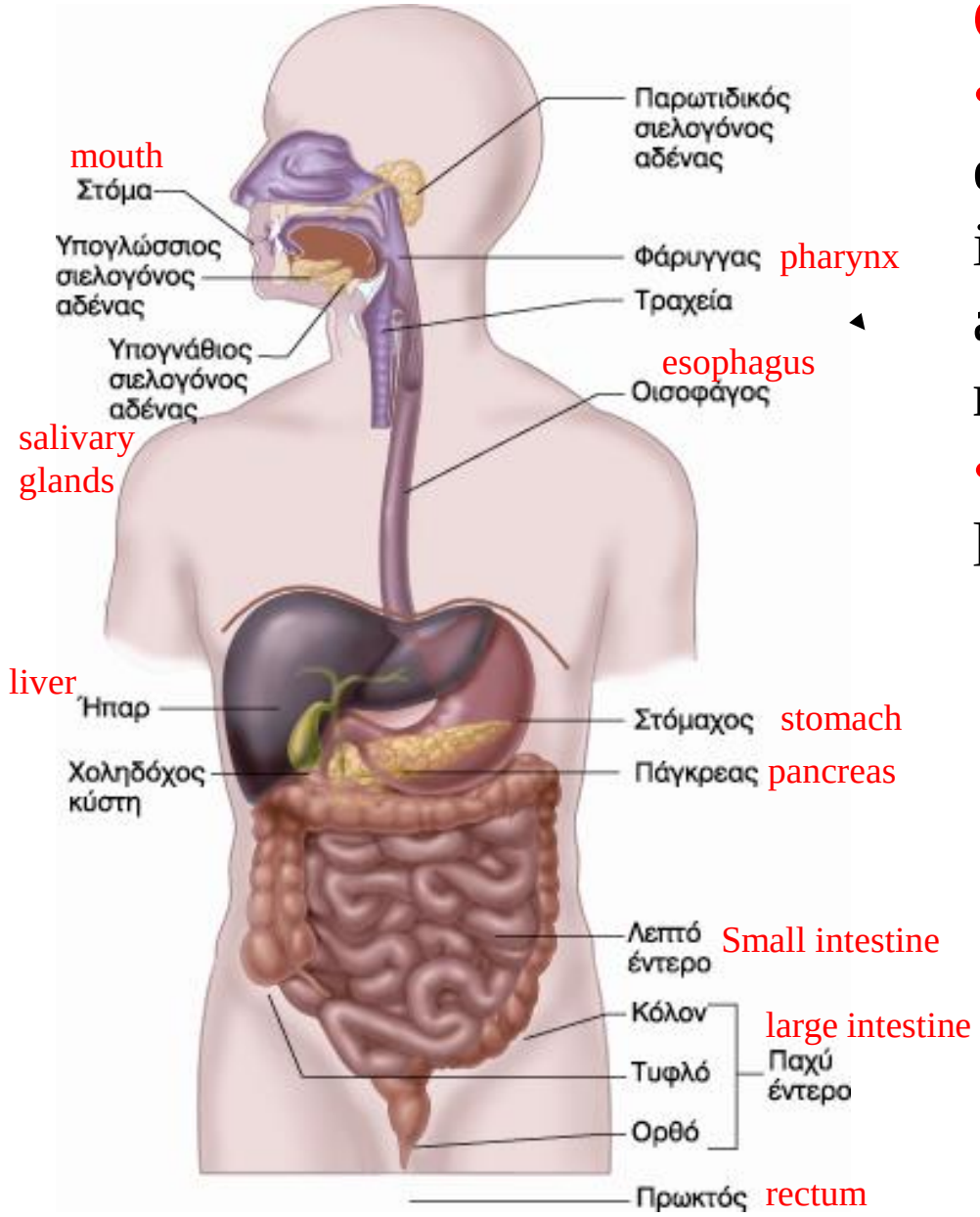
Gastrointestinal system physiology

Ada Mitsakou
Physiology Lab, School of Medicine, University of Patras
mitsacos@upatras.gr



GI is composed of:

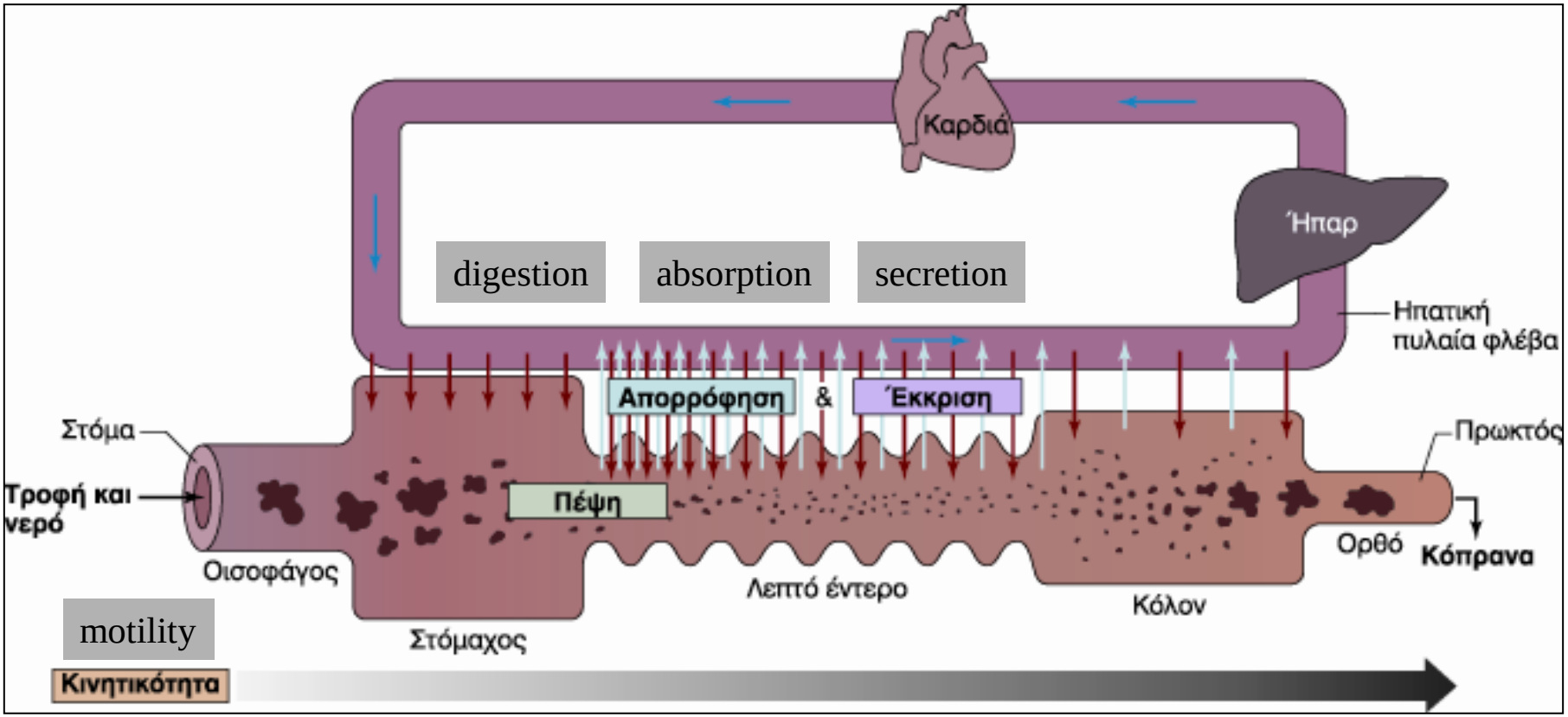
•GI tract (mouth, pharynx, esophagus, stomach, small intestine –duodenum, jejunum and ileum- large intestine, rectum)

•Glands (salivary, pancreas, liver, gastric, enteric)

Major function of the GI system is to *digest* foodstuff and *absorb* nutrient molecules into the bloodstream

