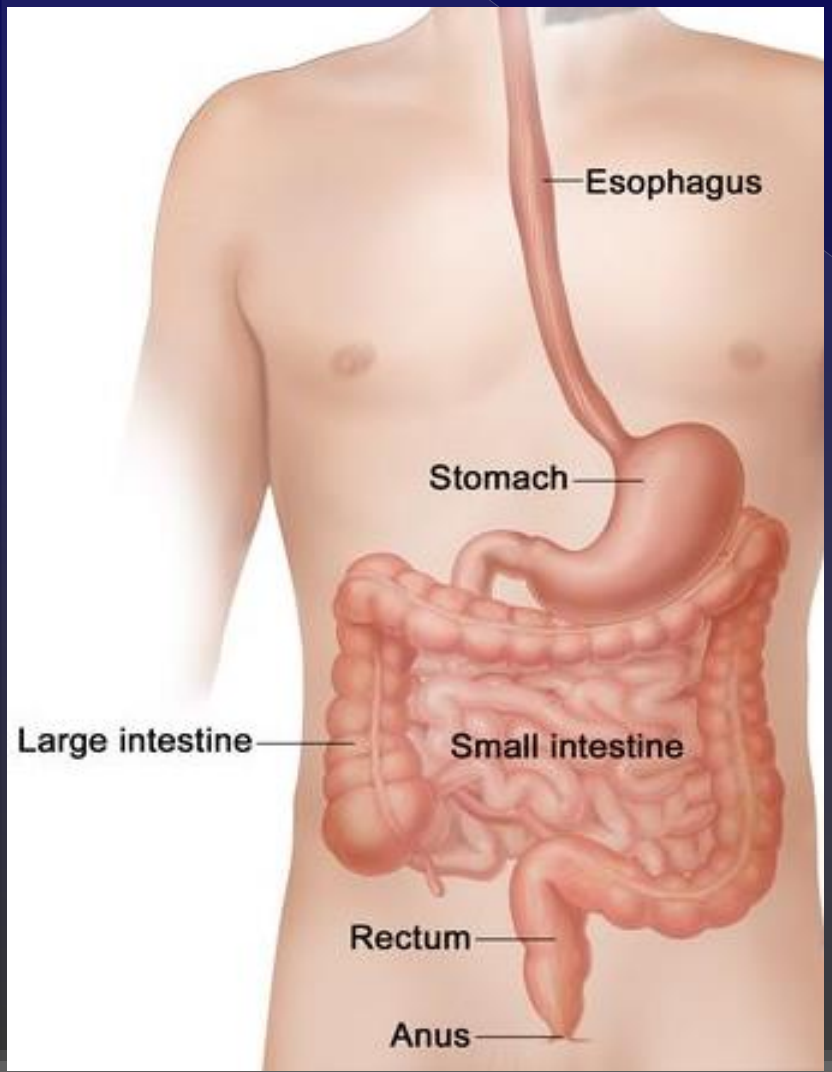
DIGESTIVE SYSTEM (PART 2)

ALIMENTARY CANAL

Functions

- digestion of food
- absorption of nutrients and water
- elimination of indigestible elements of food

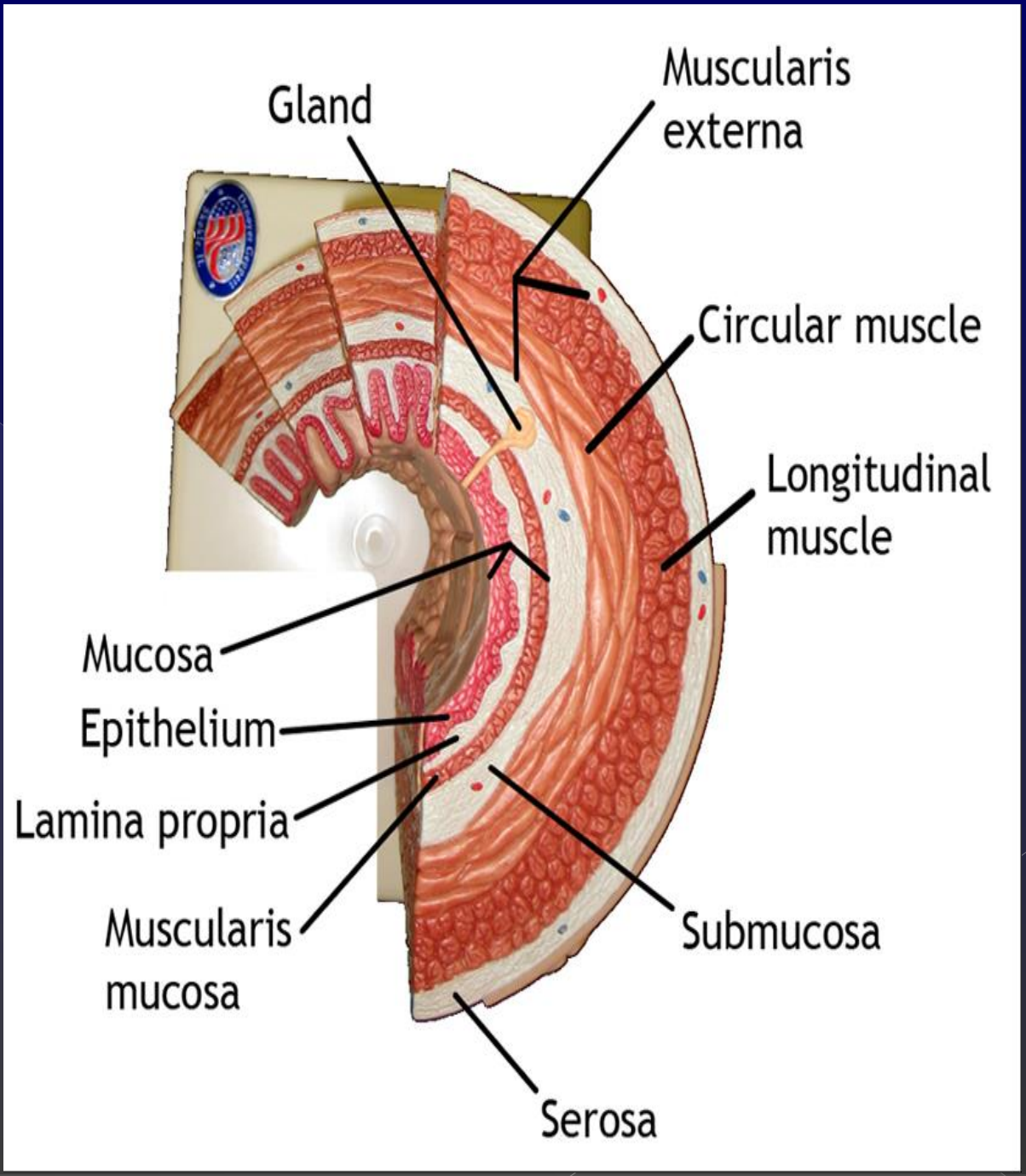
Alimentary Canal



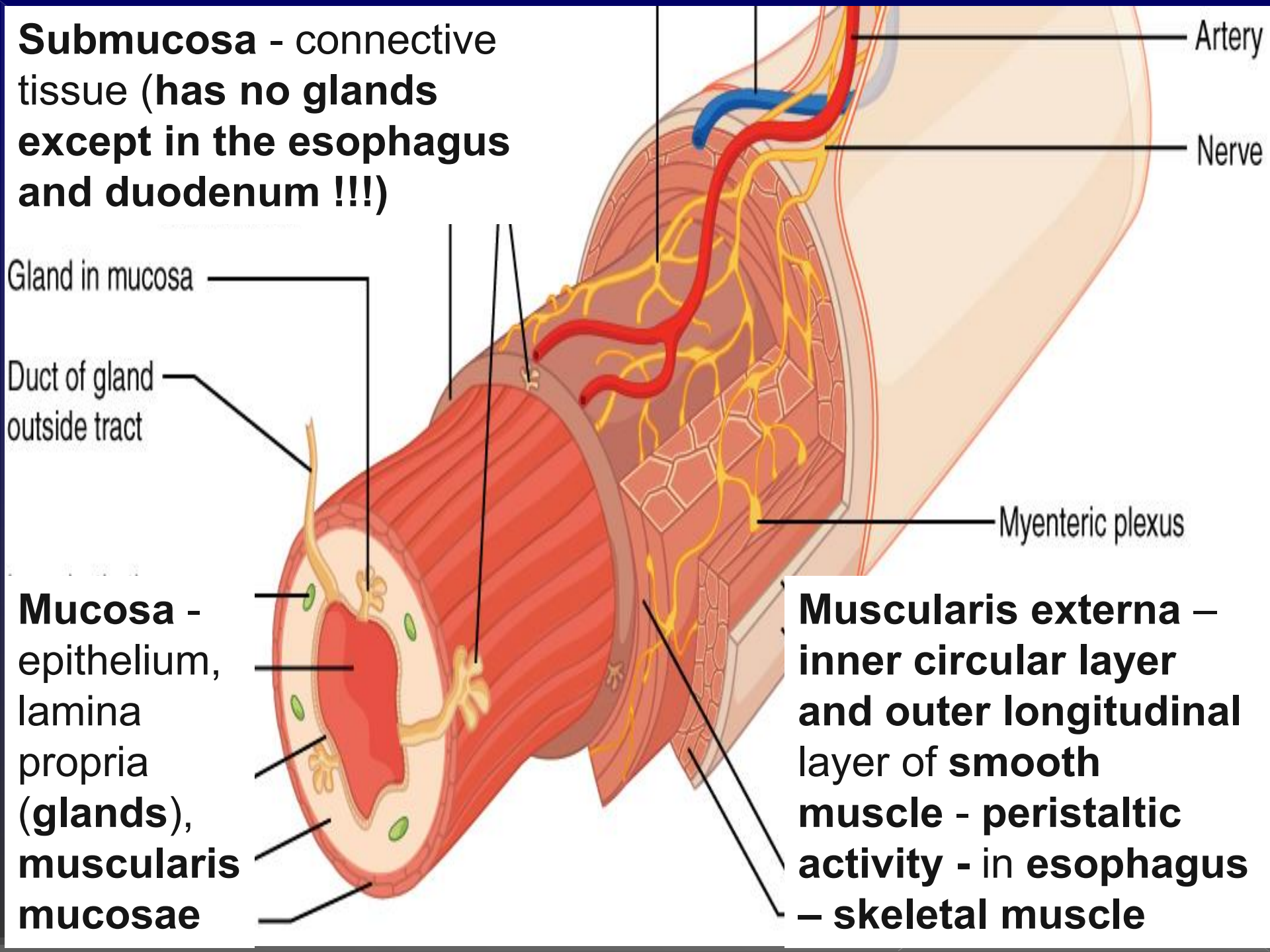
Esophagus
Stomach
Small intestine – Duodenum
Jejunum
Ileum
Large intestine – Cecum
Colon
Rectum
Anal Canal
Appendix

The wall of alimentary canal

- **mucosa**
- **submucosa**
- **muscularis externa**
- **serosa** (simple squamous epithelium – mesothelium, connective tissue) or **adventitia** (connective tissue)



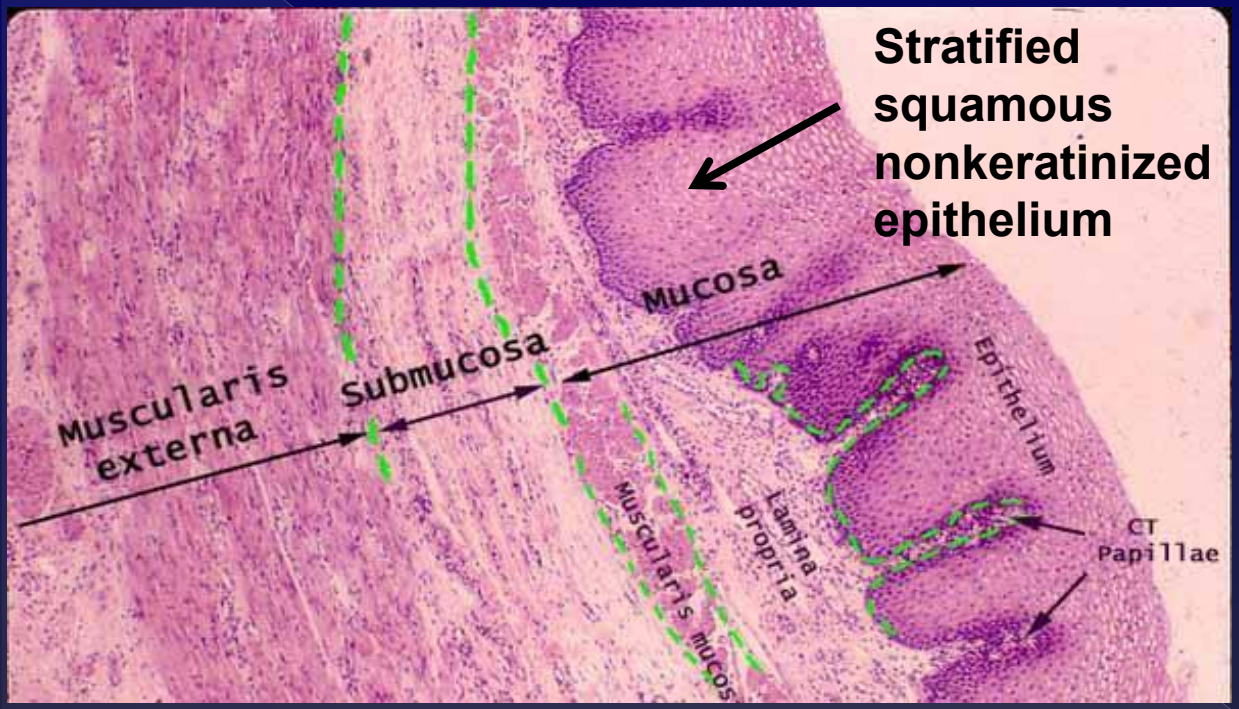
Submucosa - connective tissue (**has no glands except in the esophagus and duodenum !!!)**

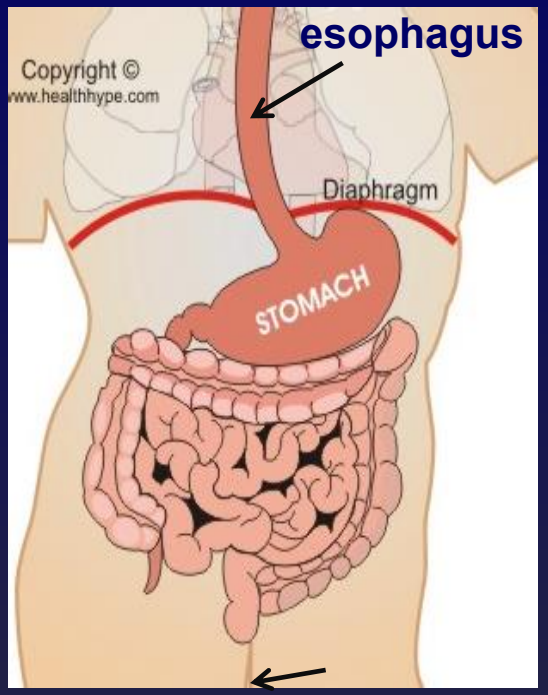


Mucosa - epithelium, lamina propria (**glands**), **muscularis mucosae**

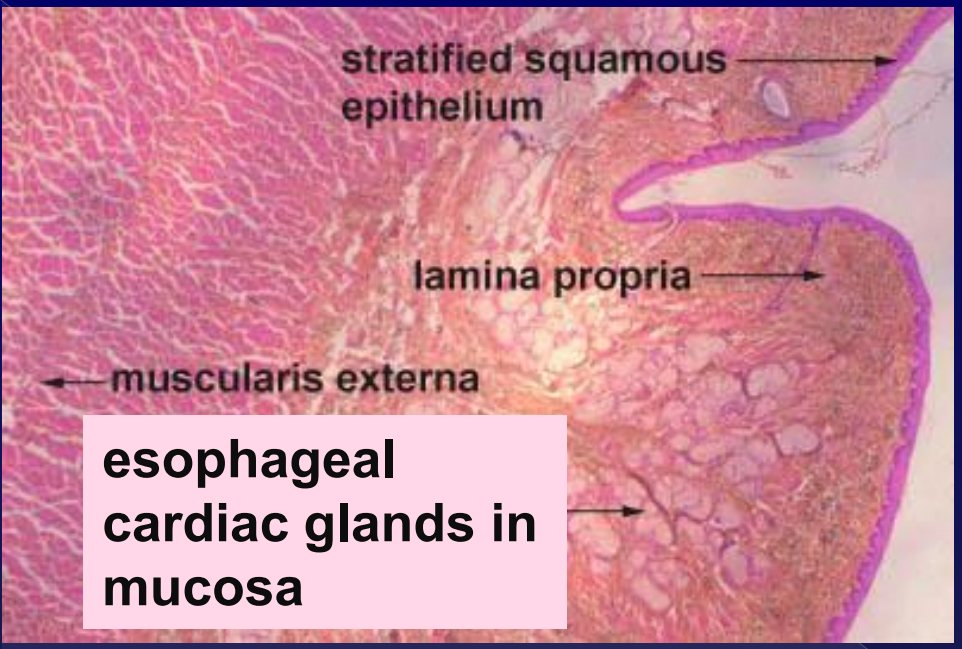
Muscularis externa – **inner circular layer and outer longitudinal** layer of **smooth muscle - peristaltic activity -** in **esophagus – skeletal muscle**

Esophagus - conveys the masticated food (bolus) from oral cavity to the stomach



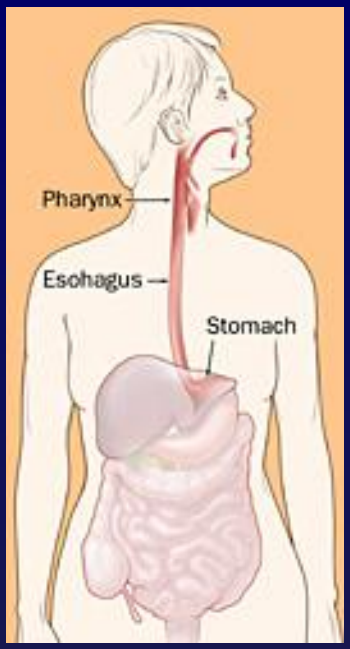


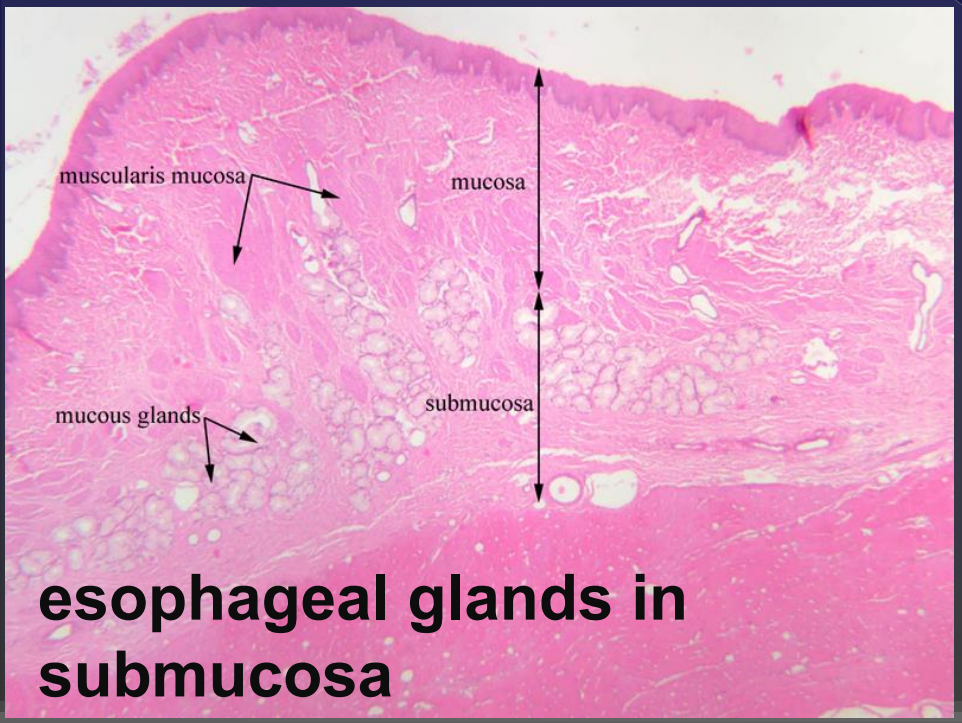
- **Mucosa** (Stratified squamous nonkeratinized epithelium, lamina propria, muscularis mucosae)
- **Submucosa**
- **Muscularis externa**
- Part of the esophagus in the peritoneal cavity - **serosa**, the rest by **adventitia**.



esophageal cardiac glands in mucosa

Lamina propria – near the stomach - **esophageal cardiac glands** - mucus.



