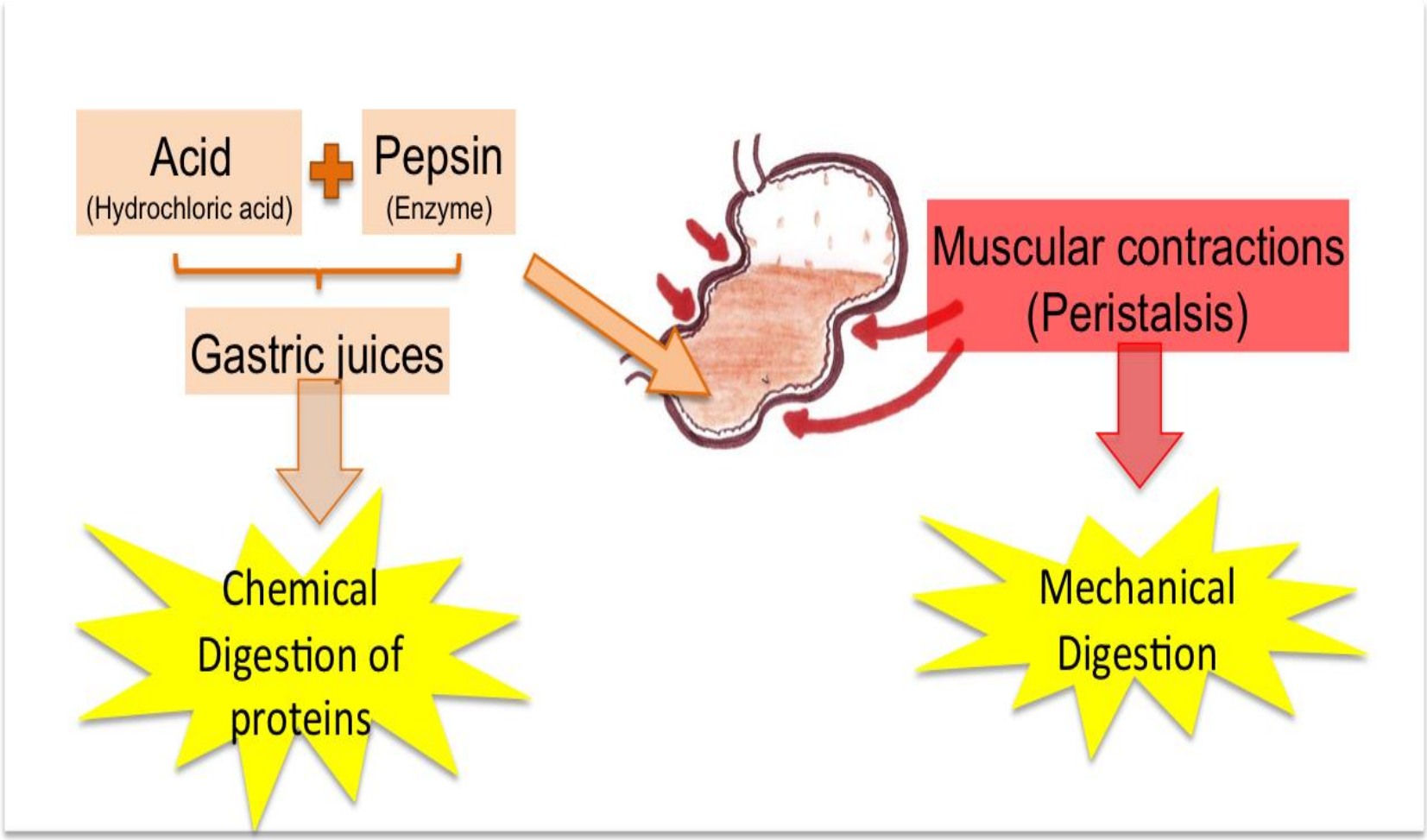
Digestion and Absorption

Digestion and Absorption

- **Digestion is a process essential for the conversion of food into a small and simple form.**
  - **Mechanical digestion** by mastication and swallowing
  - **Chemical digestion** by enzymes
- **Absorption is the process of transporting small molecules from the lumen of the gut into blood stream or** lymphatic vessel.

