Digestion in stomach. Regulation of secretory and motor functions of stomach. Digestion in duodenum, role of pancreas and live in digestion. Digestion in intestinal lumen. Regulation of secretory and motor function of intestine. Absorption

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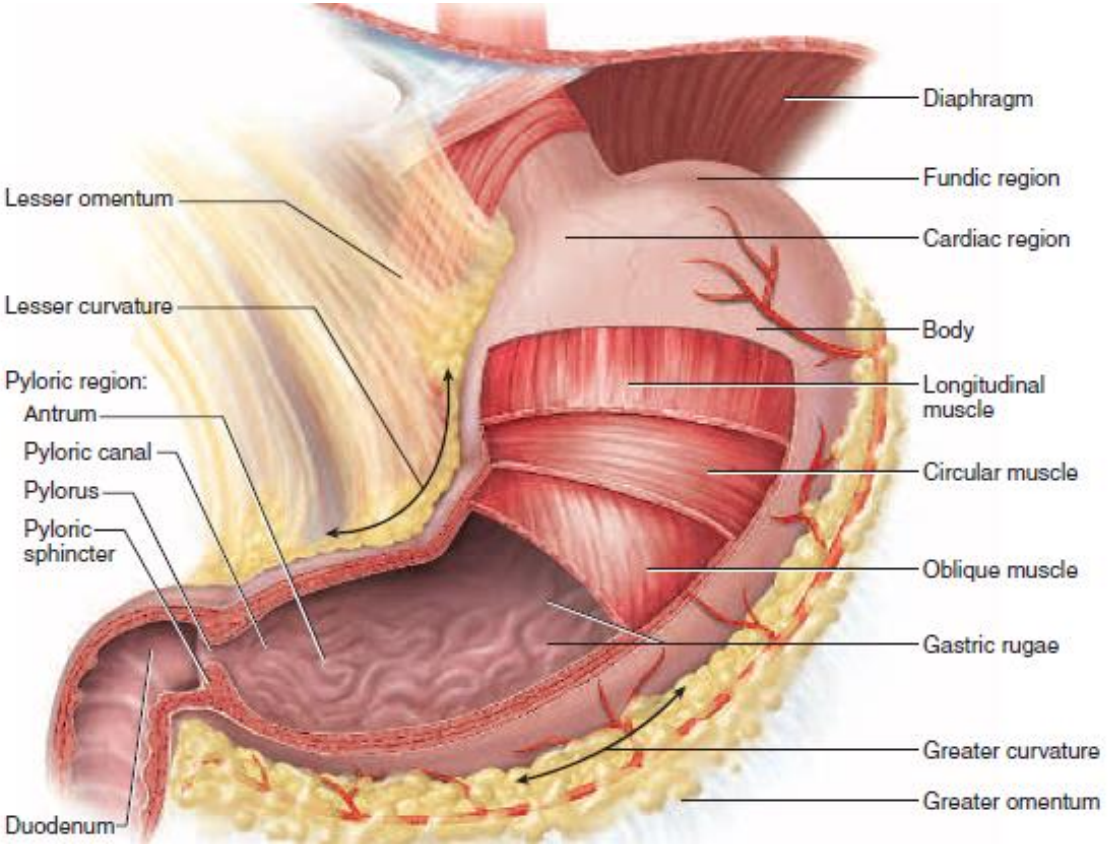
Functions of stomach

- Digestive (proteins), bolus → chyme.
- Mixing, storing, and evacuation of chyme.
- Defensive (hydrochloric acid kills bacteria).
- Excretory function.
- Production of intrinsic Castle (gastric) factor (effect on haematopoiesis).

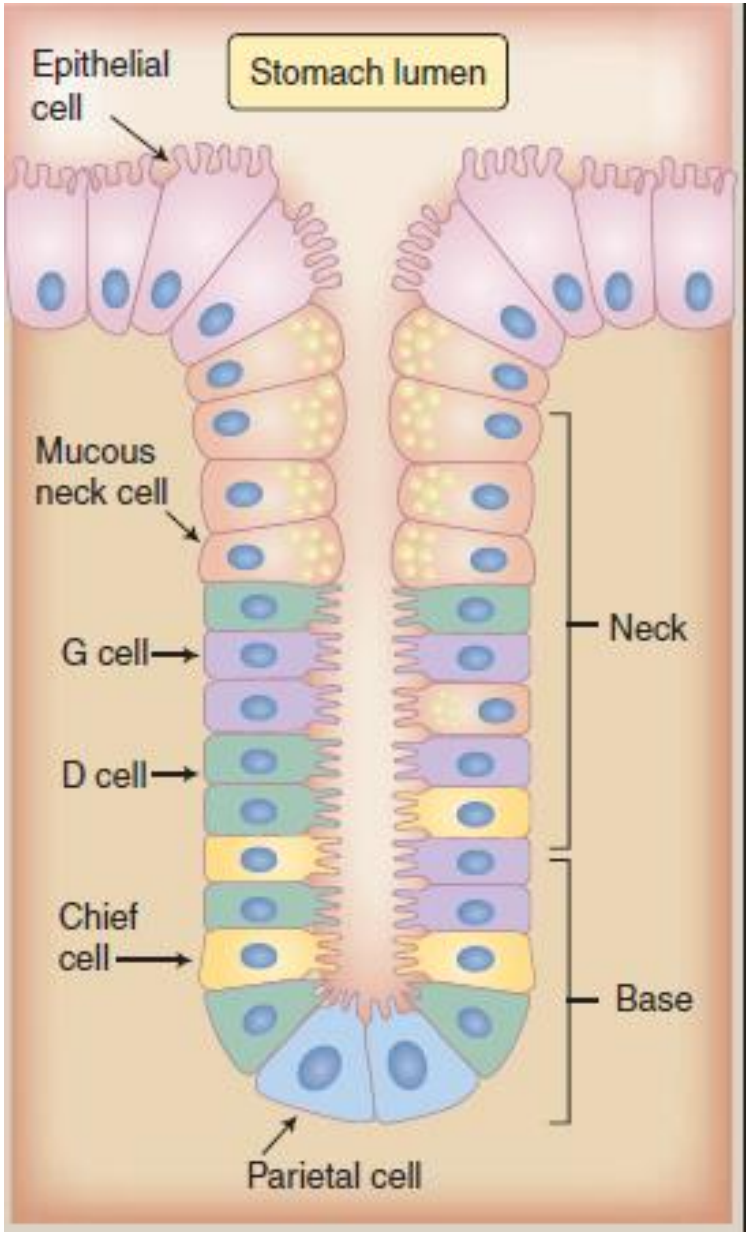
Stomach structure

- The hollow organ lies under the diaphragm on the left.
- The empty volume is 50 ml, after a meal up to 1-1.5 liters, a maximum of 3-4 liters.
- Parts: cardia, fundus, body, antrum, pylorus.



Gastric glands

- Fundic glands (fundus and body): parietal (oxyntic) cells, chief cells, mucous neck cells, enterochromaffin cells (EC-cells), enterochromaffin like cells (ECL-cells).
- Pyloric glands: chief cells, mucous neck cells, G-cells, D-cells, EC-cells , ECL-cells.
- Cardiac glands: chief cells, mucous neck cells, EC-cells , ECL-cells.



Types of cells in stomach

Cells	*Secretion*
Chief	*Pepsinogen, gastric lipase, gelatinase*
Parietal (oxyntic)	*Hydrochloric acid, intrinsic factor*
Mucous neck cells	*Mucus*
G-cells	*Gastrin*
D-cells	*Somatostatin*
EC-cells	*Serotonin*
ECL-cells	*Histamin*

Gastric juice

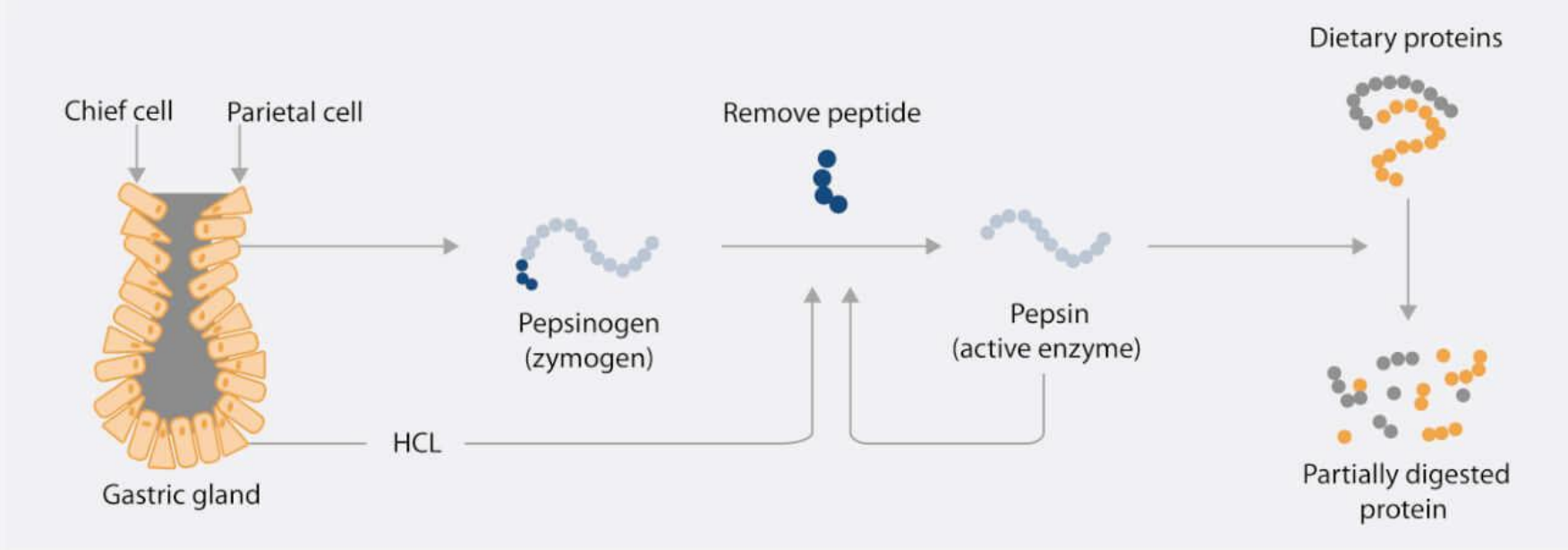
- 1.2-1.5 l/day.
- pH 0.9-1.2.
- Specific gravity 1.002-1.004.
- Composition: 99.5% - water, solids:

- Organic: enzymes (pepsin, gastric lipase, gelatinase), mucins, Castle's intrinsic factor.

- Inorganic: hydrochloric acid (HCl), sodium, potassium, calcium, phosphates, sulfates.

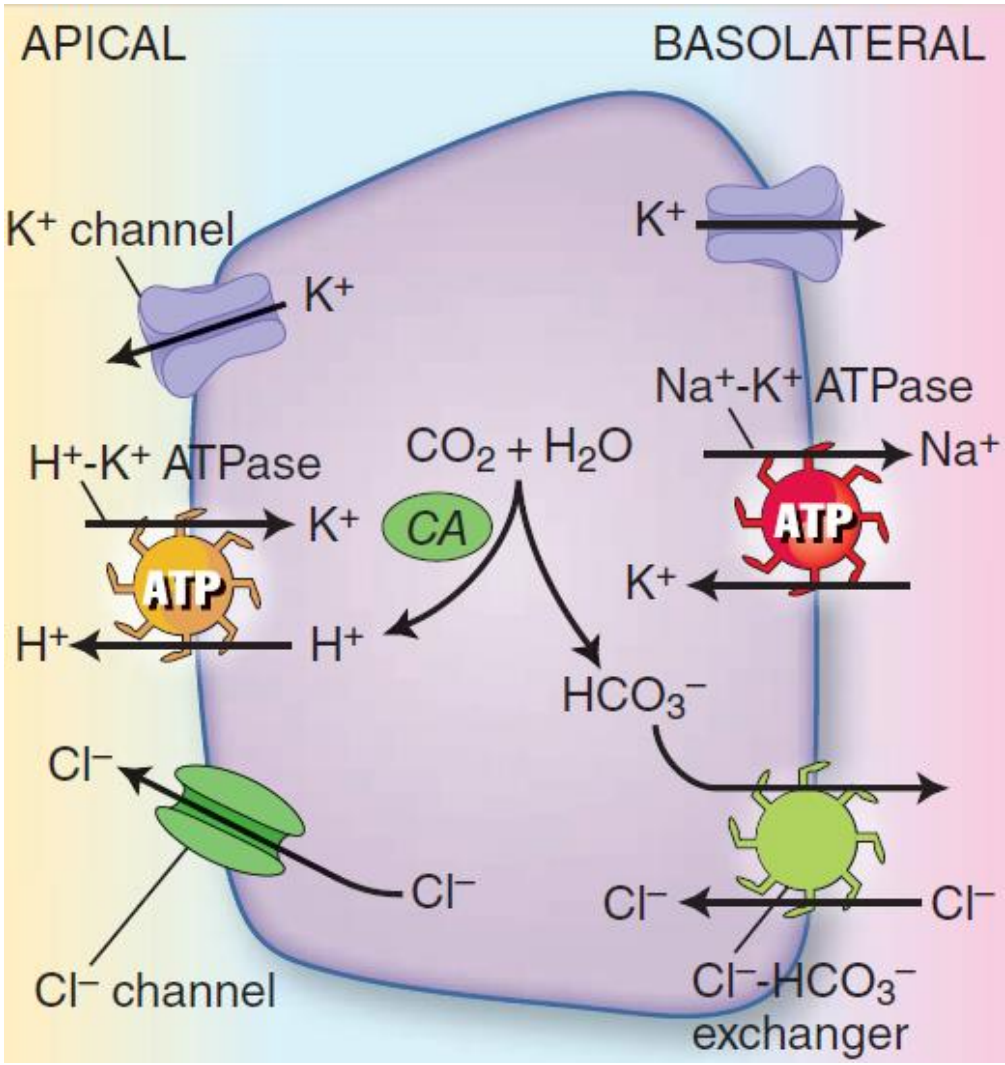
Pepsinogen

- Zymogen is activated by hydrochloric acid.
- Optimal pH 1,5-2.
- There are 2 major types of pepsinogens (pepsinogen I is produced mainly by chief cells in fundus and pepsinogen II is synthesized mostly by antral mucosa).
- Endopeptidase has cleavage specificit: cleavage of peptide bonds of aromatic amino acids (tyrosine, tryptophan, phenylalanin).
- Products of hydrolysis – peptons and peptides.



Secretion of hydrochloric acid

- Carbonic anhydrase converts H_2O and CO_2 into carbonic acid H_2CO_3, which dissociates into bicarbonate, which goes into the blood (alkaline tide) in exchange for chloride ions, which go into the lumen of the stomach through chloride channels.
- Hydrogen ions are secreted by H^+-K^+ ATPase (proton pump) into the lumen of the stomach.
- The proton pump is blocked by blockers (omeprazole).



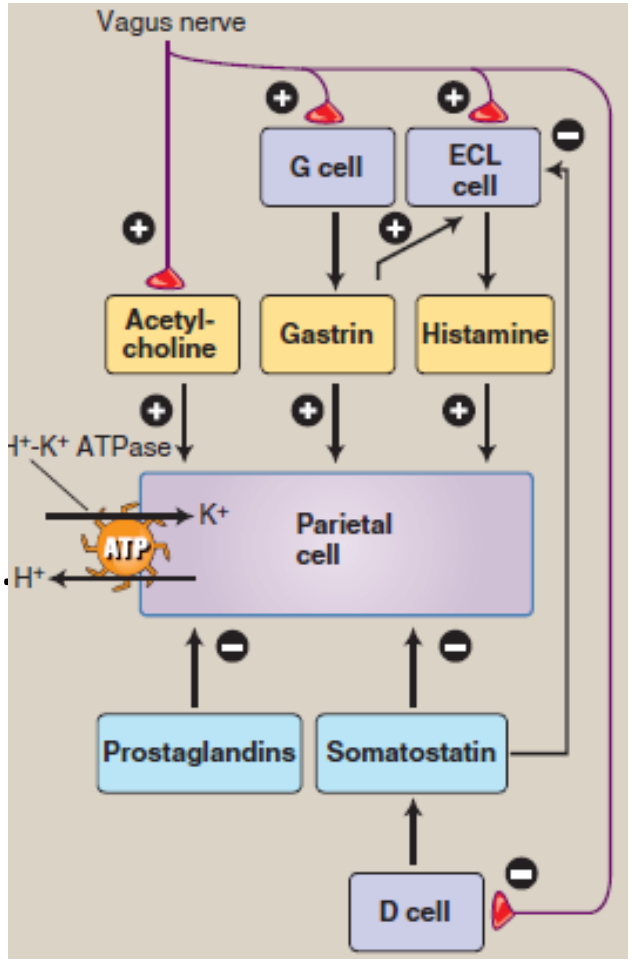
Regulation of HCl secretion

- Stimulation:

1. The vagus, transmitter is acetylcholine, M_3 cholinergic receptors (muscarinic), the second messenger IF_3, calcium activates the proton pump. Blocked by atropine.
2. Gastrin, gastrin (CCK_B) receptors, second messenger cAMP, calcium activates the proton pump. Blocked by proglumide.
3. Histamine, histamine (H_2) receptors, secondary messenger cAMP, calcium activate sthe proton pump. They are blocked by ranitidine, cimetidine.

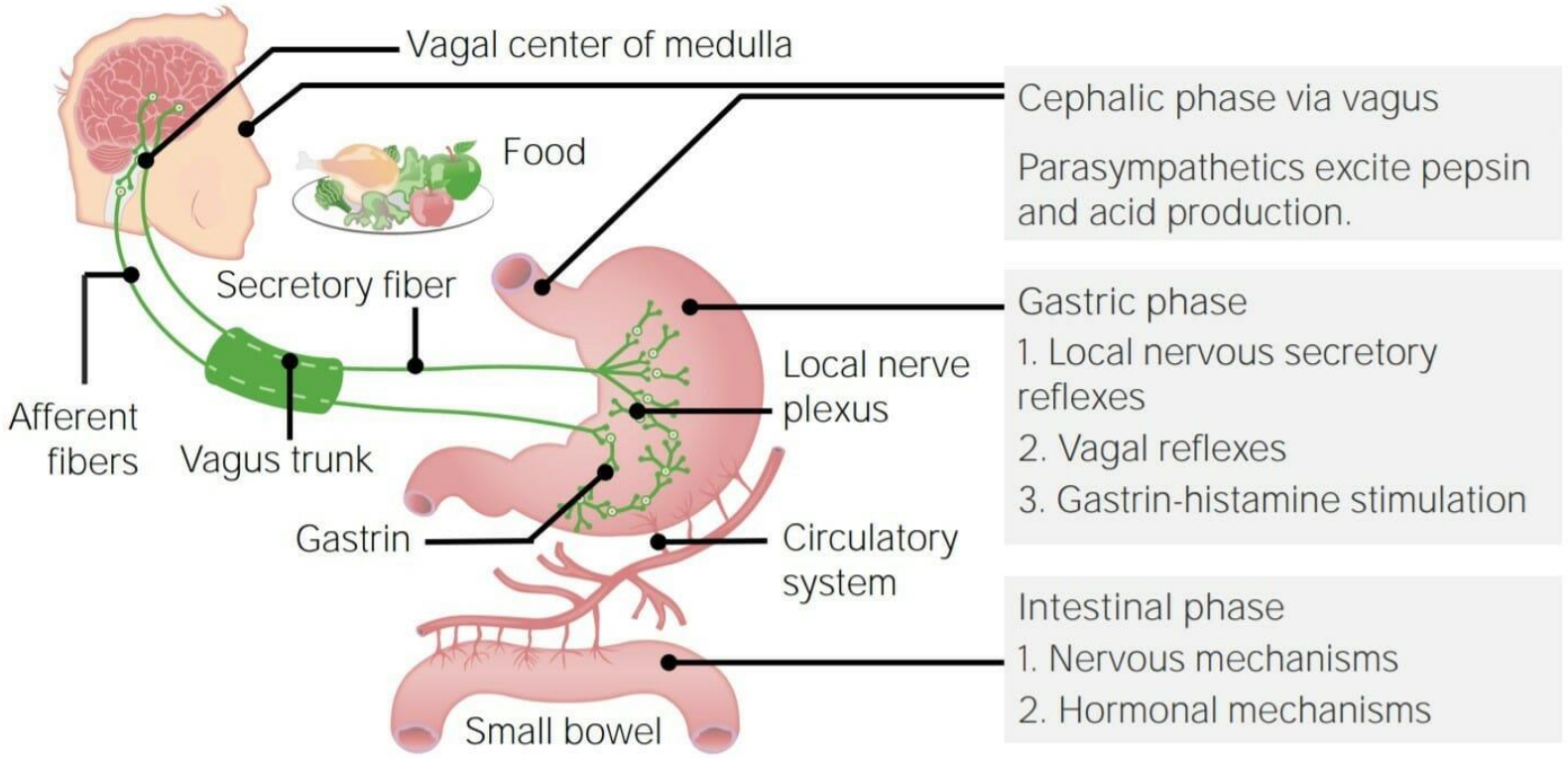
- Inhibition:

1. Somatostatin, G_i-coupled receptors (reduce cAMP levels).
2. Prostaglandins (E_2) potentiate the action of somatostatin.
3. Cholecystokinin, secretin, gastric inhibitory peptide.