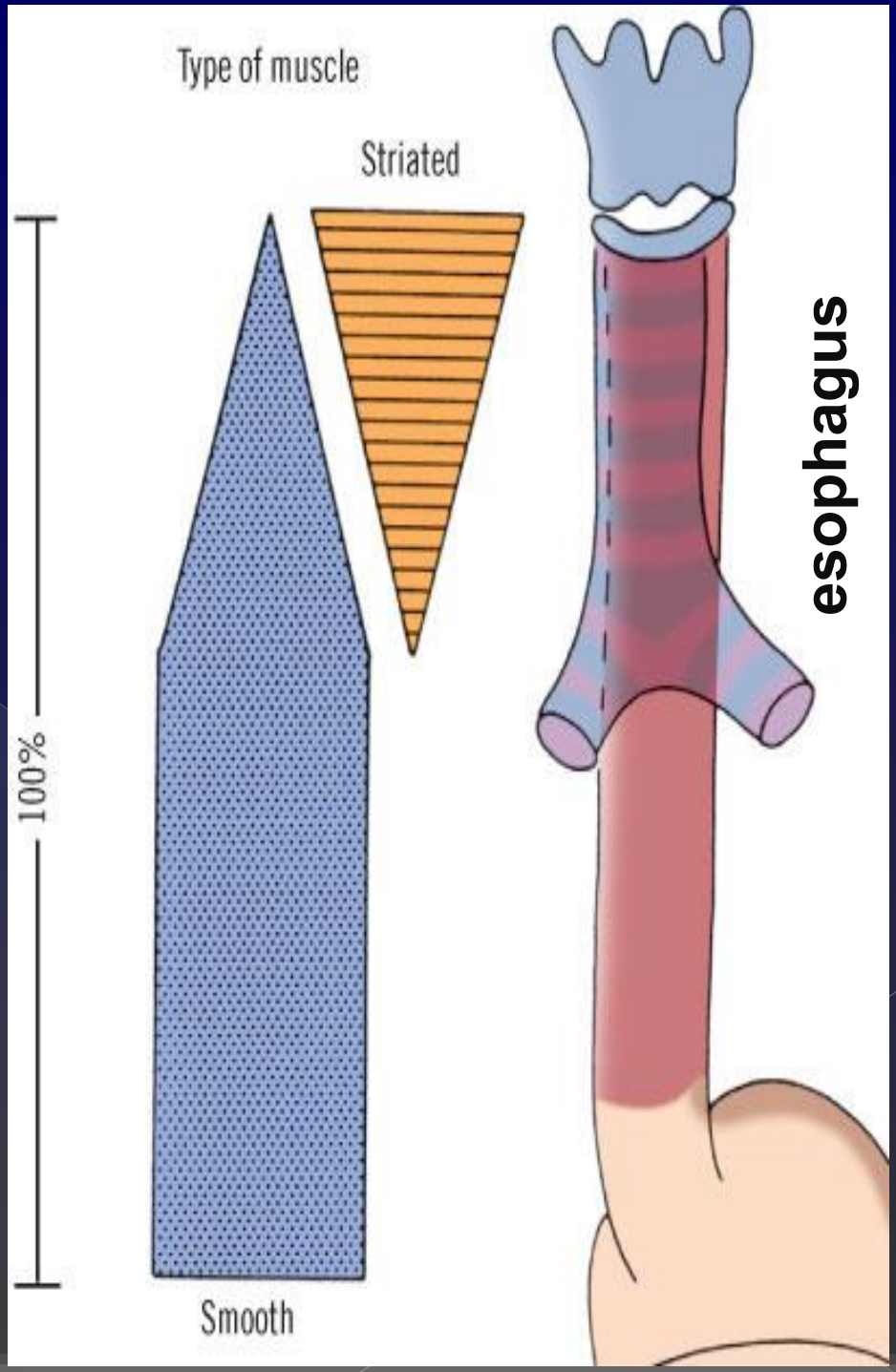


esophageal glands in submucosa

Submucosa – main esophageal glands - mucus and serous cells (**only esophagus and duodenum glands in submucosa).**

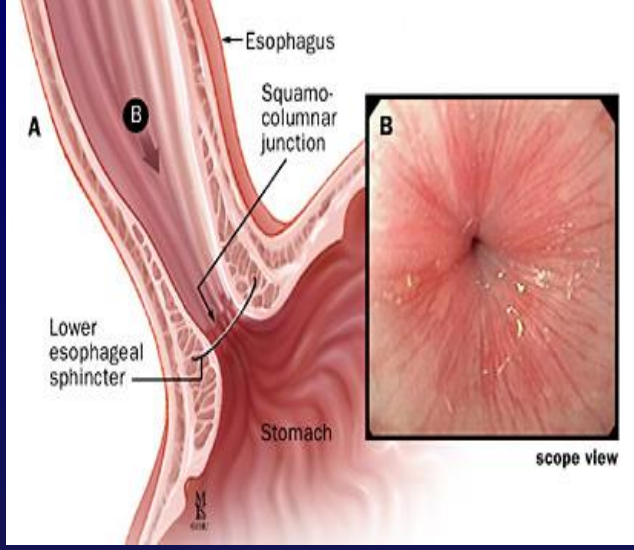
The muscularis externa of the esophagus

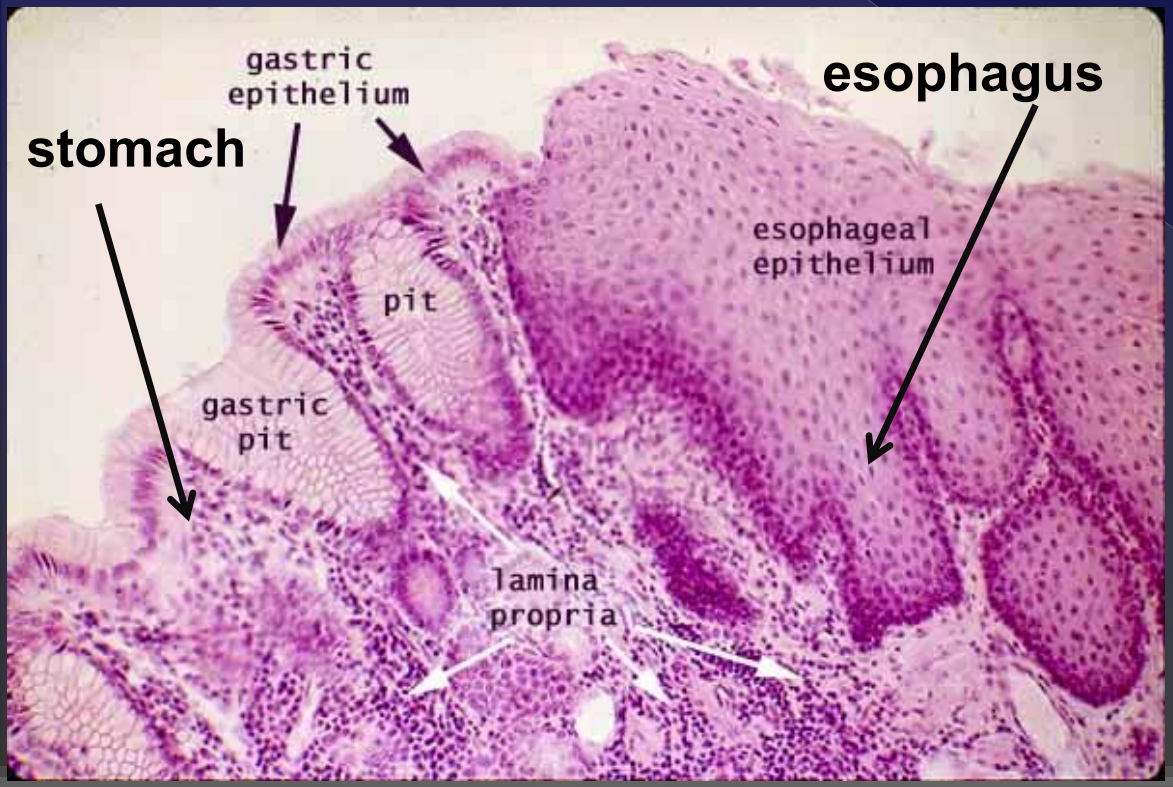
- the **upper third of the esophagus - skeletal muscle (swallowing)**
- the **middle third** - both **skeletal and smooth muscle,**
- the **lowest third** - only **smooth muscle (**inner circular and outer longitudinal)



Gastro-esophageal junction

- abrupt transition between the **nonkeratinized stratified squamous** epithelium of the esophagus and the **simple columnar** epithelium of the stomach





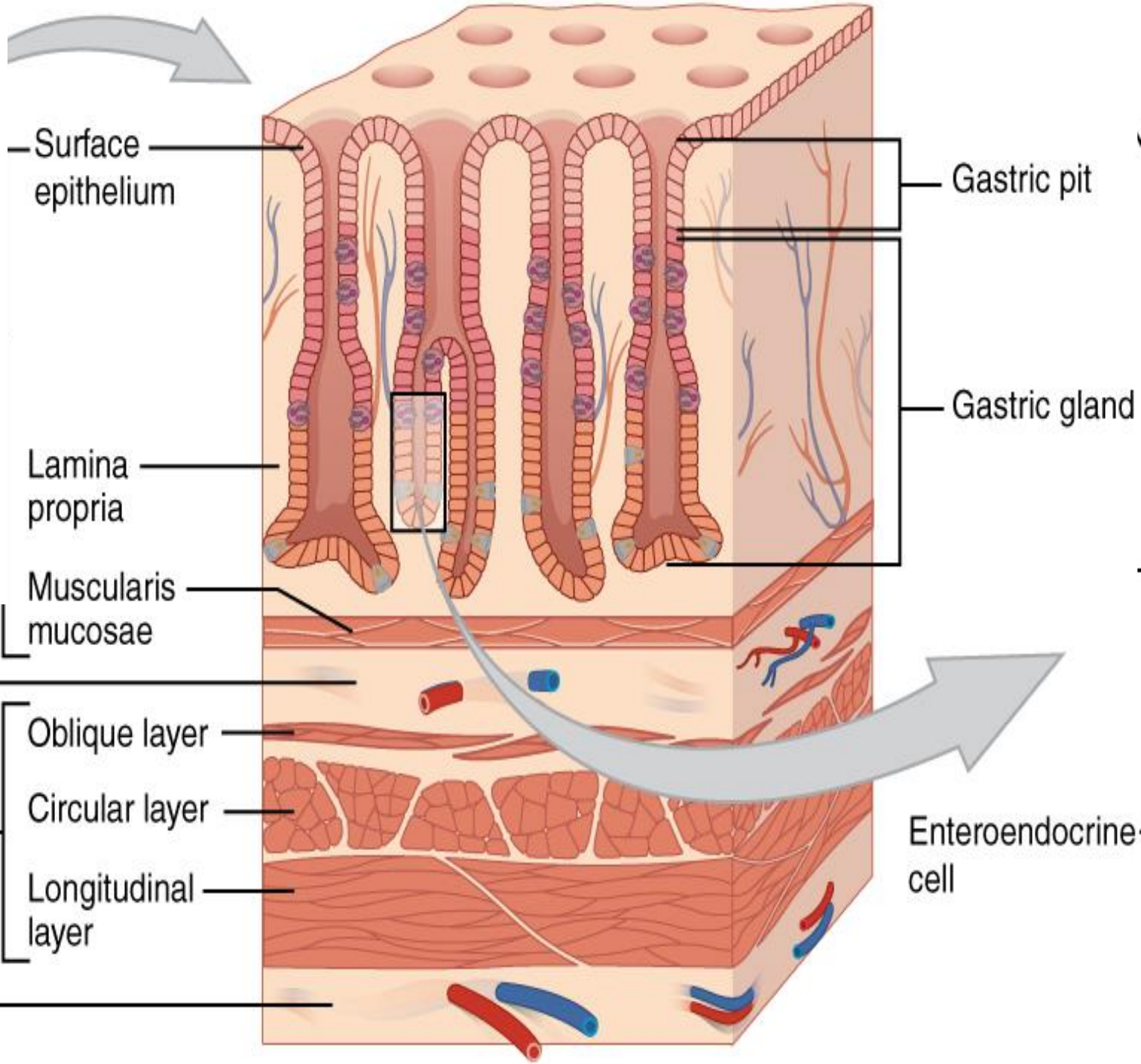
Stomach - the wall

Mucosa – invaginations of epithelium- **gastric pits**. **Lamina propria - gastric glands.**

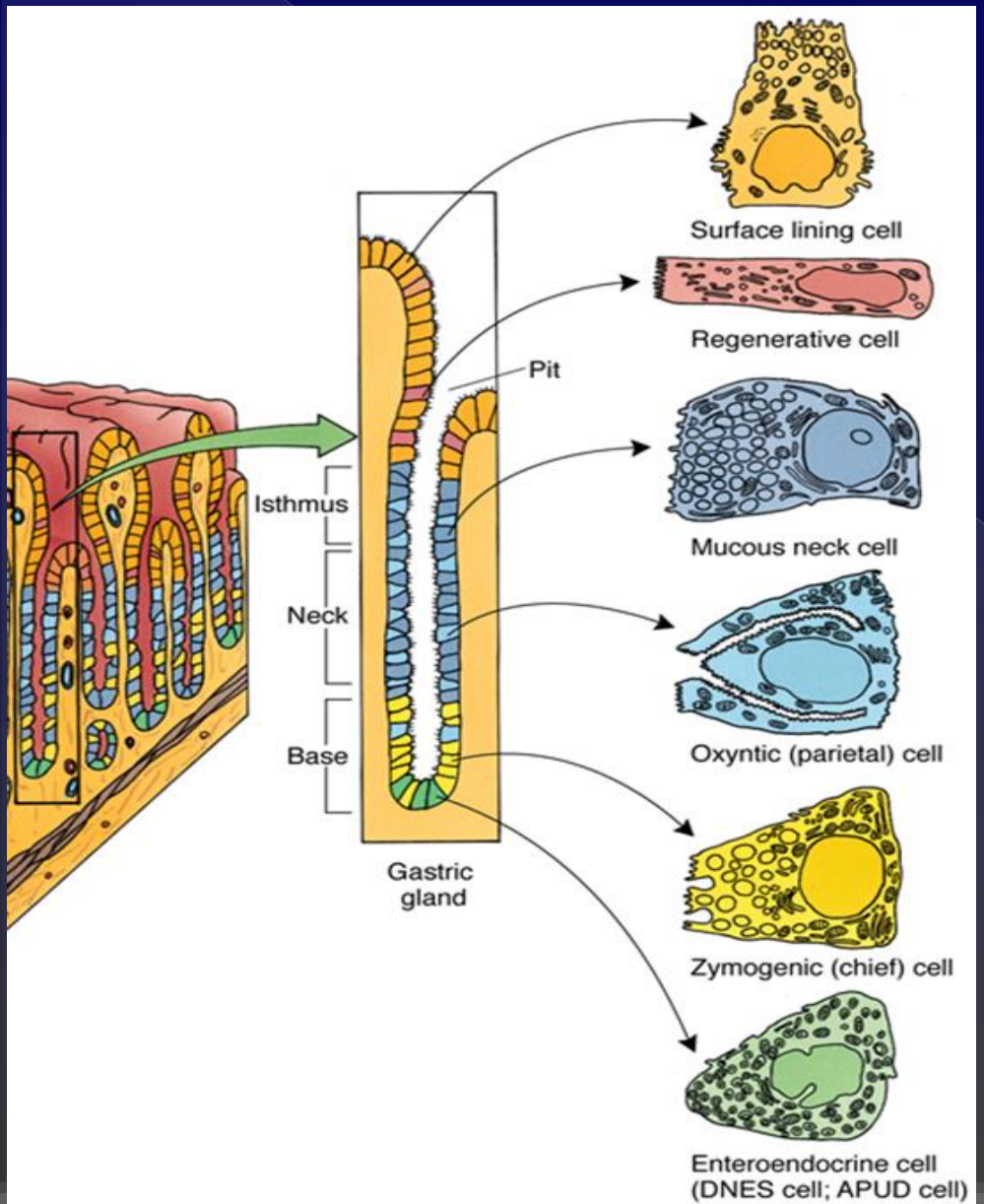
Submucosa

Muscularis externa -
3 layers !

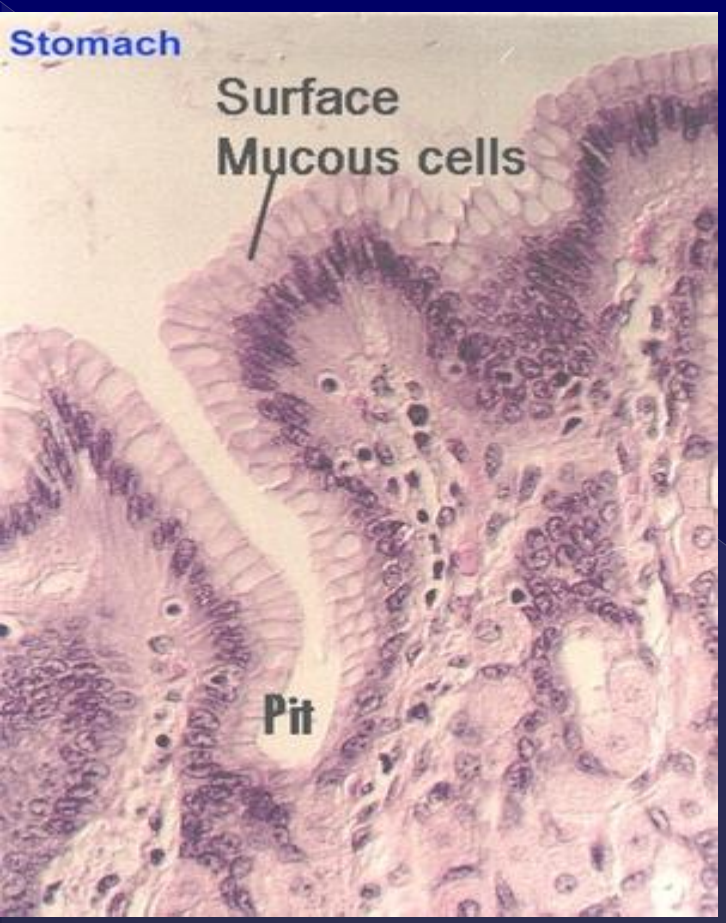
Serosa

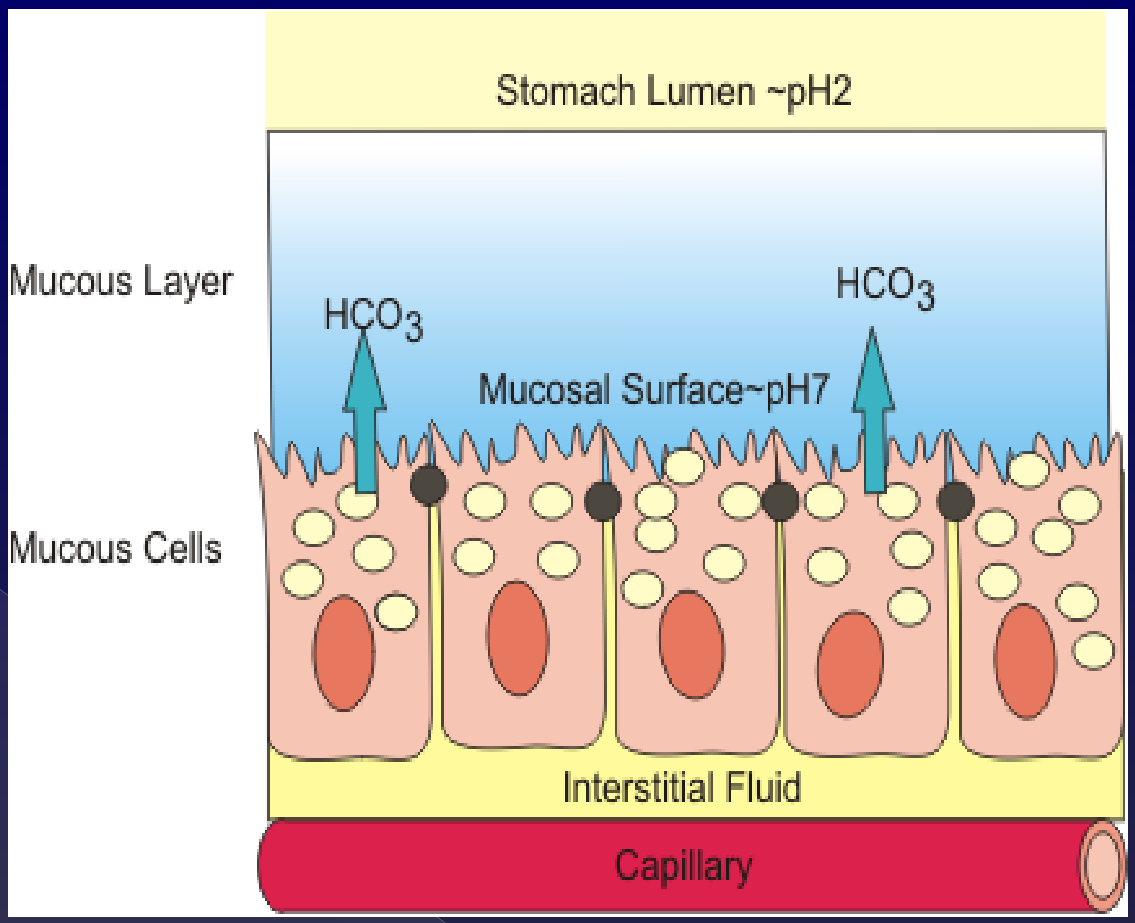


Stomach (fundus and body) - mucosa - gastric glands - simple columnar epithelium - six cell types:



