Pathophysiology of GIT I

Oral cavity and salivary glands
Esophagus
Stomach and duodenum
Small and large intestine

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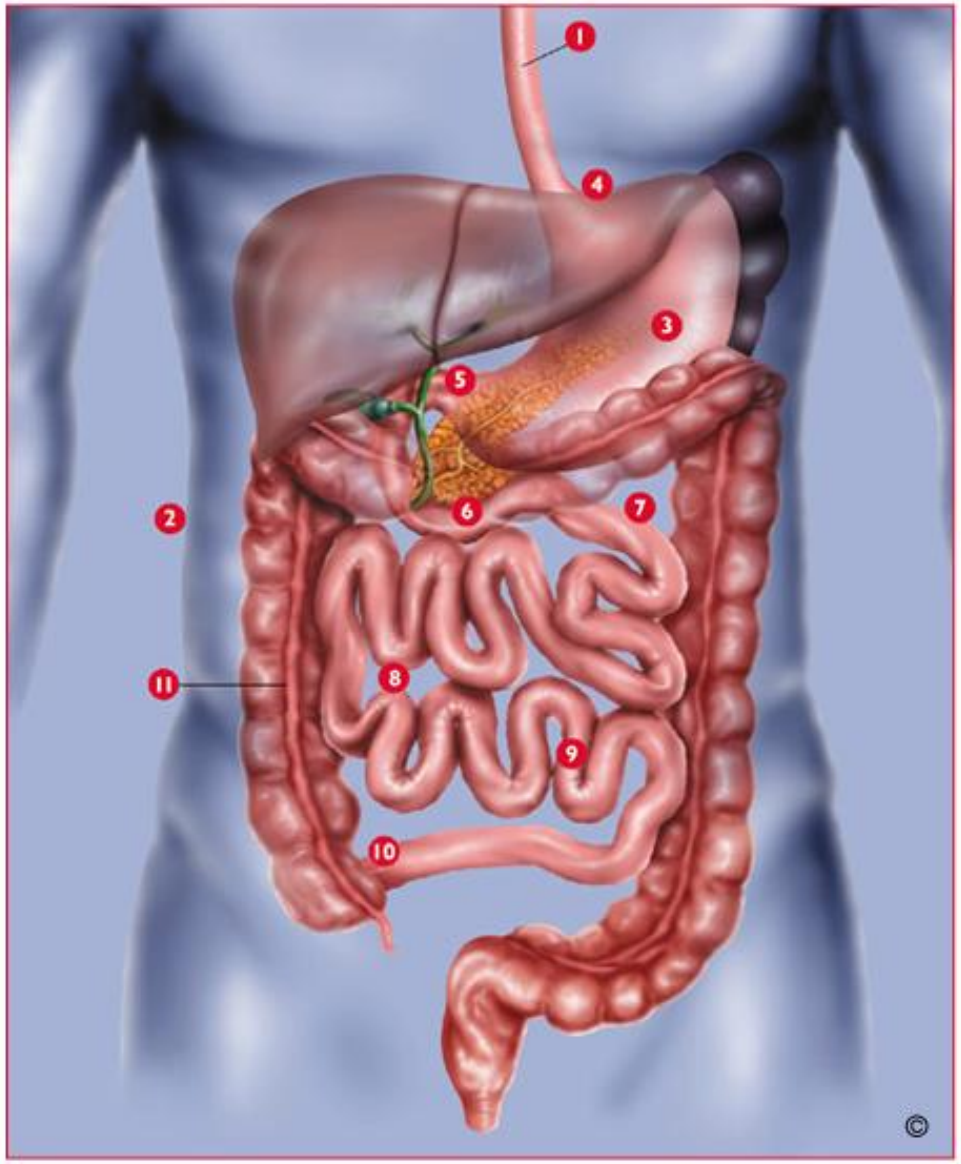
GIT



- 1- oesophagus
- 2- organs of peritoneal cavity
- 3- stomach (1.5l)
- 4- gastroesophageal junction
- 5- pylorus
- 6- small intestine (4.5 – 6m)
  - 7- duodenum
  - 8- jejunum
  - 9- ileum
- 10- ileocaecal valve
- 11- large intestine
  - ascendant
  - horizontal
  - descendant
  - rectum + anus

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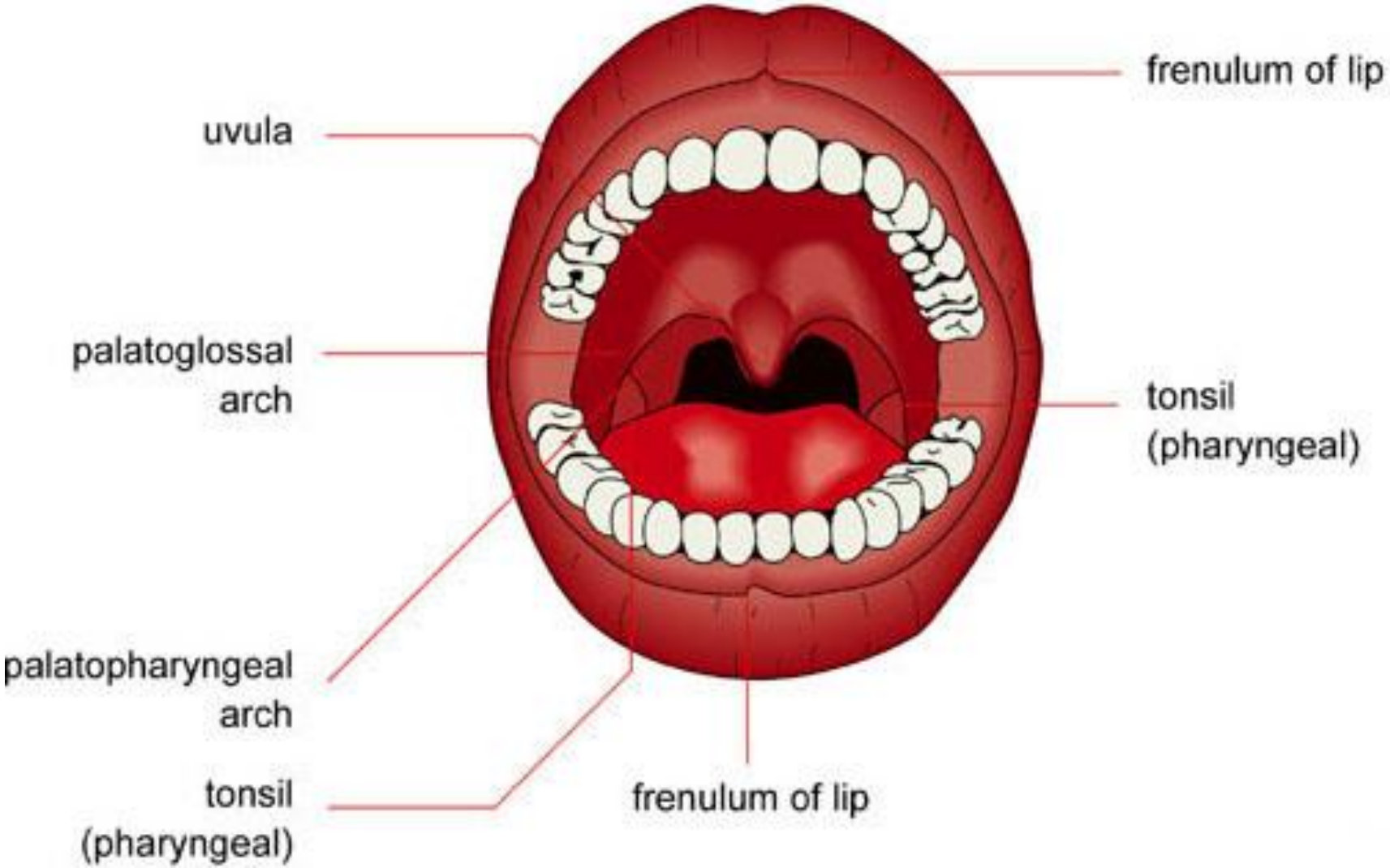
Pathophysiology of oral cavity



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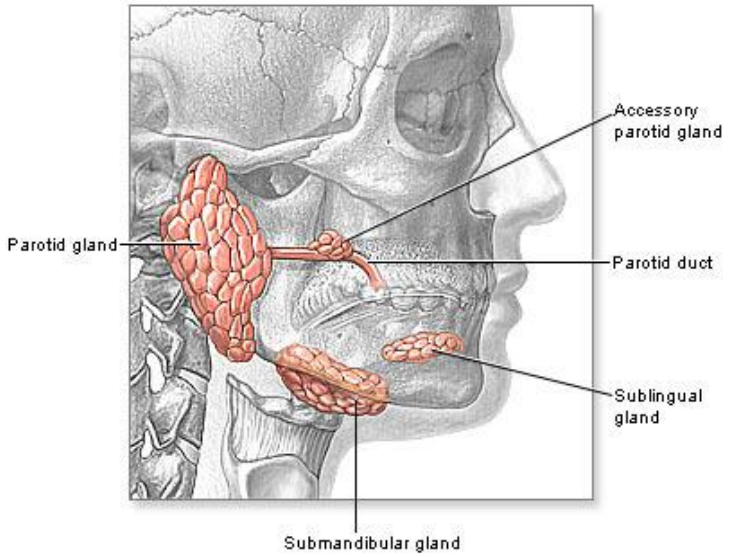
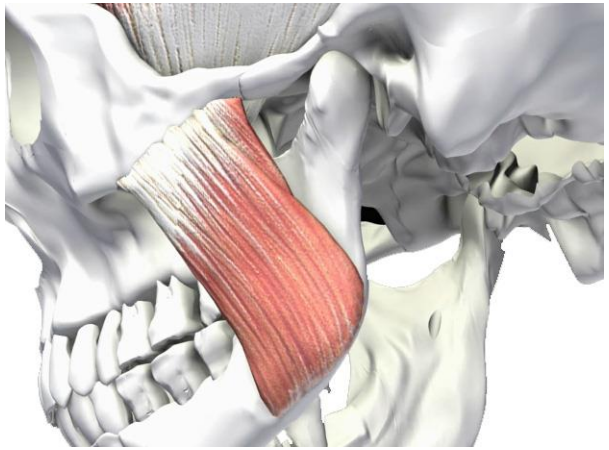
Pathophysiology of oral cavity





- salivary glands - salivation (1 - 1.5l/day)
  - continual production by small salivary glands
  - large glands secerns only upon stimulus
    - centrum in medulla oblongata → sal. glands (via n. facialis)
    - afferentation from upper centres (cortex, hypothalamus) upon stimuli (taste, smell, chewing, …)
  - enzymes and ions of saliva
    - α-amylase (polysaccharides), lipase
    - lysozyme (bactericide)
    - K+, Na+, Cl-, HCO3-
- disease of oral cavity
  - abnormal secretion of saliva
    - ↑ - inflammation (e.g. tonsillitis), mechanical irritation
    - ↓ (xerostomy) - dehydration, Sjögren syndrome, drugs
  - abnormal chewing
    - painful mandibular joint
    - injury of tongue
    - painful teeth
    - mucosal inflammation
  - infections
    - herpetic (HSV-1), bacterial, candidiasis (in immune compromised patients)
  - diseases of temporomandibular joint
    - pain
    - dislocation (habitual)
  - precanceroses and tumors of oral cavity
    - leucoplakia
    - carcinoma – smokers, alcoholics
  - signs of systemic diseases in oral cavity
    - anaemia
    - vitamin and iron carrncy
    - malnutrition
    - cyanosis
    - Crohn's disease

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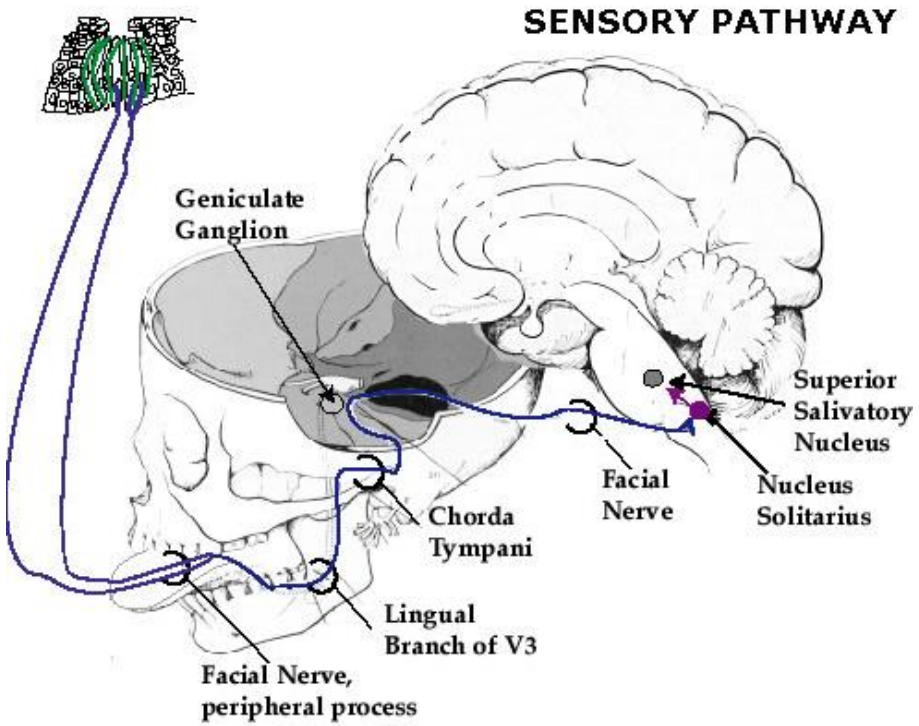
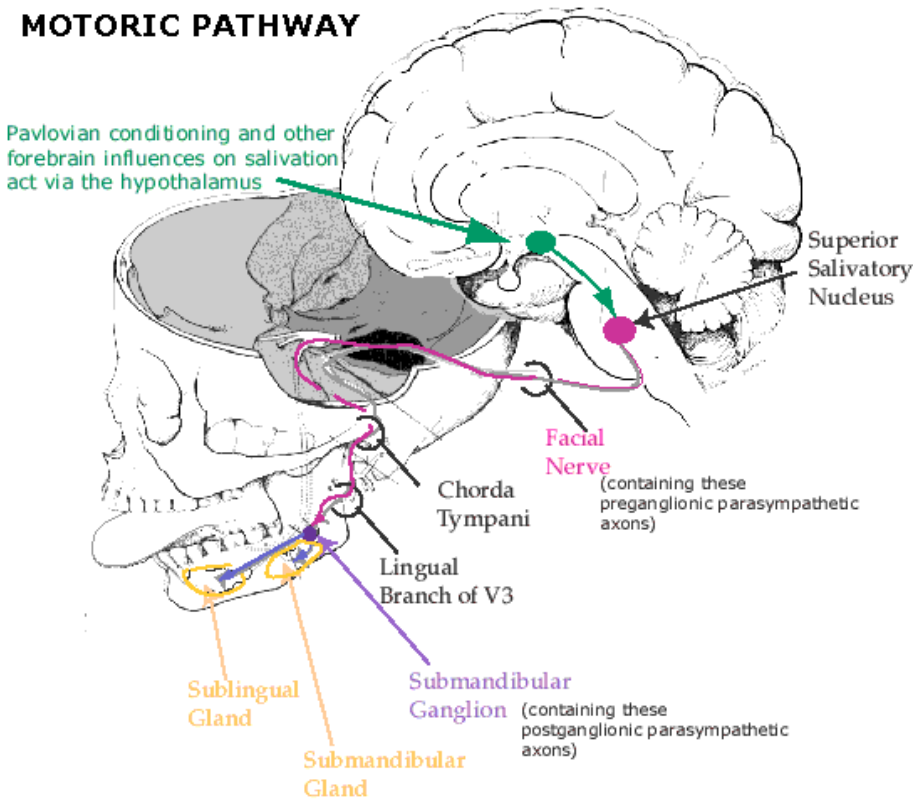
Reflexive salivation





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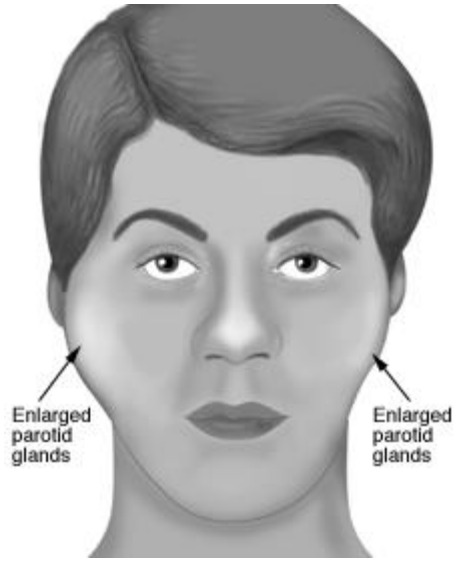
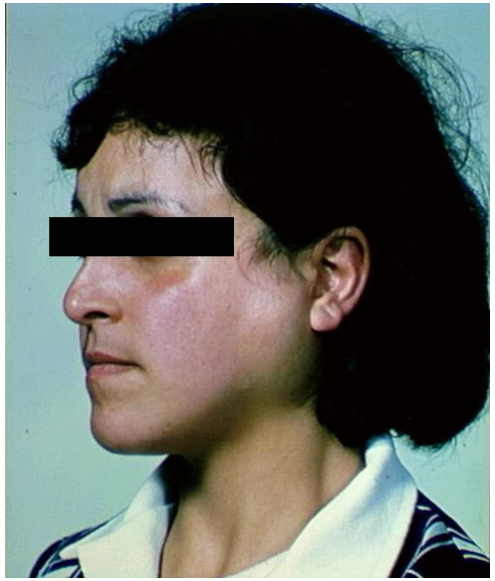
Sjögren syndrome

- syn. keratoconjunctivitis sicca
- autoimmune reaction against salivary (xerostomy) and tear glands (xerophtalmy)
  - initiated by viral infection?
- symptoms
  - difficulties of chewing and swallowing
  - difficult talking
  - dry cough
  - irritation, eye burning, foreign body feeling and reddening of eye
  - sometimes accompanied by joint and muscle pain
- SS can coexist with other autoimmune diseases
  - rheumatoid arthritis
  - systemic lupus erythematodes
  - thyreopathy





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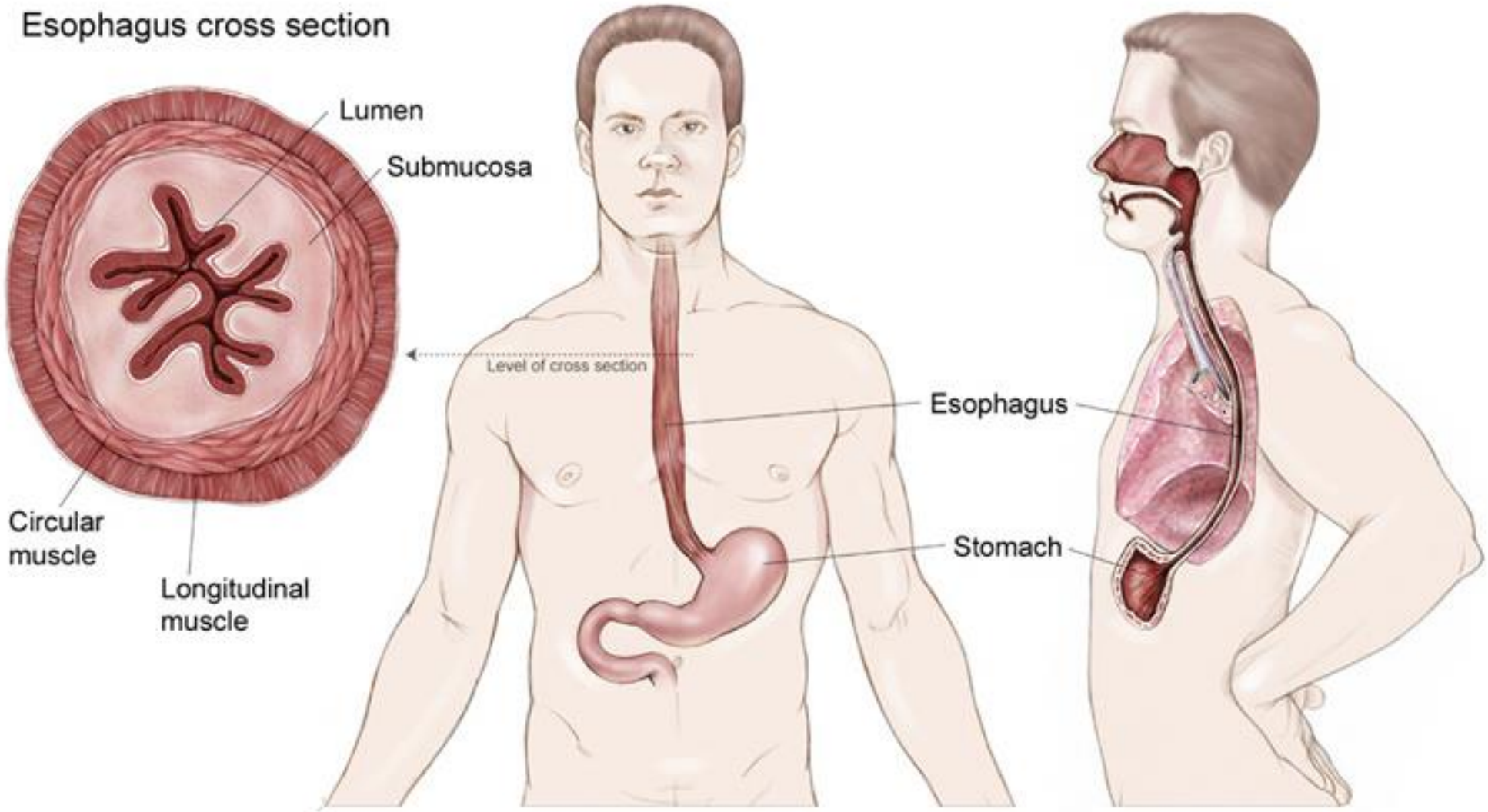
Pathophysiology of oesophagus



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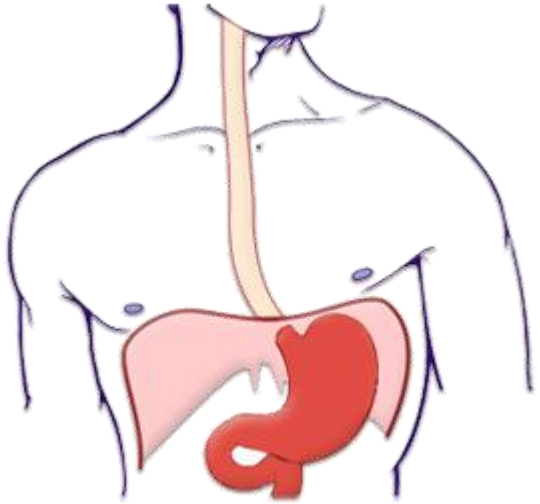
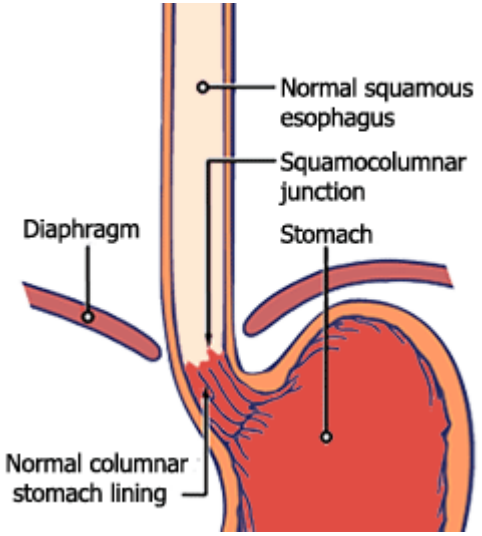
Pathophysiology of oesophagus





- anatomy and histology
  - upper 2/3 striated muscle + squamous epithelium
    - upper sphincter (m. cricopharyngeus)
  - bottom 1/3 smooth muscle
    - lower sphincter (smooth muscle)
    - in terminal part cylindrical epithelium
  - peristaltics
- disorders of motility and swallowing
  - dysphagia (oropharyngeal or oesophageal)
    - painful swallowing (odynophagia) + block of passage
  - 1) functional
    - e.g. scleroderma, amyotrophic lateral sclerosis or vegetative neuropathy in diabetes mellitus, achalasia, reflux. esophagitis, Chagas disease
  - 2) mechanical obstruction
    - strictures, peptic ulcer, tumours

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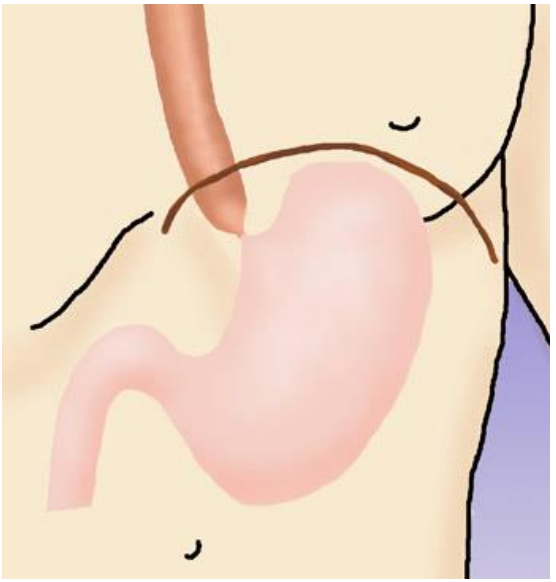
Disorders of oesoph. motility

- achalasia
  - inability to relax lower oesoph. sphincter + lack of peristaltics
    - due to inborn or acquired impairment of myenteric nerve plexus (Meissneri) and production of NO by NO synthase
- Chagas disease
  - common in Middle and Latin America
    - affect approx. 15 mil. people
    - 25% of Latin-American population endangered
  - infection by parasite Trypanosoma cruzi
    - incest born
  - acute phase – only swelling in the site of bite
    - e.g. periorbitaly
  - chron. stage
    - GIT (megacolon and megaoesophagus)
    - heart (dilated cardiomyopathy)
  - later stages malnutrition and heart failure
  - dementia



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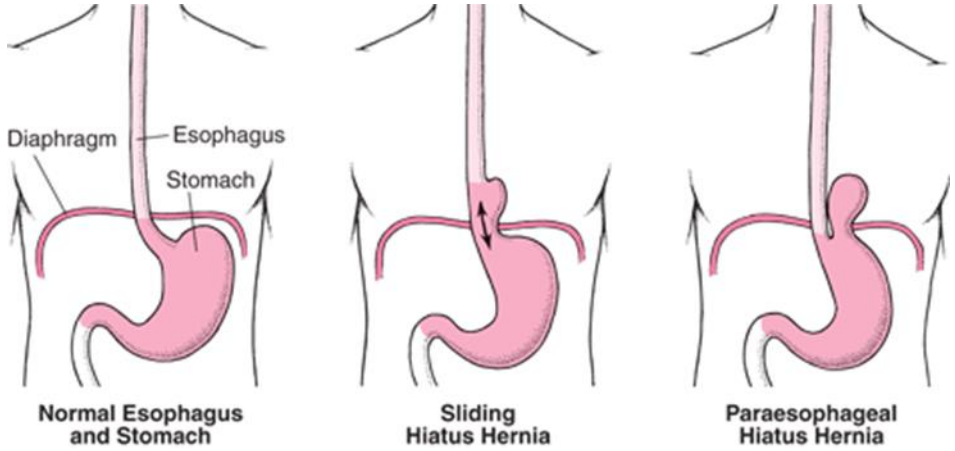
Hiatal hernias

- protrusion (herniation) of the part of the stomach through the opening in the diaphragm into chest cavity (posterior mediastinum)
  - 1) sliding
  - 2) rolling (paraoesophageal)
- risk factors
  - inborn larger diaphragm hiatus
  - obesity
  - increased intraabdominal pressure (e.g. chron. obstipation)
  - gravidity
- complications
  - acute complete herniation
  - gastroesophageal reflux and Barrett's oesophagus



