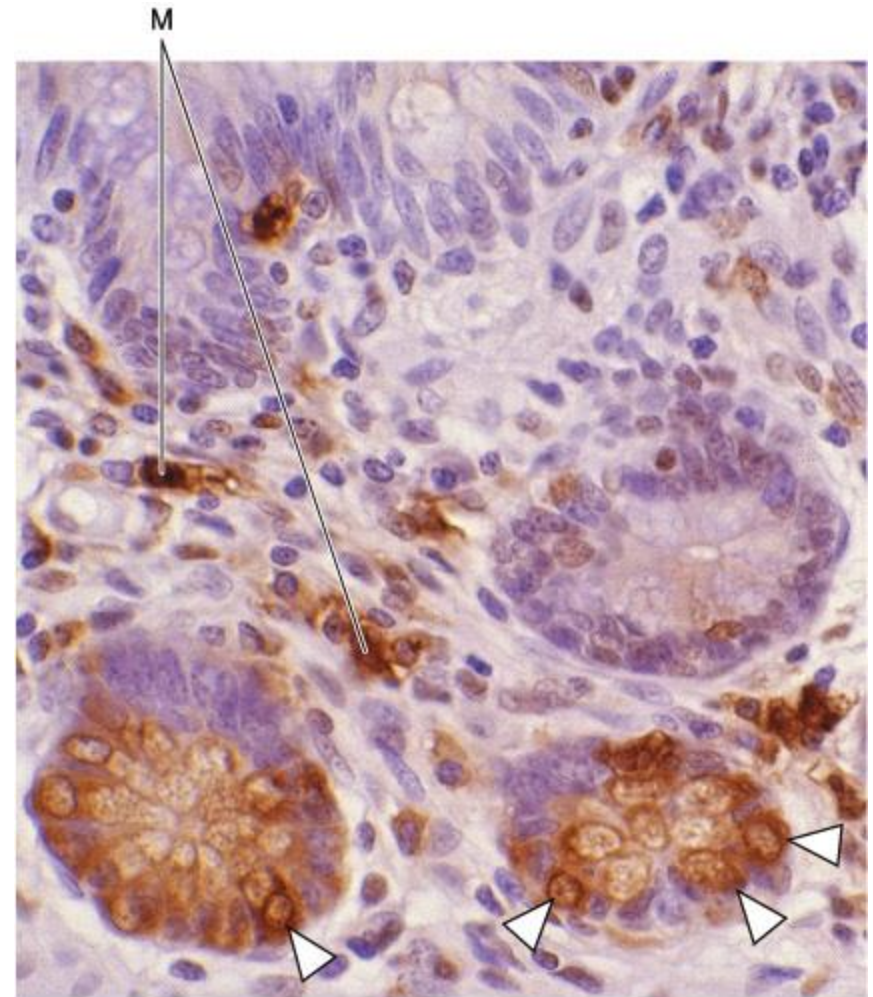


A Absorptive columnar epithelium

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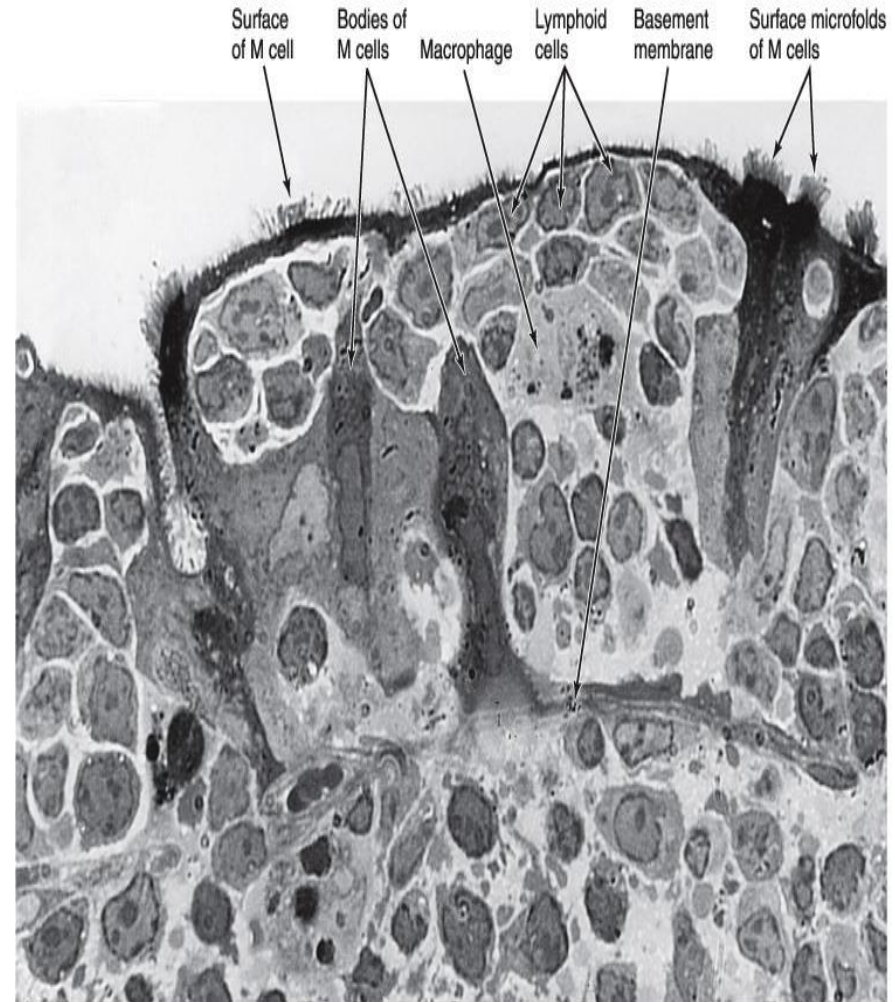
Paneth's cells

