

Section 5

Absorption in the small intestine



Absorption

The small molecules (digested product, water, vitamins) move from the lumen of the gut across a layer of epithelial cells (enterocyte) and enter the **blood or **lymph****



Location of absorption

- **Mouth & esophagus:** **no absorption**
- **Stomach:** **water and alcohol**
- **Duodenum/ jejunum:** **most of nutrients**
- **Ileum:** **bile salts and Vit B₁₂**
- **Large intestine:** **water, inorganic salts**

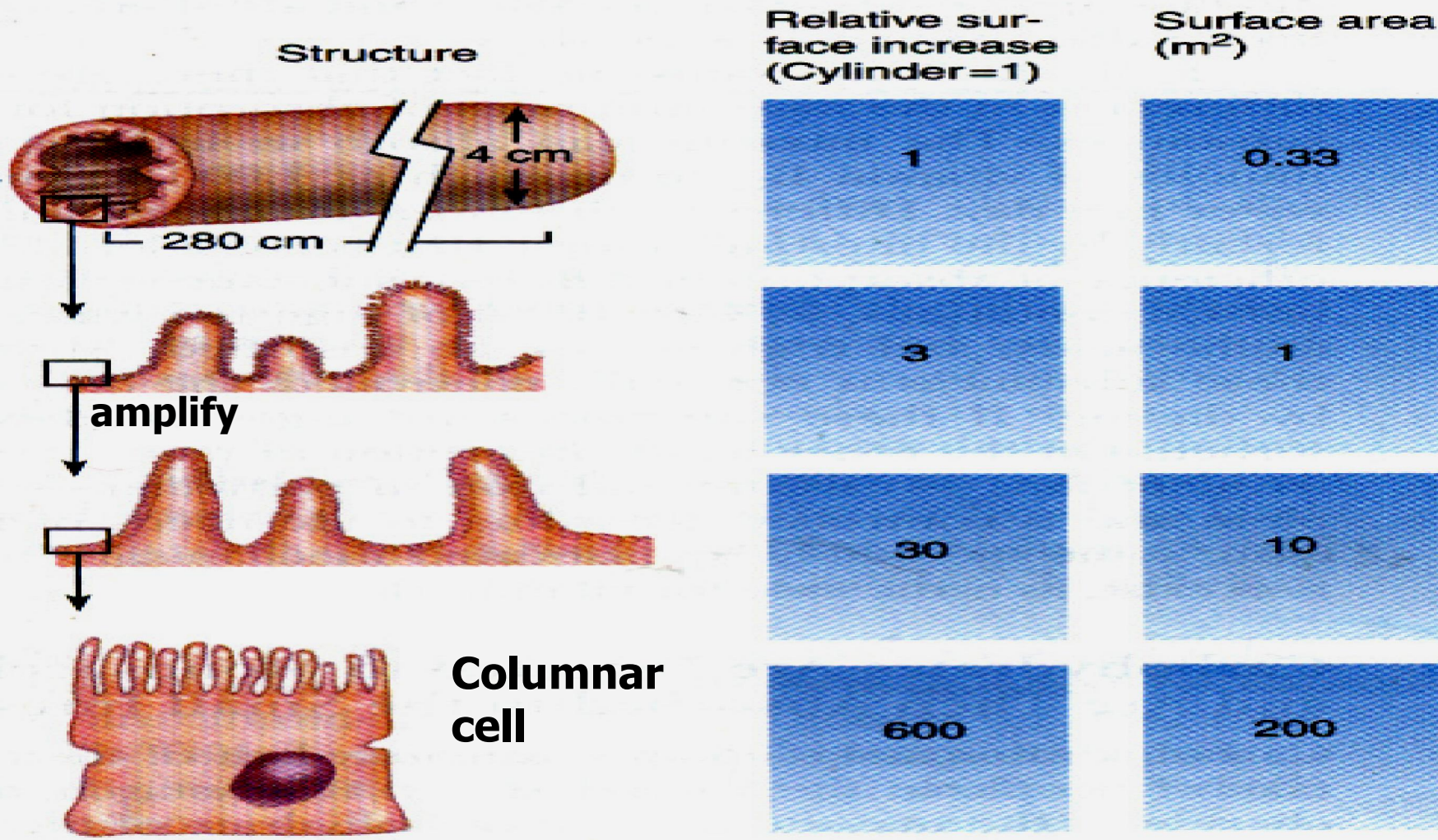
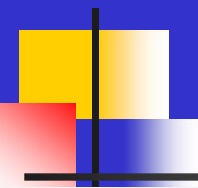