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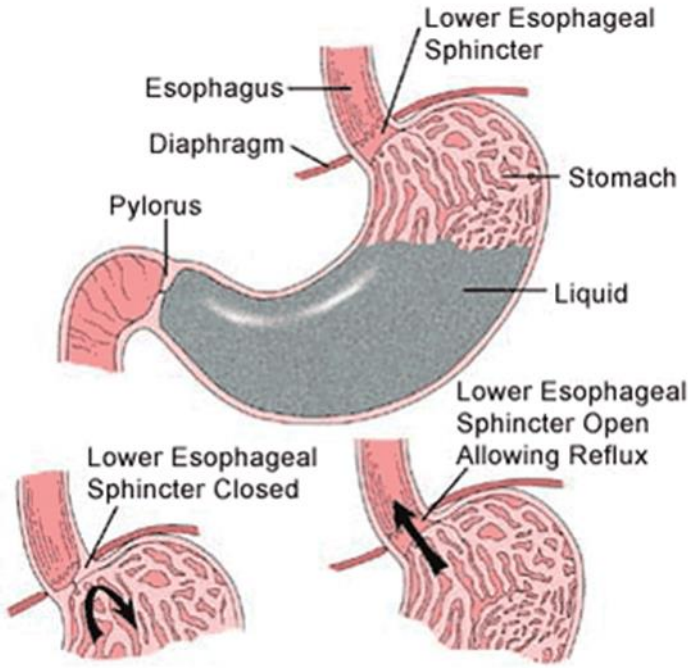
Gastroesophageal reflux (GER)

- retrograde passage of gastric content up to oesophagus where it acts aggressively
  - due to HCl, enzymes – proteases (pepsin) and event. bile (when dudodeno-gastric reflux also present)
- occasional reflux appears in healthy subjects
- risk is substantially higher in hiatal hernia
- anti-reflux barrier
  - lower oesoph. sphincter
  - mucosal rugae
  - angel between stomach and oesophagus
  - oesoph. peristaltics
- symptoms (oesoph. reflux disease)
  - dysphagia
  - heart burn (pyrosis)
  - regurgitation
    - even up to mouth, risk of aspiration
  - vomiting
- complications of GER
  - reflux esophagitis
  - ulcers, strictures, bleeding
  - Barrett's oesophagus
    - approx. 10% patients with GER



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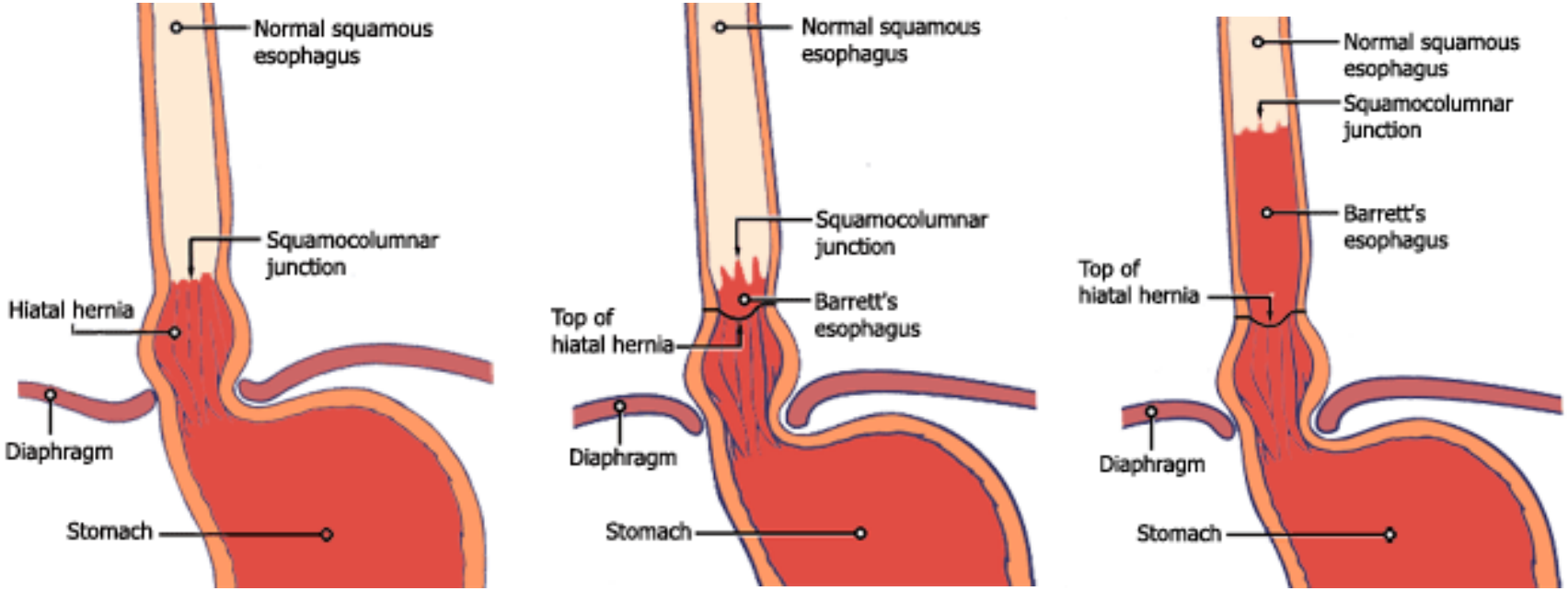
Barrett's oesophagus

- metaplasia of mucosa in long term GER
  - squamous epithelium changes to cylindrical
- ↑ risk of adenocarcinoma
  - up to 40x higher than in healthy subjects
- pathogenesis not clear
  - suspected error of differentiation of pluripotent stem cells



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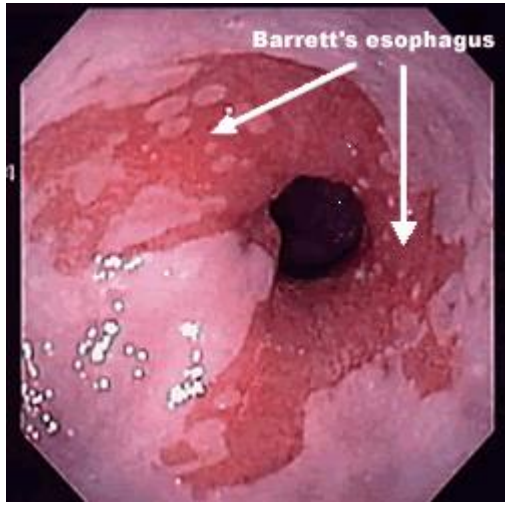
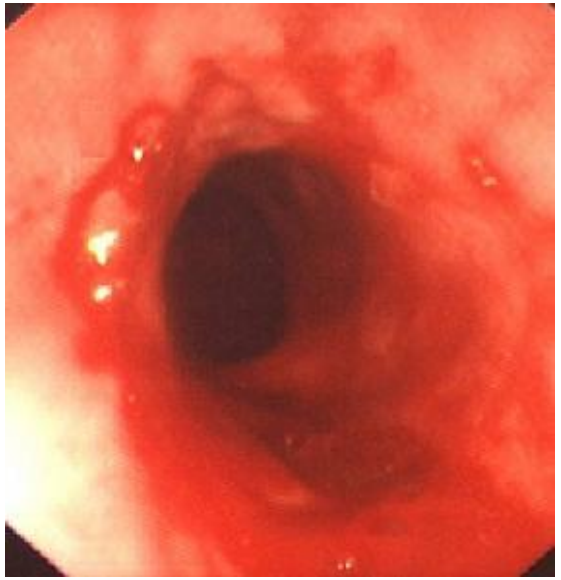
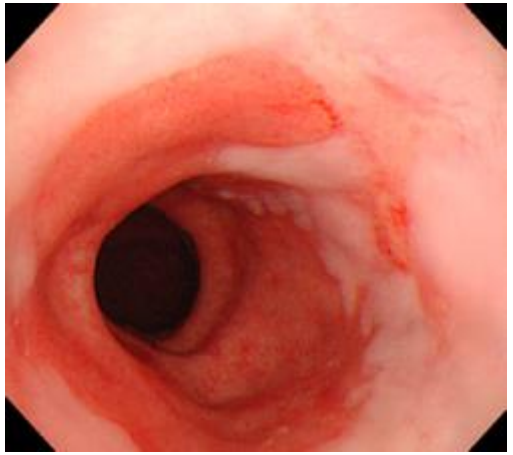
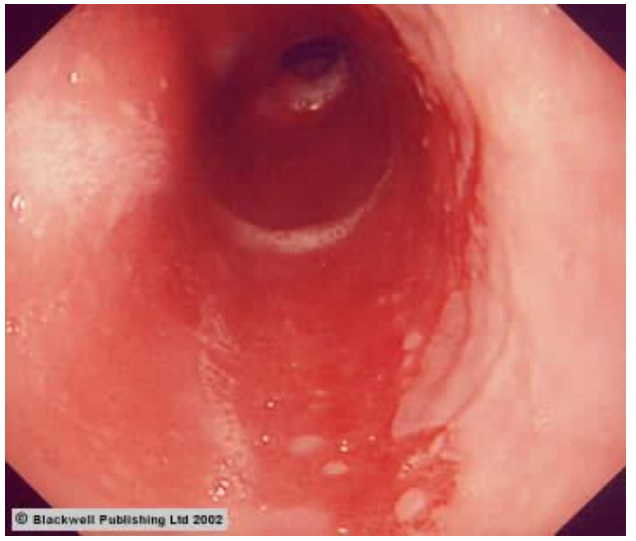
Barrett´s oesophagus









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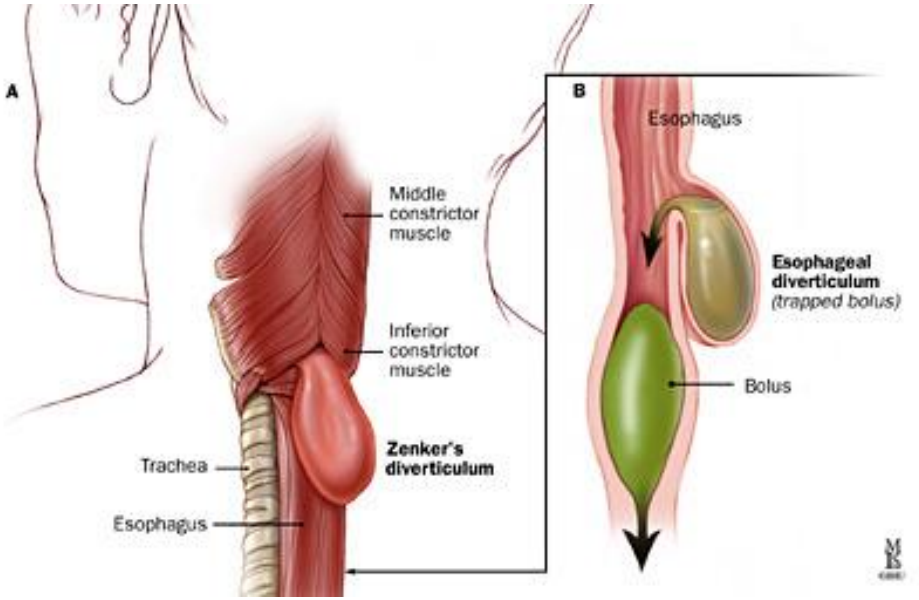
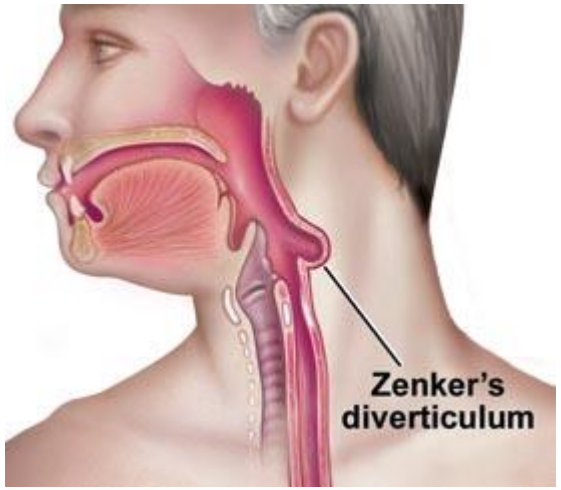
Oesophageal diverticula

- according to the mechanism of development
  - traction
  - passion
  - combined
- according to localization
  - hypopharyngeal
    - Zenker's (pulsion)
      - false (only mucosa)
      - regurgitation without dysphagia
      - risk of aspiration
  - epibronchial
    - often due to traction by mediastinal lymph node in TBC
  - epiphrenic
    - due to increased intraluminal pressure
    - regurgitation of fluid at night





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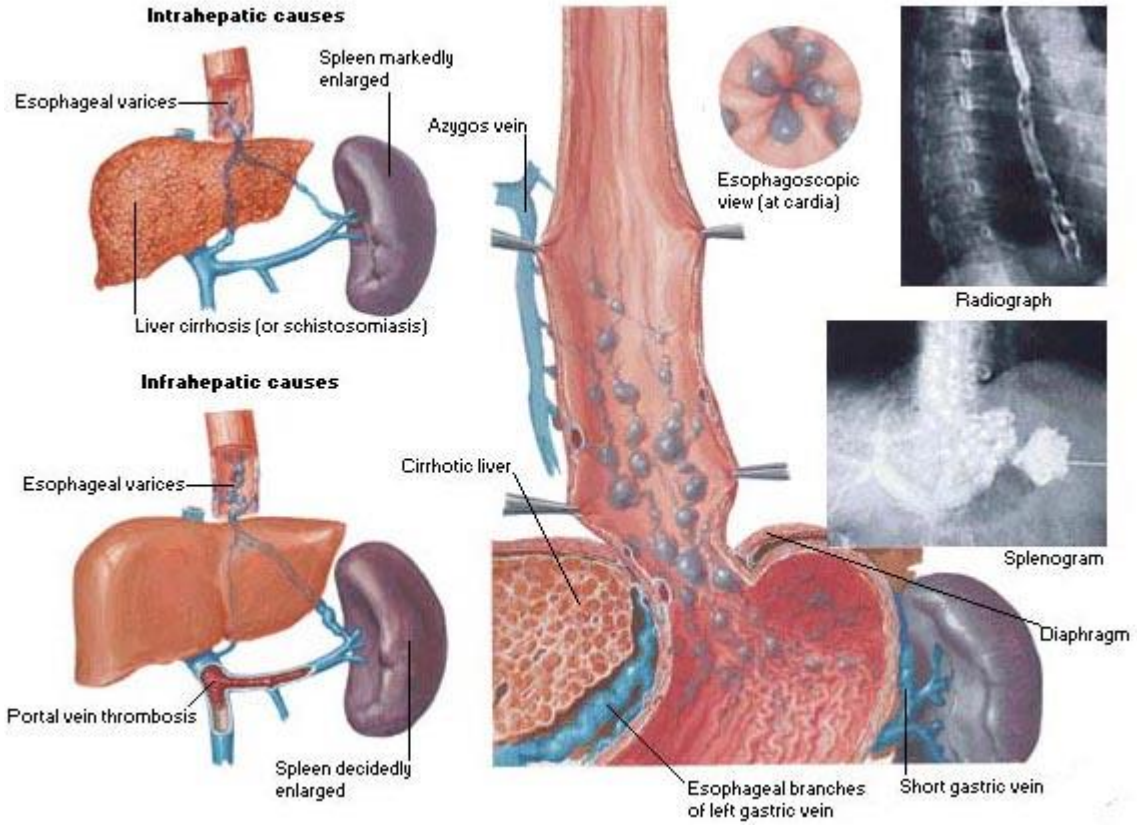
Oesophageal varices

- due to portal hypertension (increased pressure in v. portae)
  - pre-hepatic (congestive heart failure)
  - hepatic (liver cirrhosis)
  - post-hepatic (thrombosis of v. portae)
- blood circumventí liver and enters the syst. circulation (lower v. cava) via
- portocaval anastomoses
- risk of bleeding from superficially located veins



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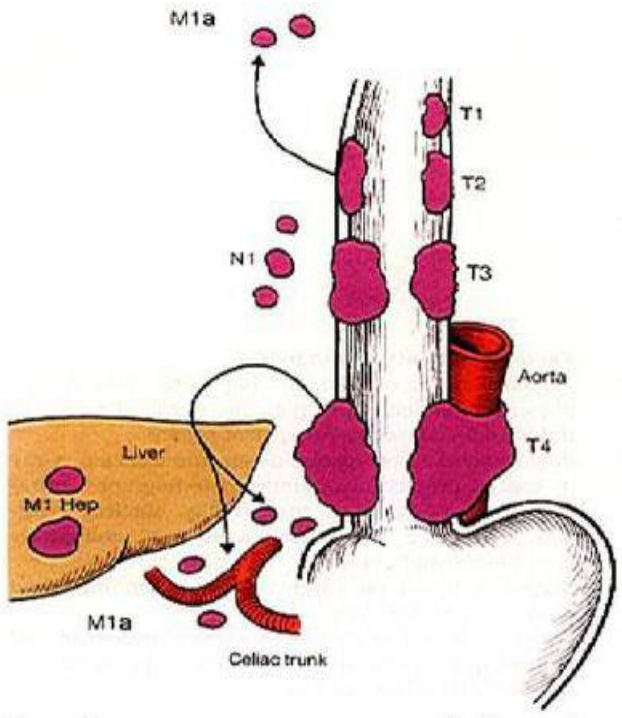
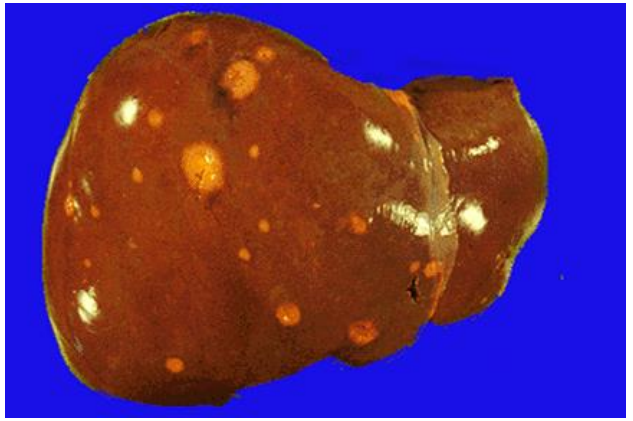
Tumours of oesophagus

- benign
  - leiomyoma
  - fibroma
  - haemangioma
- malign
  - adenocarcinoma
    - late complication of chron. GER!!!
    - males > females
    - only 10% of patients survives 5 yrs after diagnosis
    - TNM classification
      - T = tumour (size and depth of invasion)
      - N = lymph nodes (regional and distant)
      - M = metastases (most often liver)





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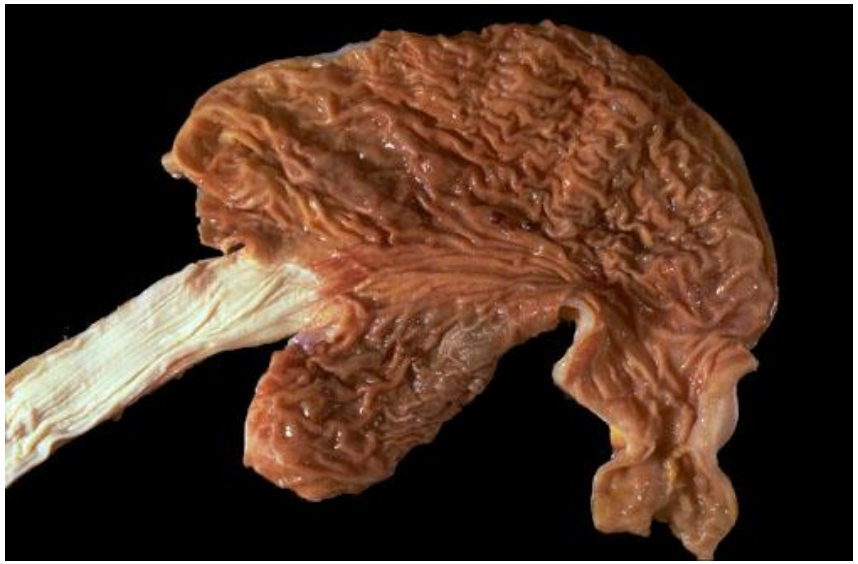
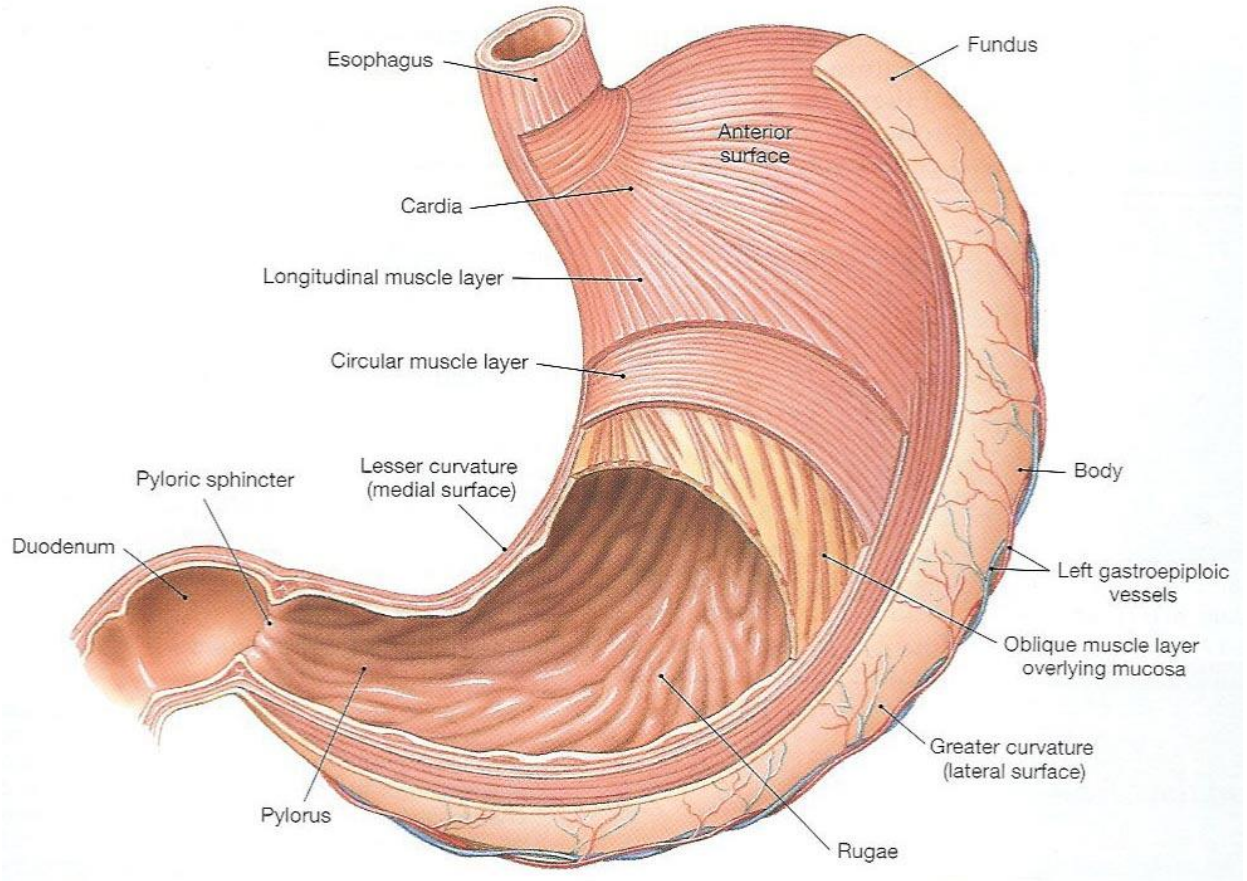
Pathophysiology of stomach





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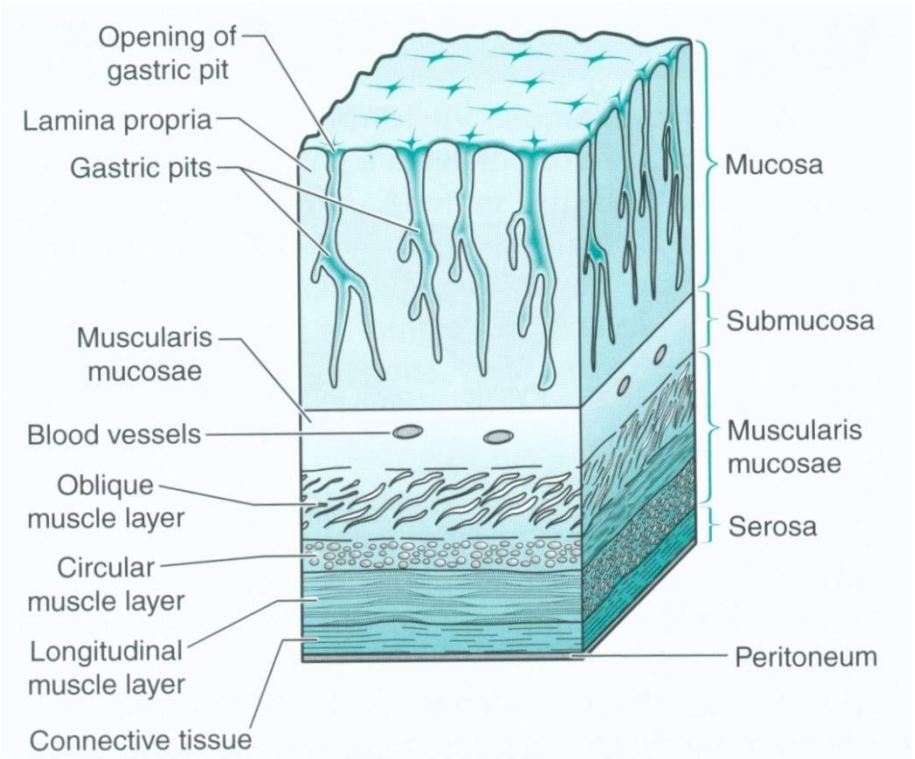
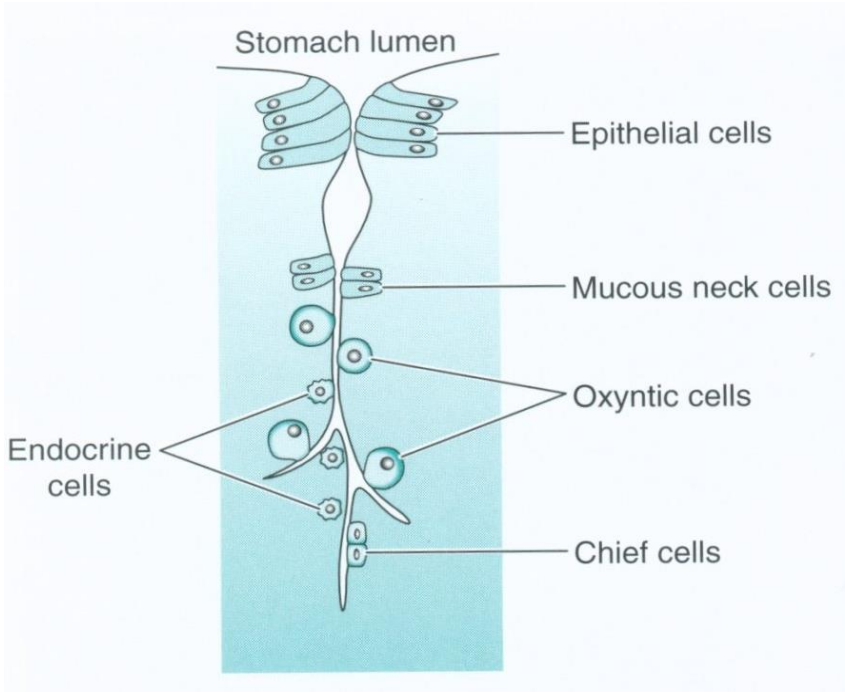
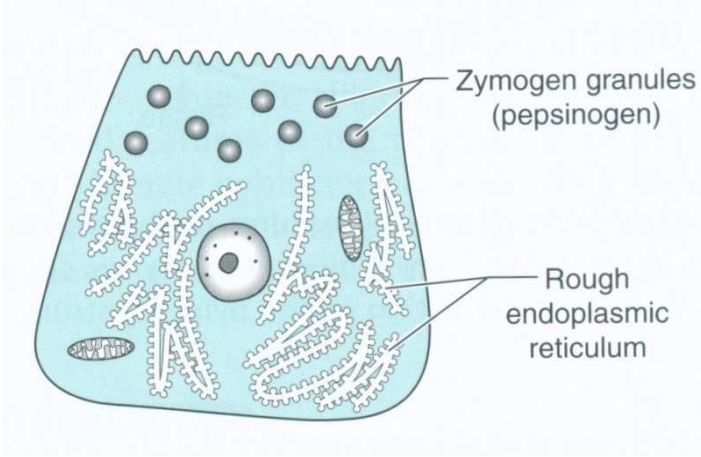
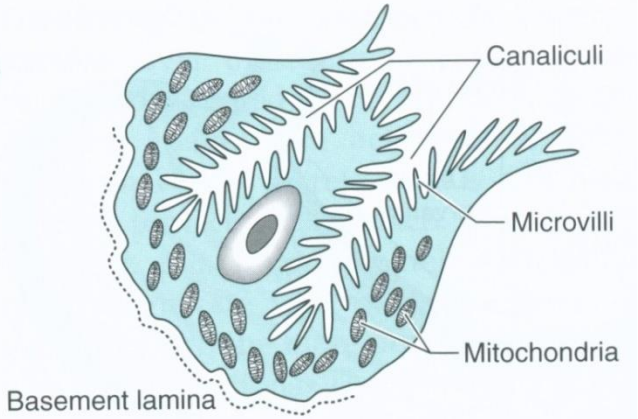
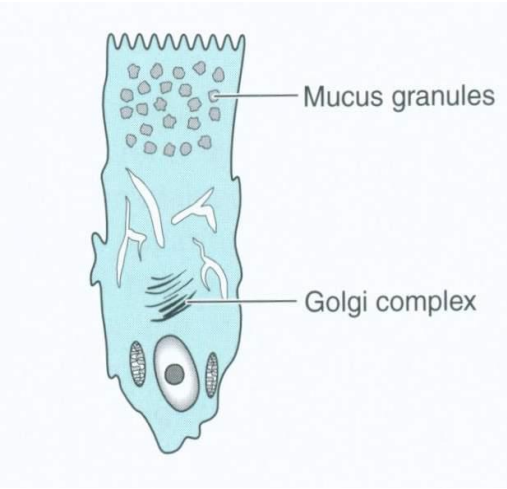
Gastric mucosa and glands











