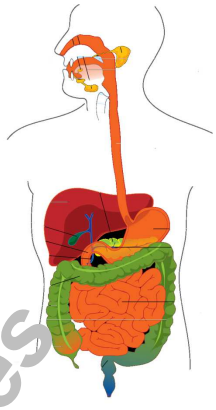
Digestive system



1. **Microscopic anatomy of esophagus, stomach, small and large intestine, anus**
2. Microscopic anatomy of liver, gall bladder and pancreas
3. Embryonic development of GIT

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General architecture of hollow organs incl. gut tube

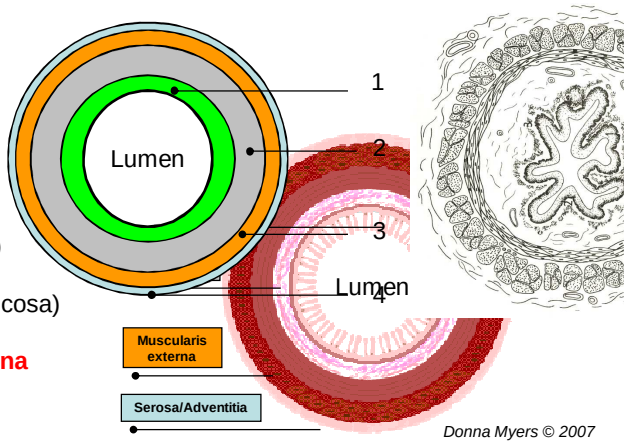
Four layers

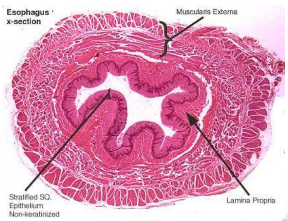
1. Mucosa (Tunica mucosa)

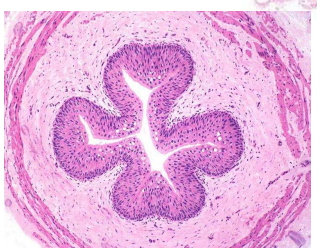
2. Submucosa (Tela submucosa)

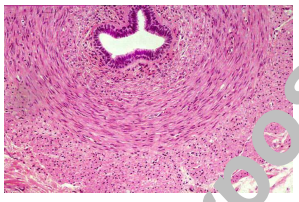
3. Tunica muscularis externa

4. Serosa/adventitia

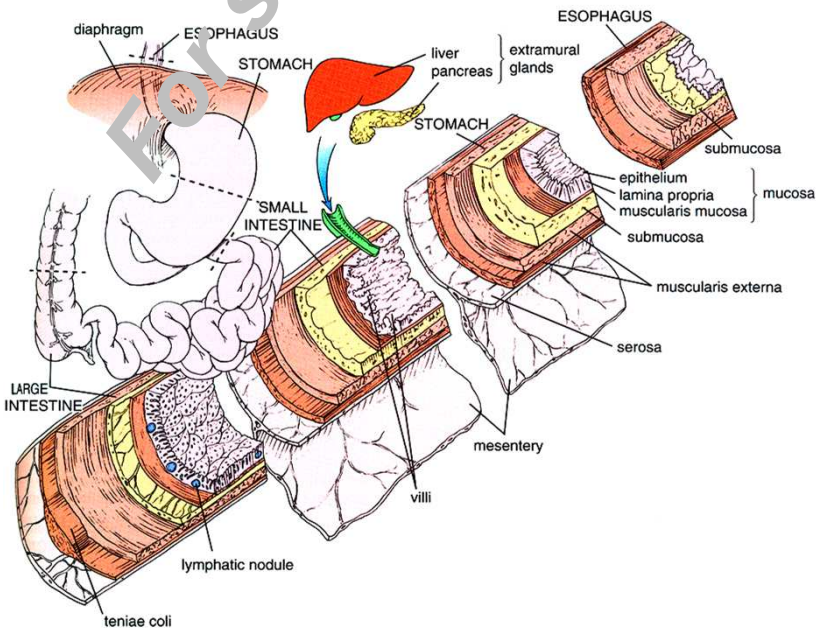






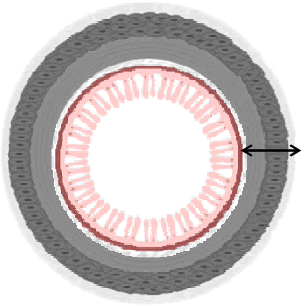


General architecture of hollow organs incl. gut tube

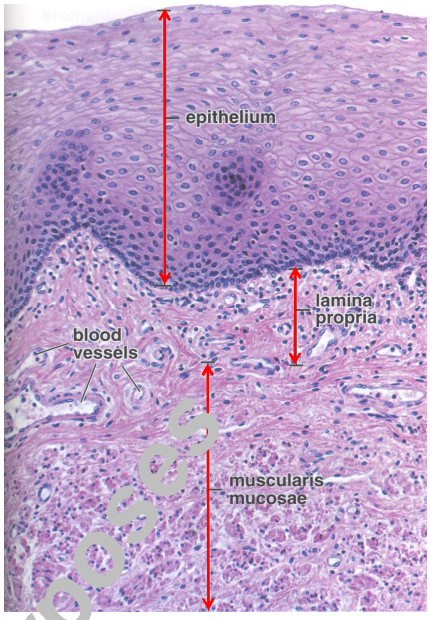


Mucosa (Tunica mucosa)

- inner layer of gut tube
- protective, absorption and resorption
- microscopic structure depending on localization



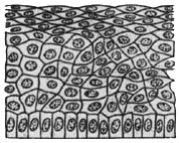
- **Lamina epithelialis** mucosae
- **Lamina propria** mucosae
- **Lamina muscularis** mucosae

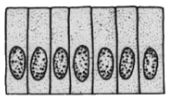


Mucosa (Tunica mucosa)

- Lamina epithelialis mucosae

- epithelium type corresponding to function of gut tube
- oral cavity, pharynx, esophagus, anus – **stratified squamous ep.**
- stomach, intestine – **simple columnar**
- **mucus** - secreted by mucosal or submucosal glands (oral cavity, esophagus), secretory epithelium (stomach) or goblet cells (intestine)



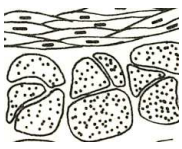


- Lamina propria mucosae

- Layer of mucosal connective tissue – loose collagen
- Fenestrated blood capillaries – transport of metabolite (intestine)
- mucosal glands in some regions /esophagus)
- innervations, immune system

- Lamina muscularis mucosae

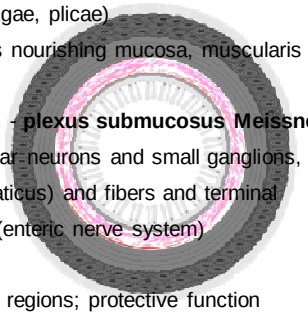
- thin smooth muslce layer
- well developer in esophagus, stomach and intestine
- small mechanical movements of mucosa facilitating secretion and absorption independently on peristaltic movements.



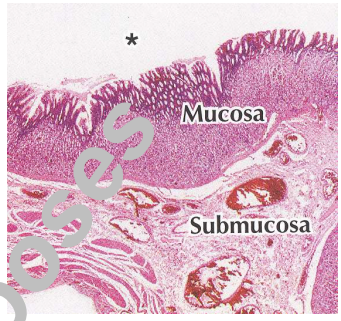
Submucosa (Tela submucosa)

Submucosal connective tissue

- distinct layer of loose connective tissue
- defines shape of mucosa (rugae, plicae)
- larger blood and lymph veins nourishing mucosa, muscularis externa and serosa
- **innervations** – nerve plexus - **plexus submucosus Meissneri**
  = groups of multipolar neurons and small ganglions, visceral sensory fibers (sympaticus) and fibers and terminal ganglions of parasympaticus (enteric nerve system)

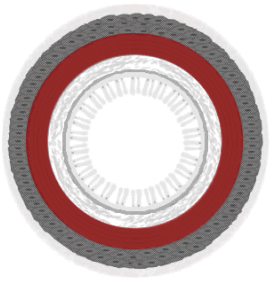


- glands – different in different regions; protective function

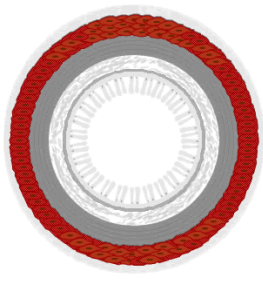


Outer muscular layers (Tunica muscularis externa)