-proteins, carbohydrates, fat, minerals, vitamins, water-

GI system activities: *motility, secretion, digestion, absorption*



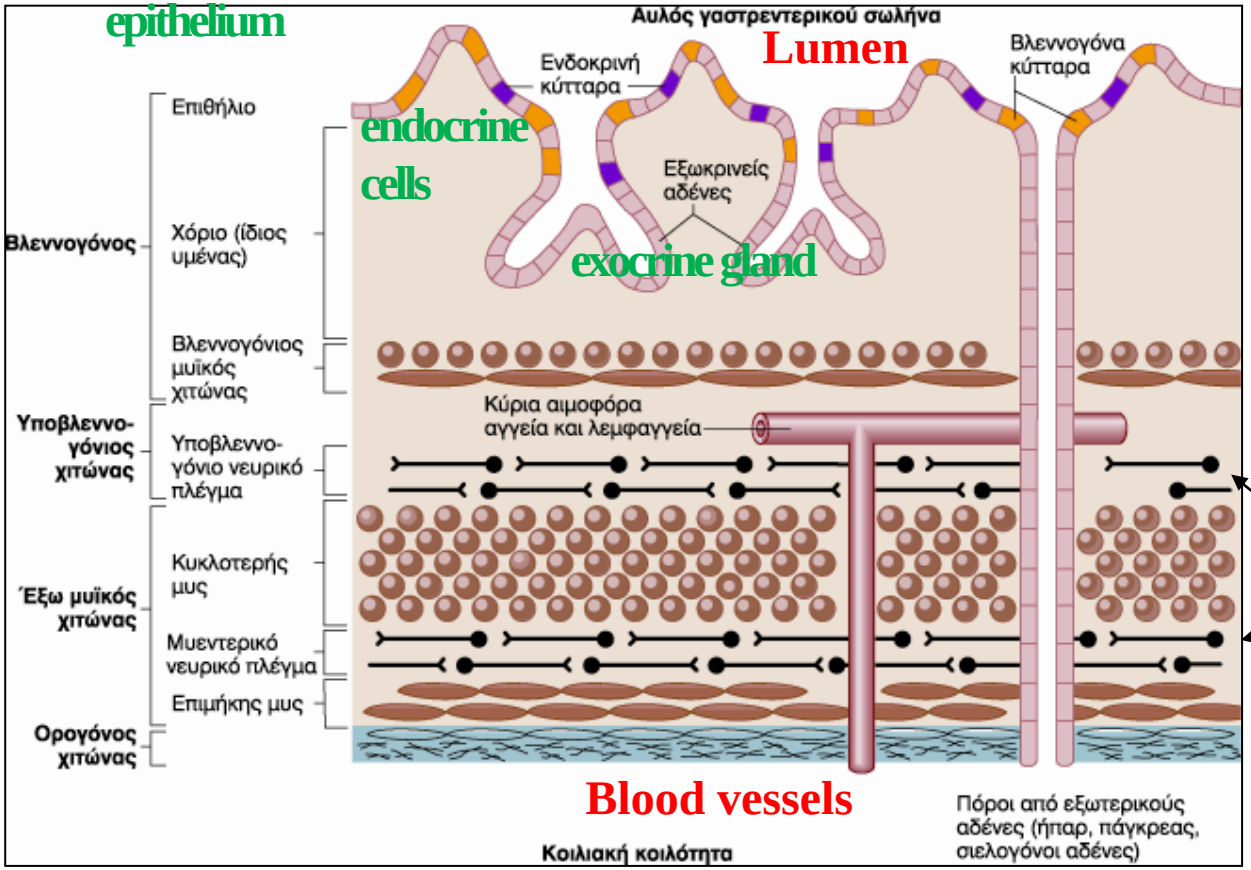
Motility refers to movements that mix, circulate and propel contents
Secretion refers to release of water and substances from glands
Digestion is the chemical breakdown of food by enzymes.
Absorption is the transport of nutrient moleculs from the intestine to the blood stream.

The wall of the gastrointestinal tract

mucosa

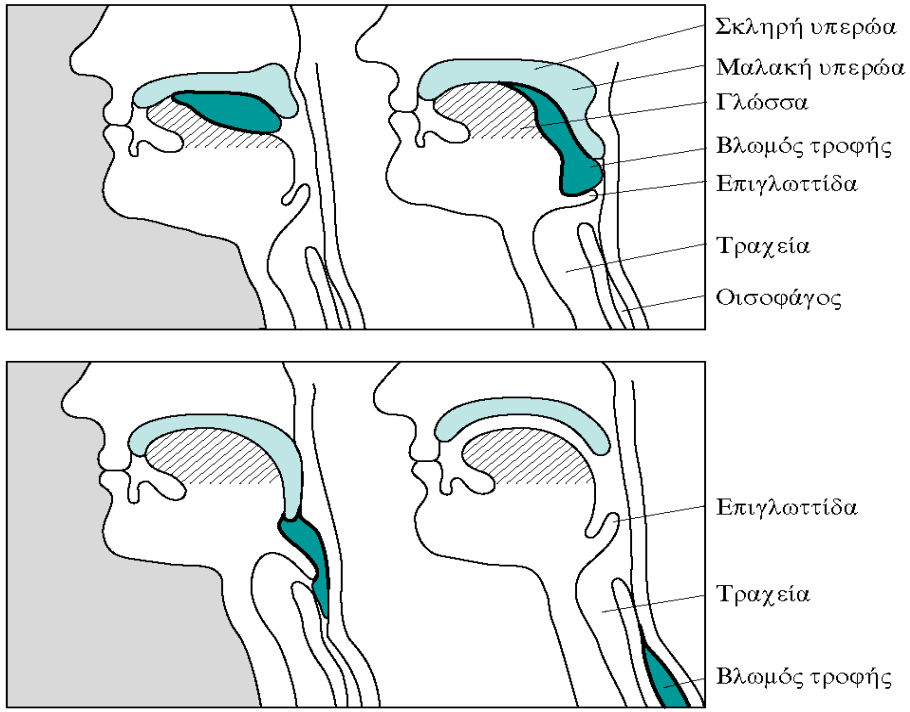
submocosa

muscular layer- circular, longitudinal



3 layers (mucosa, submucosa, muscular layer) and the enteric nervous system.
Mucosa (epithelial/absorptive cells, mucous cells, endocrine cells and exocrine glands).
The muscular layer with *smooth muscle cells* regulates motility.
The GI tract is the largest endocrine organ in our body.
The GI functions are regulated by hormones and by nerves (autonomic nervous system and ENS).

