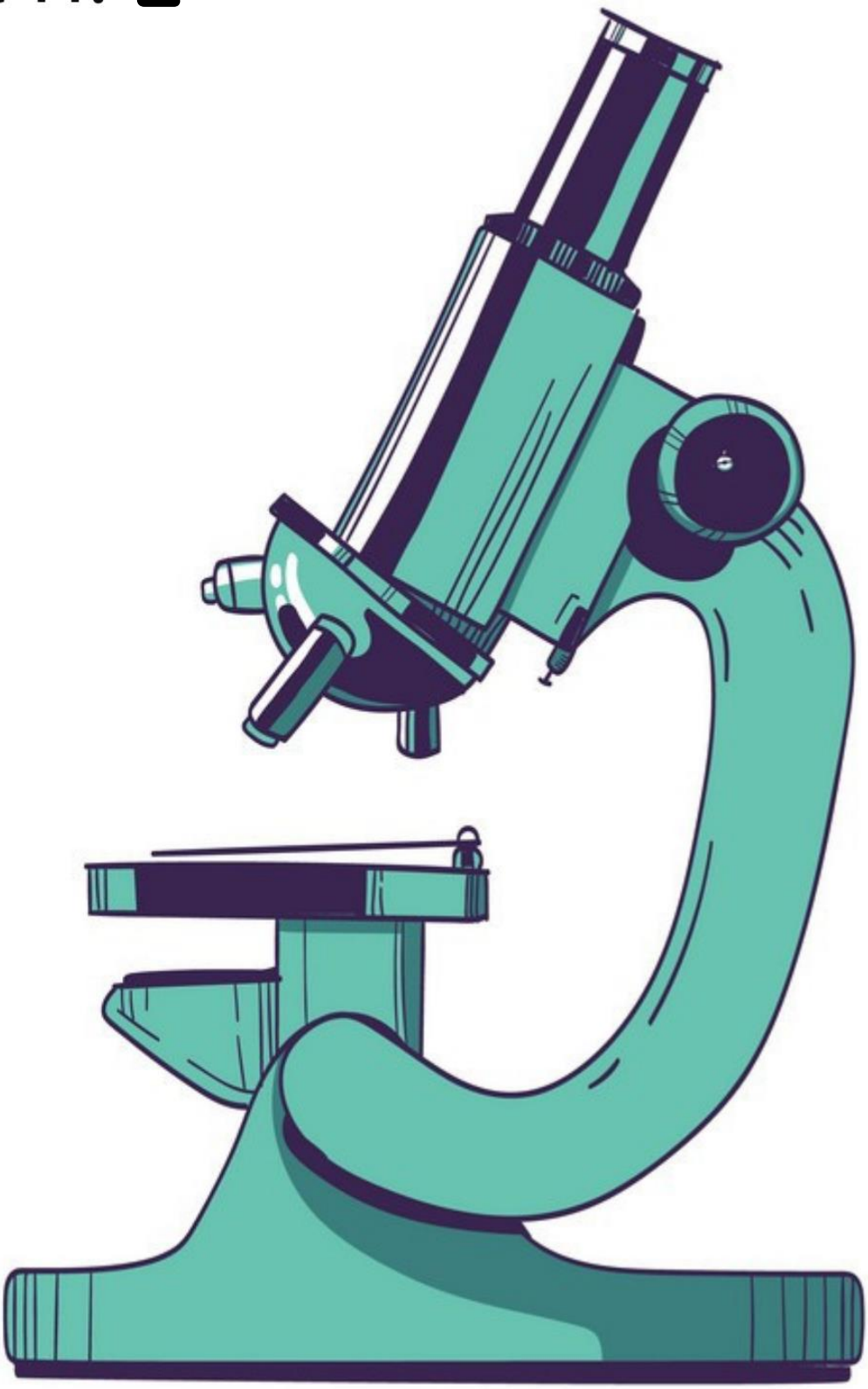
Histology

Sheet n. **2**



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Purple: Slides, the underlined sentences indicate what the doctor reads from slides.

Black: The professor's speech

Blue: Outside material for extra explanation

Red: Important subjects

Esophagus

• is a muscular tube (its wall consists of 4 layers, among them there's a muscular layer) whose function is to transport (propagate) foodstuffs (bolus) from the mouth (orорpharynx) to the stomach and to prevent the retrograde flow of gastric contents.

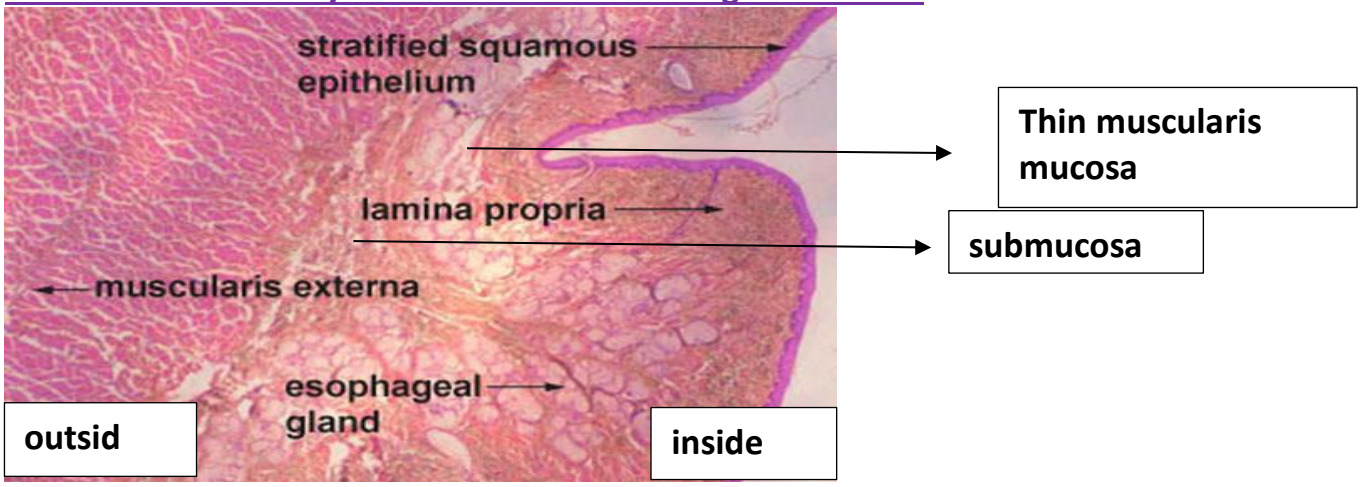
It starts from the 6th cervical vertebrae as a continuation of pharynx and ends in the cardia of the stomach. It's about 25 cm long, but from incisors it's 45 cm.

• 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.



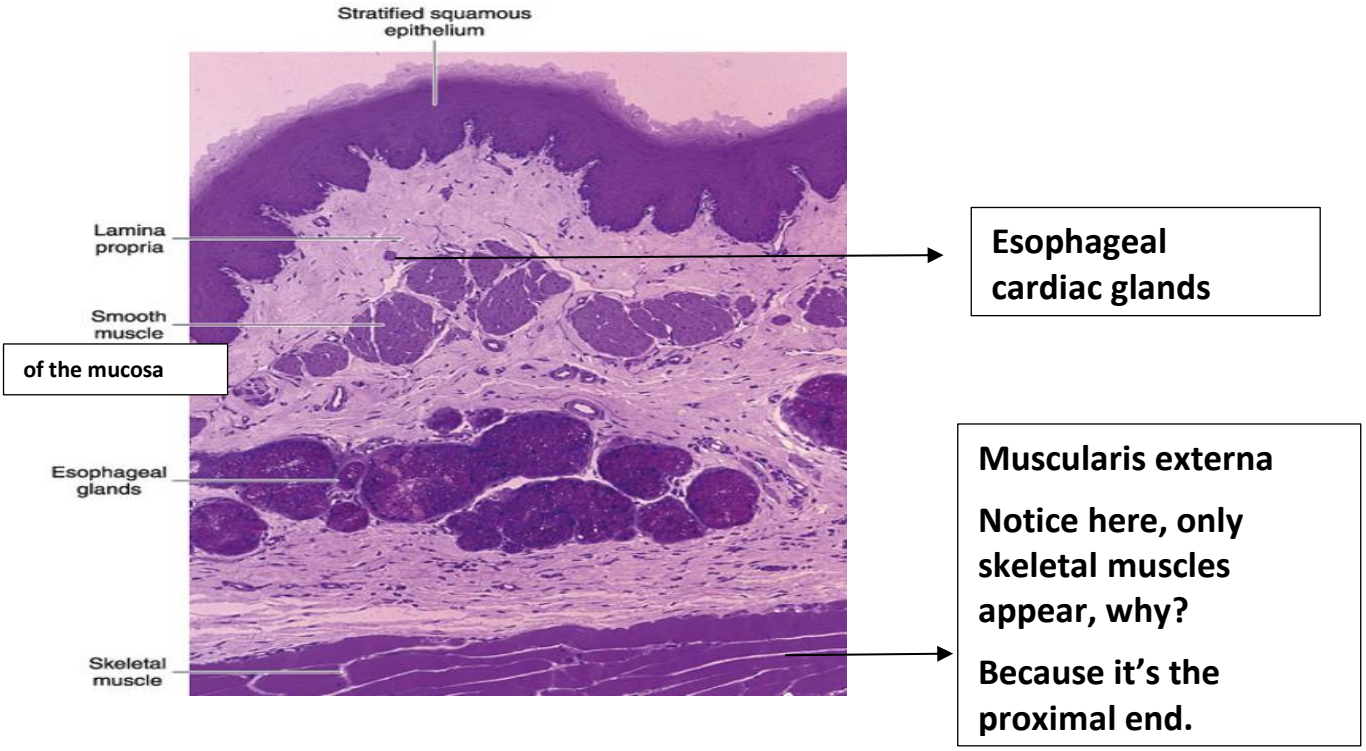
Divided into four layers from inside to outside : **1. Mucosa** that is divided into three sublayers (lining epithelium, lamina propria and muscularis mucosa), **2. Submucosa**, **3. Muscularis externa** and **4. Serosa or Adventitia**.