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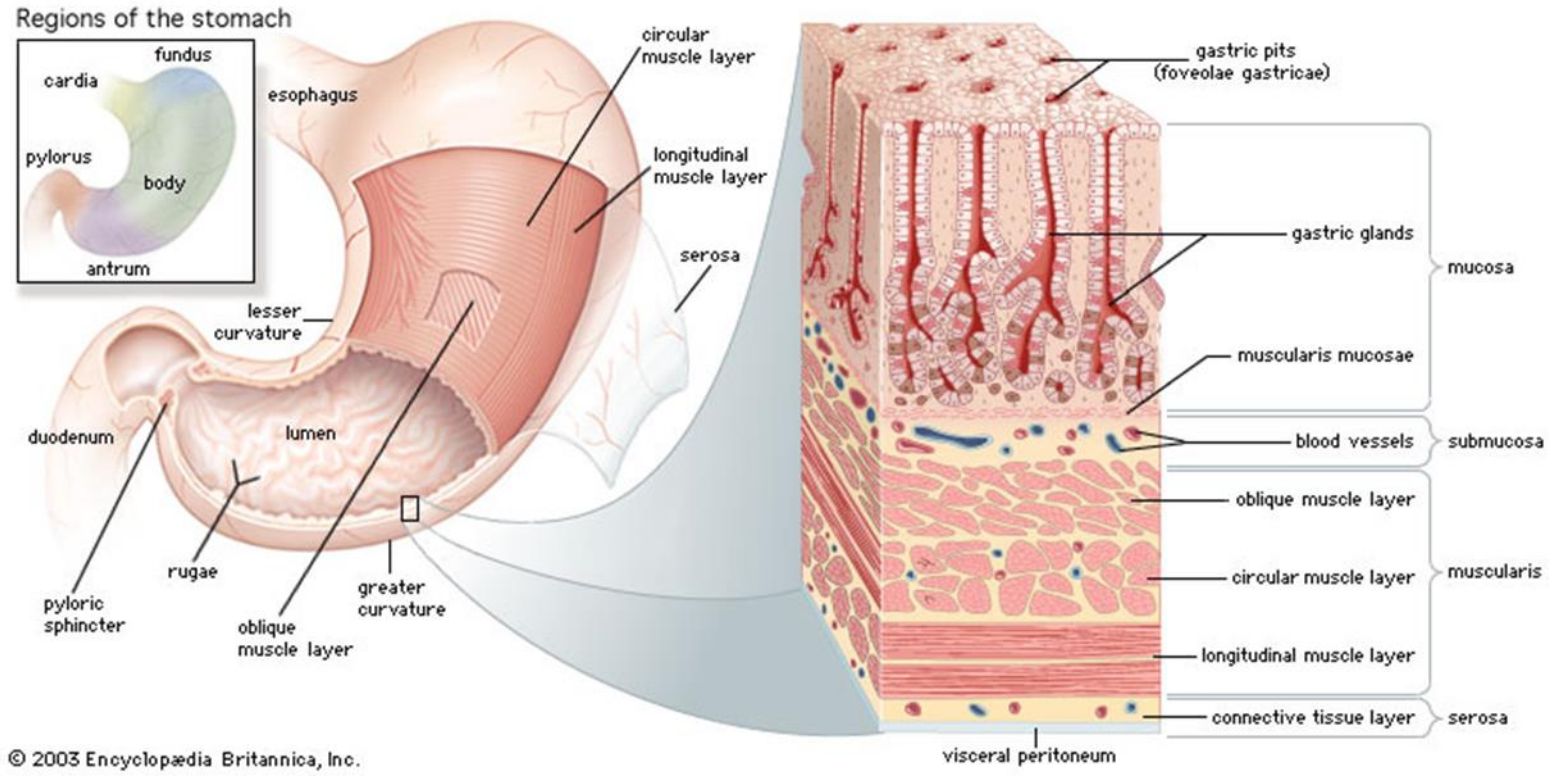
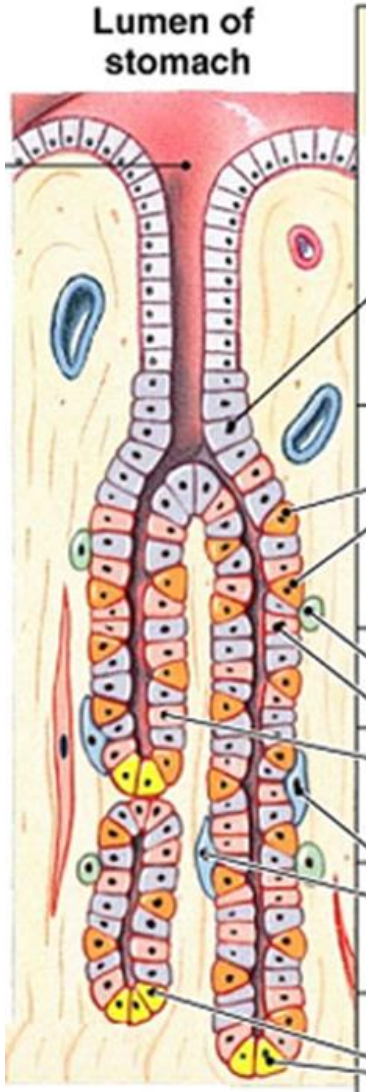
Gastric mucosa (pits & glands)



Function of stomach

- motoric function
  - reservoir
  - mechanical crushing
  - emptying
- secretion
  - upper 2/3 of stomach contain mainly parietal and chief cells
  - antrum contains mucous and G cells



Cell Types	Substance Secreted
Mucous neck cell	Mucus (protects lining)
	Bicarbonate
Parietal cells	Gastric acid (HCl)
	Intrinsic factor (Ca++ absorption)
Enterochromaffin-like cell	Histamine (stimulates acid)
Chief cells	Pepsin(ogen)
	Gastric lipase
D cells	Somatostatin (inhibits acid)
G cells	Gastrin (stimulates acid)

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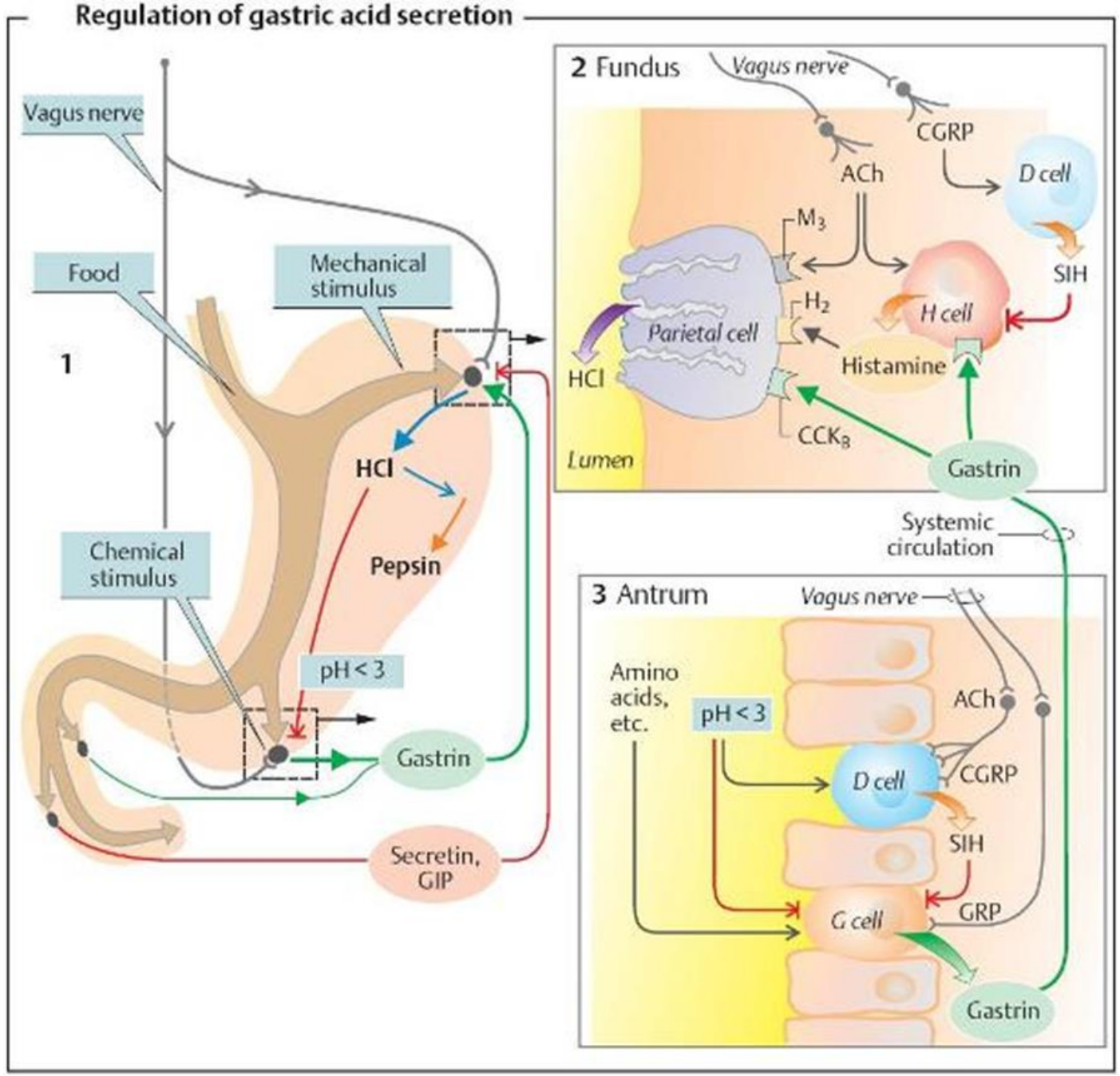
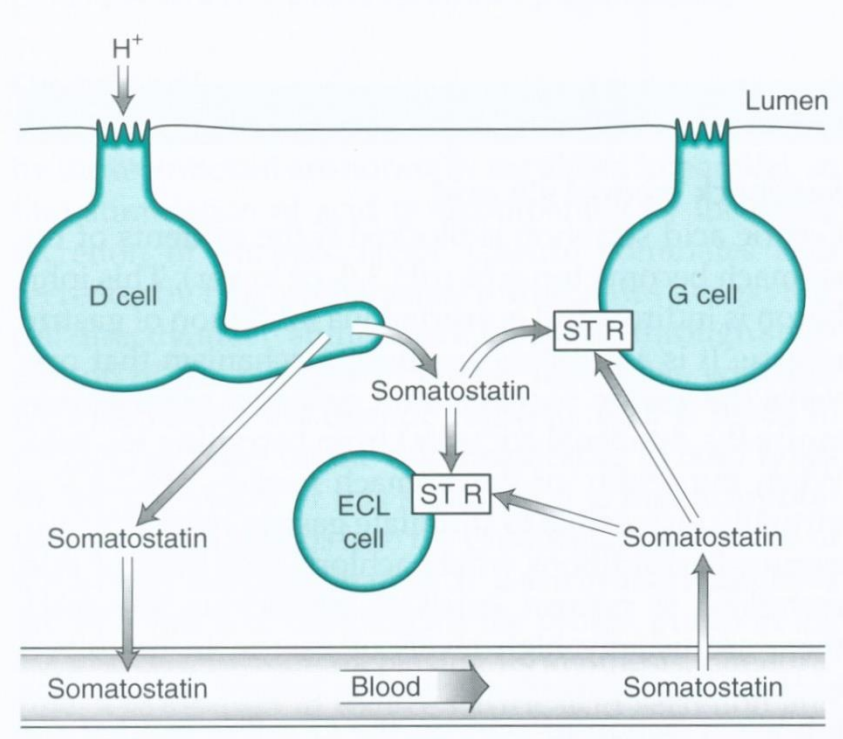
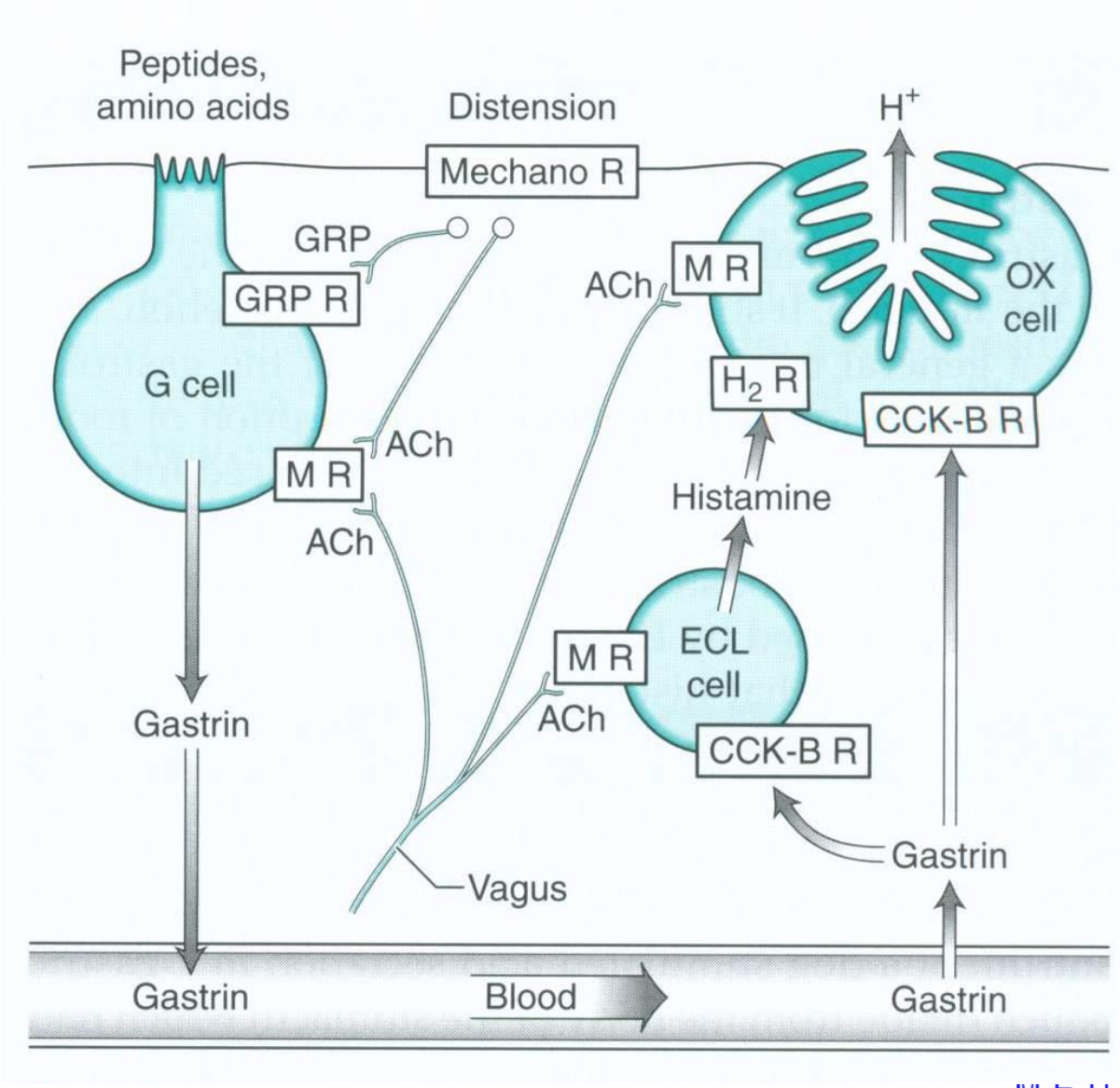
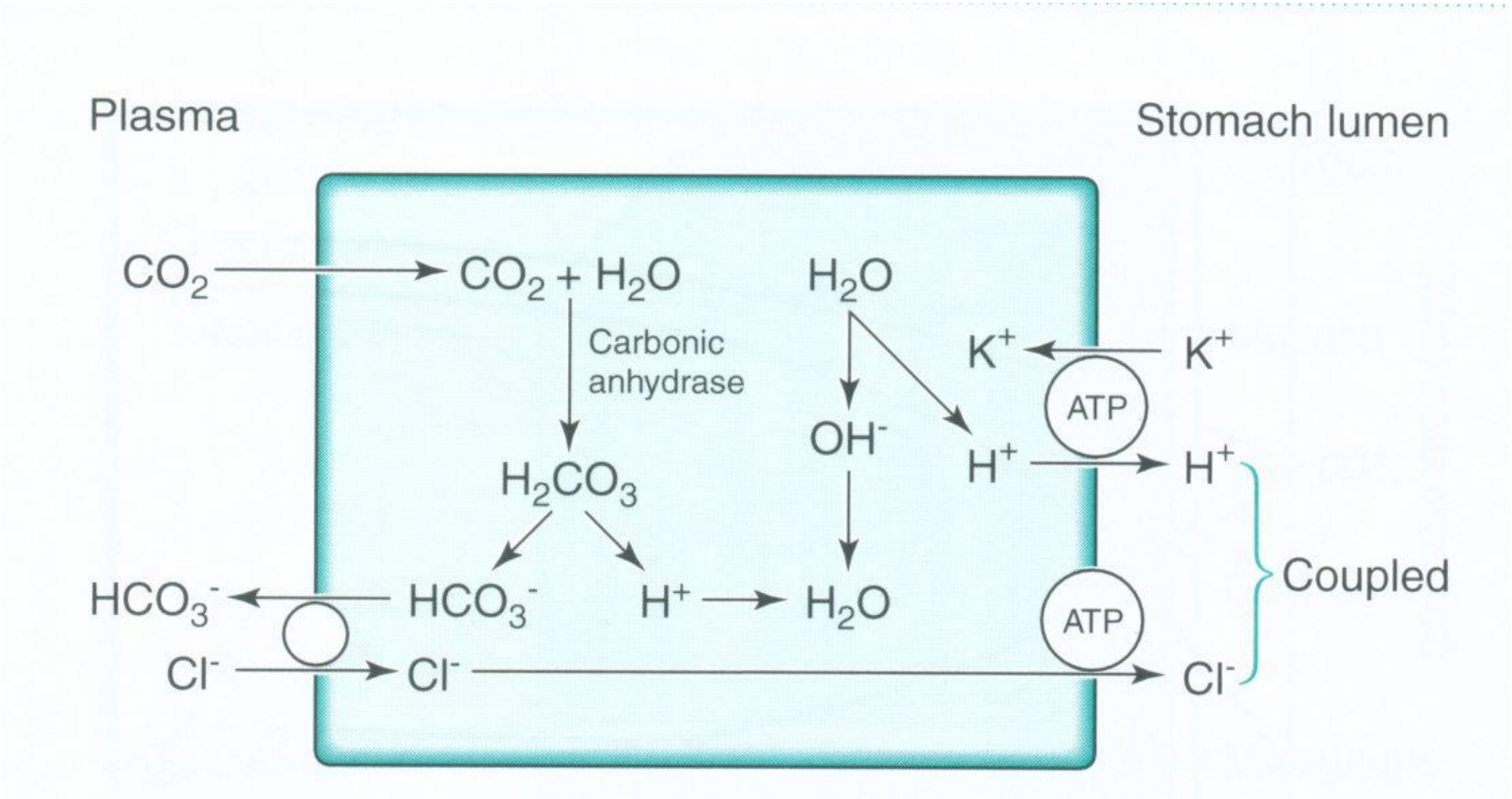

Regulation of gastric acid secretion
Vagus nerve
Food
Mechanical stimulus
1
HCl
Pepsin
Chemical stimulus
pH < 3
Gastrin
Secretin, GIP
2 Fundus
Vagus nerve
CGRP
ACh
D cell
M3
SIH
H2
H cell
Parietal cell
HCl
Histamine
CCK8
Lumen
Gastrin
Systemic circulation
3 Antrum
Vagus nerve
Amino acids, etc.
pH < 3
ACh
D cell
CGRP
SIH
G cell
GRP
Gastrin

Details of stimulation and inhibition



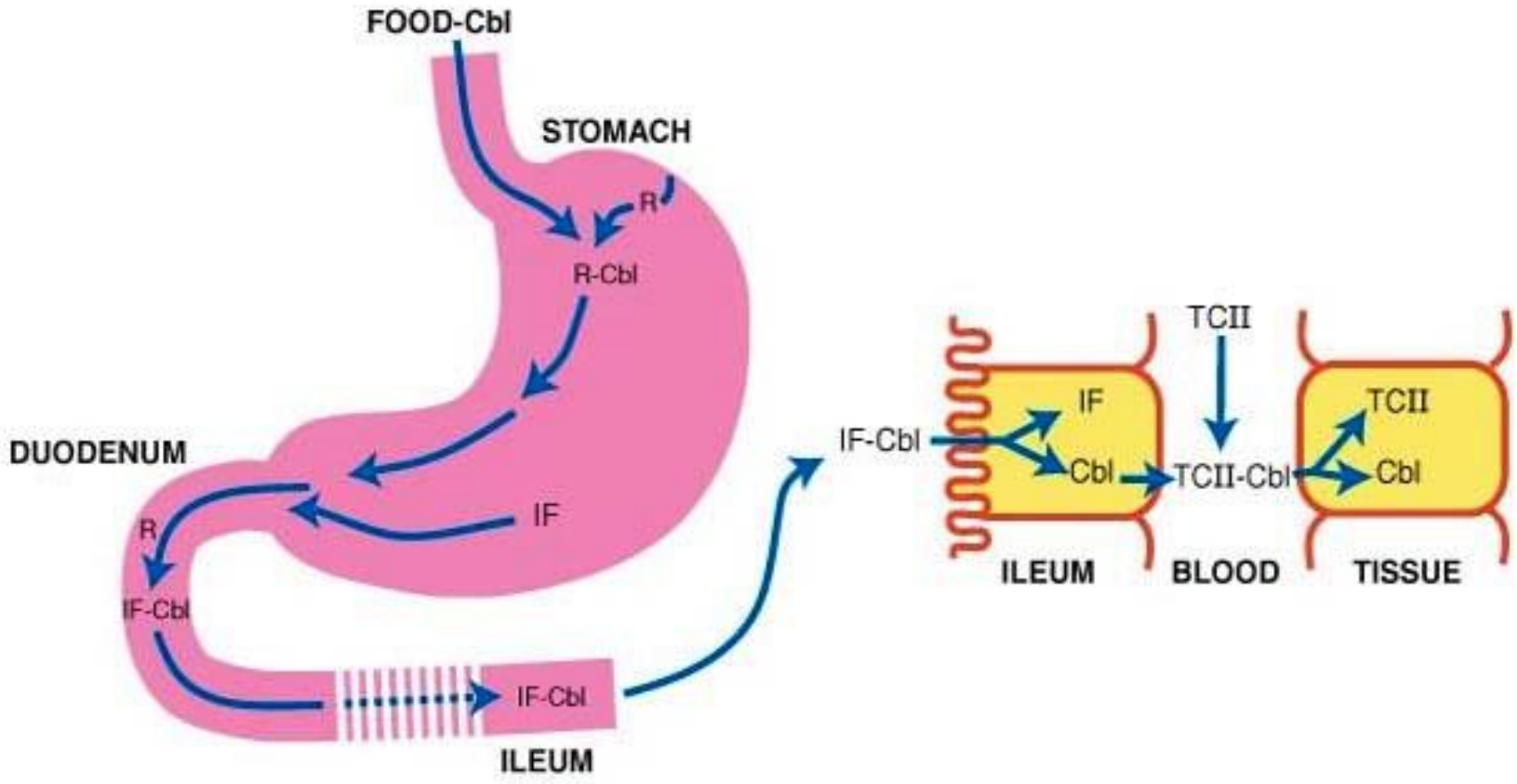


Principle of HCl secretion



Resorption of B_{12}

- stomach: binding to R factor (non-specific carrier protecting it from acid)
- duodenum: IF
- ileum (inside epithelia): transcobalamin (circulating)