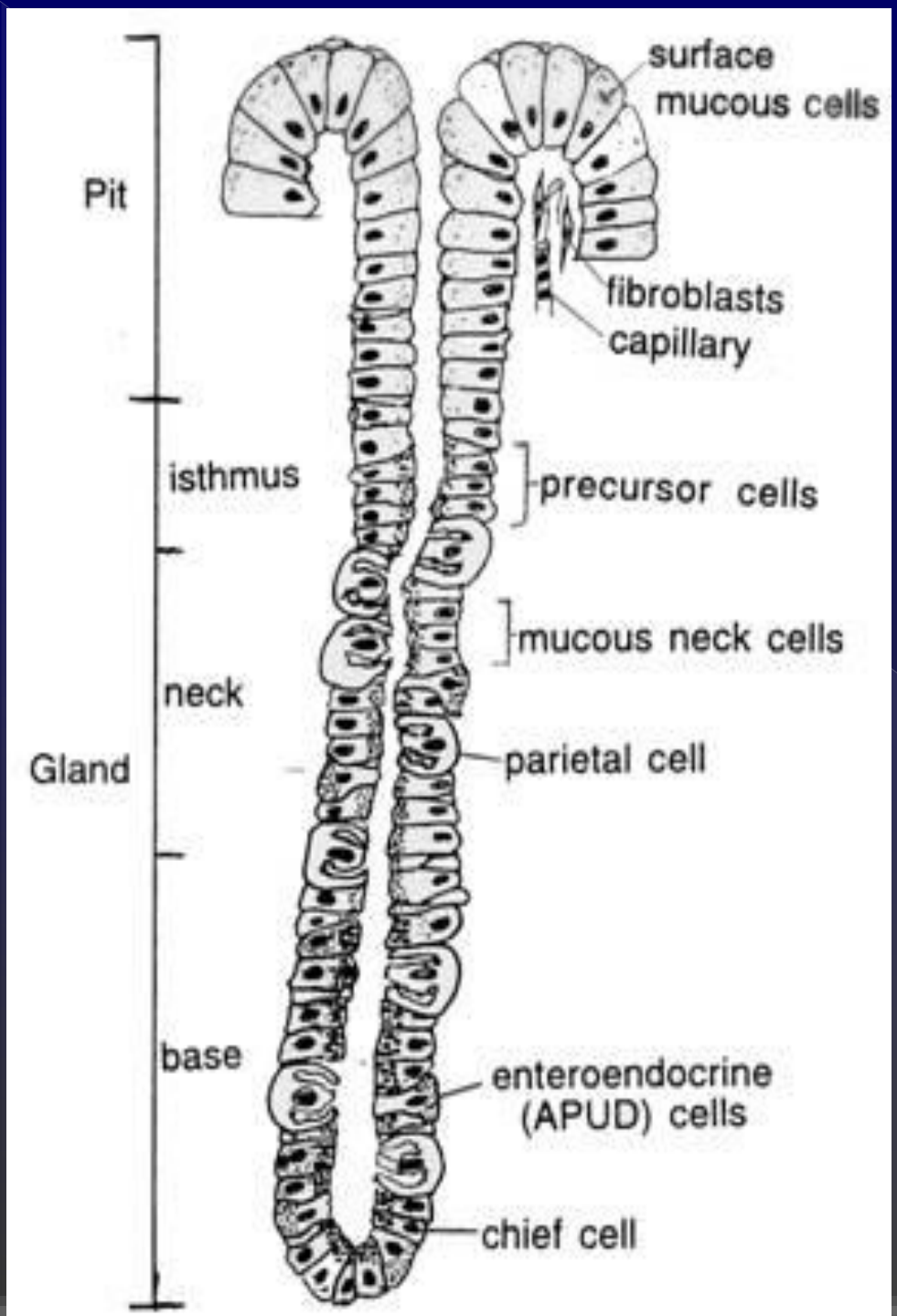
1. **surface lining cells**,
2. **stem** cells,
3. **mucous neck** cells,
4. **parietal** (oxyntic) cells,
5. **chief (zymogenic)** cells,
6. **Enteroendocrine cells (diffuse neuroendocrine system** - DNES) **cells**





surface-lining cells

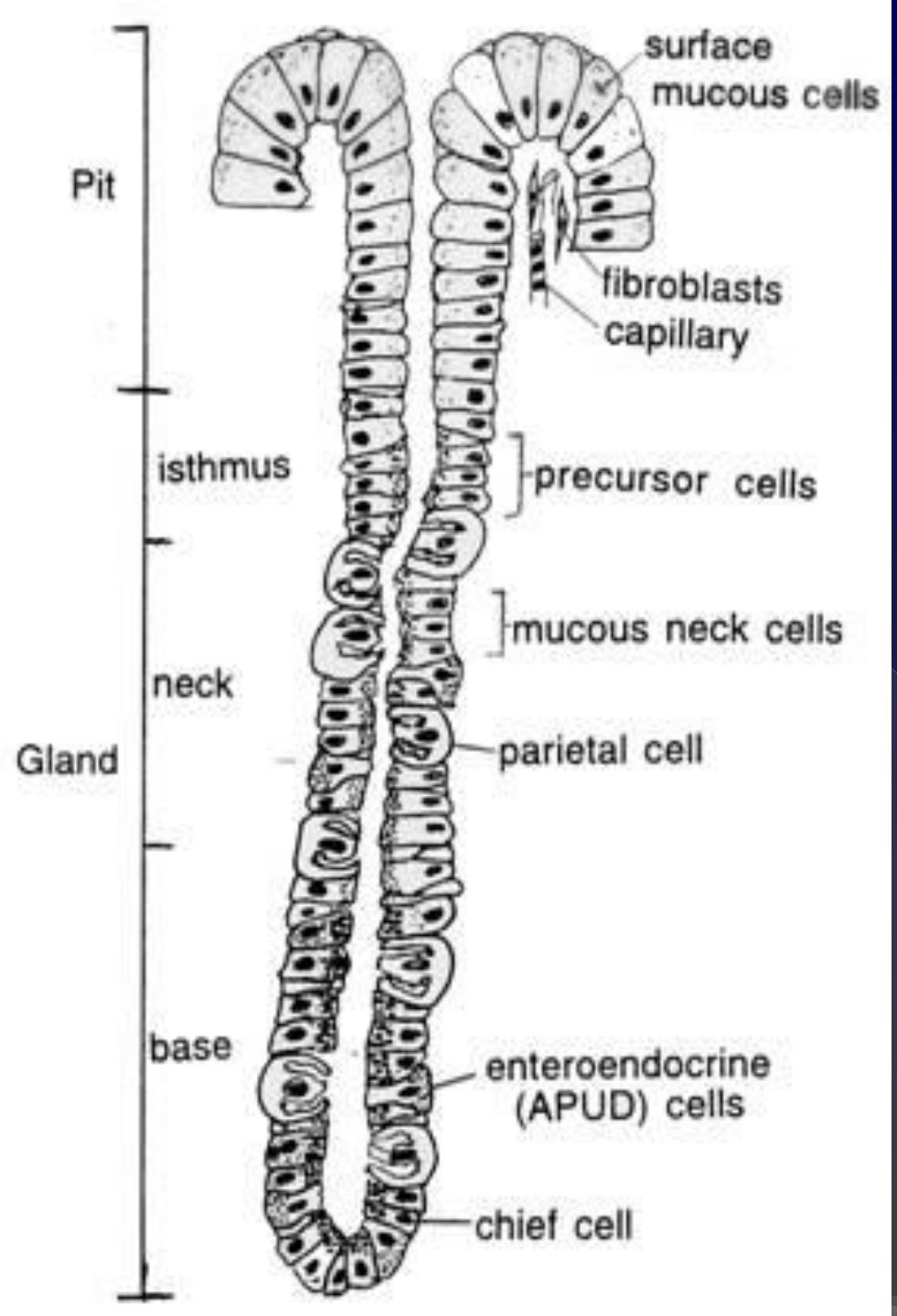
- production **a thick mucus layer - visible mucus**
- gel-like substance containing trapped bicarbonate ions, adheres to the epithelium
- protects from autodigestion and maintains neutral pH.



1. **surface-lining cells - visible mucus**

2. **mucous neck cells - soluble mucus**
   - mixed with the chyme, reducing friction as it moves along the digestive tract

3. **stem cells -** proliferate to replace all of the specialized cells of stomach epithelium every 5-7 days

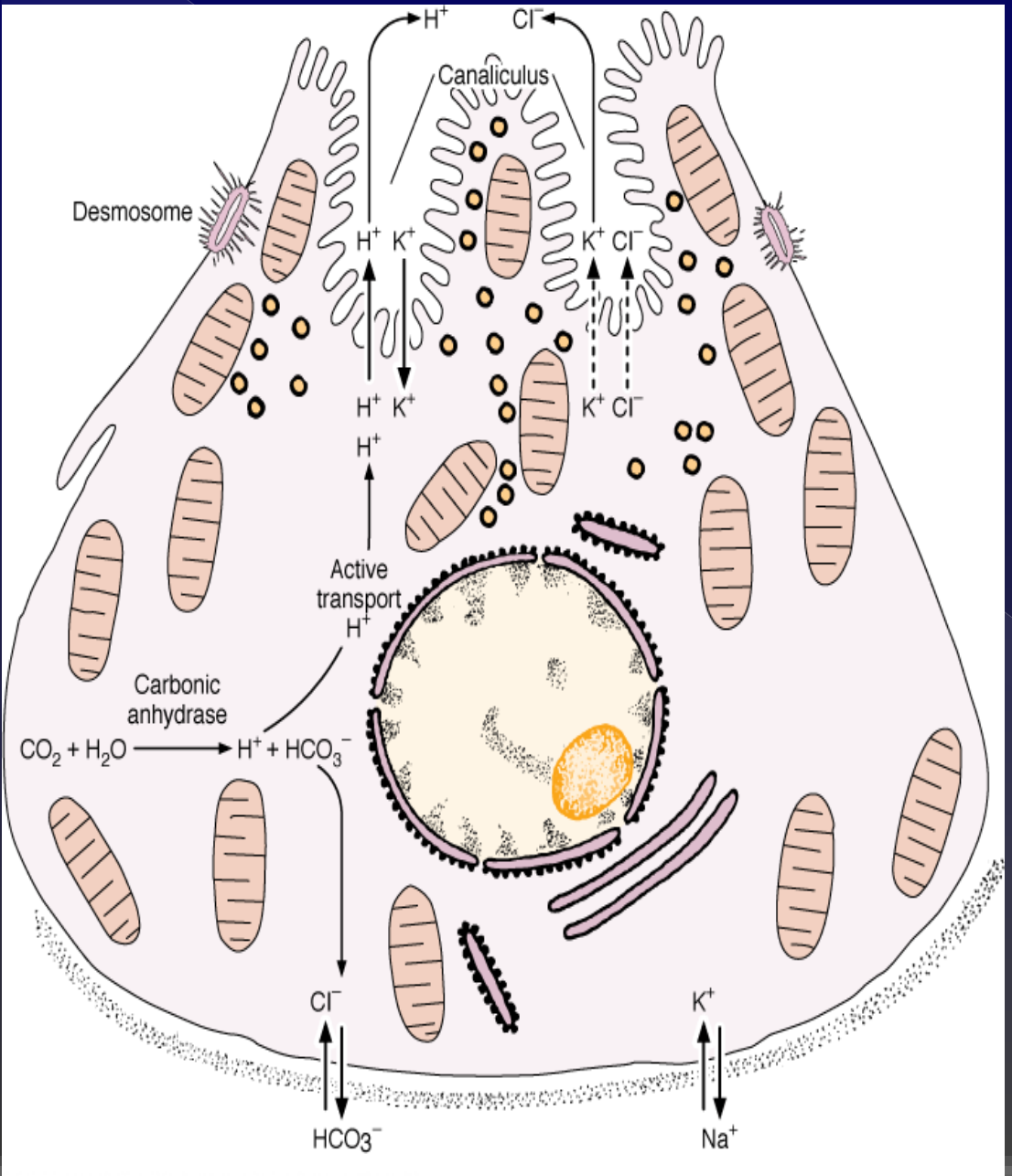


4. **Parietal (oxyntic) cells**
- **hydrochloric acid** and **gastric intrinsic factor**

5. **Chief (zymogenic) cells** - enzymes: **pepsinogen** and **gastric lipase.**

6. **Enteroendocrine cells** – hormones (**serotonin, gastrin, histamine**)

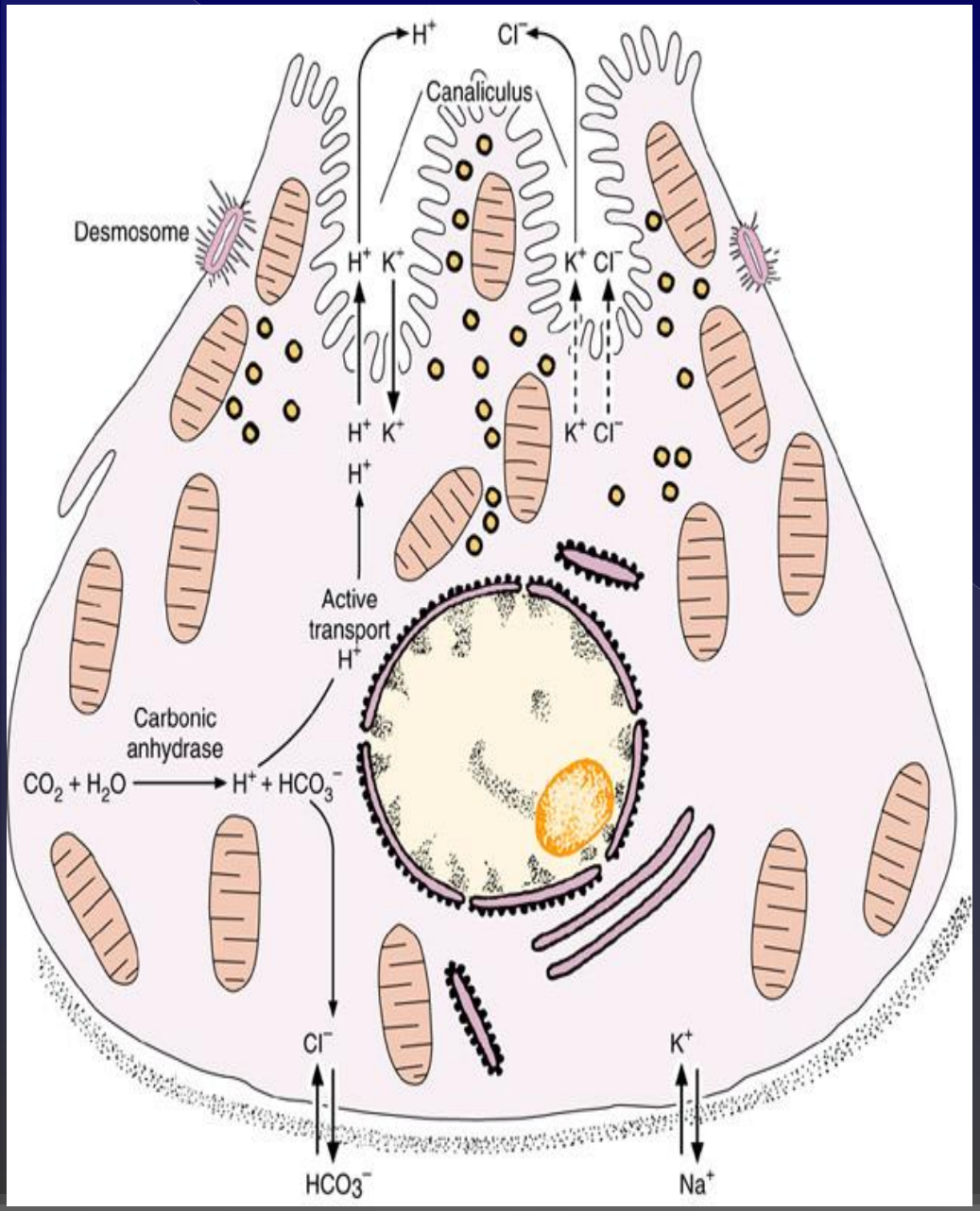
Parietal (oxyntic) cells



carbonic anhydrase

- formation of carbonic acid (H_2CO_3) from carbon dioxide and water. Carbonic acid dissociates into H^+ ions and bicarbonate ions ($HCO3^-$).

Parietal (oxyntic) cell - hydrochloric acid production

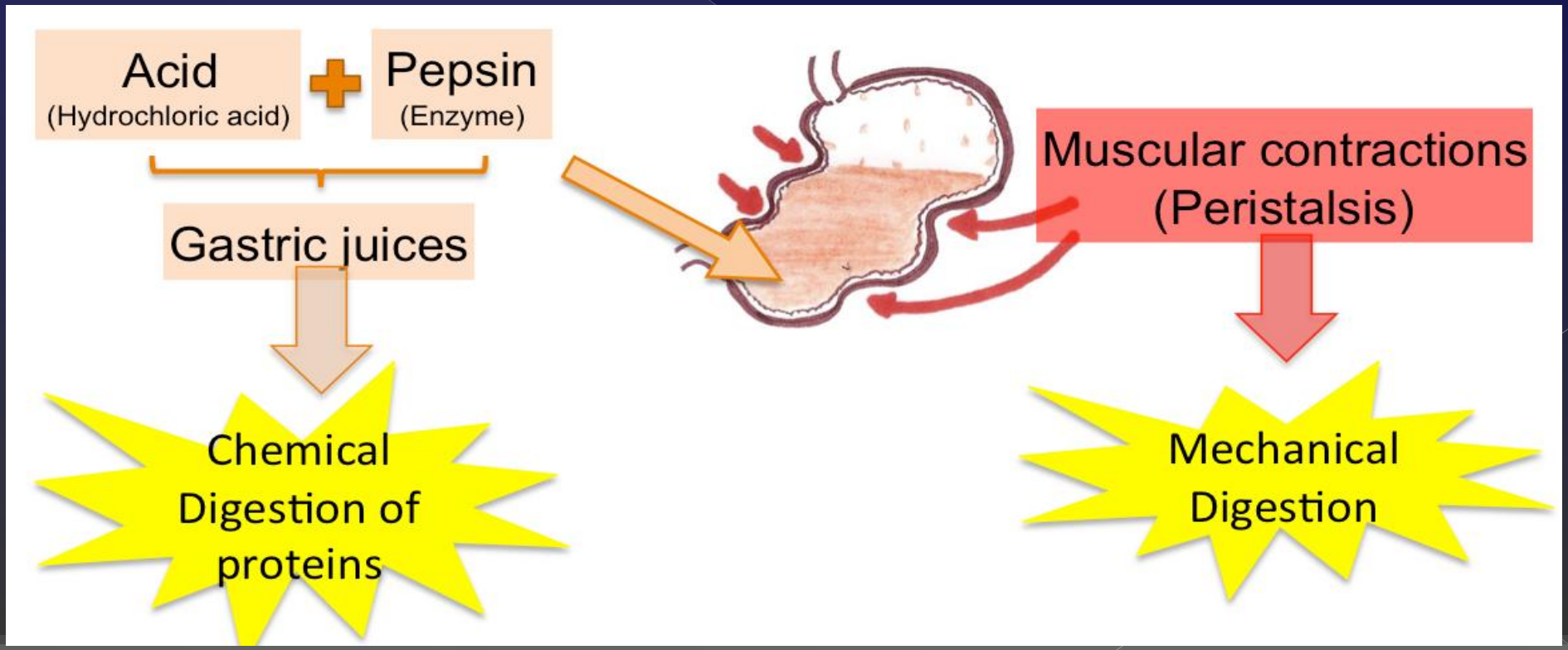


in **canaliculi**

- **H^+, K^+-ATPase** – H^+ pumped out of the cell, K^+ in.
- bicarbonate ions exchanged for a chloride ions.
- Cl^- ions transported out of the cell - formation of **HCl**.

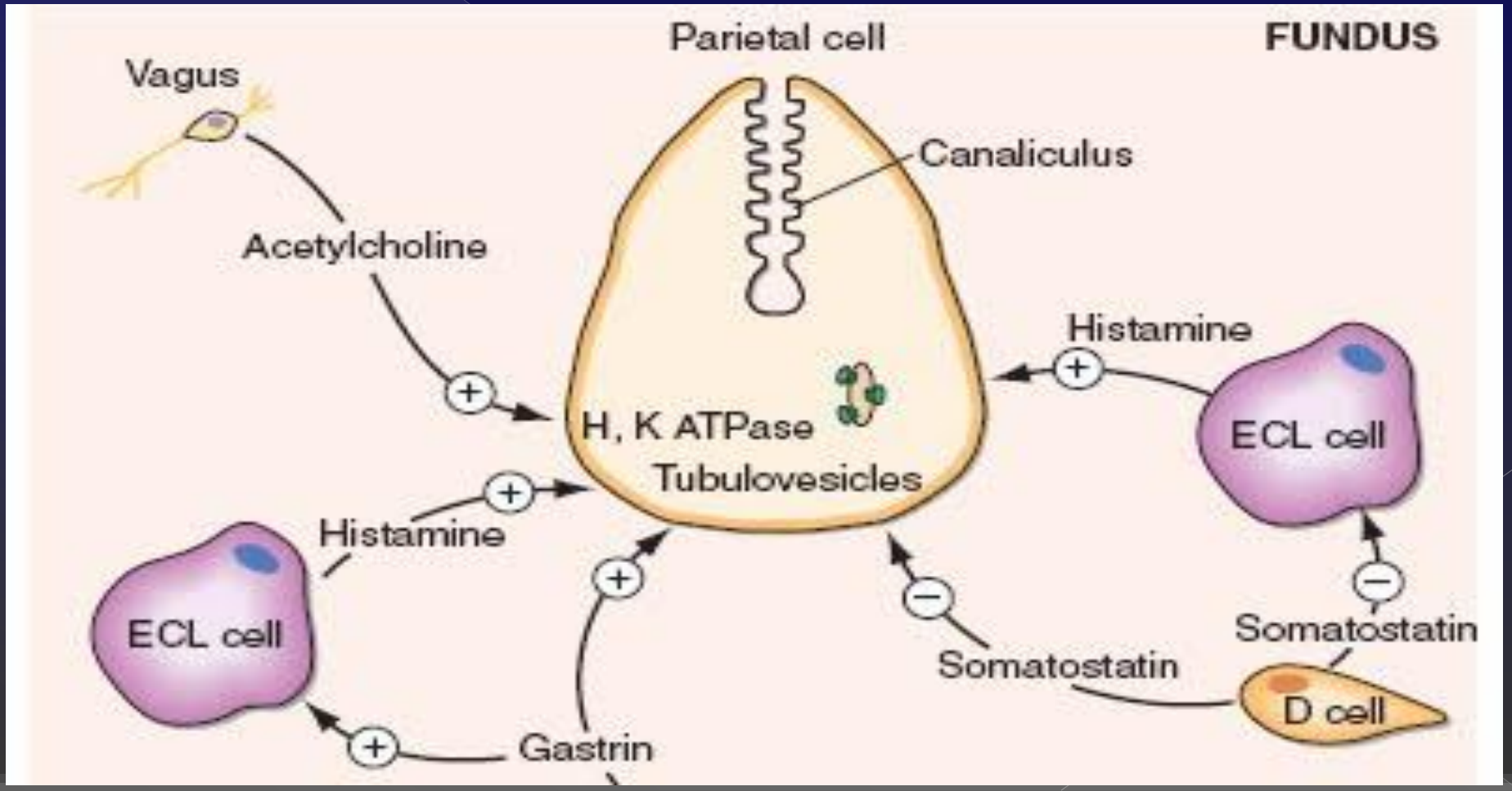
hydrochloric acid - function

- a barrier against microorganisms
- digestion of food - low pH denatures proteins - susceptible to degradation by **pepsin**.
- low pH activates pepsinogen into the active enzyme **pepsin** (breaks down proteins into peptides).