1)***Mucosa***: In humans, the esophagus is covered by ***NONKERATINIZED STRATIFIED SQUAMOUS EPITHELIUM*** as the oral cavity, pharynx and anal canal.

Encountering frequent injurious agents to our mucosal tissues during daily life isn't a major concern. This is because our mucosa possesses a beneficial characteristic **which is the high mitotic activity that enables rapid healing and regeneration** after injuries. In fact, it only takes about 6 hours for the mucosa to repair itself.

• In the lamina propria of the region near the stomach, which is loose CT there are *lymph vessels and nodes, BVs and* groups of glands named as *(Esophageal cardiac glands), 'cardiac' refers to the stomach as these glands exist in the lamina propria of the stomach and are also prominent in the lower part of the esophagus* to secrete mucus.

•Muscularis mucosa is a thin layer which consists of two layers of smooth muscles, inner circular and outer longitudinal.



2) *Submucosa* which is composed of dense CT and contains lymphatic vessels, BVs, Meissner's plexus and groups of small mucus- secreting glands named as esophageal glands proper, whose secretion facilitates the transport of foodstuffs and protects the mucosa.

Recall that the presence of glands in the submucosa is a distinctive feature of the esophagus and duodenum, whereas other GI organs only have glands in their lamina propria.

3) *Muscularis externa* of the esophagus varies in its composition, hence the esophagus is divided into 3 parts according to it.

→ At the distal end of the esophagus that is close to the stomach (lower 1/3): muscularis externa consists of smooth muscle cells only -sympathetic and parasympathetic innervation-: (inner circular and outer longitudinal) and in between there is the myenteric or (Auerbach's) nervous plexus which contains

parasympathetic secretomotor fibers for glands and innervates the smooth muscles to assists the peristaltic movement. It forms the lower esophageal sphincter.

→ In the mid portion (middle 1/3): mixture of striated(skeletal) and smooth muscle cells.

→ at the proximal (upper 1/3) end: only striated muscle cells.

Swallowing begins with voluntary muscle action (that's why there are skeletal muscles at the upper 1/3) and ends with involuntary peristalsis (that's why there are smooth muscles at the lower 1/3)

4) The majority of the esophagus is in the neck and thorax (extra abdominal) thus covered by a layer of connective tissue named as the adventitia that blends into the surrounding tissue.

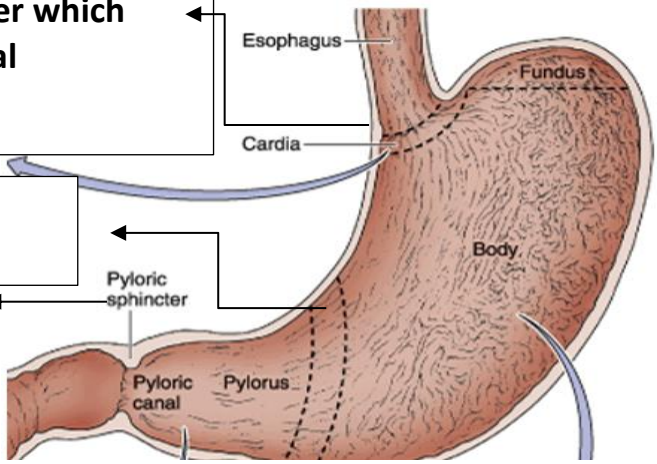
1.3 cm lies below the diaphragm (Intra abdominal), only this portion of the esophagus that is in the peritoneal cavity is covered by serosa.

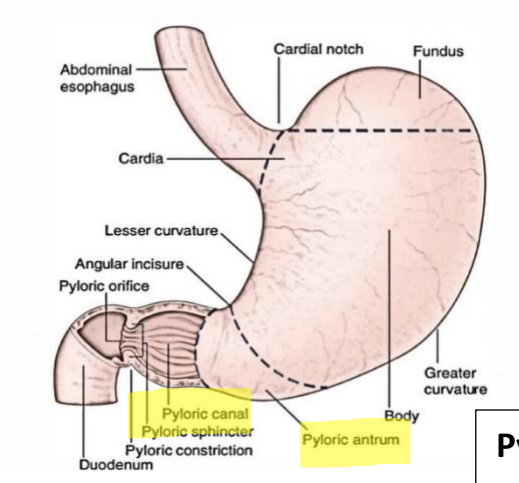
Stomach

Cardiac sphincter which is a Physiological sphincter

Incisura angularis that separates body from pylorus.

Anatomical sphincter





The sphincter is regulated by the sympathetic nervous systems which causes its contraction. But when the sympathetic nervous system is inhibited, the parasympathetic nervous system increases the peristaltic movements therefore causing drainage.

Pylorus is divided into 3 parts:

Canal, sphincter and antrum.

• 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 (semifluid chyme which is digested food with gastric acids), this prosses takes about 2-4 hours, after 4 hours it's drained into the small intestine through the pyloric sphincter.

-The main function of the small intestines is absorption.

• 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

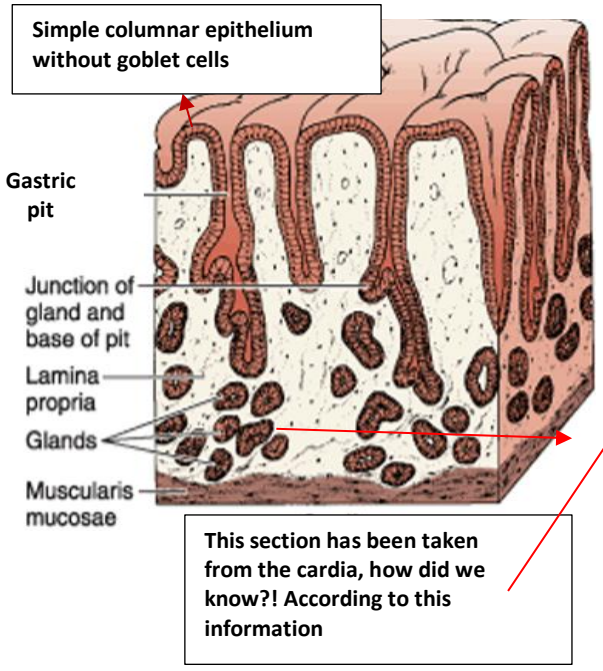
- The stomach also has mucosa, submucosa, muscularis externa and serosa (because it's completely covered by peritoneum)

• The mucosa and submucosa of the distended stomach lie in longitudinally directed folds known as RUGAE (which are foldings of the submucosa through the mucosa). When the stomach is filled with food, these folds flatten out.

Mucosa

• The gastric mucosa consists of a ***lining epithelium which is simple columnar epithelium without goblet cells*** that invaginates to various extents into the lamina propria to form ducts of glands called gastric pits (can be seen by the magnifying glass) and those *columnar epithelial* cells secrete an alkaline mucus to protect mucosa from autodigestion because it contains a lot of acids.