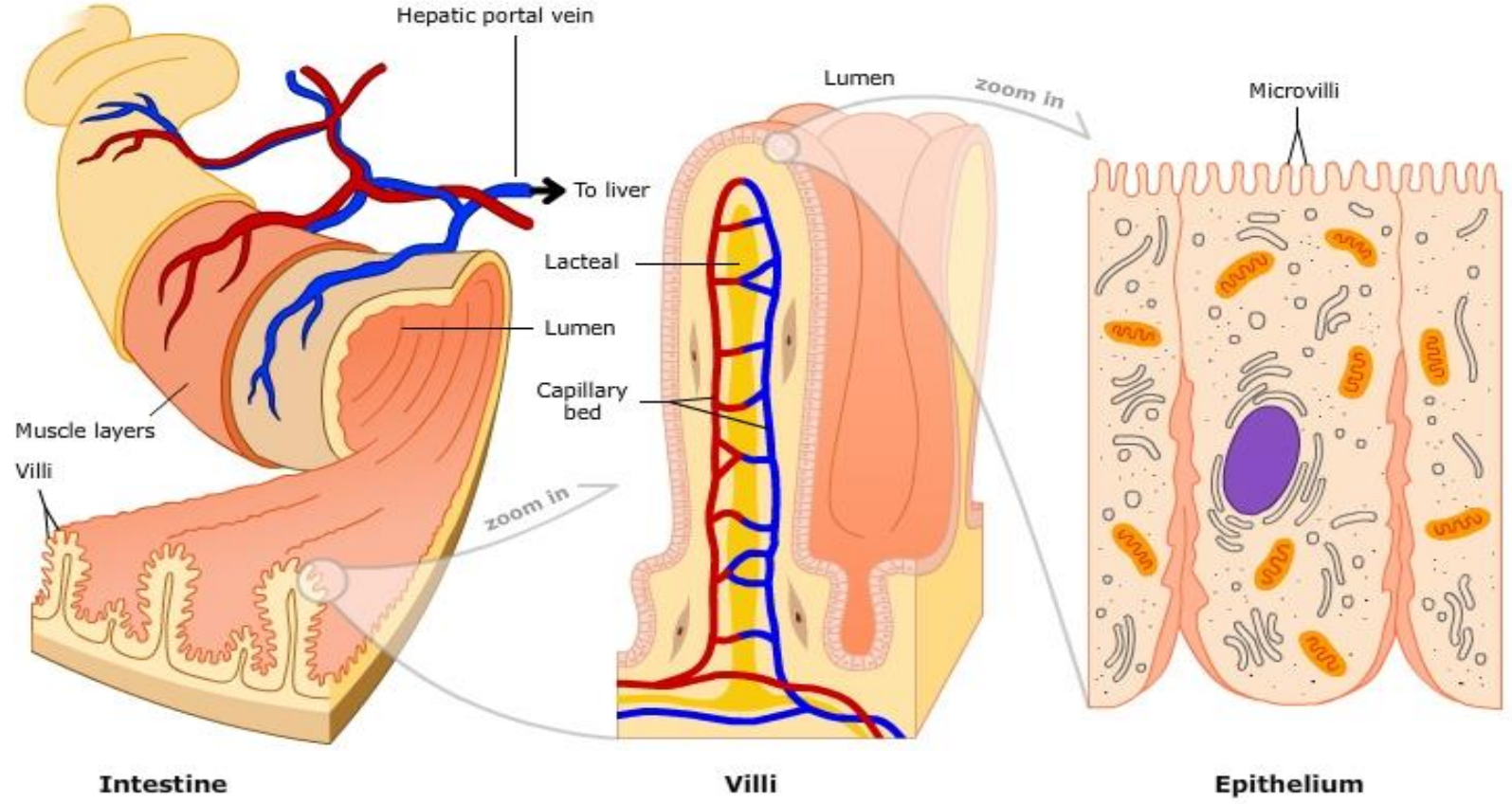
Chemical and Mechanical Digestion



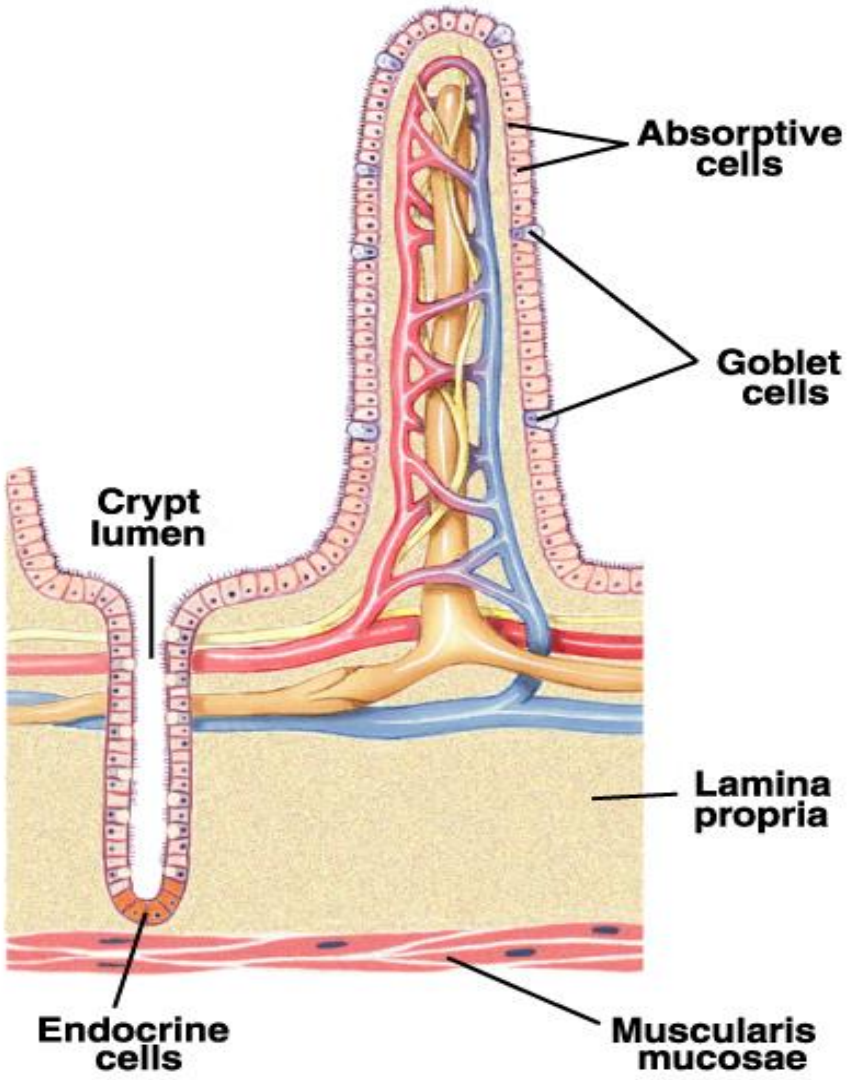
Digestion and Absorption

- **Small intestine** is primary site **for digestion** and **absorption** of food.
- **Digestion** occurs in the GI lumen by **secreted enzymes** and on surface of enterocytes by **membrane-bound enzymes**.
- Absorption occurs by **simple diffusion**, **facilitated diffusion**, **active transport**, **endocytosis**, and **paracellular transport**.
- **Surface area** of small intestine is greatly increased by extensive **folding** and the projection of **fingerlike villi** covered with **microvilli**.