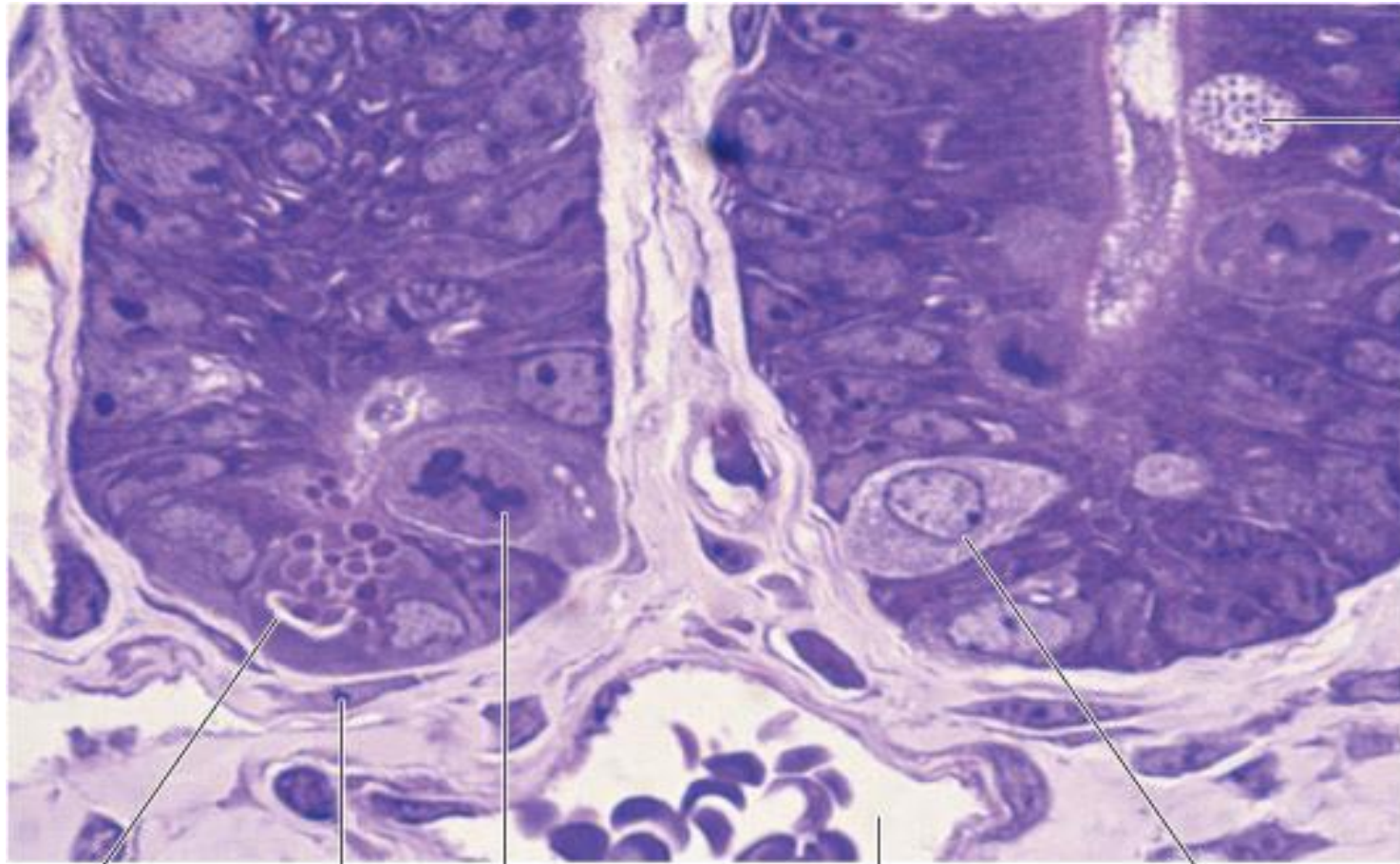
- in the basal portion of the intestinal glands are exocrine cells with secretory granules in their apical cytoplasm.
- lysozyme—an enzyme that digests the cell walls of some bacteria— was detected in the large eosinophilic secretory granules of these cells
- Lysozyme has antibacterial activity and may play a role in controlling the intestinal flora.