• Emptying into the gastric pits are branched, tubular glands (cardiac, gastric, and pyloric) characteristic of each region of the stomach.



The appearance of gastric glands varies depending on the cross-section, which may show them as circular, oblique, or coiled.

The cardia, body, and pylorus of the stomach differ from each other based on variations in the ratio between the thickness of gastric glands to the thickness of gastric pits.

1:1 in the cardia (IMPORTANT)

3:2 in the body and the pits are round(wide) and short

Also the body of the stomach is important in digestion so it has numerous glands that outnumber the gastric pits

In the pyloris (which has no digestive functions) the thickness of glands is little and pits are thick and narrow

Gastric pits are the same as gastric ducts which open into the lumen of the stomach.

• The lamina propria of the stomach is composed of loose connective tissue interspersed with smooth muscle and lymphoid cells, and it's filled with gastric glands compatible with the digestive functions of the stomach, these glands are composed of different types of cells, each having different secretory functions, but generally, the main function of the glands is secretion of mucus to protect the mucosa of the stomach from being auto-digested by the acid it produces. The glands are also covered with simple columnar epithelium without goblet cells.

• Separating the mucosa from the underlying submucosa is a thin layer of smooth muscle, the muscularis mucosa.

• Submucosa contains BVs, lymph nodes and Meissner's plexus.

• The muscularis externa is composed of three layers of muscles: an outer longitudinal layer, an inner circular layer, and the innermost oblique layer. However, at the pyloric canal and sphincter within the pylorus, the oblique muscles are absent because the inner circular layer is thickened to form the sphincter, thus the innermost oblique layer is absent.

• numerous small circular or ovoid invaginations of the epithelial lining are observed. These are the openings of the gastric pits which are the ducts of glands.

• The epithelium covering the surface and lining the pits is a simple columnar epithelium, and all the cells secrete an alkaline mucus

• **Gastric glands secrete mucus (especially the lining epithelium of the glands), This mucus consists primarily of water (95%), lipids, and glycoproteins, which, in combination, form *a hydrophobic protective gel* to protect abdominal mucosa. But the secretion differs according to the organ as in the small intestine cells are responsible for the absorption and mucus is secreted by goblet cells, however, in the stomach there are no goblet cells, so mucus secretion becomes the function of simple columnar epithelial cells.**

• **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 columnar 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 alkalinization.**

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, covered by a simple columnar epithelium without goblet cells (like the surface),these glands contain various cell types:**

1) Mucus cells

2) Enteroendocrine cells secreting gastrin

3) Chief cells secreting pepsinogen

4) Parietal cells secreting HCl

5) Stem cells for mitosis which are precursors of other cells

• **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) and chief cells can be found in cardia, but they're numerous in the body.**

• **These glands are similar in structure to the cardiac glands of the terminal portion of the esophagus.**

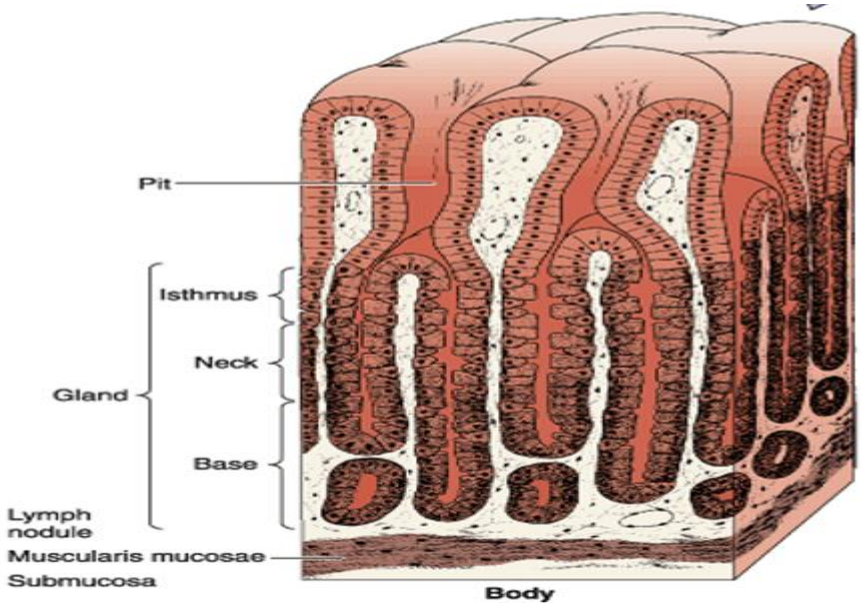
- **The thickness of gastric glands is equal to the thickness of gastric pits.**

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.**

Gastric glands are thick, and the gastric pits are short and wide. The shorter length of the gastric pits in this region allows for efficient secretion and delivery of gastric juices into the stomach lumen.

- **Each gastric gland has three distinct regions: the isthmus, neck, and base**

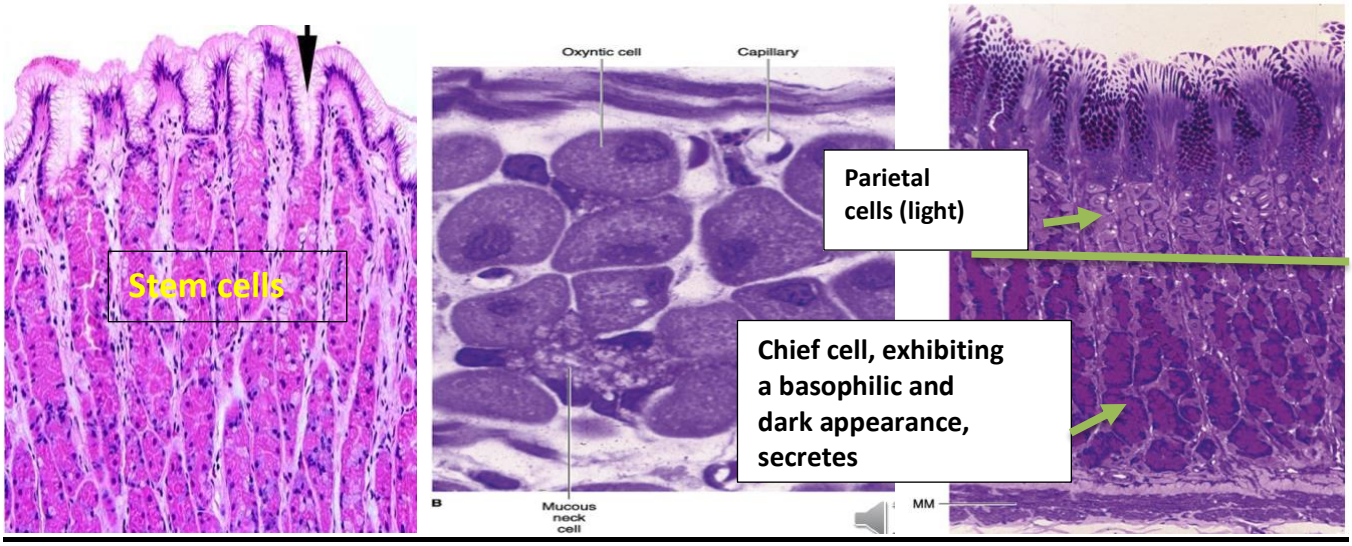


Again, gastric pits are characterized by their short and wide structure, while gastric glands are thicker and more numerous compared to the pits.

- **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) mucous is very numerous in the neck, 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.**

-Parietal cells are primarily concentrated in the neck and upper portion of the body.

So, chief cells are in the base (at the bottom), patietal cells are upwards and stem cells are at the middle (moving upwards and downwards)



Stem Cells

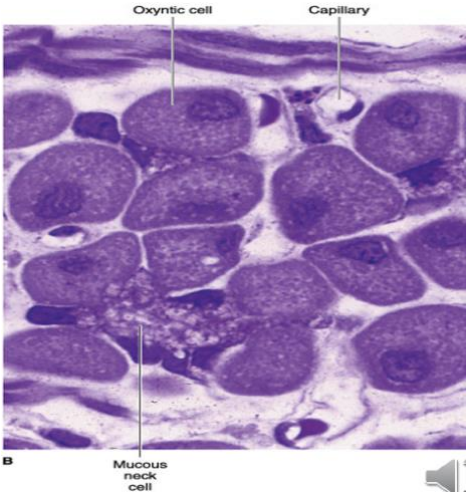
- **Found in the isthmus and neck regions but few in number stem cells are low columnar cells with oval nuclei near the bases of the cells**
- **These cells have a high rate of mitosis and concentrated in the middle, some of them move upward to replace the pit and surface mucous cells, which have a turnover 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.**

Mucous Neck Cells

- ***Mucous neck cells are present in clusters or as single cells between parietal cells in the necks of gastric glands.***

*** The foamy appearance of Mucous Neck Cells occurs when the mucus dissolves during slide preparation.**

- **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, and acidophilic so they appear faint.**

• **They are rounded or pyramidal cells, with one centrally placed spherical nucleus and intensely eosinophilic cytoplasm and may be binucleated (2).**

-Parietal cells have two stages: Active and Resting.