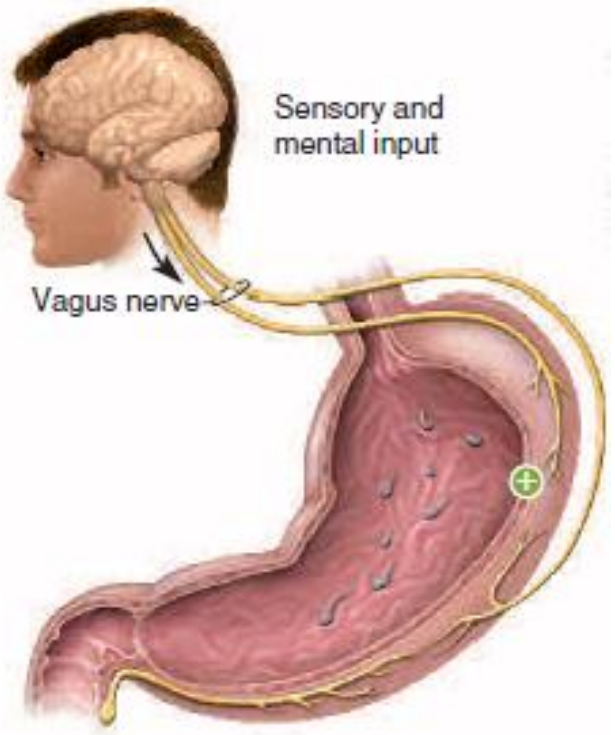
Phases of gastric secretion

1) Cephalic: 20-30% of secretion, occurs before food enters the stomach.
2) Gastric: 60% of secretion, occurs when chyme in the stomach.
3) Intestinal: 10% of secretion, occurs when chyme in the duodenum.



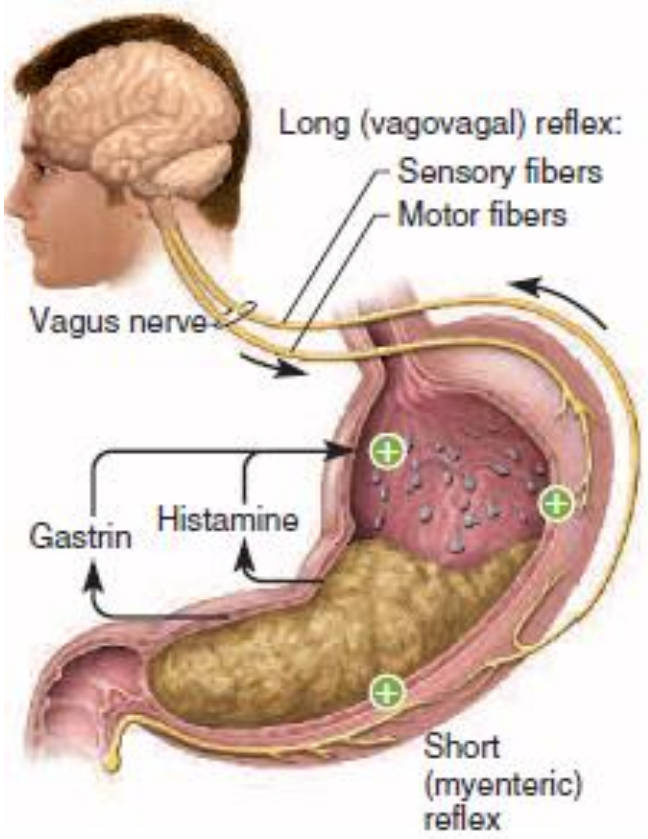
Cephalic phase

- Unconditioned reflex: irritation of the receptors of the oral cavity → afferent fibers CN V, VII, IX, X → nucleus of solitary tract → dorsal motor nucleus of the vagus → efferent fibers of the vagus → parietal cells (HCl) or G cells → gastrin → parietal cells (HCl), or ECL cells → histamine → parietal cells (HCl).
- Conditioned reflex: sight of food → cortex → hypothalamus → dorsal motor nucleus of the vagus → vagus ...
- Sympathetic nervous system (stress response) inhibits secretion.



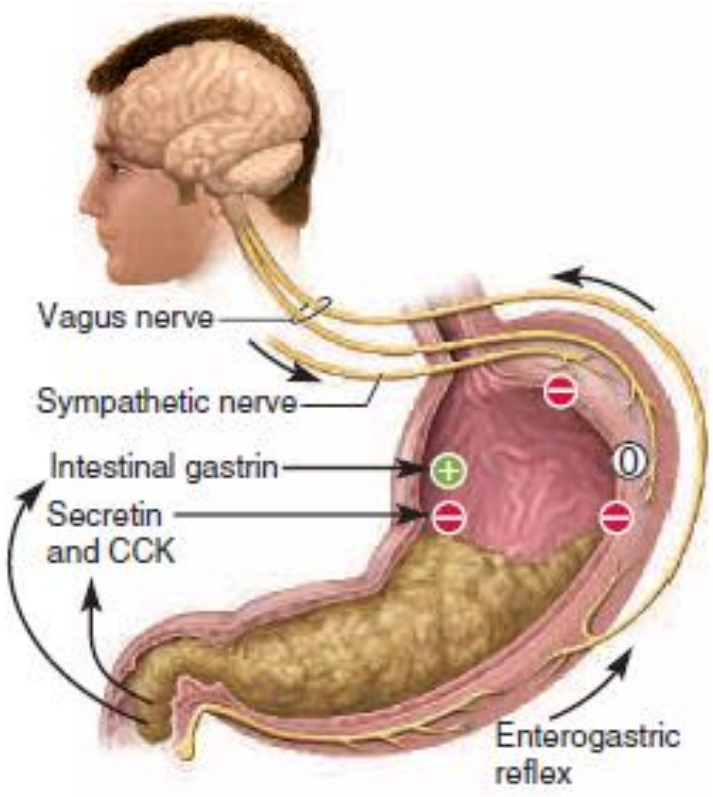
Gastric phase

- Distension of the stomach activates mechanoreceptors → afferent fibers of the vagus → dorsal motor nucleus of the vagus → efferent fibers of the vagus → parietal cells (HCl) – vago-vagal reflex.
- Irritation of the mucous membrane activates the receptors of the neurons of Meissner's submucosal plexus (enteric system).
- Peptides and extractive substances activate G-cells → gastrin → parietal cells (HCl).
- Protons activate D-cells → somatostatin → inhibits secretion (negative feedback).
- Sympathetic nervous system inhibits secretion.



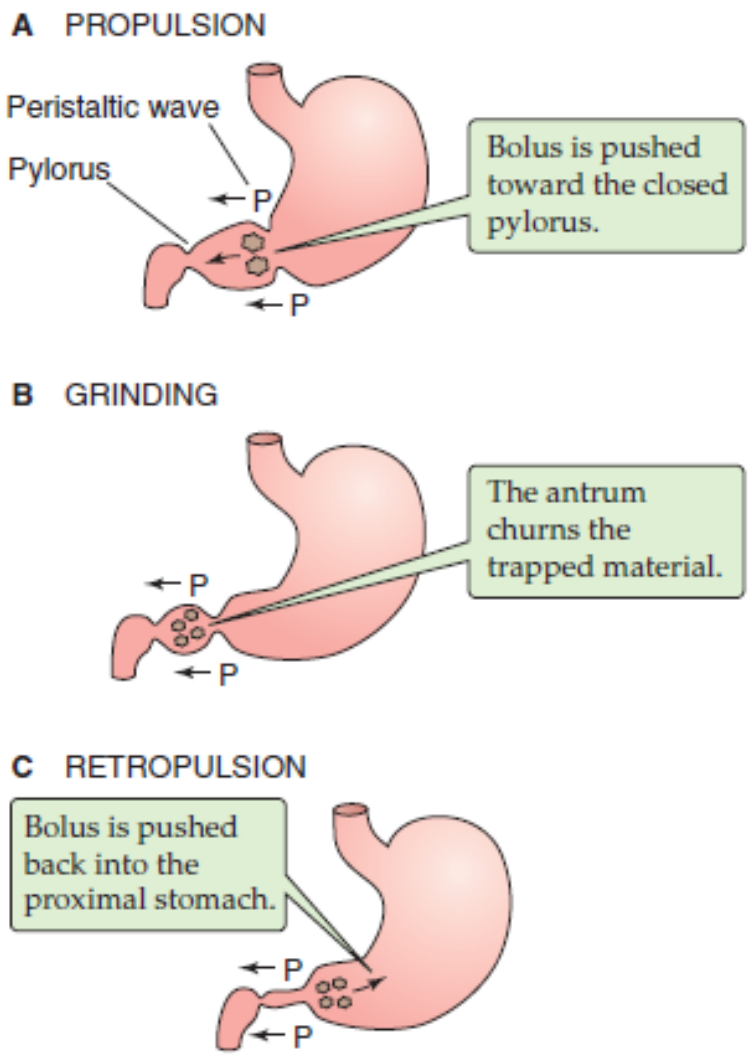
Intestinal phase

- Protons in chyme activate duodenal G cells → intestinal gastrin → parietal and chief cells.
- S-cells → secretin → inhibits parietal cells, but stimulates chief cells.
- Gastric inhibitory peptide, VIP, cholecystokinin inhibit gastric secretion.
- Enterogastric reflex (local, Auerbach's nerve plexus) suppresses motility and secretion of the stomach.



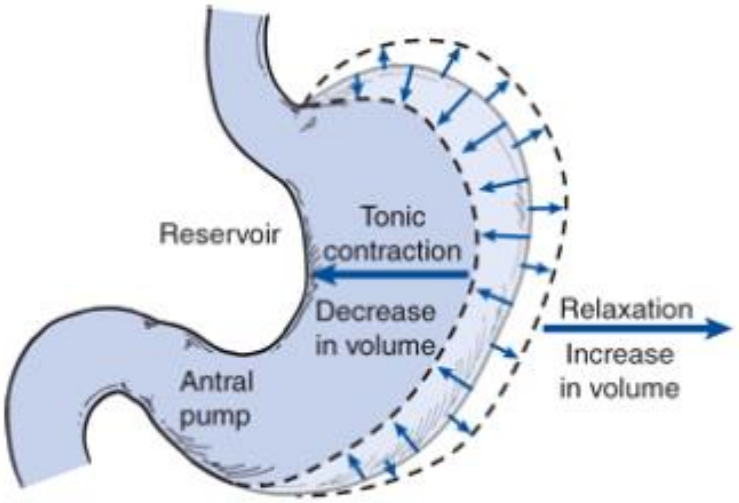
Motility of the stomach

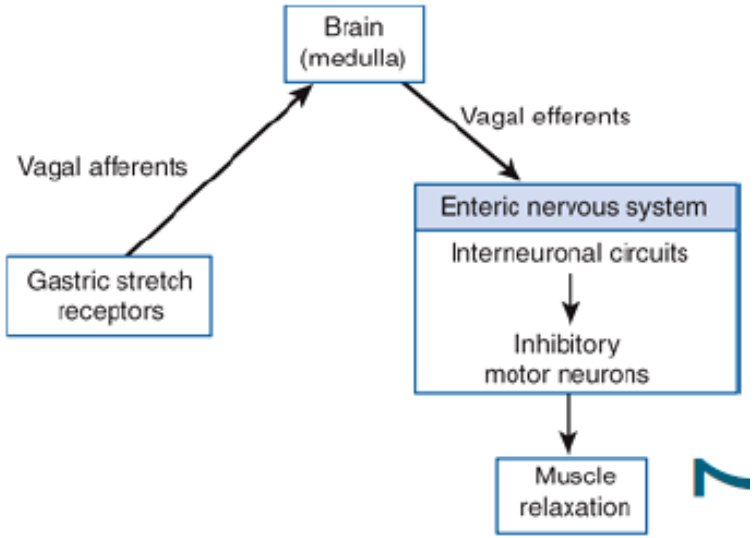
- Accepting food (receptive relaxation).
- Storing food.
- Mixing food with gastric secretion, grinding of bolus.
- Emptying chyme to the small intestine.
- Hunger contractions.



Receptive relaxation

- Accommodation of the stomach to a change in volume (from 50 ml to 1-3 l) without a significant increase in intragastric pressure.
- Stretching of the stomach wall causes reflex relaxation (vago-vagal reflex).
- Transmitters – VIP and NO.
- The peptones in the chyme activate G cells, which secrete gastrin, which causes relaxation.



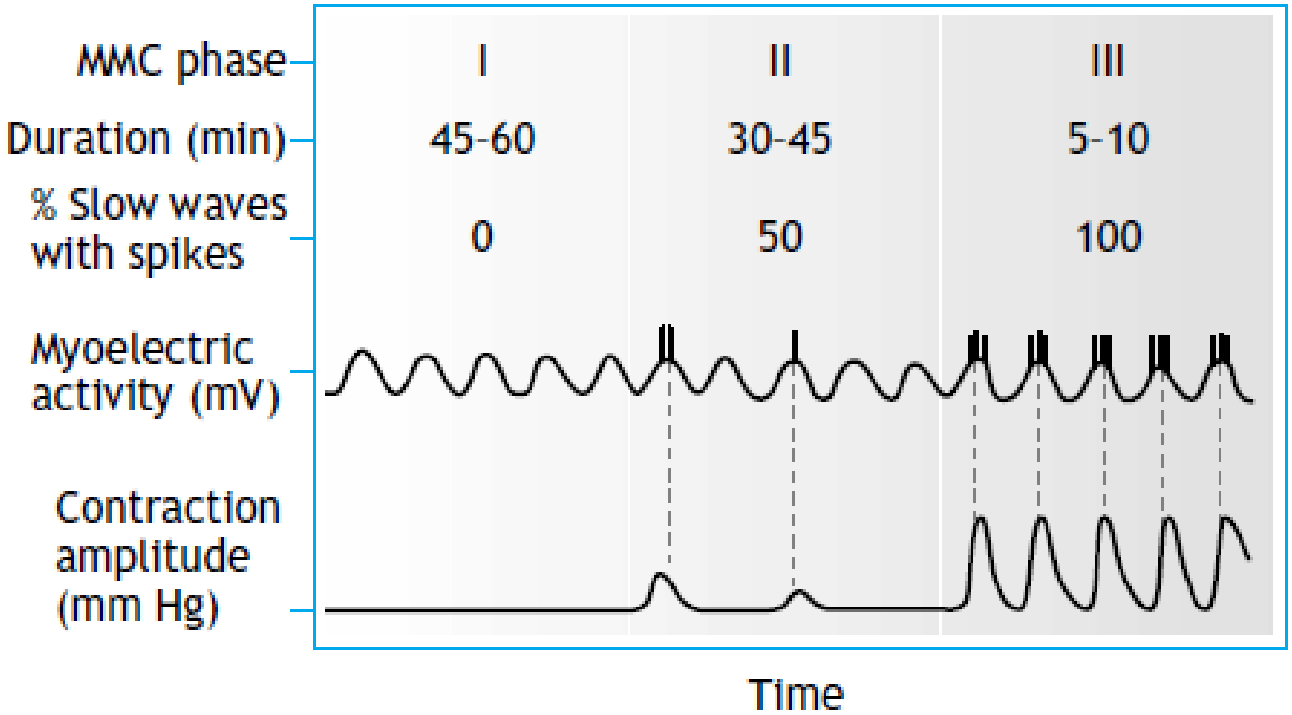


Emptying of the stomach

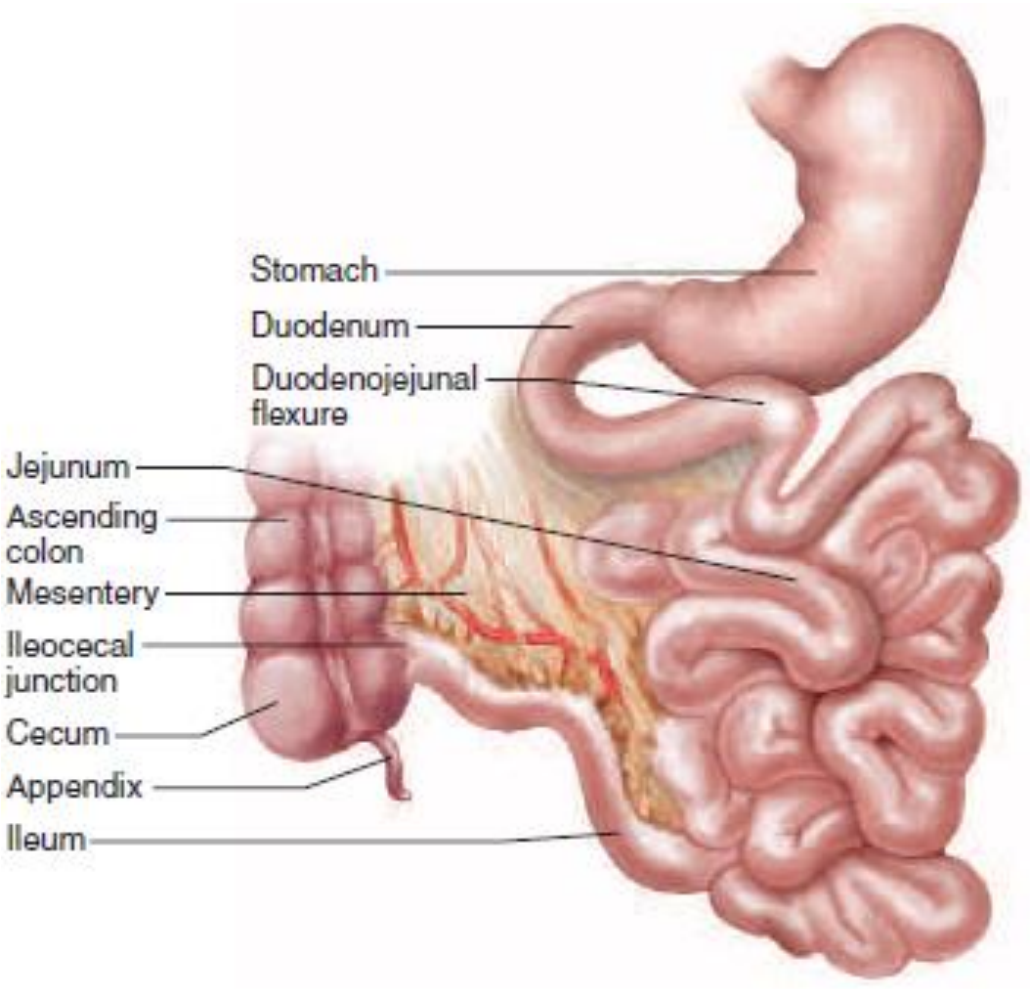
- At a time - 3-5 ml of chyme, takes 3-4 hours, with fatty food, the time increases to 6-9 hours.
- Factors affecting:
- The rate of evacuation of isotonic liquid is proportional to the volume (stretching) of the stomach;
- Osmolality (hypertonic and hypotonic content is evacuated more slowly than isotonic)
- pH: the lower the pH, the slower the evacuation;
- Content consistency: large particles slow down evacuation (liquid chyme speeds it up);
- Chemical composition (carbohydrates are faster than proteins, and proteins are faster than lipids);
- The difference in intragastric and duodenal pressure;
- Pyloric sphincter resistance.

Hunger contractions

- The function is cleaning of food residues, gastric juice and exfoliated epithelium.
- Migrating motor complex (MMC), pacemaker - smooth muscles of the circular layer of the stomach.
- Activated by motilin (Mo cells).
- Occurs every 90 minutes.
- Cycle: phase I - no contractions, phase II - irregular contractions, phase III - regular strong contractions.