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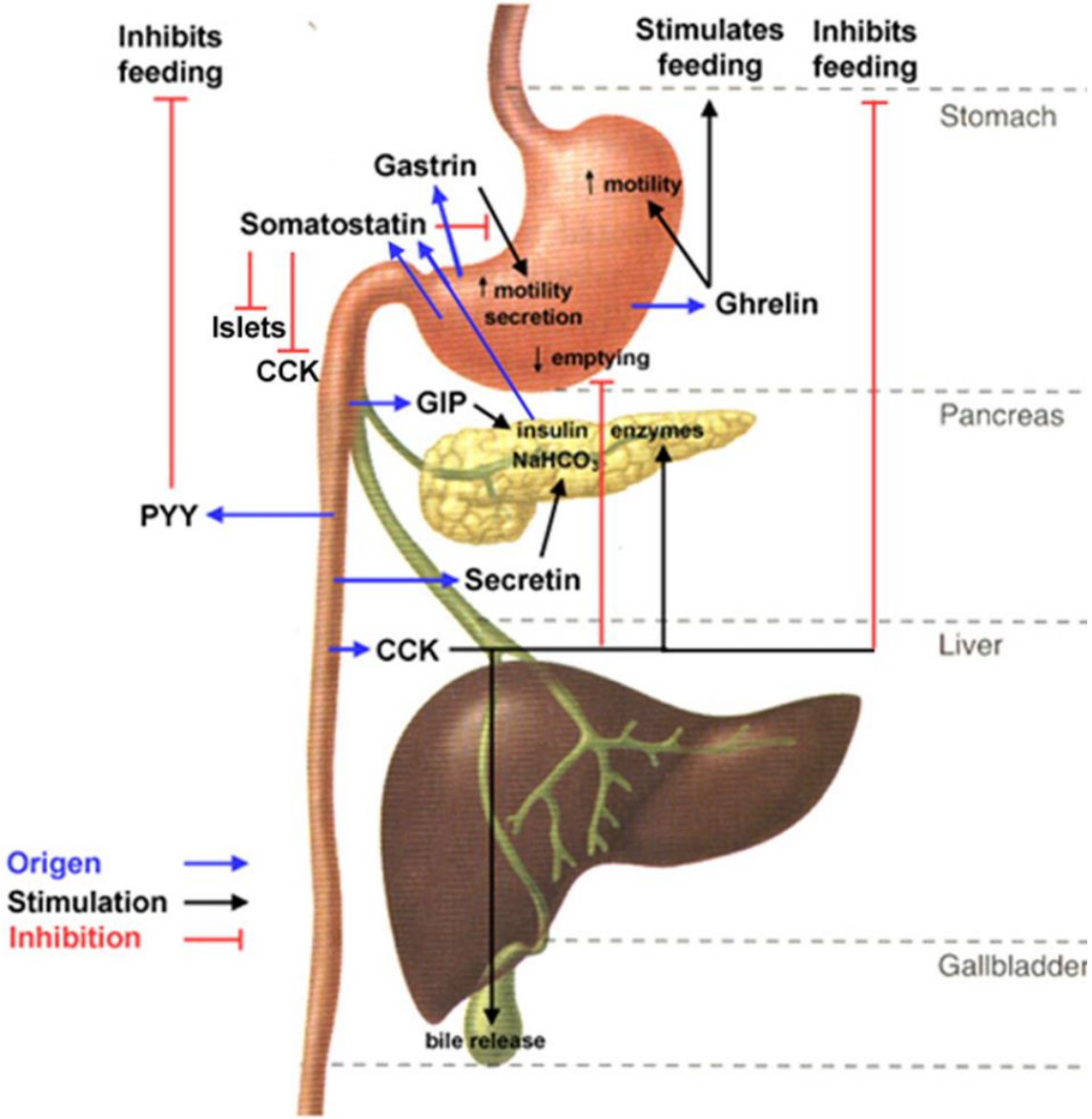
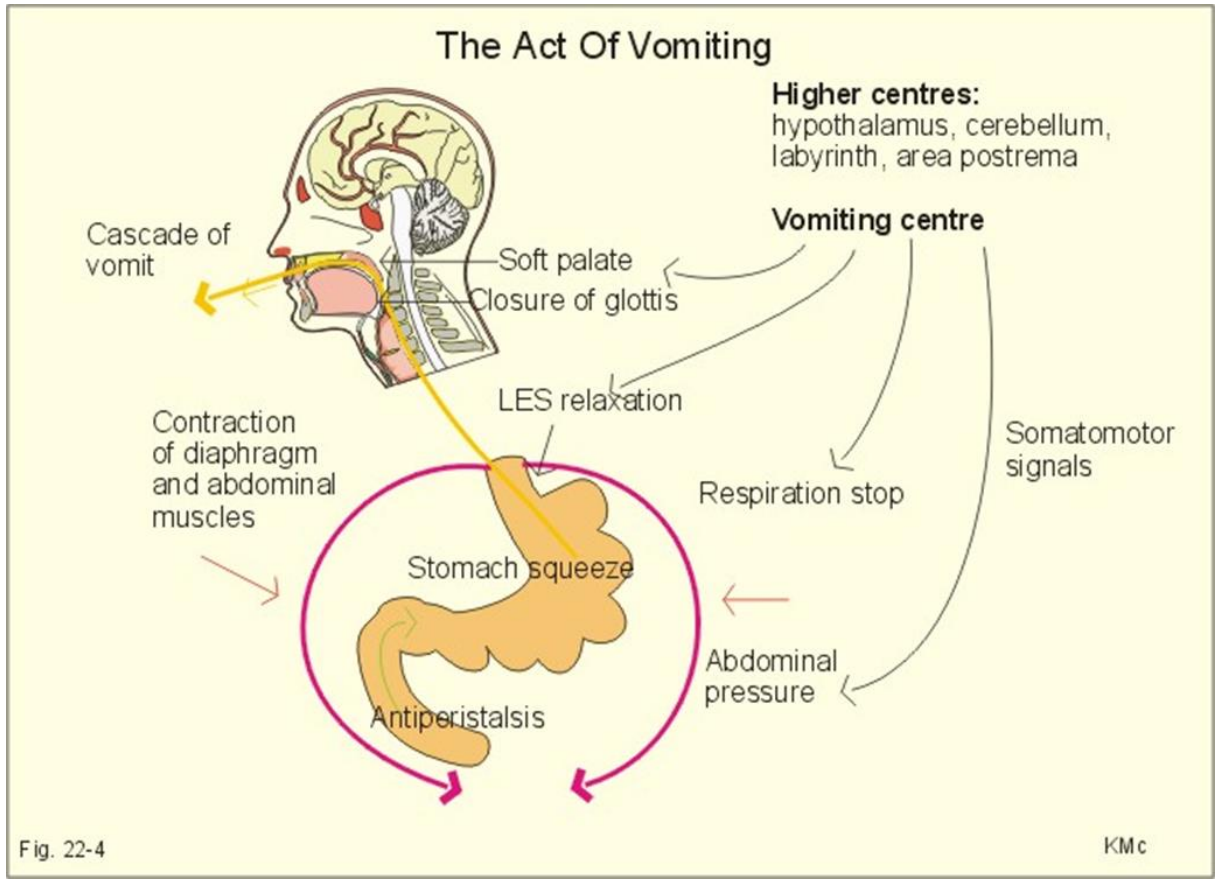
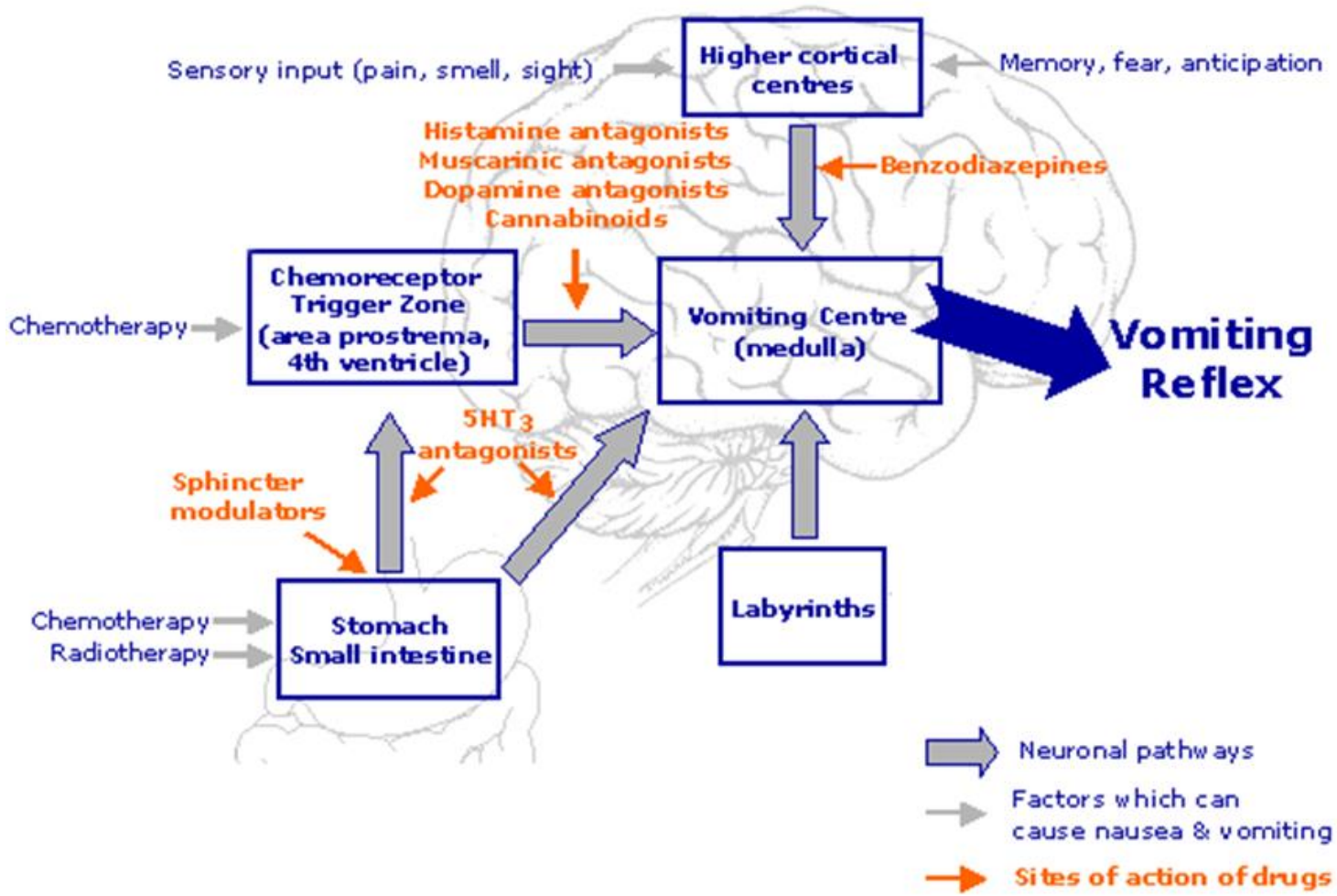
Interplay of paracrine GIT factors



Disorders of gastric motility

- vomiting reflex (emesis)
  - reflex act leading to expulsion of gastric content by mouth
- initiated from emetic centre in reticular formation in oblongate medulla
  - in proximity of respiratory and vasomotor and salivation centres
    - therefore increased heart frequency and salivation
- act of vomiting
  - deep inspirium followed
  - closure of glottis
  - contraction of diaphragm, abdominal and chest muscles (i.e. increase of intra-abdominal and intra-thoracic pressure)
  - contraction of pylorus and duodenum and – vice versa - relaxation of stomach and lower oesoph. sphincter
    - stomach has obviously a passive role, everything is due to increased intraabdominal pressure
- vomiting is usually preceded by nausea
  - sensoric stimuli (sight, smell, taste)
  - distension of stomach, slow emptying, gastritis
  - irritation of vestibular apparatus
  - pain
- vomiting of central origin
  - meningitides, head trauma, tumours, epilepsy
  - usually without nausea

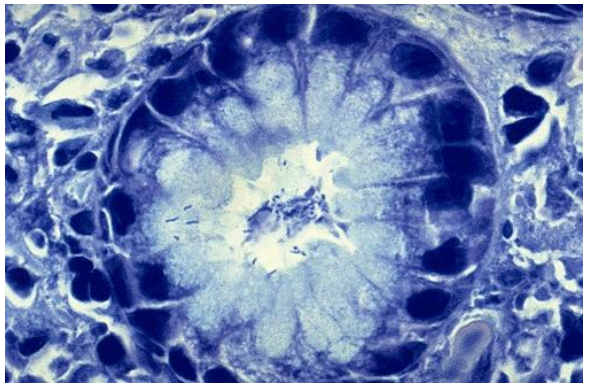


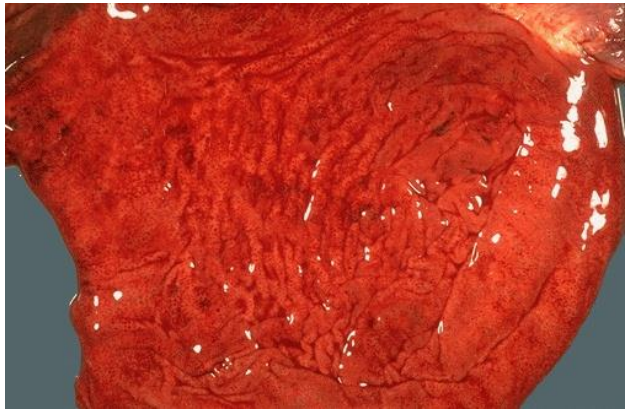

Sensory input (pain, smell, sight)
Higher cortical centres
Memory, fear, anticipation
Histamine antagonists
Muscarinic antagonists
Dopamine antagonists
Cannabinoids
Benzodiazepines
Chemotherapy
Chemoreceptor Trigger Zone (area prostrema, 4th ventricle)
Vomiting Centre (medulla)
Vomiting Reflex
5HT3 antagonists
Sphincter modulators
Chemotherapy
Radiotherapy
Stomach Small intestine
Labyrinths
Neuronal pathways
Factors which can cause nausea & vomiting
Sites of action of drugs

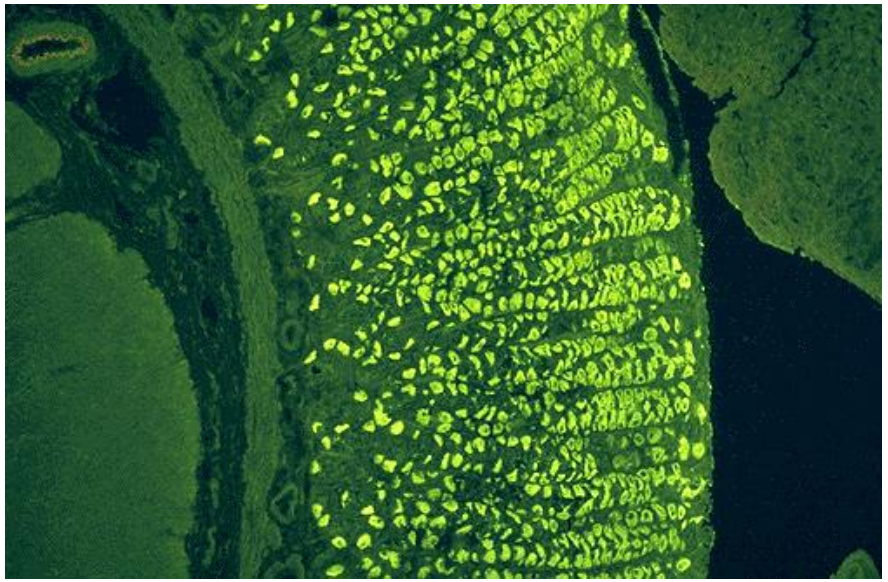
MUNI MED

Gastritis

- acute
  - stress (→ Cushing ulcer)
    - trauma, burns, after surgery
  - shock
  - infectious
  - post-radiation
  - alcohol
  - corrosive
  - systemic infection
    - bacterial and viral
  - uraemia
  - alimentary intoxication
- chronic
  - type A - autoimmune (→ atrophic gastritis)
  - type B – bacterial (infectious)
    - inflammation of antrum due to H. pylori infection (without achlorhydria and ↑ gastrin)







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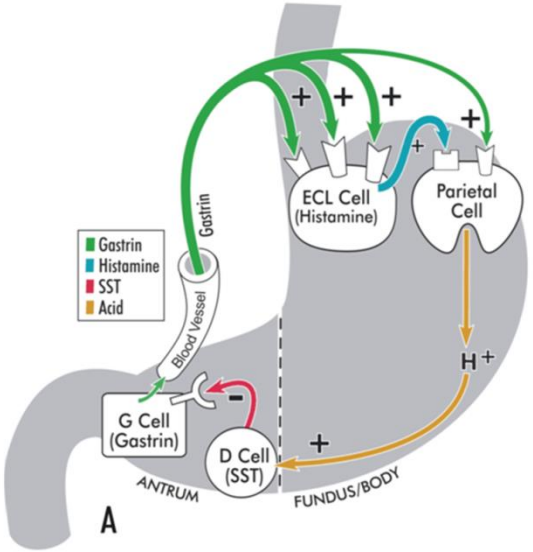
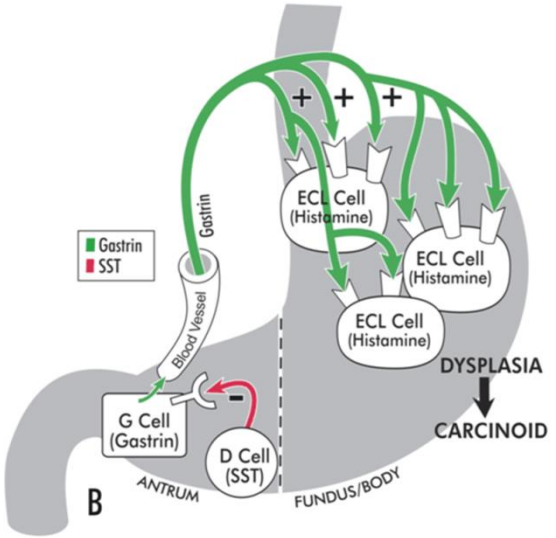
Atrophic gastritis = precancer state

- destruction of mainly parietal cells by cytotoxic T-lymphocytes
  - compensatory ↑ gastrin
- antibodies against
  - intrinsic factor (IF) and complexes IF/B12
  - Na/K-ATPase
  - carbonic anhydrase
  - gastrin receptor
- consequences
  - achlorhydria leading to sideropenic anaemia
  - later megaloblastic (pernicious) anaemia
  - precancerosis





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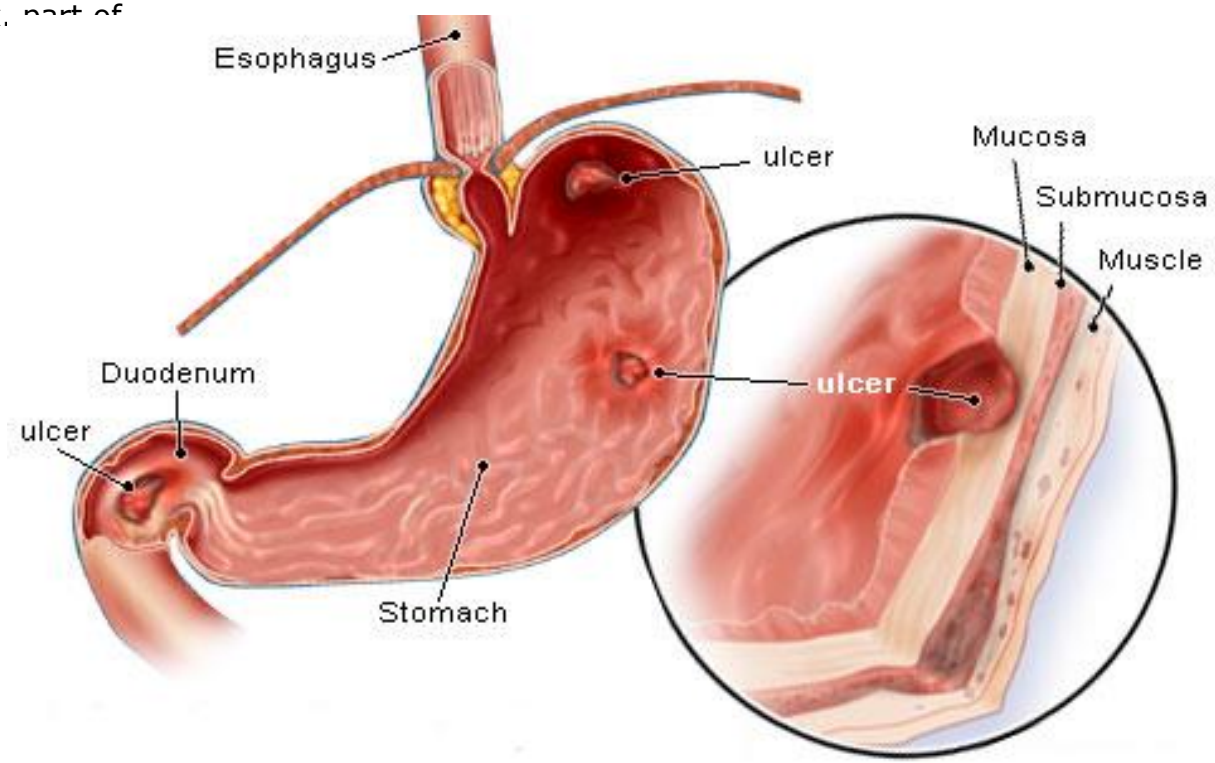
Peptic disease of gastroduodenum

- historically hyperacidity was the main etiologic factor blamed
  - but the true hyperacidity is present only in few cases (stress ulcer and gastrinoma)
- disease is always a consequence of dysbalance between aggressive and protective factors
  - localization in dist. part of oesophagus, stomach, duodenum and prox. part of jejunum
- aggressive factors
  - HCl
  - pepsin
  - bile
  - alcohol, nicotine, caffeine
  - Helicobacter pylori
  - accelerated emptying of stomach
- protective factors
  - mucous
  - bicarbonate
  - adequate blood supply
  - prostaglandins
- extent/severity
  - ulcer = mucosal defect penetrating muscularis mucosae
  - erosion = defect limited only to mucous
- complications of pept. ulcer
  - bleeding
  - perforation
  - penetration
  - stricture



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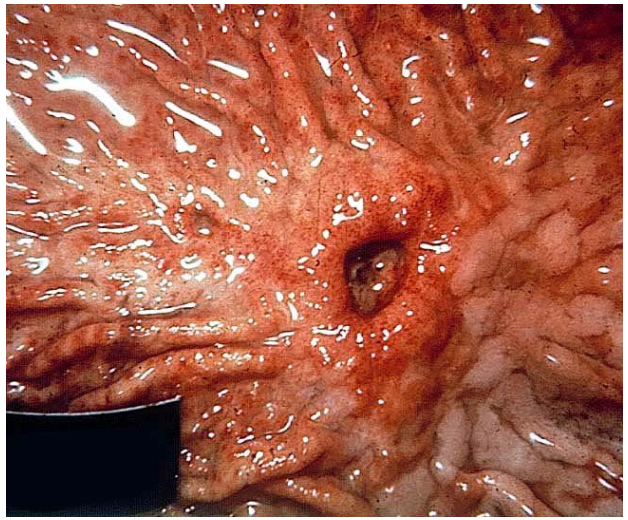
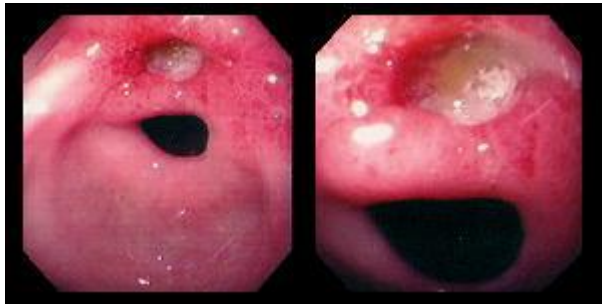
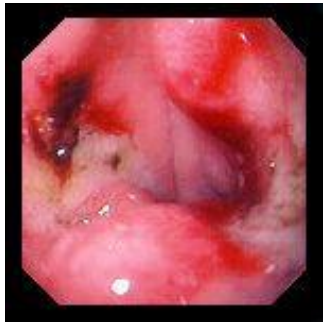
Ulcerogenic factors

- (A) hyperacidity
  - habitually increased secretion of parietal cells
    - ↑ basal secretion
    - ↑ number
    - ↑ sensitivity to histamine or gastrin
  - gastrinoma (Zollinger-Ellison syndrome)
    - tumour from D-cells of pancreas
      - secretion of gastrin by D-cells is normally minimal
  - chronic gastritis type B – infection by H. pylori
    - in ~75% patients with gastric ulcer
    - in ~ 90% patients with duodenal ulcer
    - in ~ 50% patients with dyspepsia
    - in ~ 20% healthy
- (B) loss of barrier function of stomach
  - ↑ pepsin (in ~50% cases) → increased permeability of mucosa → retrograde diffusion of H+ ions
  - impaired trophic
  - stress – low perfusion
  - drugs
    - NSAID (např. aspirin)
      - inhibitors of cyklooxygenase
    - corticoids
      - inhibitors of phospholipase A







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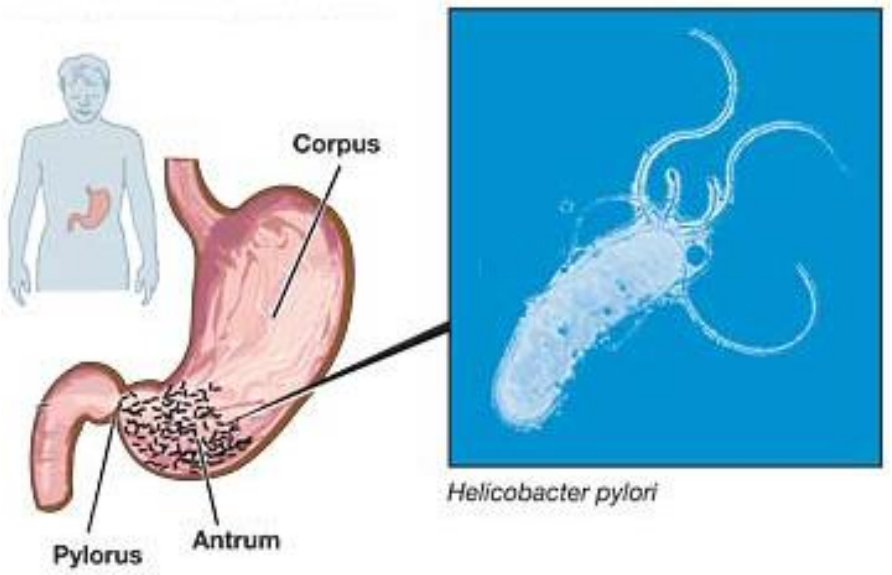
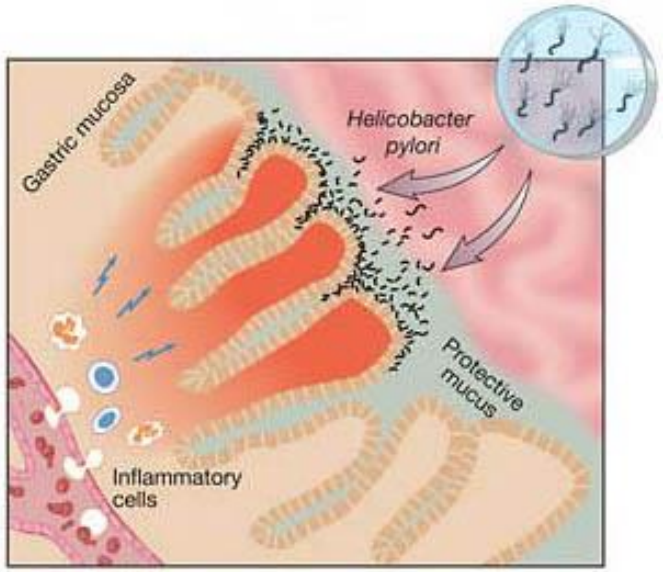
Helicobacter pylori

- successful human microbial pathogen
  - infects >20% of population
- induces chron. gastritis B-type, peptic ulcers and contributes likely to the development of gastric carcinoma
- localization mainly in antral part and duodenum
- mechanisms of action and resistance to acid environment
  - encapsulated flagellum enables H. pylori to move quickly in acidic surface and penetrate to the deeper layers (higher pH)
  - produces urease (and thus NH3) = local neutralization of HCl
  - produces protein stimulating production of gastrin = ↑ HCl
  - activates proton pump
  - produces proteases and phospholipases = destruction of mucus
  - produces catalase = resistance to phagocytosis
- do not penetrate through epithelium → minimal or none systemic immune reaction
  - IgA antibodies
- infiltration by neutrophils