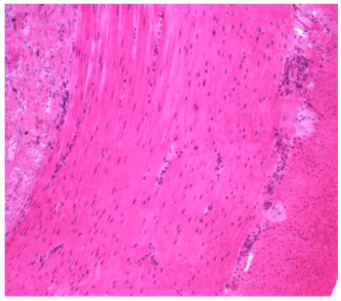
- Two concentric, thick layers of smooth muscle, separated by thin layer of connective tissue
- Inner – **circular**, outer – **longitudinal** (spiral)
- Myenteric (Auerbach) plexus
- Peristaltic – passage through the gut tube
- **Local modifications of m.e.**
  - pharyngoesophagal sphincter + external anal sphincter – skeletal muscles
  - stomach – third - oblique - layer
  - taenie coli – thickened part of longitudinal layer in colon



Circular



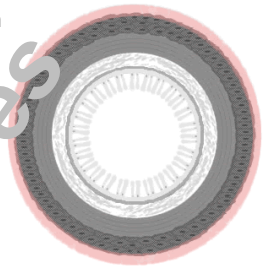
Longitudinal



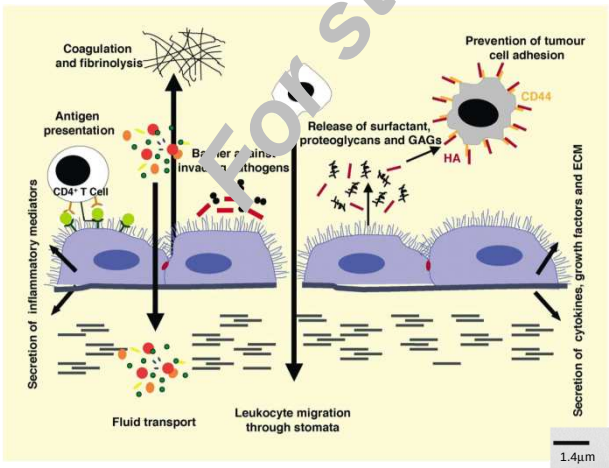
Serosa/Adventitia (Tunica serosa/adventitia)

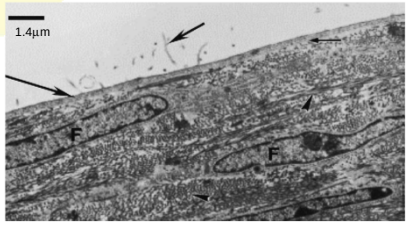
- outermost layer of gut tube
- **Serosa**
  - serous membrane of loose connective tissue (Lamina propria serosae) and single layer squamous epithelium (L. epithelialis serosae)
  - syn. mesothelium, visceral peritoneum
  - continuous with mesenterium
  - barrier against various pathogens , antiadhesive properties – intracoelomic movements, immune functions (Ag presentation), ECM production, etc.

- **Adventitia**
  - some parts of the tube are not covered with epithelium
  - esophagus in thorax, parts of digestive system in peritoneal cavity in walls (duodenum, part of colon, rectum, anal canal)
  - connective tissue only continuous with connective tissue of the wall



Serosa/Adventitia (Tunica serosa/adventitia)

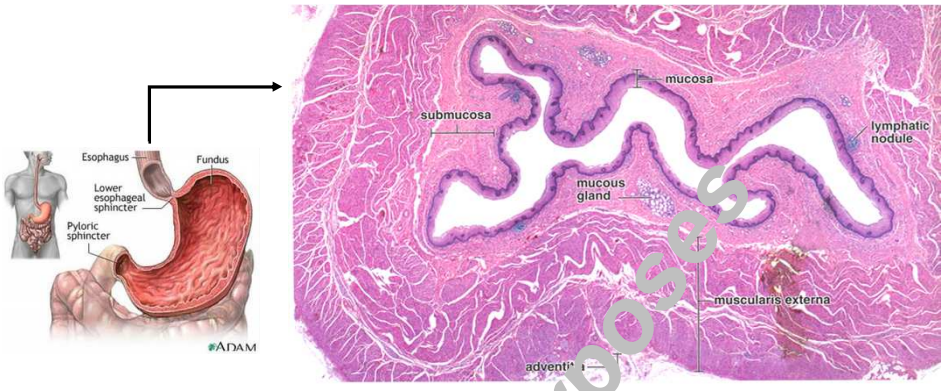




S.E. Mutsaers / The International Journal of Biochemistry & Cell Biology 36 (2004) 9–16

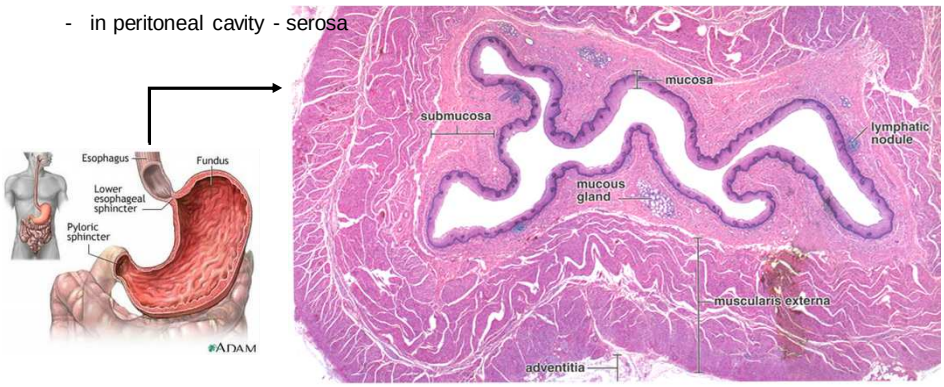
Esophagus (Oesophagus)

- **Mucosa**
  - nonkeratinized stratified squamous epithelium → mechanically protects esophageal tissue
  - L. propria contains cardial glands (tubular mucinous) and diffuse lymphatic tissue
- **Submucosa**
  - loose collagen connective tissue, defines shape of mucosa
  - blood and lymph veins, plexus submucosus Meissneri
  - submucosal glands (tubular mucinous)
  - diffuse lymphatic tissue



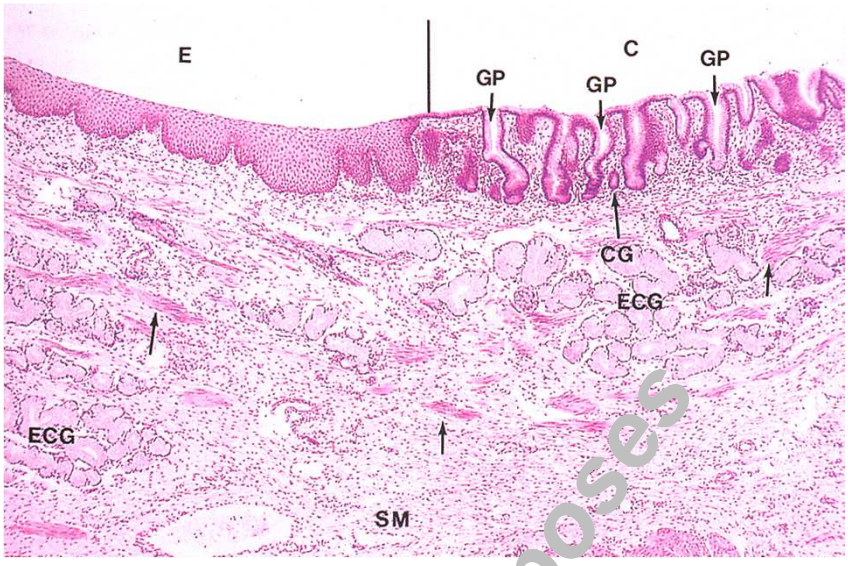
Esophagus (Oesophagus)

- **Muscularis externa**
  - inner circular and outer longitudinal layer
  - plexus myentericus Auerbachi
  - upper third – skeletal muscle, mid third – mixed smooth and skeletal, lower third – smooth muscles only
- **Adventitia**
  - neck and chest – connects esophagus with surrounding tissue
  - loose connective tissue
  - in peritoneal cavity - serosa