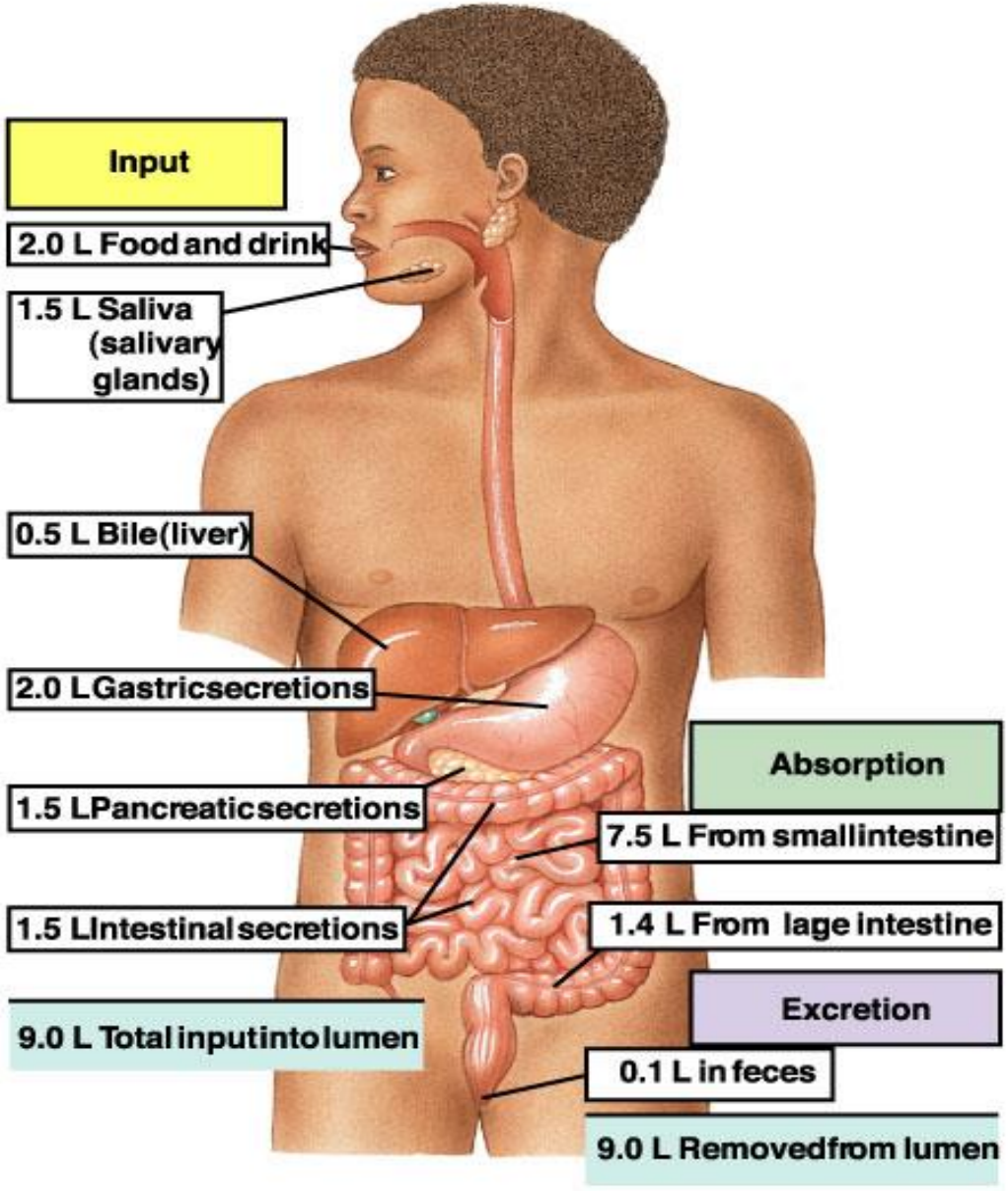
Intestinal Mucosa



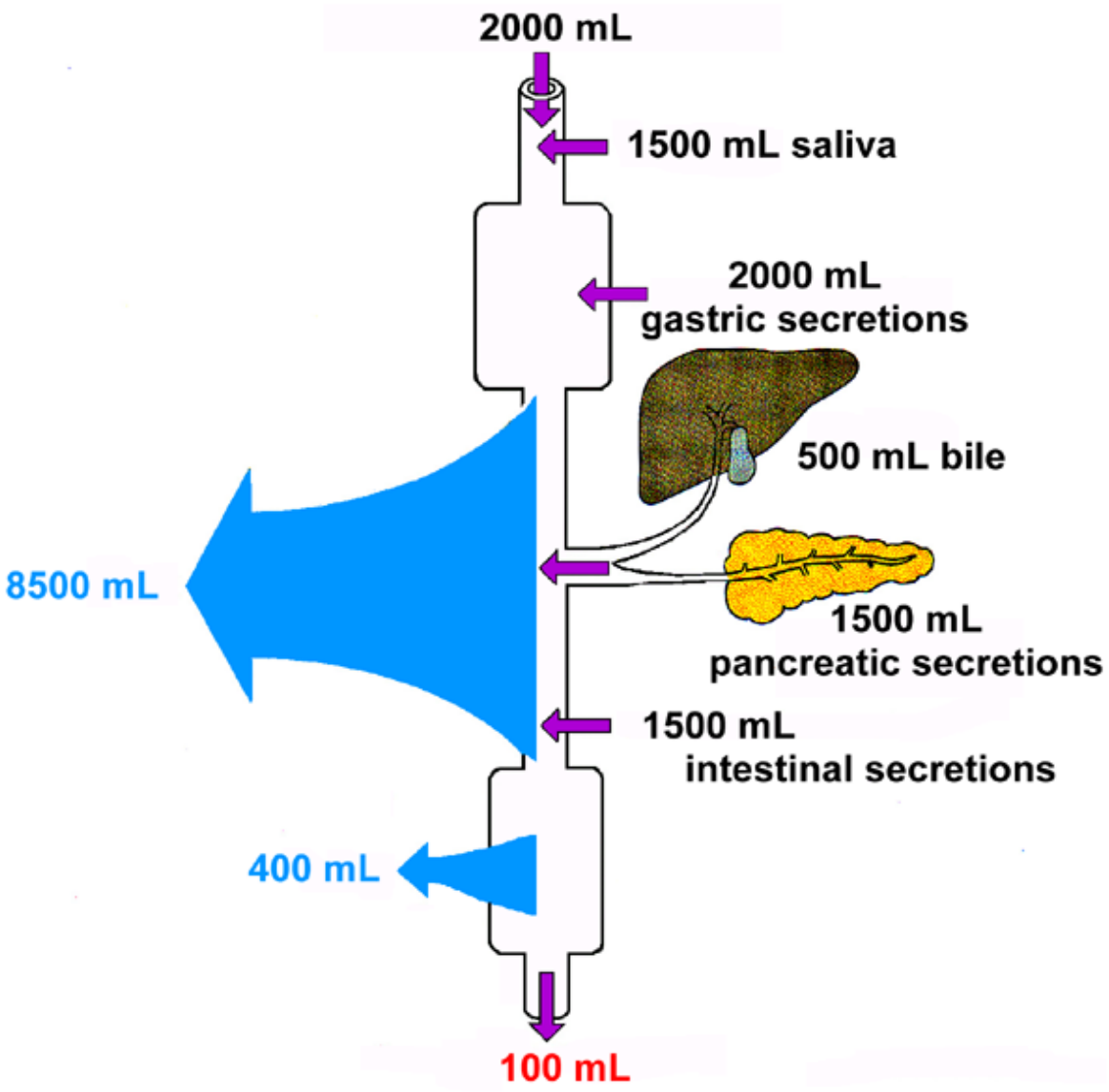
Intestinal Villi



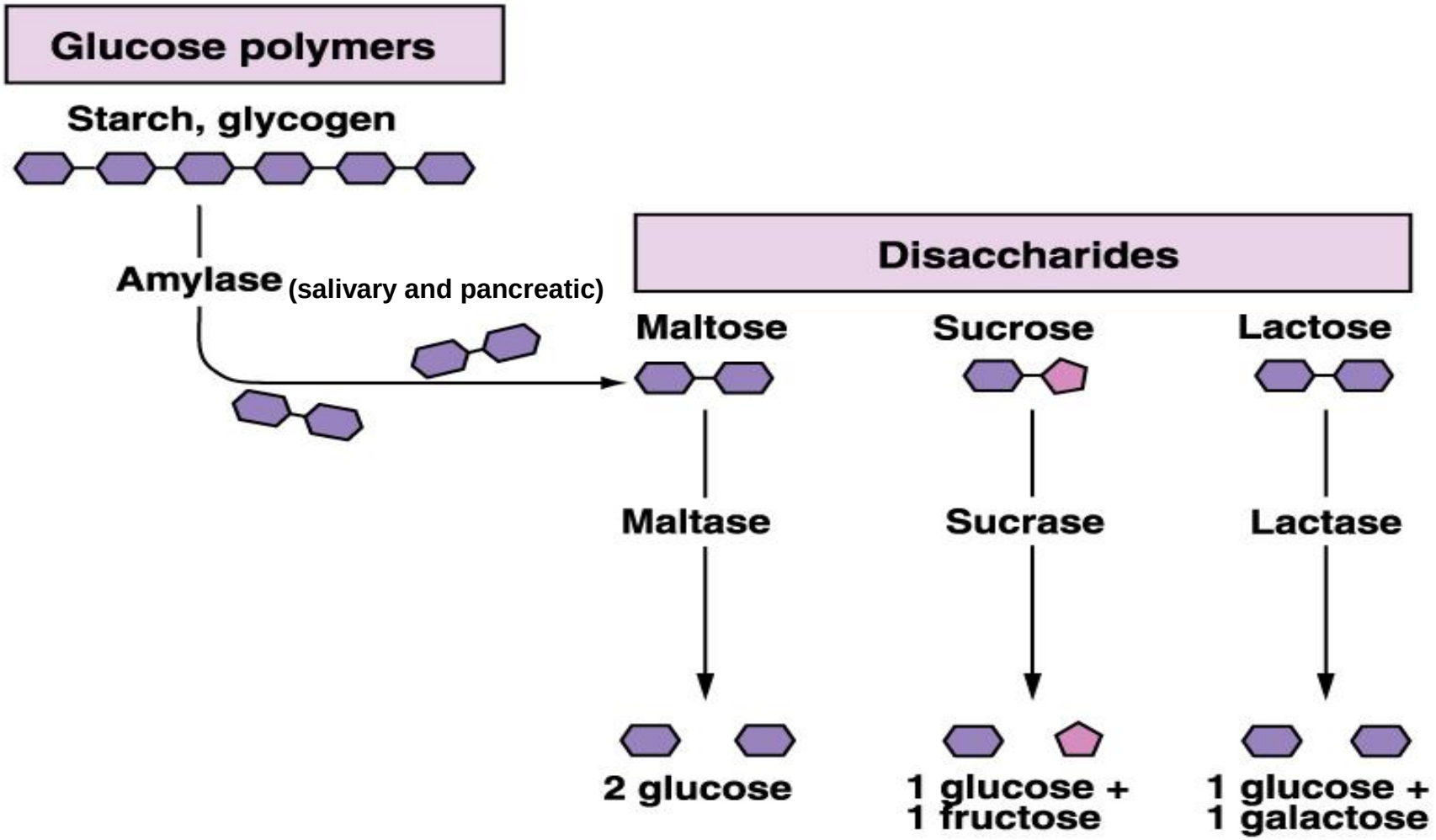
Absorption of Water



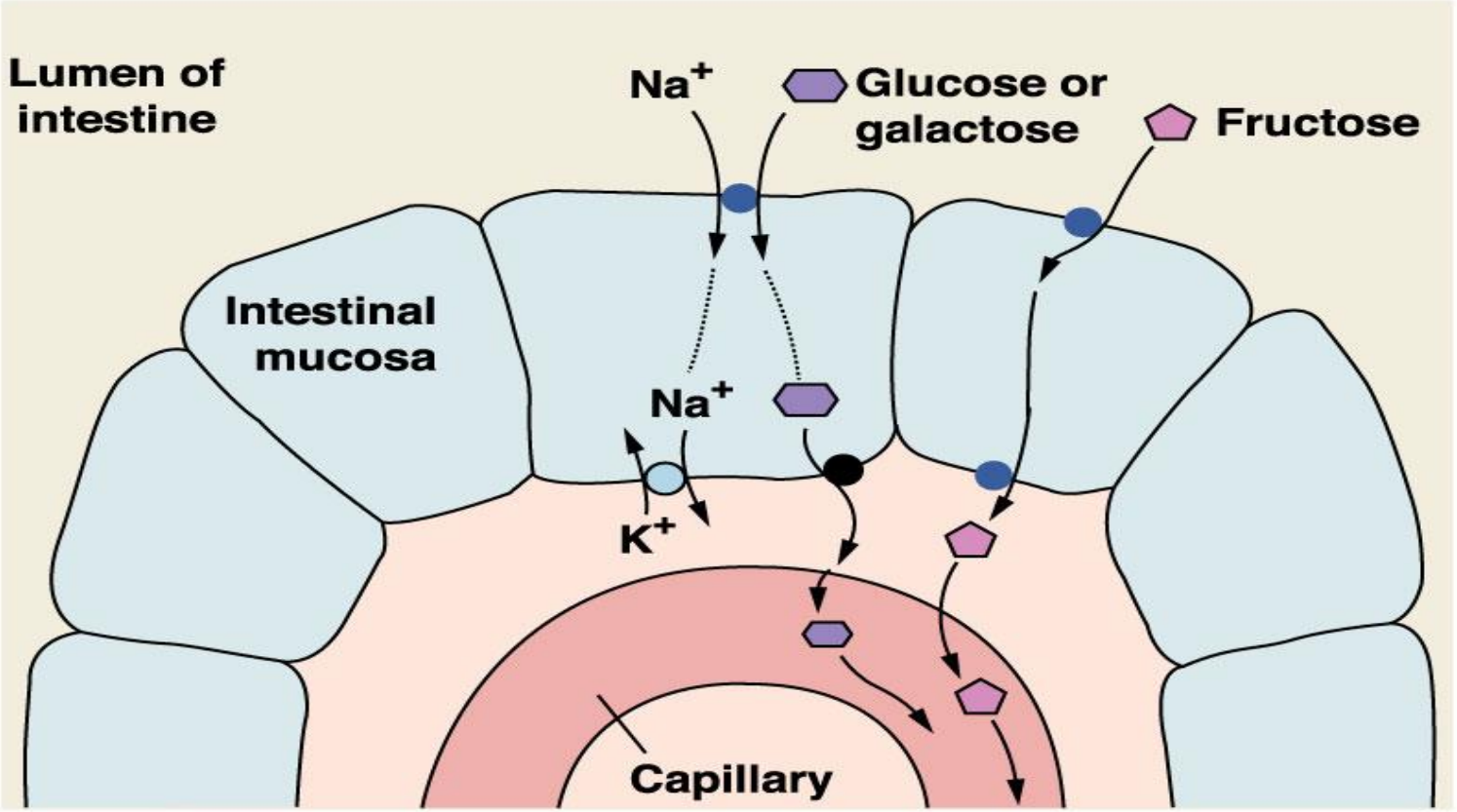
Absorption of Water



Digestion of CHO



Absorption of CHO