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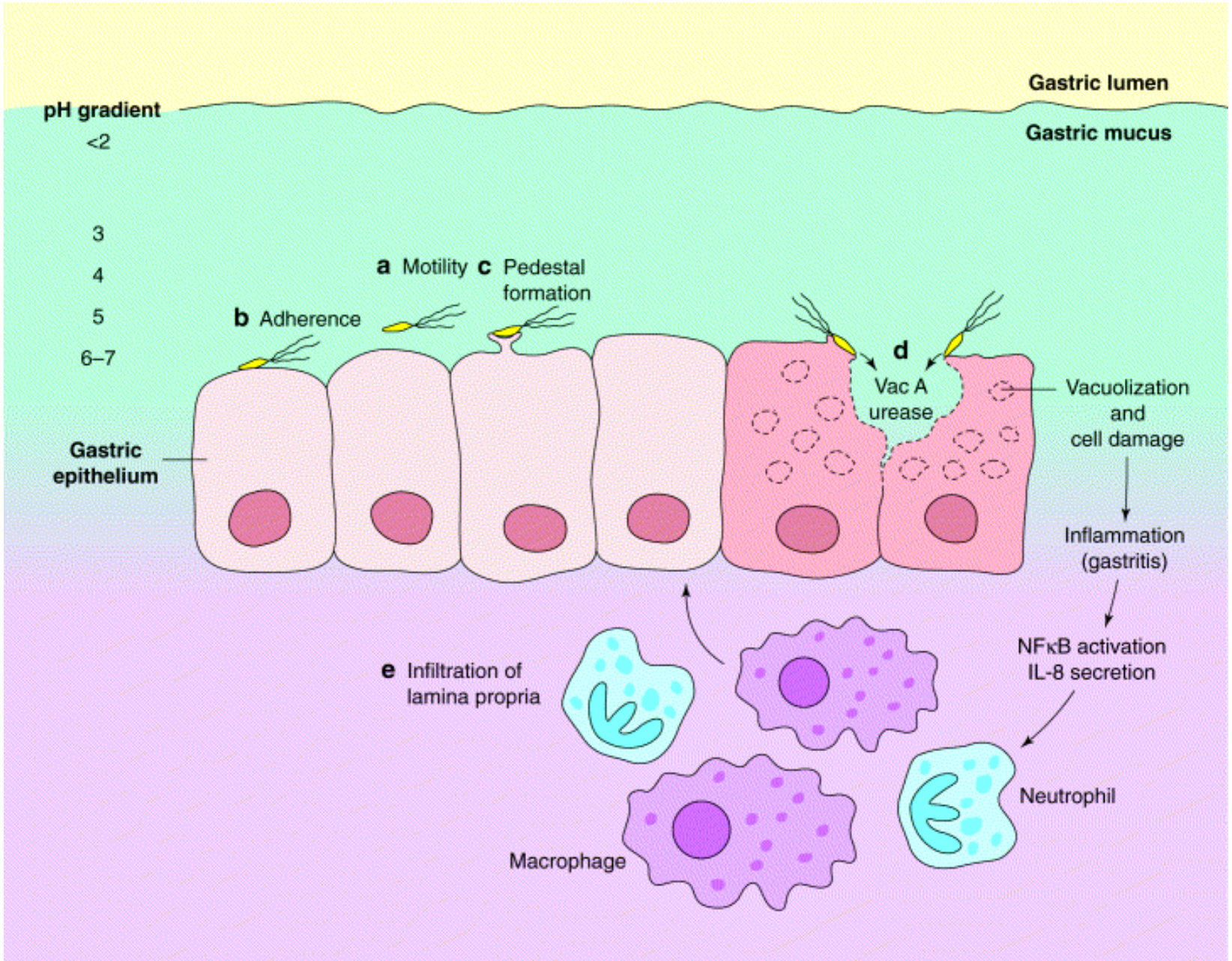
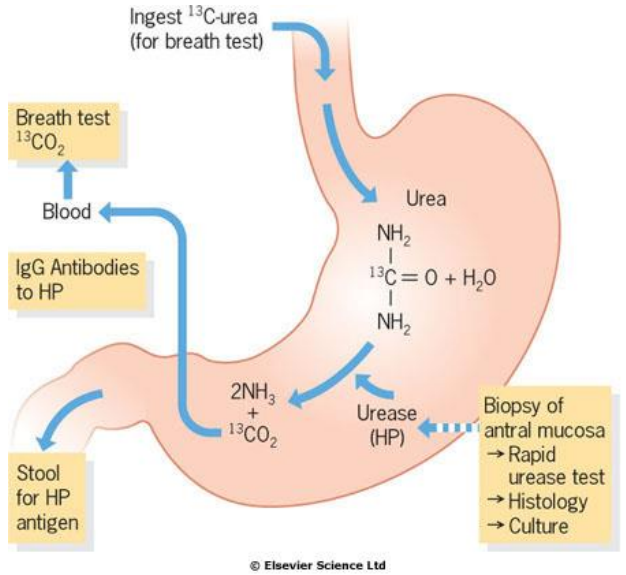
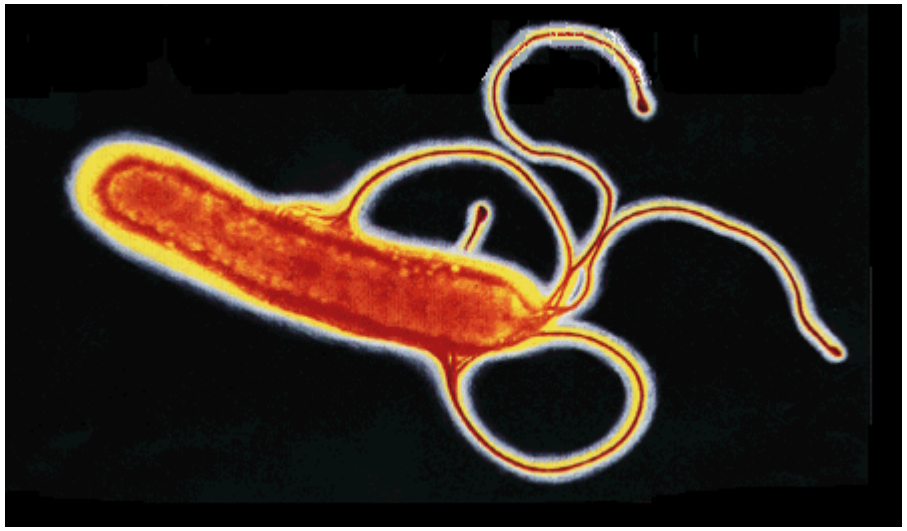

Gastric lumen
pH gradient
<2
Gastric mucus
3
4
5
6–7
a Motility
c Pedestal formation
b Adherence
d
Vac A
urease
Vacuolization and cell damage
Gastric epithelium
Inflammation (gastritis)
NFκB activation
IL-8 secretion
e Infiltration of lamina propria
Neutrophil
Macrophage

Detection of H. pylori





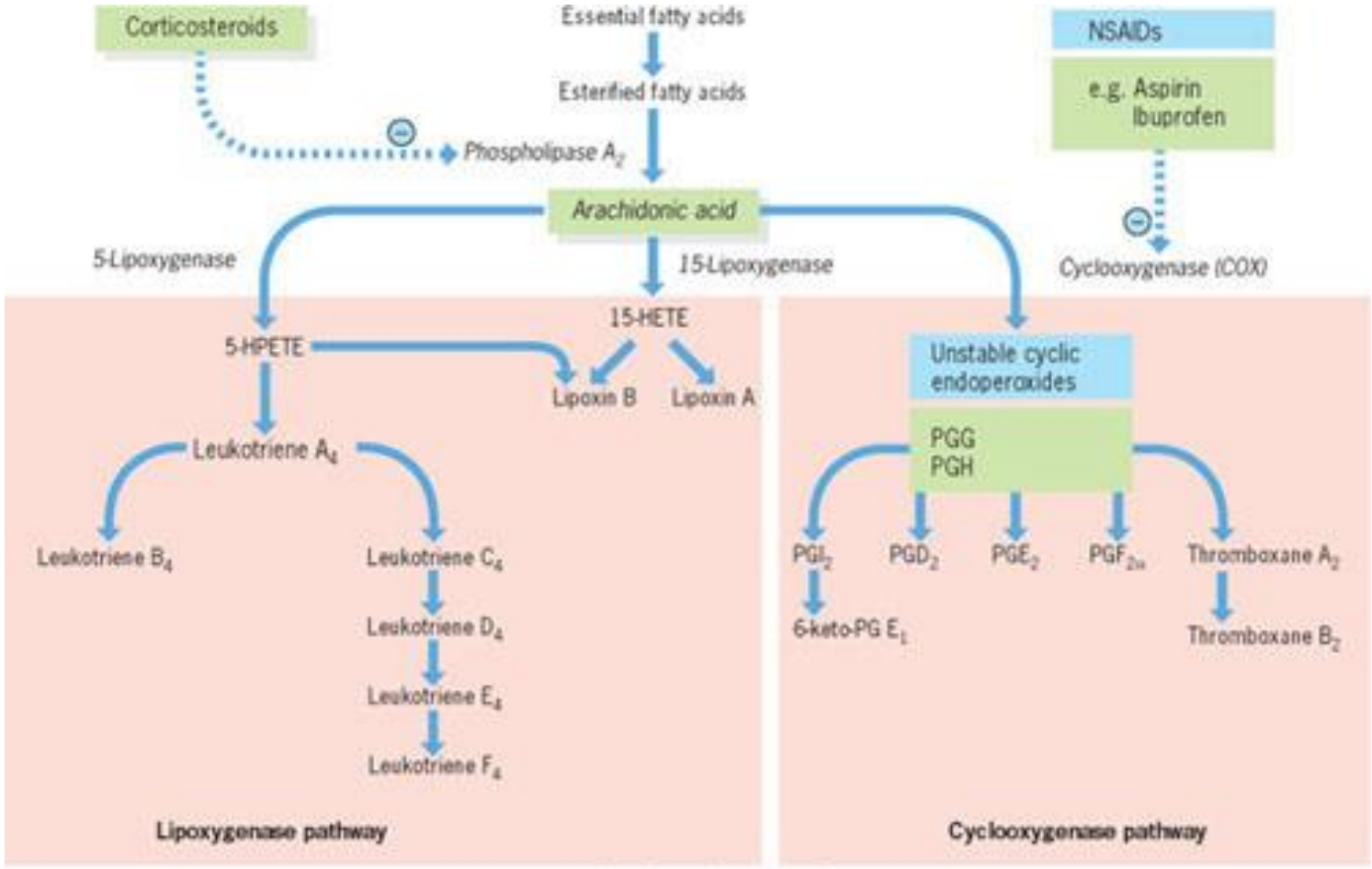
- invasive – by biopsy during gastroscopy
  - light microscopy
  - PCR
  - cultivation
  - intravital microscopy
- non-invasive
  - aspiration of gastric juice by nasogastric tube with subsequent PCR
  - PCR from stool
  - breath test

MUNI MED

Symptoms of gastric vs. duodenal

- stomach
  - etiologically more often contribution of loss of barrier function rather than true hyperacidity
    - chron. gastritis type B
    - duodenogastric reflux
    - drugs
  - older people
  - painful in a fasting state, relieved by meal
    - patients often put on weight
- duodenum
  - protection of duodenum weak
    - Brunner's glands secreting alkalic mucus
    - coordinated peristaltics mixing gastric content with pancreatic and biliary juices which then acidic content
  - etiologically more often hyperacidity and infection by H. pylori
  - genetic effects
    - often blood group 0
    - HLA-B5
  - younger people
  - neurotics (faster gastric motility)
  - painful after meal
  - seasonal manifestion

Ulcerogenic drugs



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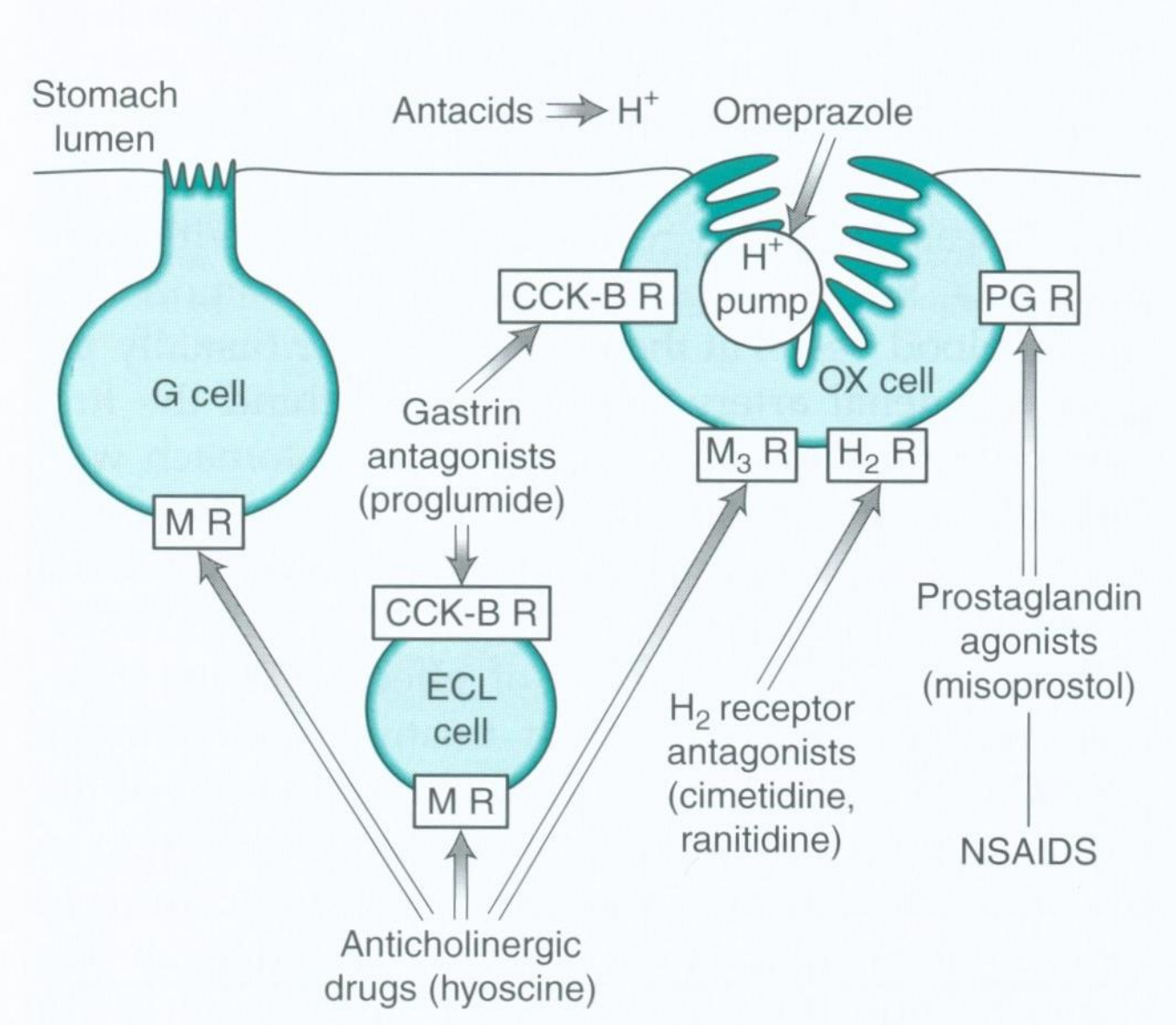
Principles of treatment



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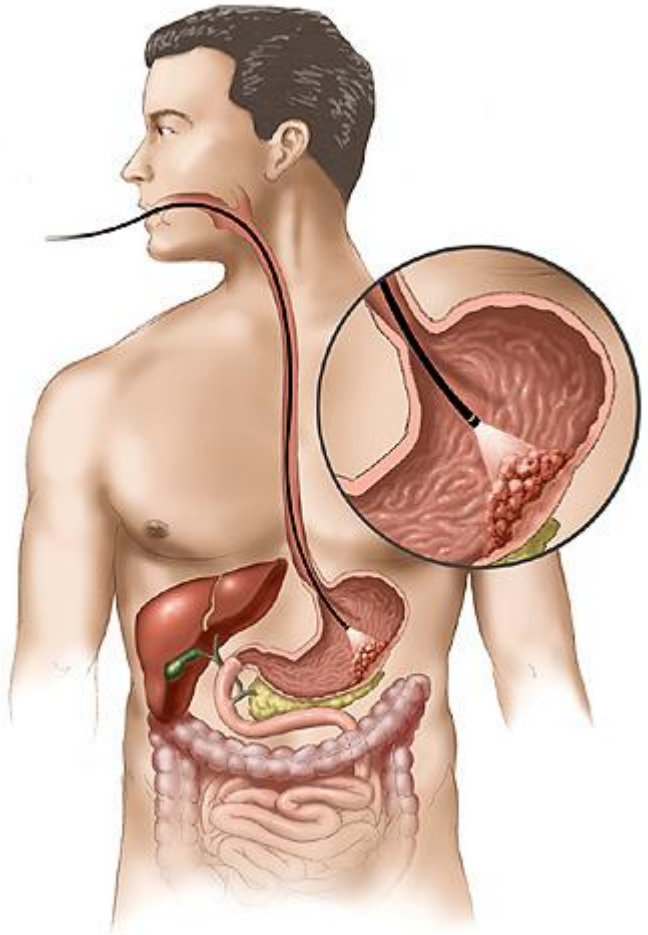
Tumours

- benign
  - rare
- malign
  - lymphoma
    - also in small and large intestine
  - carcinoid
    - also in intestine, pancreas, bronchi and lungs
  - carcinoma
    - bordered × diffuse
    - aetiology
      - nutrition!
        - nitrates (conservation) → nitrits → nitrosamines (= mutagens)
        - carcinogens from smoked meat
        - lack of fiber (delayed emptying, longer contact of mutagens with gastric wall)
        - aphlatoxins
      - smoking
      - H. pylori/atrophic gastritis



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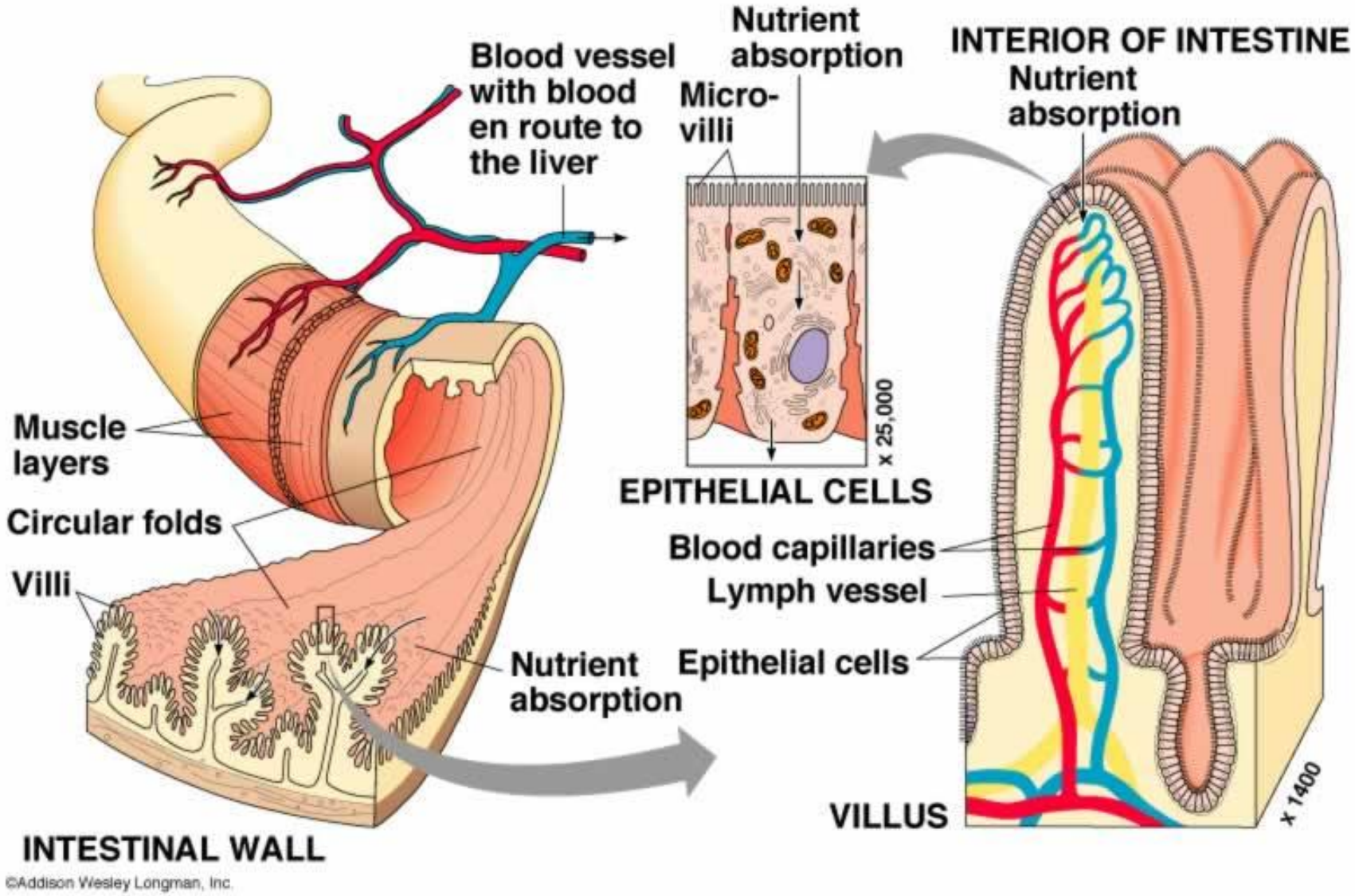
Small intestine – anatomy & histology



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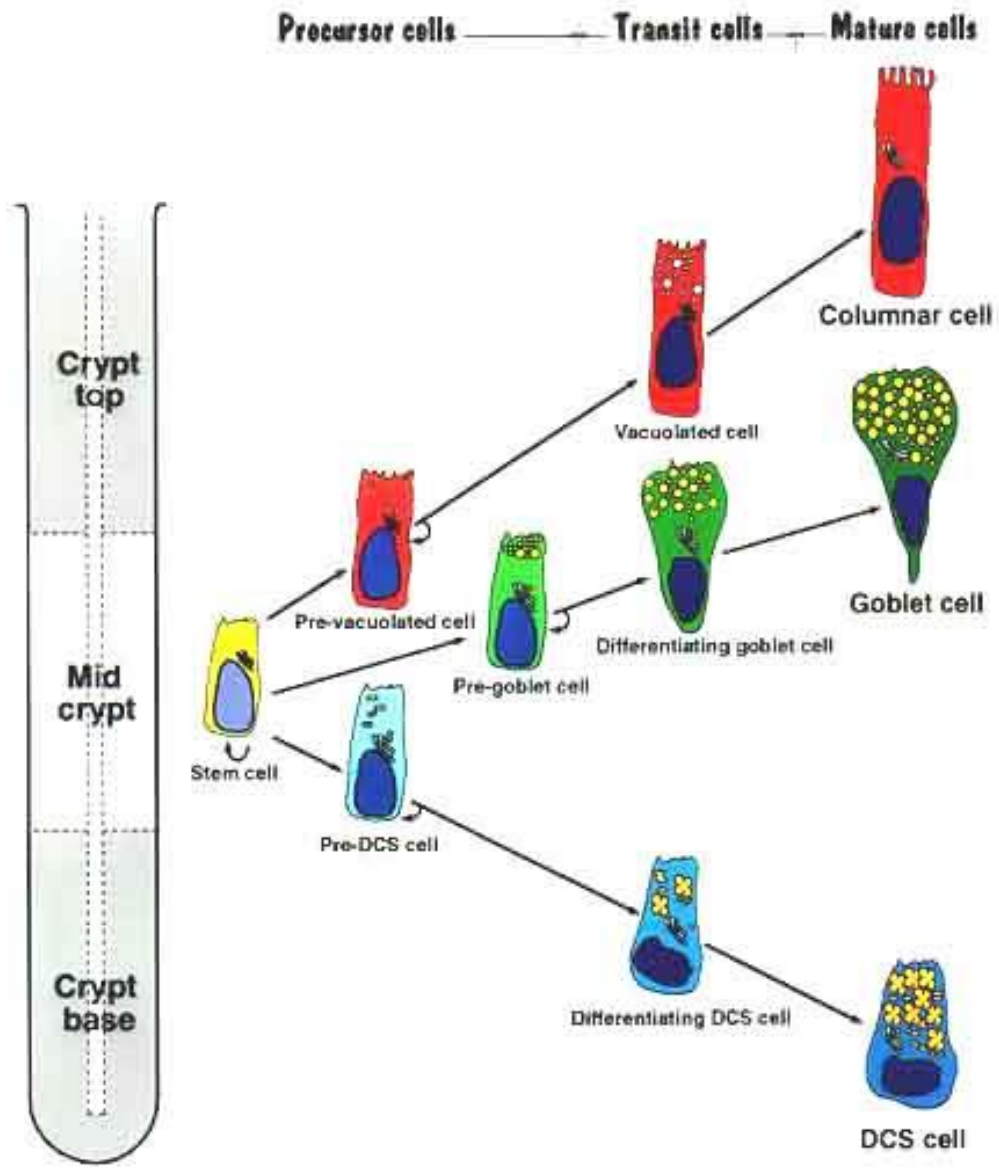
Physiology of small intestine



- cells of small intestine
  - enterocytes – enzyme digestion and resorption
  - goblet cells – production of mucus
  - Paneth (granular) cells – immune defense
  - APUD cells – production of hormones
- blood supply (~10% cardiac output) from a. mesenterica sup.
- functions
  - digestion and resorption – large area
    - total length 4.5–6m (large functional reserve - approx. 1/3 sufficient)
    - further increased by villi
  - immunity
    - by far the largest immune organ!!
    - Peyer's plaques + dispersed immune cells
    - non-specific: lysozyme, defensins, HCl, bile, mucous
    - specific: lymphocytes, IgA
  - motoric – peristaltics, segm. contractions
    - stimulated by: gastrin, CCK, motilin, serotonin, inzulin
    - inhibice: glukagon, sekretin, adrenalin
  - secretion
    - intestinal juice: water, NaCl, HCO_3^-, mucous, enzymes (carboxypeptidases, intest. lipase, disacharidases, maltase, lactase, izomaltase …)

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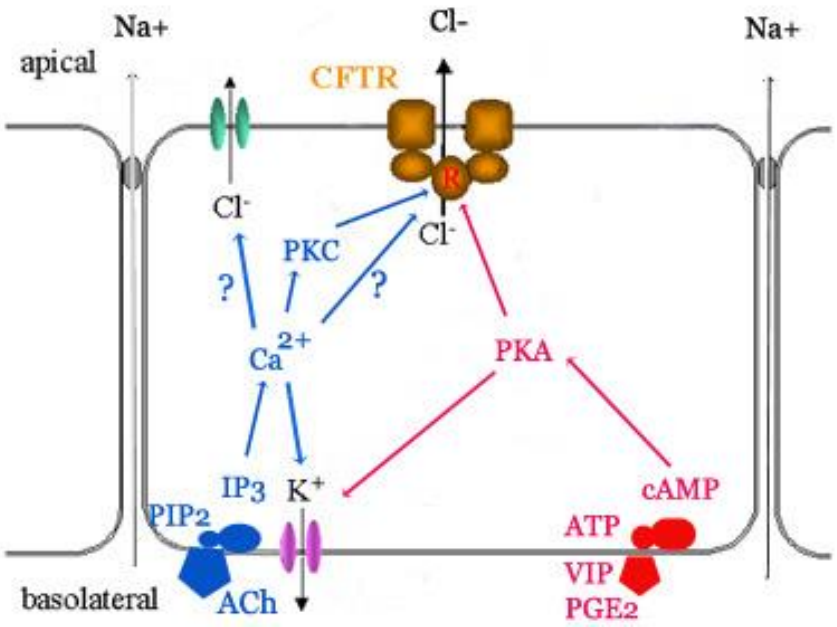
Intestinal secretion and absorption



- enterocytes in in jejunum and ileum produce alkalic fluid
  - water
  - electrolytes
  - mucous
- control of secretion
  - hormones
  - drugs
  - toxins (e.g. cholera, dysentery, E. coli)
- types of intest. absorption
  - passive diffusion (conc. gradient)
    - aqueous pores (e.g. urea, some monosaccharides)
    - transmembrane (e.g. ethanol, FFA)
    - via tight junctions (e.g. ions, water)
  - carriers
    - ions, Glc, AA
  - active transport on the basolateral membrane
    - Na/K ATPase produces conc. gradients for secondary active transports