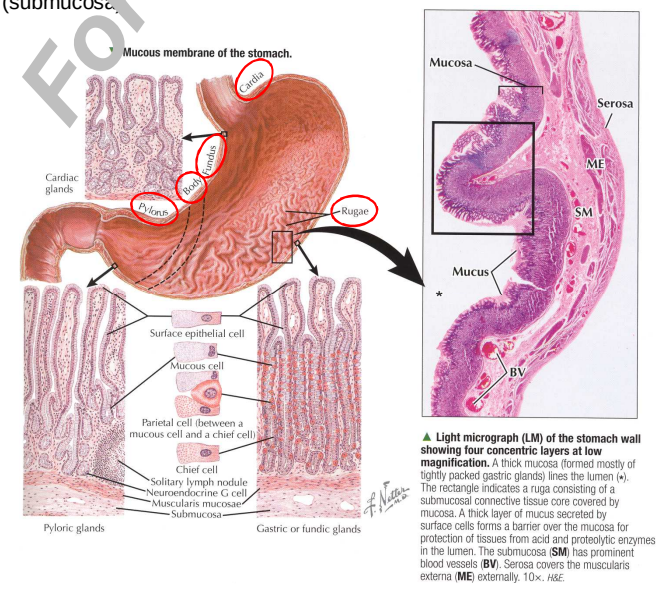
Cardia of stomach – connection with esophagus

Nonkeratinized stratified squamous epithelium → simple columnar epithelium



Stomach (Ventriculus, Gaster)

- general anatomy of hollow tube
- anatomical regions differ also in histologic structure
- rugae gastricae (submucosa)



▲ **Light micrograph (LM) of the stomach wall showing four concentric layers at low magnification.** A thick mucosa (formed mostly of tightly packed gastric glands) lines the lumen (*). The rectangle indicates a ruga consisting of a submucosal connective tissue core covered by mucosa. A thick layer of mucus secreted by surface cells forms a barrier over the mucosa for protection of tissues from acid and proteolytic enzymes in the lumen. The submucosa (**SM**) has prominent blood vessels (**BV**). Serosa covers the muscularis externa (**ME**) externally. 10×. *H&E.*

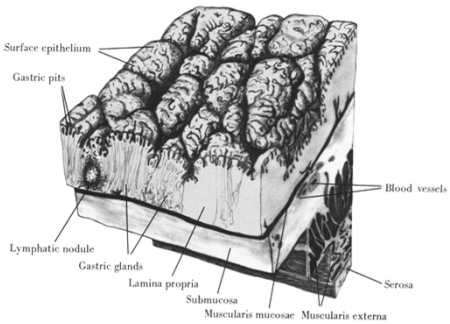
Stomach (Ventriculus, Gaster)

- **Gastric mucosa**
- simple columnar epithelium
- surface epithelium produces mucus

(mucinogenic granules, high content of HCO_3^-, K^+)

= protective function

- areae gastricae, foveolae gastricae

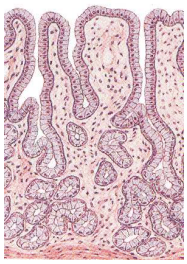


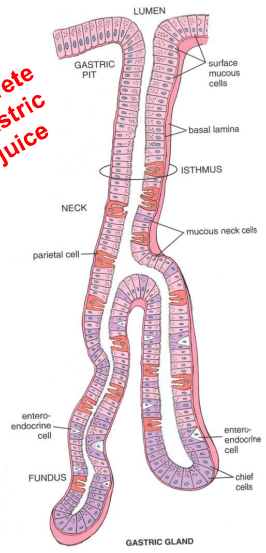
Stomach (Ventriculus, Gaster)

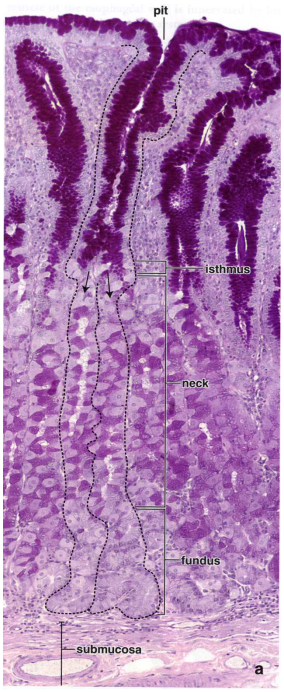
- **Gastric mucosa**
- L. propria contains large amount of glands
  - Gl. cardiacae
  - Gl. pyloricae
  - Gl. gastricae propriae

Mucous

Secrete gastric juice



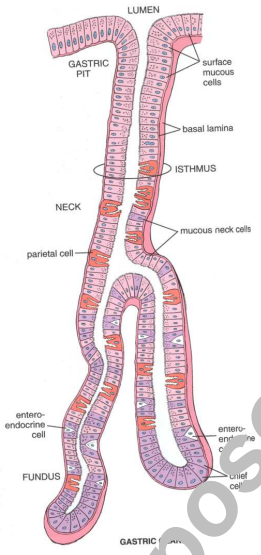


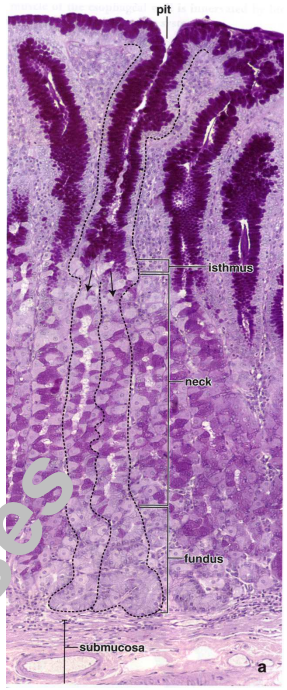


Stomach (Ventriculus, Gaster)

- **GI. gastricae propriae**
- glands of fundus and body
- simple tubular or branched
- 2-4 opens to the gastric pits

- **four cell types of gl. gastricae propriae**

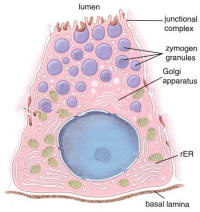




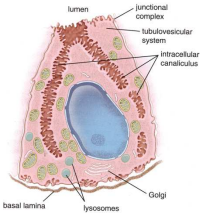
Stomach(Ventriculus, Gaster)

GI. gastricae propriae

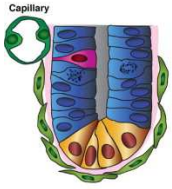
chief
- most abundant, lower part of body and fundus of the gland
- pyramidal shape, basophilic cytoplasm, RER, pepsinogenic granules



parietal
- neck-body junction
- eosinophilic cytoplasm, high numbers of mtch., SER
- complex and dynamic ultrastructure
- intracellular canals in apical part with microvilli – membrane bound enzyme complexes producing H^+ a Cl^- (HCl originates extracelullarly)

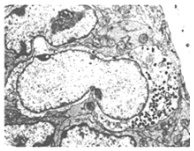


neck cells
- cubic, mucinous
- capable of regeneration of all cell types in gastric epithelium



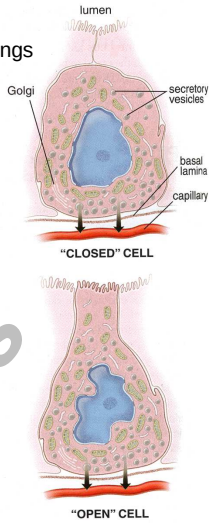
Stomach (Ventriculus, Gaster)