Enterocytes absorb **glucose and galactose** through an **Na-dependent secondary active transport process**, while **fructose** is absorbed by **facilitated transport**.

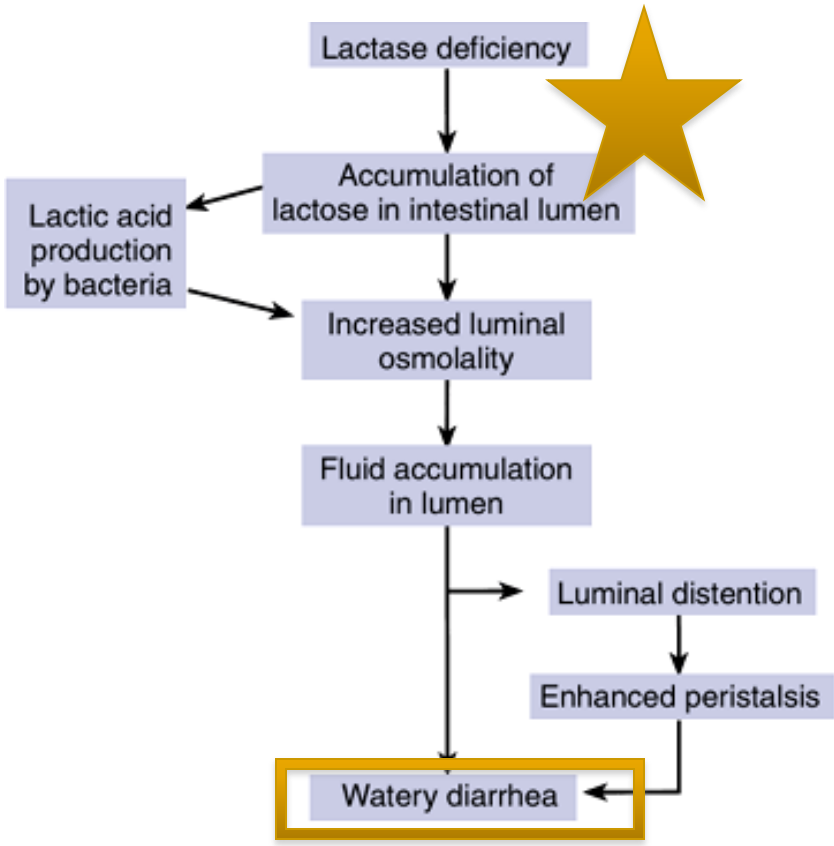
LACTOSE INTOLERANCE

- **Failure to produce lactase**
  - Undigested lactose enters the large intestine where it is fermented by the bacteria resulting in gases