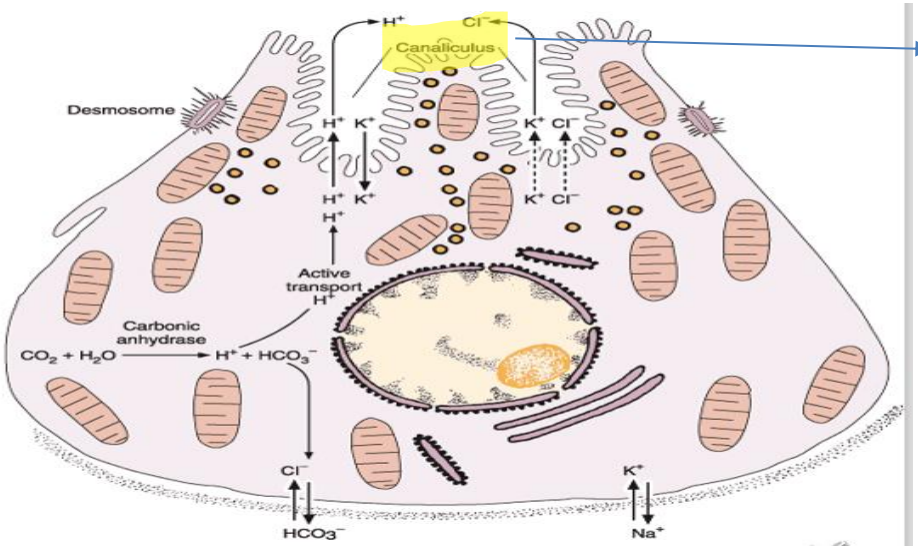
1) Active stage: The most striking features of the active secreting cell seen in the electron microscope are an abundance of mitochondria and a deep, circular invagination of the apical plasma membrane, forming the intracellular canaliculus and secreting HCL.

2) Resting stage: In the resting cell, a number of tubulovesicular structures can be clearly seen in the apical region just below the plasmalemma, at this stage, the cell has few microvilli

So, when they form intracellular canaliculi that means these cells are in the active stage and are secreting HCl. While when they form vesicles, it means that they're in the resting stage

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

Parietal cells secrete hydrochloric acid.

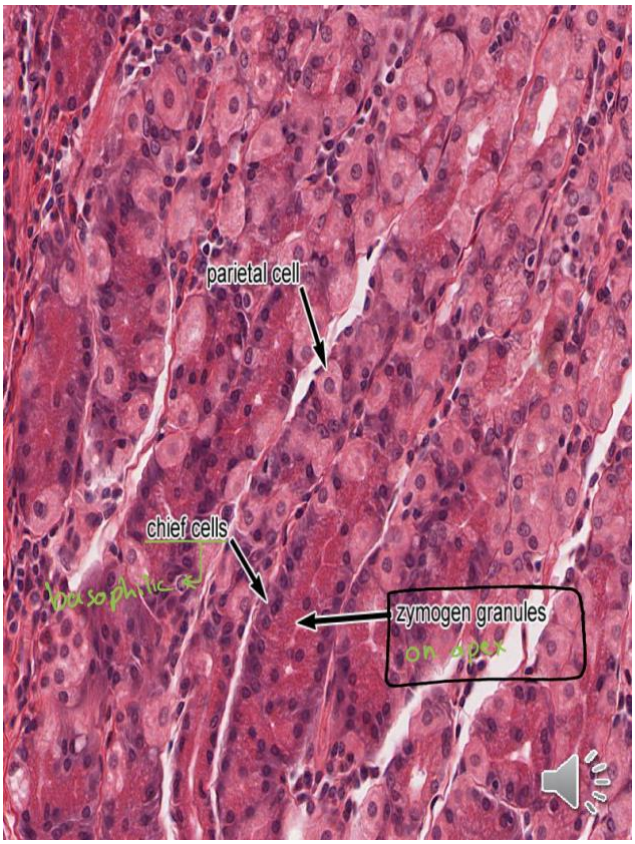


Indicates active stage.

-Biochemistry part: (Dr didn't give this part any attention)

- **The ion H+ originates from the dissociation of the H2CO3 produced by the action of carbonic anhydrase, an enzyme abundant in oxyntic cells**
- **Once produced, H2CO3 dissociates in the cytoplasm into H+ and HCO32**
- **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



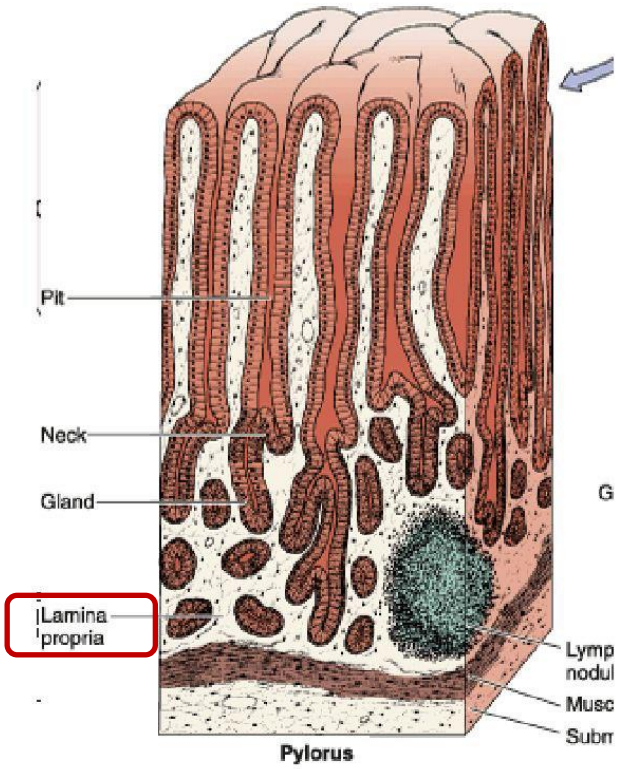
- Chief cells predominate in the lower region of the tubular glands.
- Characteristics of protein-synthesizing and - exporting cells.
- Their basophilia is due to the abundant rough endoplasmic reticulum. The granules in their cytoplasm contain the inactive enzyme pepsinogen which it secretes. Zymogen granules are in the apex.
- 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.
- It has secretory granules and a large nucleus.
- In the fundus of the stomach, 5-hydroxytryptamine (serotonin) is one of the principal secretory products.
- It secretes either Serotonin or Gastrin hormones.

- In the stomach the G—pylorus cells produces Gastrin that lead to the Stimulation of gastric acid secretion and Gastric mucosal growth.

The doctor has only mentioned the sentence in black, but it would be better if we read the underlined ones

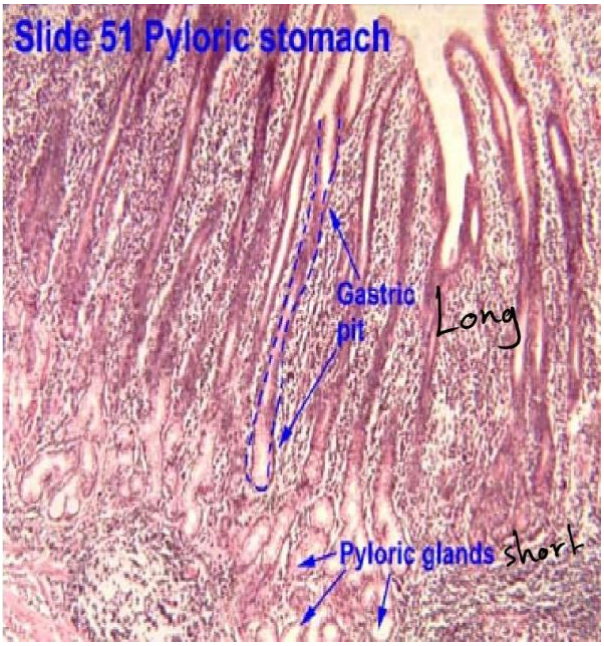


PYLORUS

- Has deep gastric pits into which the branched, tubular pyloric glands open.
- Compared with the glands in the cardiac region, pyloric glands have longer and narrow pits and shorter coiled secretory portions.
- These glands secrete mucus as well as appreciable amounts of the enzyme lysozyme.
- There are no Chief cells neither Parietal cells, most of the cells are mucus cells to neutralize the acidity of the chyme before it reaches the duodenum.
- Gastrin (G) cells (which release gastrin) are enteroendocrine cells intercalated among the mucous cells of pyloric glands.