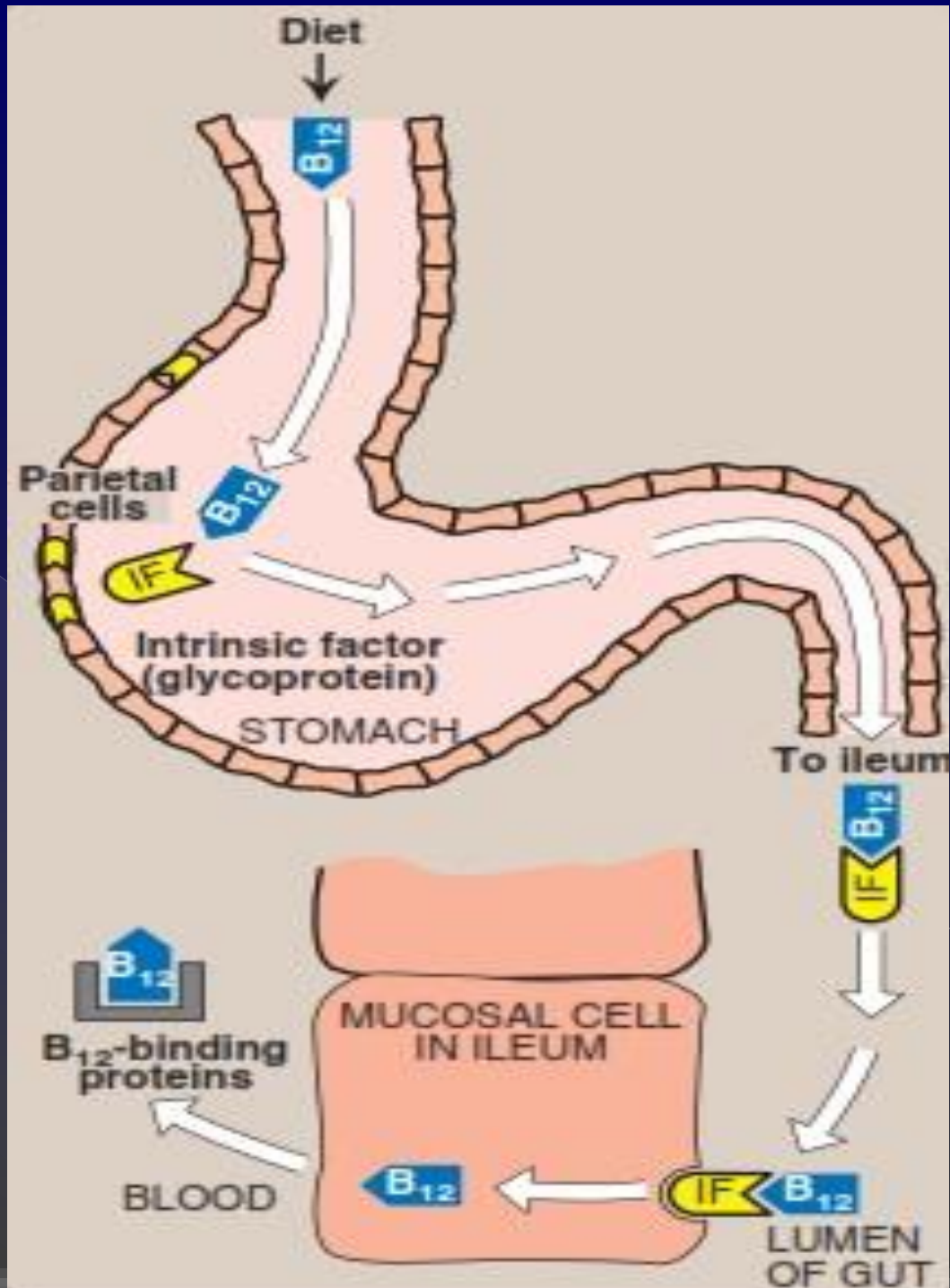
Parietal cell - hydrochloric acid production **- DNES cells**

- stimulated by **gastrin (G cells)**, **histamine (ELS cells)**
- inhibited by **gastric inhibitory peptide (K cells)** and **somatostatin (D cells)**



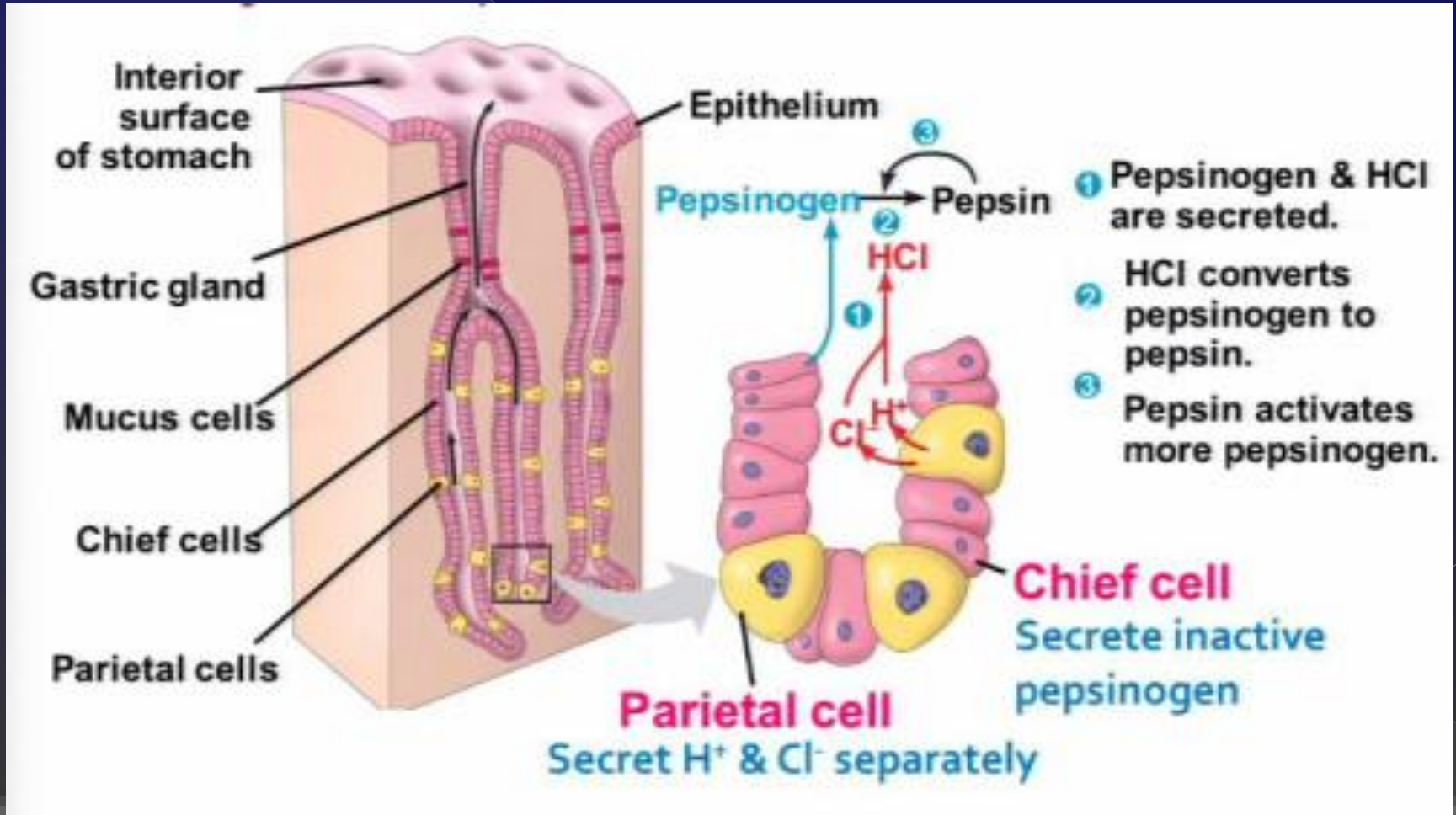
Parietal (oxyntic) cells

- **gastric intrinsic factor (**vitamin B_{12} absorption in the ileum)



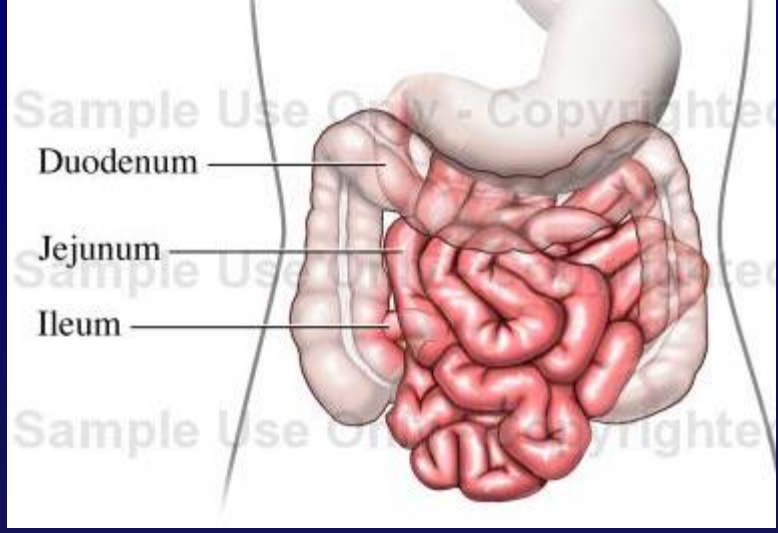
Chief (zymogenic) cells

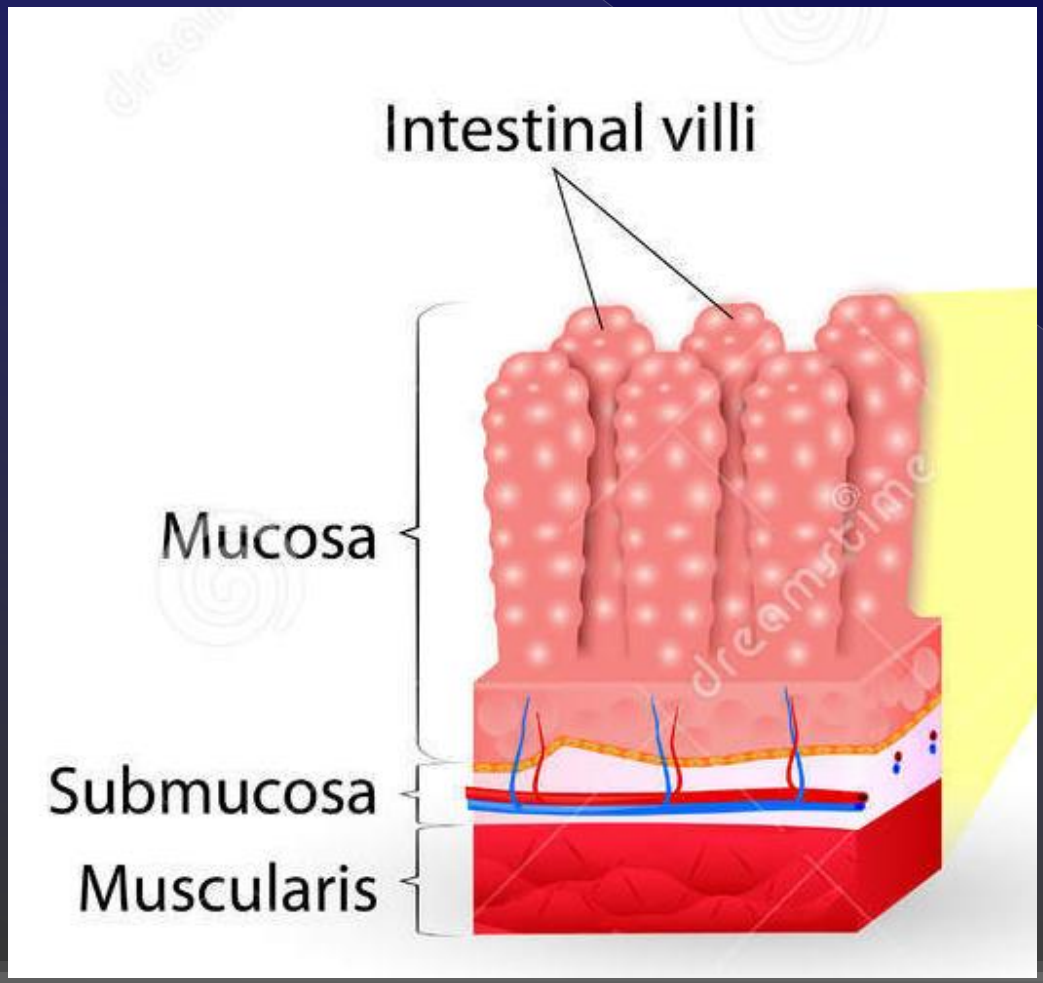
- **pepsinogen** (proenzyme) – HCl converts pepsinogen to active **pepsin -** breaks down proteins into peptides
- **gastric lipase – lipid** digestion



Small intestine

- **duodenum, jejunum, ileum**
- digestion of food and absorption of nutrients

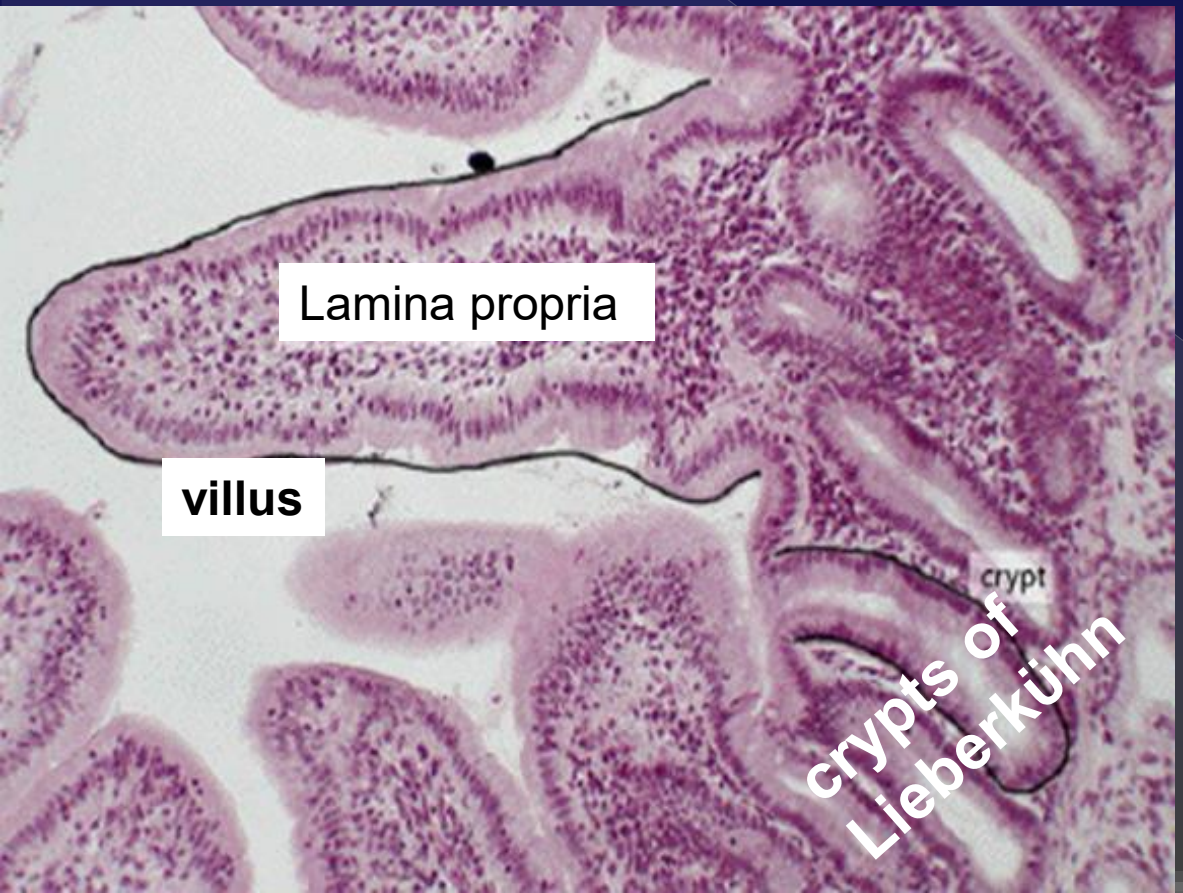


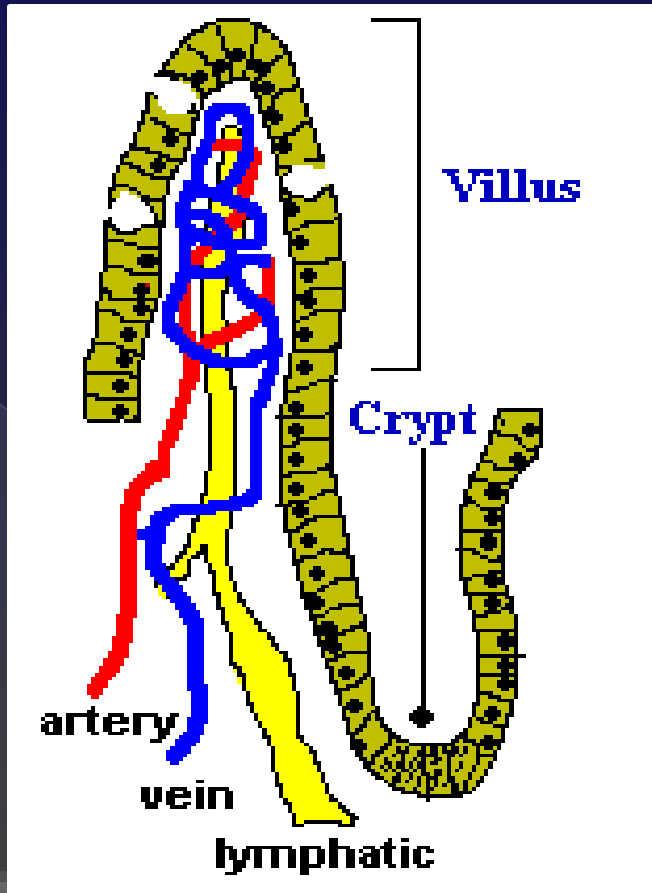


- Mucosa - villi
- Submucosa
- Muscularis externa
- Serosa/adventitia

Lamina propria - highly vascularized loose connective tissue - forms finger-like protrusions – **villi** (increase the surface area by factor 10).