The mouth – the secretion of saliva

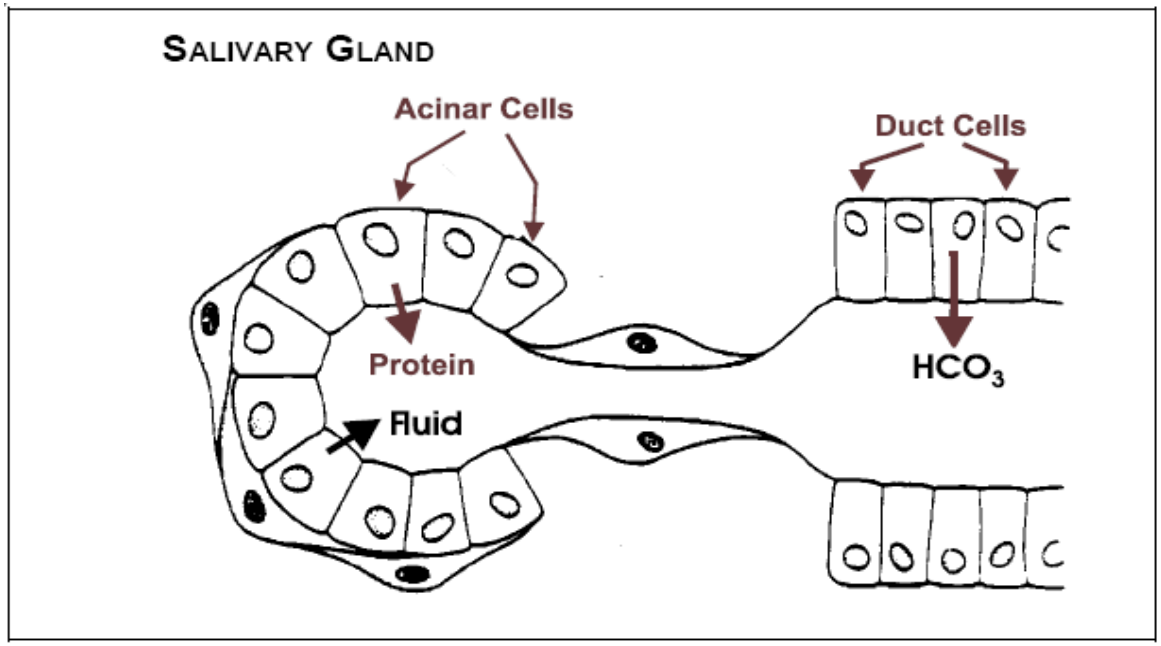


•Mechanical digestion of food - **chewing**

•Chewing is voluntary but more frequently a reflex behavior

•Chewing lubricates the food by mixing it with the saliva

•Secretion of saliva by **salivary glands**



Saliva

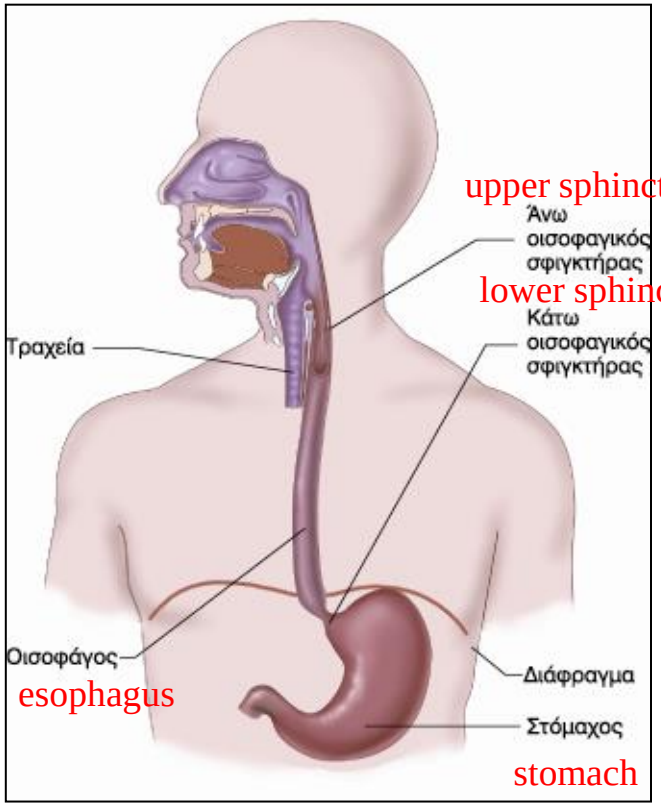
Functions of the saliva:

- Lubricates food to facilitate swallowing -Keeps mouth moist to facilitate speech

- Initiates digestion of carbohydrates -facilitates taste (taste buds are stimulated by breakdown products of carbohydrates)

- Has a neutral pH (around 7) –helps to minimize tooth decay

The esophagus – transportation of food to the stomach

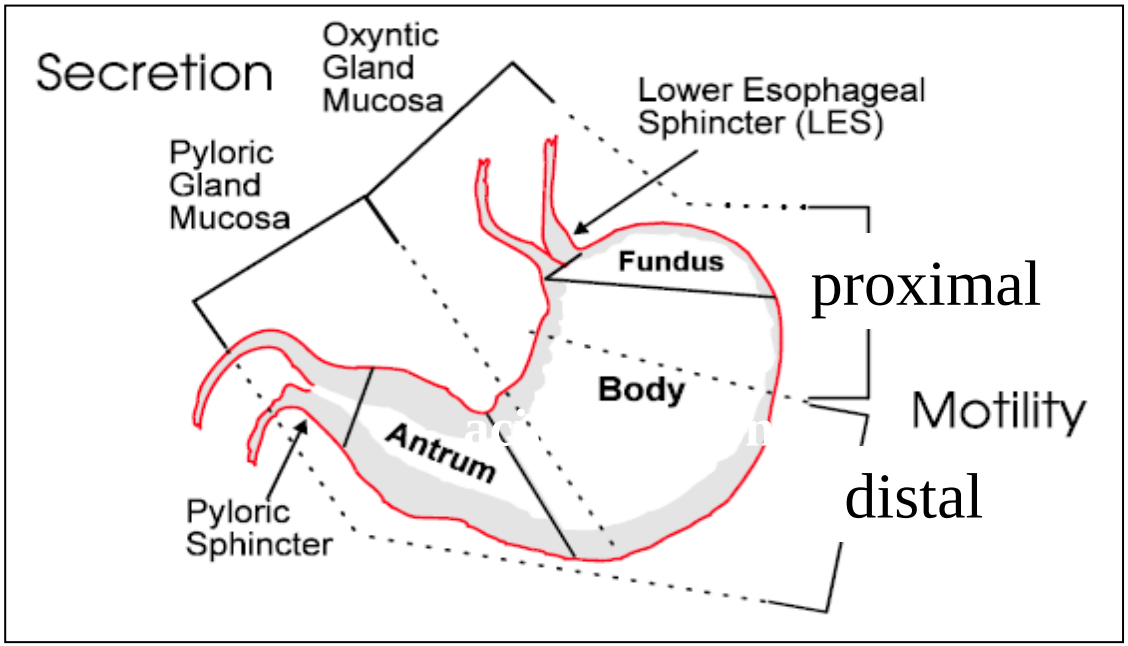


The **swallowing reflex** starts as the bolus of food touches the pharynx

The esophagus propels food material from the pharynx to the stomach – process of *swallowing*

Upper and lower sphincters are closed between swallows

During swallowing the upper sphincter opens first – the esophagus contracts – the lower sphincter relaxes to let food pass to the stomach

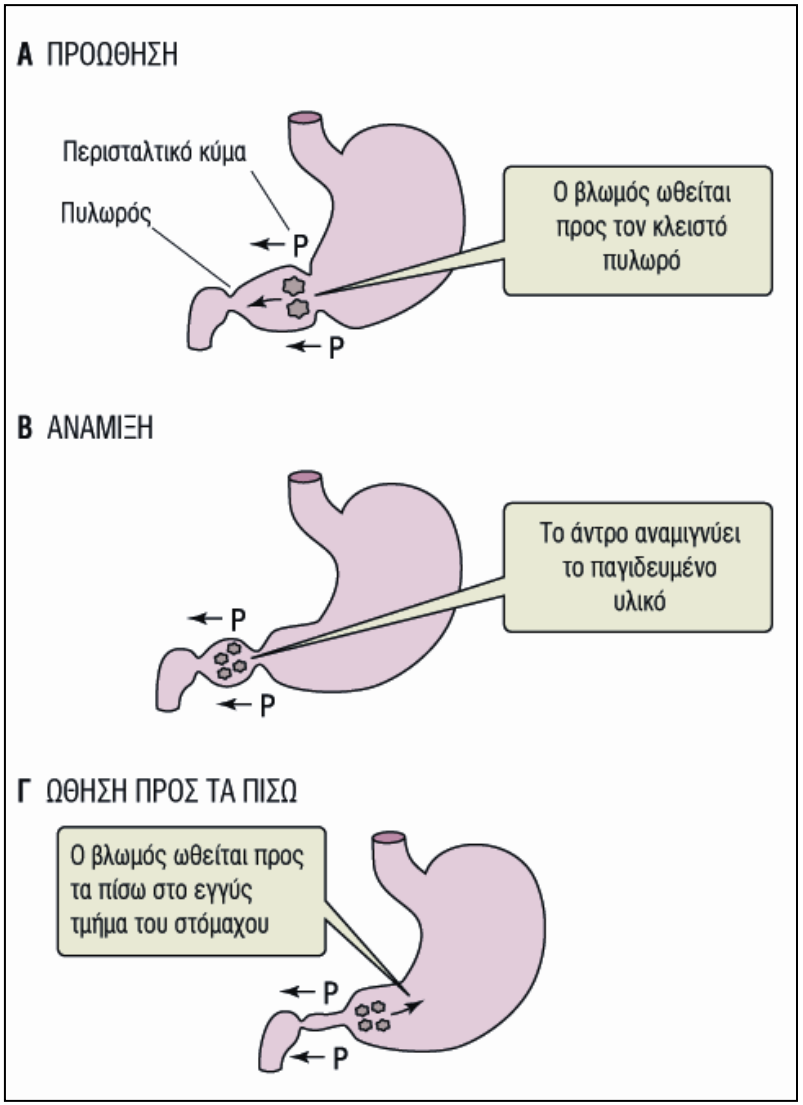


The stomach:

Lower esophageal sphincter - pyloric sphincter

Functions of the stomach:

- Proximal serves as a *reservoir* – the proximal region relaxes when food enters (up to 1.5lt) with no rise in internal pressure.
- Kills some bacteria and parasites
- Begins the process of digestion (exposes food to low pH, secrets protein enzymes, mixing and breakup of food)