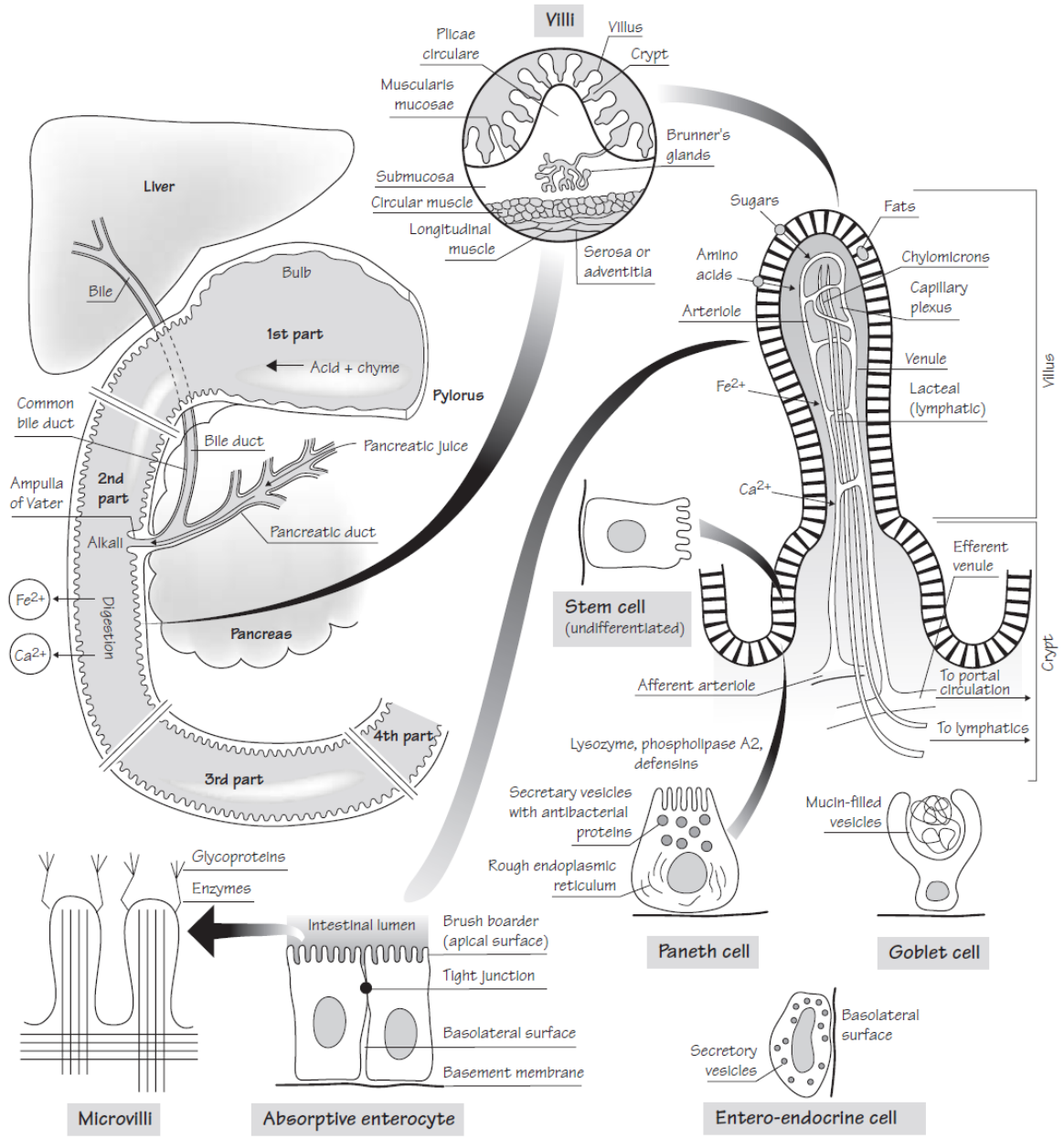


Duodenum



- Between the pylorus of the stomach and the jejunum, length is about 25-30 cm.
- It consists of 4 parts: upper (bulb), descending, horizontal and ascending.

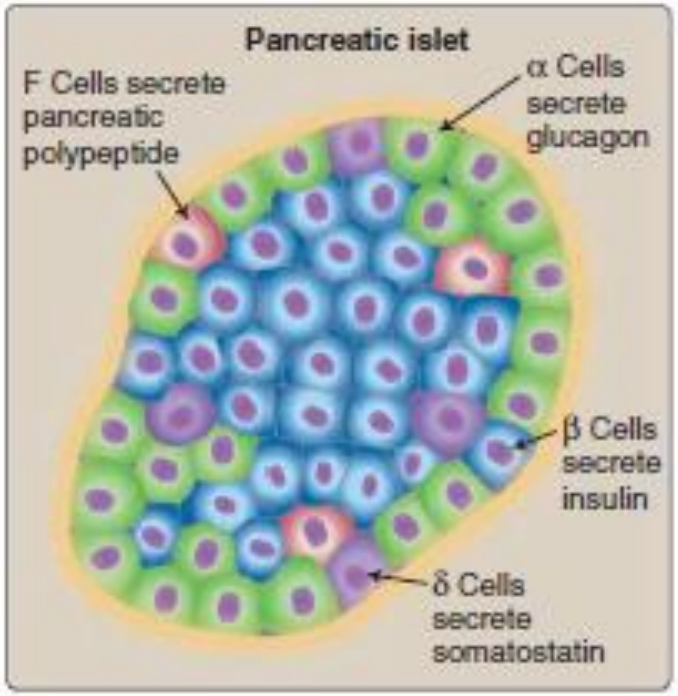
Functions of duodenum



- Neutralization of acidic chyme.
- Creation of optimal pH for enzymes and their activation (enterokinase).
- Digestive processes with the participation of bile and pancreatic juice.
- Absorption.
- Motility.
- Secretion of hormones by entero-endocrine cells.

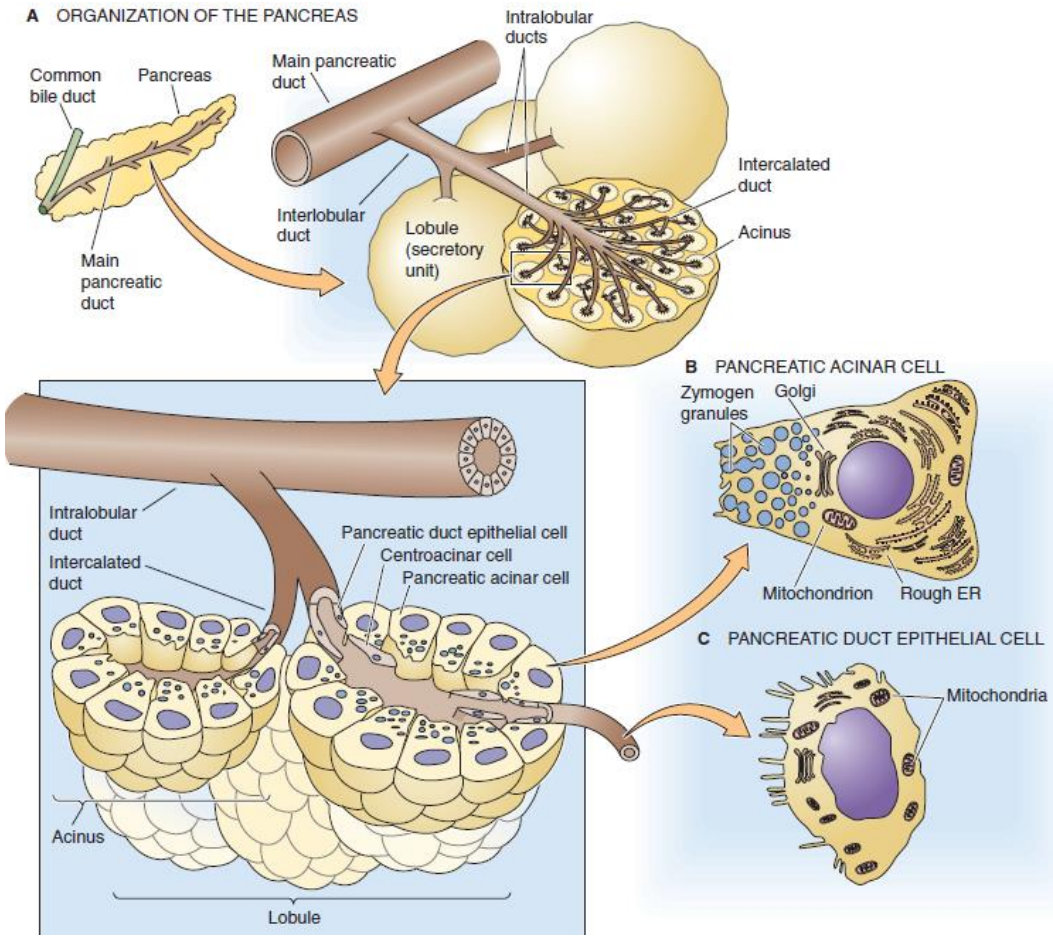
Functions of pancreas

- The exocrine part produces pancreatic juice:
- neutralizes the acid content of the stomach;
- digestion of proteins, carbohydrates and lipids.
- The endocrine part (Islets of Langerhans) produces hormones:
- insulin;
- glucagon;
- somatostatin;
- pancreatic polypeptide.



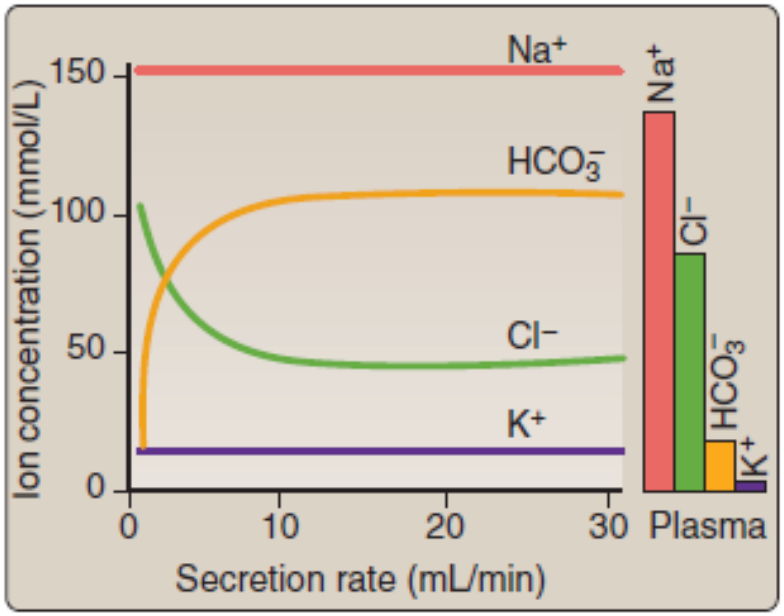
Pancreas structure

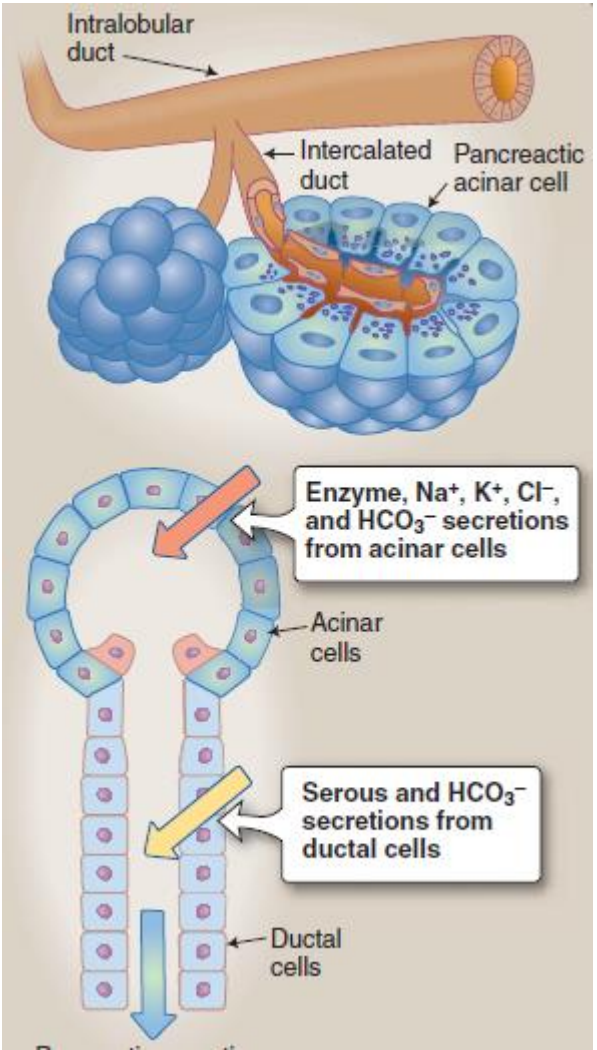
- The exocrine part (97% of the mass) is a tubular-alveolar gland.
- The structural unit is an acinus (100-150 µm), consisting of acinar cells (exocrine pancreatocytes).
- Ducts: intercalated, intralobular, interlobular, common pancreatic duct.



Pancreatic juice

- 1.5-2 l/day (basal level of secretion 0.2-0.3 ml/min fasting, increases to 4.0-4.5 ml/min during stimulation);
- Isotonic;
- pH 8-8.5.





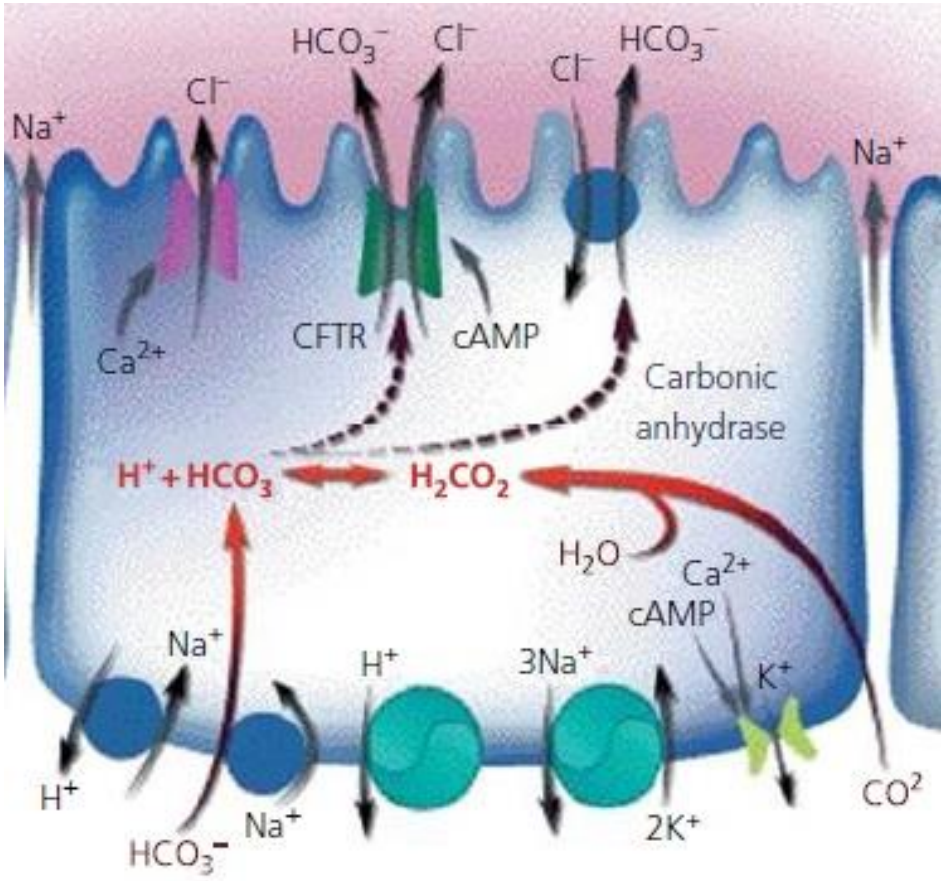
Pancreatic juice composition

- 99.5% - water;
- 0.5% - solids:
- Organic:
- Enzymes (approximately 20 isoforms of 12 enzymes);
- Other proteins (albumins, trypsin secretory inhibitor);
- Non-protein components.
- Inorganic:
- Bicarbonates (HCO_3-) 110-150 mmol/l (in plasma 24 mmol/l), chlorides, sulfates;
- Sodium, potassium, calcium (1-2 mmol/l), magnesium, zinc.

Secretion in pancreatic ducts

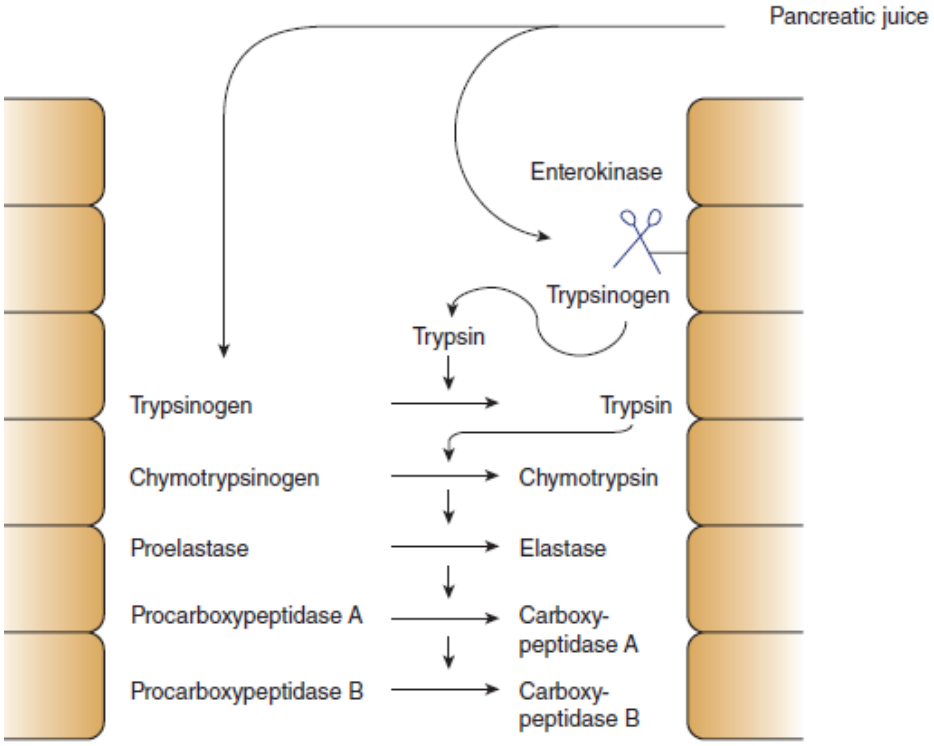
- The liquid is rich in bicarbonates (HCO_3-): carbonic anhydrase forms carbonic acid from H_2O and CO_2, which dissociates into protons and bicarbonates.
- Bicarbonates go into the lumen in exchange for chloride ions, which leave through CFTR (cystic fibrosis transmembrane regulator protein).
- Bicarbonates neutralize acids:

$NaHCO_3 + HCl \rightarrow NaCl + H_2CO_3 \rightarrow H_2O + CO_2$



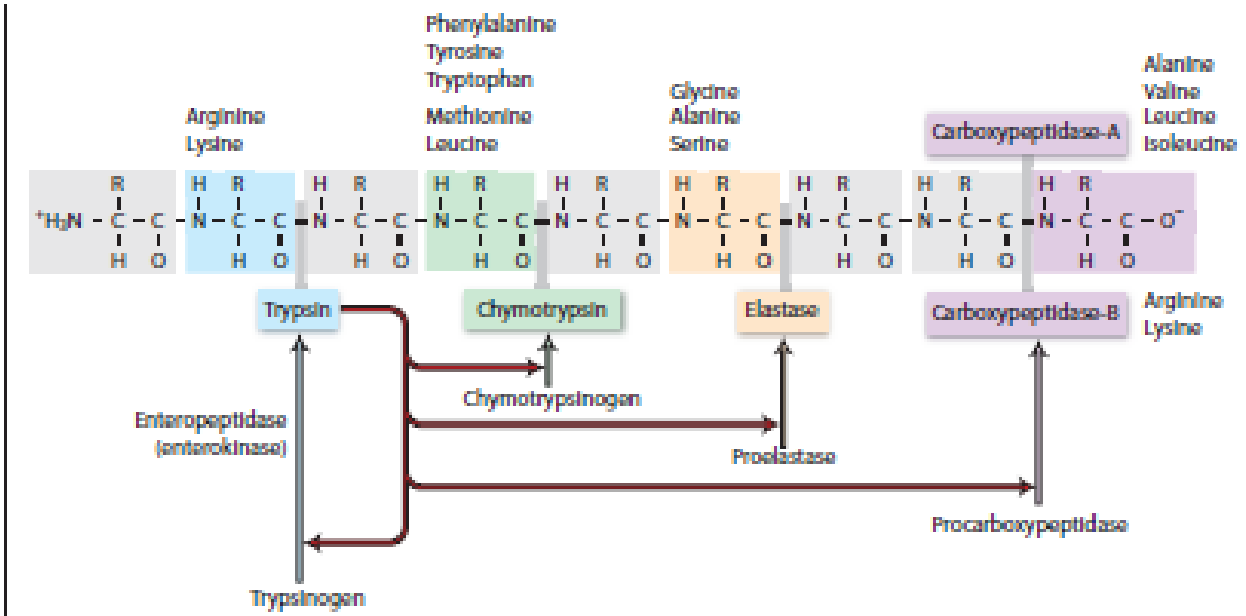
Proteolytic enzymes

- Proteolytic enzymes make up 75-80% of all proteins of the pancreatic juice and ensure the formation of 40% of free amino acids and 60% of oligopeptides in the lumen of the small intestine (the rest is membrane digestion).
- Trypsinogen is converted into trypsin under the action of duodenal enterokinase (enteropeptidase), located on the brush border of enterocytes, and by autocatalysis.
- Activates other enzymes.