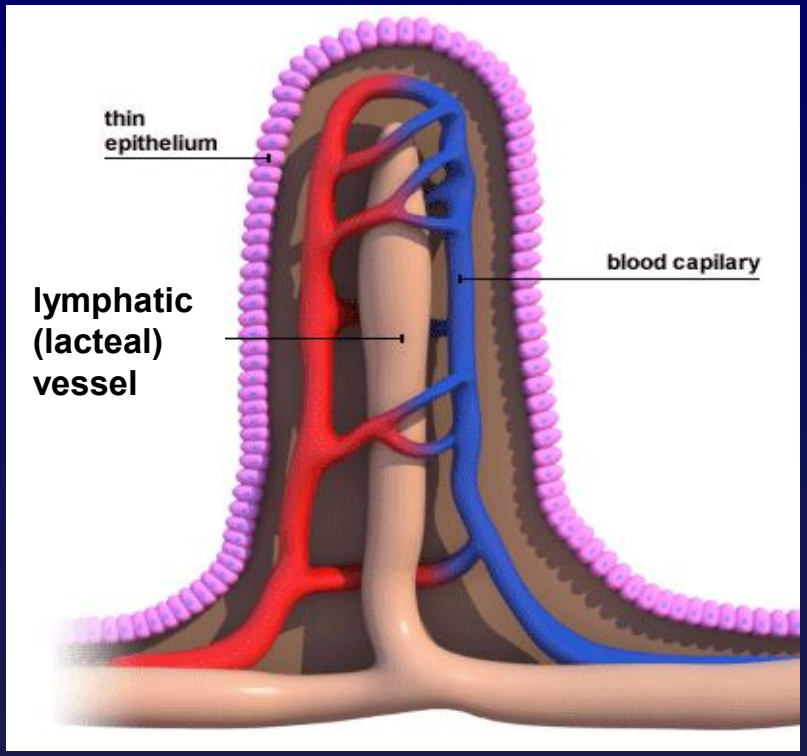
- invaginations of the epithelium into lamina propria form intestinal glands – **crypts of Lieberkühn**

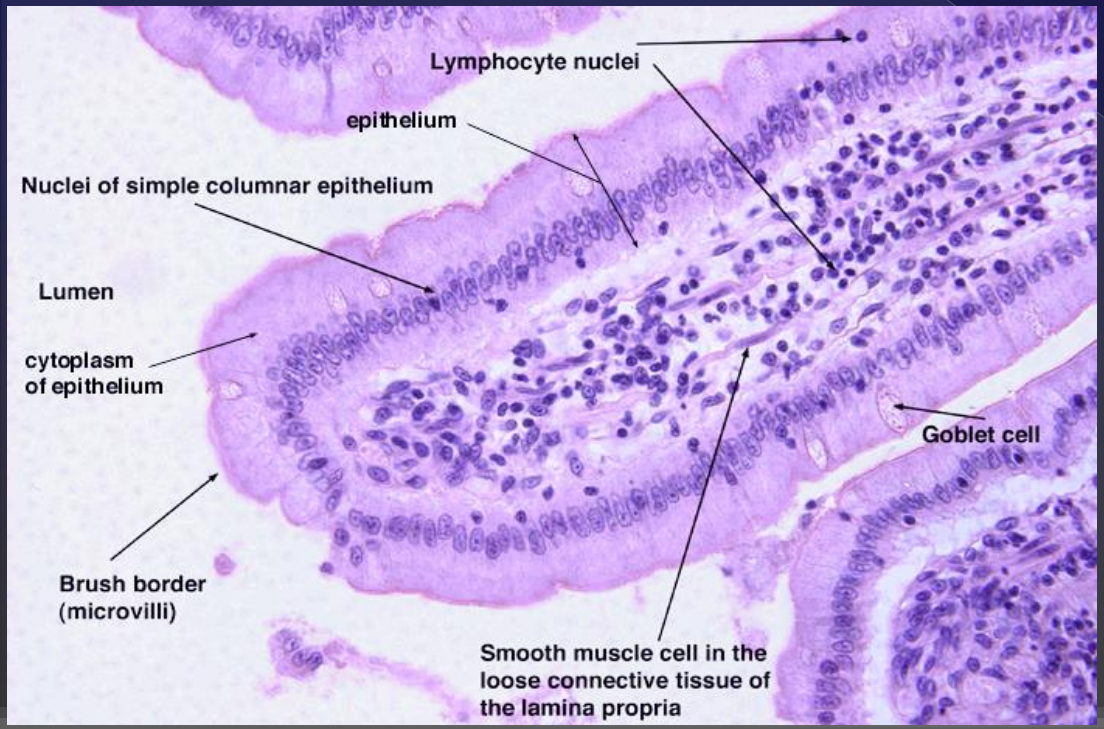




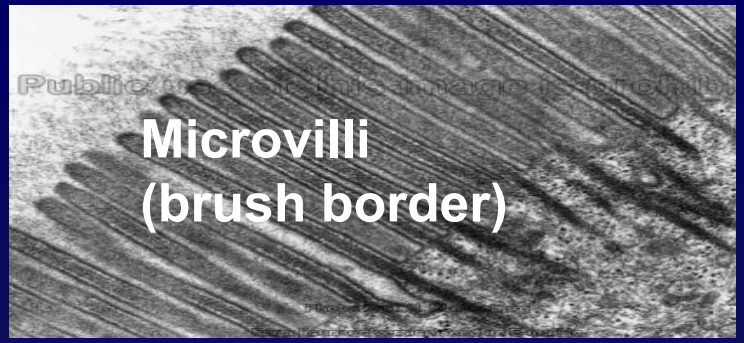
Villus

- loose connective tissue with smooth muscle cells of muscularis mucosae,
- lymphoid cells,
- capillary blood and lymphatic (**lacteal**) vessels



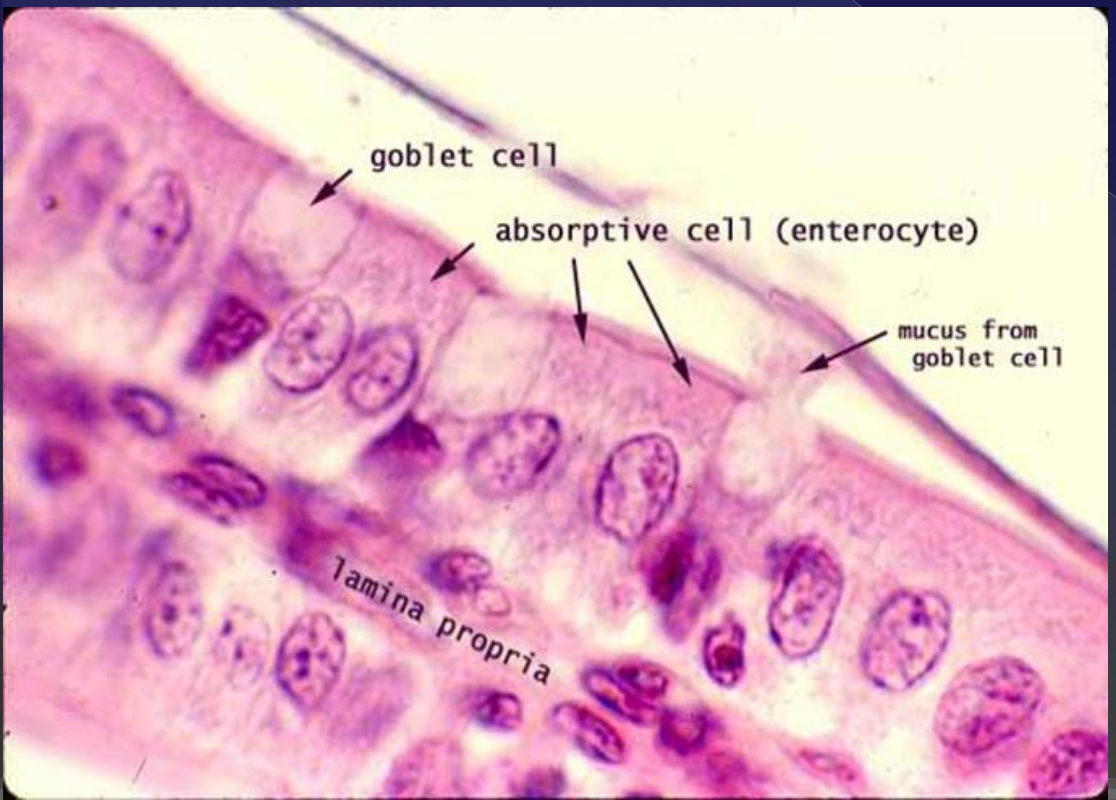


Villi

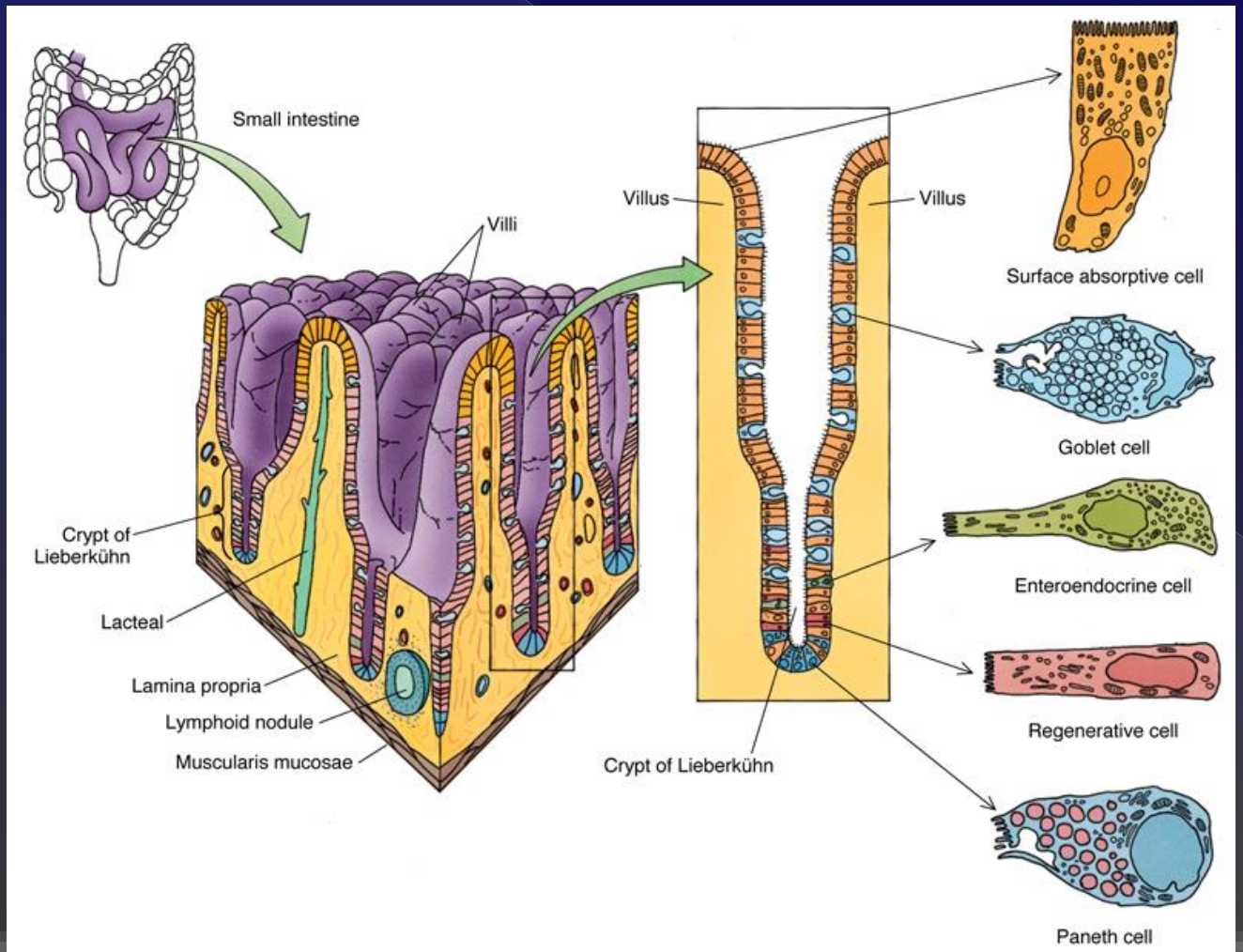


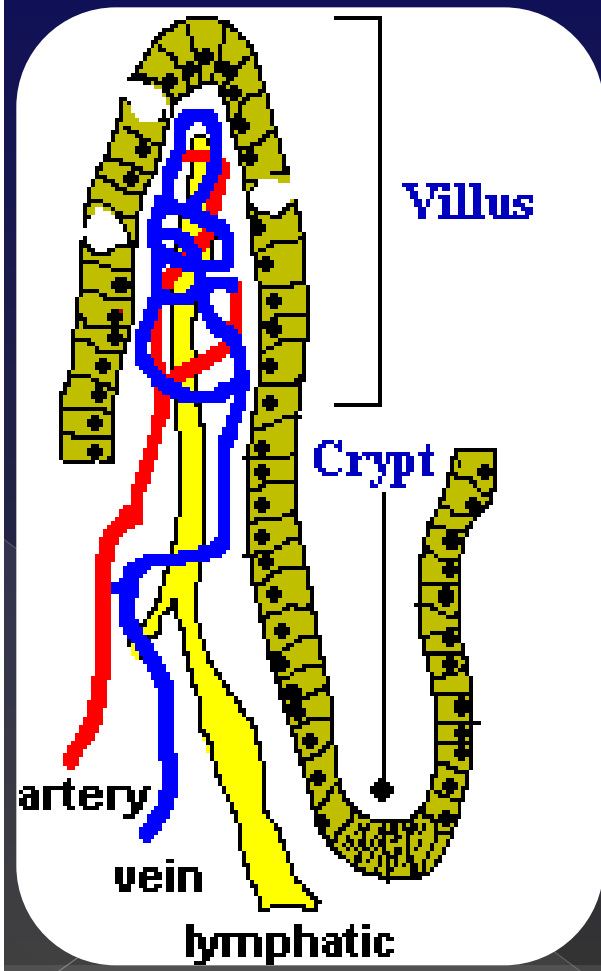
Simple columnar epithelium

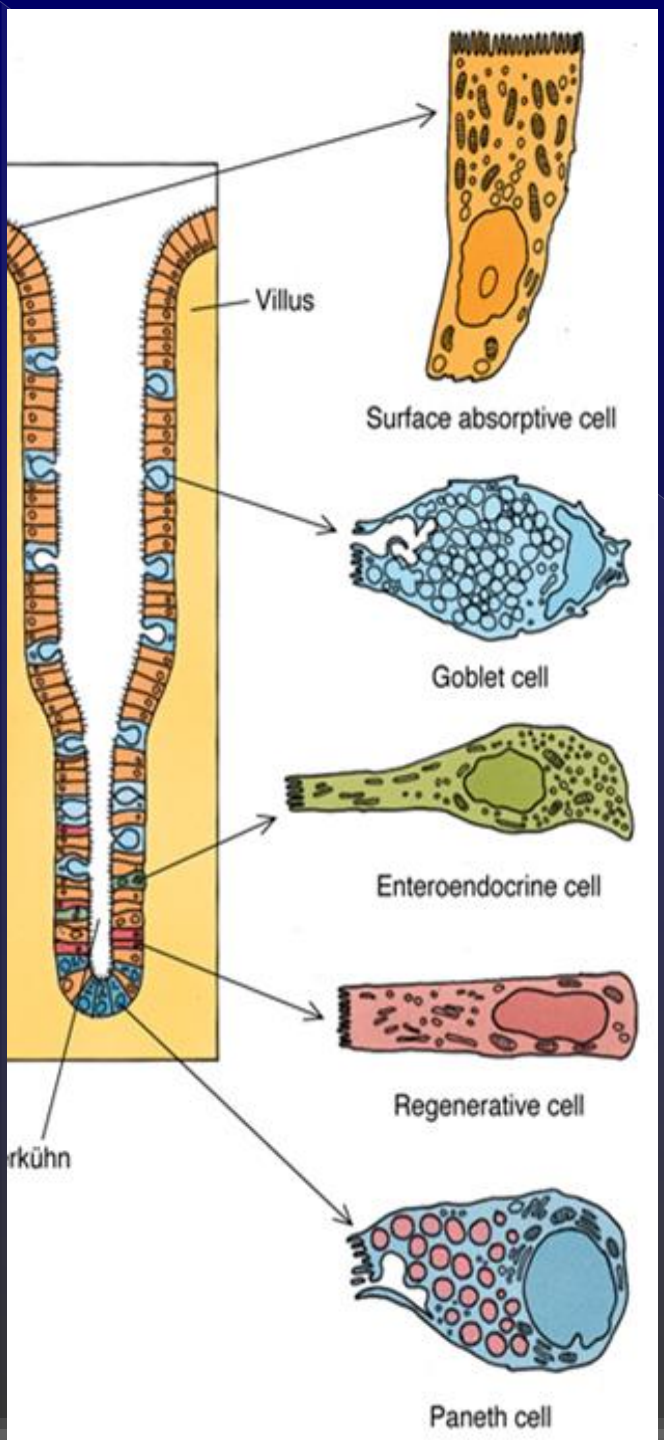
- **surface absorptive cells, goblet cells, DNES cells**.
- surface absorptive cells - **microvilli (brush border**) - increase the surface area by a factor 20.



- **simple columnar epithelium:** surface absorptive cells, goblet cells, DNES cells.
- **crypts of Lieberkühn:** surface absorptive cells, goblet cells, regenerative cells, DNES and Paneth cells







Surface absorptive cells with microvilli - terminal digestion and absorption of water and nutrients.

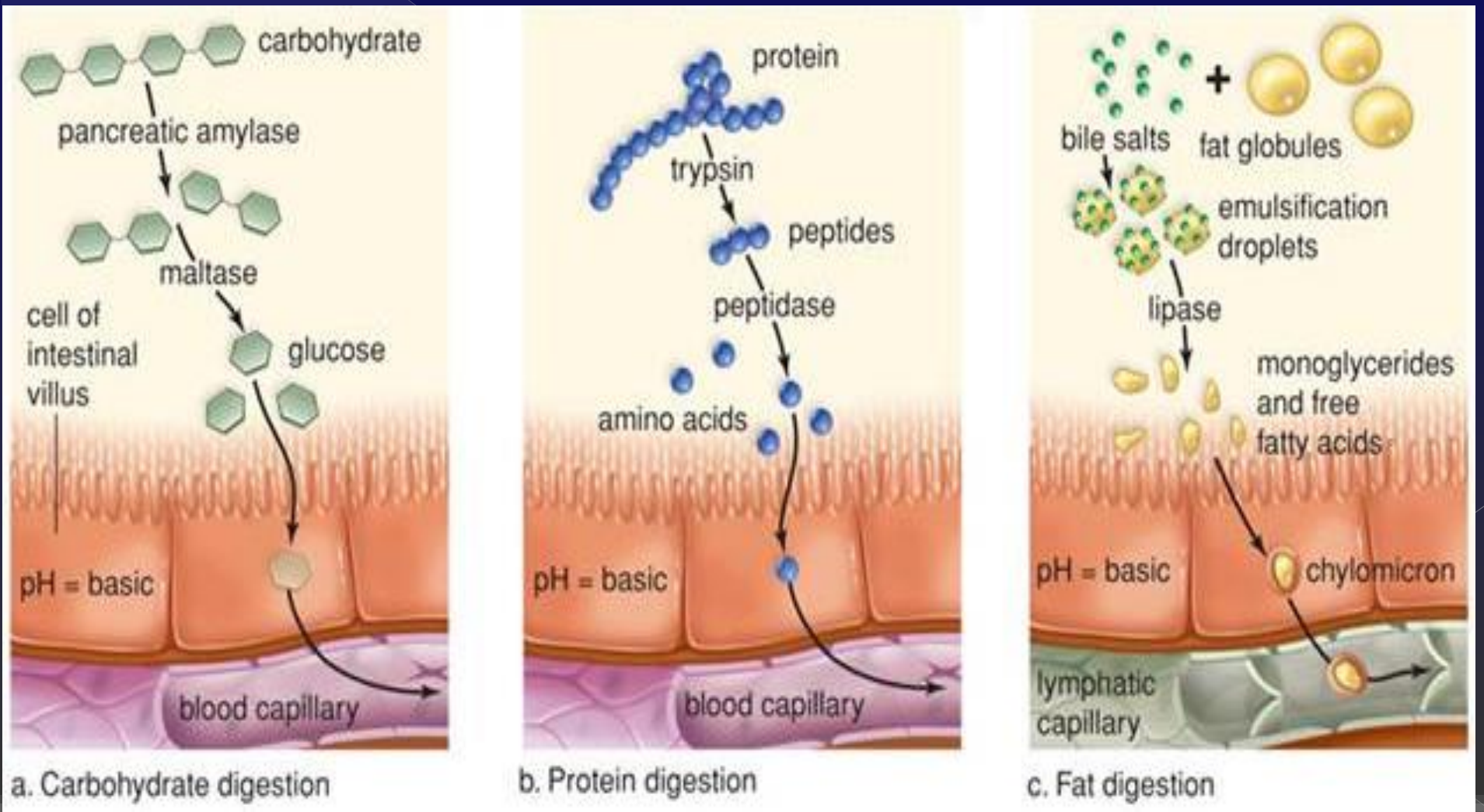
Goblet cells – mucinogen - hydrated form – mucin - a component of mucus (protective layer).

Paneth cells – in the bottom of the crypts - **lysozyme, defensin** – protection

Regenerative cells – stem cells

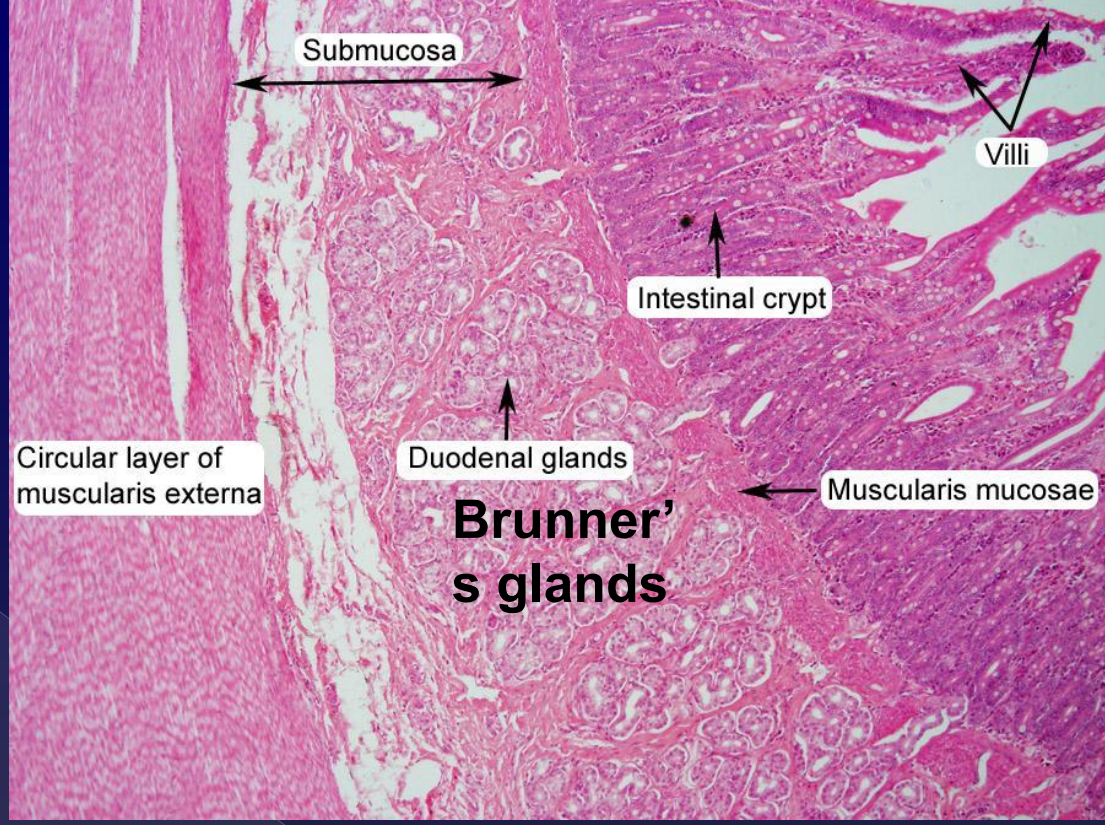
DNES cells – polypeptide hormones

Absorption - amino acids, ions, monosaccharides, glycerol and short-chain fatty acids - enter surface absorptive cells, are released into lamina propria and enter the capillary bed of the villi.