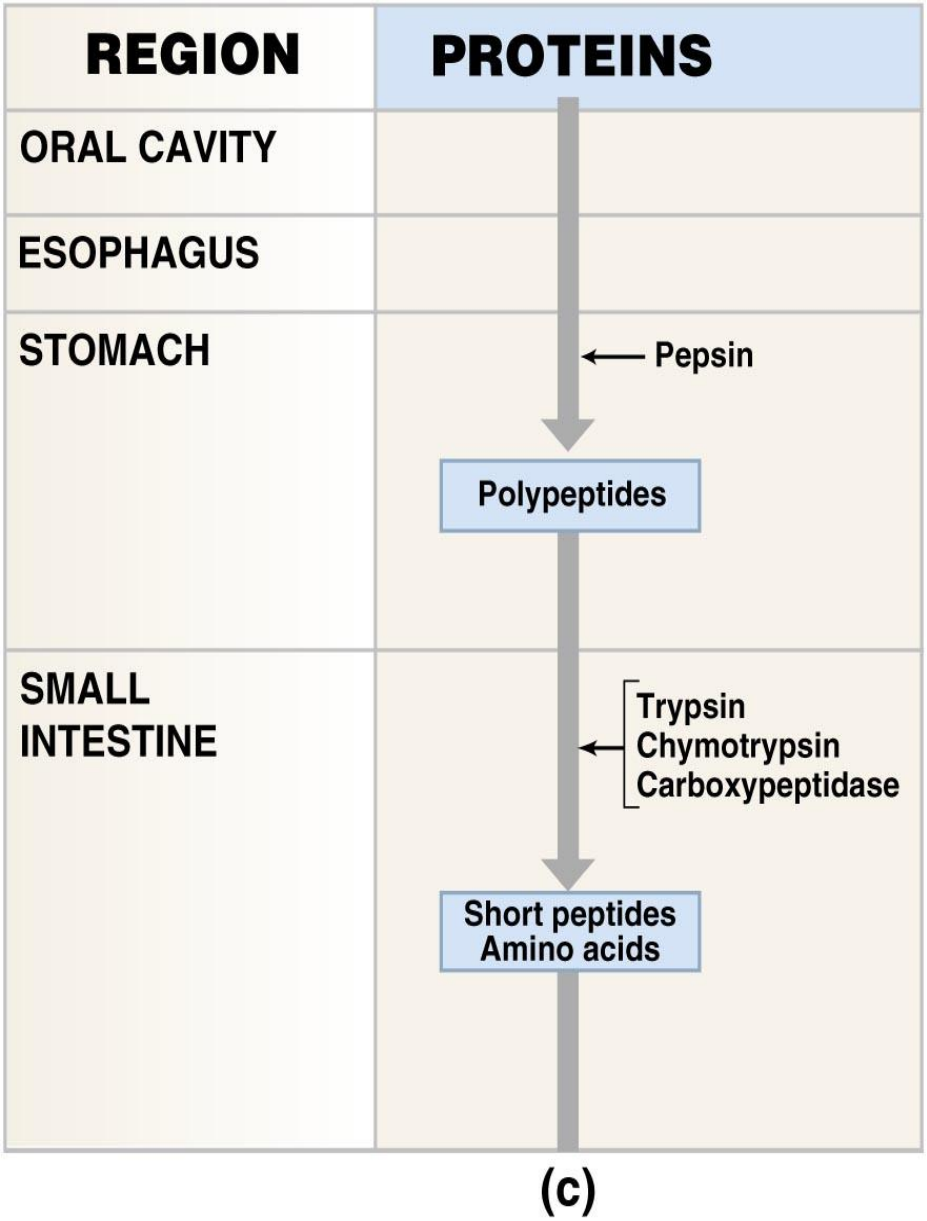
- **<u>Symptoms and signs</u>** include osmotic diarrhea (large volume, watery, no blood, improves with fasting), gas bloating, and abdominal cramps

- **Avoiding diary products** is helpful

- **Supplemental lactase** can be used



Digestion and absorption of proteins



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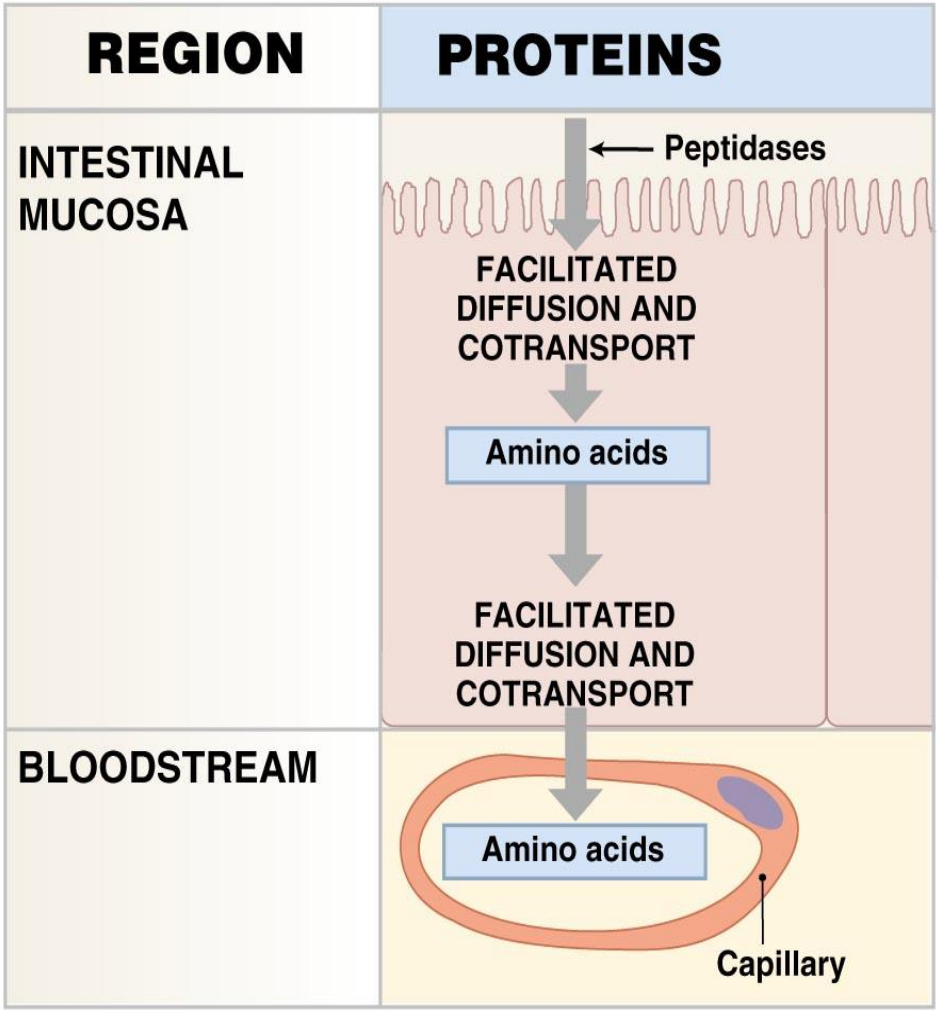
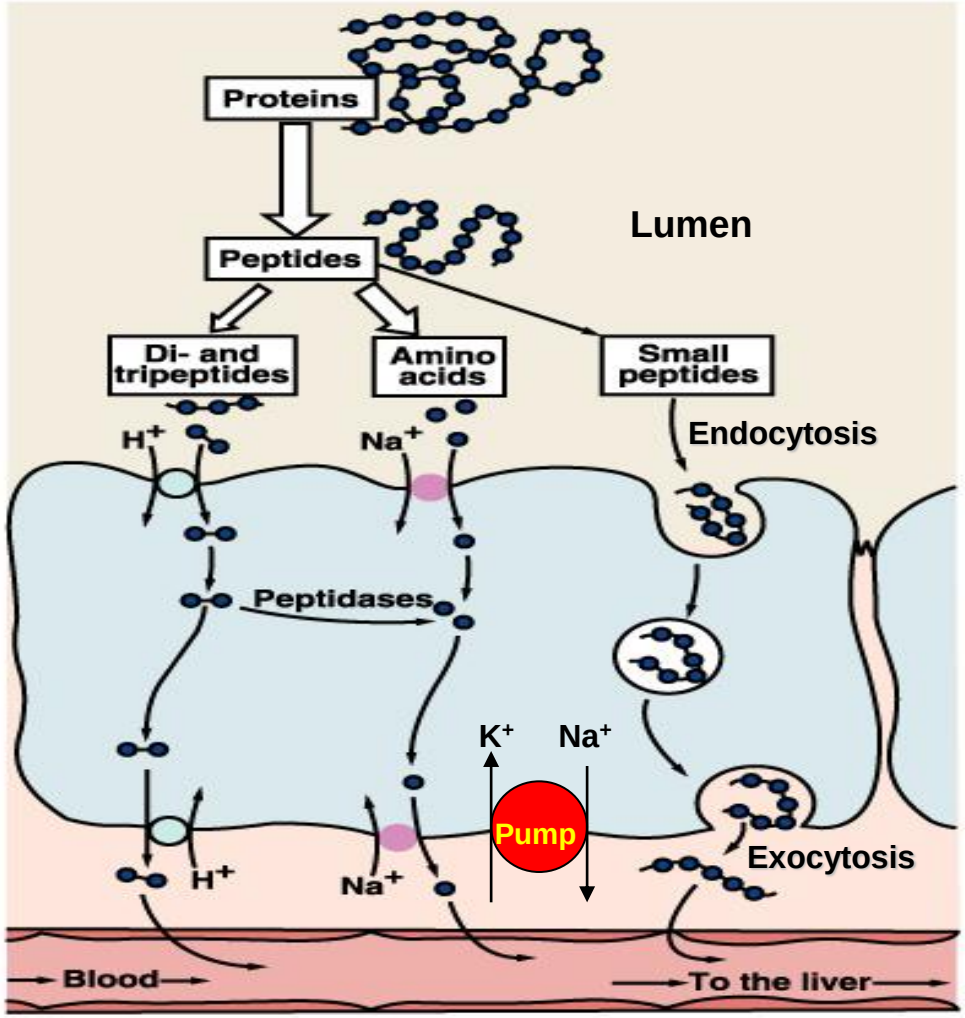