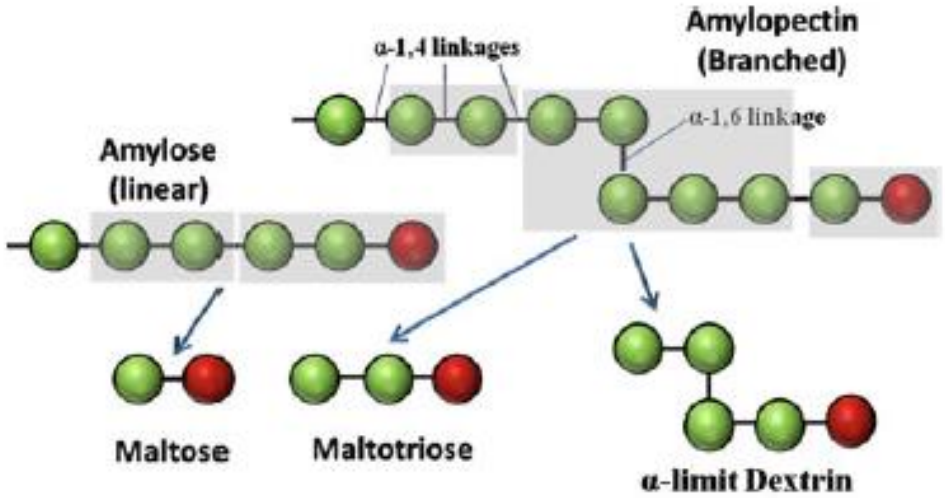
Proteolytic enzymes

- Endopeptidases (trypsin, chymotrypsin, elastase) destroy internal peptide bonds: trypsin - formed by basic amino acids (lysine, arginine), chymotrypsin – aromatic (tyrosine, phenylalanine, tryptophan), elastase - aliphatic amino acids (alanine, glycine, valine, leucine, isoleucine).
- Exopeptidases (carboxypeptidases) destroy peptide bonds at the C-end of the peptide: carboxypeptidase A - cleaves aromatic and aliphatic amino acids; carboxypeptidase B - cleaves basic amino acids.



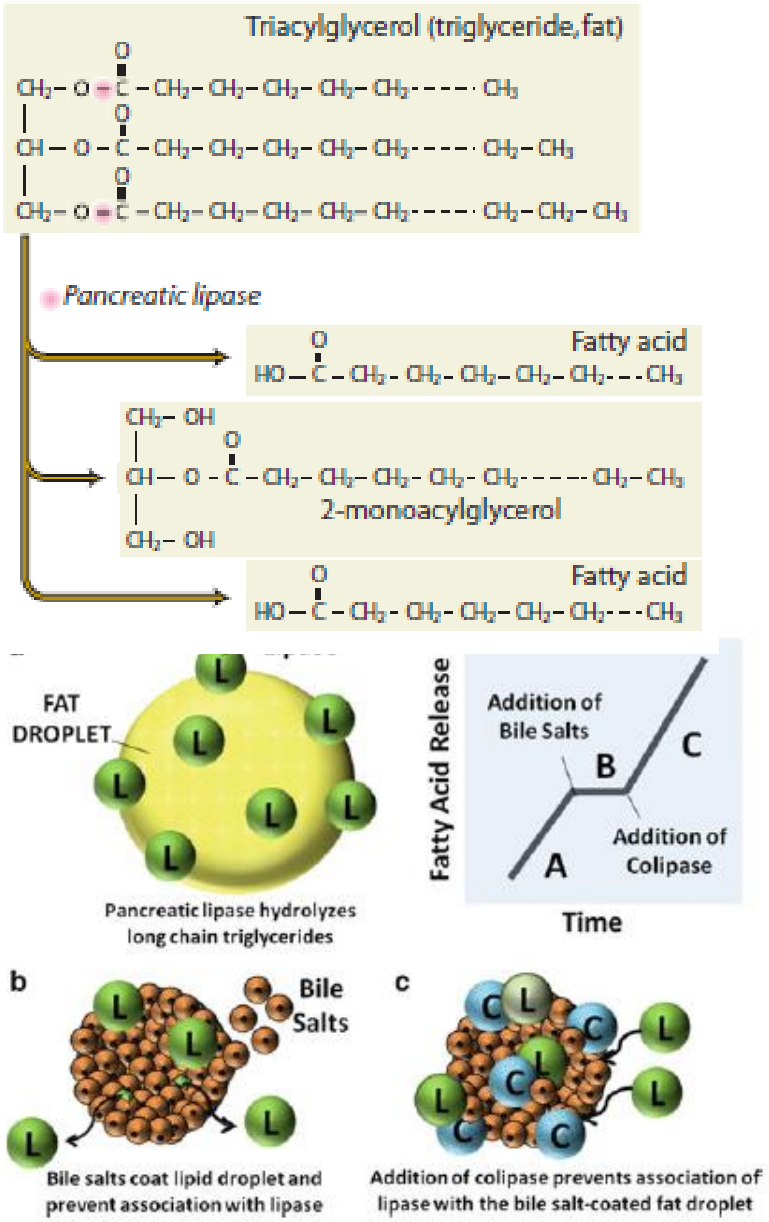
Pancreatic amylase

- Pancreatic amylase cleaves α-1,4-glycosidic bonds in starch and glycogen.
- Amylose has a linear chain, amylopectin has a branched chain (α-1,6-glycosidic bonds - amylase cannot cleave them).
- Products: oligosaccharides, dextrins (5-9 glucose residues), maltotriose, maltose.



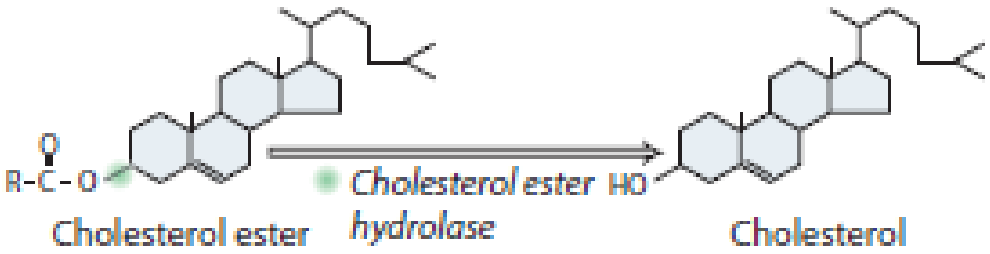
Lipolytic enzymes

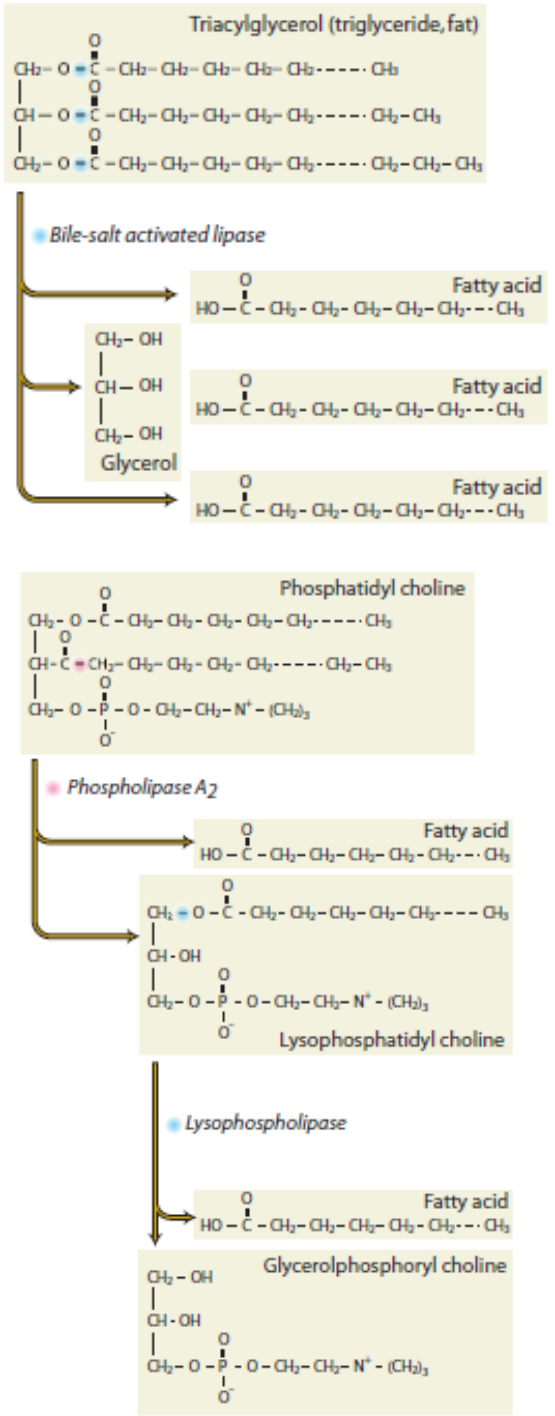
- Pancreatic lipase cleaves the ester bonds of triglycerides to 2 free fatty acids and 2-monoglyceride.
- It requires colipase (activated by trypsin), which stabilizes and ensures the interaction of lipase with fat droplets.



Lipolytic enzymes

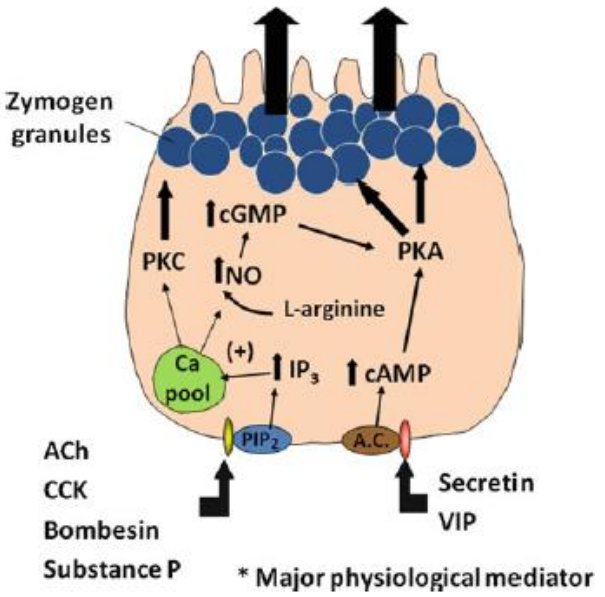
- Cholesterol esterase cleaves ether bonds in cholesterol esters, fat-soluble vitamins.
- Phospholipase A_2 cleaves phospholipids (lecithin) into fatty acids and lysolecithin (promotes emulsification).
- Phospholipase B cleaves lysolecithin to fatty acid and glycerolphosphoryl choline.





Stimulation of pancreatic secretion

- Vagus) ↑ secretion of enzymes in acinar cells (acetylcholine - muscarinic cholinergic receptors - IF_3 mechanism).
- Secretin (produced by S-cells of the duodenum in response to H^+) mainly ↑ bicarbonate secretion in ductal cells (cAMP mechanism).
- Cholecystokinin (produced by I-cells of the duodenum in response to free amino acids, peptides, fatty acids in the chyme) ↑ secretion of enzymes in acinar cells (IF_3 mechanism) + stimulates the vagus (VIP).
- Gastrin-releasing peptide, gastrin, substance P, and vasoactive intestinal peptide (VIP) ↑ pancreatic secretion.



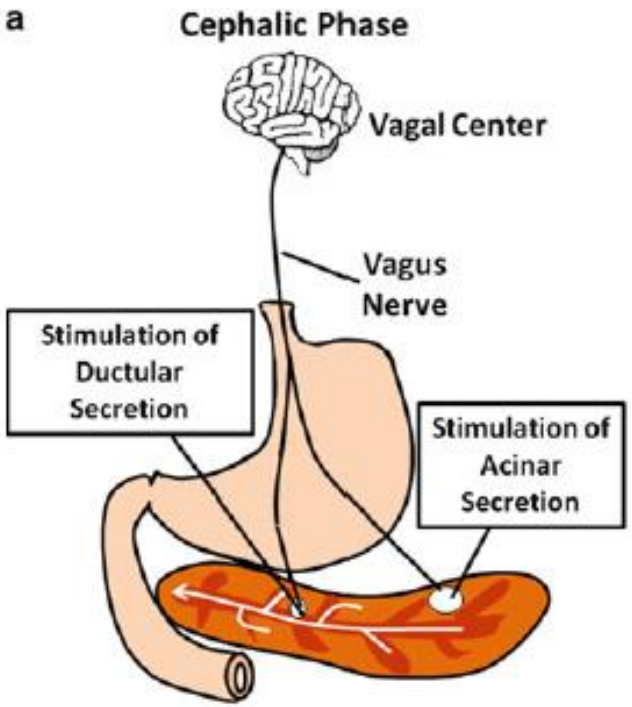
Inhibition of pancreatic secretion

- Sympathetic nervous system ↓ secretion (norepinephrine).
- Pancreatic polypeptide (produced by F- cells of the islets of Langerhans) ↓ gastric secretion.
- Somatostatin (produced by D cells of the islets of Langerhans).
- Ghrelin reduces the sensitivity of the vagus for distension of the stomach.

Phase	Stimulant	Regulatory Pathway	Percentage of Maximum Enzyme Secretion
Cephalic	Sight Smell Taste Mastication	Vagal pathways	25%
Gastric	Distention Gastrin?	Vagal-cholinergic	10%-20%
Intestinal	Amino acids Fatty acids H^+	Cholecystokinin Secretin Enteropancreatic reflexes	50%-80%

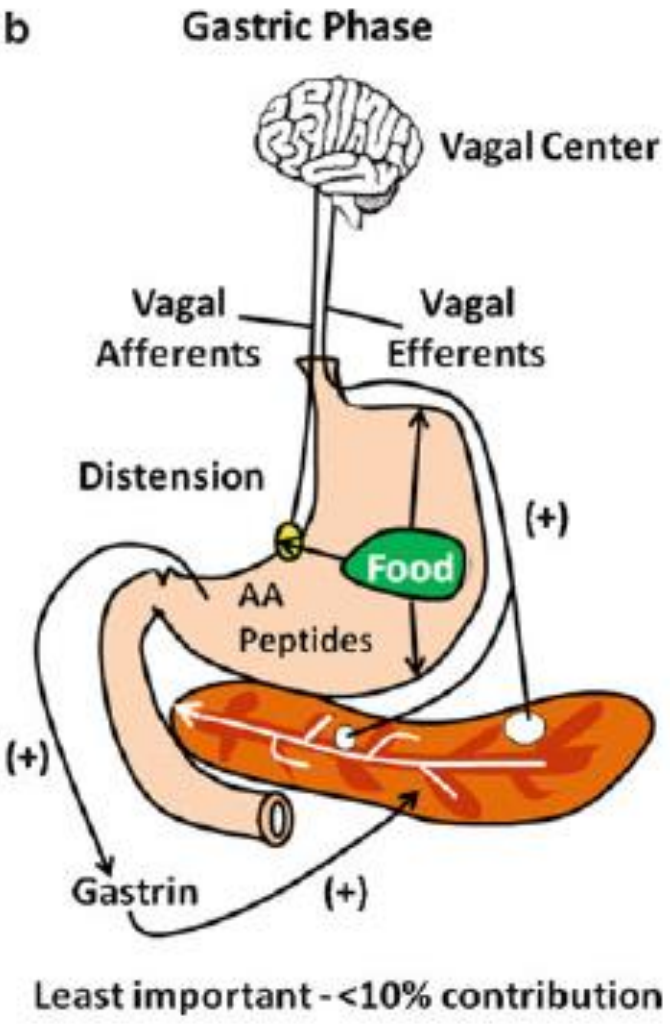
Cephalic phase

- About 25% secretion.
- Conditioned (sight of food, thoughts about food) and unconditioned reflexes (food in the mouth).
- Cortex → hypothalamus → dorsal motor nucleus of the vagus nerve → efferent branches of the vagus nerve.
- Neurotransmitters are acetylcholine and VIP.



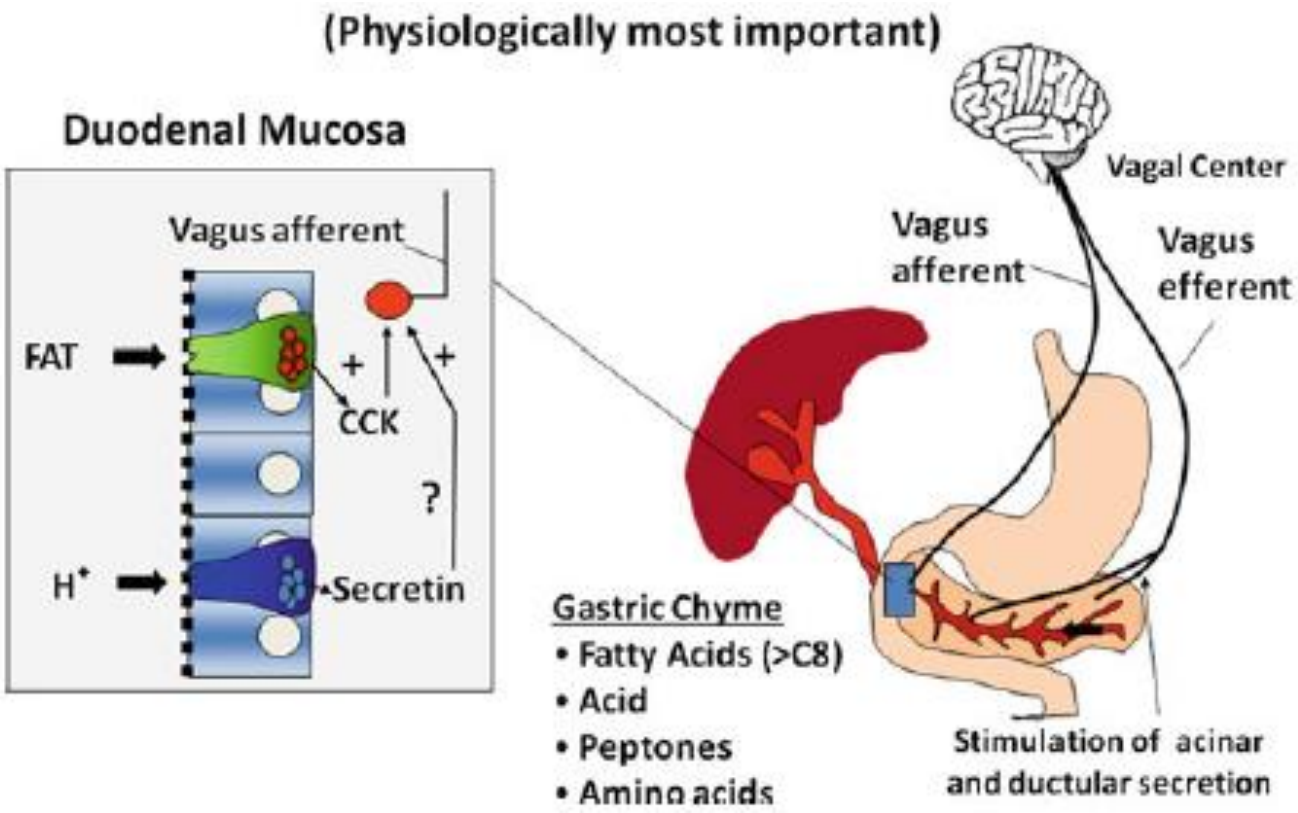
Gastric phase

- About 10% secretion.
- Distension of the stomach causes a vago-vagal reflex: mechanoreceptors of the stomach → afferent branches of the vagus → dorsal motor nucleus → efferent branches of the vagus nerve.
- Gastrin of the stomach: produced by G-cells in response to chyme peptides, distension of the stomach, vagus via bombesin (GRP) stimulates the formation of enzymes by acinar cells of the pancreas.



Intestinal phase

- About 65% secretion.
- Secretin stimulates bicarbonate secretion in the ducts.
- Cholecystokinin stimulates the secretion of enzymes in the acinar cells.



Functions of liver

- Metabolic:

1) Metabolism of carbohydrates:
- storage of glycogen (≈ 100g);
- synthesis of glucose (gluconeogenesis);
- metabolism of fructose and galactose.

2) Metabolism of fats:
- synthesis of lipoproteins;
- synthesis of cholesterol, phospholipids;
- oxidation of fatty acids, synthesis of ketone bodies.

3) Metabolism of proteins:
- synthesis of blood plasma proteins;
- synthesis of nonessential amino acids, metabolism of amino acids.

4) Metabolism of vitamins and minerals:
- storage of vitamins A, D, E, K, B_{12};
- storage of iron and copper;
- formation of the active form of vitamin D.