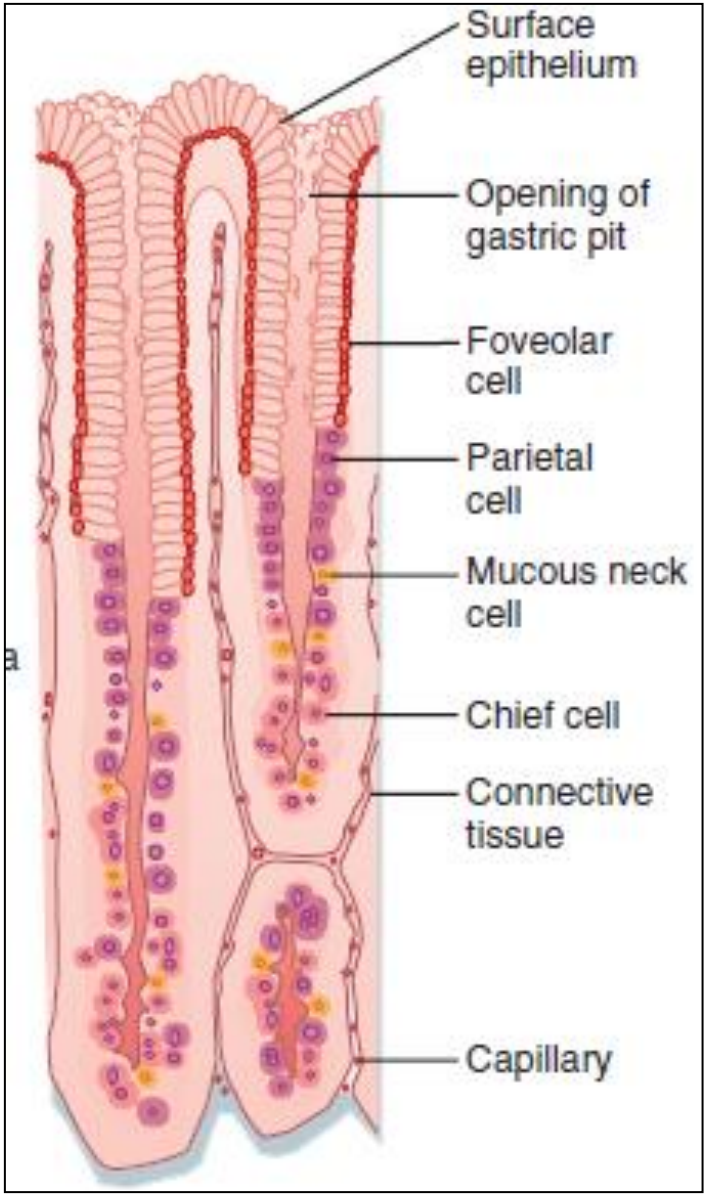
➢*Gastric emptying-distal stomach*

➢*Gastric emptying is regulated* by nerves and by hormones that are secreted by the stomach and the duodenum.

Gastrin *secreted by the stomach, increases contractions*

Secretin, cholocystokinin *secreted by duodenum decrease contractions*

Gastric glands



Mucous neck cells and ***epithelial cells*** secret mucous

Chief cells secret pepsinogen

Parietal cells secret HCl and intrinsic factor

G-cells secret gastrin

Major components of gastric juice:

- Hydrochloric acid (HCl) – denatures proteins, required for pepsins
- Pepsinogen – proenzyme - converted to pepsin–digestion of proteins
- Intrinsic factor – binds vitamin B12 and permits its absorption
- Mucous – protects stomach wall from HCl, pepsin and mechanical trauma
- Hormones (gastrin, histamine, somatostatin)

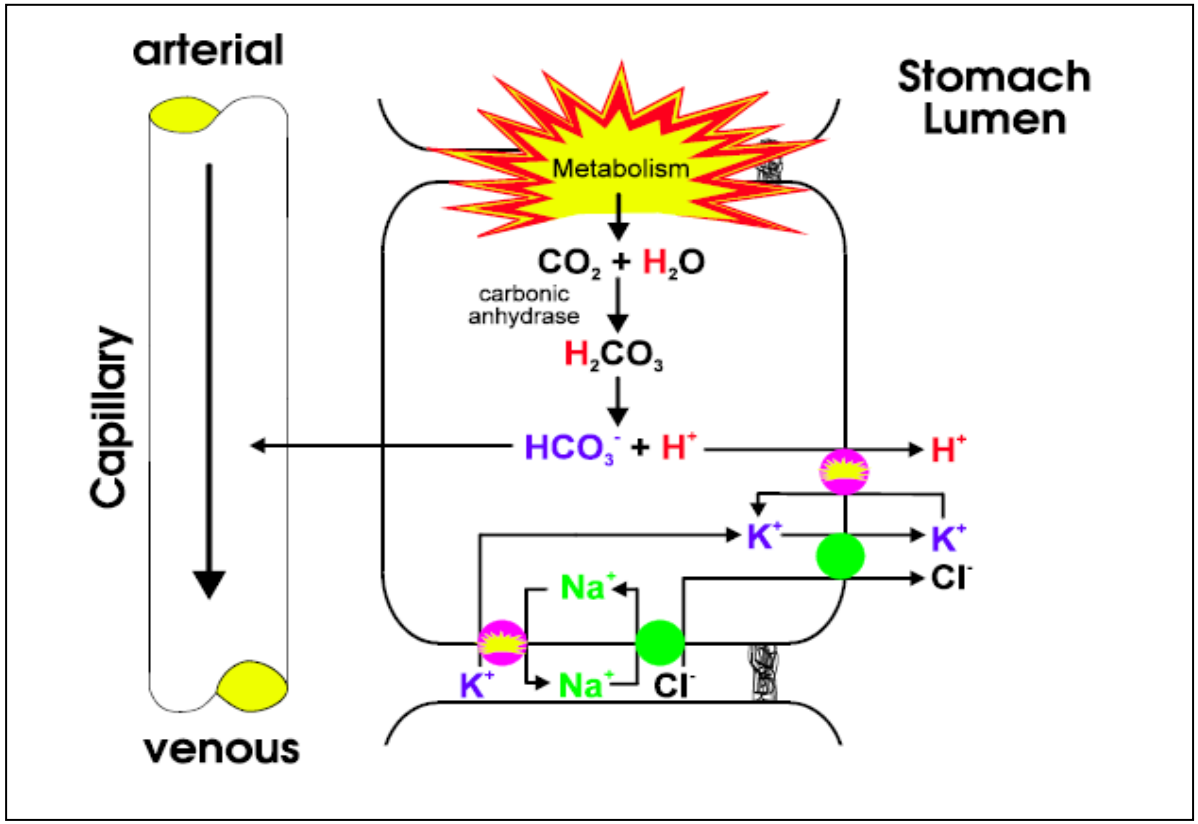
Functional roles of gastric secretions:

Acid pH

Killing microorganisms

Vitamin B12 absorption

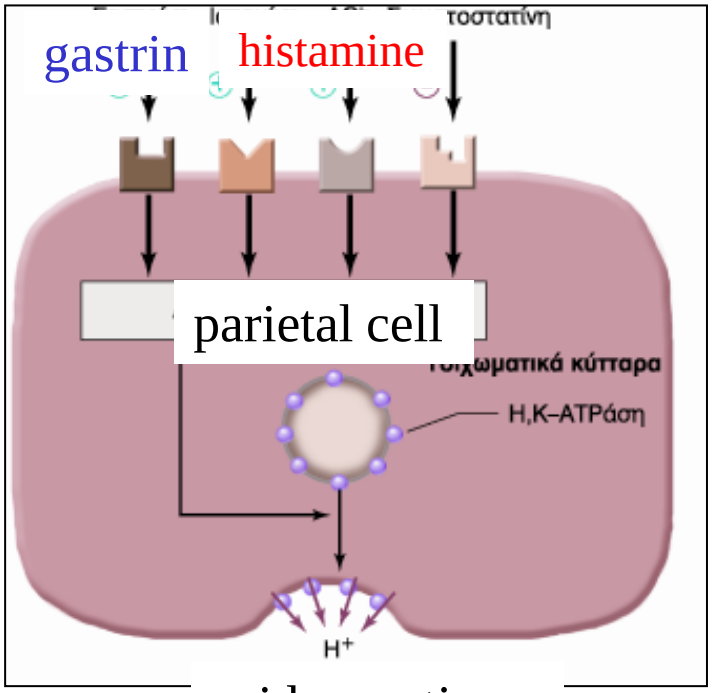
HCl secretion by the parietal cell



Hydrogen ions are driven into the stomach lumen by a ***proton pump*** of parietal cells.