(c)

Absorption of proteins

- The whole proteins by **endocytosis**
- Amino acids and di and tripetides by **Na-dependent 2ry** active transport



DISORDERS

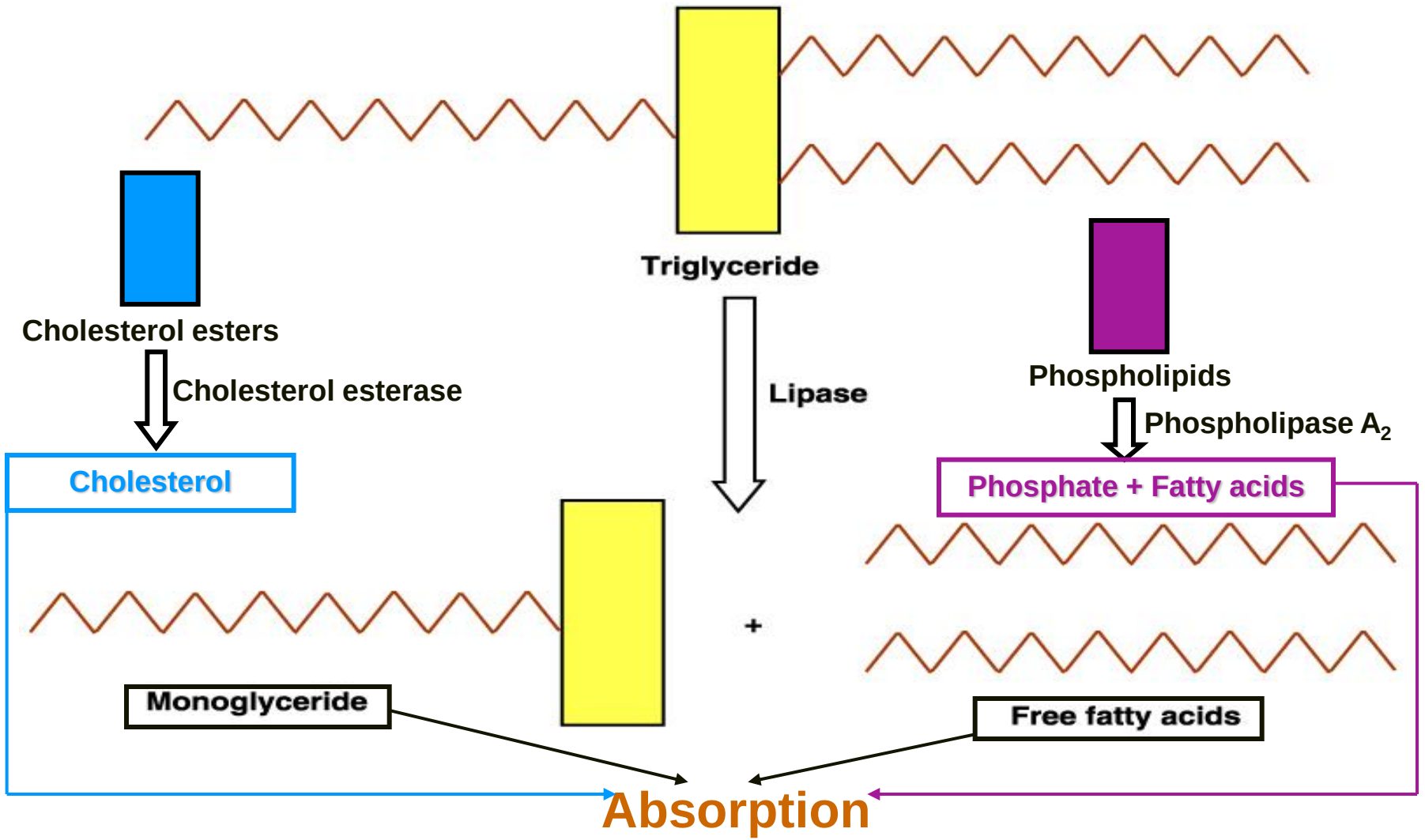
Acute/chronic pancreatitis

- Results from **inflammation or destructive autodigestion** of pancreas
- **Pancreatic duct blockage** causes loss of trypsin inhibitor and activation of proteolytic enzymes
- Results in **deficiency in pancreatic enzymes** (including proteases), **high serum amylase**