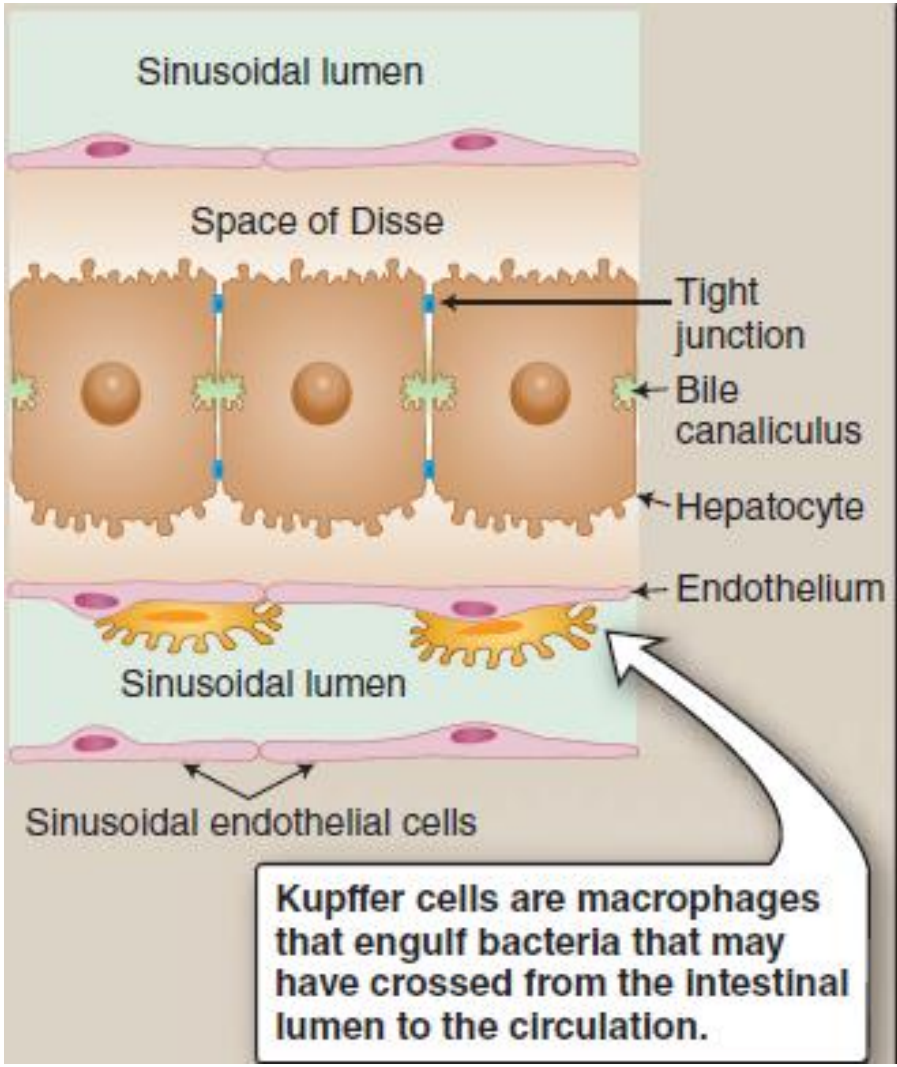
Functions of liver

- Excretory (bile pigments, cholesterol, toxins).
- Detoxification:

1. Urea synthesis (ammonia disposal);
2. Ethanol detoxification (alcohol dehydrogenase converts ethanol into acetaldehyde, it would be converted into acetyl CoA);
3. Biotransformation of xenobiotics has 2 phases: oxidation (cytochrome P450) and conjugation (glucuronic acid, sulfates).
4. Inactivation of hormones.

Functions of liver

- Defensive (Kupffer cells).
- Heat production.
- Hematopoietic (blood formation in the fetus, storage of factors necessary for hematopoiesis (iron, vitamin B_{12}), production of thrombopoietin and erythropoietin).
- Production of bile.

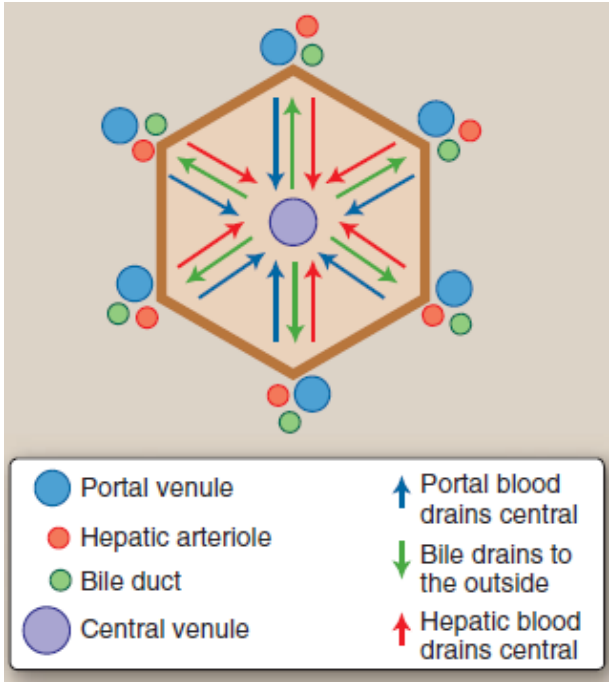


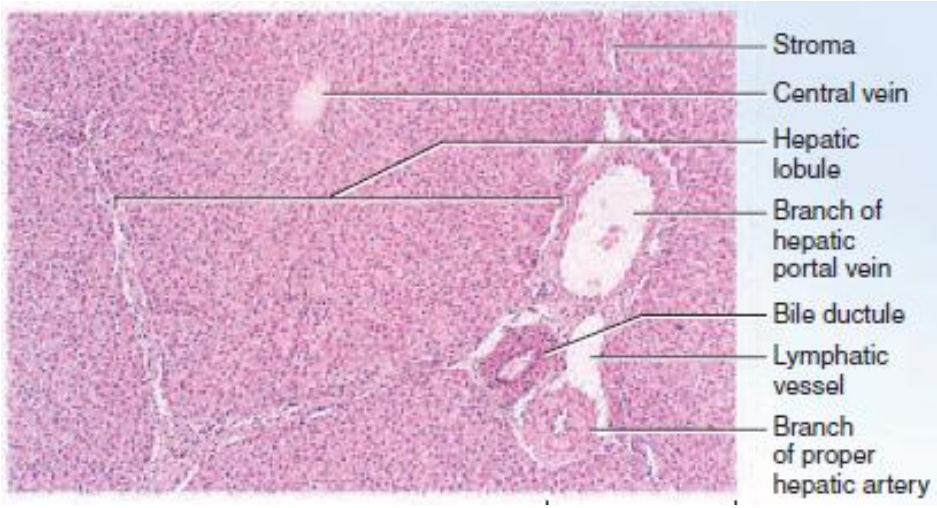
Hepatic lobule

- Functional unit of the liver.
- It has a hexagonal shape, 1-2 mm in diameter.
- Portal triad:

- hepatic arteriole;
- portal venule;
- bile duct.

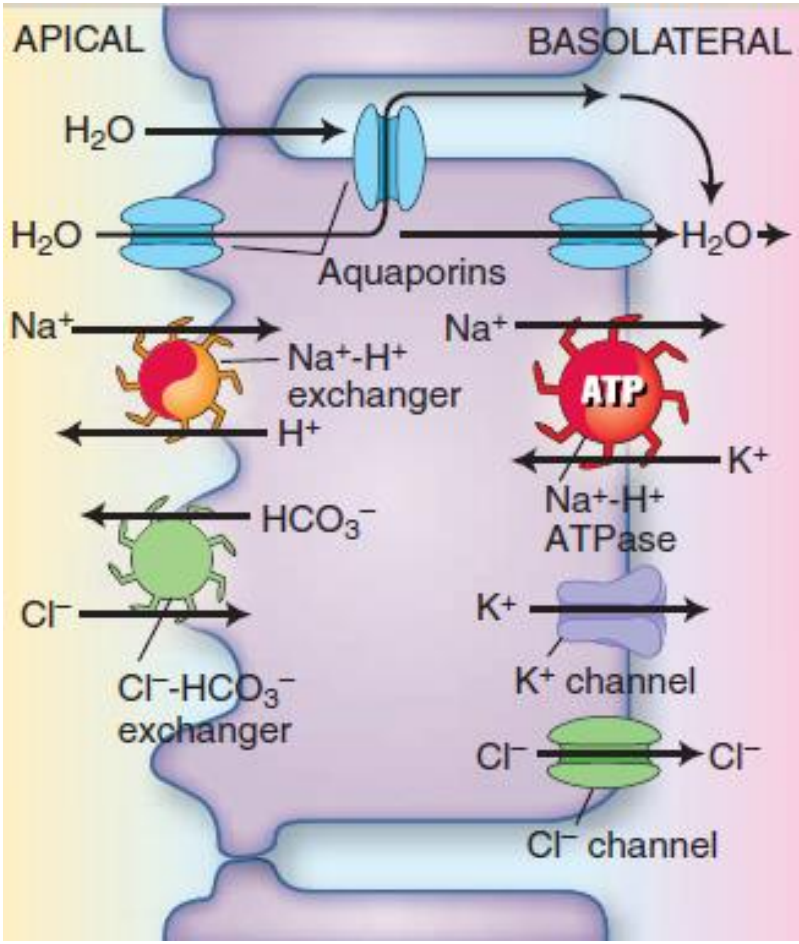
- Blood drains into the central venule.
- Bile enters the bile ducts.





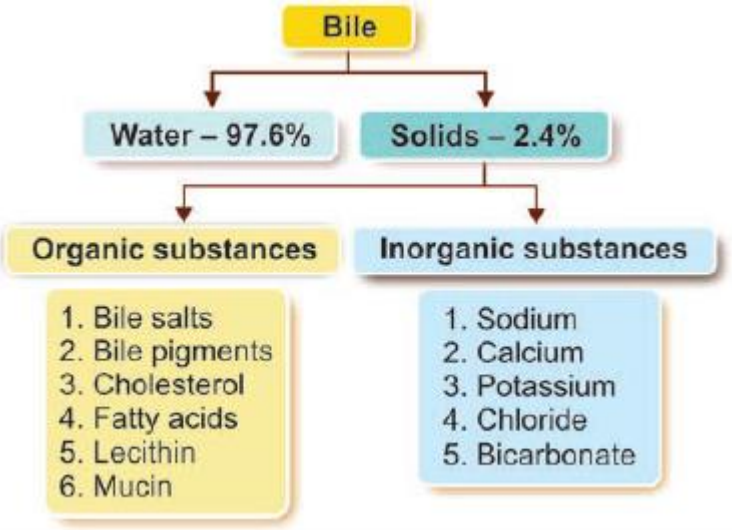
Bile

- 0.5-1.2 L/day.
- pH 8-8.6.
- Isotonic.
- Bladder bile is more concentrated, contains more mucins, pH 7-7.6, the contents of sodium and chloride are decreased, bicarbonates, calcium and potassium are increased.



Composition of bile

- 97.6% water;
- 2.4% solids:



1. Organic:

- Bile acids;
- Bile pigments;
- Cholesterol;
- Phospholipids (mainly lecithin);
- Mucin.

2. Inorganic:

- Sodium, calcium, potassium;
- Chloride, bicarbonates.

Functions of bile

- Digestive (emulsification of fats);
- Fat absorption;
- Excretory (digestive pigments, toxins, cholesterol);
- Protective (antimicrobial);
- Neutralization of the acidic chyme from the stomach;
- Regulatory (stimulates the secretion of bile);
- Laxative effect.

Bile salts

- Na^+/K^+ salts of bile acids.
- Primary bile acids are synthesized from cholesterol in hepatocytes:

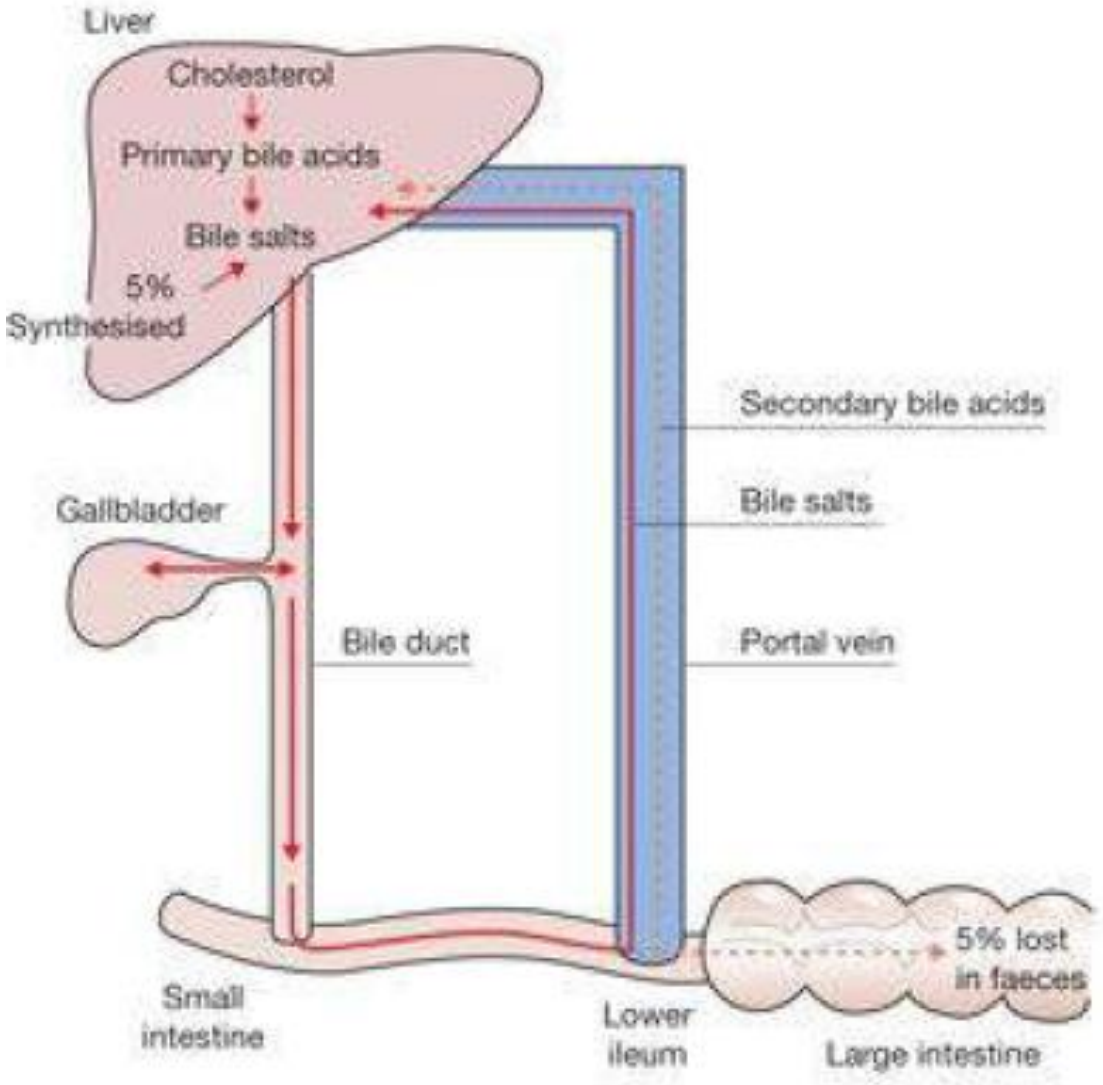
1. cholic acid;
2. chenodeoxycholic acid.

- Conjugation with amino acids (glycine and taurine): glycocholic, glycochenodeoxycholic, taurocholic, taurochenodeoxycholic acids.
- In the large intestine they are converted into secondary bile acids:

1. Cholic acid → deoxycholic acid
2. Chenodeoxycholic acid → lithocholic acid

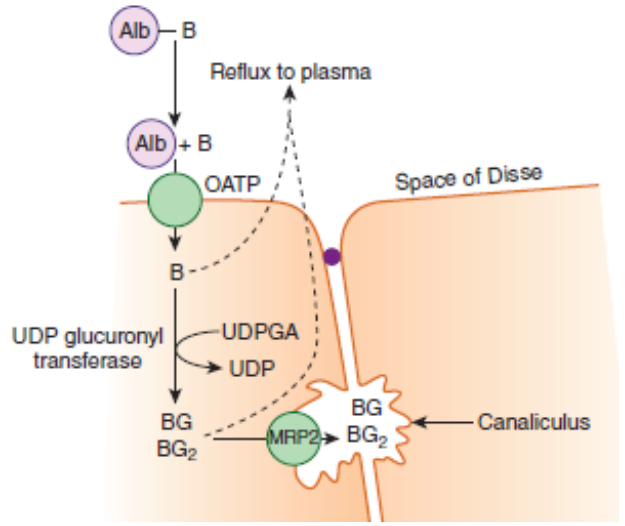
Enterohepatic circulation

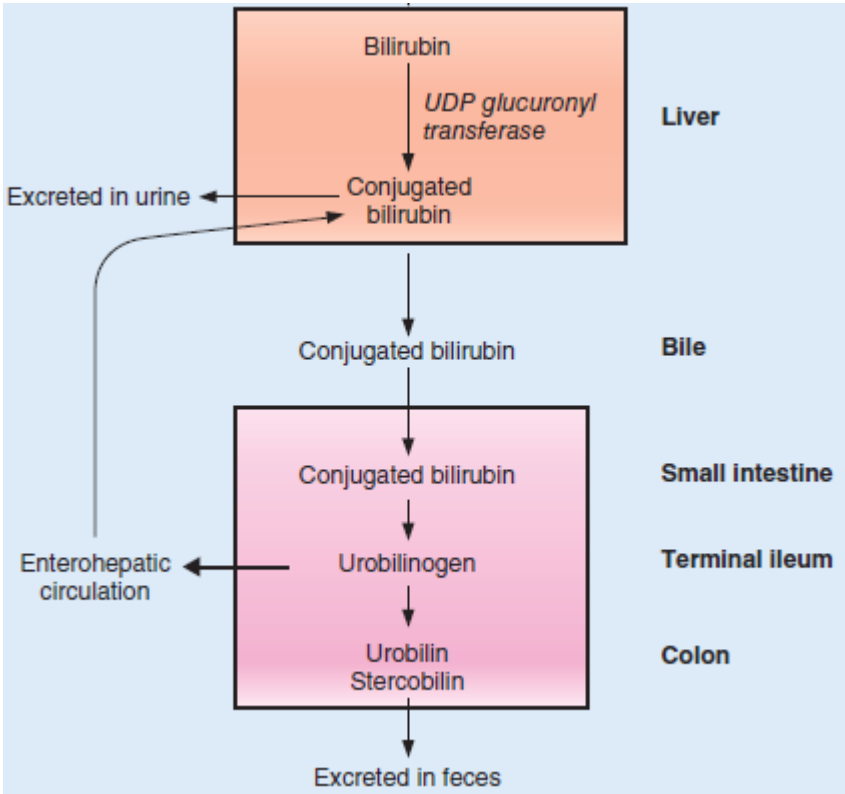
- 90-95% of bile acids are absorbed in the intestine (mainly in the ileum) and return to the liver through the portal vein, from where it is resecreted into bile.
- The pool of bile acids is 2-4 g, about 0.5 g per day is lost with feces.
- Reducing the return of bile acids to the liver increases their synthesis.
- After a normal meal, bile acids are recirculated 3-5 times.



Bile pigments

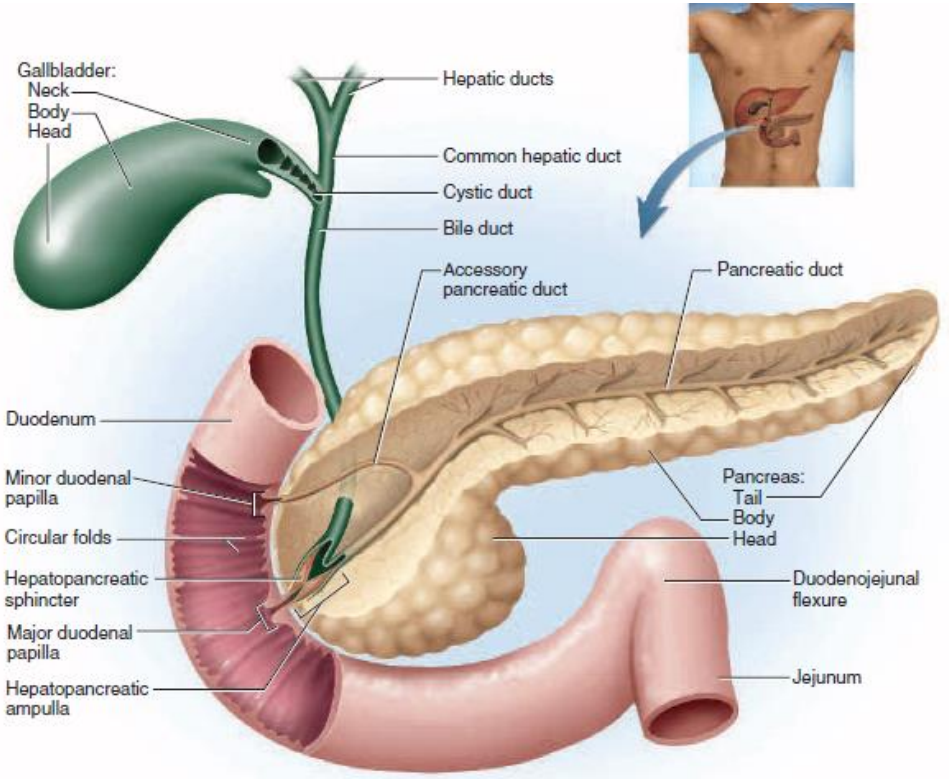
- In the liver, bilirubin is conjugated with glucuronic acid (UDF glucuronyl transferase).
- Bilirubin biglucuronide (conjugated, direct) is excreted in bile.
- In the intestines, it turns into urobilinogen (partially returns to the liver thanks to enterohepatic circulation), then urobilin and stercobilin, which are excreted in feces.