- Lymphocytes are scattered throughout the GI tract, but they tend to aggregate in the lamina propria of the pylorus —> forming lymphatic nodules, which is exclusive for the pylorus.

- 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.

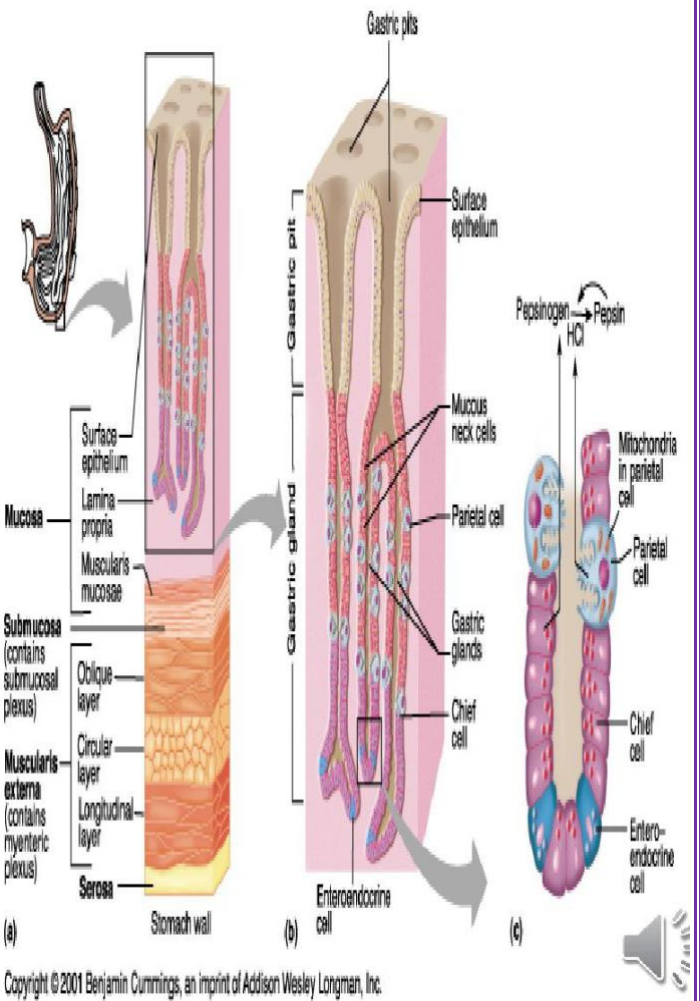


- **Secretion of somatostatin is stimulated by HCl, counterbalancing the acid secretion.**
- **Myenteric plexus and Meissner's plexus innervate glands and smooth muscles.**

OTHER LAYERS

THE DOCTOR READ THE PICTURE ONLY

- **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.**



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Small Intestine

- **The lining epithelium is simple columnar epithelium with goblet cells. Goblet cells increase when moving distally and they're very numerous in the large 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**
- **Something special about small intestine is that there are finger like projections called (intestinal villi) to increase the surface area for absorption.**
- **The small intestine is relatively long—approximately 5 m—and consists of three segments: the duodenum, jejunum, and ileum and it's important to differentiate between them.**

Some distinctive characteristics for each part:

Duodenum:

- **The intestinal villi in the duodenum are leaf like projections.**
- **Surface cells of the duodenum have microvilli (brush surface) that increase the surface area, it's prominent in the duodenum but also can be found in jejunum and ileum.**

Jejunum:

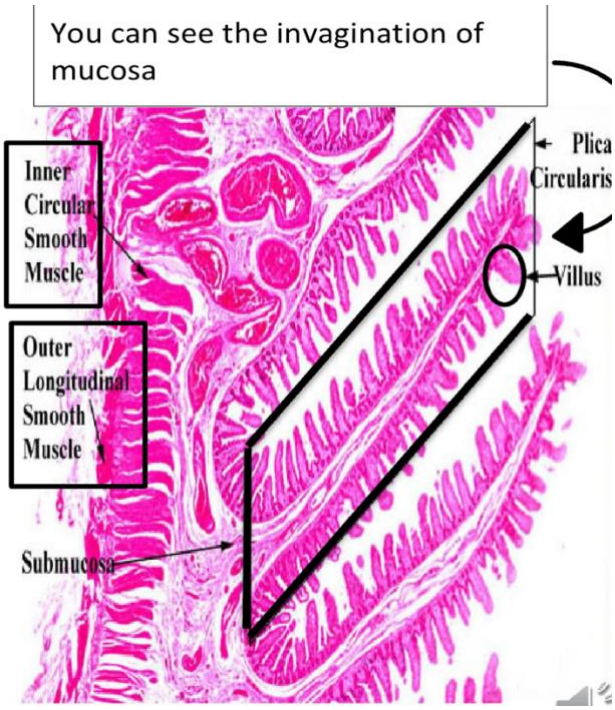
- **Submucosa makes invaginations through the mucosa -like the rugae of the stomach- and we call them plicae circulares that increase the surface area.**

Ileum:

- **Lamina propria has prominent lymphatic nodules, which are called Peyer's patches.**

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.

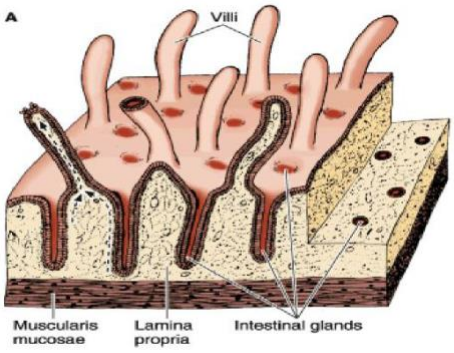


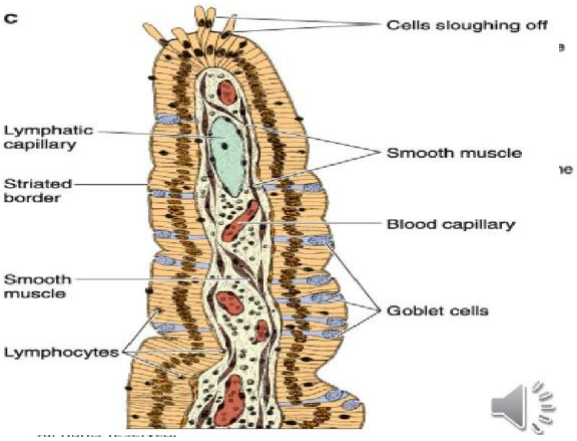
- Intestinal villi (on the lateral side of plicae circulares) are 0.5- to 1.5-mm-long outgrowths of the mucosa (epithelium plus lamina propria) projecting into the lumen of the small intestine.
- In the duodenum they are leaf shaped, gradually assuming fingerlike shapes as they reach the ileum.

- Between the villi are small openings of simple tubular glands called intestinal glands (also called crypts), or glands of Lieberkühn in the base (lamina propria)
- The gland is lined with simple columnar epithelium with goblet cells, so goblet cells are on the surface and within the galnds.
- The epithelium of the villi is continuous with that of the glands.
- In the base of intestinal crypts, there are cells called Paneth's cells (only found in the small intestine).
- The intestinal glands contain stem cells, some absorptive cells, goblet cells, Paneth's cells, and enteroendocrine cells.

- **No parietal nor chief cells in intestine.**

- **Most of the cells of intestinal glands are specialized for absorption.**
- **So, the components of mucus differ among stomach and intestine, in stomach, its main function is protection while in the small intestine it helps in absorption.**





In some books they refer to the mucosa of small intestine as fingers, upper half→villi, lower half→glands, both are connected with each other.

Upper half (villi):

Simple columnar epithelium with goblet cells.