Gl. gastricae propriae



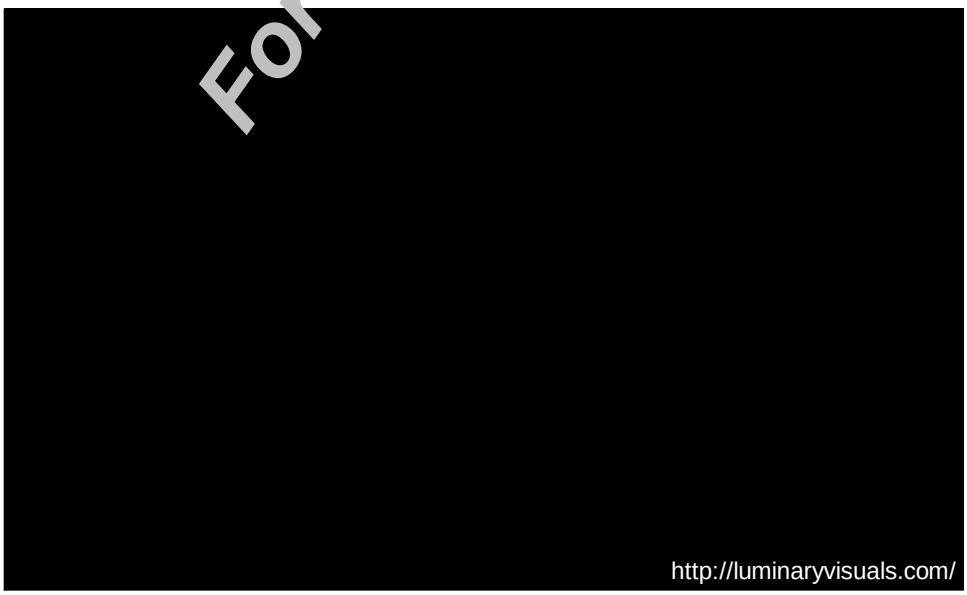
(entero)endocrine

- minor, secretion
- granules
- different cell types with different sensitivity to various histological stainings
- secretion of various biologically active compounds
- DNES/APUD
- GIT chemosensing
- see lesson spring semester 2012 - Epithelial tissue

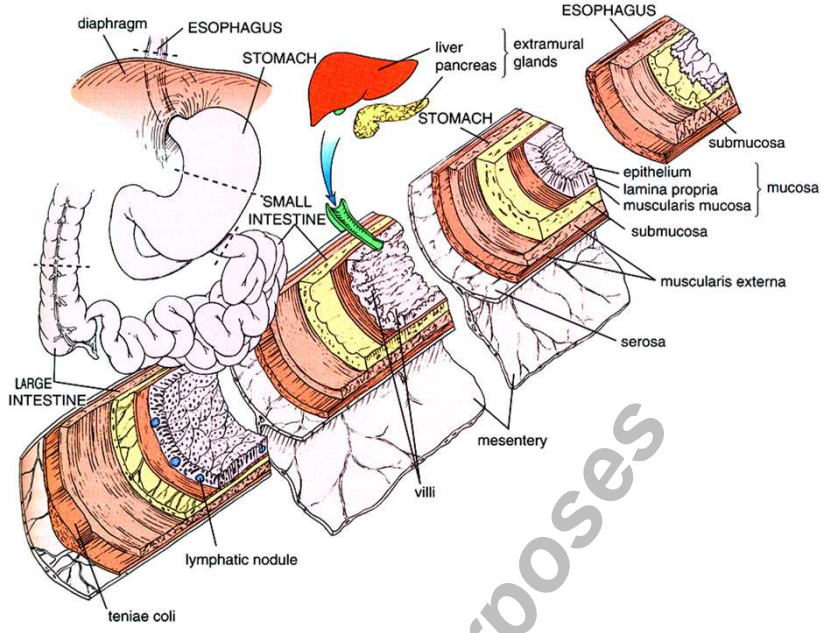


Type	Hormone	Localization/Function
D cells	Somatostatin	- Stomach, intestine, hepatic and pancreatic ducts
EC cells	Serotonin	- Stomach, gallbladder, intestine - Peristaltics
ECL cells	Histamin	- Stomach - HCl secretion
G cells	Gastrin	- Pars pylorica, duodenum - HCl, pepsin secretion
L (EG) cells	Enteroglucagon	- Stomach, intestine - attenuates secretion of pancreatic enzymes an[illegible]altics

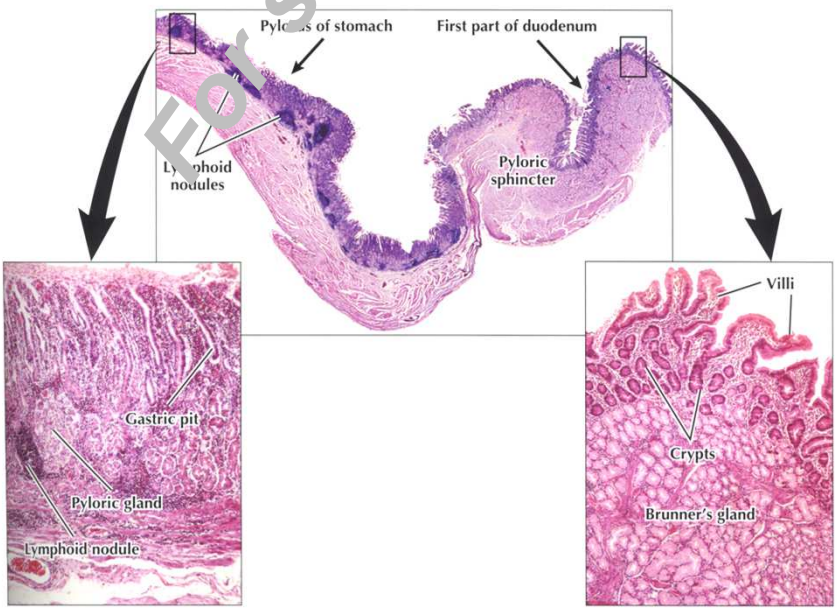
Break



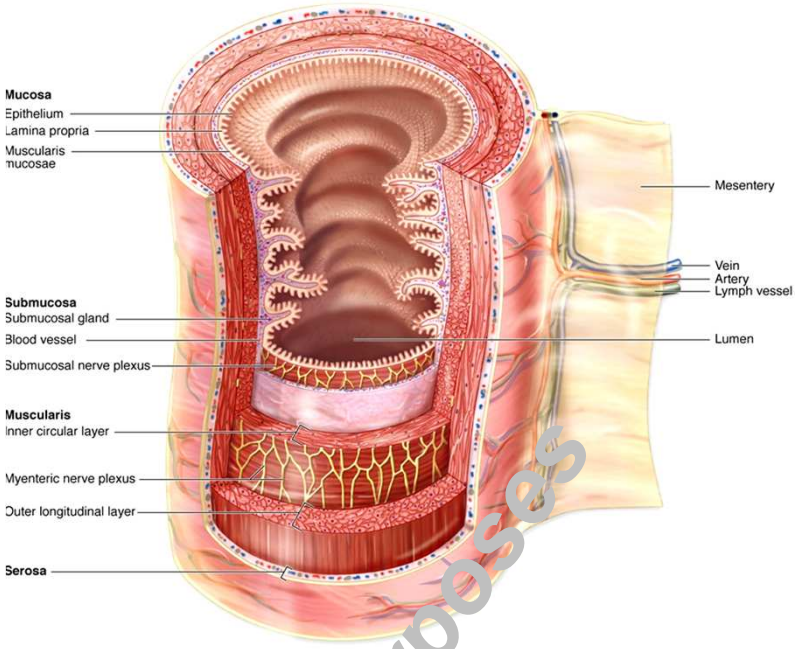
General architecture of hollow organs incl. gut tube



Gastroduodenal junction



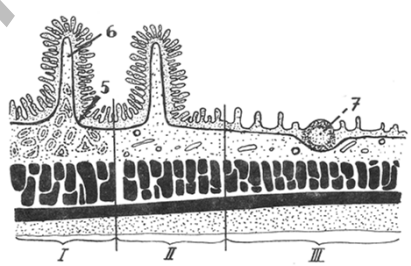
General architecture of the intestine



Small intestine – adaptation to efficient resorption

Four basic layers: **mucosa, submucosa, muscularis externa, serosa**
mucosa and submucosa maximise the resorptive area

- **plicae circulares** (Kerckringi) – mucosa + submucosa, ca 800, increase **2-3x**, distal region of duodenum