Duodenum - Brunner's glands

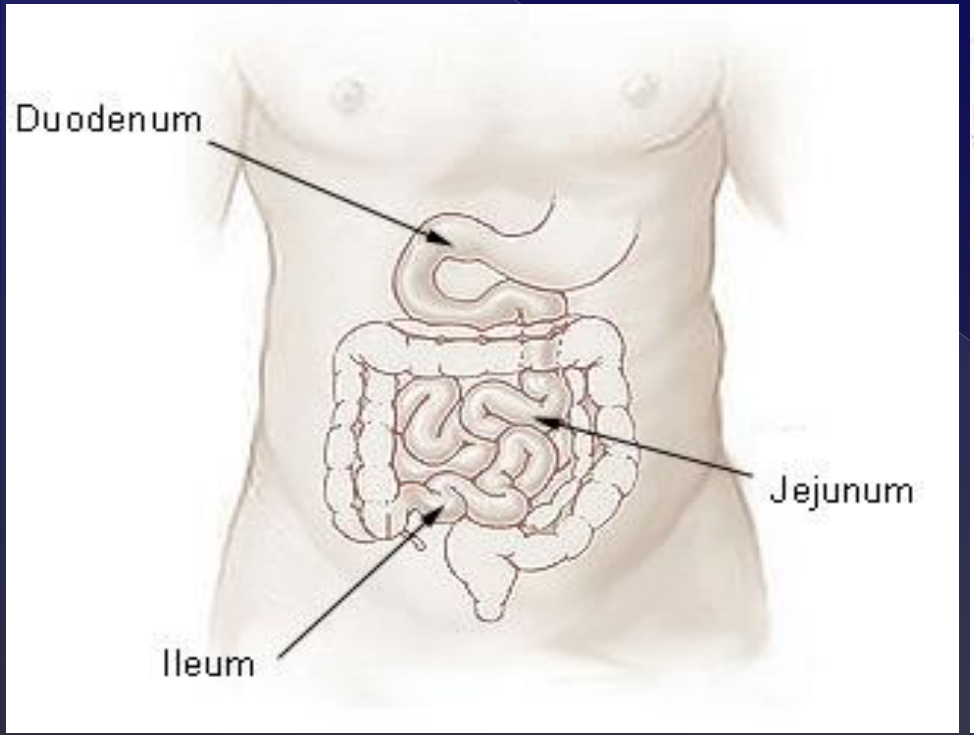
- **in submucosa !**
- branched, tubuloalveolar glands, ducts are opened at the base of crypts of Lieberkühn.



Secrete:

- an alkaline fluid - neutralization of the acidic chyme from stomach
- hormone – **urogastrone** (inhibits hydrochloric acid production by parietal cells of the stomach).

- The **ileum** - absorption of **vitamin B12**, **bile salts** and products of digestion that were not absorbed by the jejunum



Ileum - Peyer's patches - unencapsulated lymphoid nodules (differentiate the ileum from the duodenum and jejunum).

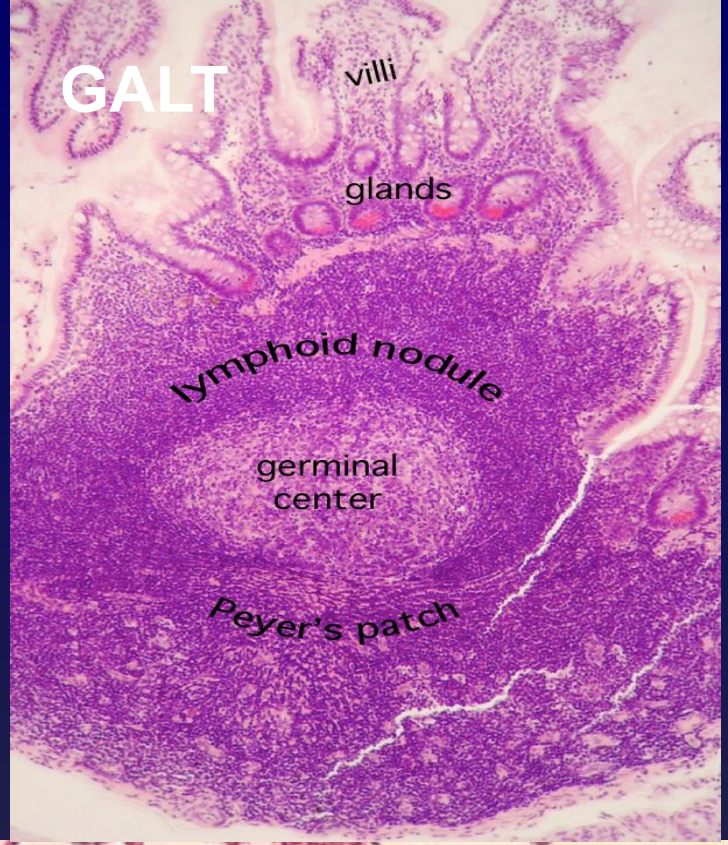
The wall of ileum

- **Mucosa (**Peyer's patches in the lamina propria)
- **Submucosa**
- **Mascularis externa**
- **Serosa**

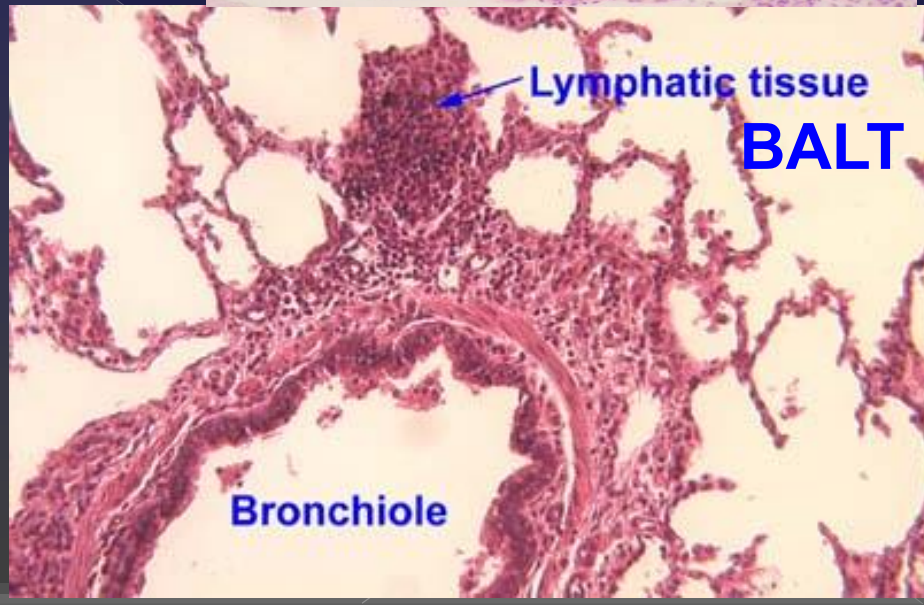
- lymphoid nodules in submucosa - strong immune response

Peyer's patches - immune response within the mucosa - **B and T cells, macrophages, and dendritic cells**

- the part of **Mucosa Associated Lymphoid Tissue (MALT) -** lymphoid nodules in the mucosa of the respiratory, digestive, and urinary systems.

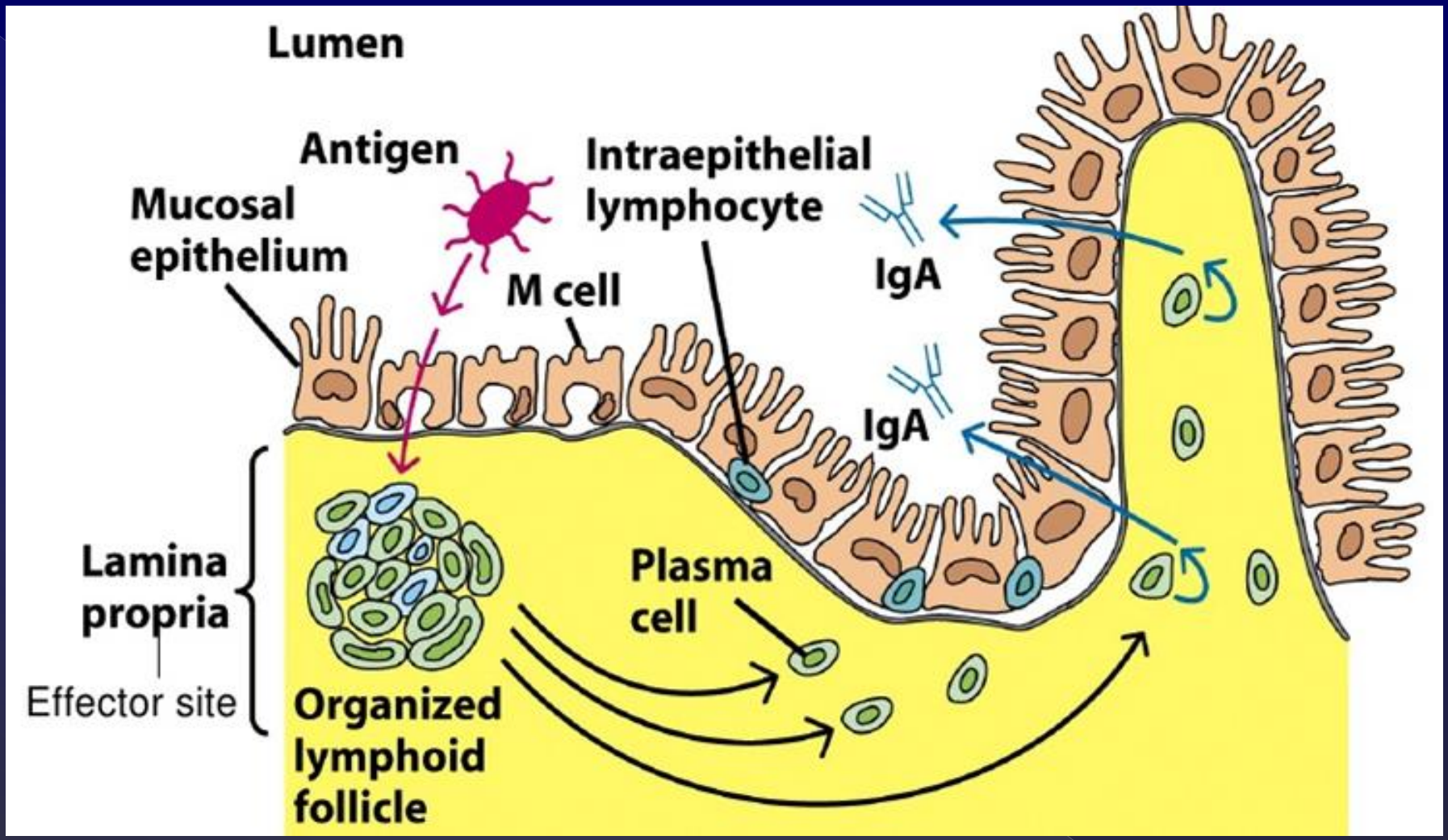


GALT/BALT/NALT (gut/bronchus/nasal-associated lymphoid tissue)



B lymphocytes - in the follicles' **germinal centers**.

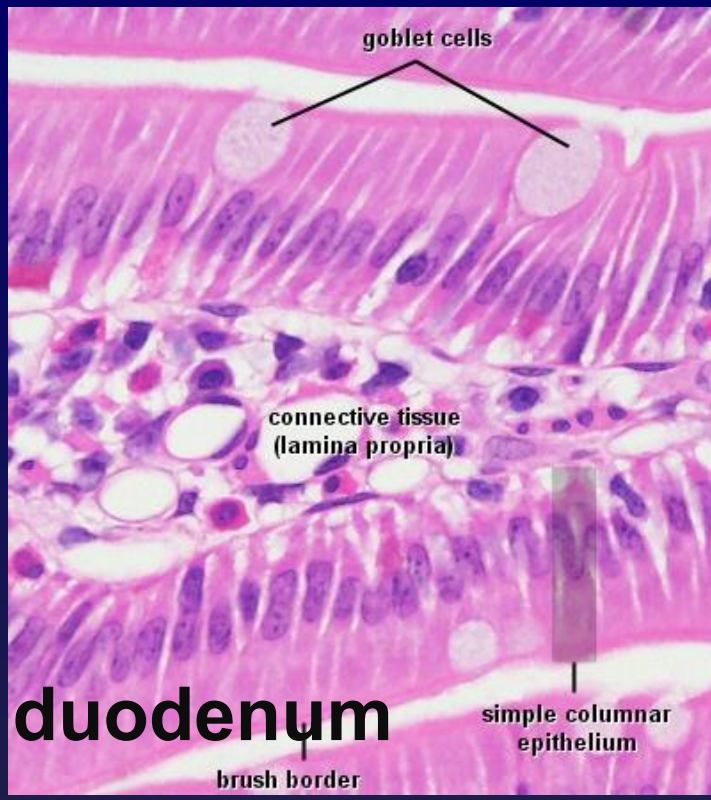
T lymphocytes - between follicles

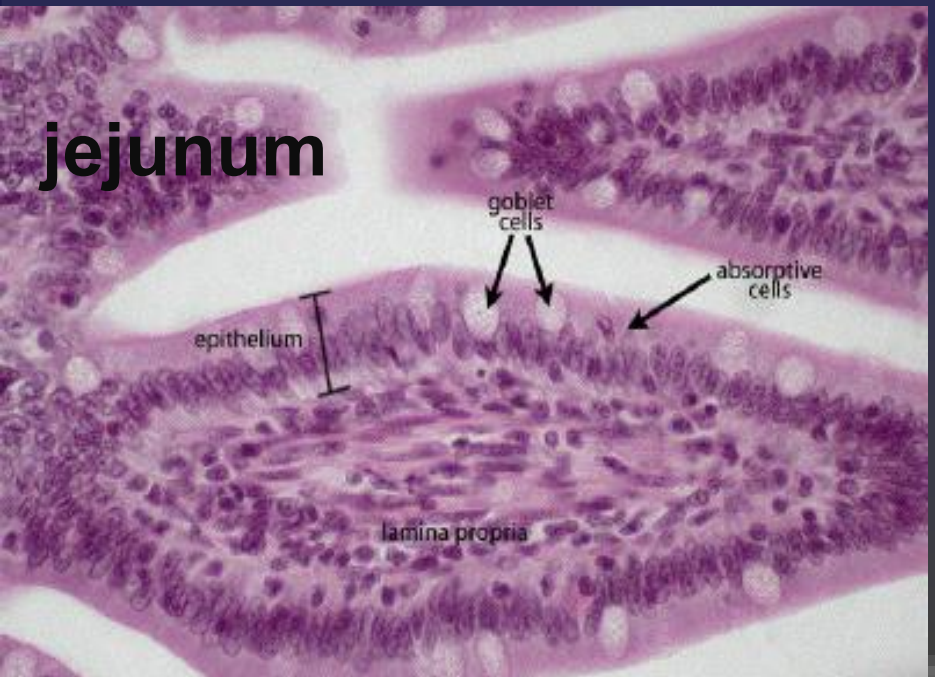


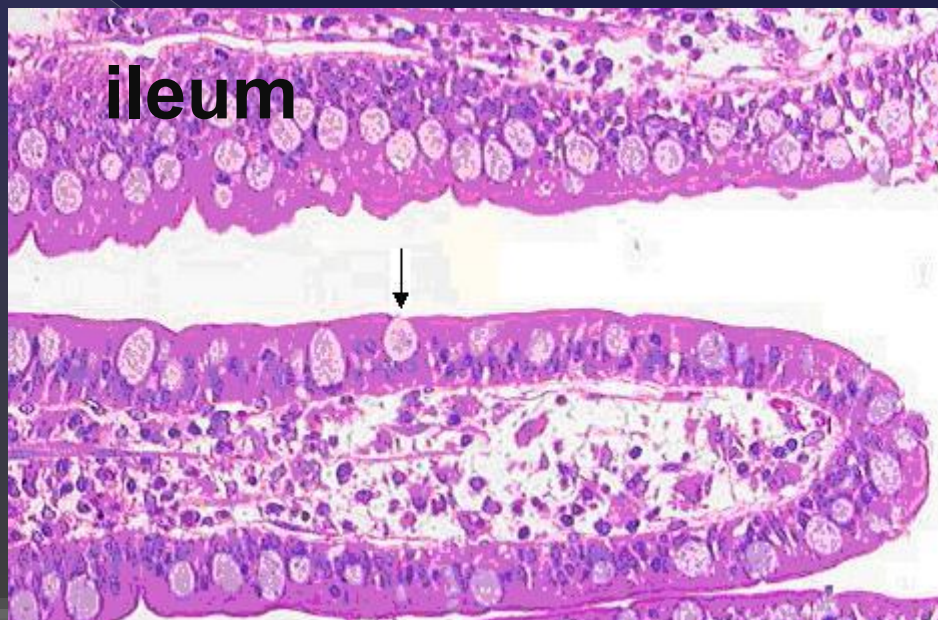
- M (Microfold) cells transport antigens (endocytosis) to APC (presentation) – activation of T cells
- B cells differentiate into plasma cells and produce **IgA**.

Small intestine - differences

- the number of **goblet cells** increases down the gastrointestinal tract
- number and size of villi decrease down the gastrointestinal tract



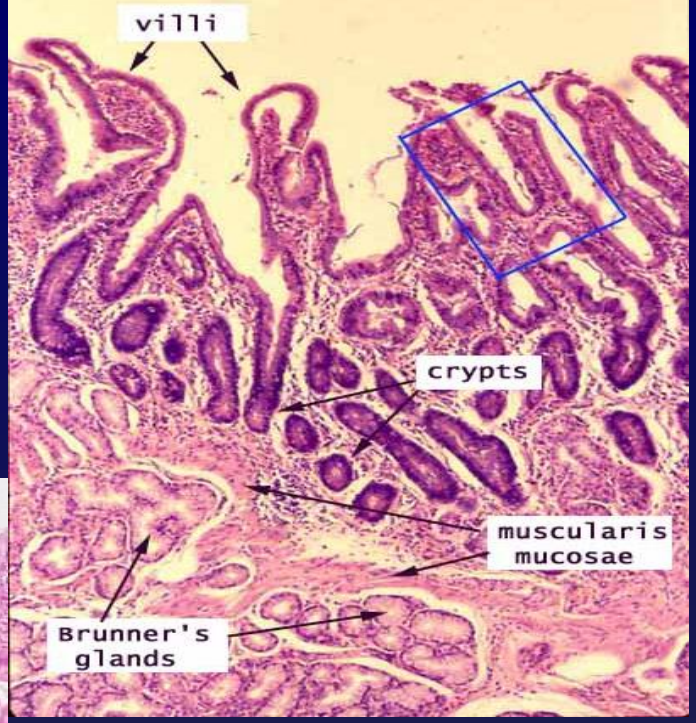




Differences in the morphology of various parts of the small intestine

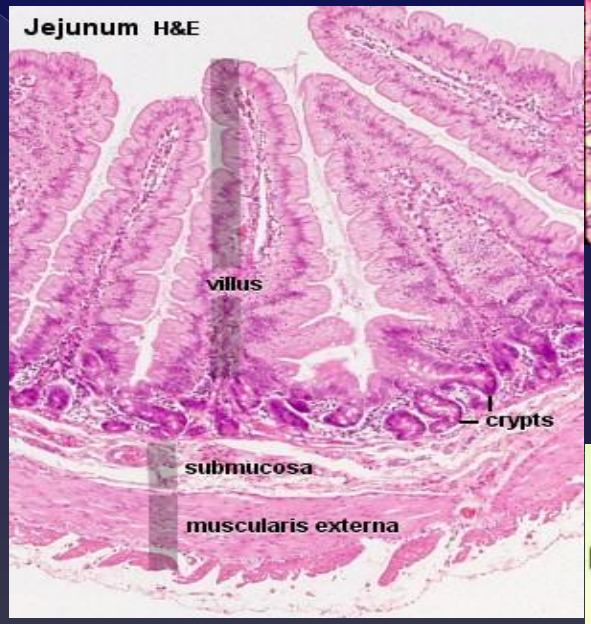
Duodenum

- **Brunner's glands** in submucosa



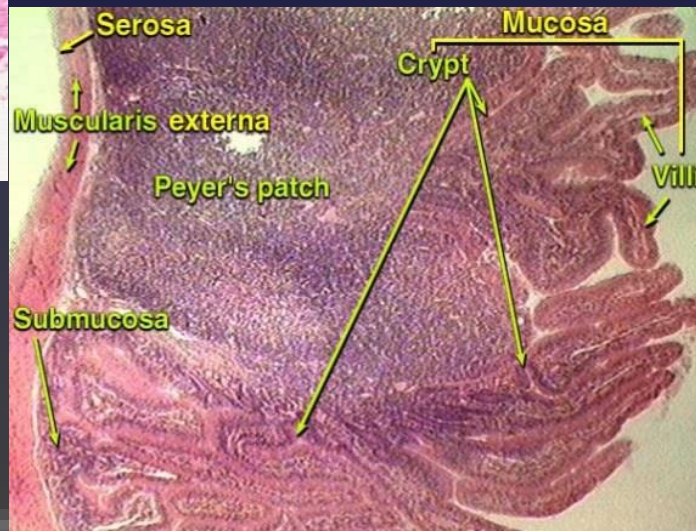
Jejunum

- neither Brunner's glands nor Peyer's patches



Ileum

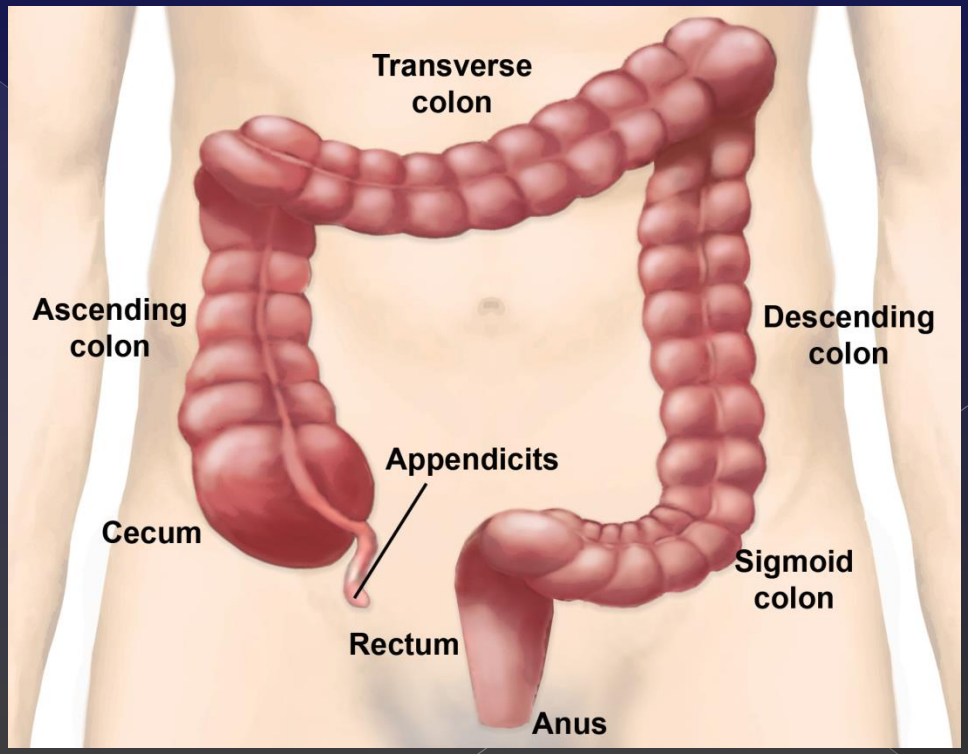
- the lamina propria - permanent clusters of lymphoid nodules – **Peyer's patches**.