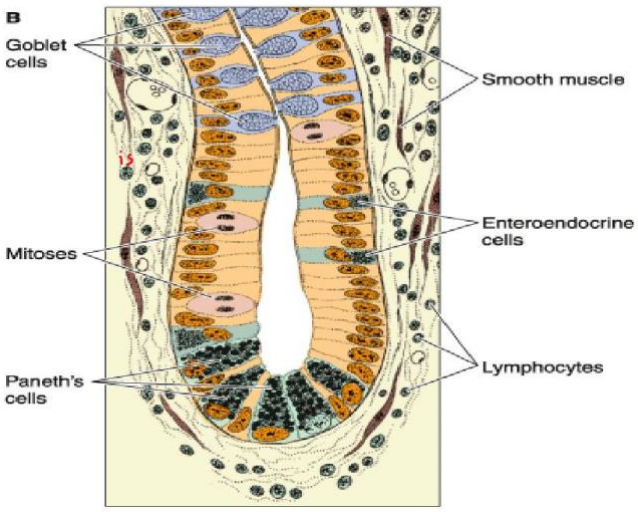
In the lamina propria there are capillaries, smooth muscles, and lacteal.

Lacteal: blind lymphatic vessels, and it is important in the absorption of fat.

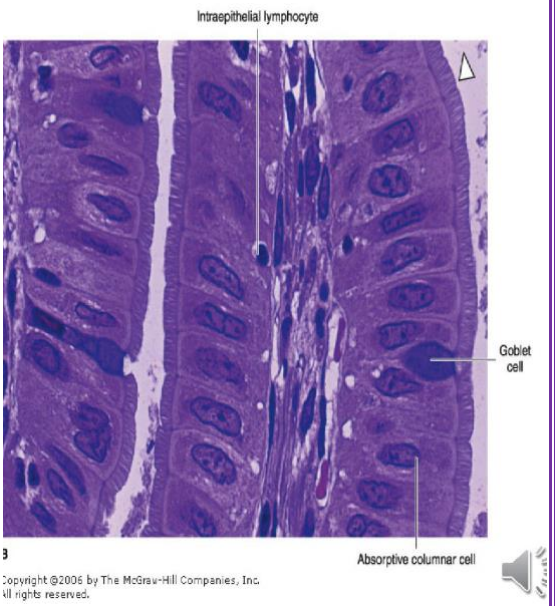
When we said that the lamina propria is a loose connective tissue, that means that it also has fibrocytes, fibroblastsand macrophages since these are the components of any loose connective tissue.

Lower half (glands):

- **In the wall, there are smooth muscles.**
- **Simple columnar epithelium.**
- **Goblet cells.**
- **Paneth's cells are in the base, secreting lysozymal enzymes (antibacterial) which are prominent in Jejunum.**
- **Mitosis by stem cells.**
- **Enteroendocrine cells secrete gastrin hormone.**

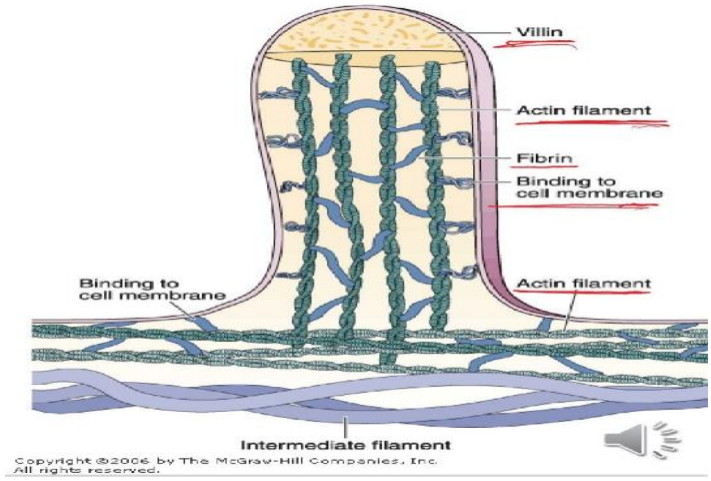


- **Absorptive cells or enterocytes are tall columnar cells, each with an oval nucleus in the basal half of the cell.**
- **At the apex of each cell is a homogeneous layer called the striated (brush) border. (Microvilli)**
- **When viewed with the electron microscope, the striated border is seen to be a layer of densely packed microvilli.**
- **Each absorptive cell is estimated to have an average of 3000 microvilli, and 1 mm^2(ملي تربيع) of mucosa contains about 200 million of these structures.**



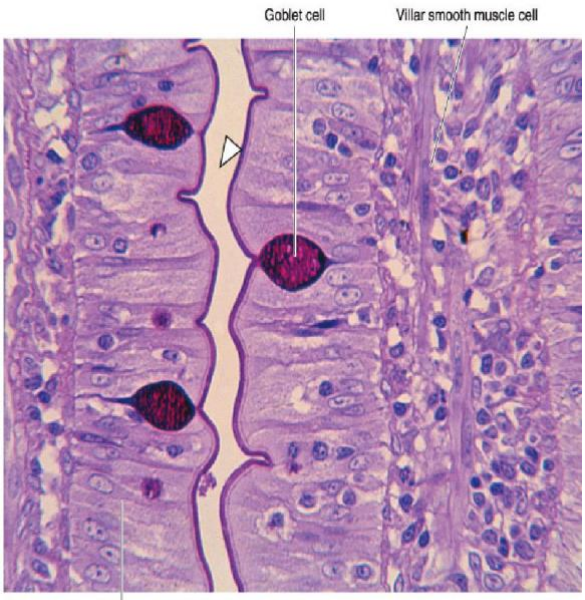
STRUCTURE THE DOCTOER SAID IT IS NOT VERY IMPORTANT

- **Each microvillus is a cylindrical protrusion of the apical cytoplasm that is approximately 1 m tall by 0.1 m 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 m2**



GOBLET CELLS

- 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. **Helps in absorption in the small intestine.**



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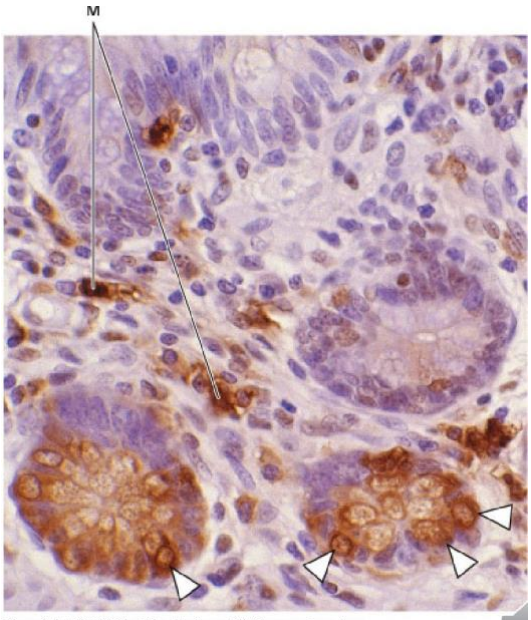
PANETH'S CELLS

- **Acidophilic cells, secretes Lysozyme.**
- 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.