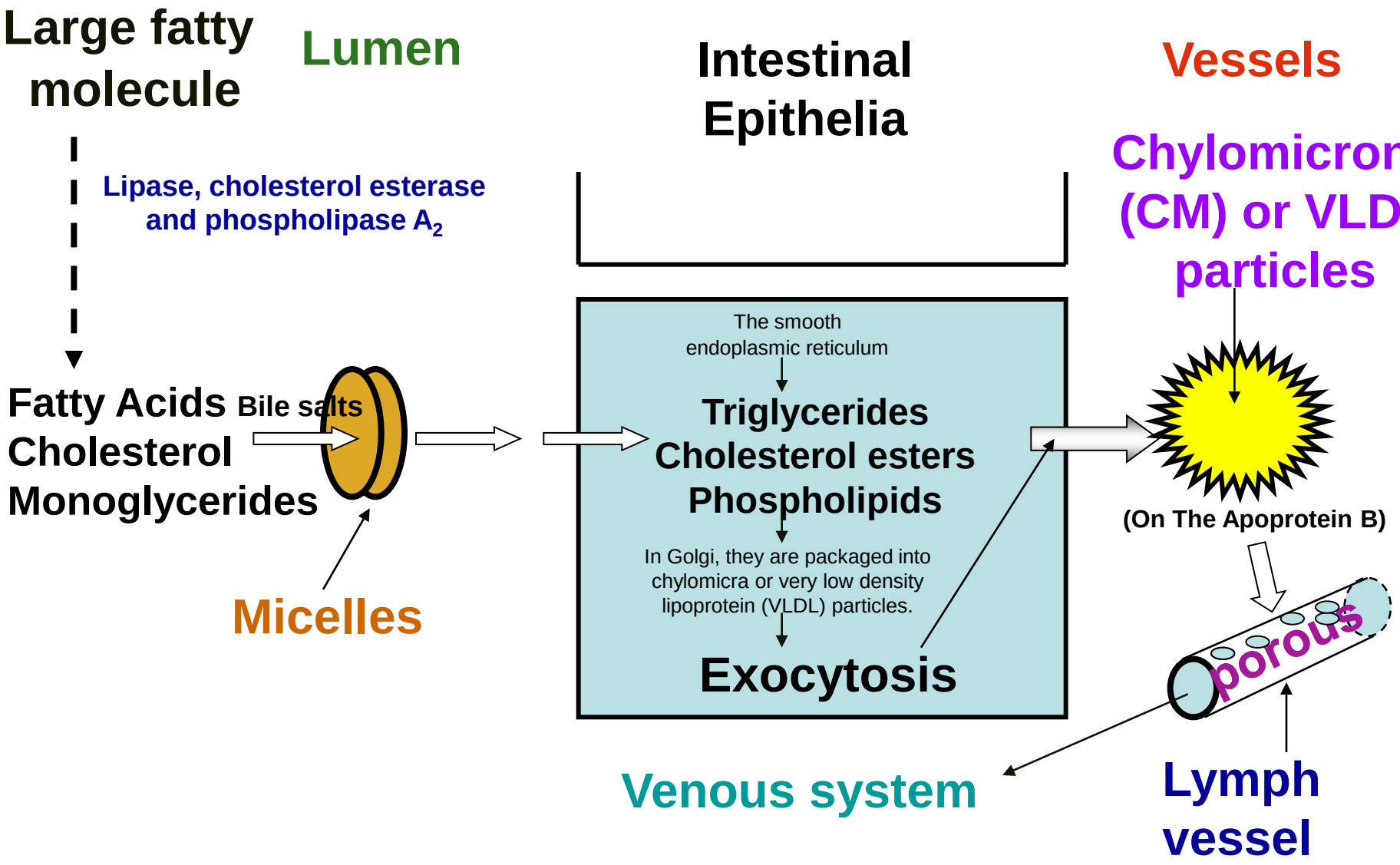
Cystic fibrosis

- **In the GIT**: failure to secrete bicarbonate and water, decreased Na+ reabsorption, intestinal obstruction by thick mucus, pancreatic insufficiency, hepatic cirrhosis, steatorrhea,

Digestion of fats



Absorption of Lipids



Absorption of Fats in the Small Intestine

ABNORMALITIES:LIPID DIGESTION & ABSORPTION

- **Pancreatic insufficiency** (chronic pancreatitis, cystic fibrosis)
- **Increased acidity** of duodenal contents
- **Deficiency of bile salts** (i.e., ileal resection)
- **Bacterial overgrowth** (de-conjugation of bile – removal of glycine and taurine from bile salts, converting them to bile acids)
- **Tropical sprue**
  - **Malabsorption syndrome**
  - **Progressive villi atrophy** in the small intestine
  - **Impairment in lipid digestion**
  - Hypothesized etiology - a **still-undefined infection**.
  - Is **endemic** in India, Southeast Asia, Africa, the Philippines, and certain Caribbean islands
- **Failure to synthesize apoproteins** (affects formation of chylomicrons) (abetalipoproteinemia). **Abetalipoproteinemia results in the absence of apo-B containing lipoproteins in the plasma (chylomicrons, LDL, VLDL), accumulation of lipid droplets in the cytoplasm of enterocytes and deficiency of fat-soluble vit.**

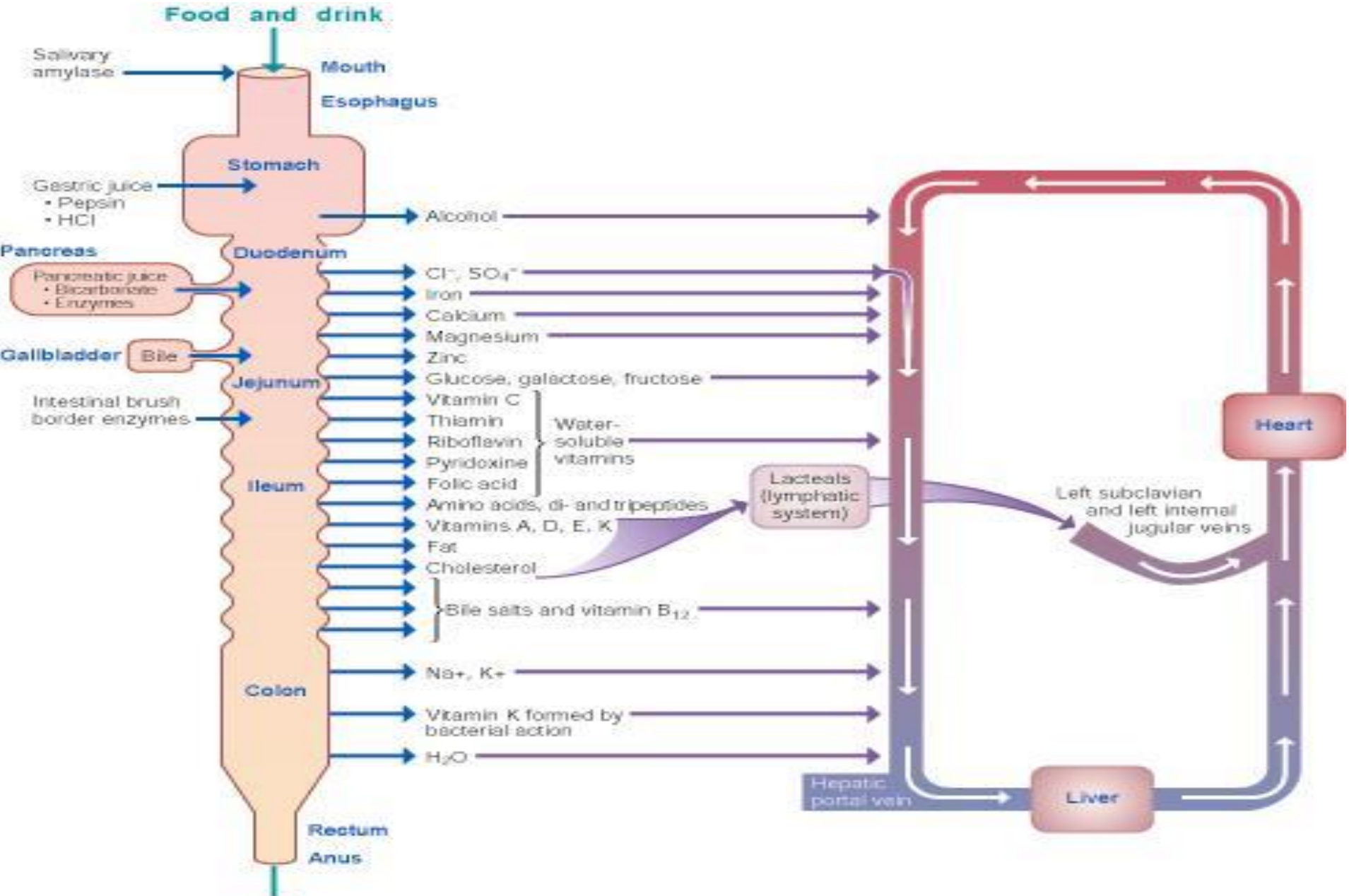
CELIAC SPRUE(GLUTEN-SENSITIVE ENTEROPATHY)

- A common disease, which involves a **primary lesion of the intestinal mucosa**
- Is caused by the **sensitivity of the small intestine to gluten** – water soluble protein (present in wheat, barley, oats, etc,)
- Gluten or products of its digestion **interact with intestinal mucosa and cause its lesion** (mechanism is not known)
- **Consequences**
  - **↓ area available for reabsorption**
  - **↓ production of intestinal digestive enzymes**
- **Treatment**: gluten-free diet