M (microfold) cells

- are specialized epithelial cells overlying the lymphoid follicles of Peyer's patches
- the presence of numerous basal membrane invaginations that form pits containing many intraepithelial lymphocytes and antigen-presenting cells (macrophages).
- M cells can endocytose antigens and transport them to the underlying macrophages and lymphoid cells, which then migrate to other compartments of the lymphoid system (nodes),
- M cells represent an important link in the intestinal immunological system
- basement membrane under M cells is discontinuous, facilitating transit between the lamina propria and M cells





Goblet cell

Paneth cell

Fibroblast

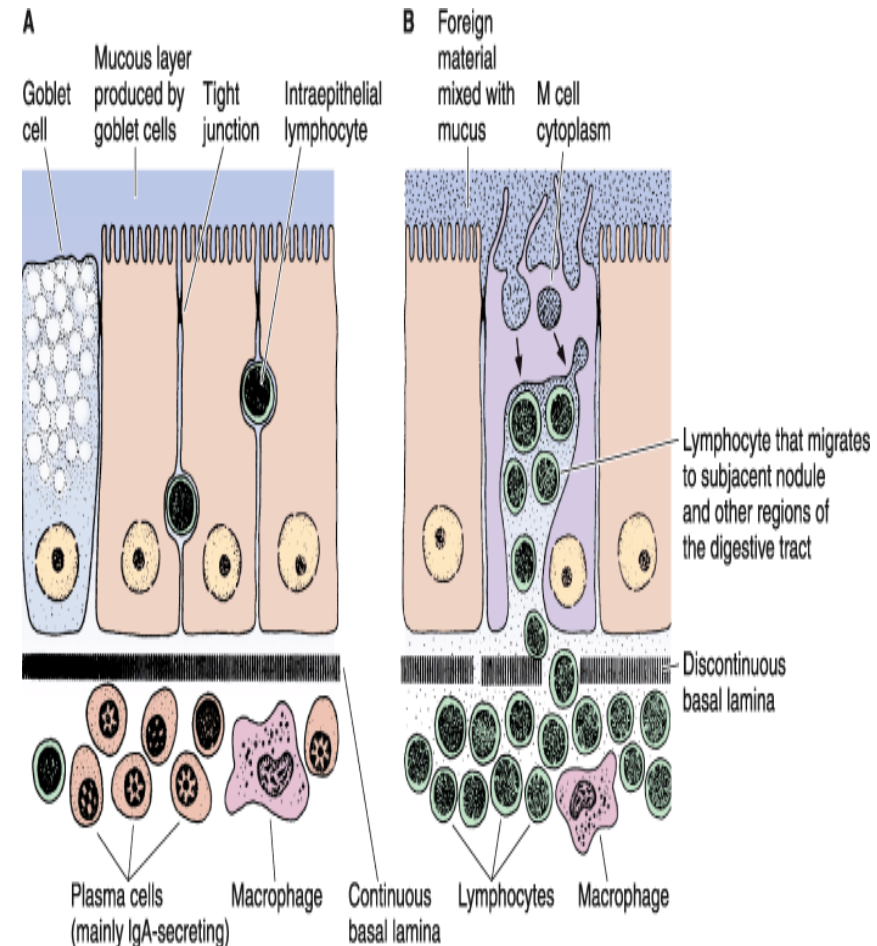
Mitosis

Vein

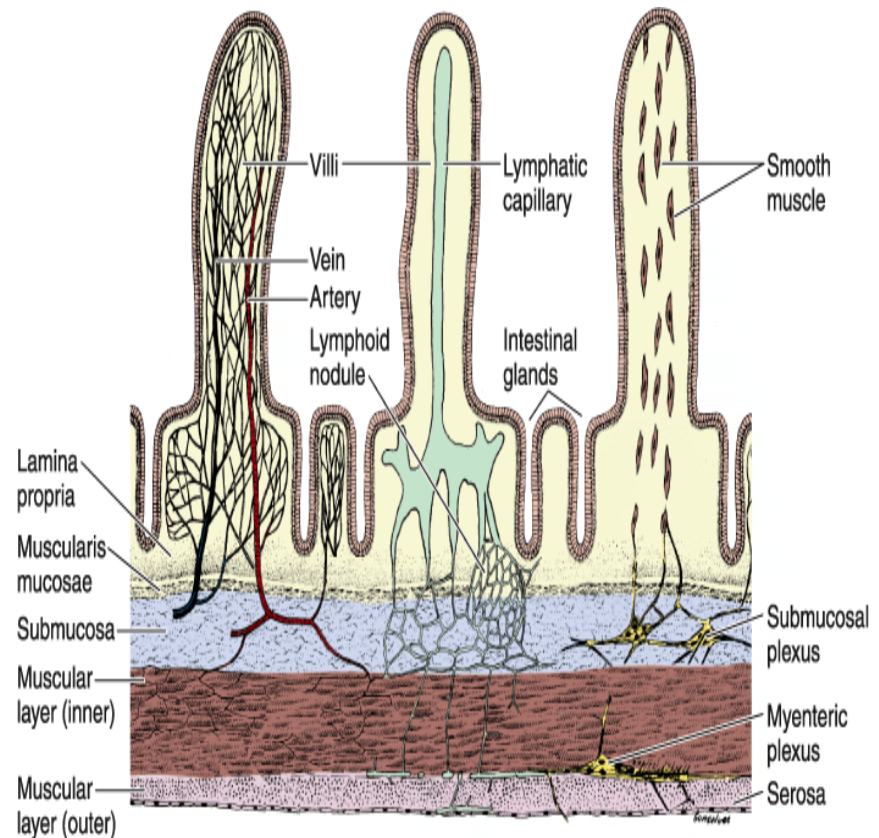
Enteroendocrine cell

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- The very large mucosal surface of the gastrointestinal tract is exposed to many potentially invasive microorganisms
- Secretory immunoglobulins of the IgA are the first line of defense
- Another protective device is the intercellular tight junctions that make the epithelial cells a barrier to the penetration of microorganisms.
- In addition the gastrointestinal tract contains antibody-secreting plasma cells, macrophages, and a very large number of lymphocytes
- located in both the mucosa and the submucosa. Together, these cells are called the gut-associated lymphoid tissue (GALT).