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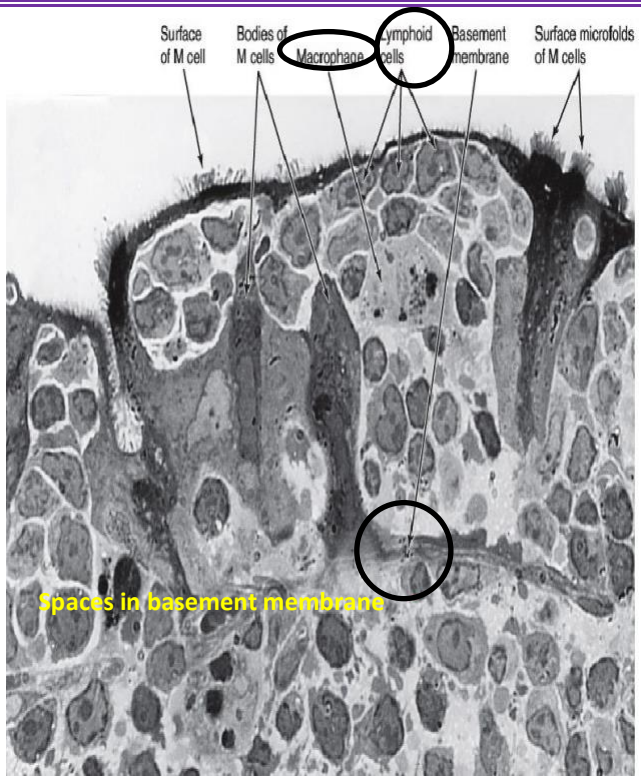
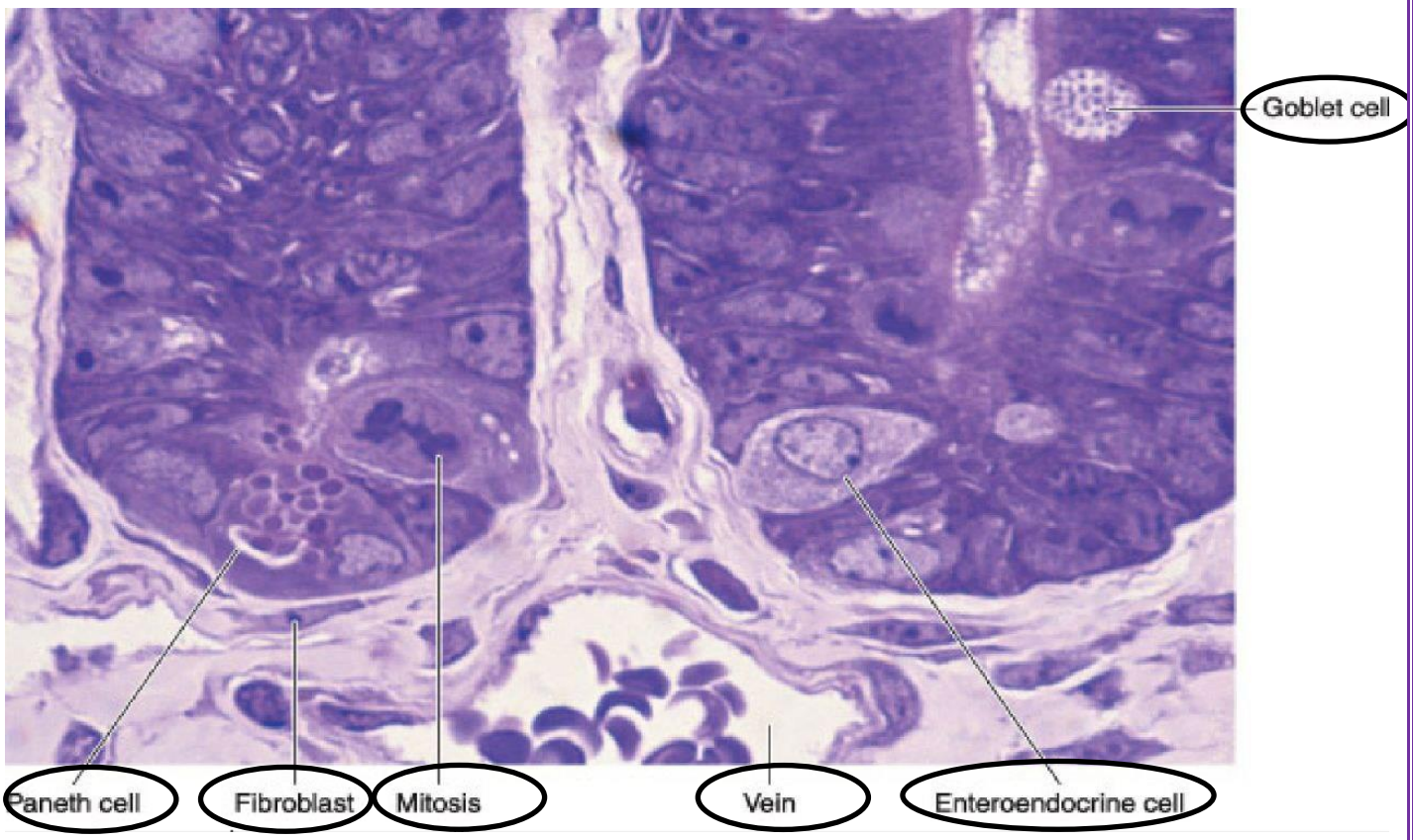
M (MICROFOLD) CELLS

- **Prominent in ileum.**
- 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).
- **There are spaces in the basement membrane for the passage of lymphocytes and macrophages.**

- **Lymphocytes and macrophages enter the cytoplasm of M cells.**
- **Then they reach the surface and engulf bacteria and foreign bodies, also it could help in antibody secretion and initiation of an immune response by delivering antigens to lymphocytes.**
- **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 are consider as part of immune system)**

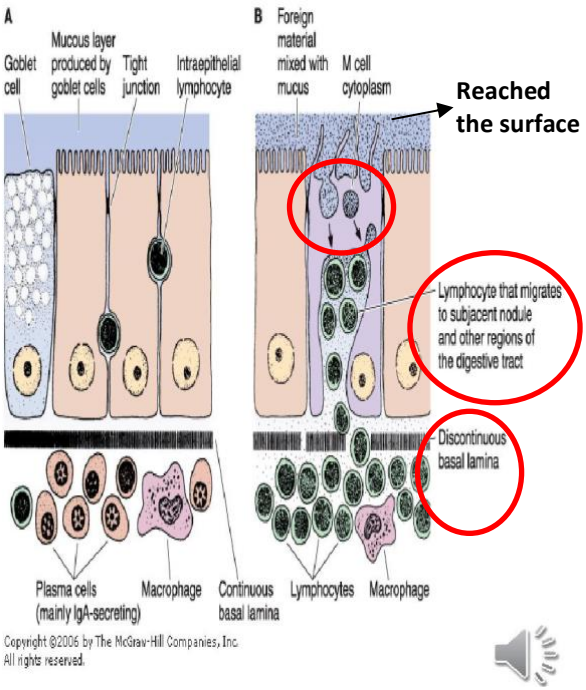


- **M cells represent an important link in the intestinal immunological system**
- **basement membrane under M cells is discontinuous, facilitating transit between the lamina propria and M cells.**



According to M cells:

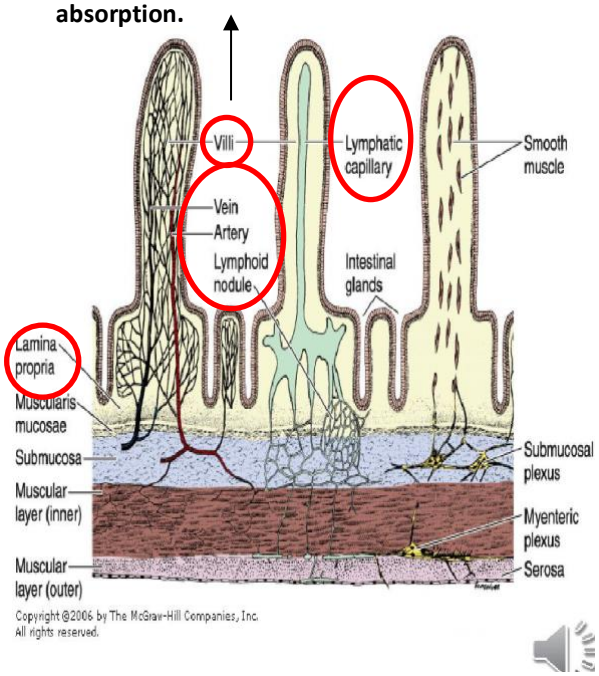
- The very large mucosal surface of the gastrointestinal tract is exposed to many potentially invasive microorganisms
- Secretory immunoglobulins of the IgA are the first line of defense
- Another protective device is the intercellular tight junctions that make the epithelial cells a barrier to the penetration of microorganisms.
- In addition the gastrointestinal tract contains antibody-secreting plasma cells, macrophages, and a very large number of lymphocytes



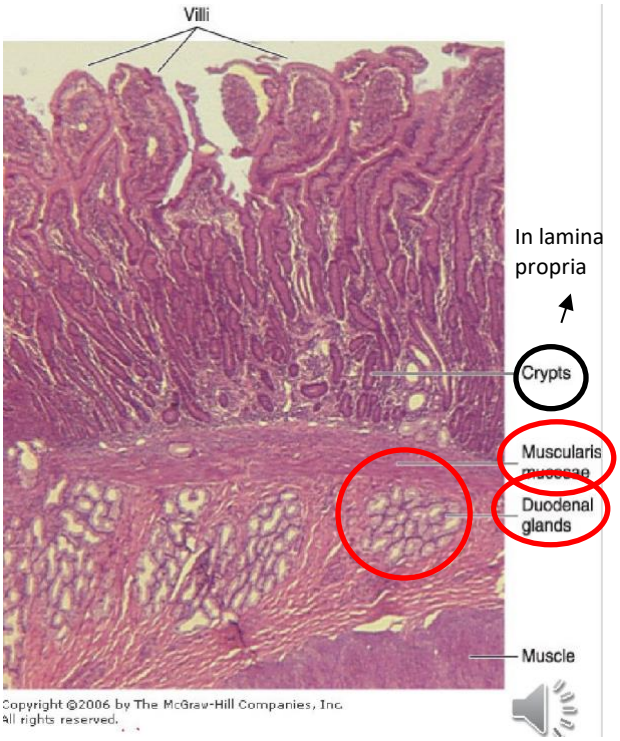
- located in both the mucosa and the submucosa. Together, these cells are called the gut-associated lymphoid tissue (GALT). **M cells are part of GALT and it's important in immunity and help in secreting immunoglobulins as well.**

- 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.