Small intestine is the main site of absorption

- (1) Food has been digested into small and absorbable molecules**
- (2) Longer residence of chyme in the small intestine (3~8h)**
- (3) Large absorptive surface: 200~250 m²
- circular folds- villi- microvilli**
- (4) Abundant network of capillaries and a lymphatic vessel in the vili**

Large absorptive surface: 200~250 m²

intestinal folds -villi- microvilli



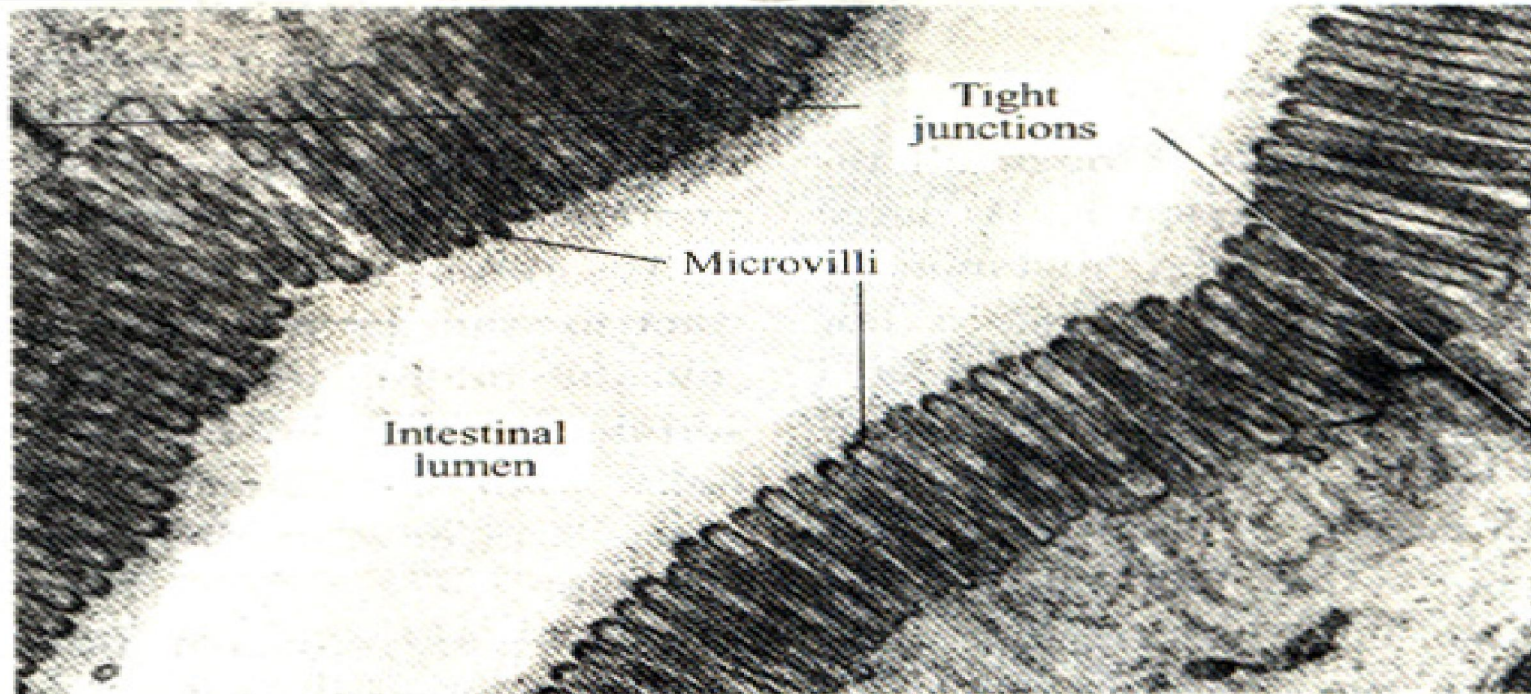
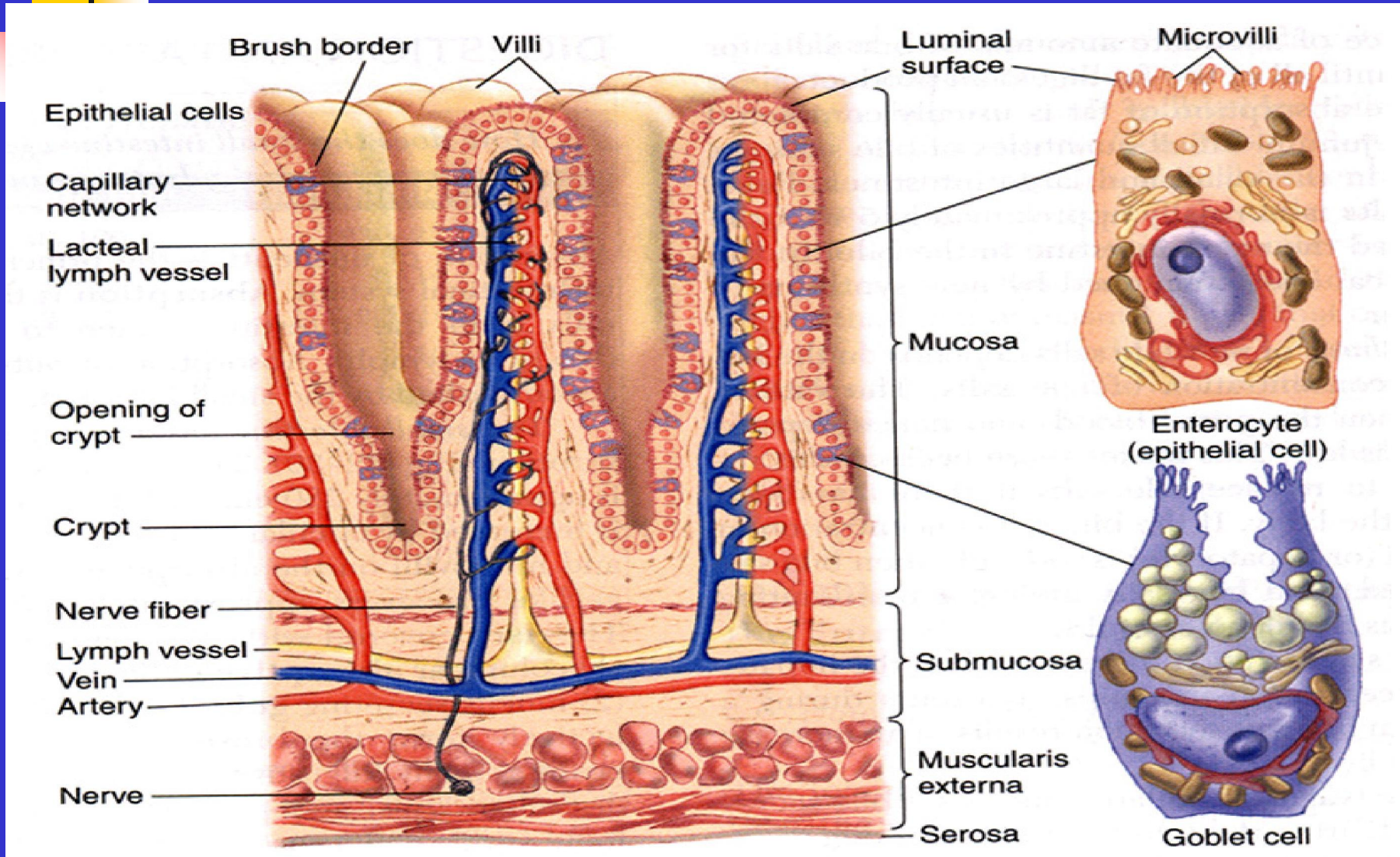


Figure 6-15 Microvilli on the surface of intestinal epithelial cells.