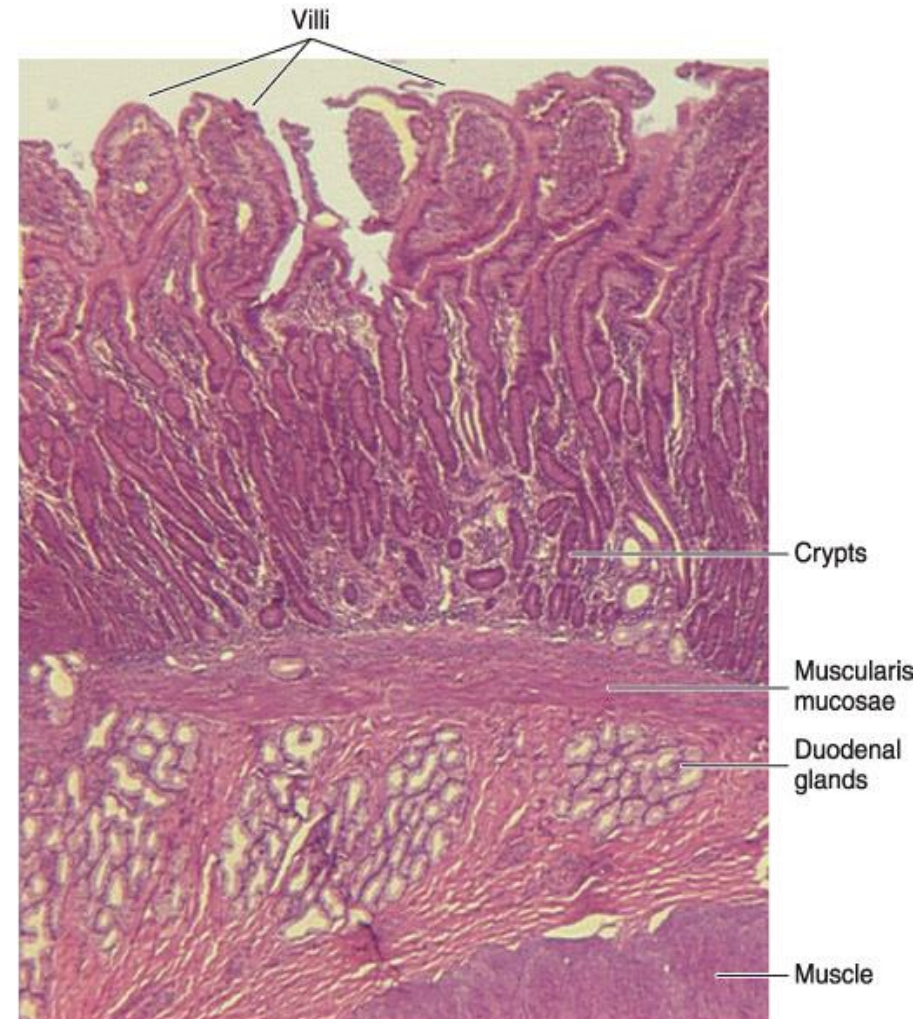


- The lamina propria of the small intestine is composed of loose connective tissue with blood and lymph vessels, nerve fibers, and smooth muscle cells.
- The lamina propria penetrates the core of the intestinal villi
- smooth muscle cells are responsible for the rhythmic movements of the villi, which are important for absorption

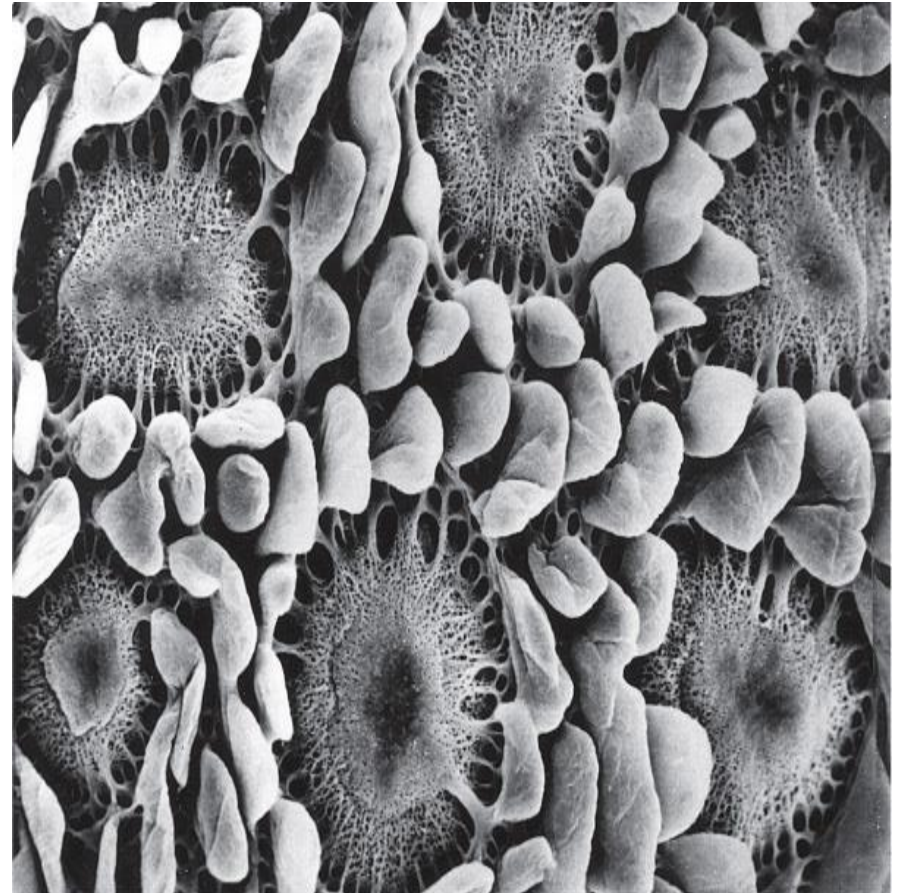


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- In the initial portion of the duodenum the **submucosa** contains clusters of ramified, coiled tubular glands that open into the intestinal glands. These are the **duodenal** (or **Brunner's**) **glands**
- The product of secretion of the glands is distinctly alkaline (pH 8.1–9.3),
- acting to protect the duodenal mucous membrane from the effects of the acid gastric juice and to bring the intestinal contents to the optimum pH for pancreatic enzyme action.