Large intestine - lack of villi

- absorption of water and ions from chyme
- compaction of chyme into feces for elimination.

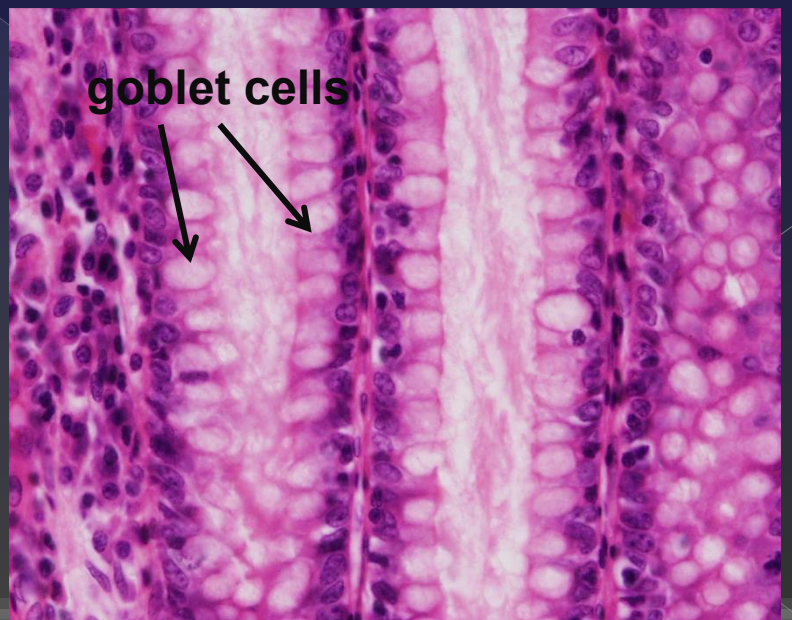
Cecum (with appendix)
Colon: ascending
transverse
descending
sigmoid
Rectum

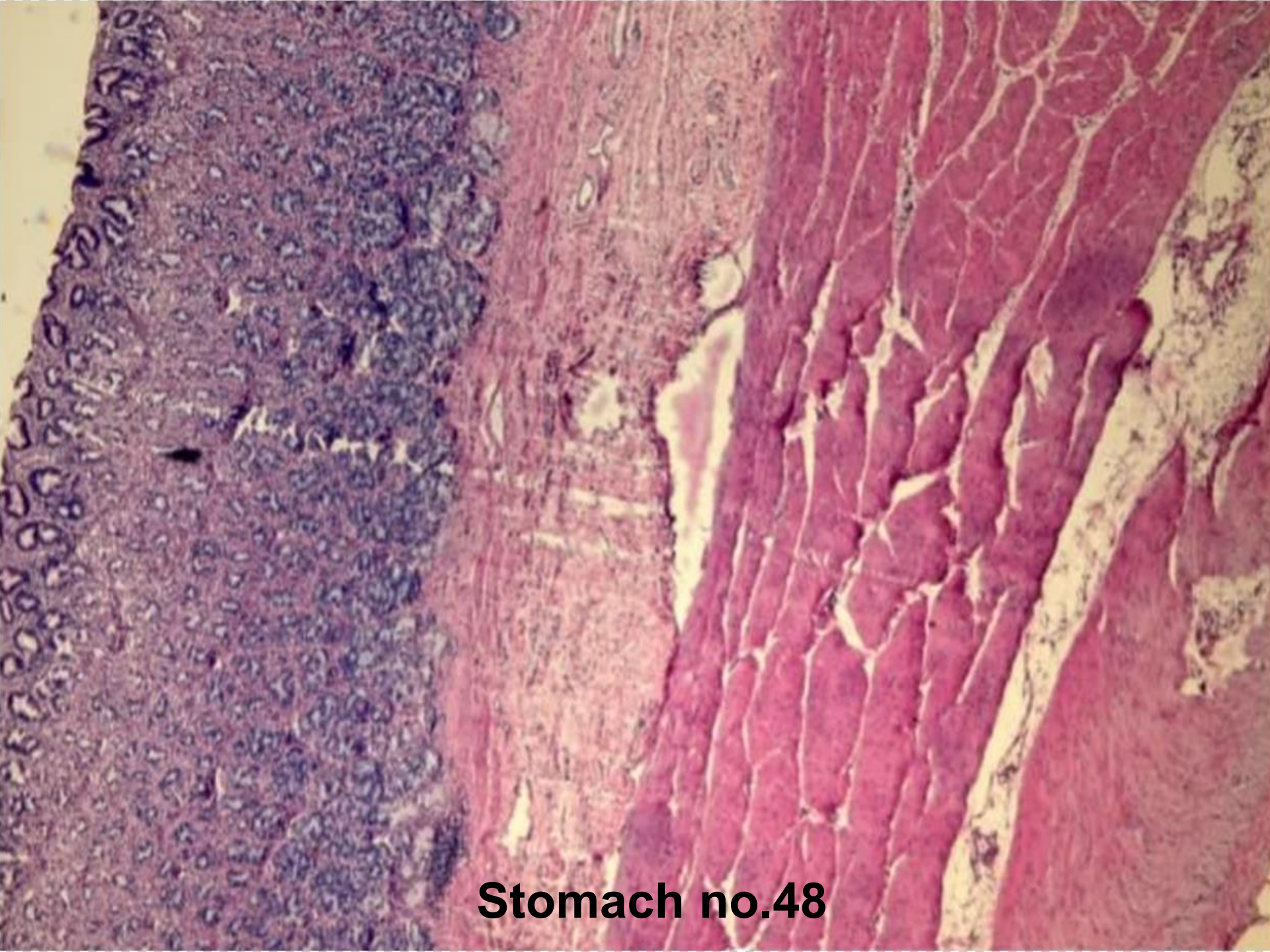


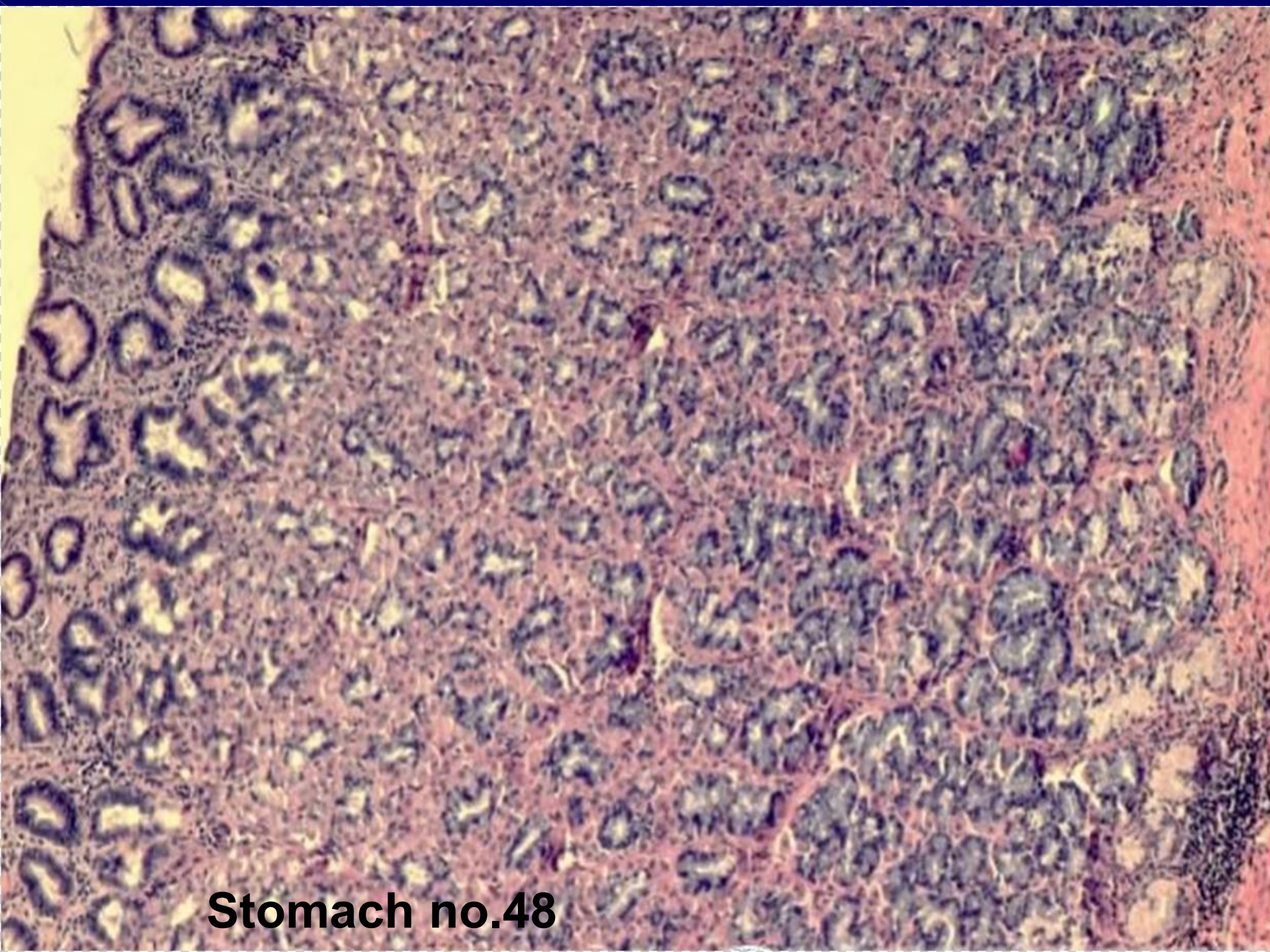
Large intestine

- **has no villi**
- **crypts of Lieberkühn - absence of Paneth cells!**

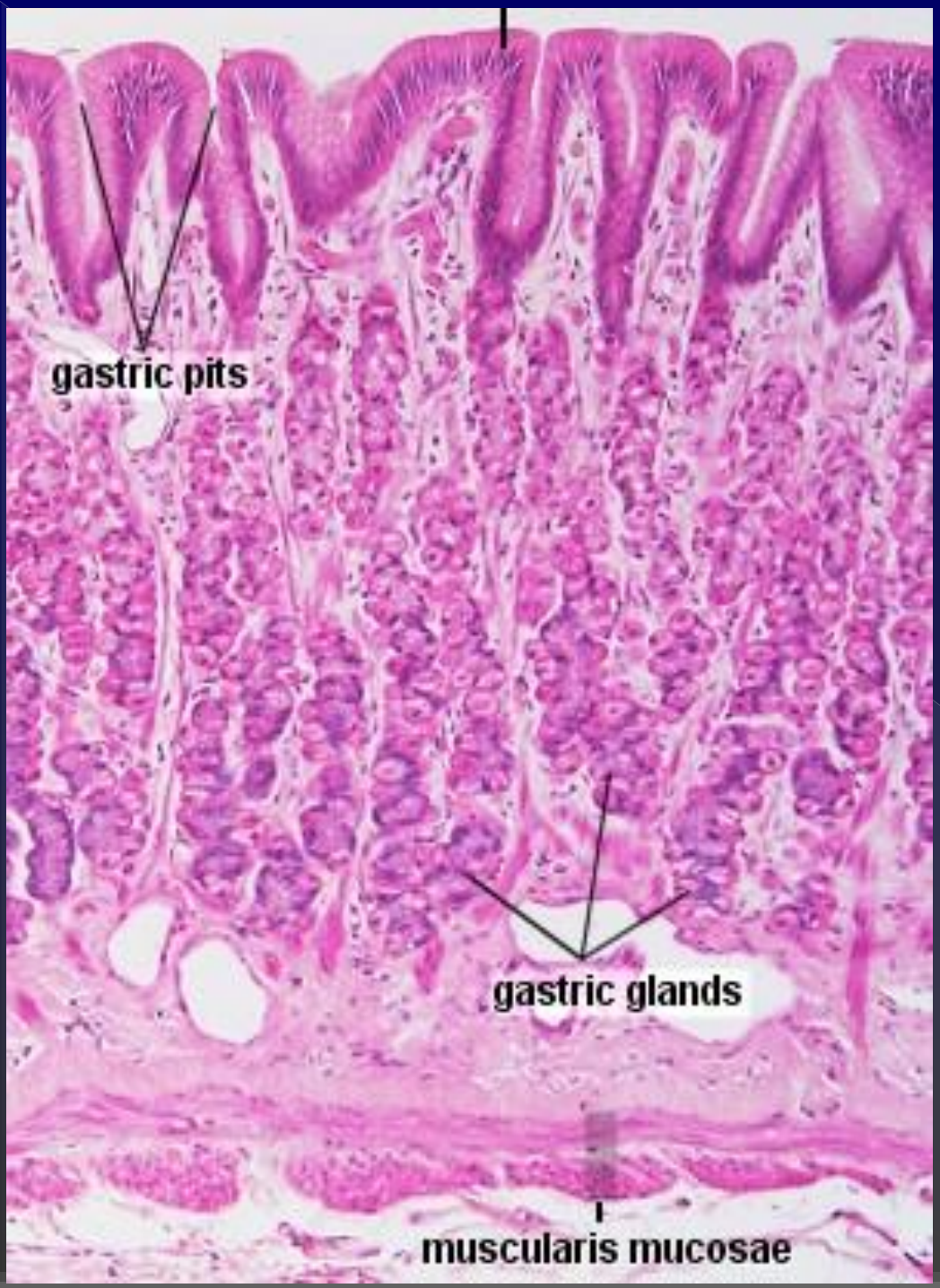
- **goblet cells** - the number of goblet cells increases from the cecum to the sigmoid colon
- **surface absorptive cells**