Brush border: Membrane digestion enzymes

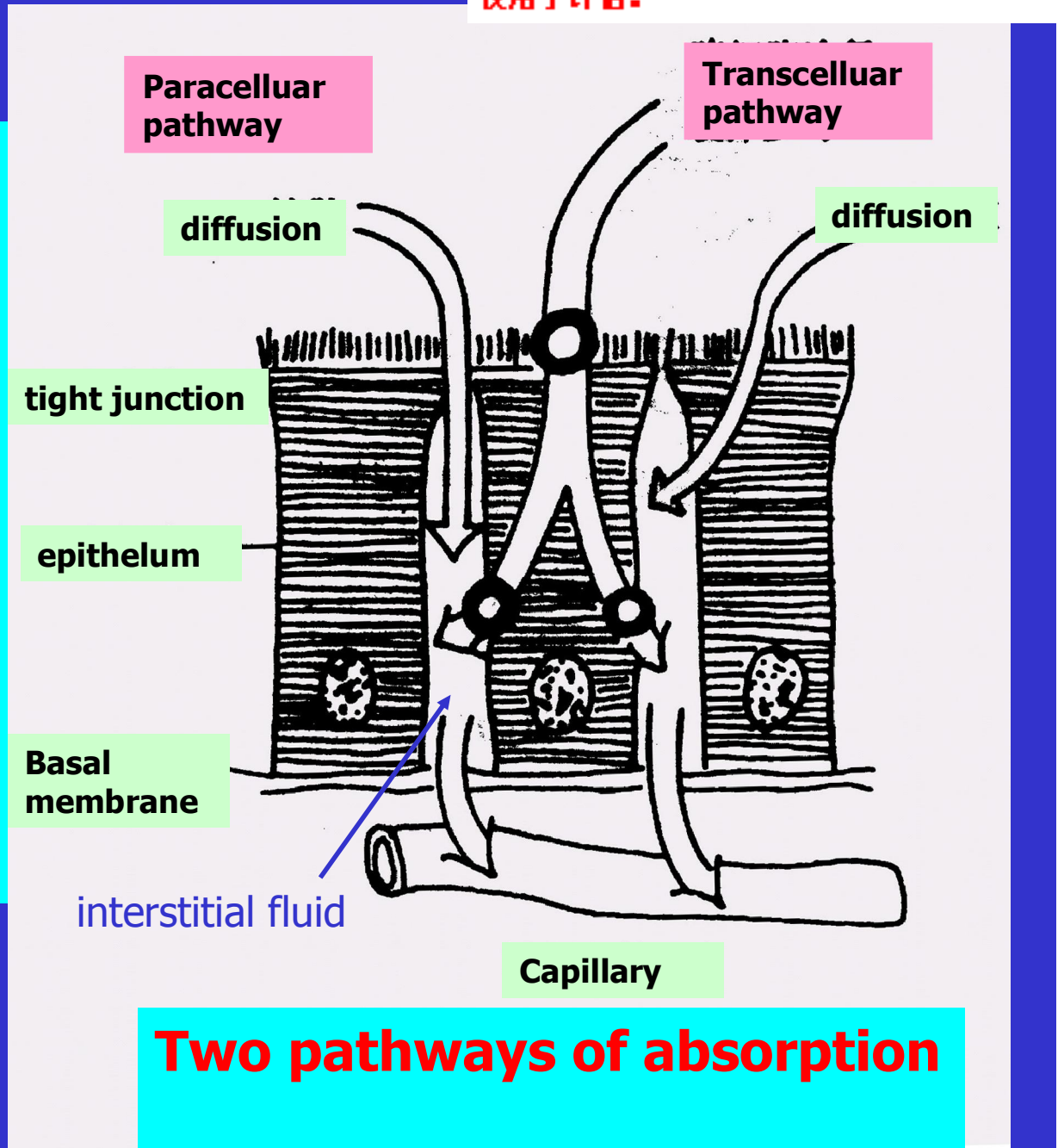
- maltase, isomaltase, sucrase, lactase, dextrinase
- peptidase