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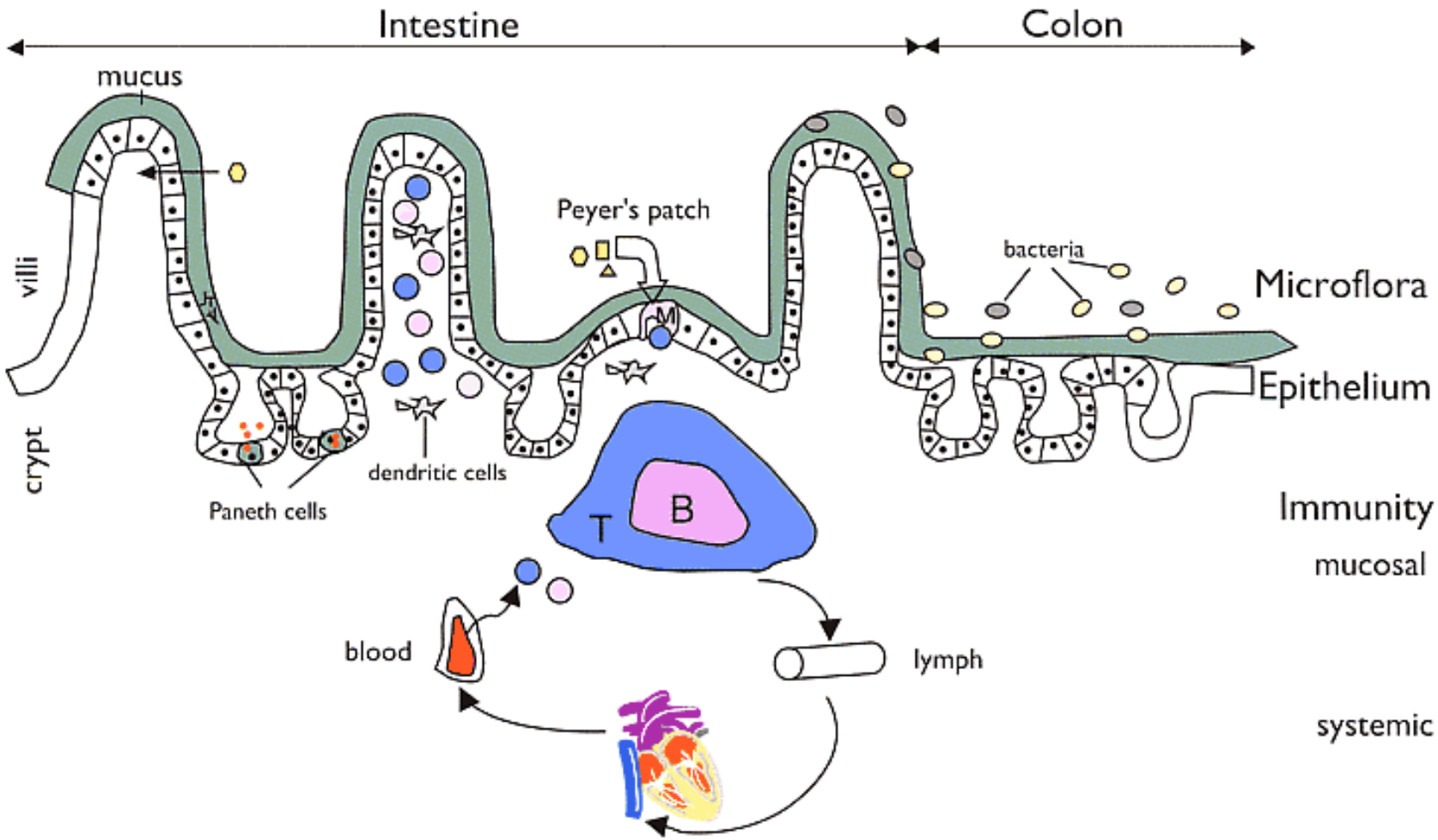
Intestinal immunity



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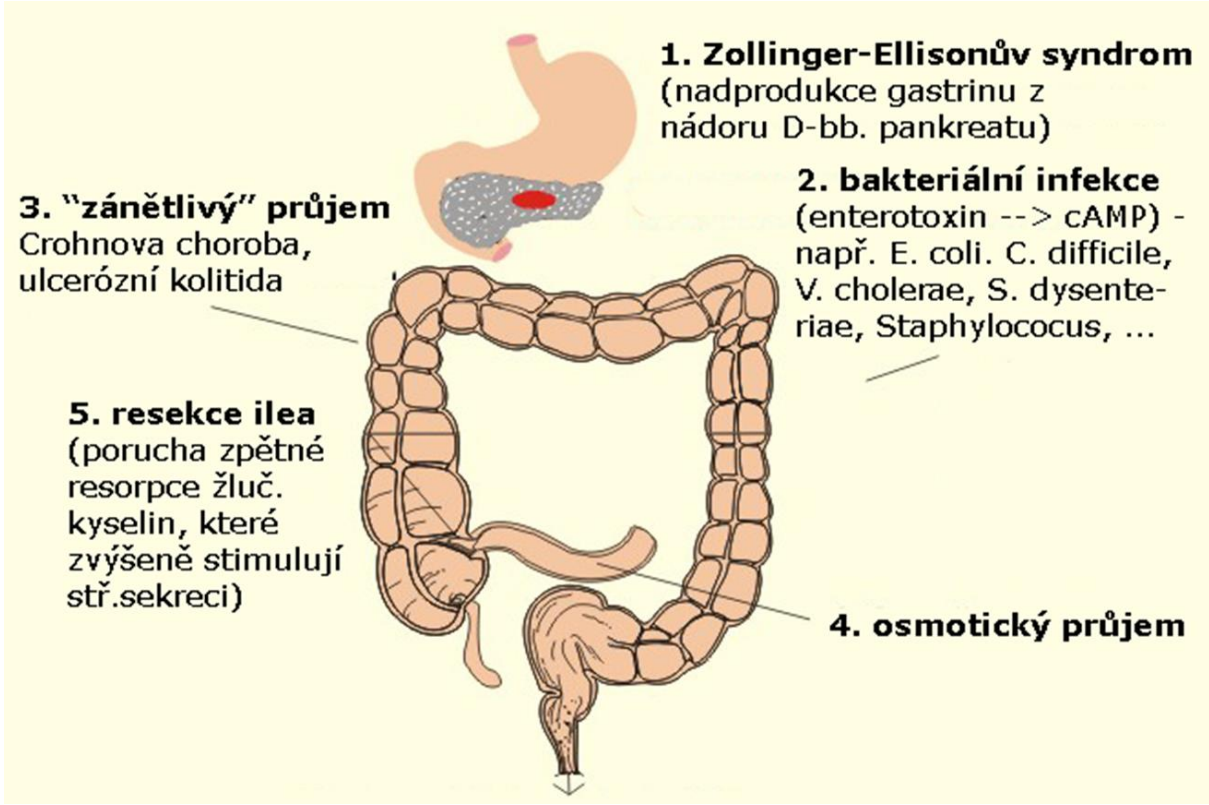
Disorders of intestinal secretion and

- diarrhea = more frequent expulsion of stools (>3×/day), often more liquid consistence → loss of fluid
- due to imbalance between 3 main factors – secretion, resorption and motility
  - acute
    - infection
    - dietary error
    - alimentary intoxication
  - chronic
    - malabsorption (inflammatory bowel disease (Crohn disease, ulcerative colitis), chron. pancreatitis, liver and biliary diseases)
    - colorectal carcinoma
    - neurogenic
    - metabolic (uremia, hyperthyreosis, adrenal insufficiency)
- etiology
  - infection, toxins, diet, neuropsychological (anxiety)
- pathogeneses
  - ↑ osmotic pressure (and thus water) in intest. lumen = **osmotic**
    - typically when large amount of undigested nutrients stays in lumen
      - malabsorption syndrome (pancreatic insufficiency, biliary, disacharidaae deficiency – e.g. lactase)
      - ingestion (overdose) of salts (Mg, sulfates), antacids
      - bacterial overgrowth, resection, obstruction of lymphatics
  - ↑ secretion of Cl (and thus water) into lumen = **secretory**
    - bacterial enterotoxins (Vibrio cholerae, Shigella dysenteriae, E. coli, Clostridium difficile, Salmonella typhi)
    - inflammatory exudation (Crohn d., ulcerative colitis)
  - **hypemotility**
    - some regulatory peptides (VIP, serotonin, PGE)



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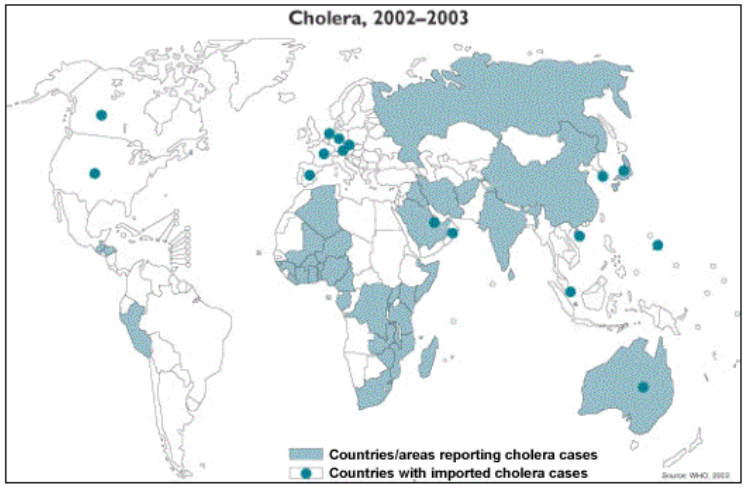
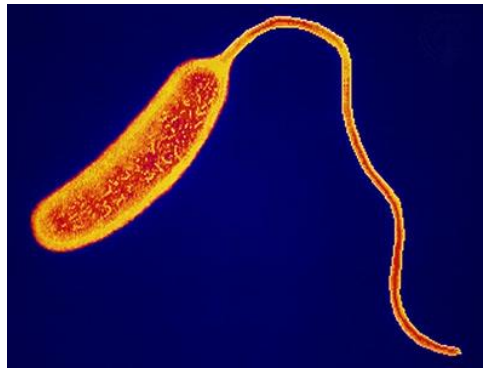
Cholera

- Vibrio cholerae
  - produces toxin binding to monosialoganglioside receptor on the luminal membrane of enterocytes
  - activation of cAMP signaling cascade and CFTR channel
  - secretion of Cl and Na (and thus water) into the intest. lumen
    - production of up to 20l of fluid daily
- transmission by contaminated water (rivers, wells, lakes) and food
- V. cholerae carriers
  - in gallbladder
  - ~5% population in endemic areas





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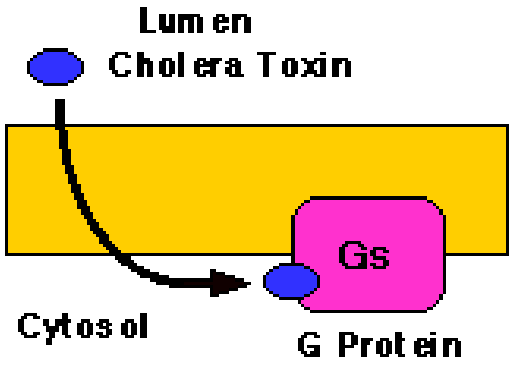
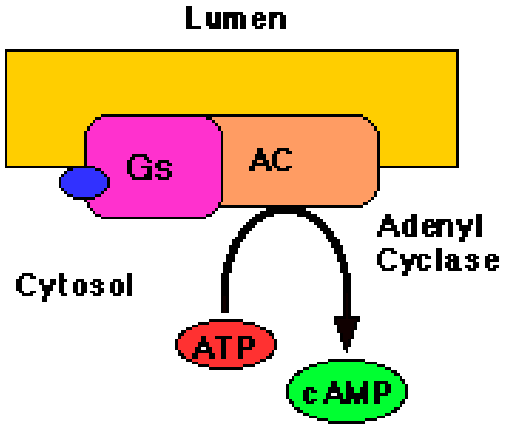
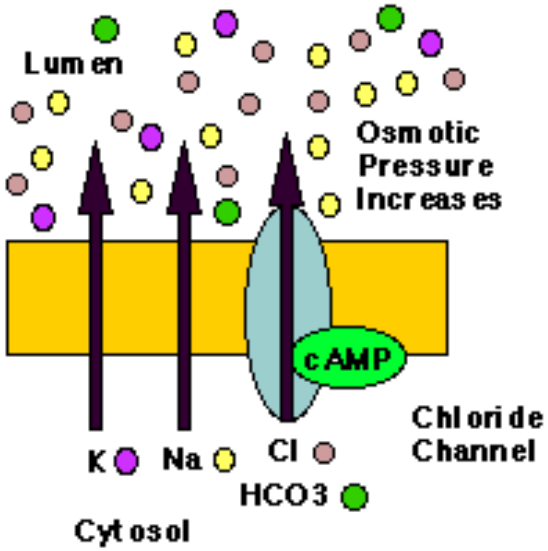
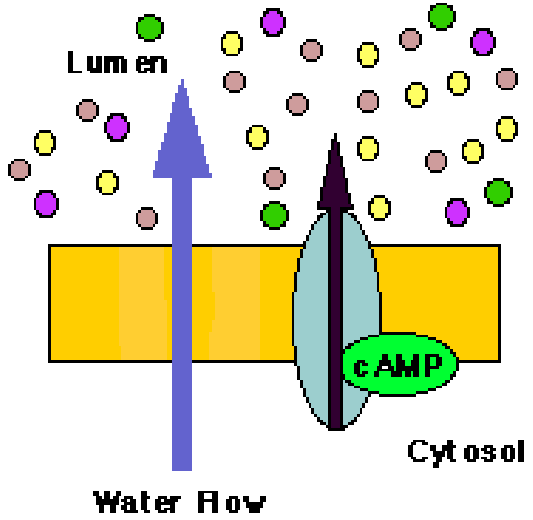
Action of V. cholerae toxin









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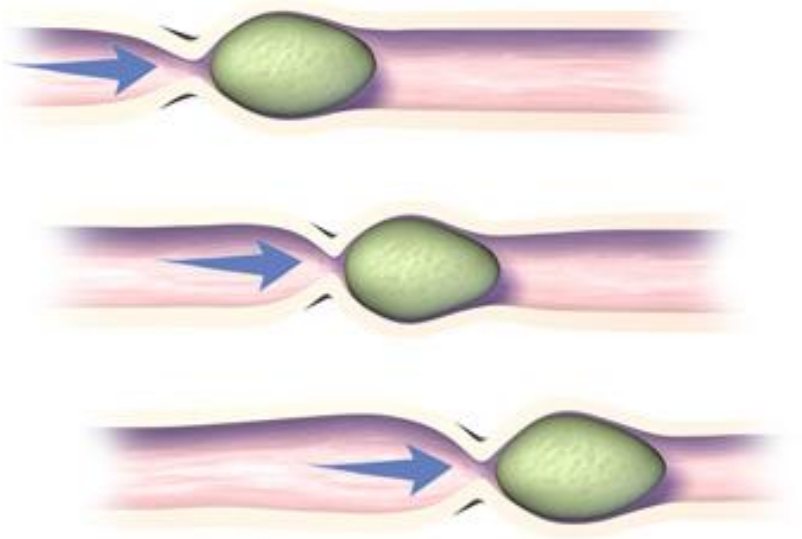
Intest. motility disorders

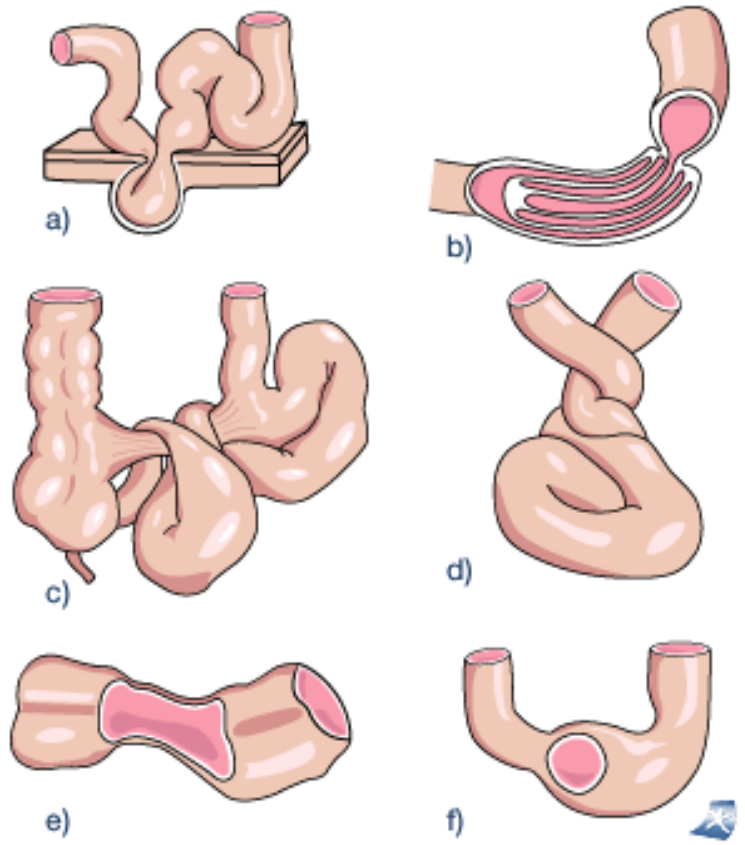
- peristaltics = coordinated contraction of muscular layers
  - necessary for mixing of lumen content with pancreatic juice and bile and aboral movement of digested content
- regulation
  - peristaltics is spontaneous but intensity is regulated
    - hormonal (gastrin, secretin, CCK, motilin, VIP, somatostatin, enteroglukagon, opioids)
    - neural (vegetative nerv. syst.)
- types of movement
  - fasting state
    - spontaneous contractions
    - migrating myoelectric complex (MMC) ~1x/1.5 hr.
  - after meals
    - segmentations ~ 10x/min
    - peristalsis
- reflexes
  - intestino-intestinal
  - gastro-intestinal
  - ileogastric
  - trauma of other organs (e.g. gonads, kidneys, ..) lead to reflex. stop of peristaltics (sympathetic n.s.) → atonic (paralytic ileus)
- disorders
  - hypomotility (extreme form = ileus)
  - hypermotility
- drugs affecting intest. motility
  - purposefully – laxatives (secretory, osmotic, emolients, fiber) x prokinetics
  - side effects – opiates, sympatomimetics, anticholinergics, …



MUNI MED

Ileus

- block of intestinal passage
  - **mechanic** = due to the external or internal obstruction
    - intraluminal: obstruction by tumor (e), bile stones (f), strictures, inflammation
    - extraluminal: adhesions, compression, herniation (a), invagination (b), strangulation (c), volvulus (d)
  - **paralytic or spastic** = ↓ motility
    - postoperative
    - acute pancreatitis
    - pain (colic, trauma, myocardial infarction)
    - peritonitis
    - hypokalemia
- at first peristaltics increased as an attempt to overcome the block
- water, gases and content stagnate above the block
- distension of intestine, hypoperfusion and later necrosis of the wall
- if not quickly surgically solved then lethal – dehydration, ion dysbalance and toxemia (bacteria from lumen into circulation)



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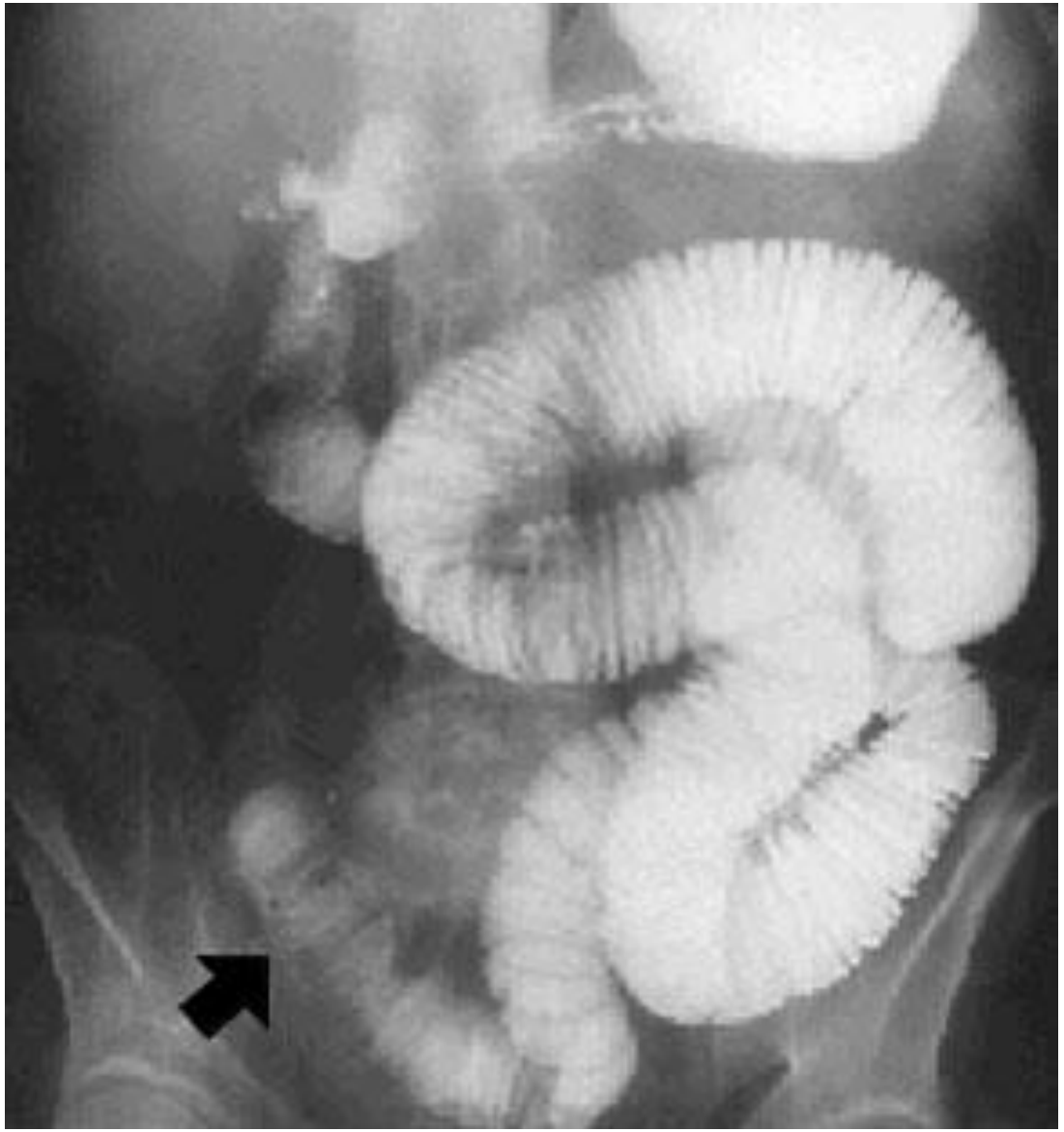
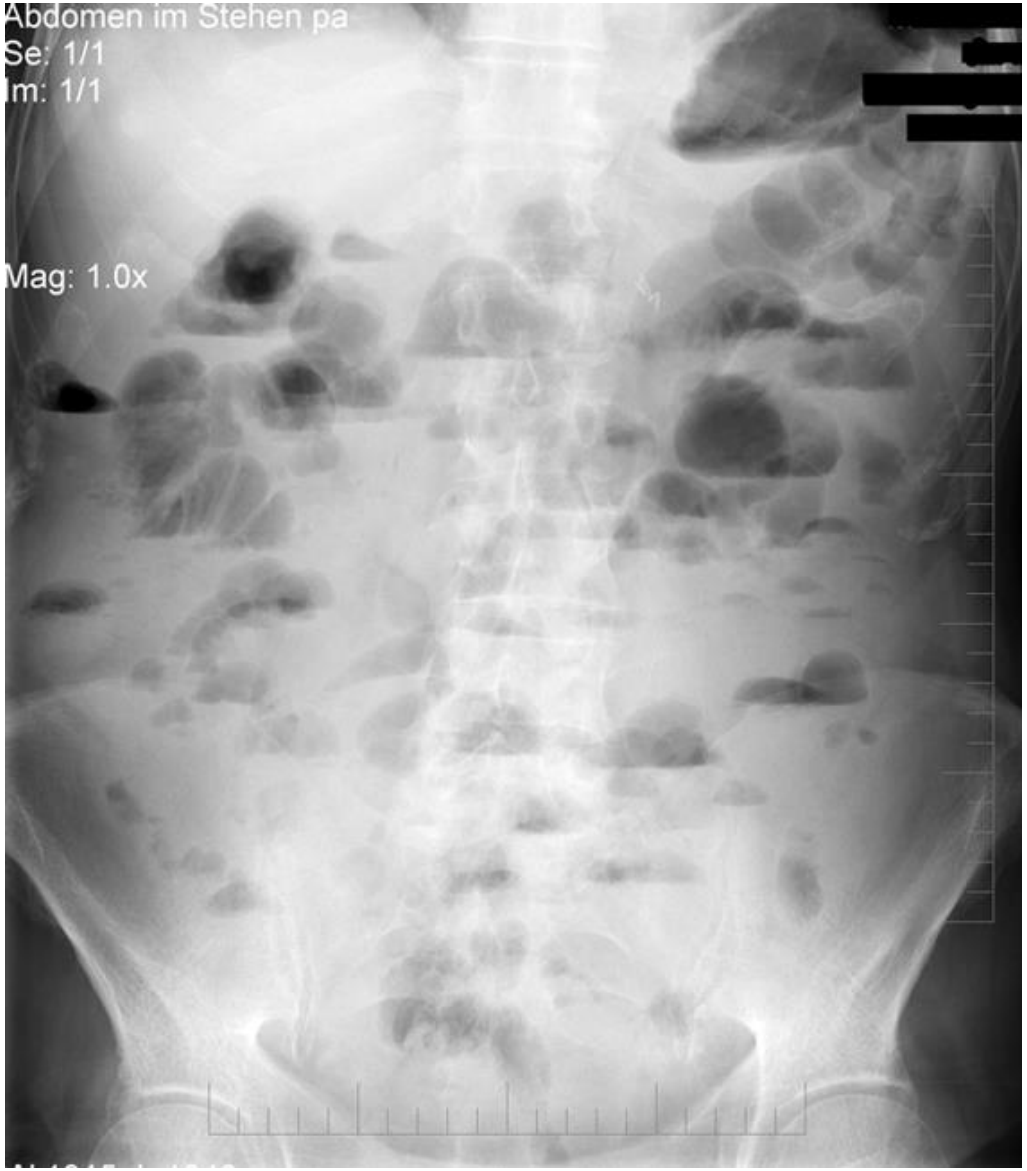
Obstructive and paralytic ileus

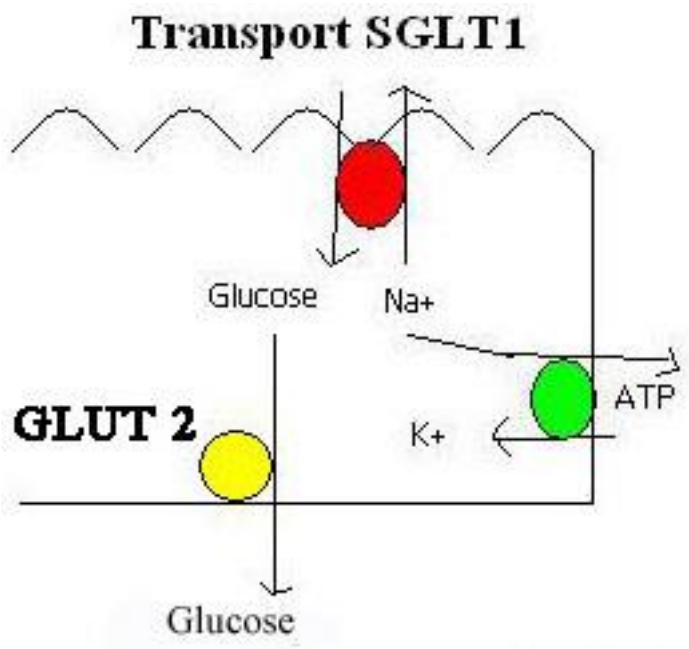




MUNI MED

Digestion and absorption in small intestine

- mechanism
  - (1) slow by passive diffusion
  - (2) fast (but saturable) by facilitated transports
- localization
  - duodenum and jejunum
    - hexoses, AA, di- and tripeptides, vitamins, FA, monoacylglycerols, cholesterol, Ca, Fe, water, ions
  - ileum
    - vit. C and B12, bile acids, cholesterol, water, ions
- saccharides (mainly poly- and disaccharides)
  - saliva α-amylase → pancreatic α-amylase → intest. enzymes (oligo- and disaccharides)
  - passivee absorption (pentoses), SGLT1 (glucose and galactose), GLUT5 (selectively for fructose)
- proteins
  - endo- (pepsin, trypsin, chymotrypsin, elastase) and exopeptidases → pancreatic carboxy- and aminopeptidases → peptidases of enterocytes
  - passive absorption, facilitated (SLC, solute carriers – many types, Na-dependent or not) and actively
  - absorption of intact proteins (e.g. Ig of maternal breast milk, antigens, toxins, …) possible in limited extent
- lipids (TGA, cholesterol esters and phospholipids)
  - pancreatic lipase (min. salivary), cholesterolesterase, pospholipase A → emulsification (conj. bile acids!!) → absorption by diffusion → reesterification in enterocyte → chylomicrons