Regulation of HCl secretion by the parietal cell –

The hormones histamine and gastrin increase the secretion of gastric acid

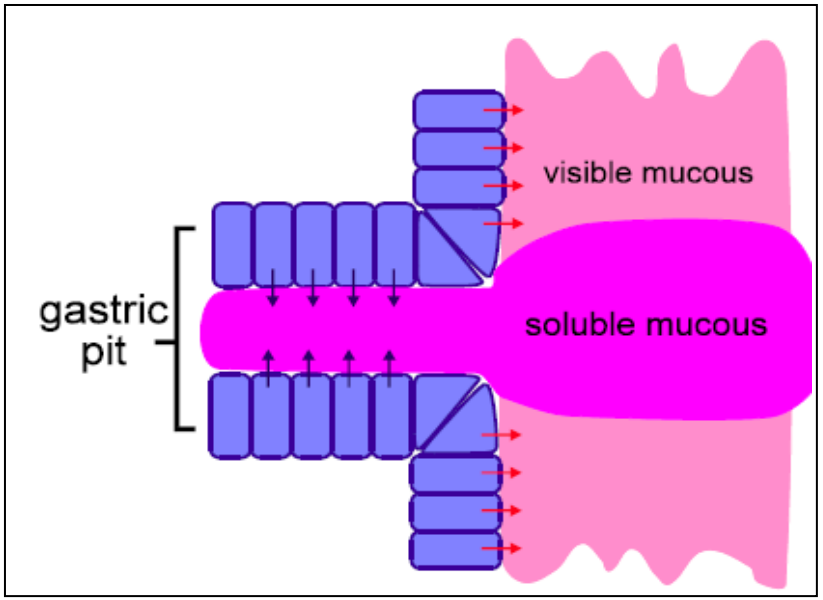


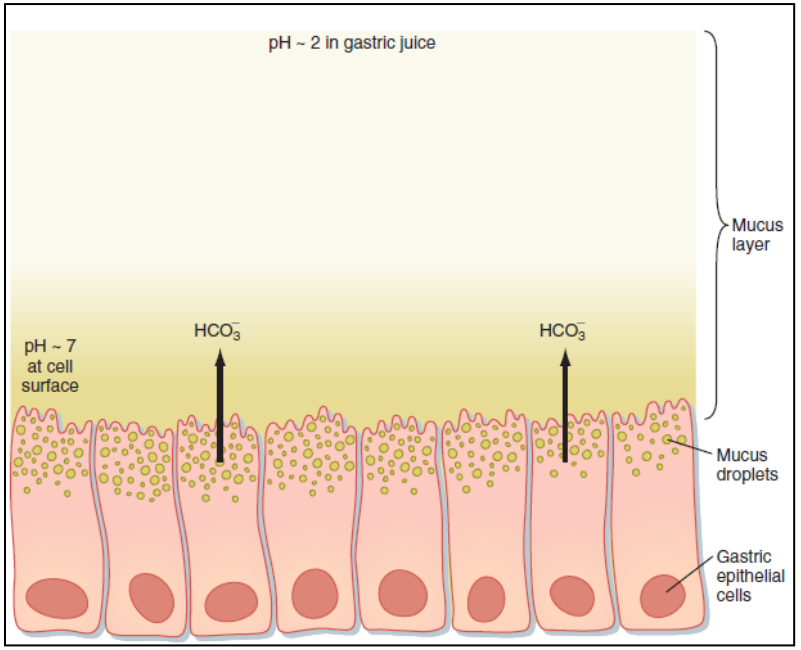
acid secretion

Drugs used for the treatment of ulcer include:

- antagonists of histamine receptors (cimetidine)
- blockers of the proton pump (omeprazole)

Mucus secretions - the gastric mucosal barrier



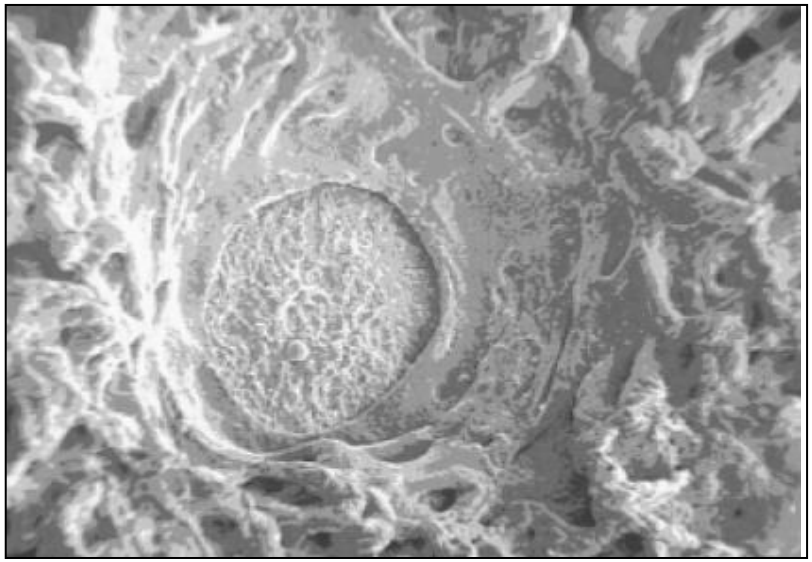


Functions of the mucus secretions:

➢Forms a gelatinous coating that protects the surface of the stomach from pepsin and acid – slows the rate of diffusion of hydrogen ions

➢Contains high concentrations of bicarbonate – keeps the pH neutral close to the surface

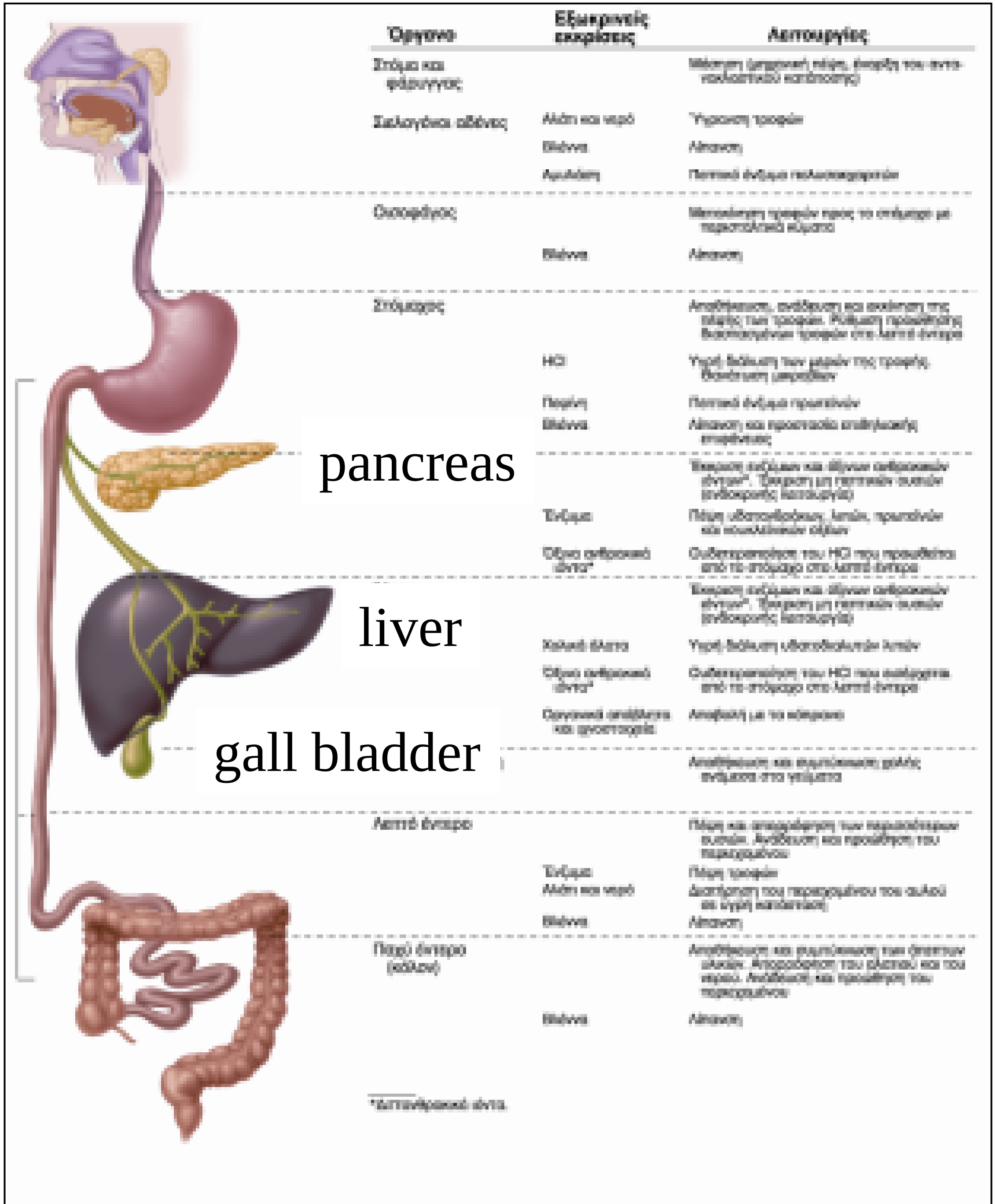
Peptic ulcer



Nobel prize 2005 to J. Robin Warren και Barry J. Marshall for Helicobacter pylori