(4) Abundant network of capillaries and a lymphatic vessel in the villi



Absorption pathways

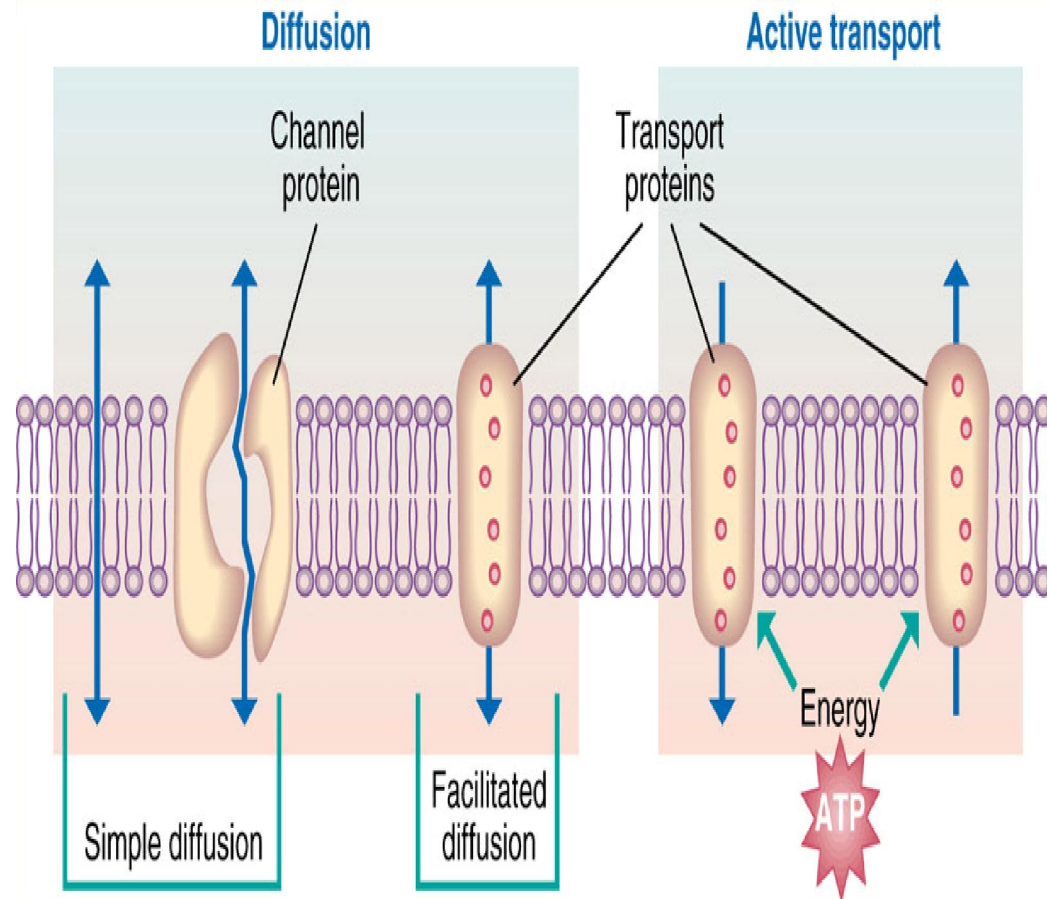
- ❖ Transcellular pathway
- ❖ Paracellular pathway



Two pathways of absorption

Mechanism of absorption

- **Passive transport**
 - simple diffusion
 - facilitated diffusion
 - osmotic pressure
- **Active transport:**
- **Endocytosis & Exocytosis**