A Summary of Digestion of Carbohydrates, Proteins and Lipids

	(a) Carbohydrate digestion	(b) Protein digestion	(c) Nucleic acid digestion	(d) Fat digestion
Oral cavity, pharynx, esophagus	Polysaccharides (starch, glycogen) ↓ **Salivary amylase** Smaller polysaccharides, maltose			**Lingual lipase**
Stomach		Proteins ↓ **Pepsin** Small polypeptides		**Gastric lipase**
Lumen of small intestine	Polysaccharides ↓ **Pancreatic amylases** Maltose and other disaccharides	Polypeptides ↓ **Trypsin, Chymotrypsin** Smaller **Aminopeptidase, Carboxypeptidase** Amino acids	DNA, RNA ↓ **Nucleases** Nucleotides	Fat globules ↓ **Bile salts** Fat droplets (emulsified) **colipase** ↓ **Lipase** Glycerol, fatty acids, glycerides
Epithelium of small intestine (brush border)	↓ **Disaccharidases** Monosaccharides	Sm **Aminopeptidase,** ↓ **Dipeptidases** Amino acids	↓ **Nucleotidases** Nucleosides ↓ **Nucleosidases** Nitrogenous bases, sugars, phosphates	

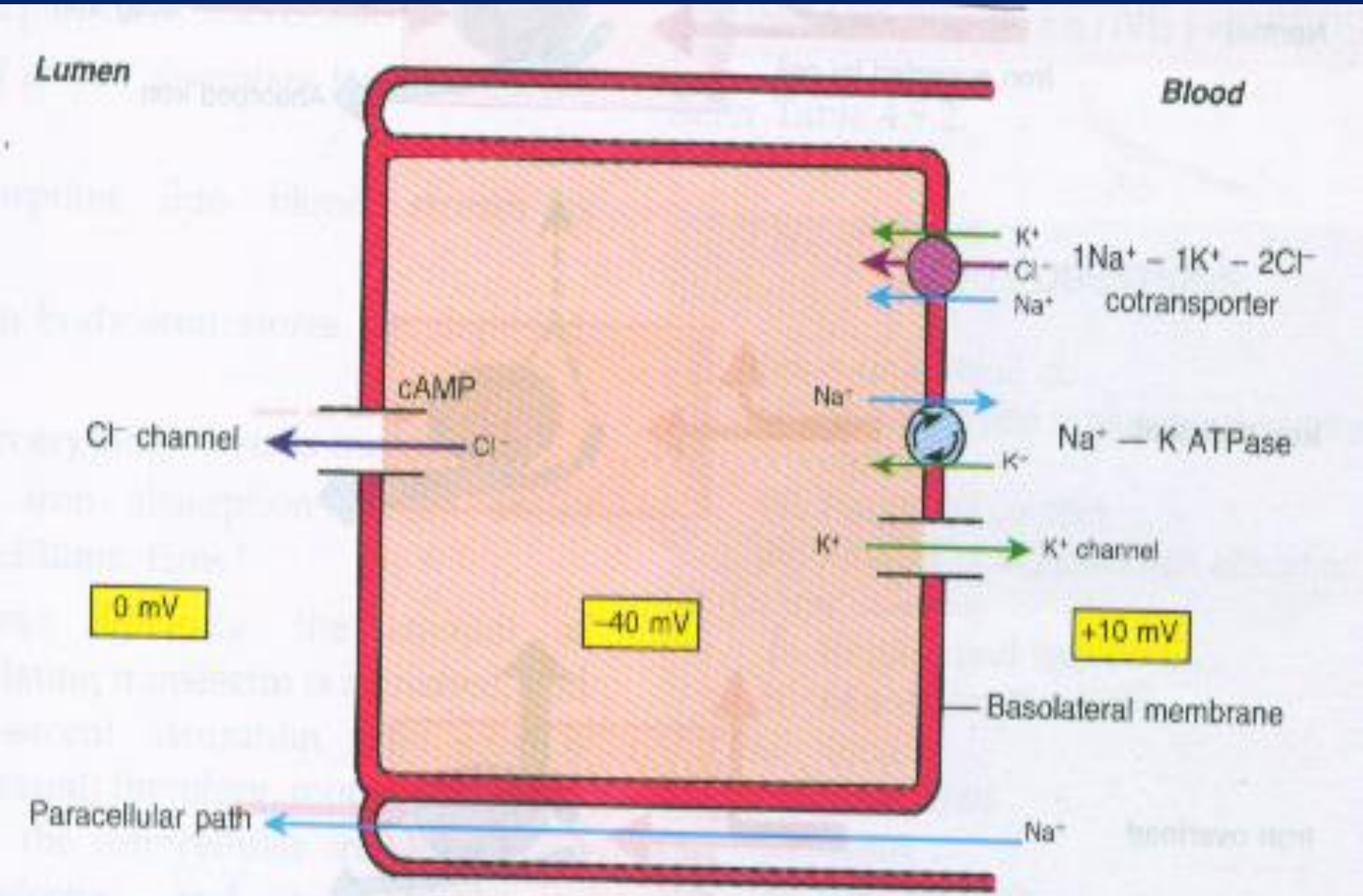
Sites of Secretion and Absorption into Gastrointestinal Tract



ABSORPTION OF OTHER SUBSTANCES

Substrate	Absorption
Na+	Na+ channels, cotransport with AA, glucose, Cl-; Na/H countertransport (role of **aldosterone**)
Cl-	Na-Cl cotransport, Cl/HCO3 countertransport; Cl is also **secreted** into the lumen (**cAMP, cholera toxin**)
Vitamins A, D, E, and K	Lipid soluble and take up in **micelles** (SI)
Water soluble vitamins	**Na+ dependant co-transport** in the SI
Vitamin B 12 combines with IF	Active transport mechanism in the **distal ileum**
Alcohol	In the stomach and SI (depends on the rate of gastric emptying); **gastric alcohol dehydrogenase**
Water	**Osmosis** (mainly in the SI) -95-98%

Absorption of electrolytes



Absorption of vitamins & minerals

Vitamins

- Water soluble – absorbed rapidly
- Fat soluble (A,D,E & K) – decreases if fat absorption decreases
- Vitamin B_{12} binds to intrinsic factor (I.F) – Vit B_{12} – IF complex is absorbed in the ileum

Calcium

- Normal intake – 1gm / day
- 30 – 80% of ingested Ca^{2+} is absorbed by active transport in upper small intestine (some also by passive)

- Factors affecting:

  - Facilitated by
    - DHCC (dihydroxycholecalcifereol)
    - Lactase
    - proteins
  - Inhibited by
    - Phosphate
    - oxalates

Iron

- Total iron in body : 4-5 gms
  - 70% in hemoglobin
  - 3% myoglobin
  - 27% ferritin
- Average Iron intake ~ 20-25 mg / day
- Iron absorbed is ~ 3-6 % of ingested amount
- Amount absorbed = loss

- Readily absorbed in ferrous (Fe^{2+}) state
- Most dietary iron is in ferric form (Fe^{3+})
- Fe^{3+} reduced by HCl to Fe^{2+}
- Absorption is an active process
- Absorbed in upper small intestine (duodenum & jejunum)
- Iron bound to iron binding protein (apoferritin) to form ferritin
- Ferritin is the principle storage form of iron in intestine & many tissues

- Hemosiderosis – iron overload, leading to accumulation of hemosiderin in tissues
- The tissue damage by hemosiderin - Hemochromatosis
  - Skin pigmentation
  - Pancreatic damage (Bronze diabetes)
  - Cirrhosis of liver
  - Gonadal atrophy

Malabsorption syndrome

- Absorptive defect due to lack of digestive enzymes
- Causes :
  - **Lactose intolerance** – lactase deficiency leads to intolerance to milk
  - Biliary obstruction
  - Pancreatic disease
  - Coeliac disease & sprue
  - Extensive intestinal resection
  - Irradiation of the bowel


THANKS