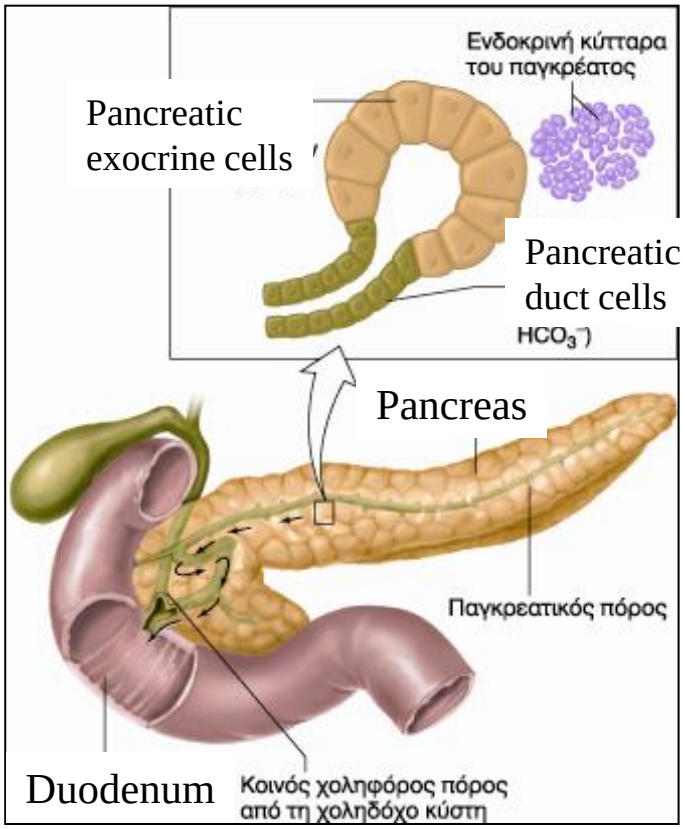
Gastric and duodenal ulcers – when the capacity of the mucosa to protect itself is overwhelmed by gastric acid secretion.

➢Chronic use of non-steroidal anti-inflammatory drugs (such as aspirin) are a common cause for gastric ulceration.
➢The bacterium *Helicobacter pylori* is also causing ulcer.
➢Stress ulcers: chronically elevated levels of epinephrine suppress HCO_3^- secretion and decrease protection of gastric surface



Pancreatic secretions

Liver secretions



Function of pancreatic juice: ***Digestion - chemical breakdown of food.***

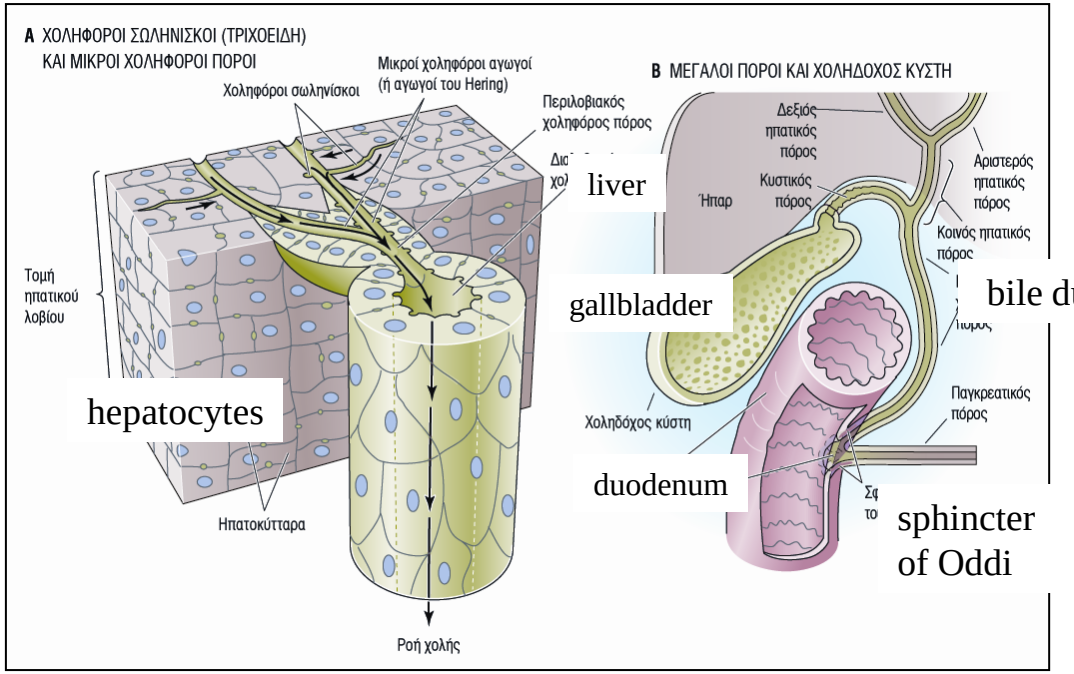
Endocrine cells release secretin, CCK

The pancreatic juice contains:

- bicarbonate – neutralizes the HCl-rich chyme from the stomach
- digestive enzymes – mostly in inactive forms – breakdown proteins, fats and carbohydrates

The secretion of the pancreas is regulated by hormones (cholokystokinin-CCK and secretin) secreted by endocrine cells of the duodenum

Bile secretion from the liver

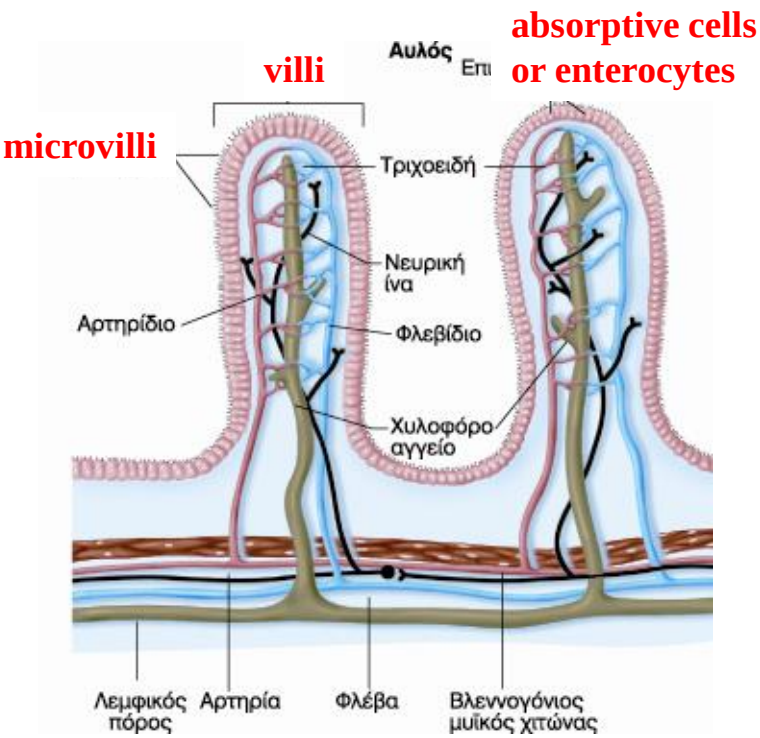


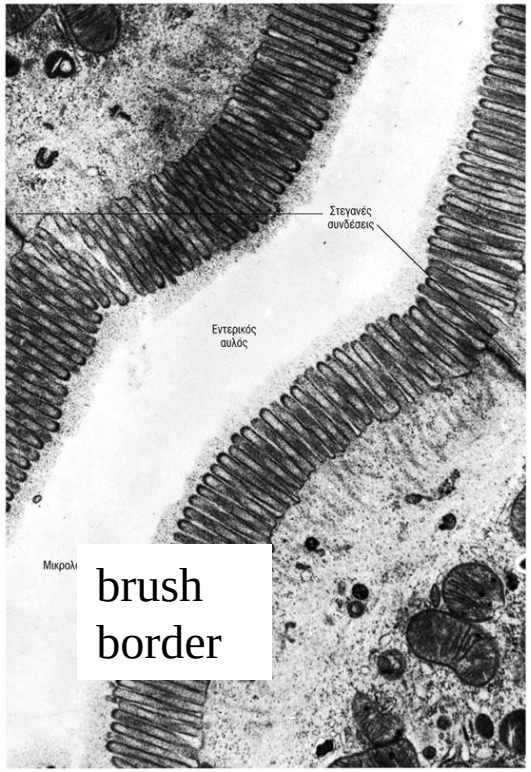
Bile is produced by the liver – stored in gall bladder – secreted in duodenum

Major component of bile: bile salts

- When the sphincter of Oddi is closed (*fasting state*) hepatic bile is diverted to the gallbladder, where it is concentrated.
- During the *fed state*, the gallbladder contracts (mostly due to cholecystokinin), expelling large quantities of bile into the duodenum.
- Bile contains *bile salts* - essential for fat digestion and absorption.