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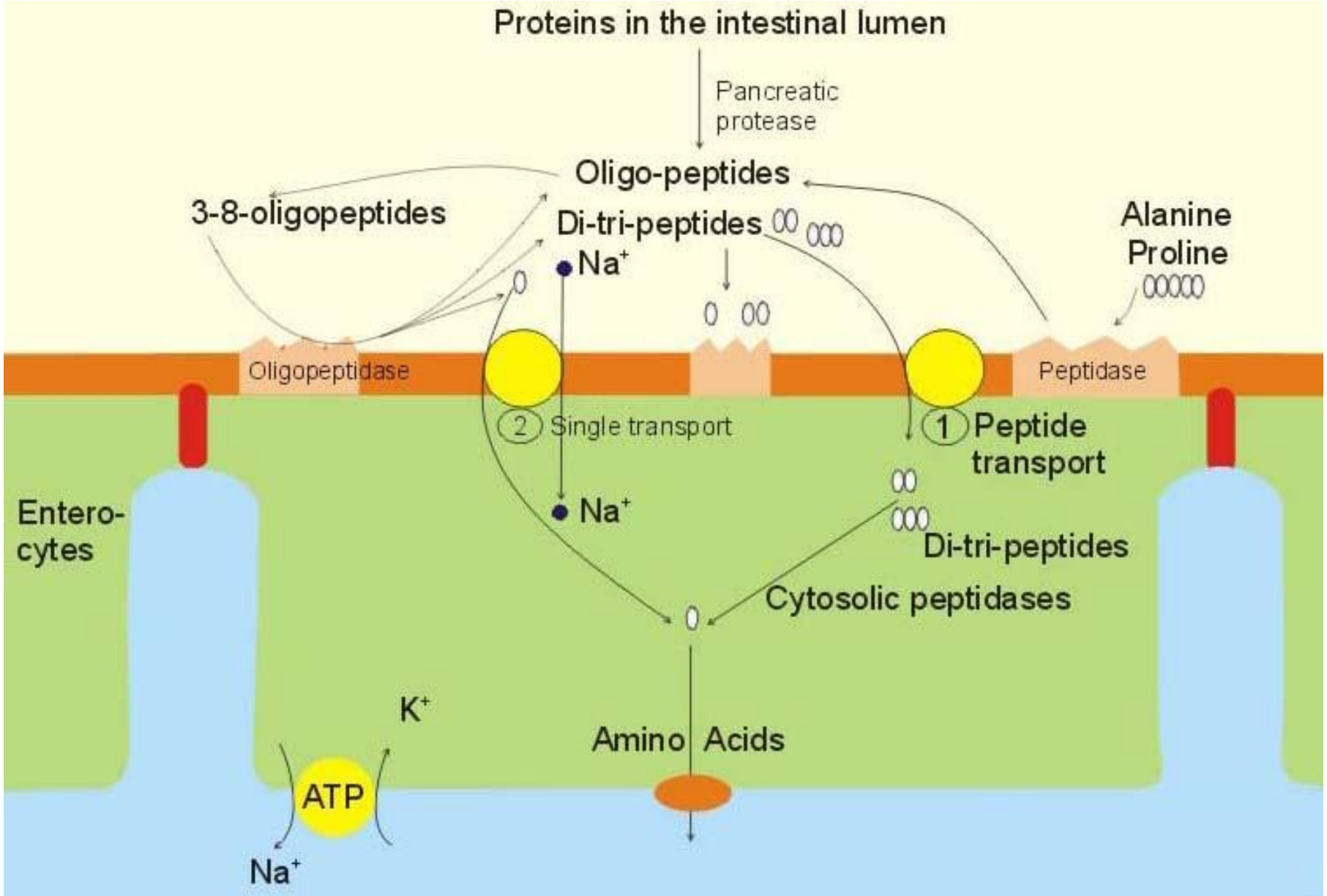
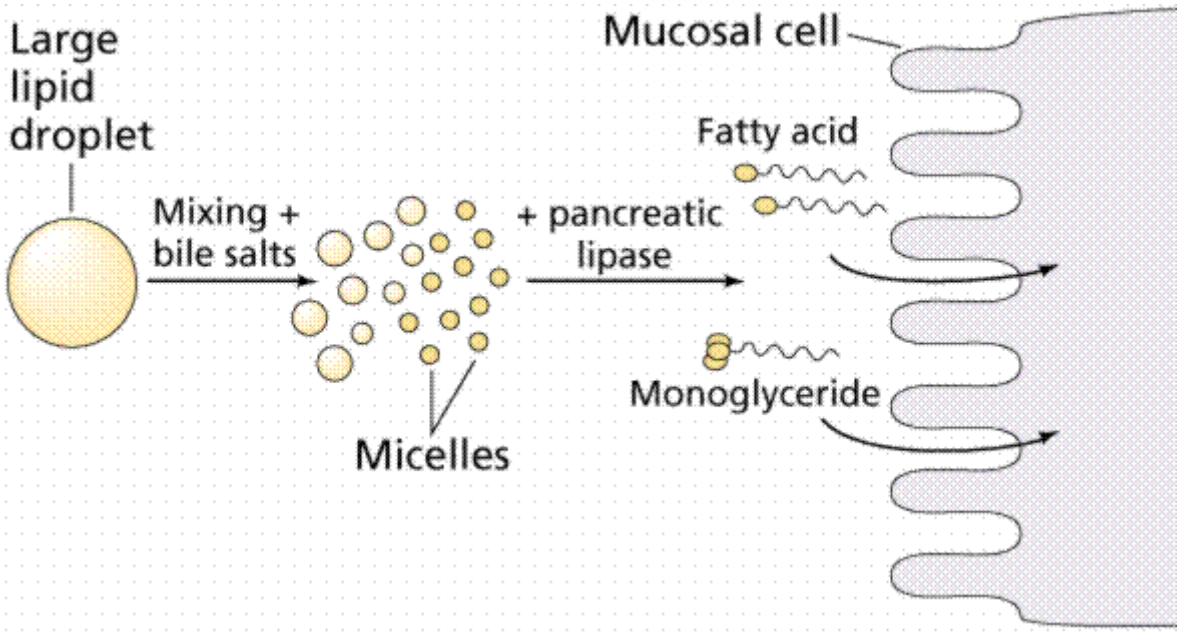
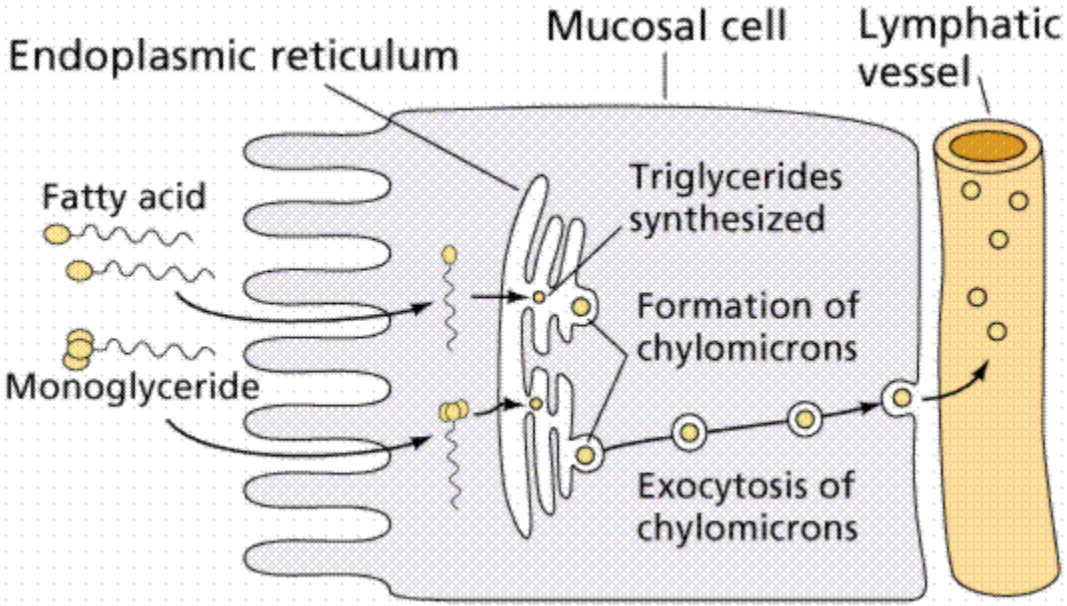

Proteins in the intestinal lumen
Pancreatic protease
Oligo-peptides
3-8-oligopeptides
Di-tri-peptides
Na+
Alanine
Proline
Oligopeptidase
Peptidase
2 Single transport
1 Peptide transport
Na+
Di-tri-peptides
Entero-cytes
Cytosolic peptidases
K+
Amino Acids
ATP
Na+

Absorption of lipids in small intestine





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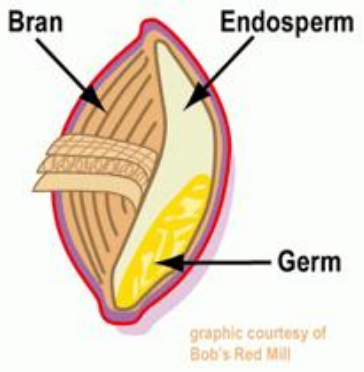
Malabsorption syndrome (MAS)

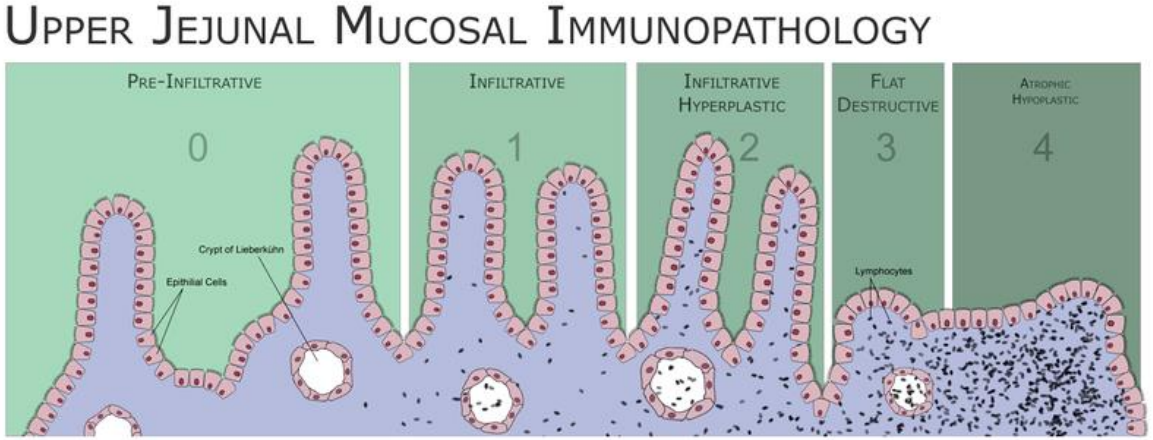
- **maldigestion** = impaired enzymatic digestion in stomach or intestine
- **malabsorption** = impaired absorption of digested compounds

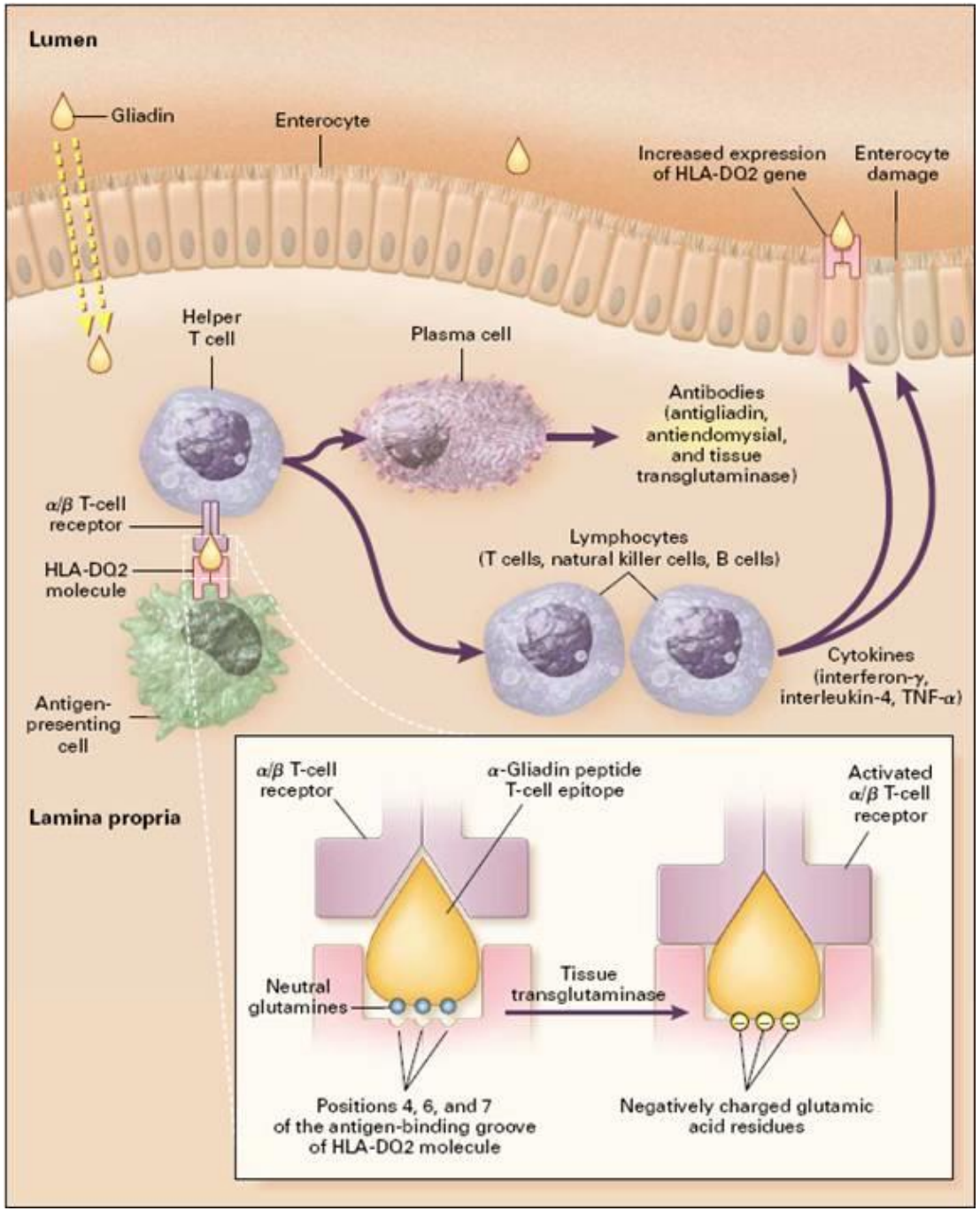
- MAS impairs the normal sequence:
  - mechanical processing of food (chewing, gastric motorics) →
  - digestion in gastric and intest. lumen by secreted enzymes (gastric, pancreas, bile) →
  - digestion by membrane enzymes fo enterocytes →
  - absorption by intest. epithelium → processing in enterocyte →
  - transport by blood and lymph to livet and syst. circulation
- **practically every GIT disease can lead in chronic duration to MAS**
- MAS can be global or specifically affect
  - basic nutrients
    - saccharides –flatulence, osmot. diarrhea (e.g. lactase deficiency)
    - proteins – muscle atrophy, edemas (e.g. chron. pankreatitis)
    - lipids – steatorhea, vitamin A, D, E, K deficiency (e.g. chron. pankreatitis, m. Crohn, m. Whipple, celiac d.)
  - vitamins
  - elements (Fe, Ca, Mg)
  - bile acids (impairment of enterohepatal cycle)
  - any combination

MAS – selected examples – coeliac disease

- = gluten-sensitive enteropathy
- autoimmune reaction against intest. mucosa initiated by gluten and its products (gliadins)
  - gluten is a part of endosperm of cereals (wheat, rye, barley, oats)
- diseases starts in child after breast feeding when flour is introduced
- pathogenesis
  - gen. disposition – variants of MHC II genes (DQ2 and DQ8 haplotypes)
    - often associated with other autoimmunities, e.g. T1DM
  - external factors
    - gluten in diet
    - infection by adenoviruses (molecular mimicry)
- clinical course
  - immunization (antibodies against gliadin, reticulin and transglutaminase), infiltration by cytotox. T-lymph.) – injury of enterocytes of small intestine
  - malabsorption of main nutrients, vitamins, elements
    - hypo-/malnutrition, slow growth, anemia, neuromuscular disorders
  - in 20-40 years risk of intest. lymphoma (50%) or carcinoma (10%)
  - disorders of fertility



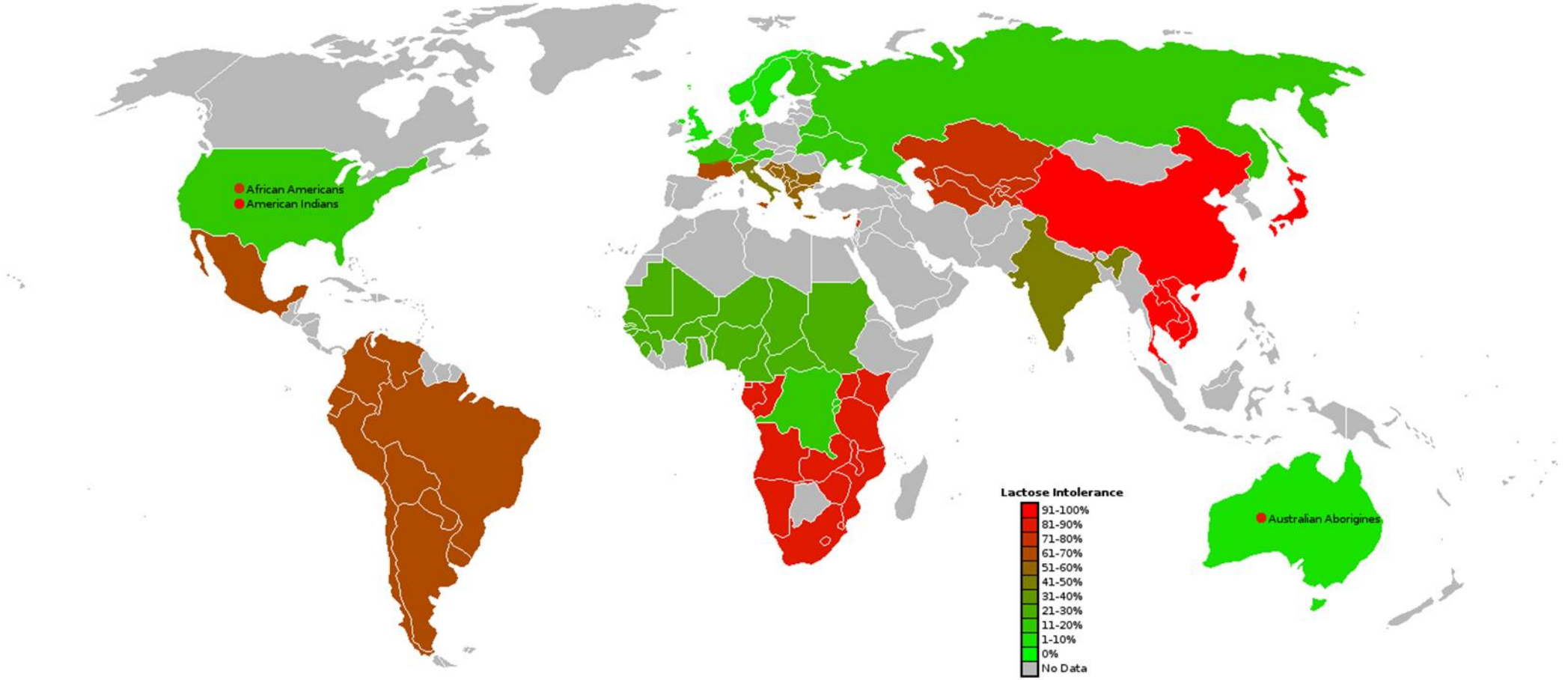



Lumen
Gliadin
Enterocyte
Increased expression of HLA-DQ2 gene
Enterocyte damage
Helper T cell
Plasma cell
Antibodies (antigliadin, antiendomysial, and tissue transglutaminase)
α/β T-cell receptor
HLA-DQ2 molecule
Lymphocytes (T cells, natural killer cells, B cells)
Cytokines (interferon-γ, interleukin-4, TNF-α)
Antigen-presenting cell
Lamina propria
α/β T-cell receptor
α-Gliadin peptide T-cell epitope
Activated α/β T-cell receptor
Neutral glutamines
Tissue transglutaminase
Positions 4, 6, and 7 of the antigen-binding groove of HLA-DQ2 molecule
Negatively charged glutamic acid residues

MAS - selected examples – lactase deficiency

- leads to **lactose intolerance**
- extremely frequent – mainly due to the fact that lifetime ability to digest milk (i.e. lactose) is considered a normal state
  - however, most mammals and part of human population loses the activity of lactase after weaning
  - the lifetime activity could be considered exceptional – **persistence of lactase**
    - genetic polymorphism (geographical distribution is evidently a consequence of genetic selection) in promoter of gene for lactase
      - highest prevalence of lactase persistence in Europe in Swedes a Danes (~90 %)
      - Czech population ~ 70 %
      - lowest in Turks (~ 20 %)
      - outside Europe high fervency of persistence e.g. in desert nomadic populations in North Africa
        - the reason for selection of persistence haplotype in northwest Europe could be the richer source of calcium in low vit. D generation climate
- manifestation
  - intestinal discomfort after fresh milk intake (not after diary fermented products such as cheese or yogurt)
  - diarrhea, flatulence, abdominal pain

Lactose intolerance prevalence



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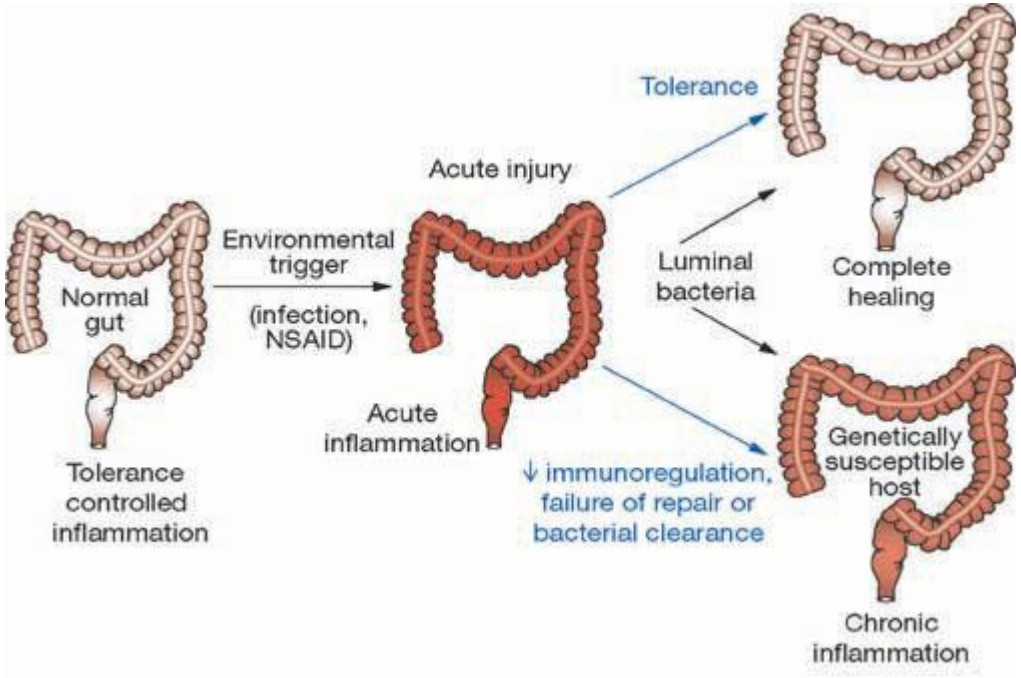
Inflammatory bowel diseases (IBD)



- Crohn's disease and ulcerative colitis
- both exhibit some similar features
  - manifestation in young adults
  - genetic predisposition
  - abnormal reactivity of immune system (T-lymph.) to intest. bacteria
  - impairment of intest. epithelial barrier
- localization
  - m. Crohn – any segment of GIT
  - ulcerative colitis – only colon
- incidence rises in Europe and N. America
  - environmental factors

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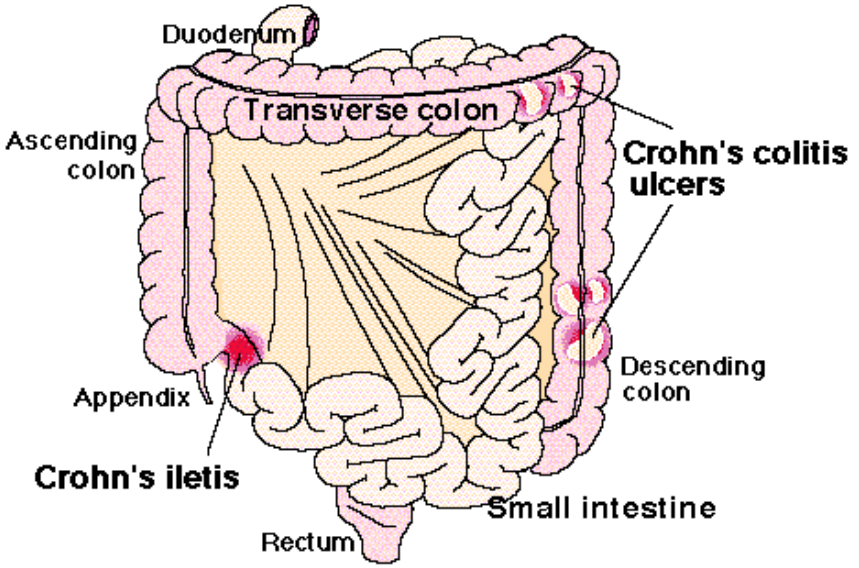
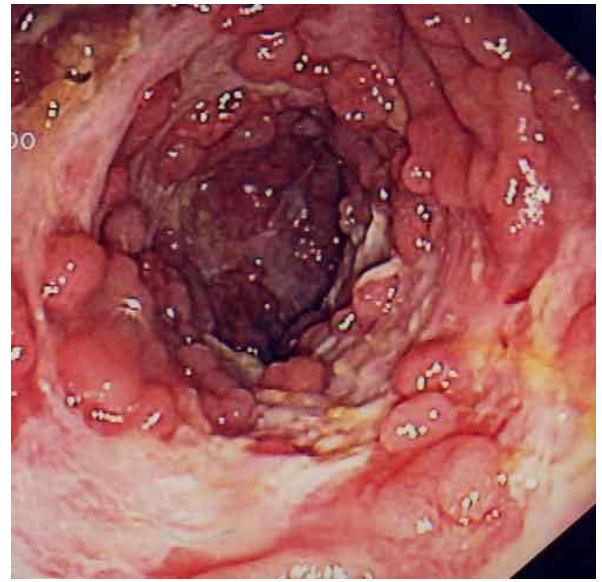
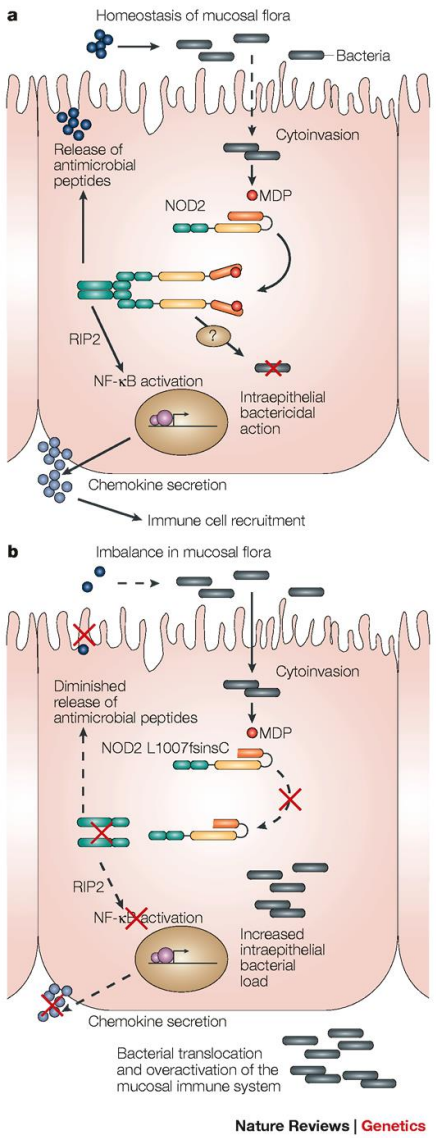
Crohn’s disease

- = ileitis terminalis, enteritis regionalis
- chronic idiopathic inflammatory disease of commonly small intestine
  - but can affect any part of GIT beginning with oral cavity to anus
  - manifestation typically between 3. to 6. decade, more often women
- pathogeneses (multifactorial)
  - genetic factors (= disposition) lead to abnormal immune response of intest. mucosa to natural commensal bacterial antigens (>500 bact. strains)
    - normally opposed by production of defensins
    - mutation in gene for CARD15 in patients
  - triggering factors nor known (infection?) = sterile animals protected
    - lipopolysaccharide, peptidoglycan, flagellin, …
- clinical course – typically exacerbations (stomach pain, diarrhea, fever, seizures, blood in stools (enterororhagia)/remise
  - granulomatous type of inflammation affects all layers of intest. wall
  - ulcerations and bleeding
  - penetrated ulcers create fistulas (often perirectal)
  - affected areas interspersed by inaffected
- extraintestinal manifestations
  - arthritis
  - uveitis





Intestinal "controlled inflammation"



- reaction to intraluminal bacteria – normally "controlled inflammation"
- intracellular recognition of components of bacterial wall (pathogen-associated molecular patterns, PAMPs), e.g. muramyl-dipeptide (MDP) by NOD2 (product of CARD15 gene) lead to oligomerization and activation of NFk-B
  - secretion of chemokines and defensins by Paneth cells
- variants of NOD2 associated with Crohn's d. lead to deficient epithelial response, loss of barrier function and increased exposition to intest. microflora
  - impaired secretion of chemokines and defensins
  - altered expression of pattern-recognition receptors (PRRs), e.g. Toll-like receptors
  - production of inflammatory cytokines
  - activation of dendritic cells and production of Ig and activation of Th1 lymph.