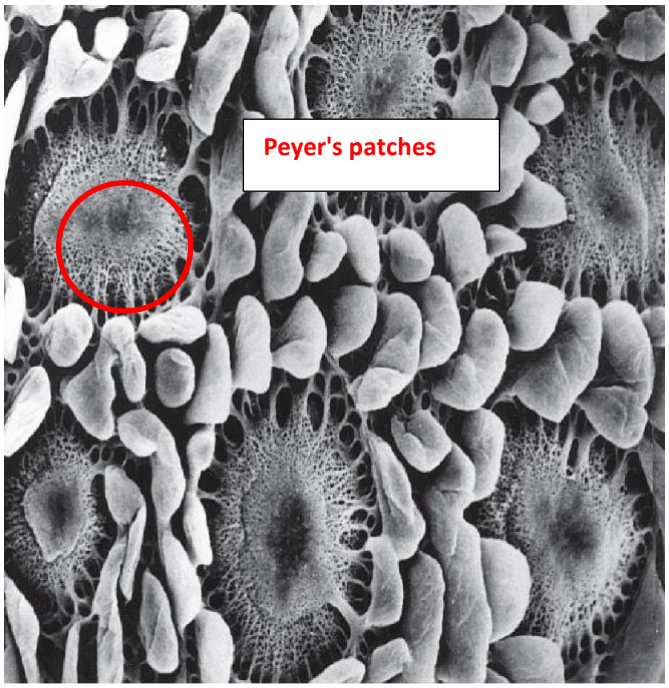
The most important function :Increases the surface area, deliver blood vessels and lymphatics for absorption.



SECTION IN DUODENUM



- Leaf like projections.
- 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 in submucosa.
- So, duodenum is the second organ in the GIT (esophagus is the first) possessing glands in submucosa, why?
- because it receives acidic chyme from stomach, pylorus also make neutralization.
- They Secrete alkaline secretion for neutralization therefore protecting against peptic ulcers.
- 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.
- There are glands (Brunner's gland) in the submucosa
- 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.
- So Peyer's patches and M cells are part of GALT.
- Peyer's patches are prominent in ileum.

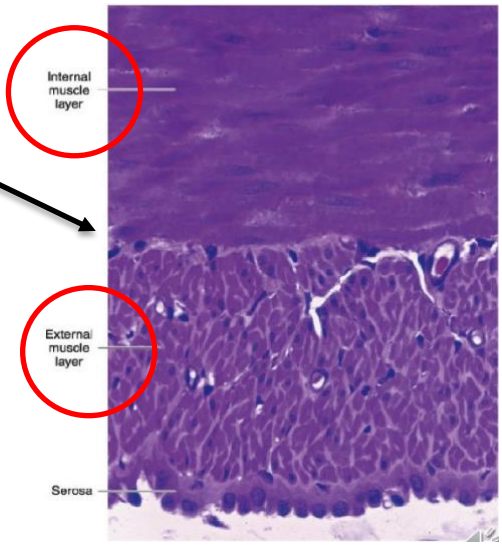


- Each patch consists of 10–200 nodules and is visible to the naked eye as an oval area on the antimesenteric side of the intestine
- There are about 30 patches in humans, most of them in the ileum
- Each Peyer's patch appears as a dome-shaped area devoid of villi
- Instead of absorptive cells, its covering epithelium consists of M cells.

- **Microvilli, villi, and plicae circulares all increase surface area.**

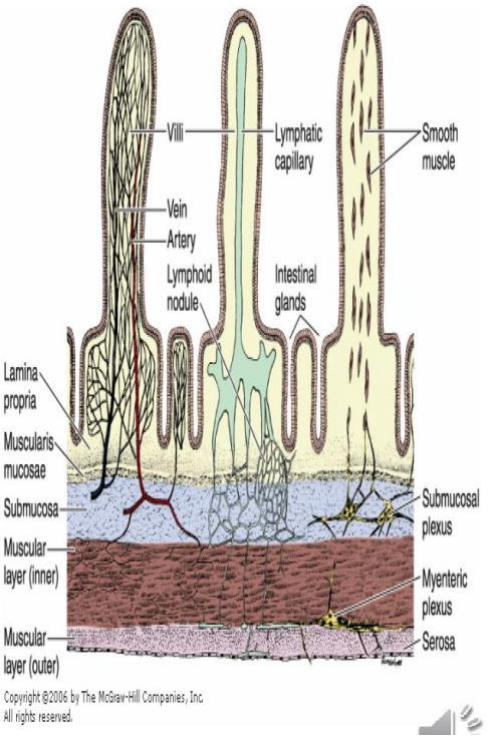
Microvilli increases the surface area by 20 folds, villi by 10 folds, plicae circulares by 3 folds → the overall available are for absorption area is 200 m^2 .

- **The muscularis is well developed in the intestines, composed of an internal circular layer and an external longitudinal layer**
- **myenteric plexus in between.**



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.**



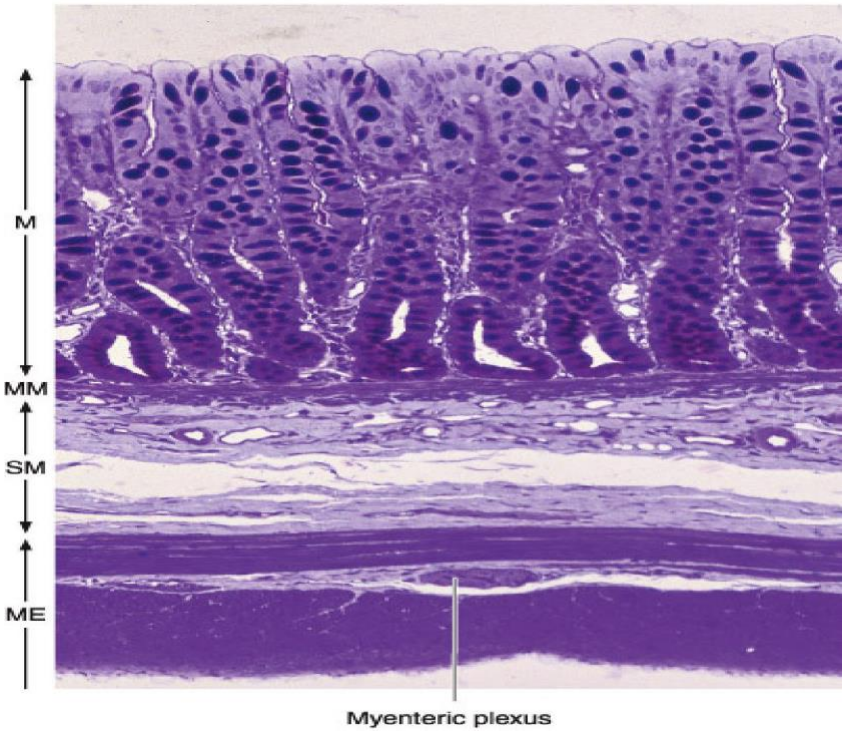
- **Lacteals anastomose repeatedly and leave the intestine along with the blood vessels.**

- 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 , some physiologists call it 'enteric plexus(داخلي)'. It's Parasympathetic, meaning that there is a synapse between the preganglionic fibers of vagus nerve post ganglionic short fibers within the plexus that will eventually innervate glands and smooth muscles.
- Also there are axons and Schwann cells between inner and outer muscles.
- While sympathetic postganglionic fibers emerge from Celiac Ganglion and Superior Mesenteric Ganglion.

- **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.**
- **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.**

وَقُلِ ٱعۡمَلُواْ فَسَيَرَى ٱللَّهُ عَمَلَكُمۡ وَرَسُولُهُۥ وَٱلۡمُؤۡمِنُونَۖ