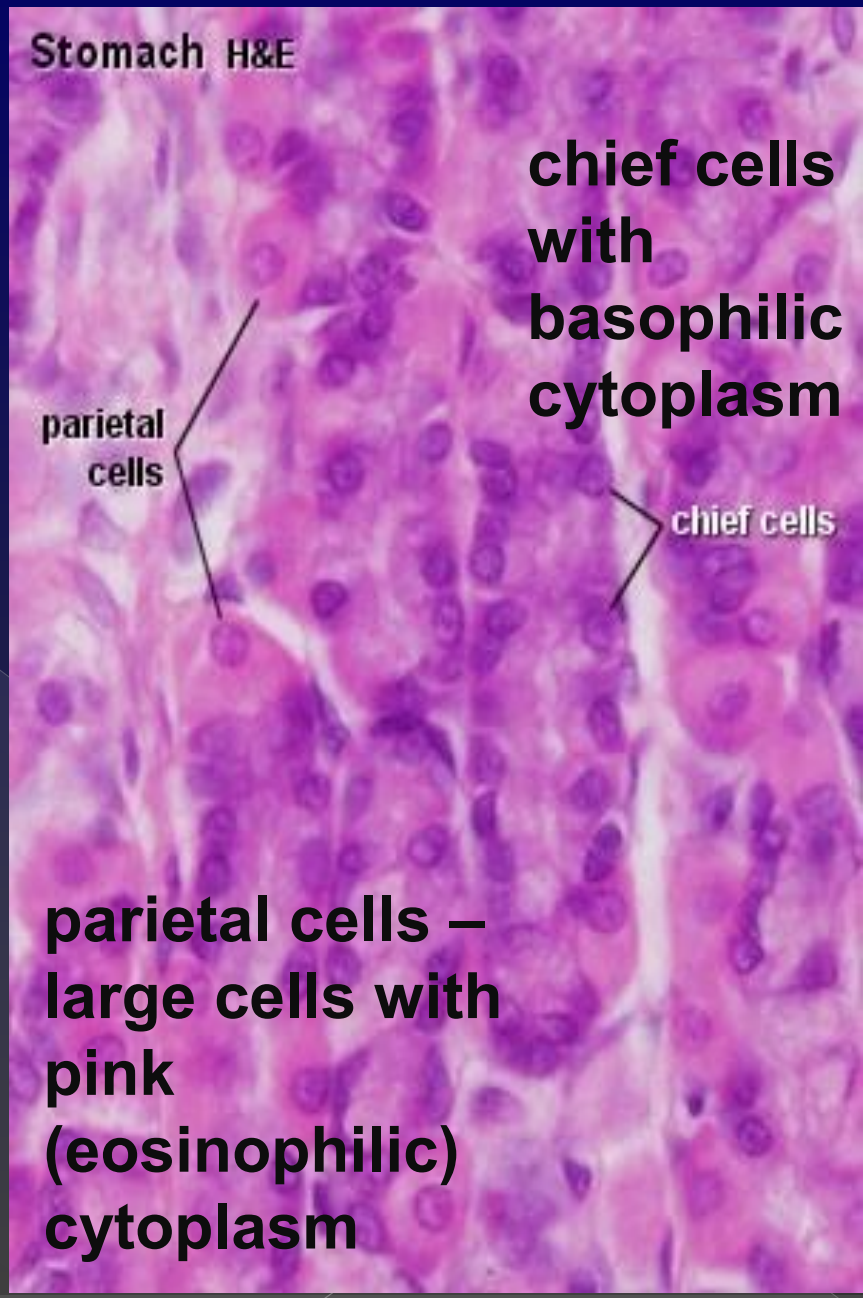



Stomach no.48


Stomach no.48

Stomach no.48

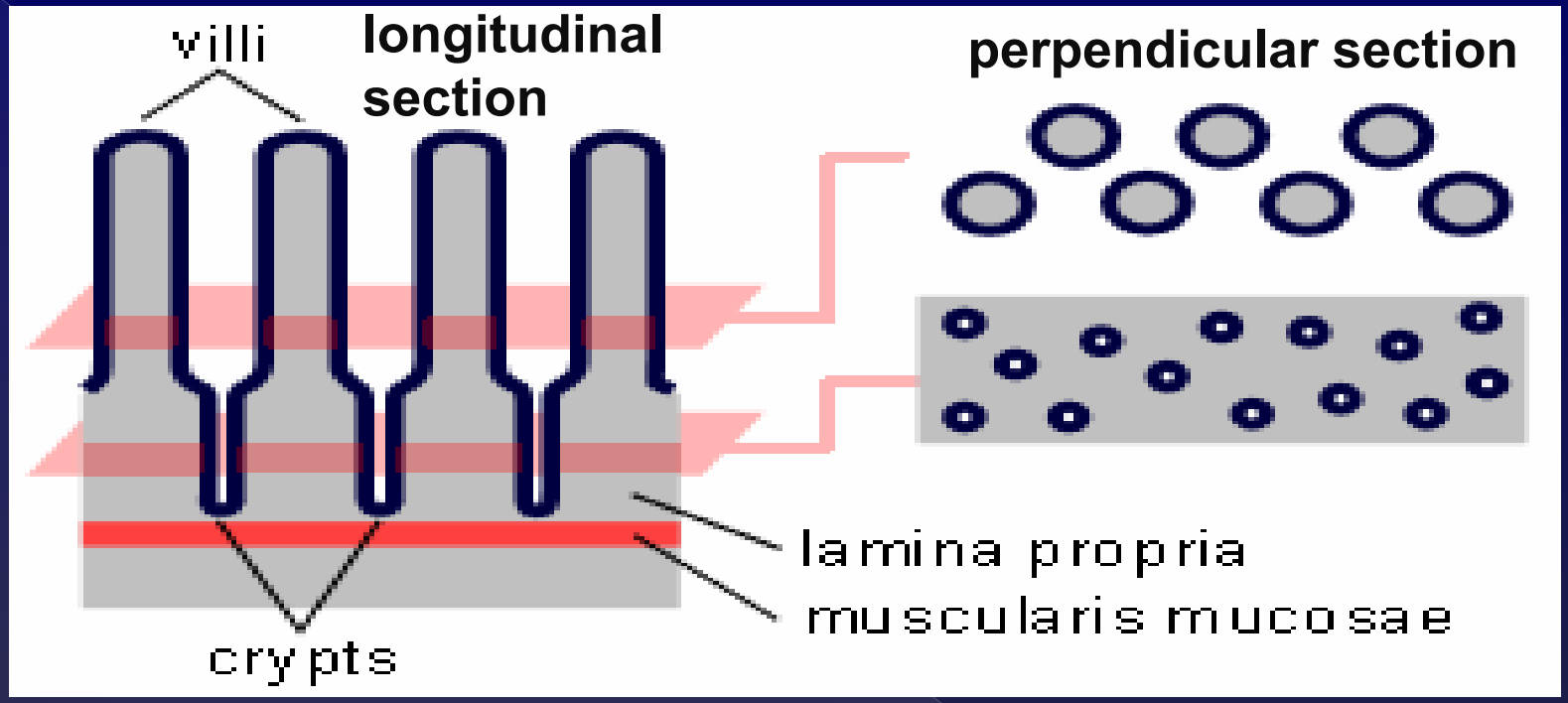


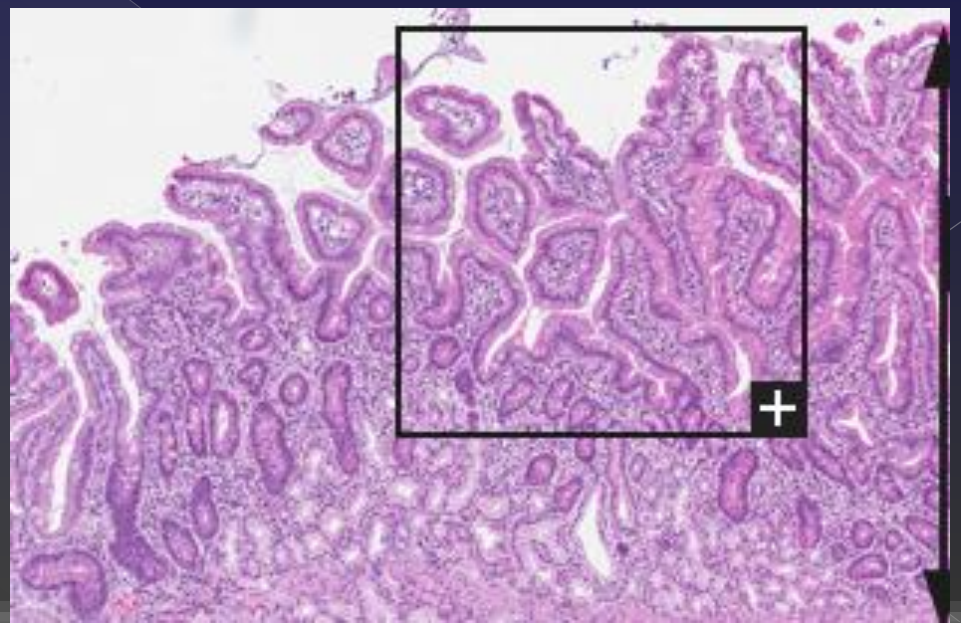


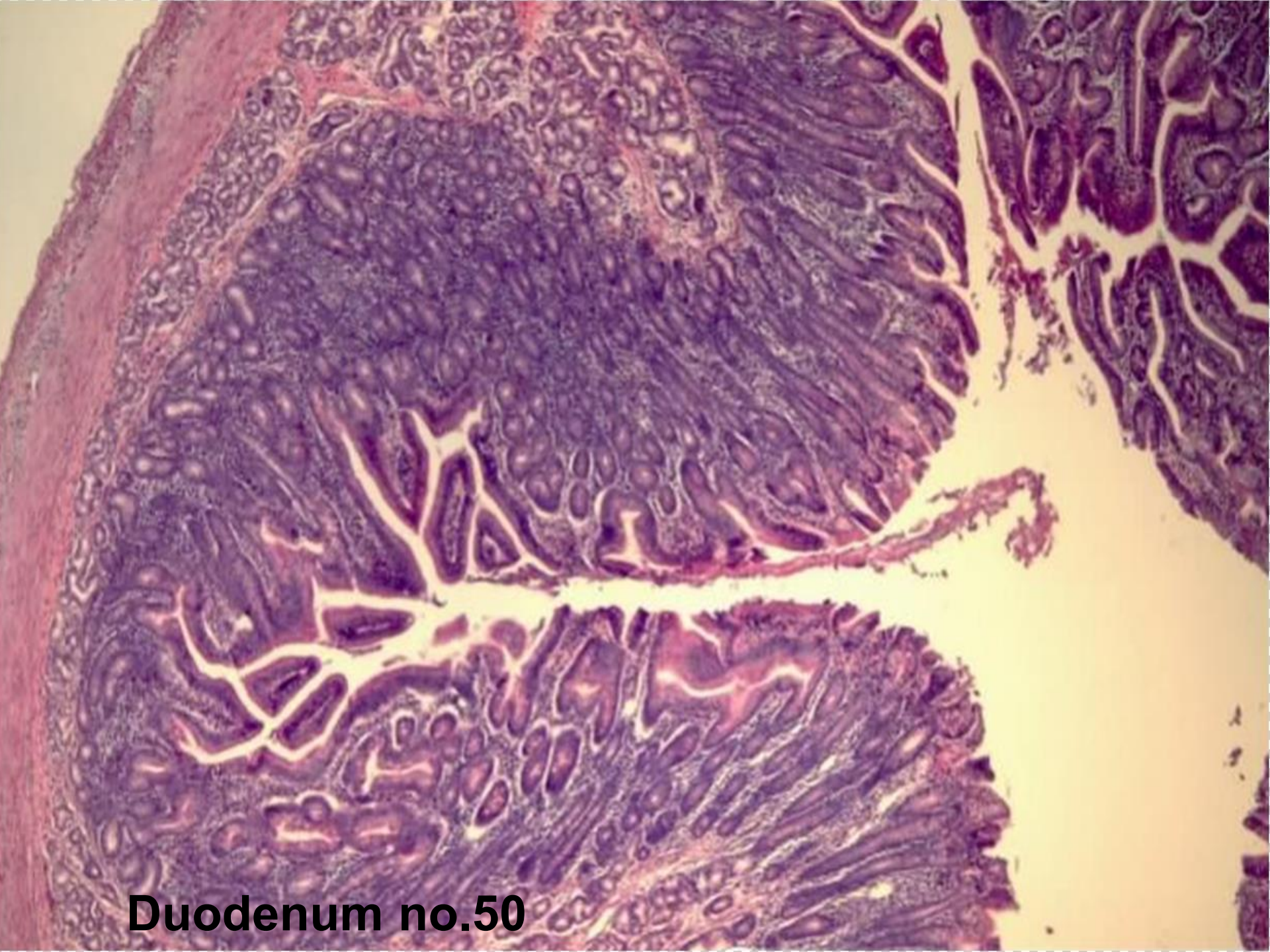
chief cells with basophilic cytoplasm

parietal cells – large cells with pink (eosinophilic) cytoplasm

Lamina propria of small intestine






Duodenum no.50

Duodenum

#50; 100x

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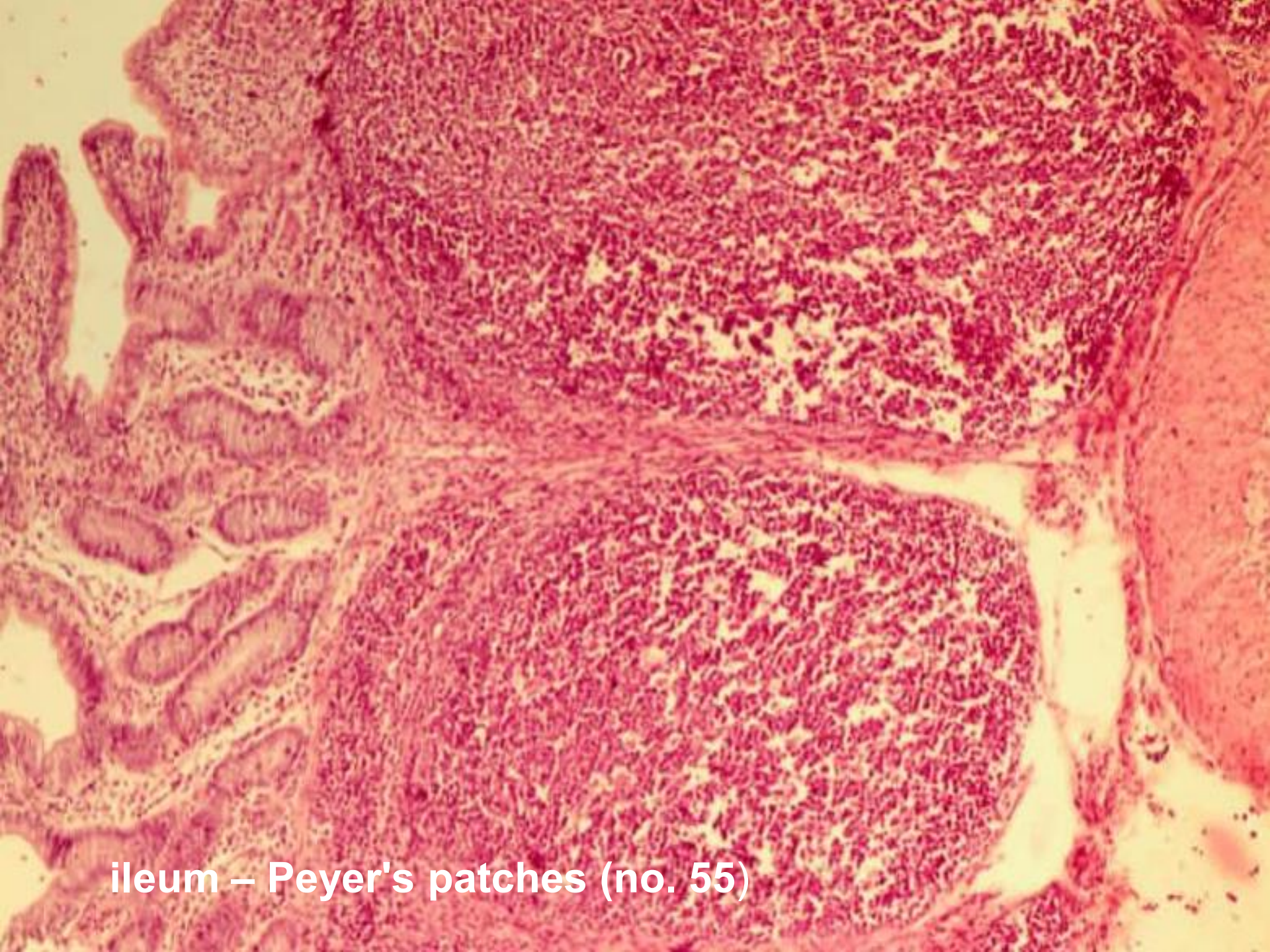
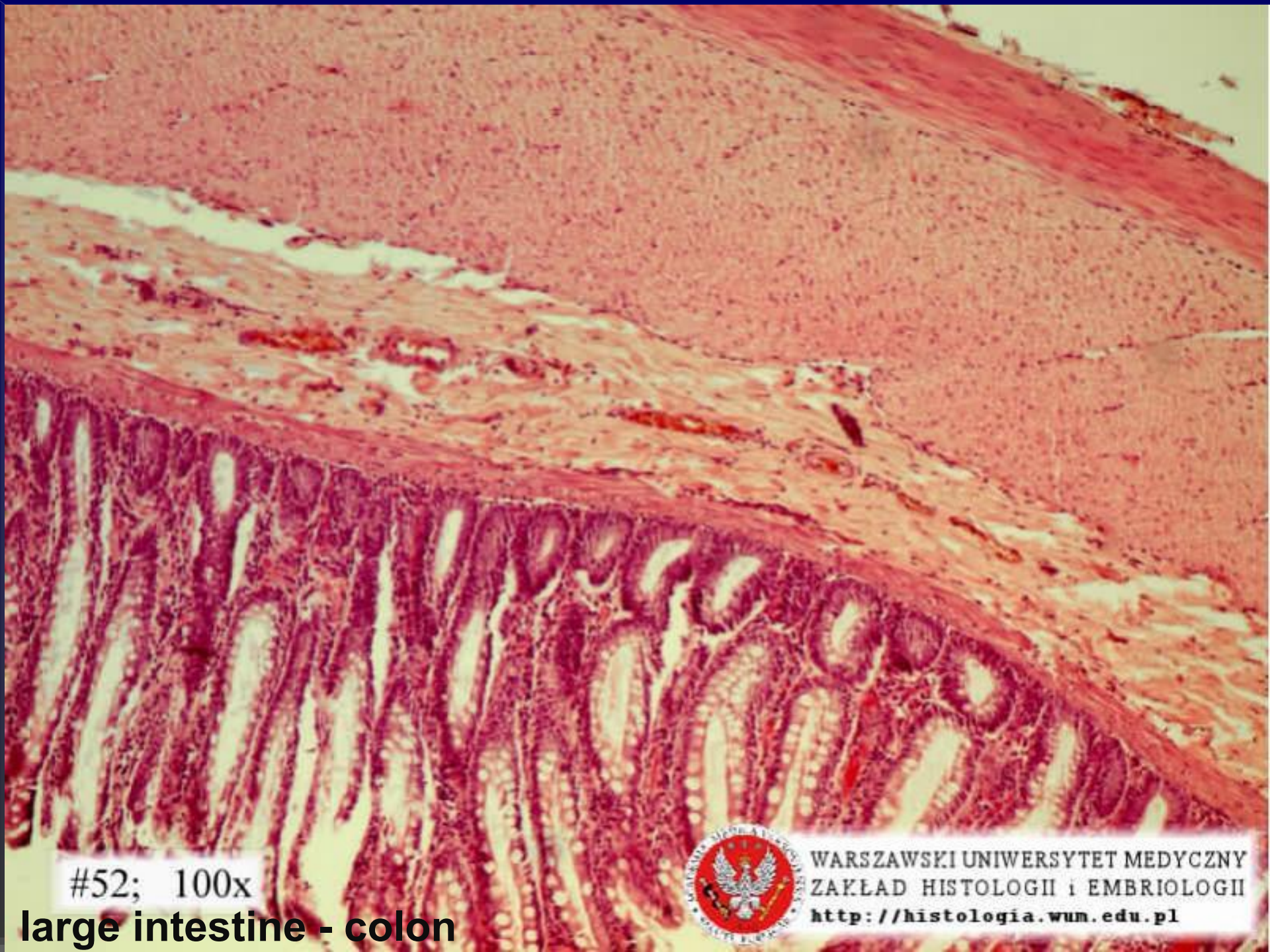
Small intestine - jejunum no.51

ileum – Peyer's patches (no. 55)

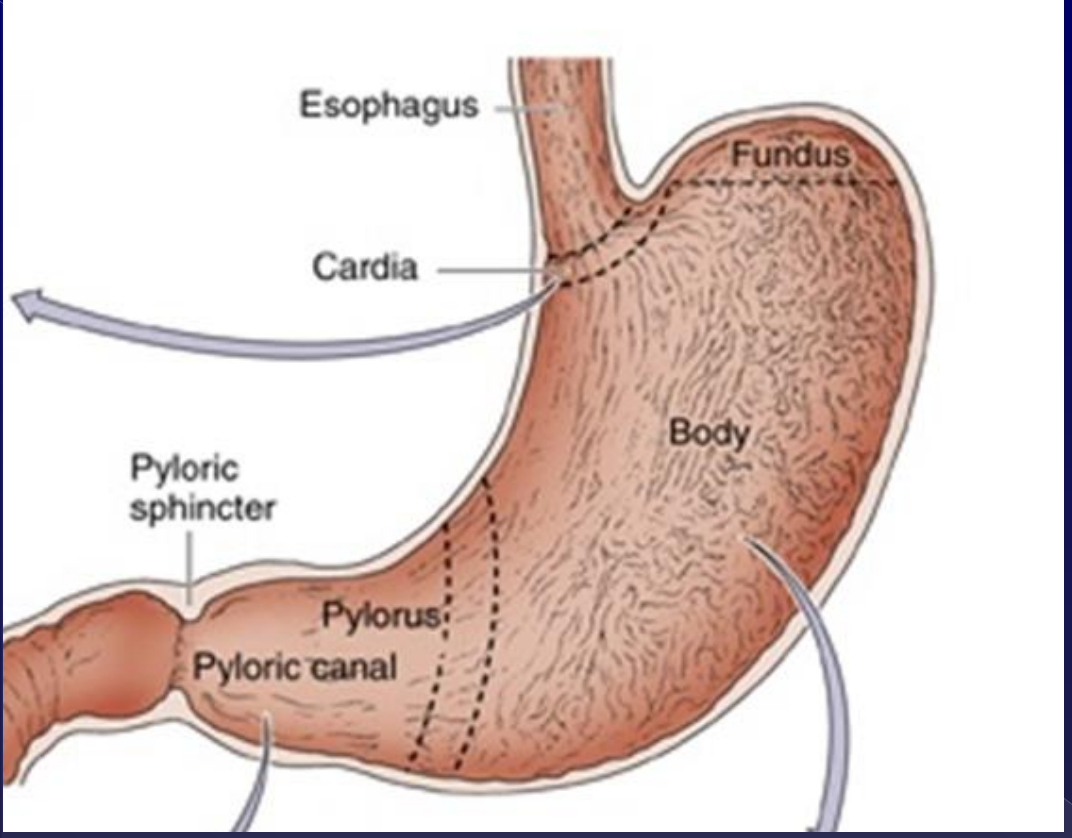


ileum – Peyer's patches (no. 55)



large intestine - colon

Next class - Digestive system part 3 (GLANDS)

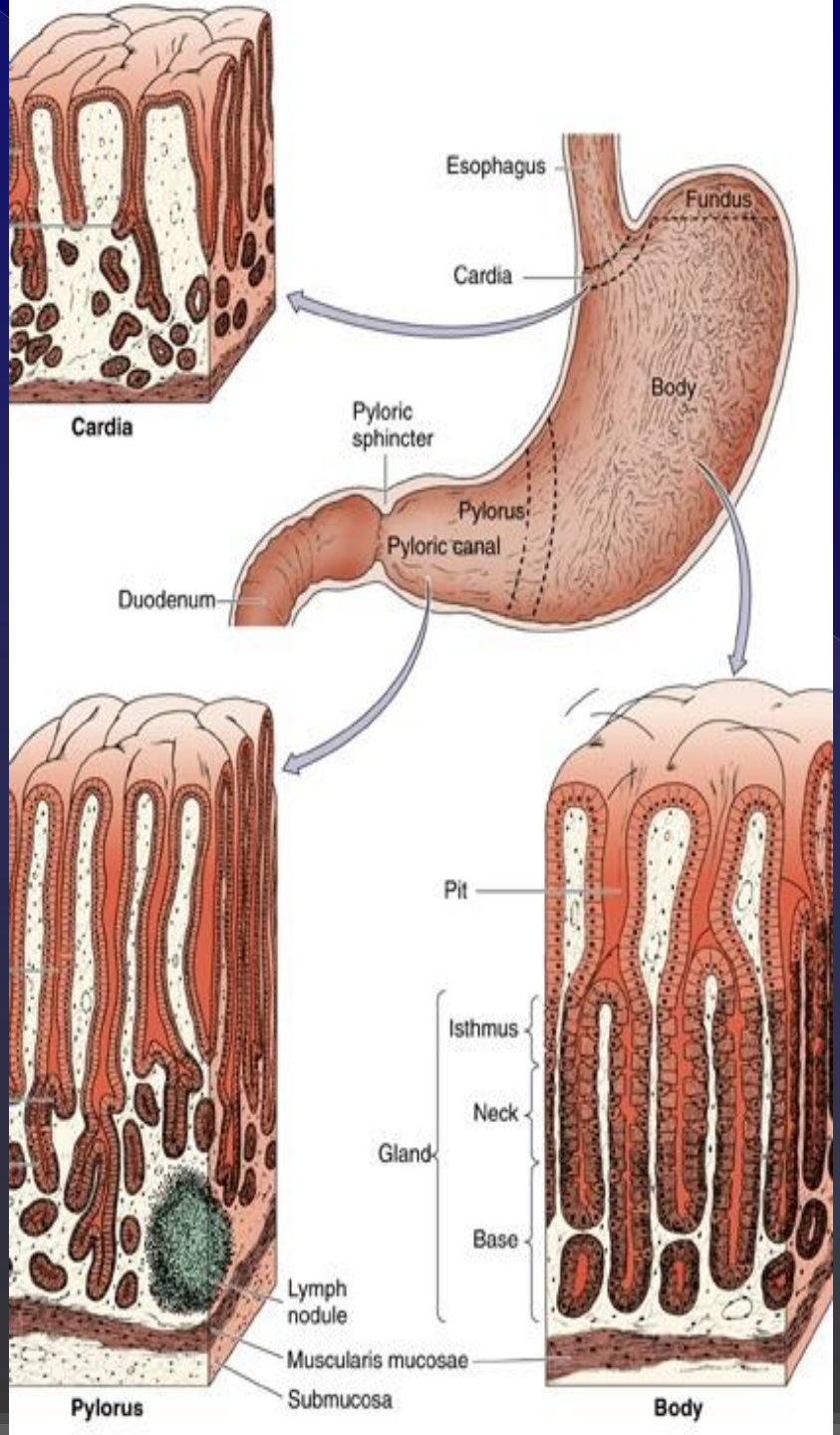


Stomach - the most dilated region of the alimentary canal

- **Cardia**
- **Fundus**
- **Body**
- **Pylorus**

Function

- storage, digestion, mechanical breakdown of food and production of **chyme (partly digested food)**



Cardiac glands (cardia) - **surface-lining cells (visible mucus), mucous neck cells (soluble mucus), stem cells, DNES cells**

Pyloric glands (pylorus) – similar to cardiac glands.

Cardiac glands and pyloric glands do not have parietal (oxyntic) and chief (zymogenic) cells

Fundus and body - Gastric glands

Interstitial cells of Cajal - between smooth muscle cells of muscularis externa **-** modified smooth muscle cells

- undergo rhythmic contractions (**pacemaker cells** for the contraction of muscularis externa)