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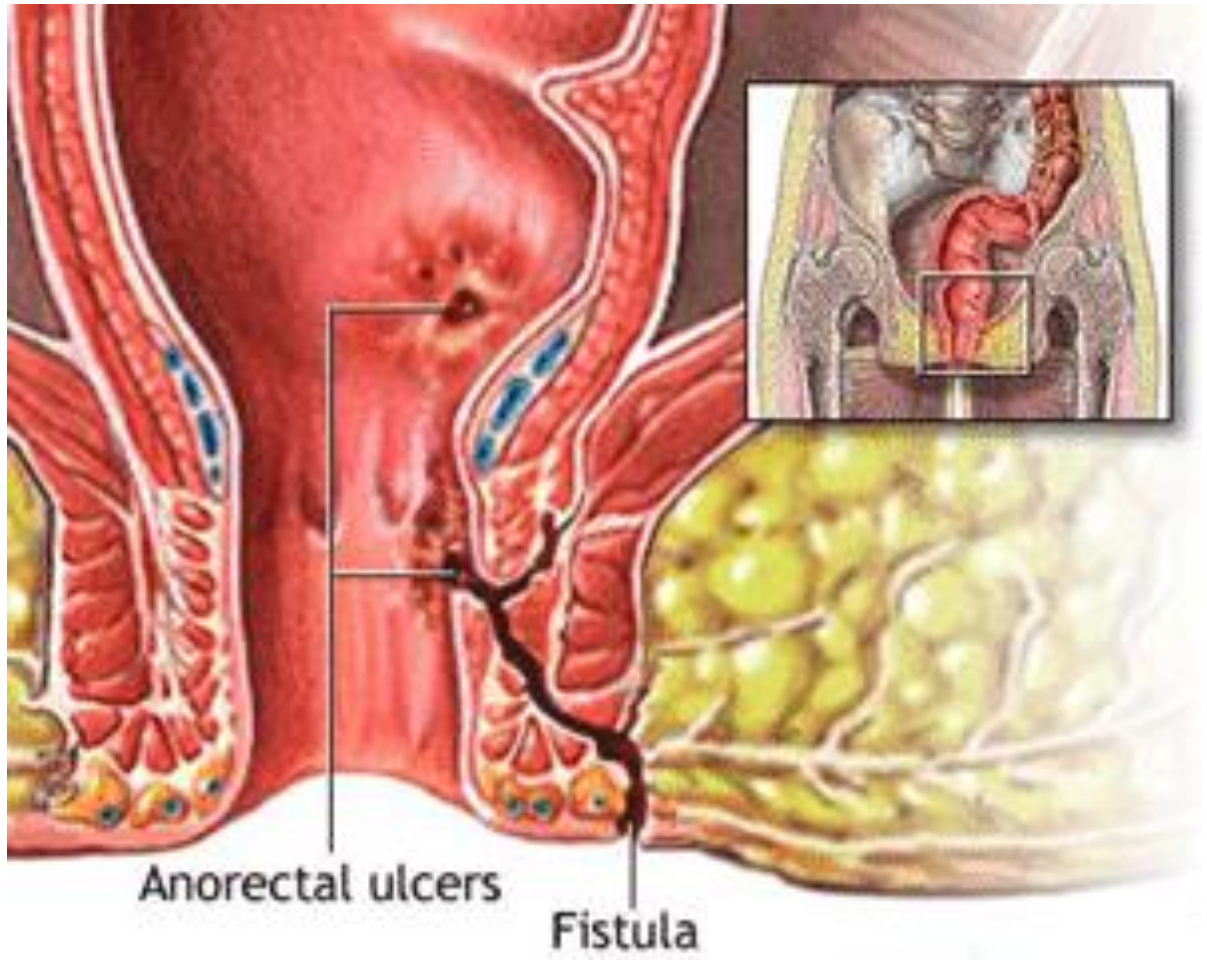
Complications of Crohn’s disease



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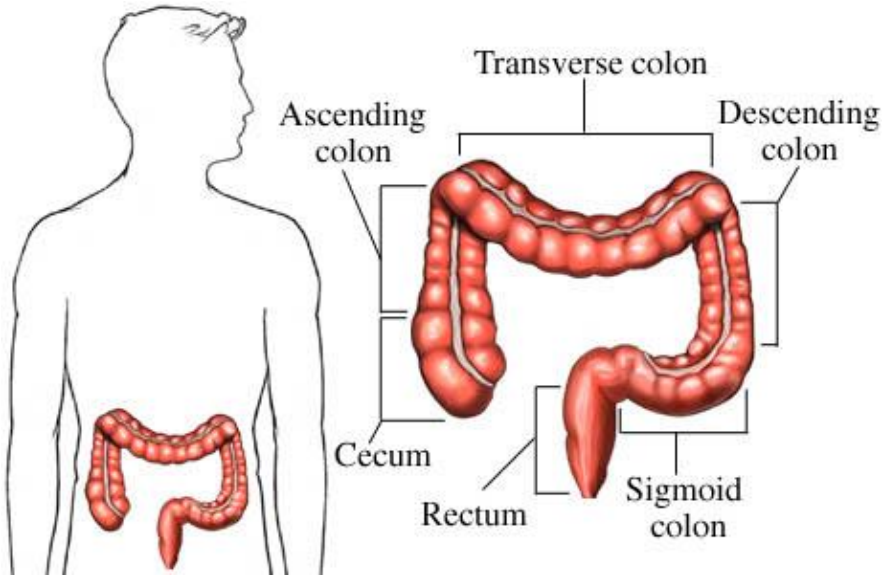
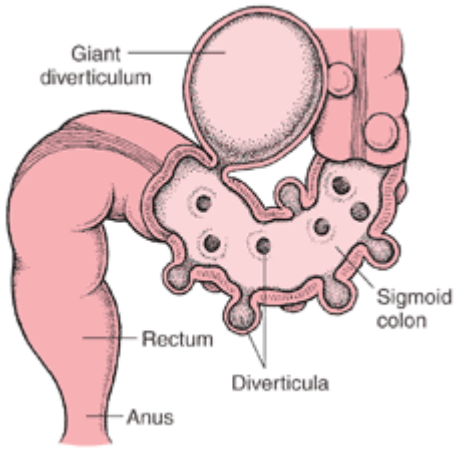
Pathophysiology of large intestine





- functions
  - resorption of water (0.5-1l/24h)
    - along the whole length
  - motoric
- pathology
  - obstipation
  - diverticulosis
    - event. diverticulitis
  - polyposis
  - carcinoma
    - hereditary
      - polyposis
      - non-polypose
    - non-hereditary (sporadic)

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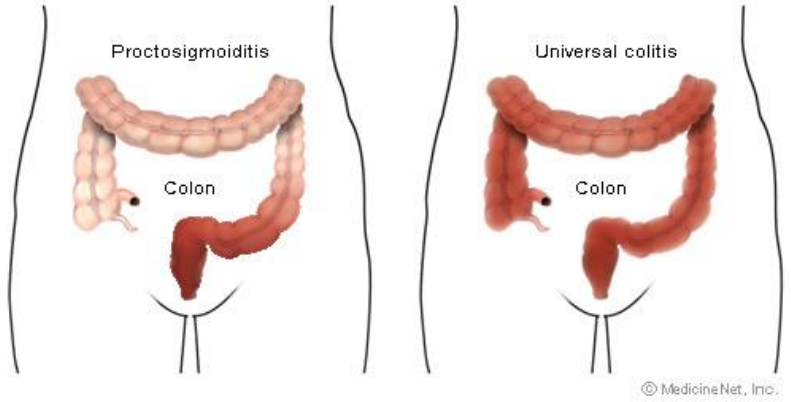
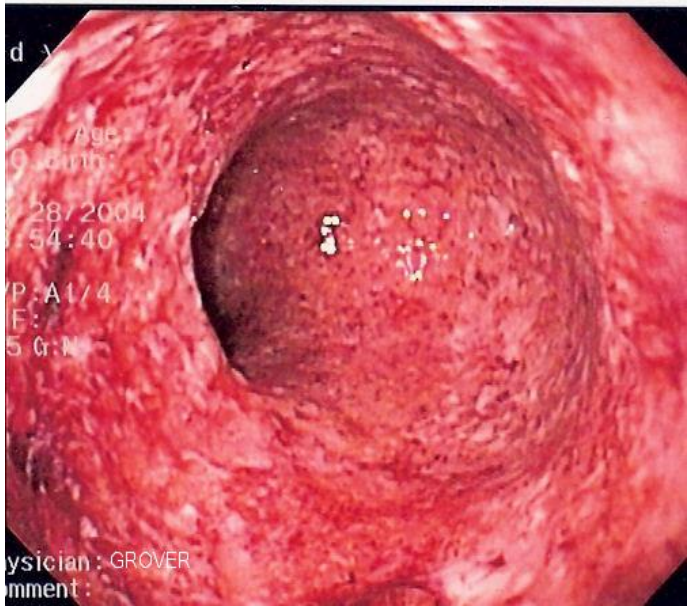
Ulcerative colitis

- max. incidence between 20 – 40. years of age
- typically Caucasian race, north-south gradient
- inflammation limited to mucosa
  - starts at the bottom of Lieberkuhn's crypts (infiltration by immune cells)
    - mainly rectum and sigmoideum
  - hyperemia, abscesses and ulcerations, bleeding, pseudopolyps, event. strictures
- clinical course
  - periodical = exacerbations x remissions (diarrhea, bleeding, abdominal pain, fever)
  - extraintestinal manifestations (5 – 15%): polyarthritis, osteoporosis, uveitis, cholangitis
  - chronic anemia, strictures, hemorrhoids, carcinoma





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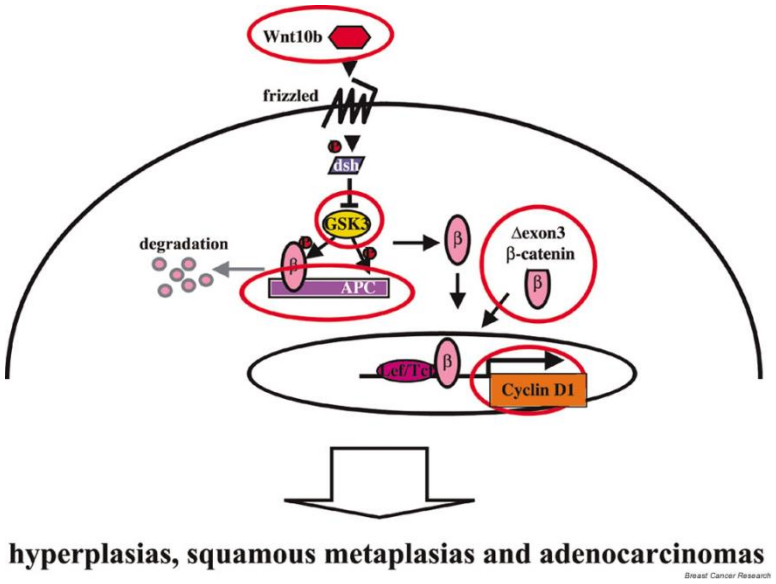
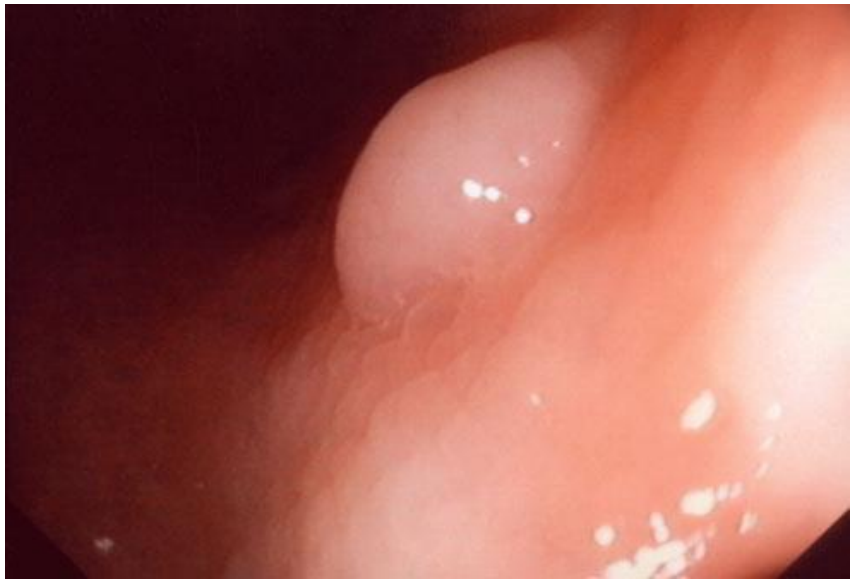
Polyps of large intestine

- polyp = any lesion/prominence into the lumen
- types
  - solitary
  - multiple
    - familiar polyposis, FAP)
      - autosomal dominant
      - precancerosis, polyps in puberty, carcinoma after 30th year of age
      - polyps more common in rectum but also in ileum
      - mutation in APC gene (Wnt pathway)
    - Gardner's syndrome
    - juvenile polyposis
- etiology
  - hyperplasia in the inflammatory terrain
  - neoplastic
    - benign
    - malign





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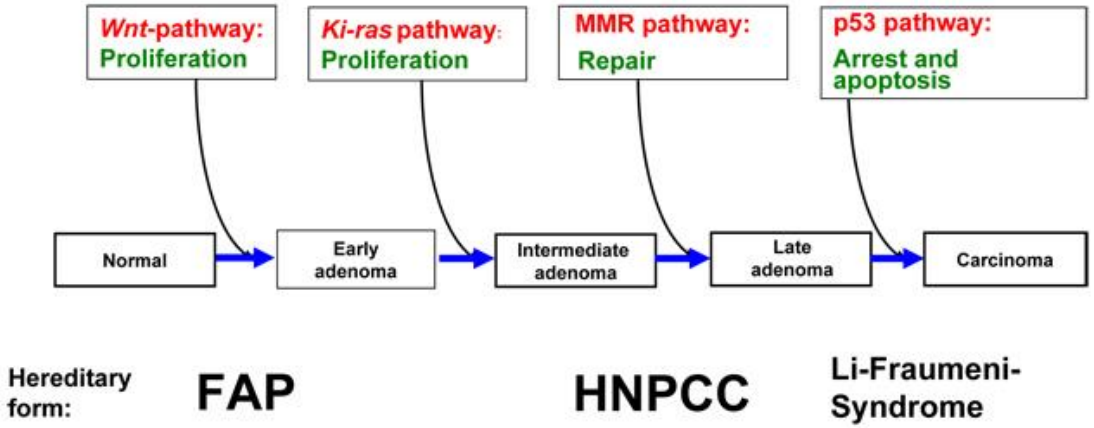
Tumors of large intestine

- benign
  - adenoma (adenomatous polyp)
  - fibroma
  - leiomyoma
  - hemangioma
- malign
  - lymphoma
  - carcinoid
  - carcinoma
    - hereditary
      - polypose
        - FAP (mutation in APC gene)
        - Gardner's syndrome
      - non-polypose
        - HNPCC or Lynch syndrome (mutation in mismatch repair genes)
        - Li-Fraumeni syndrome (mutation in p53 gene)
    - non-hereditary (sporadic) – **most common**



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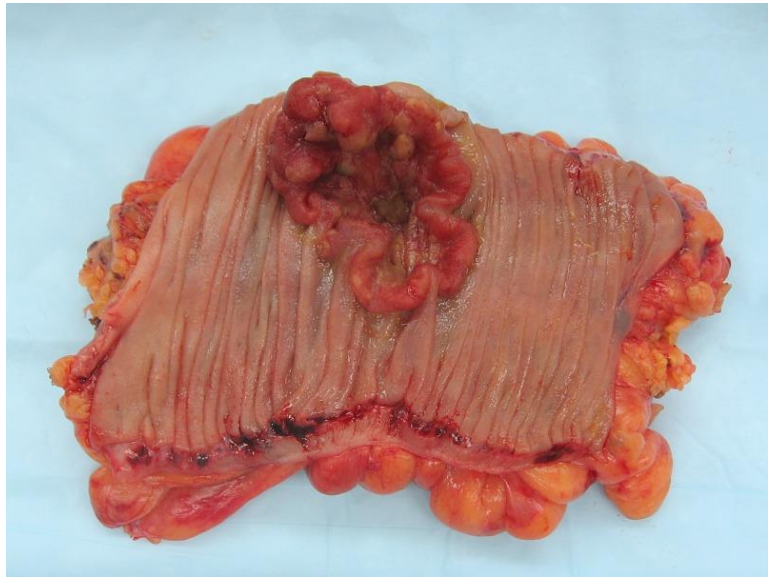
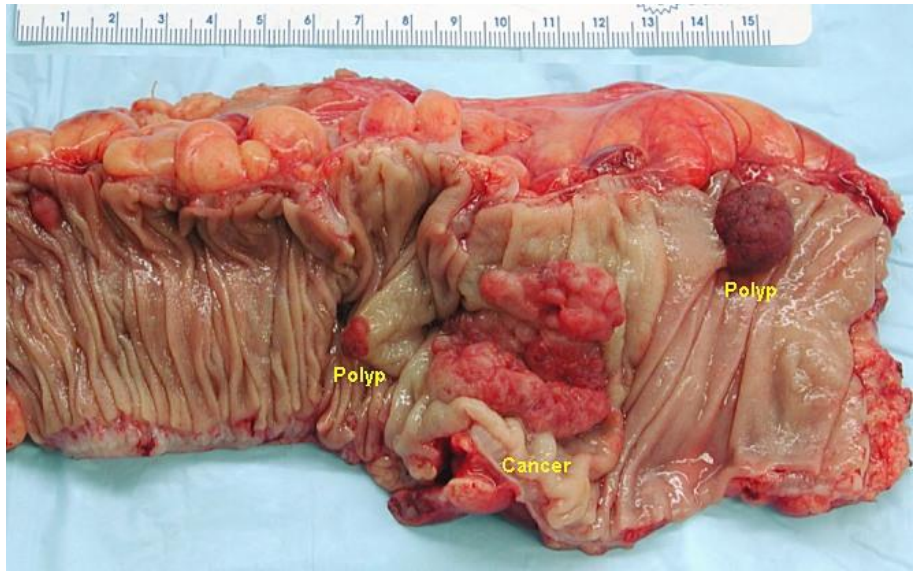
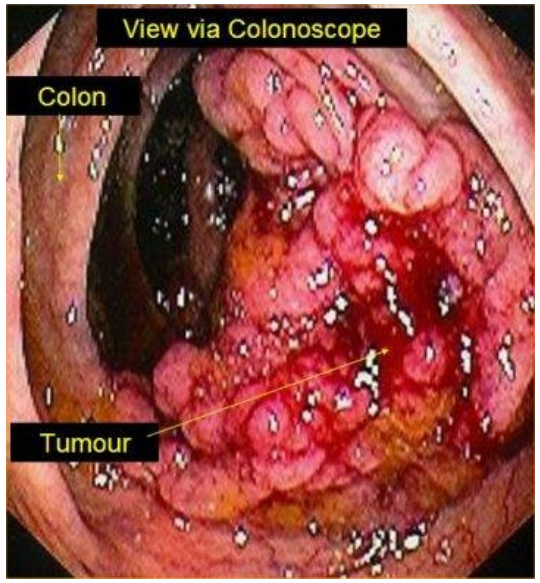
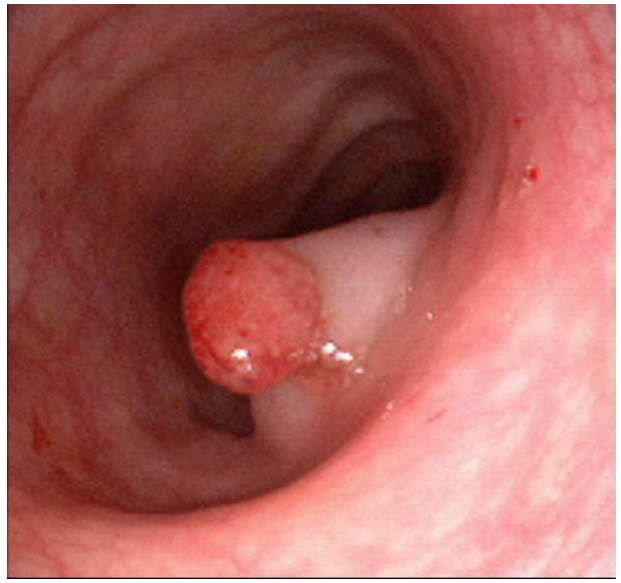
Colorectal carcinoma









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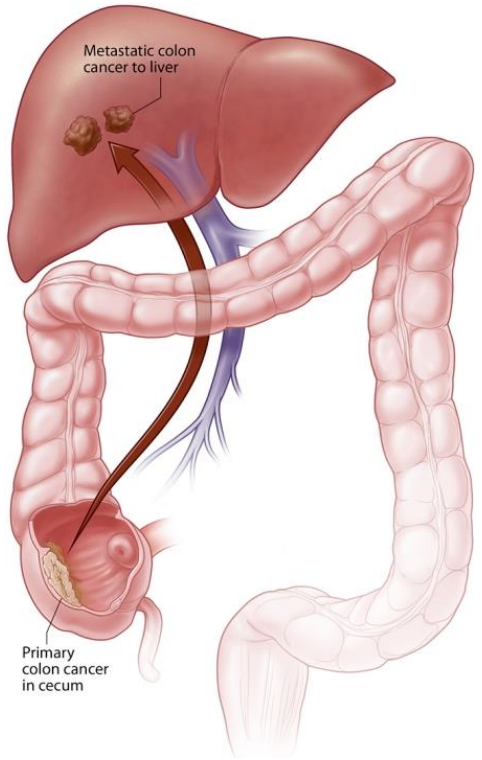
Colorectal carcinoma

- carcinogenesis in the intestine progresses slowly upon the exposure to dietary carcinogens and event. with contribution of genetic predisposition of the subject
- risk factors
  - age, genetics, polyps, bowel inflammation, obstipation, diet, smoking
- symptoms
  - bleeding, blood in stools
  - change of peristaltics
    - diarrhea
    - obstipation
    - tenesmus
  - intest. obstruction
  - pain
  - extraintestinal
    - liver metastases
      - icterus, pain, cholestasis = acholic stools
    - hematologic
      - sideropenic anemia, thrombosis
    - fatique
    - fever
    - anorexia, weight loss



- stages
  - 0 in situ
  - I invasion into the wall
  - II
  - III presence in local lymph nodes
  - IV distant metastases

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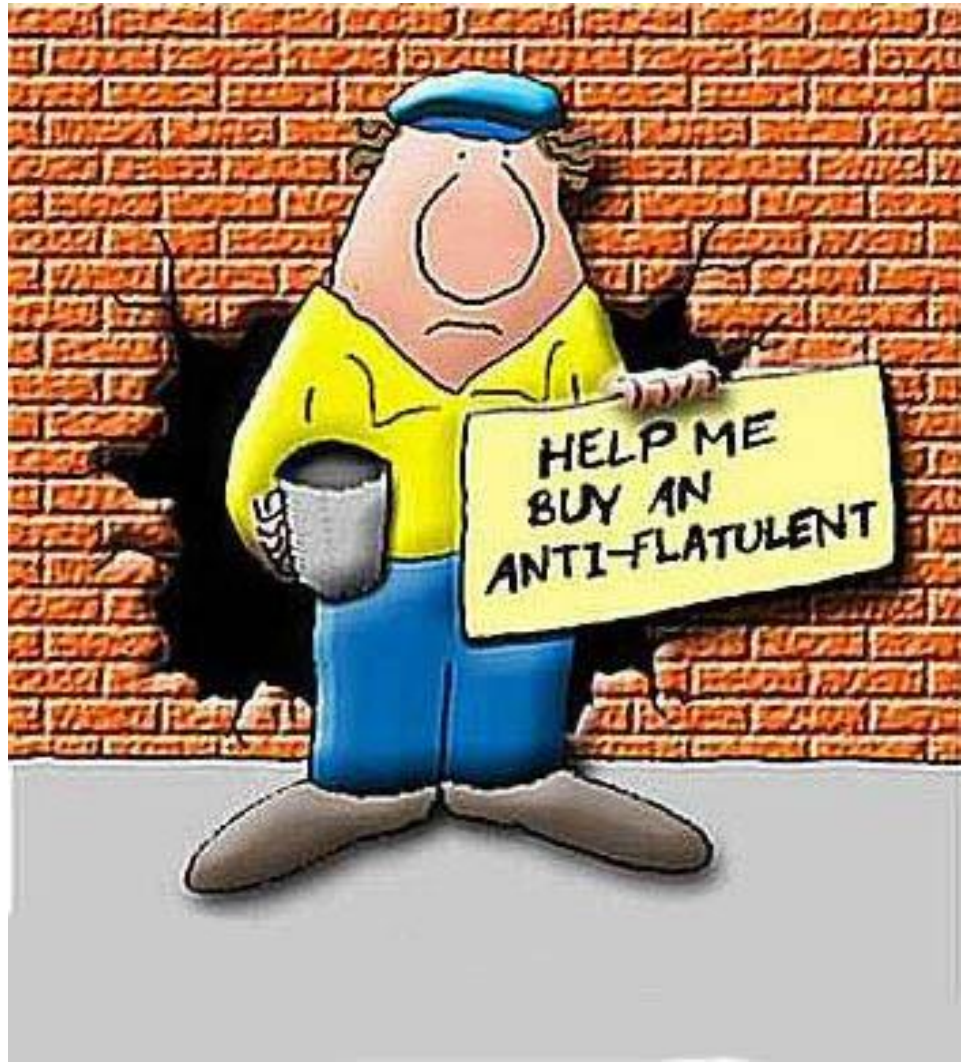

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