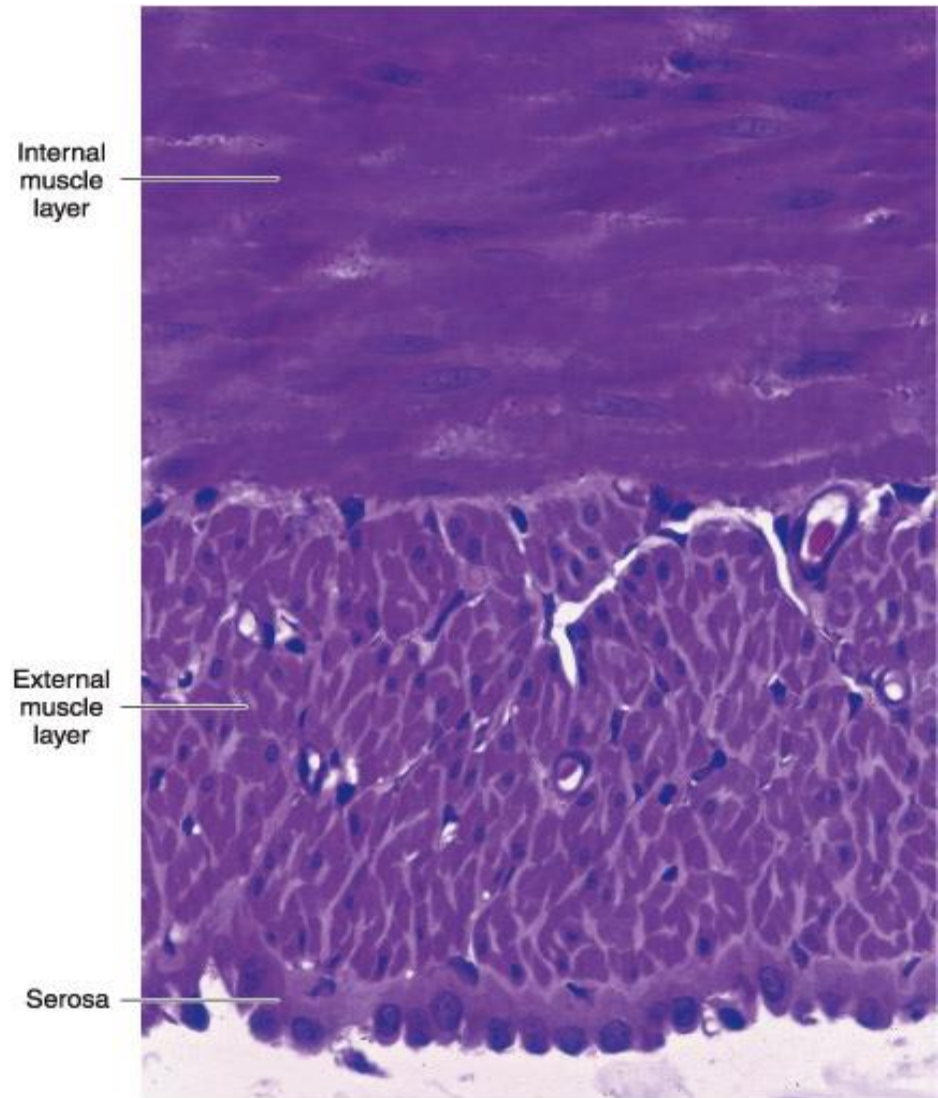


- The lamina propria and the submucosa of the small intestine contain aggregates of lymphoid nodules known as **Peyer's patches**, an important component of the GALT
- Each patch consists of 10–200 nodules and is visible to the naked eye as an oval area on the antimesenteric side of the intestine
- There are about 30 patches in humans, most of them in the ileum
- each Peyer's patch appears as a dome-shaped area devoid of villi
- Instead of absorptive cells, its covering epithelium consists of **M cells**



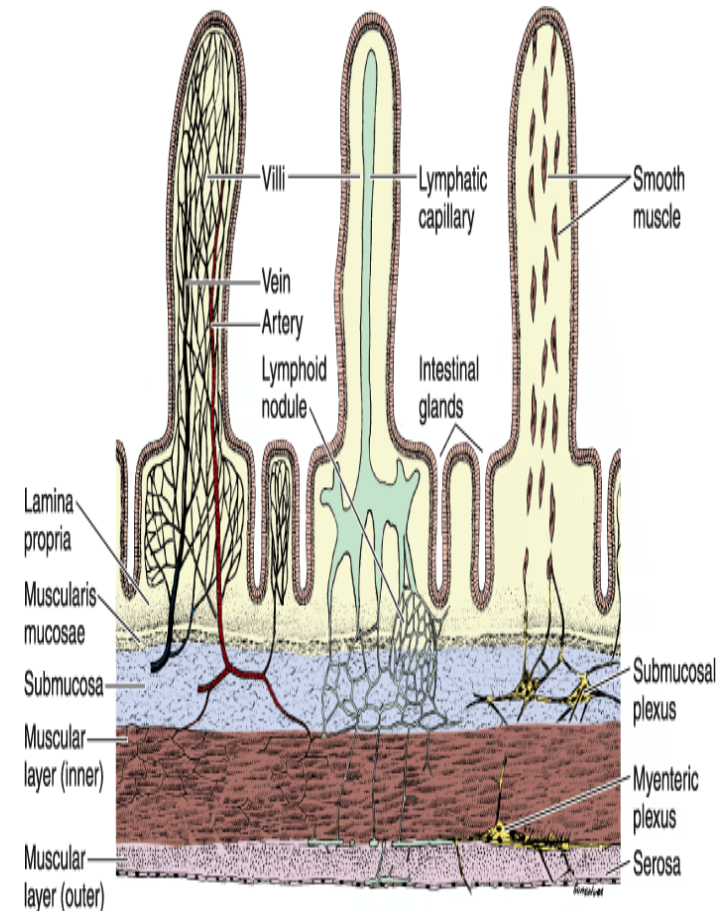
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- The muscularis is well developed in the intestines, composed of an internal circular layer and an external longitudinal layer