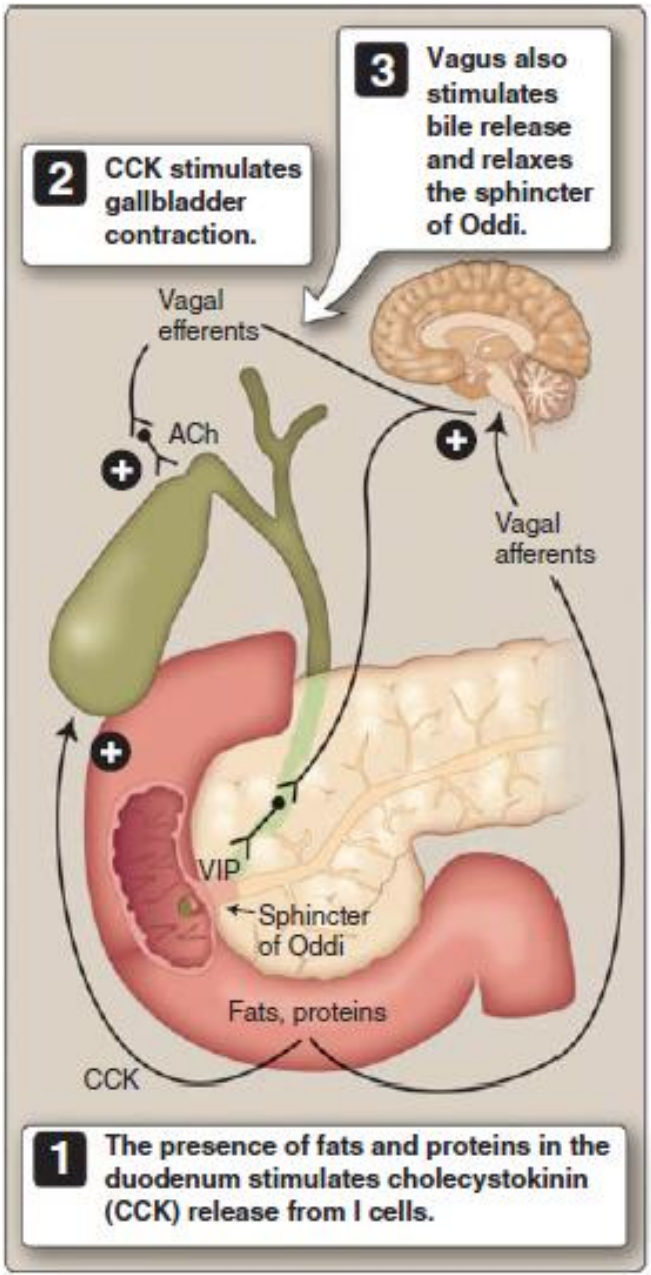
Gallbladder

- It contains about 40-70 ml of bile.
- It consists of a neck, a body and a head.
- Functions: storage of bile; concentration of bile; pressure maintenance (approximately 7 cm H_2O); mucus secretion.



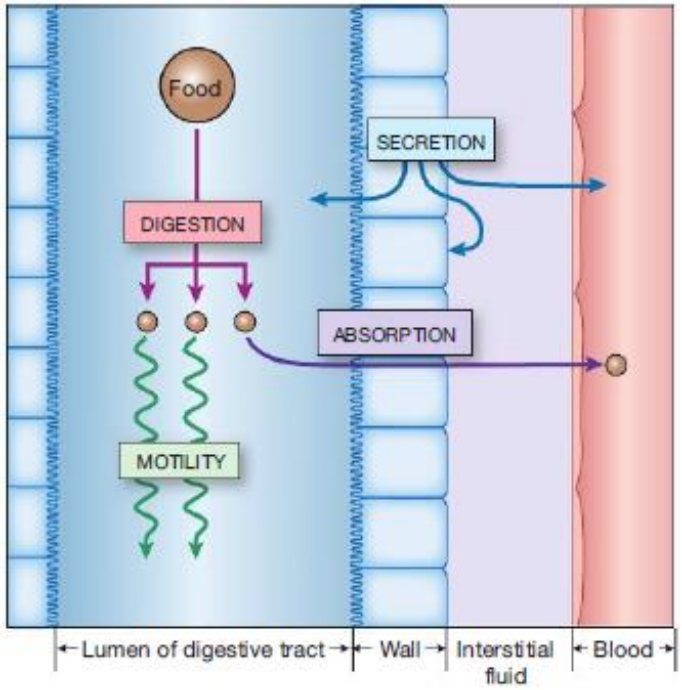
Contraction of gallbladder

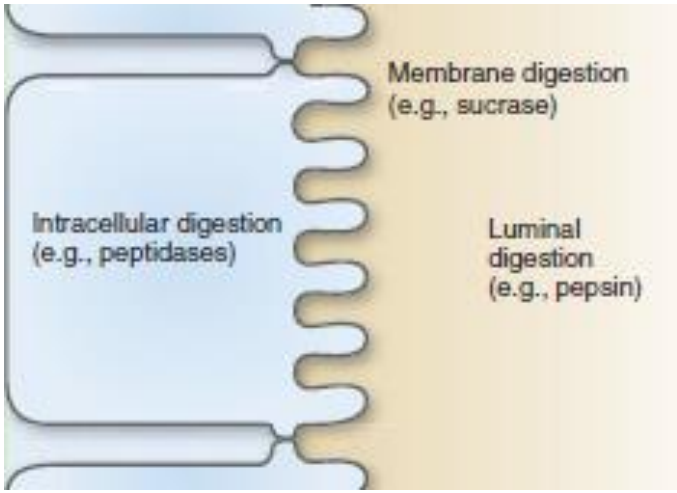
- Nervous regulation: stimulated by the vagus nerve (during the cerebral and gastric phases);
- Hormonal regulation: stimulated by cholecystokinin (during the intestinal phase);
- The sphincter of Oddi relaxes under the influence of cholecystokinin and the vagus nerve (VIP).



Function of small intestine

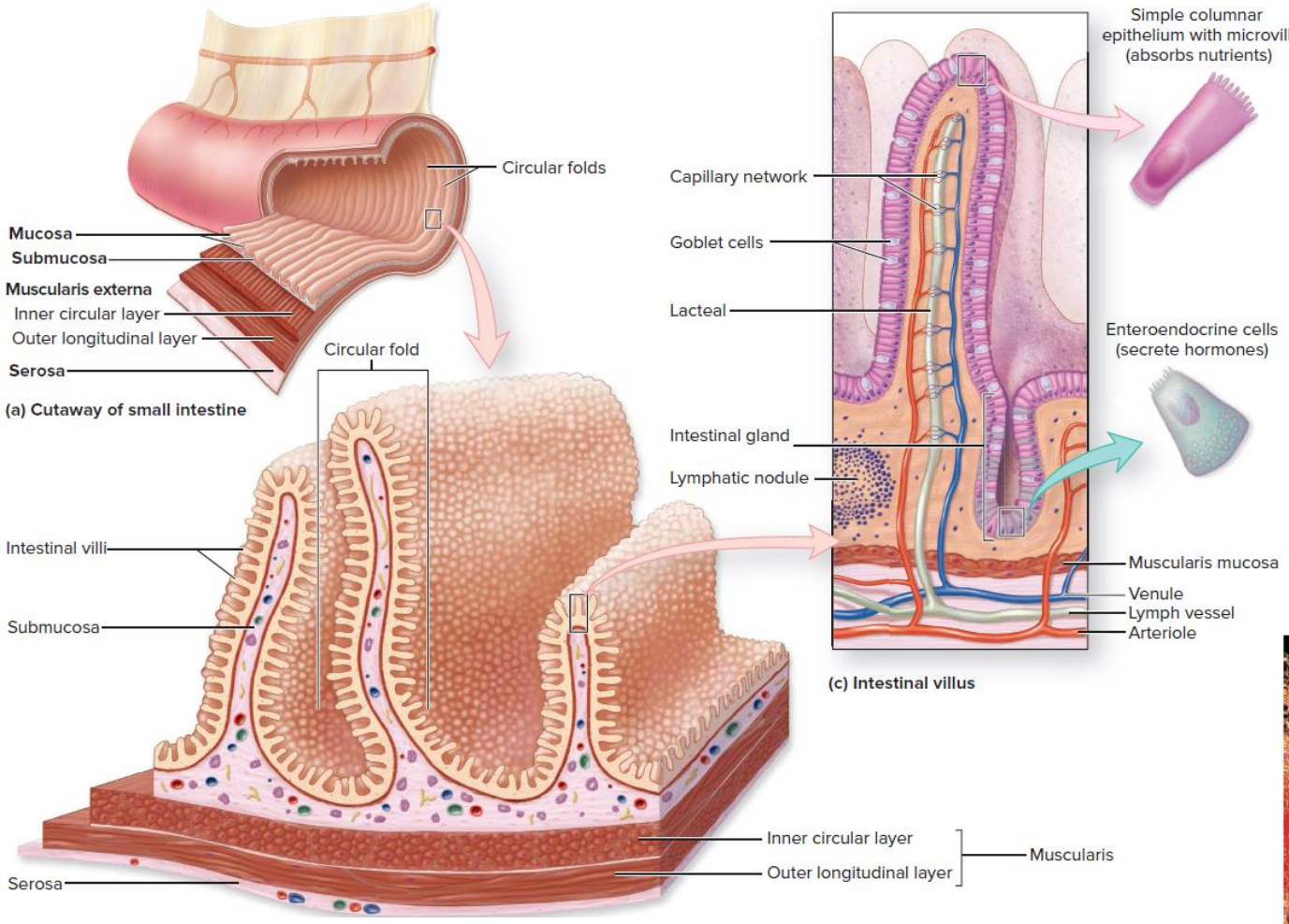
- Secretion (succus entericus);
- Digestion;
- Absorption;
- Hormone production;
- Motility;
- Defensive.
- Types of digestion: luminal (in the intestinal lumen, secreted enzymes), membrane (enzymes are fixed on the brush border of enterocytes) and intracellular (enzymes are within enterocytes).

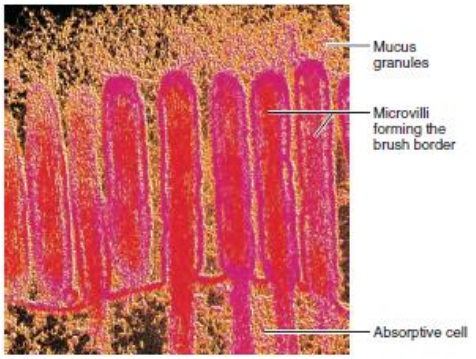




Anatomy of small intestine

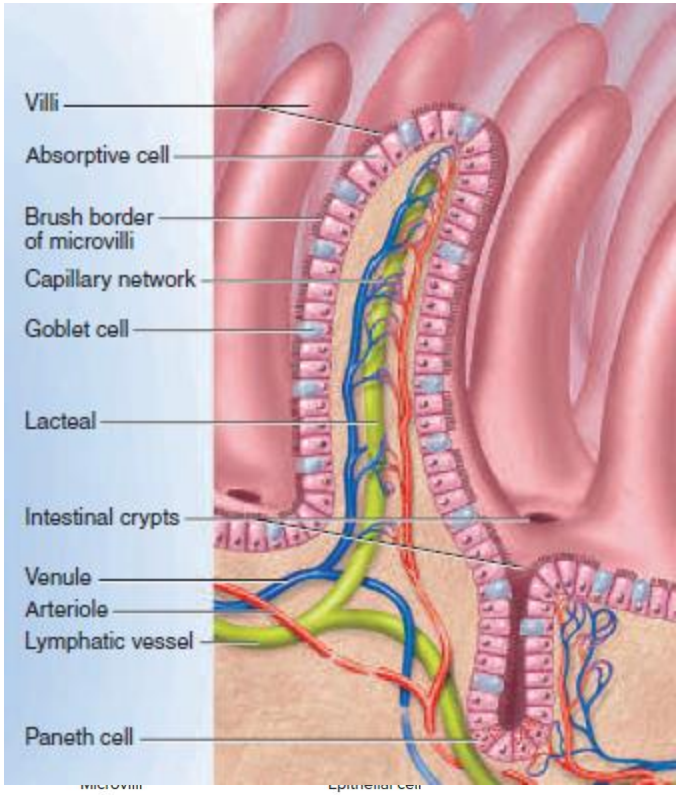
- Surface area is increased due to circular Kerckring folds (×3), villi (×10), and microvilli (×20), together 600-fold, total SA ≈ 200 m^2.

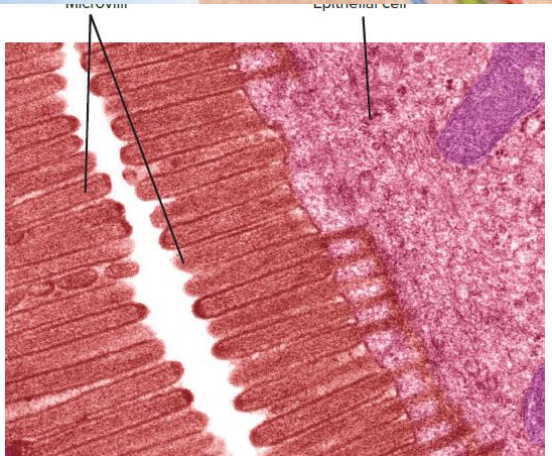




Villi

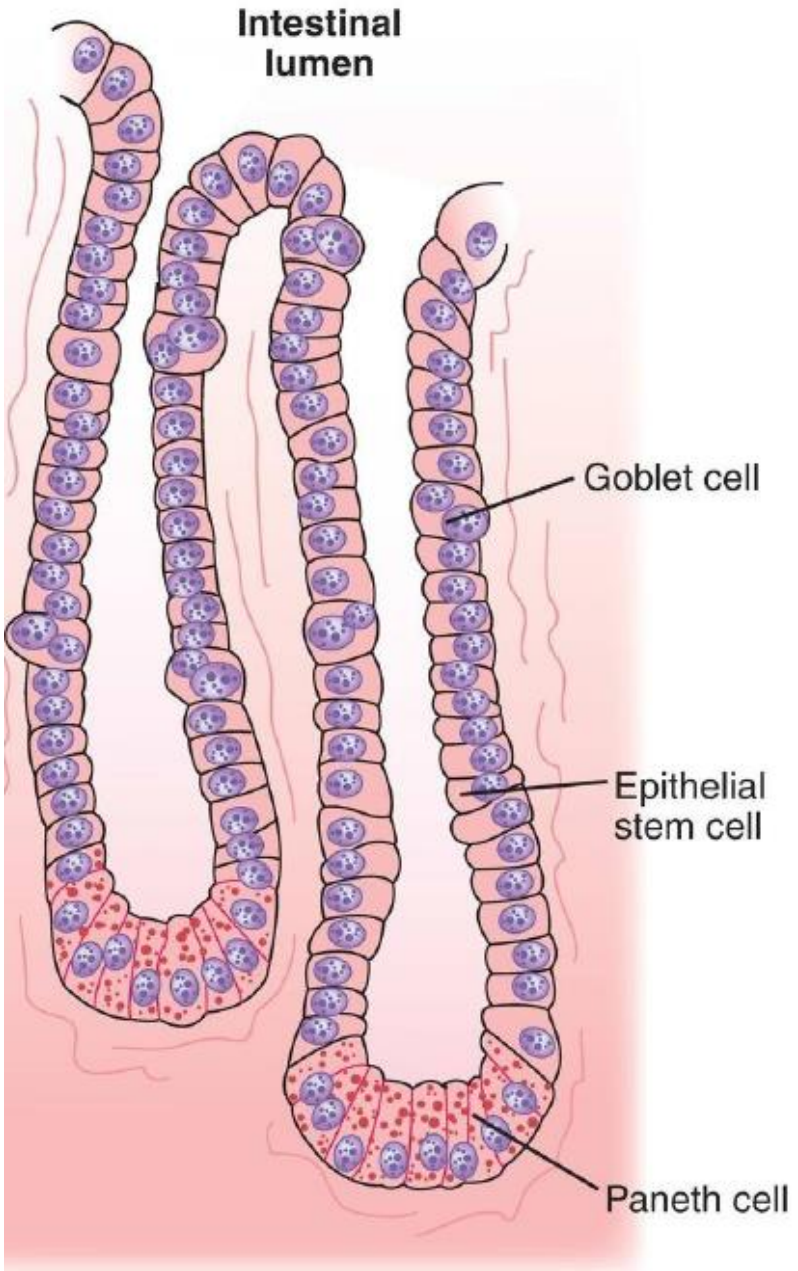
- 1 mm long.
- The villus contains blood, lymphatic vessels, and nerve endings.
- The villus is lined with enterocytes, which have microvilli (brush border).
- The villi movements: shorten and lengthen, which empties the lymphatic vessels.
- Vilikinin is a hormone that makes villi to move.





Intestinal glands

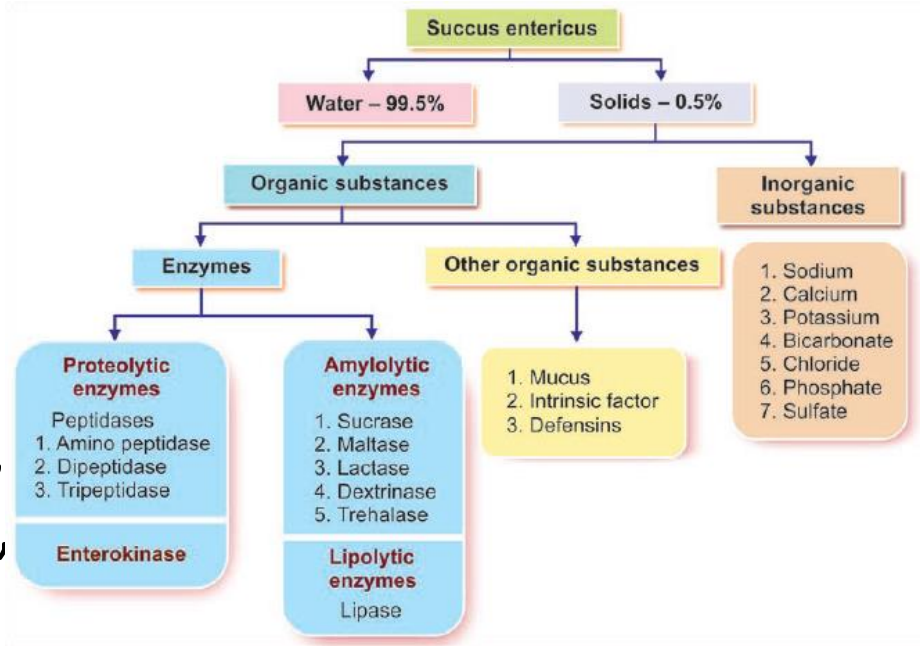
- Enterocytes (enzymes);
- Enterochromaffin cells (gastrointestinal hormones);
- Goblet cells (mucus);
- Paneth cells (lysozyme, cytokines, defensins).



Succus entericus

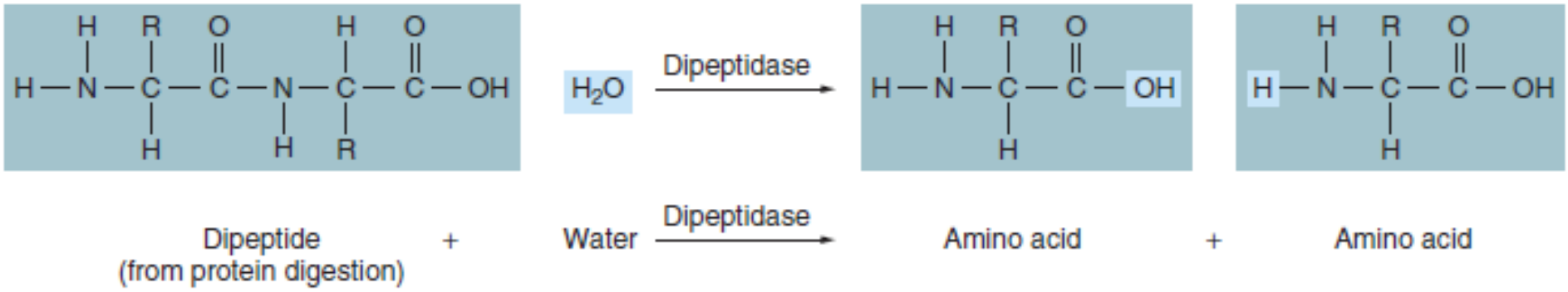
- Approximately 1.5-2 l/day.
- pH 8.0-8.3.
- Composition:
- 99.5% water;
- 0.5% solids:

1. Organic (mucus, brush border enzymes: dextrinase, maltase, sucrase, lactase, enterokinase, aminopeptidase, dipeptidase, nucleosidase, phosphatase, intestinal lipase);
2. Inorganic (sodium, potassium, calcium, bicarbonates, chlorides, phosphates, sulfates).