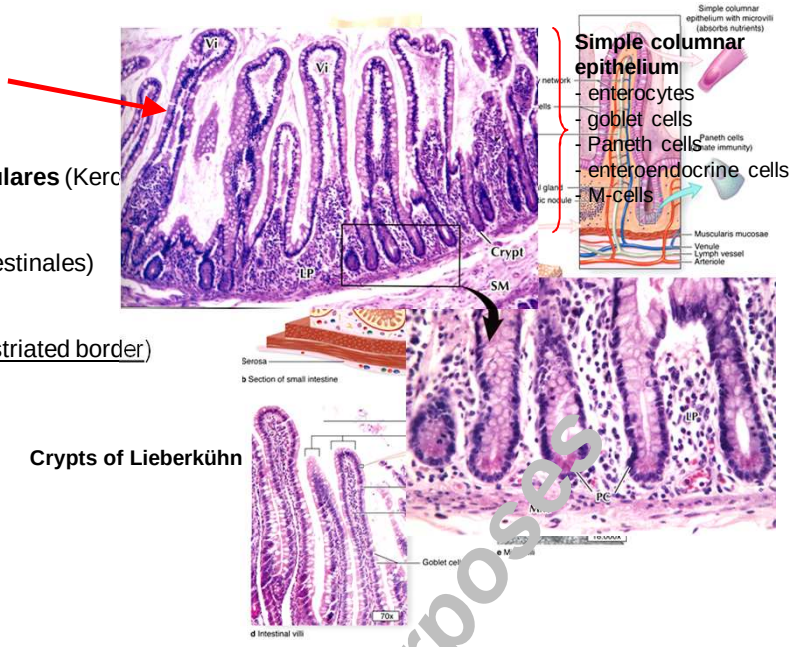
- **villae** (villi intestinales) – mucosa (l. propria + epithelium) 0,5-1,5 mm long, 10-40/mm^2 , 4 000 000, increase **5-10x**
- **microvillae** – apical part of enterocytes – 1- 2 µm long, 0,1 µm wide, 100 mil./mm^2, increase **20x**

Small intestine – adaptation to effective resorption

plicae circulares (Kerc
– **2-3x**

villi (villi intestinales)
– **5-10x**

microvilli (striated border)
– **20x**



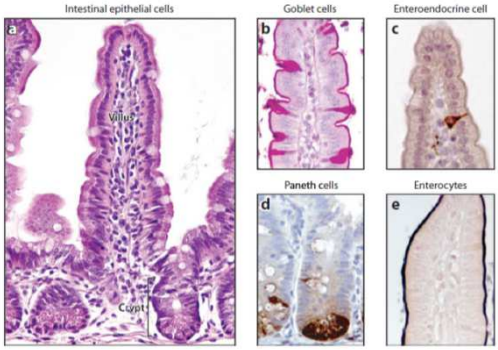
Simple columnar epithelium
- enterocytes
- goblet cells
- Paneth cells
- enteroendocrine cells
- M-cells

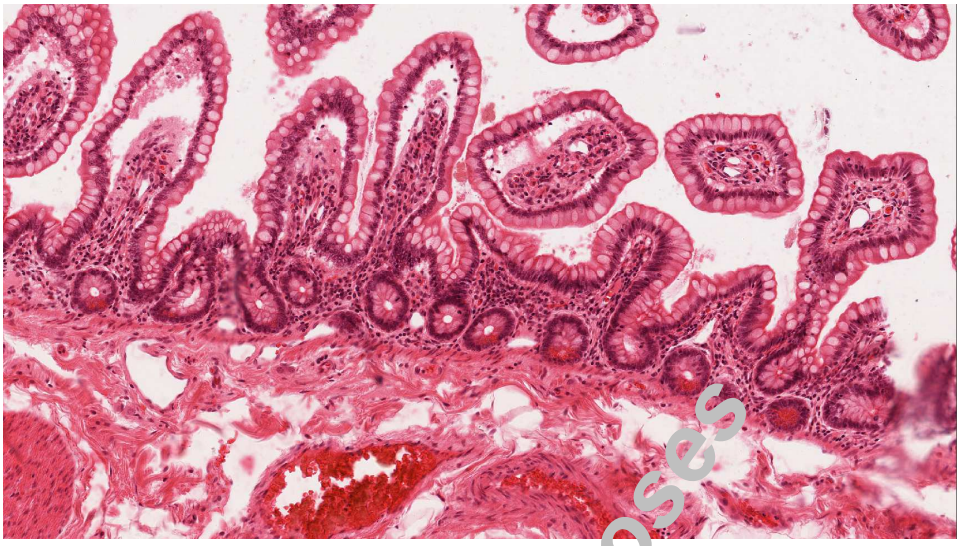
Crypts of Lieberkühn

200-600x

Crypts of Lieberkühn (gl. intestinales)

- simple tubular structures of intestinal mucosa, depth 0,3-0,5 mm
- pass through l. propria and open to lumen
- different cell types
  - secretion of digestive enzymes
  - epithelial renewal
  - enteroendocrine cells
  - immune response





Intestinal mucosa

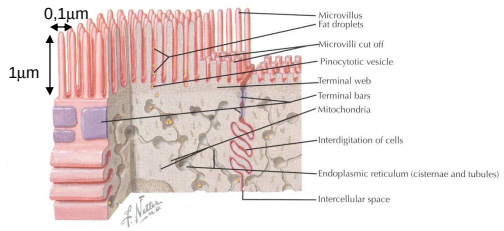
Enterocytes

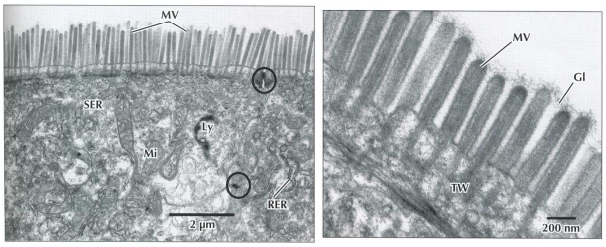
- tall, columnar cells
- nucleus located in basi[illegible] of the cell
- apical surface mo[illegible]fied- microvilli (3000) + glycocalyx (0,5µm) = *striated border (cuticle)*
- tight intercellular connections, interdigitations

Function:

- digestion – enzymatic complexes on microvilli membrane
- absorption and transport – passive, facilitated i active
- lipid uptake - chylomicrons

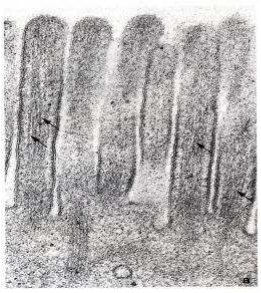
▼ Three-dimensional scheme of striated border of intestinal epithelial cells.

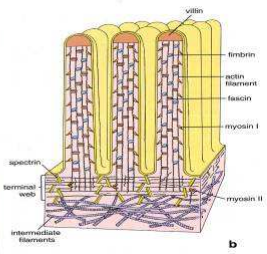


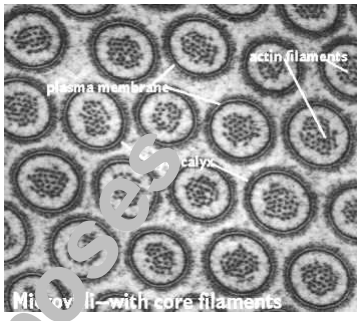


▲ **EMs of enterocytes at low (Left) and high (Right) magnification.** Apical microvilli (**MV**) make up a striated border and extend from free surfaces of the cells. A fuzzy glycocalyx (**GI**) covers them. A terminal web (**TW**) of actin filaments in the apical cytoplasm reaches into microvilli. Intercellular junctions (**circles**) are between adjacent cells. The cytoplasm contains mitochondria (**Mi**), lysosomes (**Ly**), and smooth (**SER**) and rough (**RER**) endoplasmic reticulum. **Left:** 10,000×; **Right:** 50,000×.