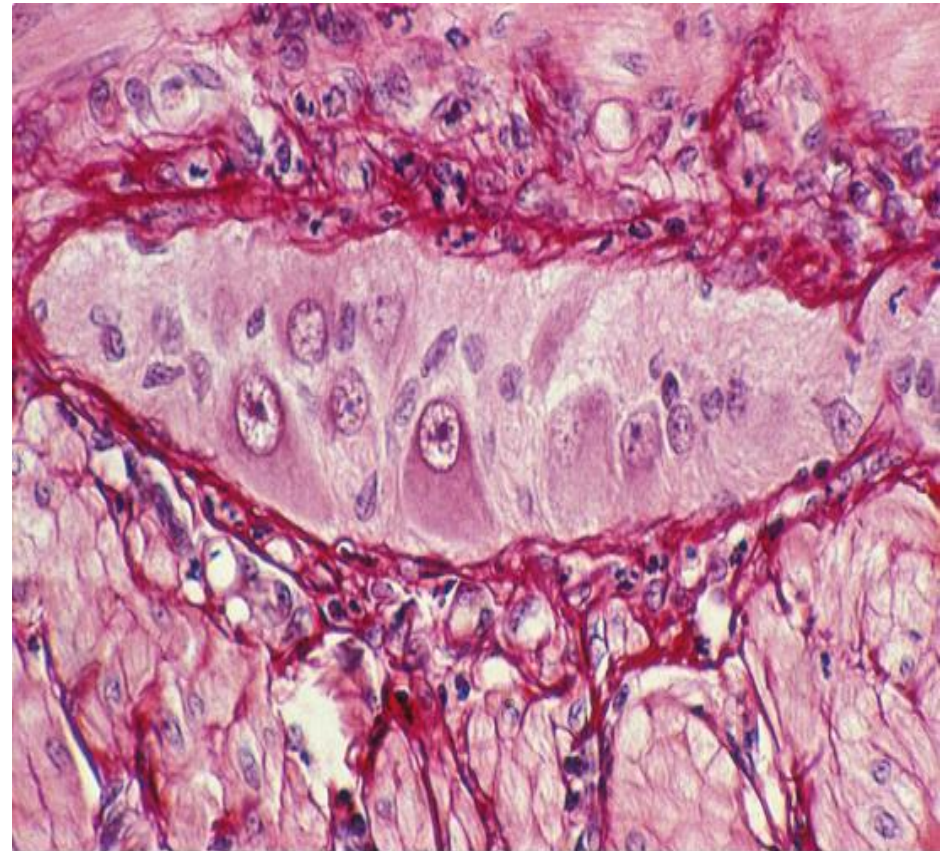
Vessels & Nerves

- The blood vessels that nourish the intestine and remove absorbed products of digestion penetrate the muscularis and form a large plexus in the submucosa
- From the submucosa, branches extend through the muscularis mucosae and lamina propria and into the villi.
- Each villus receives, according to its size, one or more branches that form a capillary network just below its epithelium
- At the tips of the villi, one or more venules arise from these capillaries and run in the opposite direction, reaching the veins of the submucosal plexus
- These capillaries (**lacteals**), although larger than the blood capillaries, are difficult to observe because their walls are so close together that they appear to be collapsed
- Lacteals run to the region of lamina propria above the muscularis mucosae, where they form a plexus. From there they are directed to the submucosa, where they surround lymphoid nodules
- Lacteals anastomose repeatedly and leave the intestine along with the blood vessels.
- They are especially important for the absorption of lipids, because blood circulation does not easily accept the lipoproteins produced by the absorptive cells during this process