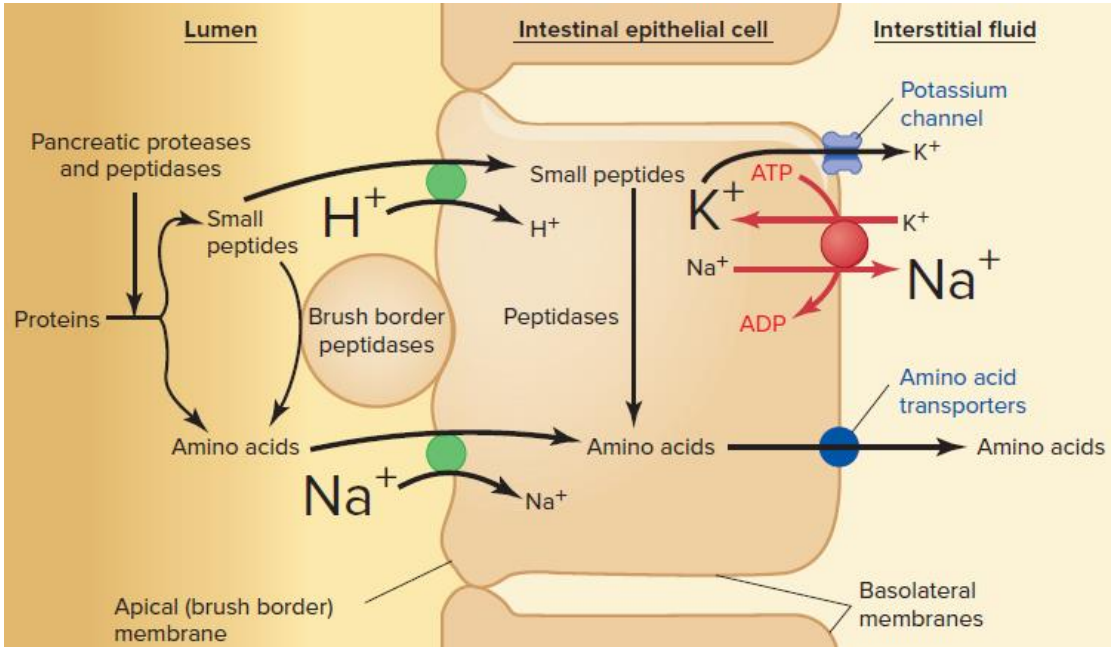
Digestion of proteins

- Lumen digestion in the small intestine: pancreatic proteases (endopeptidases trypsin, chymotrypsin, elastase, exopeptidases - carboxypeptidases).
- Membrane digestion in the intestine: aminopeptidases, dipeptidases, free amino acids and oligopeptides (di- and tripeptides) are formed.
- Duodenal enterokinase converts trypsinogen into trypsin.



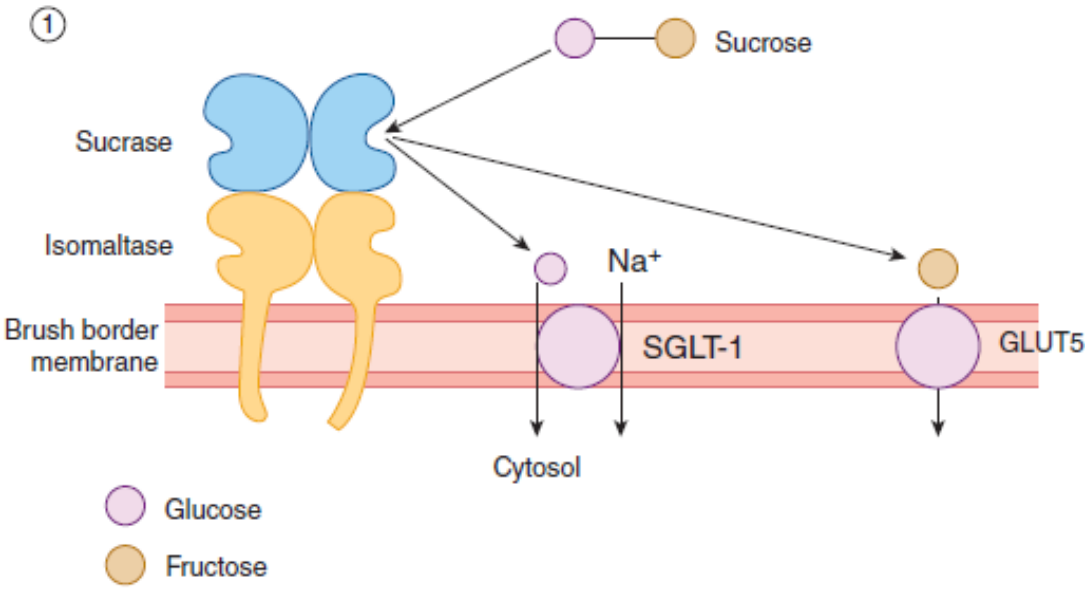
Absorption of amino acids

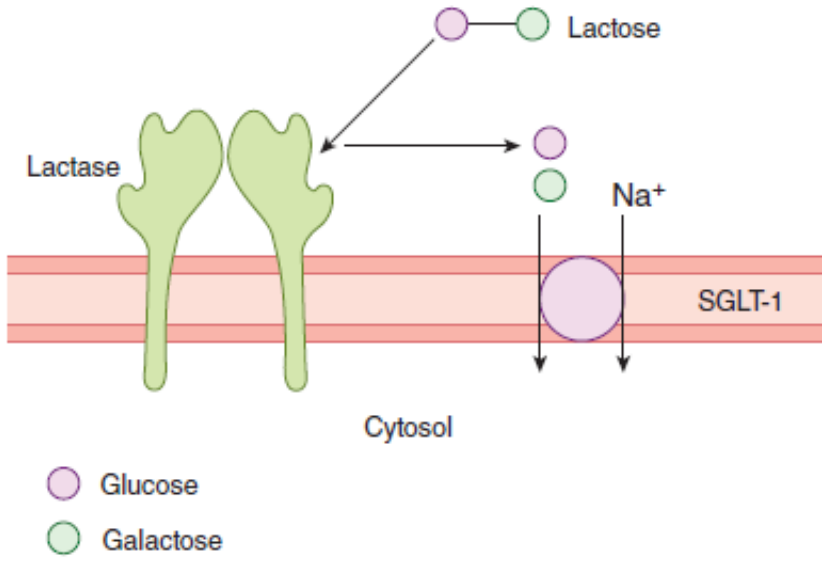
- Secondary active transport: Na^+- amino acid cotransporters (5 types: for different amino acids). The Na^+-K^+ ATPase pumps out sodium.
- In the intestine, dipeptides and tripeptides (1%) can be absorbed by the H^+-oligopeptide cotransporter (PepT 1).
- Amino acids enter the portal vein system by facilitated diffusion.



Digestion of carbohydrates

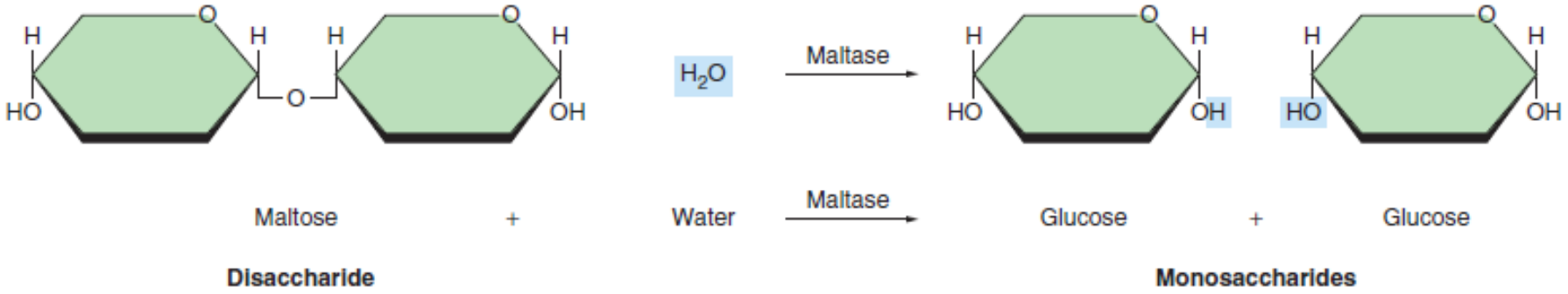
- Lumen digestion in the small intestine is provided by pancreatic amylase (substrates - starch and glycogen, products - maltose, maltotriose and dextrins).
- Membrane digestion is carried out by oligosaccharidases and disaccharidases (lactase, sucrase, maltase, isomaltase, trehalase) of the small intestine.





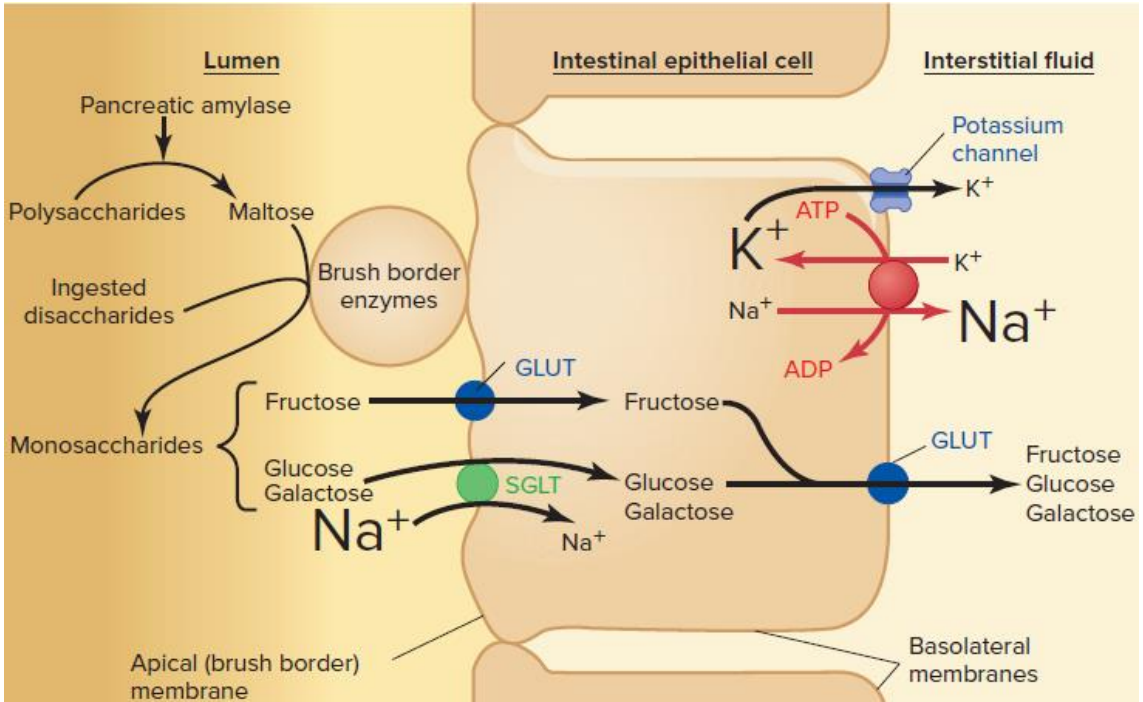
Digestion of carbohydrates

- α-dextrinase cleaves dextrin oligosaccharides → glucose,
- Sucrase cleaves sugar (sucrose → fructose + glucose),
- Maltase cleaves maltose → 2 glucoses.
- Isomaltase cleaves α-1,6 glycosidic bonds (isomaltose → 2 glucoses),
- Lactase cleaves milk sugar (lactose → galactose + glucose),
- Trehalase cleaves the fungal disaccharide trehalose → 2 glucoses.



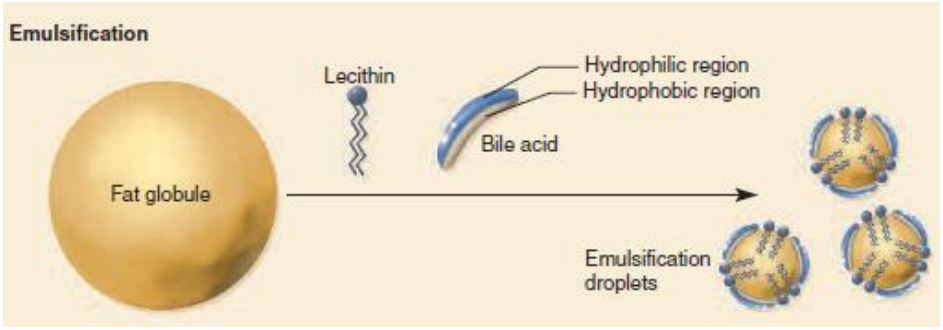
Absorption of carbohydrates

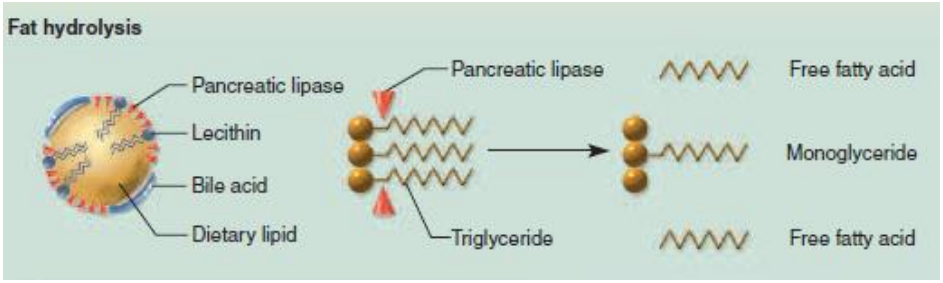
- Glucose and galactose are absorbed due to secondary active transport: cotransport with sodium: SGLUT 1 (sodium dependent glucose transporter 1), sodium is pumped out by Na^+/K^+ ATPase.
- Fructose is absorbed by facilitated diffusion through GLUT 5.
- Trough the basolateral membrane, all monosaccharides are transported by GLUT 2 (into the portal vein system).

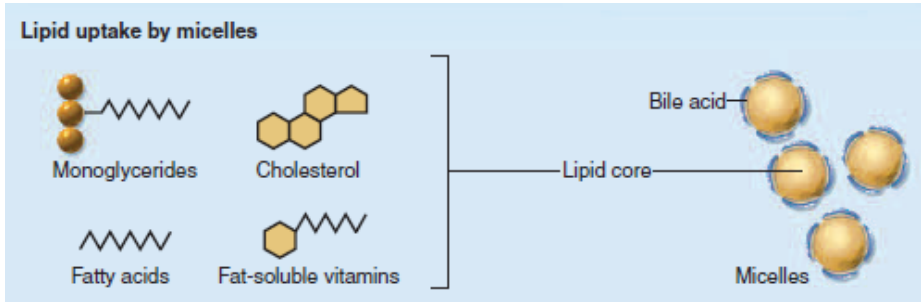


Digestion of fats

- Lumen digestion in the small intestine includes emulsification, lipolysis (pancreatic lipase, cholesterol esterase, phospholipase), formation of micelles.
- Lipolytic enzymes of the small intestine: intestinal (intestinal) lipase cleaves triglycerides into fatty acids.

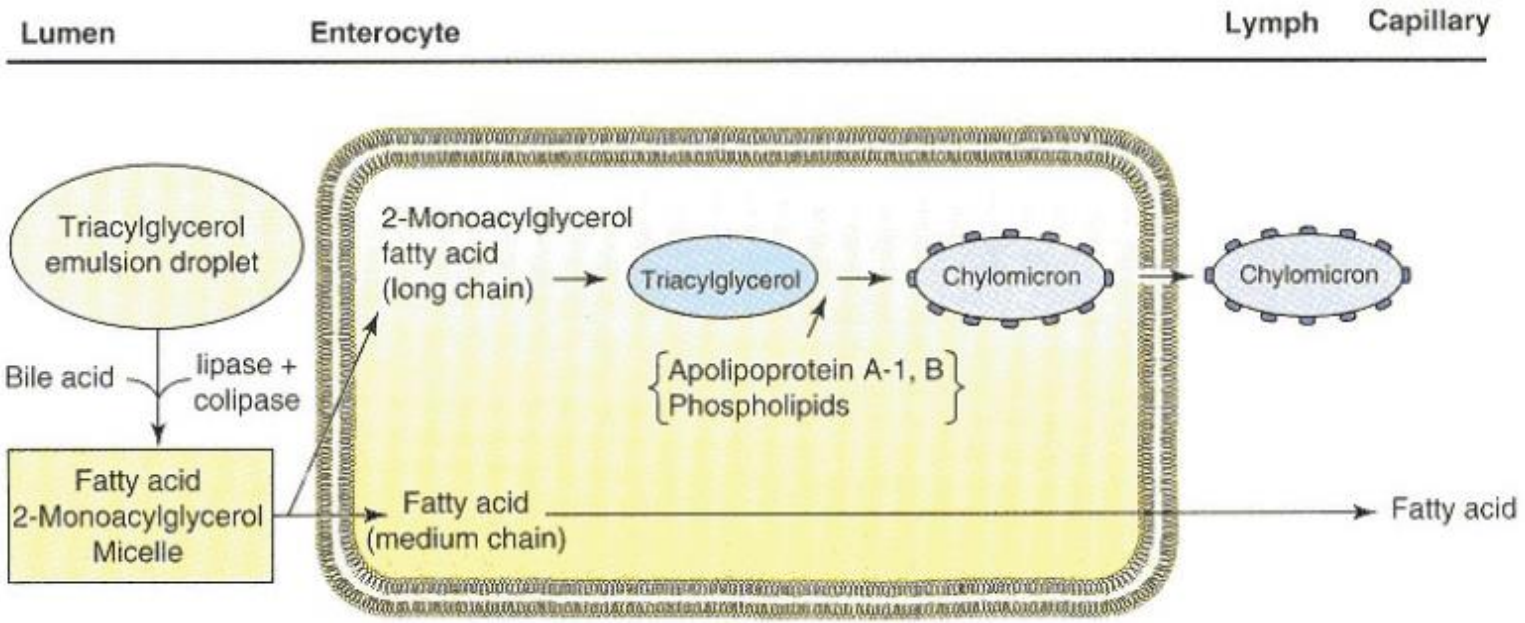






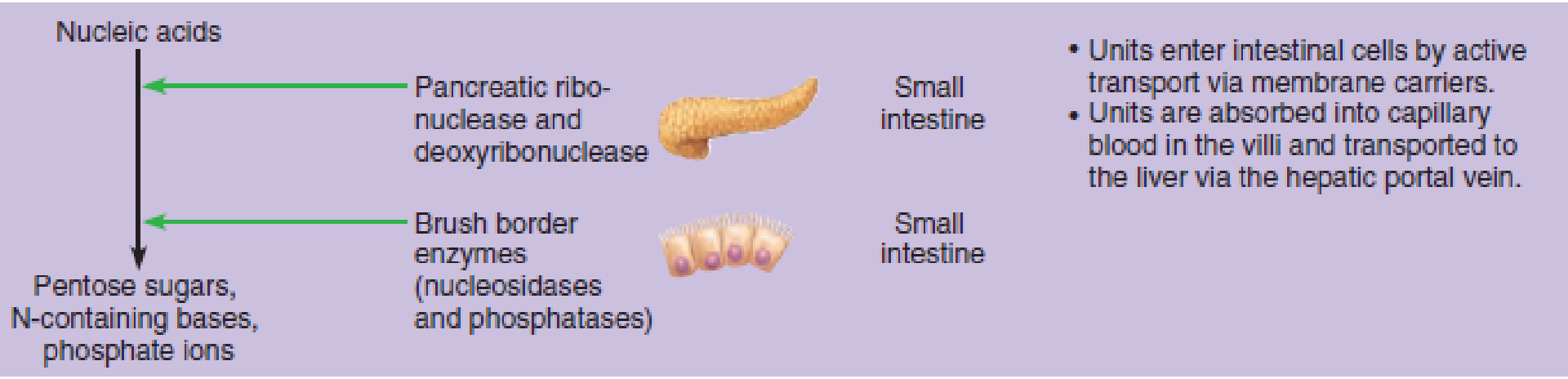
Absorption of fats

- Micelles are spherical molecular complexes that have bile acids and phospholipids on their surface, oriented with the hydrophilic parts outward, and the hydrophobic parts inward.
- Absorption occurs by simple diffusion.
- In enterocytes: reesterification, binding to apoprotein B-48, formation of chylomicrons, exocytosis of chylomicrons into the lymphatic system.



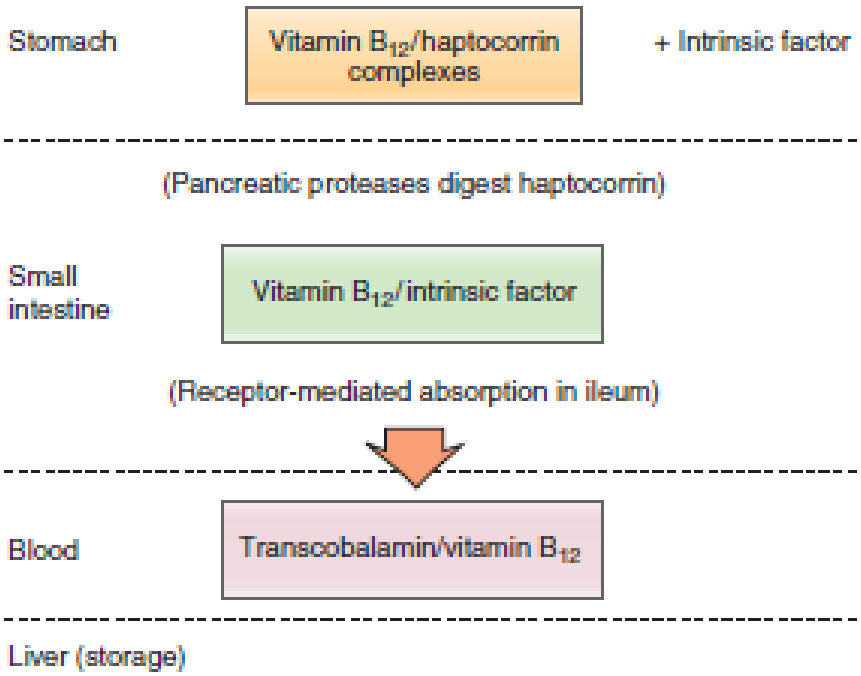
Digestion of nucleic acids

- Lumen digestion: deoxyribonuclease and ribonuclease of pancreatic juice cleave nucleic acids into nucleotides.
- Membrane digestion: nucleosidases and phosphatases on the brush border destroy nucleotides to N-containing bases, pentose sugars and phosphates.
- N-containing bases are absorbed by active transport.