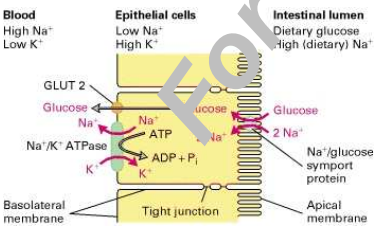
Microvilli

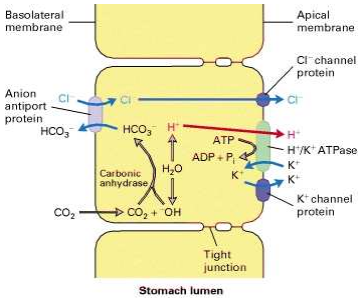






Transportion and resorption





Transport of glucose from intestinal lumen to blood stream

Na^+/K^+ ATPase - basolateral surface - concentration gradient Na^+ and K^+

K^+ gradient generates negative membrane potential

Na^+/glucose symport on apical surface

Facilitated diffusion by glucose uniporter (GLUT2) in basolateral membrane

http://www.ncbi.nlm.nih.gov/books/NBK21502/

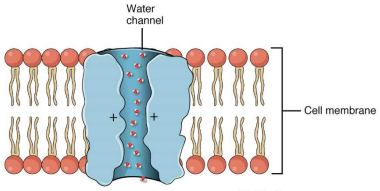
Acidification of stomach fluid by parietal cells

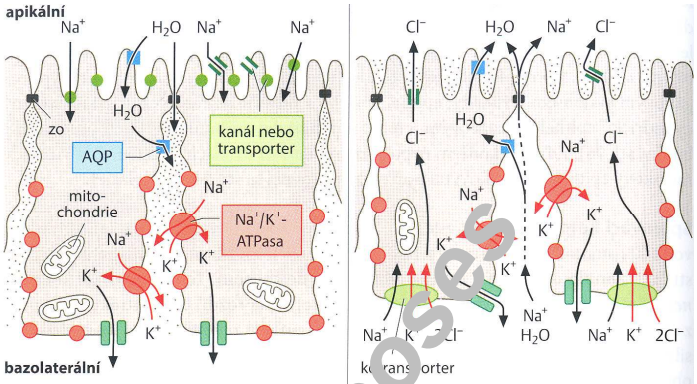
Apical membrane - H^+/K^+ ATPase + Cl^- a K^+ canals

Basolateral membrane – anion antiporter HCO_3^- and Cl^- ions

Combined activity of ion channels a cells keeps the electroneutrality and neutral cytoplasmic pH while reaching high extracellular concentration of H^+ and Cl^- in lumen of stomach

Transportion and resorption





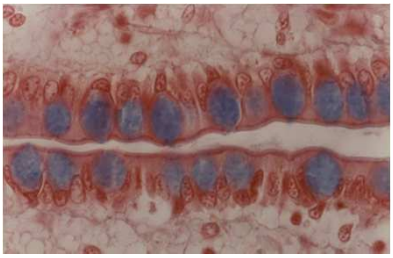
water resorbing epithelium

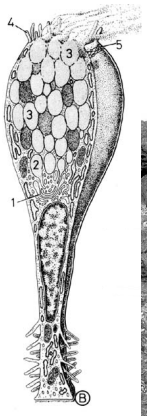
water secreting epithelium

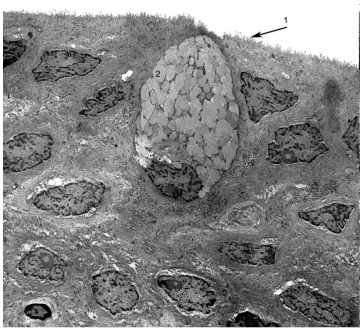
Intestinal mucosa

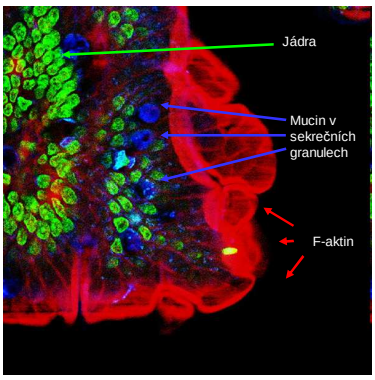
Goblet cells

- Cylindrical glandular epithelial cells
- Apical surface – apocrine/merocrine secretion of mucin
- Basal part – RER, GA, nucleus, mitochondria
- Mucinogenic granules
- see lesson spring semester 2016 - Epithelial tissue



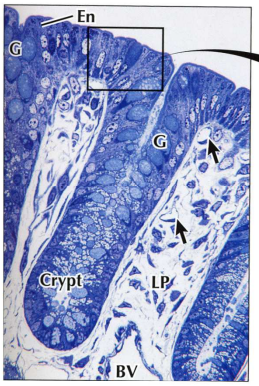




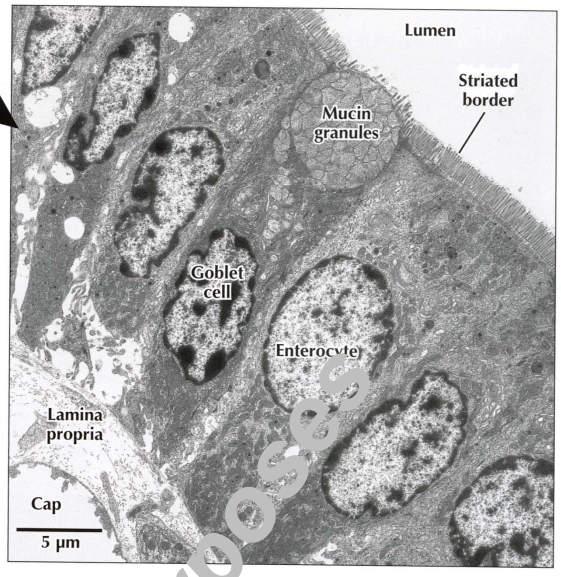


Intestinal mucosa

Goblet cells

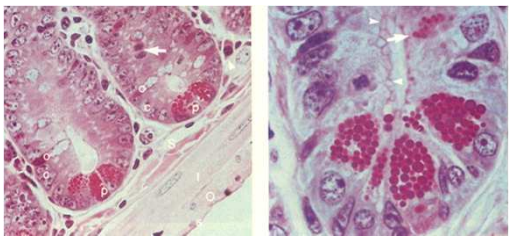


▲ **LM of the colonic mucosa.** Surface epithelium containing goblet cells (**G**) and enterocytes (**En**) invaginates to form an intestinal crypt. The lamina propria (**LP**), with capillaries (**arrows**) and larger blood vessels (**BV**), is richly cellular. 600×. *Toluidine blue.*



Intestinal mucosa

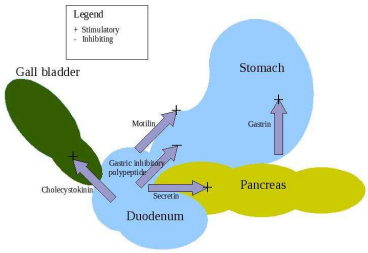
Paneth cells



- basal part of crypts of Lieberkühn
- basophilic cytoplasm
- GA located above nucleus
- acidophilic (red) granules
- immune system
- secretion granules contain biologically active substances e.g. lysozym)
- influence intestinal microflora

Enteroendocrine cells

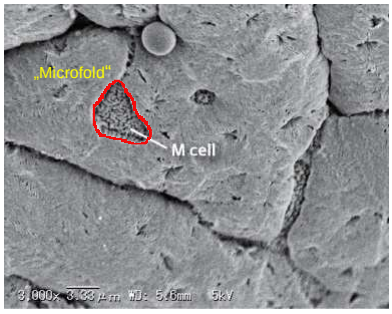
- similar to gastric enteroendocrine cells
- regulate pancreatic secretions
- homeostatic axis (brain-intestine-adipose tissue)
- cholecystokinin, secretin, GIP, motilin, neurocrine peptides etc.

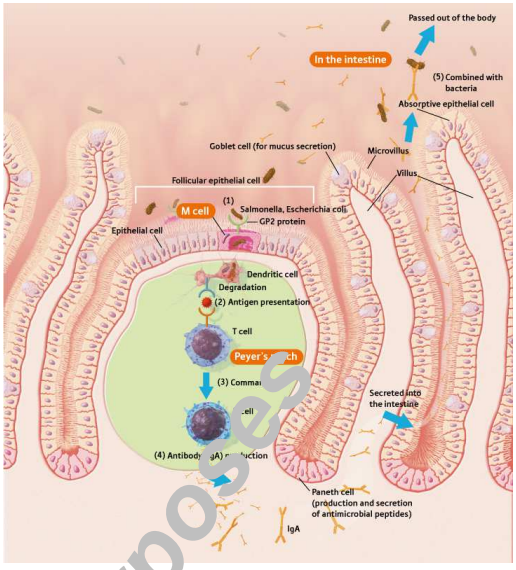


Intestinal mucosa

M cells (microfold)

- epithelial cells above Peyer's patches and lymphatic nodules
- no microvilli
- induces immune response
- MHCII
- antigen presentation to dendritic cells and lymphocytes