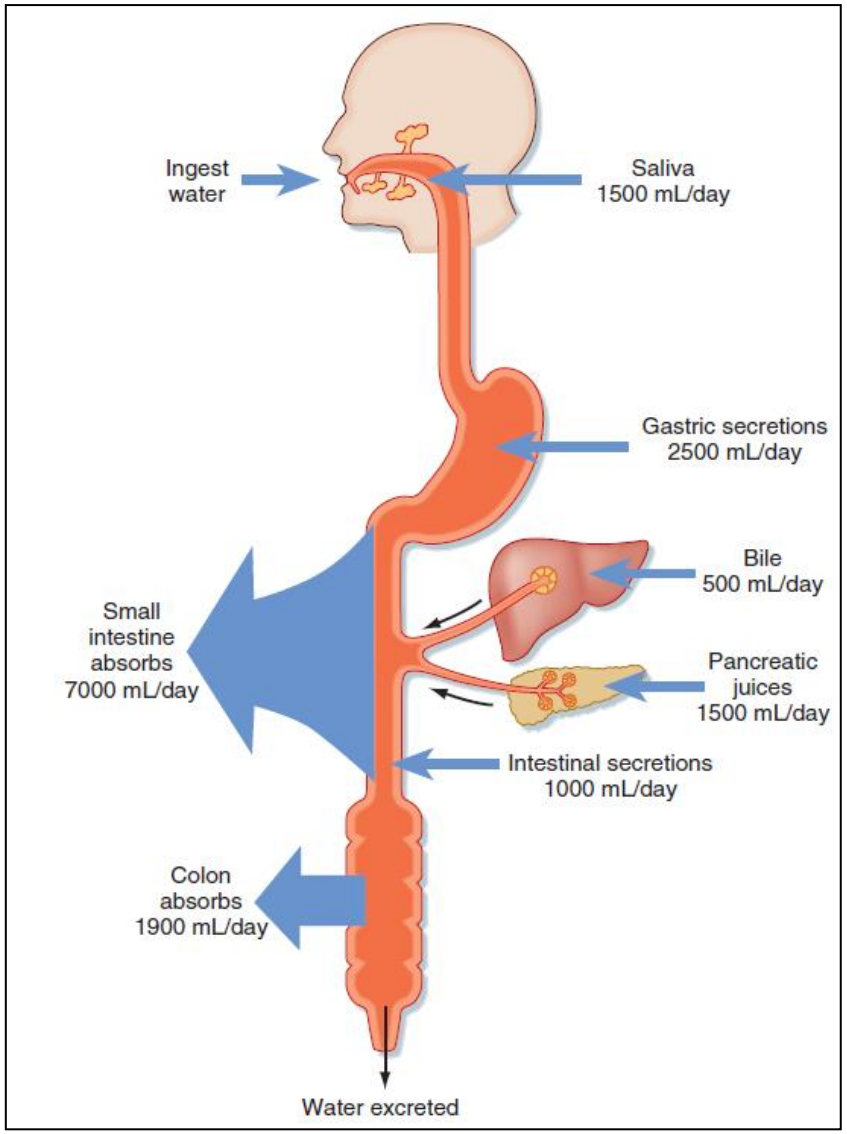
Epithelial cells of the intestine





The epithelial cells of the intestine (enterocytes, absorptive intestinal cells) contain microvilli on their apical membrane – *brush border*

Brush border enzymes of epithelial cells.

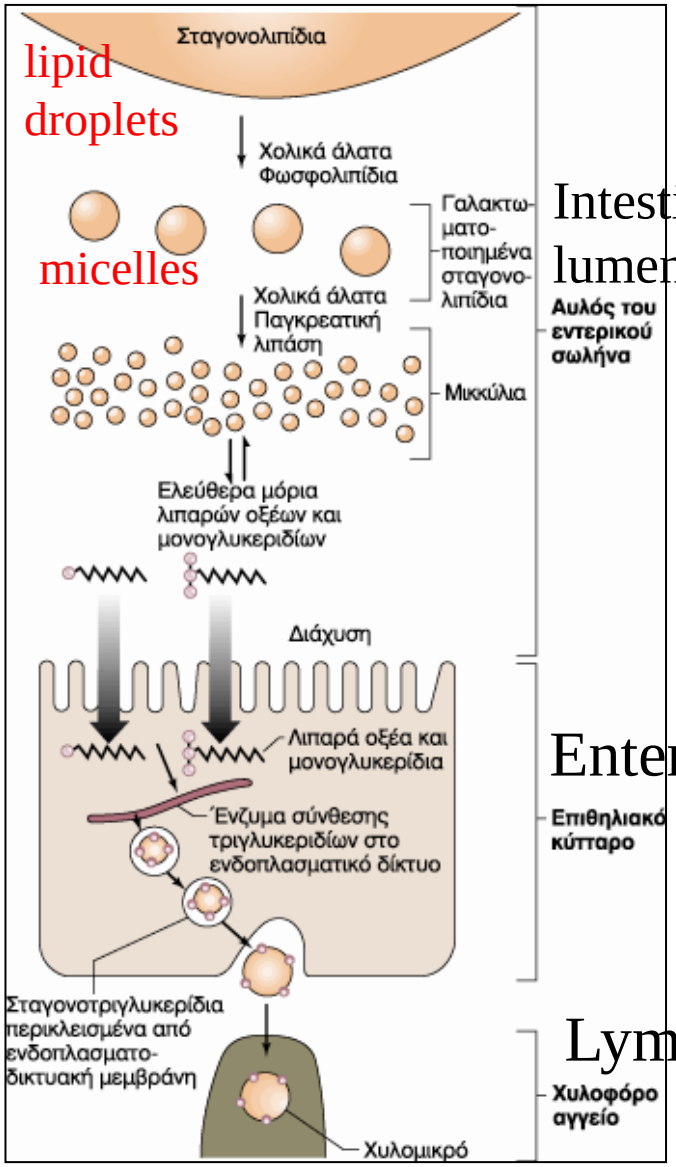


- 8,2 lt of fluid enter the GI tract – only 100ml are lost in the feces

- Absorption of electrolytes (Na^+, K^+, Cl^-) and water in the small and large intestine – fluid balance in the GI tract