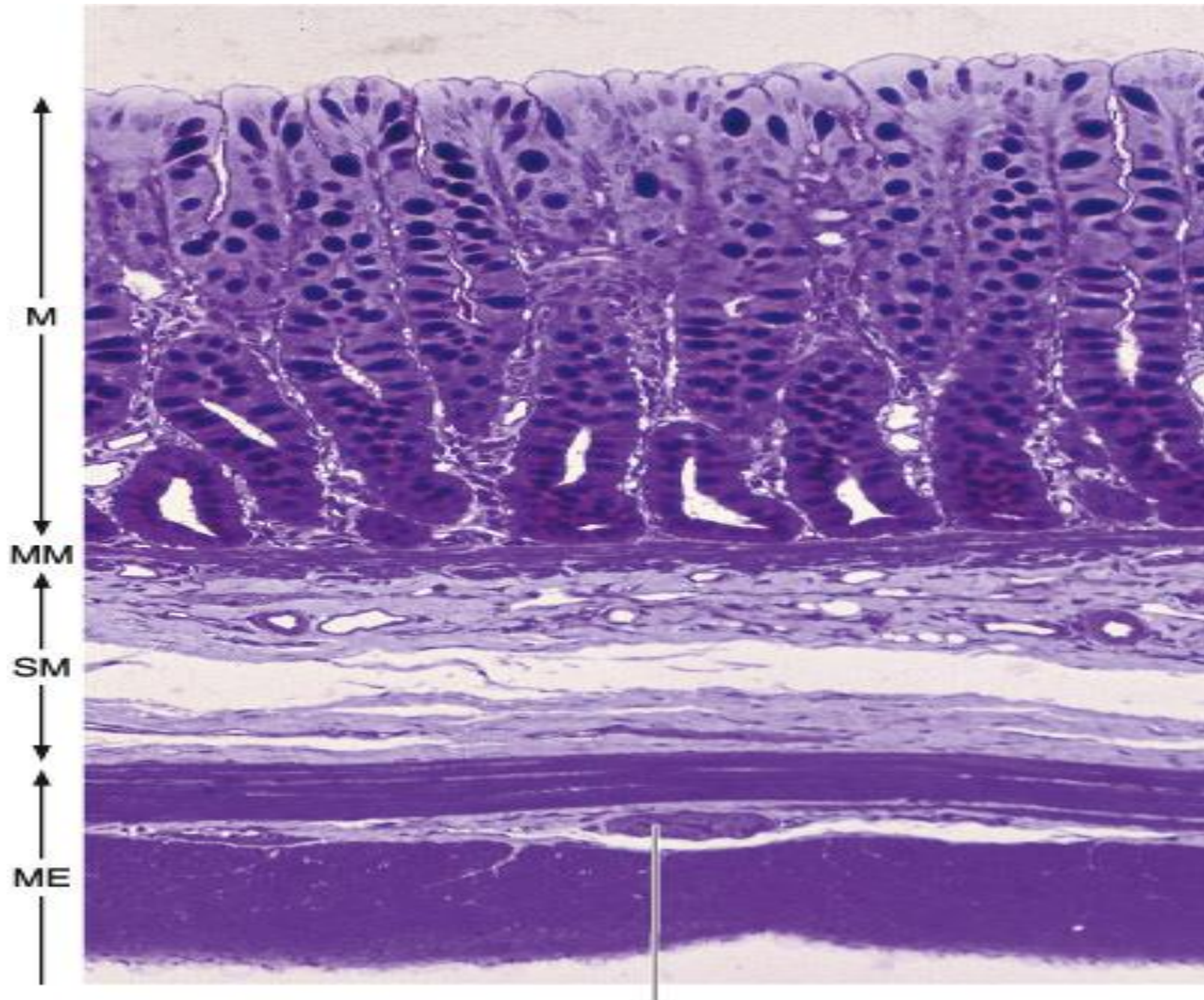


- important for intestinal function is the rhythmic movement of the villi
- This movement is the result of the contraction of smooth muscle cells running vertically between the muscularis mucosae and the tip of the villi
- These contractions occur at the rate of several strokes per minute and have a pumping action on the villi that propels the lymph to the mesenteric lymphatics.

- The innervation of the intestines is formed by both an **intrinsic component** and an **extrinsic component**
- The intrinsic component comprises groups of neurons that form the **myenteric (Auerbach's) nerve plexus** between the outer longitudinal and inner circular layers of the muscularis
- and the **submucosal (Meissner's) plexus** in the submucosa
- The plexuses contain some sensory neurons that receive information from nerve endings near the epithelial layer and in the smooth muscle layer
- regarding the composition of the intestinal content (chemoreceptors) and the degree of expansion of the intestinal wall (mechanoreceptors)
- The other nerve cells are effectors and innervate the muscle layers and hormone-secreting cells



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Myenteric plexus

- The intrinsic innervation formed by these plexuses is responsible for the intestinal contractions that occur in the total absence of the extrinsic innervation.
- The extrinsic innervation is formed by parasympathetic cholinergic nerve fibers that stimulate the activity of the intestinal smooth muscle
- and by sympathetic adrenergic nerve fibers that depress intestinal smooth muscle activity.