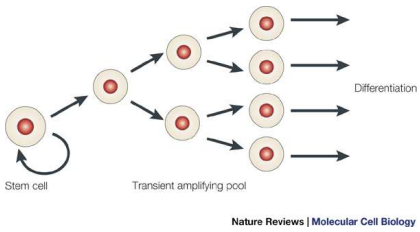


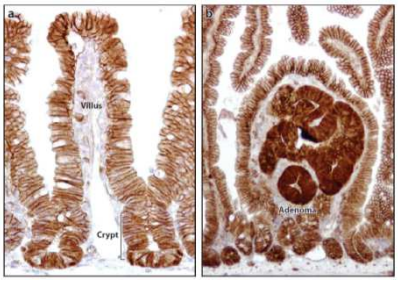


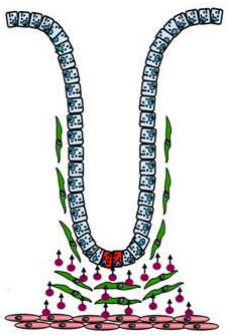
Intestinal mucosa

Intestinal stem cells

- bottom of crypts of Lieberkühn
- epithelial renewal (4-5 days)
- stem cell niche
- tumour transformation



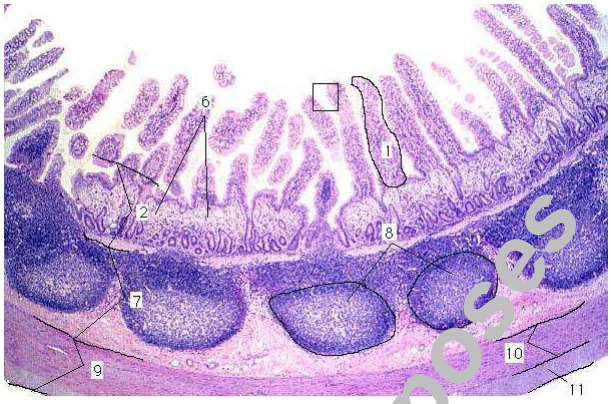




Intestinal mucosa

L. propria

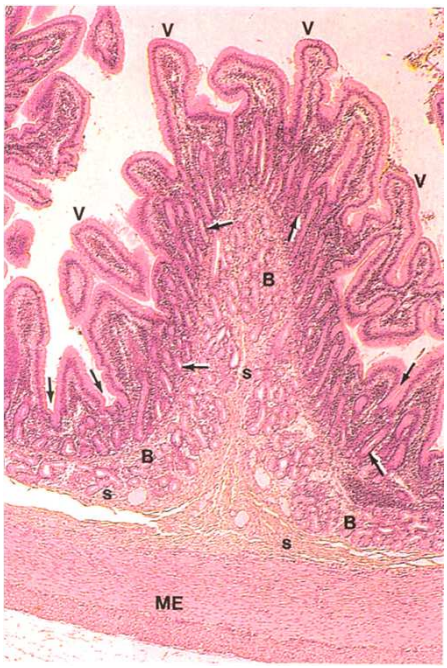
- immune system – GALT
- immunologic barrier
- Peyer's patches



Submucose

Brunner's glands

- gl. duodenale Brunneri
- branched tuboalveolar glands, columnar mucinous cells
- connective tissue reduced to thin septa between glandular lobules
- open to crypts of Lieberkühn

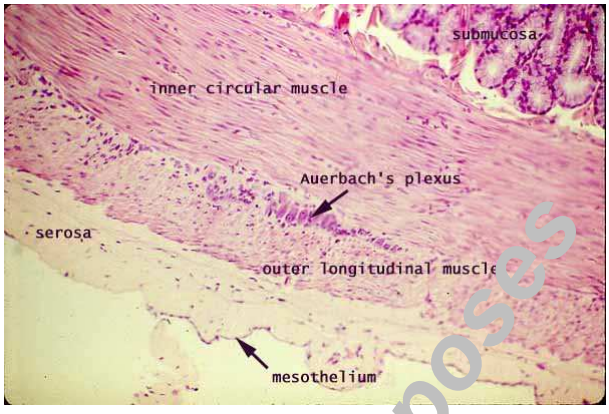


Muscularis externa

- two layers of smooth muscle (inner circular, outer longitudinal)
- plexus myentericus Auerbachi

Serosa

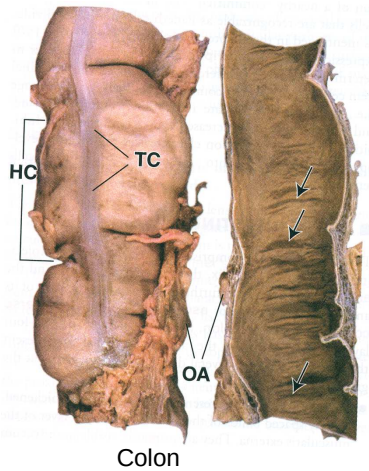
- loose collagen connective tissue + simple squamous epithelium (mesothelium)



Colon

- no plicae of Kerckring, villi
- muscularis externa – longitudinal layer forms taenie coli
- surface serosa forms appendices epiploicae (adipose)

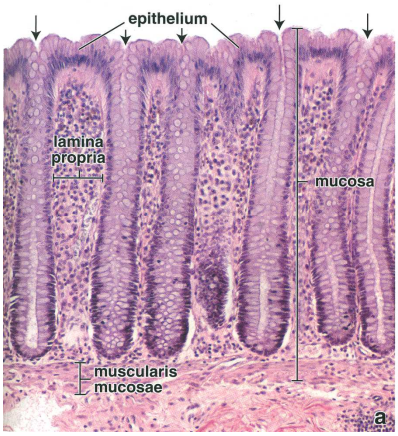
Small intestine

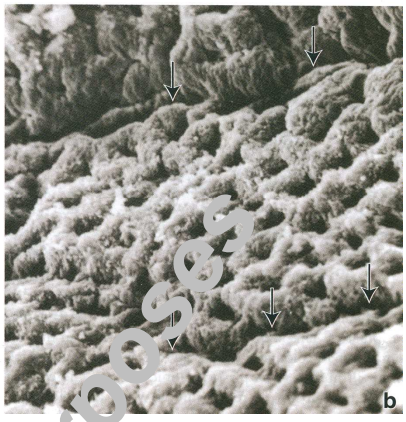


Colon

Colon

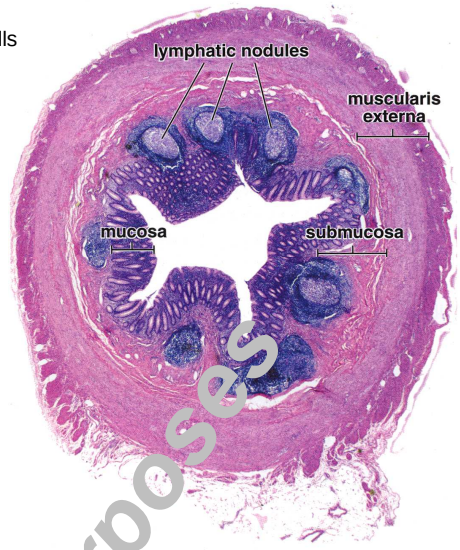
- absorption of water, electrolytes
- deeper crypts of Lieberkühn, no Paneth cells
- abundant goblet cells
- abundant lymphatic follicles in l. propria (GALT)





Apendix

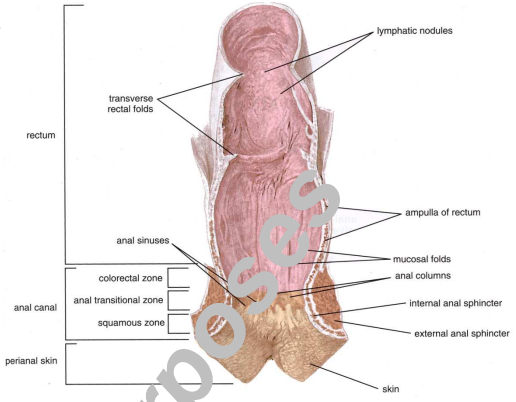
- develops from and is connected to caecum 8-10 cm (0,5-1cm)
- continuous longitudinal layer of m. externa
- lymphatic follicles reaching submucosa
- irregular crypts of Lieberkühn with Paneth cells