- Absorption of nutrients (carbohydrates, fat, proteins) in the small intestine

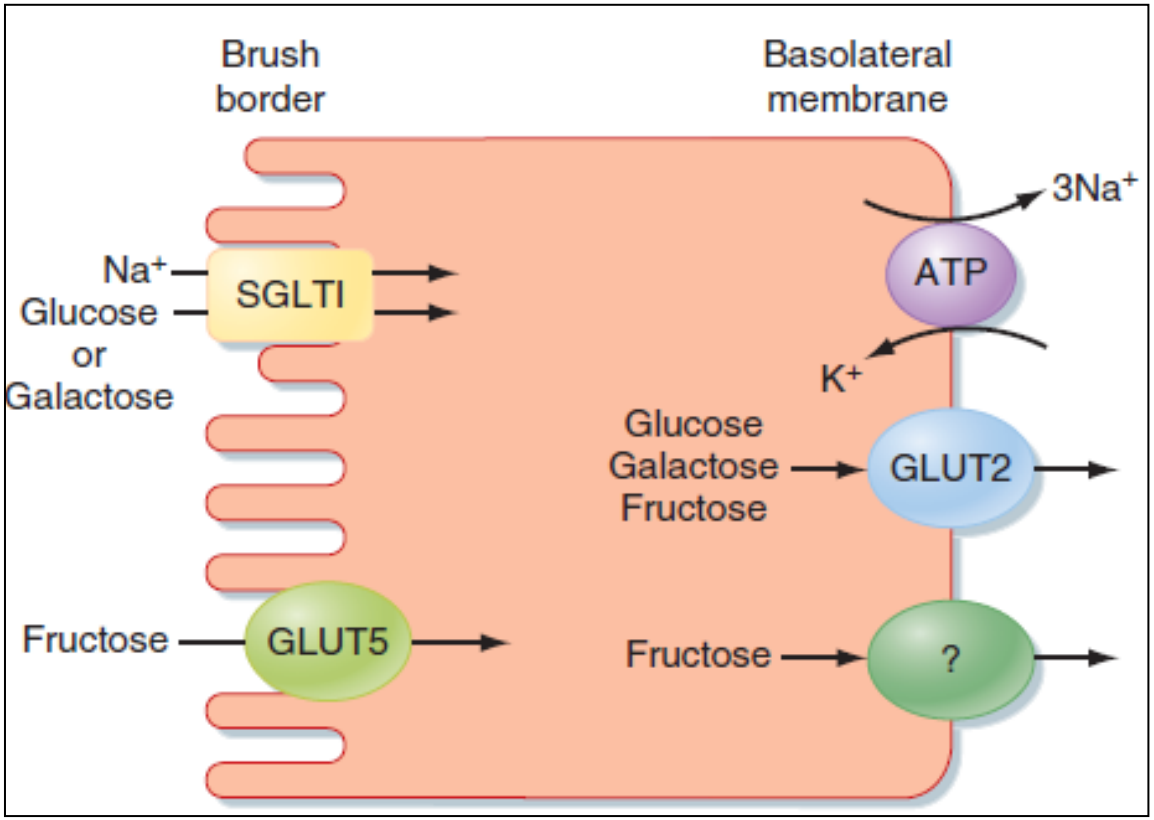
Digestion and absorption of lipids



- Fat is not water soluble
- Formation of *lipid droplets* and *micelles with bile salts* (bile)
- Pancreatic lipase digests *triglycerides* (fat)
- Fat digestion products absorbed from micelles into the enterocytes
- Absorption of triglycerides into the blood

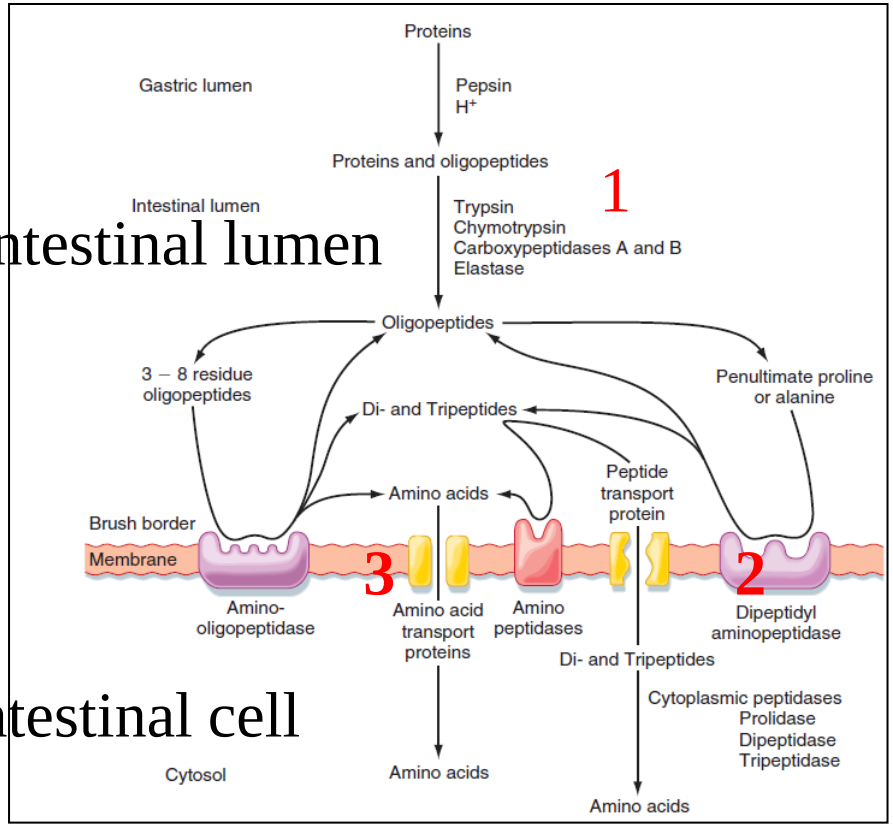
Digestion and absorption of carbohydrates

Carbohydrates in food : starch (bread), sucrose (sugar) and lactose (milk)



- Amylase (from pancreas) and brush border enzymes digest carbohydrates
- Carbohydrates are digested into monosacharides (glucose, galactose, fructose)and absorbed in the blood
- Low activity of the enzyme that breaks down lactose from milk leads to lactose intolerance

Protein digestion and absorption



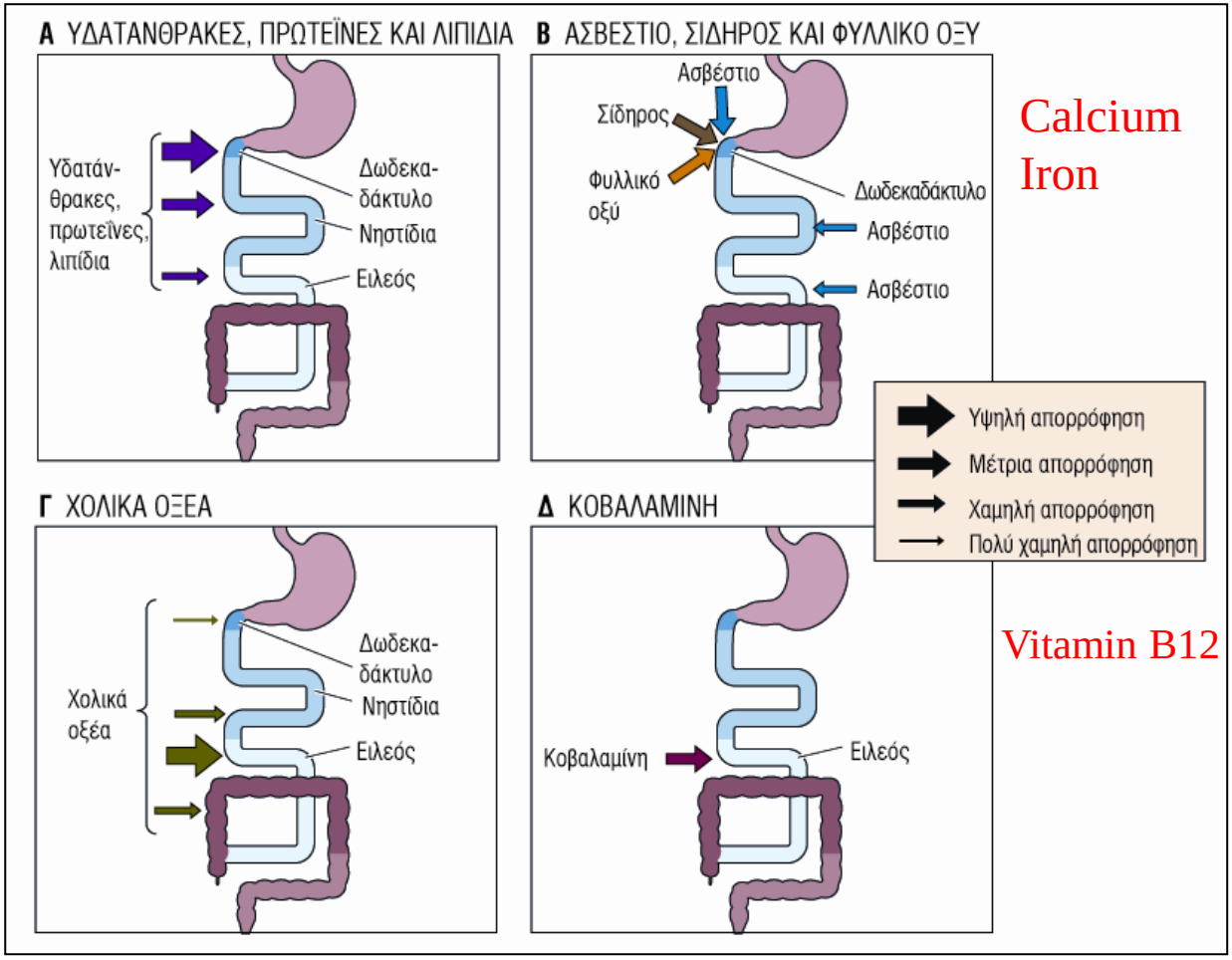
The major enzymes involved in the digestion of proteins are secreted by the pancreas in inactive forms [1].

Protein digestion continues with brush border enzymes of the intestinal cells [2]

Digested proteins leave the intestinal cell as amino acids [3].

Absorption of minerals and vitamins

Carbohydrates, proteins, fat



Calcium
Iron

Vitamin B12

Carbohydrates, proteins and fat are absorbed in the duodenum and the first region of the jejunum.

Calcium and iron are actively absorbed mainly in the duodenum.

Vitamin B12 is absorbed in the ileum with intrinsic factor.