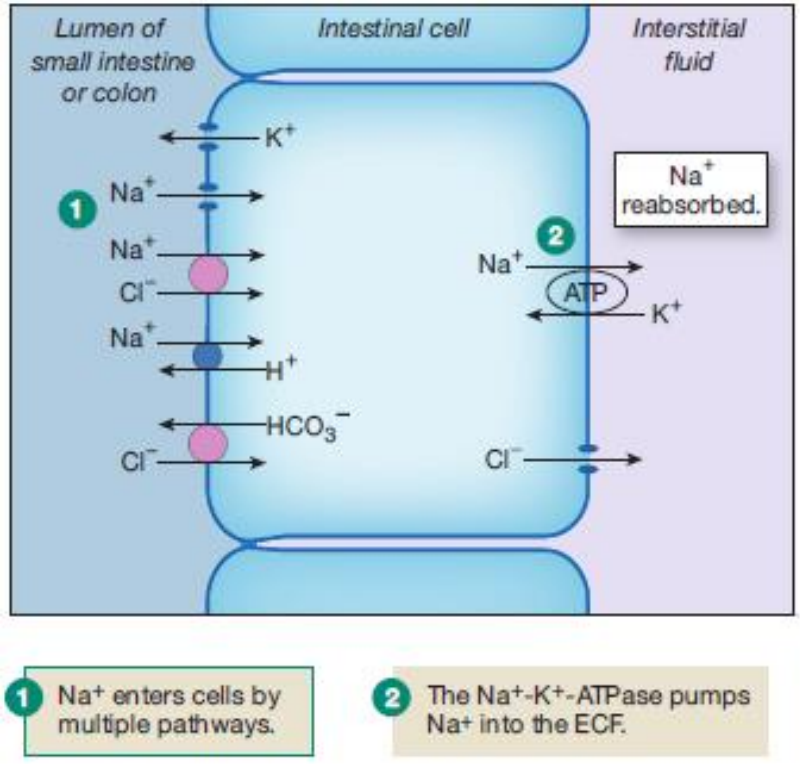
Absorption of vitamins

- Vitamins A, D, E, K (fat-soluble) are absorbed by diffusion together with micelles.
- Water-soluble vitamins are absorbed by sodium-dependent cotransport.
- Vitamin B_{12} is absorbed in a complex with intrinsic Castle factor in the ileum.



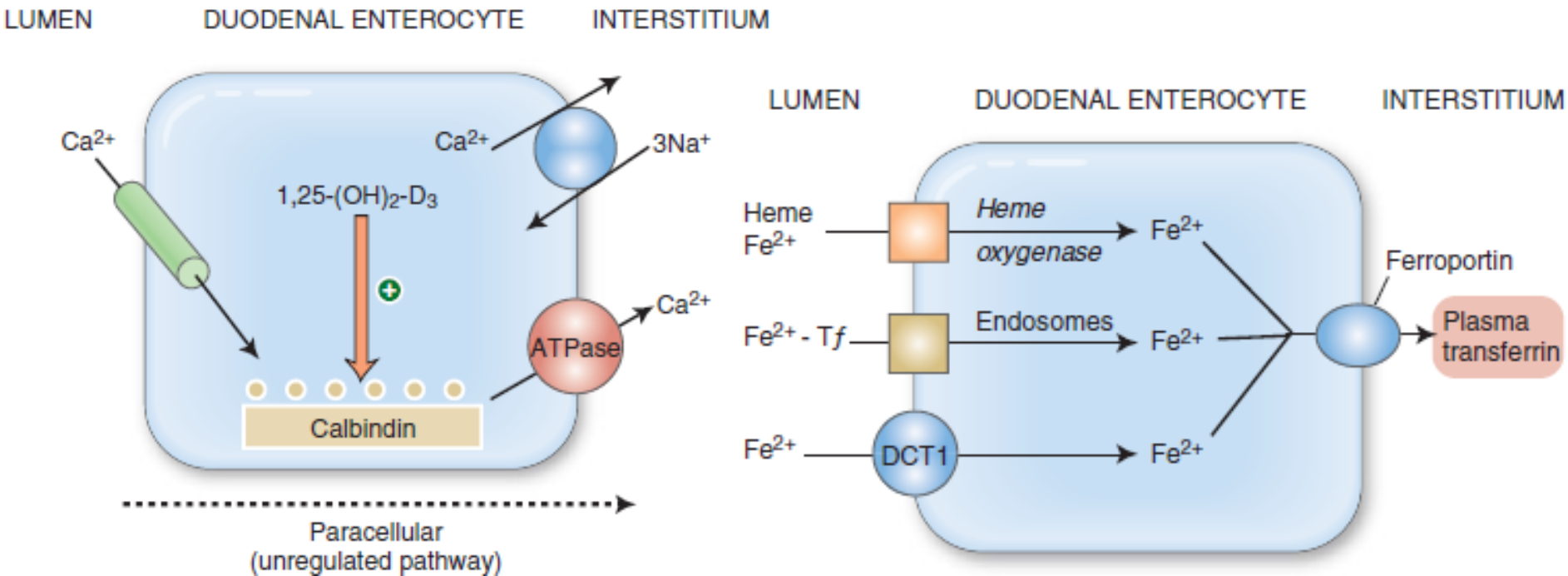
Absorption of electrolytes

- Sodium is absorbed through the apical membrane according to the electrochemical gradient (sodium ion channels, Na^+- glucose, Na^+- amino acid, Na^+- Cl^- cotransporters, Na^+- H^+ exchanger), on the basolateral membrane – it is excreted against the gradient (Na^+- K^+ pumps), also by the paracellular route.
- Chloride is absorbed by passive diffusion (paracellular pathway), through the Na^+- Cl^- cotransporter, Cl^- - HCO_3^- exchanger.
- Potassium is absorbed passively (paracellular pathway).



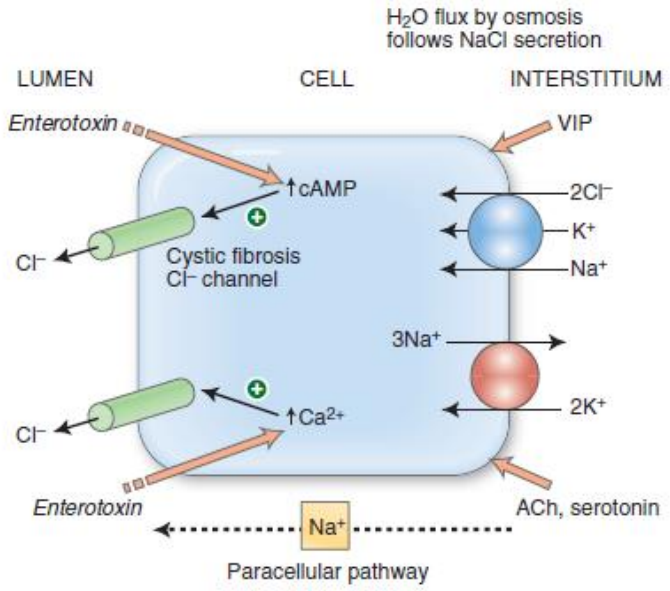
Absorption of electrolytes

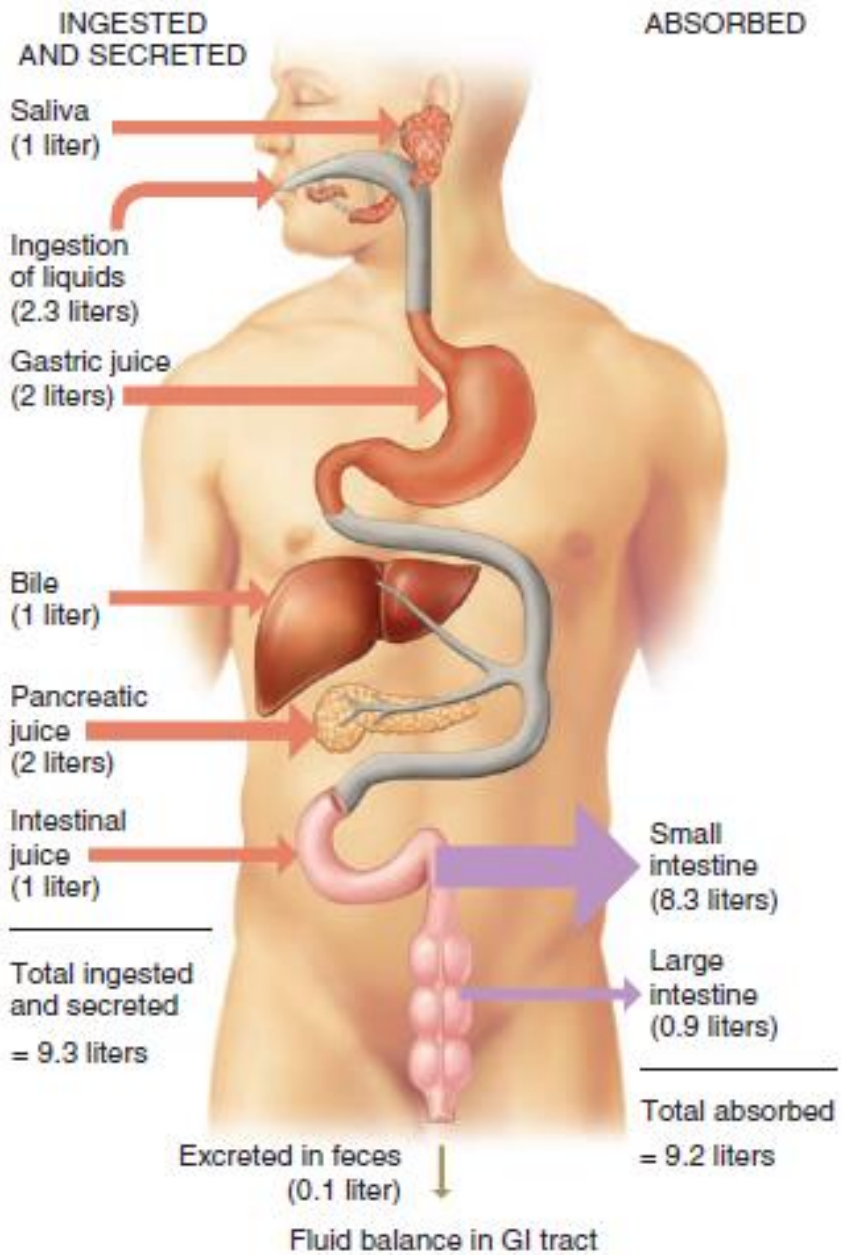
- Calcium is absorbed due to the calcium-binding protein calbindin (vitamin D dependent).
- Iron is reduced to Fe^{2+} and bound to apoferritin in enterocytes. Ferroportin transports iron into the blood.



Absorption of water

- 5-10 liters of water can be absorbed per day.
- It occurs due to osmosis (secondary to absorption of electrolytes).
- In the small intestine, chyme is isoosmotic, and in the large intestine, feces can be hypertonic due to the low permeability of the intestinal wall for water.

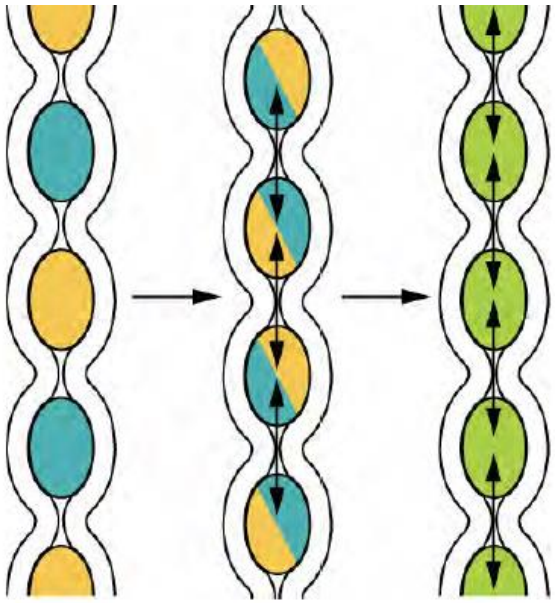




Motility of small intestine

I. Mixing movements:

1) Segmentation – ring-shaped (circular) contractions, rhythmic, short, weak. The length of the section is 1-5 cm (compartmentalization). Mixing of chyme with pancreatic juice, bile, succus entericus. Anterograde + retrograde movements. Slight promotion of chyme. It increases the contact time of chyme with the brash border (for membrane digestion and absorption). Provided by the enteric nervous system.



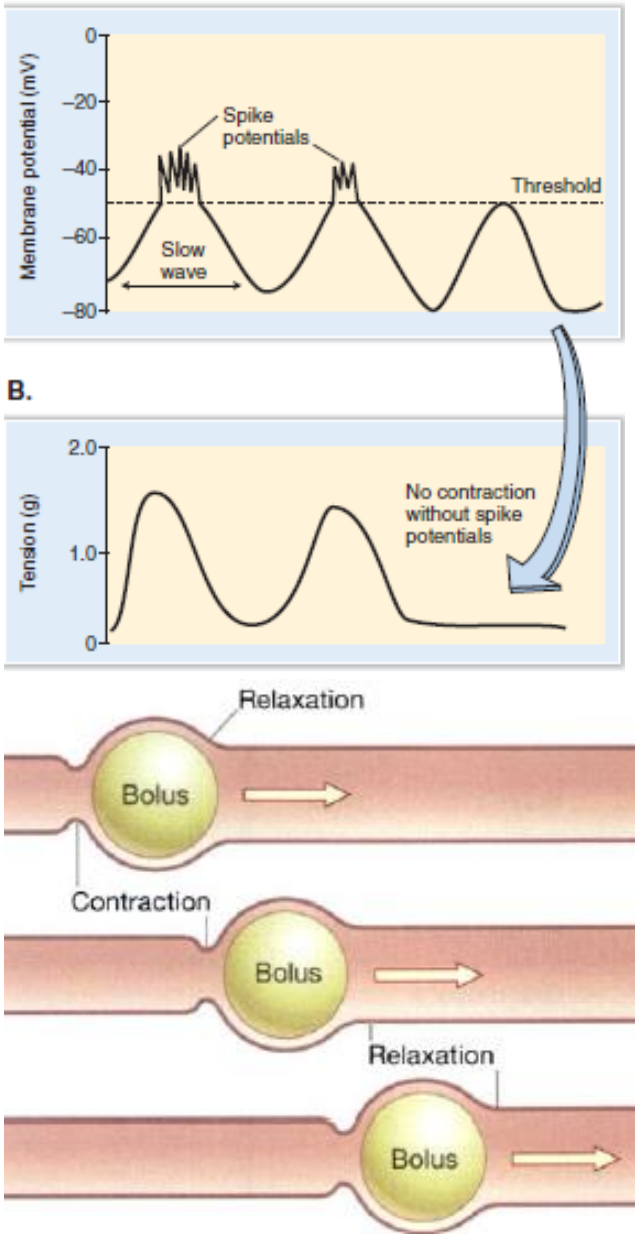
2) Pendular movements (contraction of longitudinal muscles) move the chyme and increase the contact area.

Motility of small intestine

II. Propulsive movements:

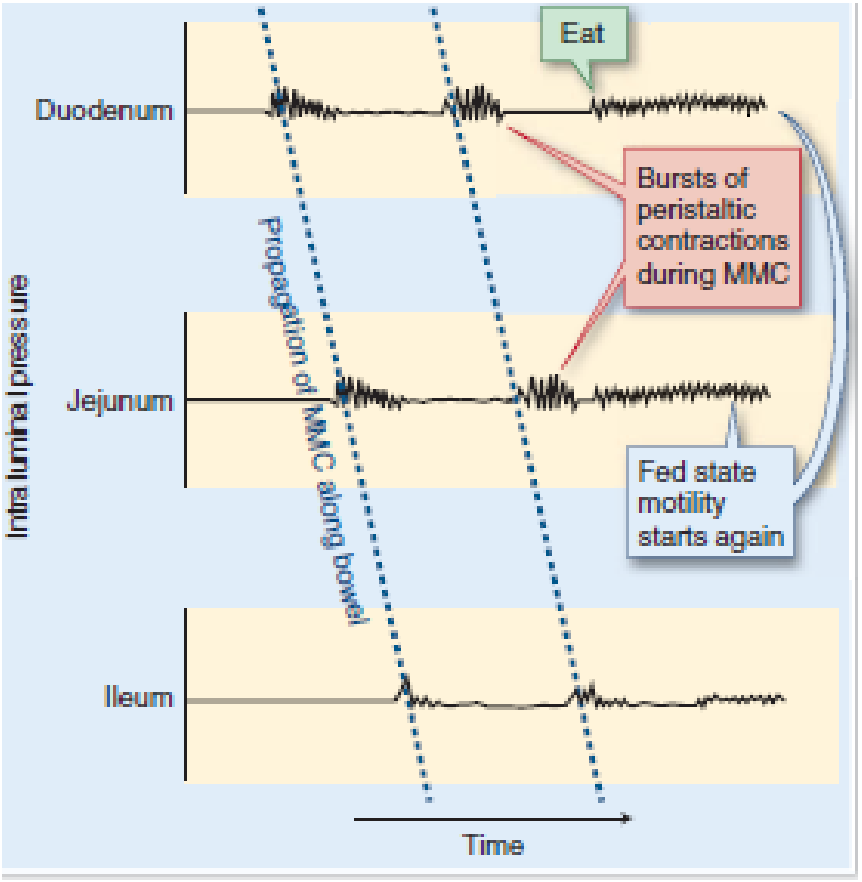
Peristalsis - movements that move the chyme to the anus. Consists of a wave of contraction above the chyme and a wave of relaxation below (Starling's law of the intestine). Speed 1-2 cm/sec. The circular layer contracts (acetylcholine and substance P), then the longitudinal layer relaxes (VIP and NO) and vice versa. Carried out by the enteric nervous system, the parasympathetic increases in response to stretching, the sympathetic suppresses peristalsis.

III. Tonic contractions (sphincters).



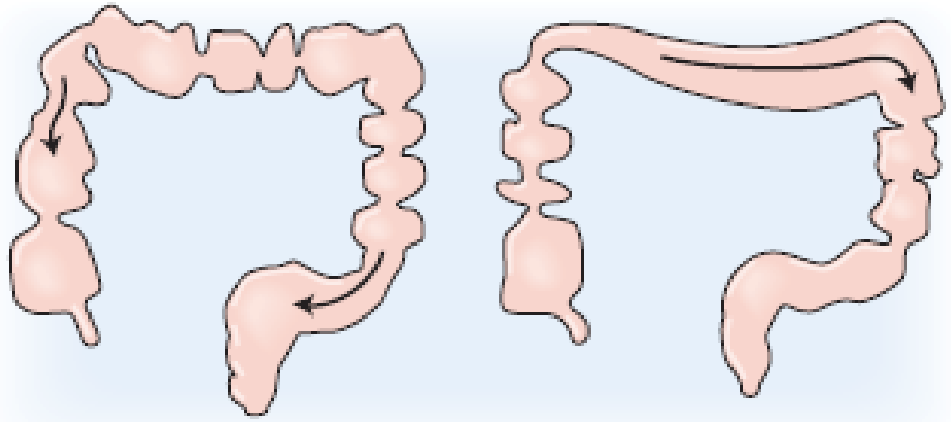
Motility of small intestine

- Peristalsis between meals: Migrating motor complex. Every 1.5-2 hours, speed 6-12 cm/sec, frequency 12 waves/min.
- It removes food residues, dead cells.
- It is enhanced by the hormone motilin (produced by Mo cells of the intestine).



Motility of large intestine

1) Haustral contractions (an analogue of segmentation) are activated by stretching the cecum. They occur in the ascending and transverse colon. Increase the contact of feces with the intestinal wall (absorption of water and electrolytes).
2) Propulsive movements (peristalsis): 1-3 times a day. It lasts 10 minutes, shortens a section up to 20 cm long. Stimulus – stretching and irritation of the wall, gastrointestinal reflex, gastrin. Vagus (acetylcholine).



"Haustral shuttling" (segmentation)

Mass movements (peristalsis)

Defecation

- Stimulus – distension of the rectum (occurs when it is filled to 25%, 15-20 mmHg).
- Parasympathetic center – sacral segments of the spinal cord (S2-S4), pelvic nerve.
- Rectal contraction and relaxation of the internal (involuntary) and external (voluntary) anal sphincters (pudendal nerve).