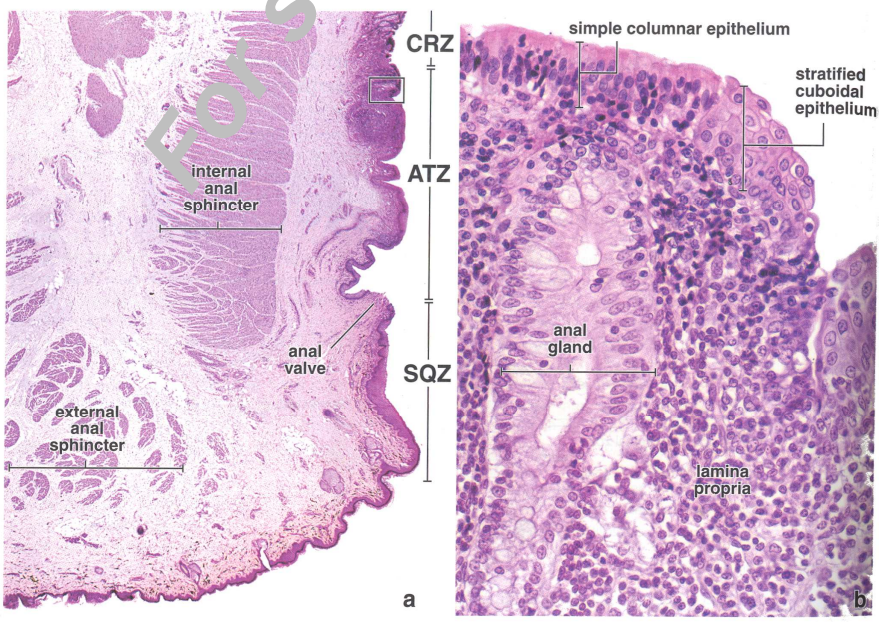
Rectum and anal canal

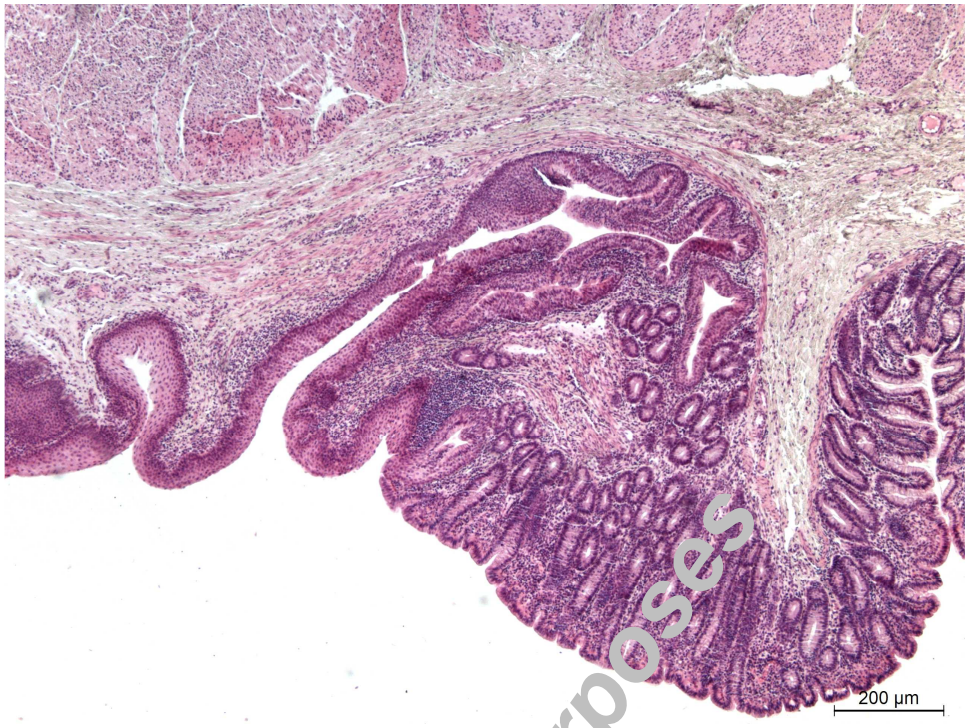
- Pars pelvina
  - *plicae transversae recti*
  - histological architecture identical to colon

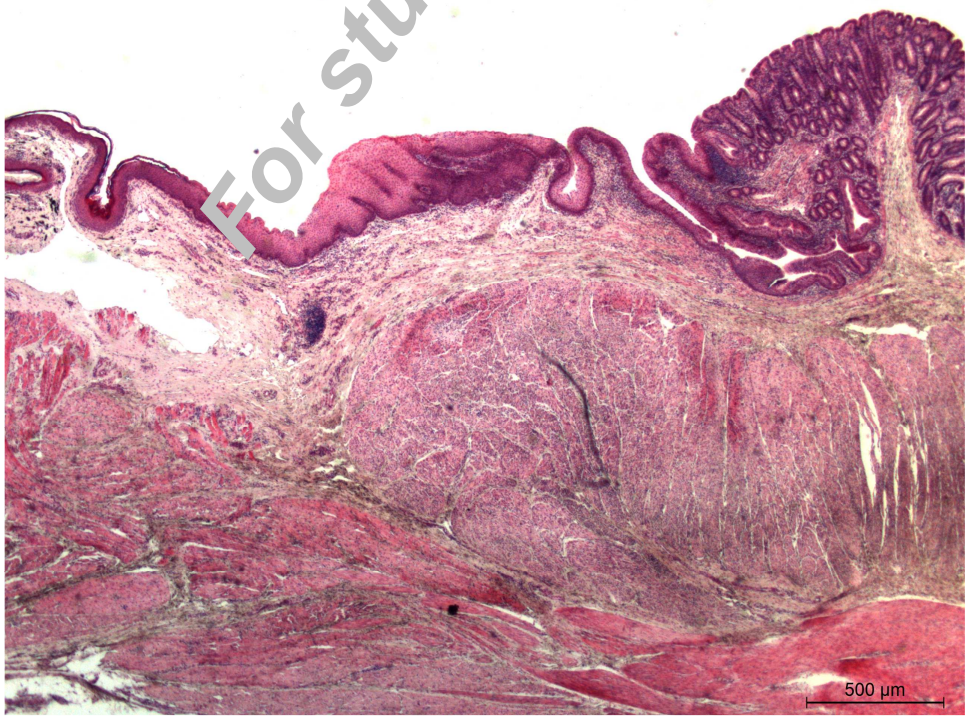
- Canalis analis
  - anulus hemorhoidalis – no L. crypts, simple columnar epithelium replaced by stratified squamous epithelium
  - rich venous plexus
  - *columnae rectales*
  - *sinus rectales* and *valvulae rectales*
  - *zona cutanea* – typical skin



Rectum and anal canal







Microscopic anatomy of the gut tube

Summary

- **General architecture of hollow organs and gut tube**: mucosa (l. epithelialis m ., l. propria, l. muscularis m.), submucosa, t. muscularis externa, serosa (l. propria s., l. epith. s.), adventitia

- **Esophagus** - structure, epithelium, mucosal and submucosal glands, differences in t. muscularis ext.

- **Stomach** – anatomical and histological structure, mucosa - areae gastricae, foveolae gastricae, gastric glands (pyloricae vs. propriae), localization, ultrastructure and function of gl. gastricae propriae and its cells (chief, parietal, neck, enteroendocrine

- **Small and large intestine, appendix** - anatomical and histological structure, mucosa, glands (crypts of Lieberkühn, Brunner's glands), cell types of intestinal mucosa, lymphatic system, modifications of intestinal wall

- **Rectum and anal canal** - anatomical and histological structure, mucosa, epithelium, description of associated structures

Embryonal development

- Development of primitive gut and its derivatives, embryonic flexion, differentiation and characteristics of individual regions and associated organs

Study materials

- **Sadler: Langman's Medical Embryology, 20**
- **Ovalle&Nahirney: Netter's Essential His**ology, 2008
- **Klika&Vacek: Histologie, 1974**
- **Ross&Pawlina: Histology (a text and atlas), 2011**
- **Ross&Romrell: Histology (a text a atlas), 1989**
- **Berman: Color Atlas of Basic Hi**
- **Ústav histologie & embryo'ogi LF MU,** www.med.muni.cz/histol/histolc.html
- **Čech S., Horký D., Sedlá ov přehled embryologie člověka, Brno, LF MU, 2011**
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