Absorption of main substances

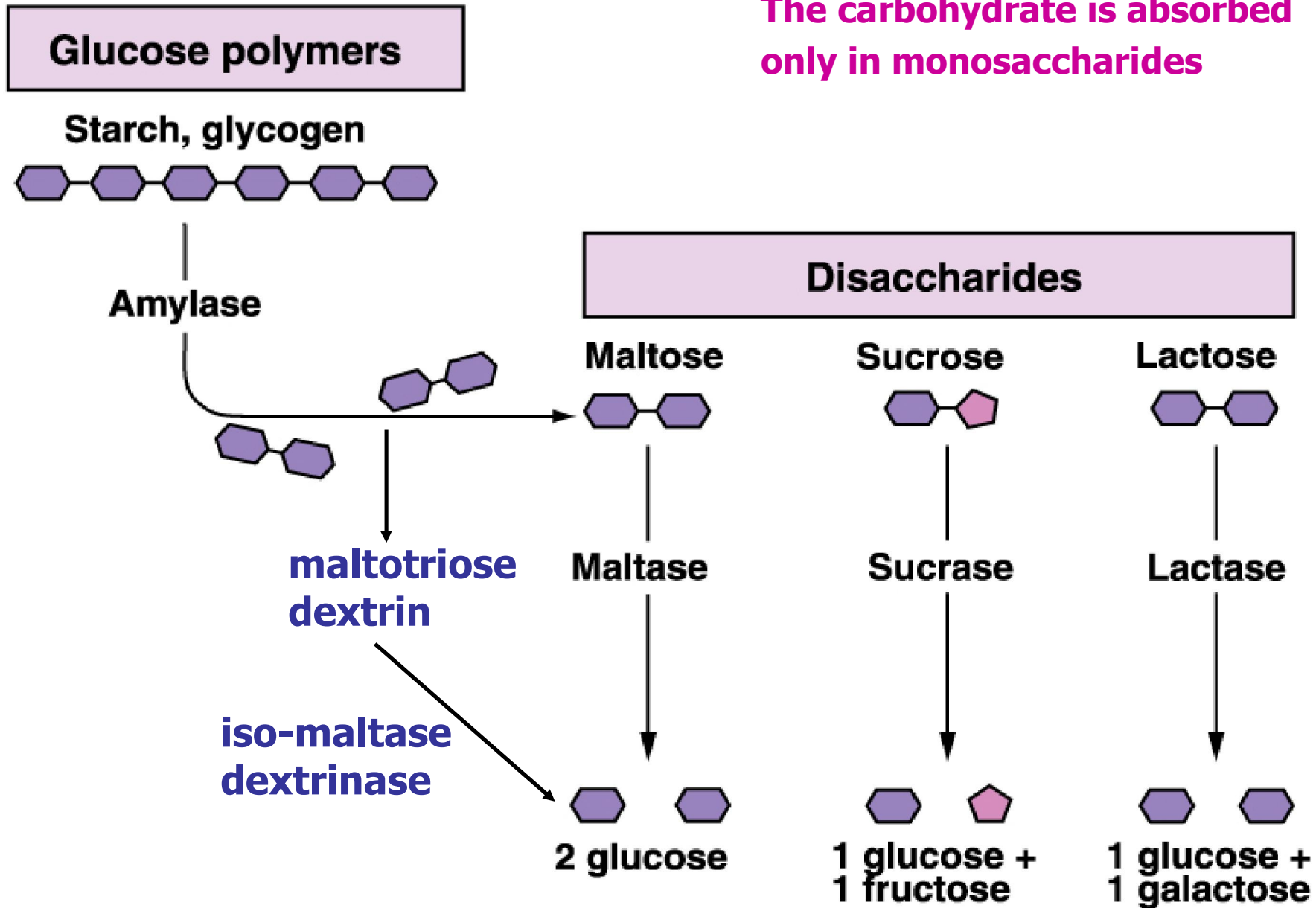
1. Absorption of carbohydrate

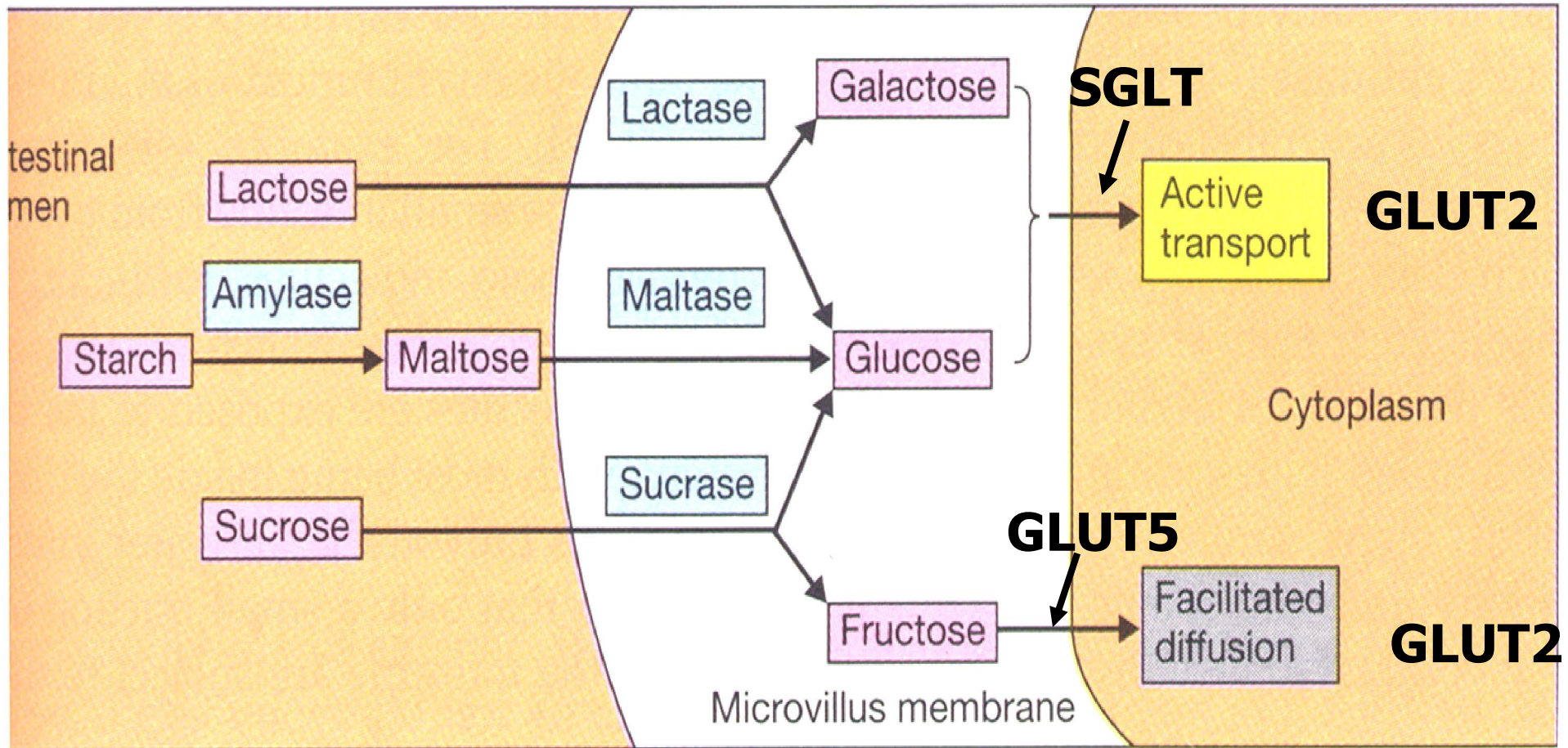
Monosaccharides: glucose, fructose,
galactose

Disaccharides: sucrose, lactose, maltose

Polysaccharides: starch, glycogen, cellulose

The carbohydrate is absorbed only in monosaccharides





The carbohydrate is absorbed only in monosaccharides

SGLT: sodium-dependent glucose transporter

GLUT: glucose transporter

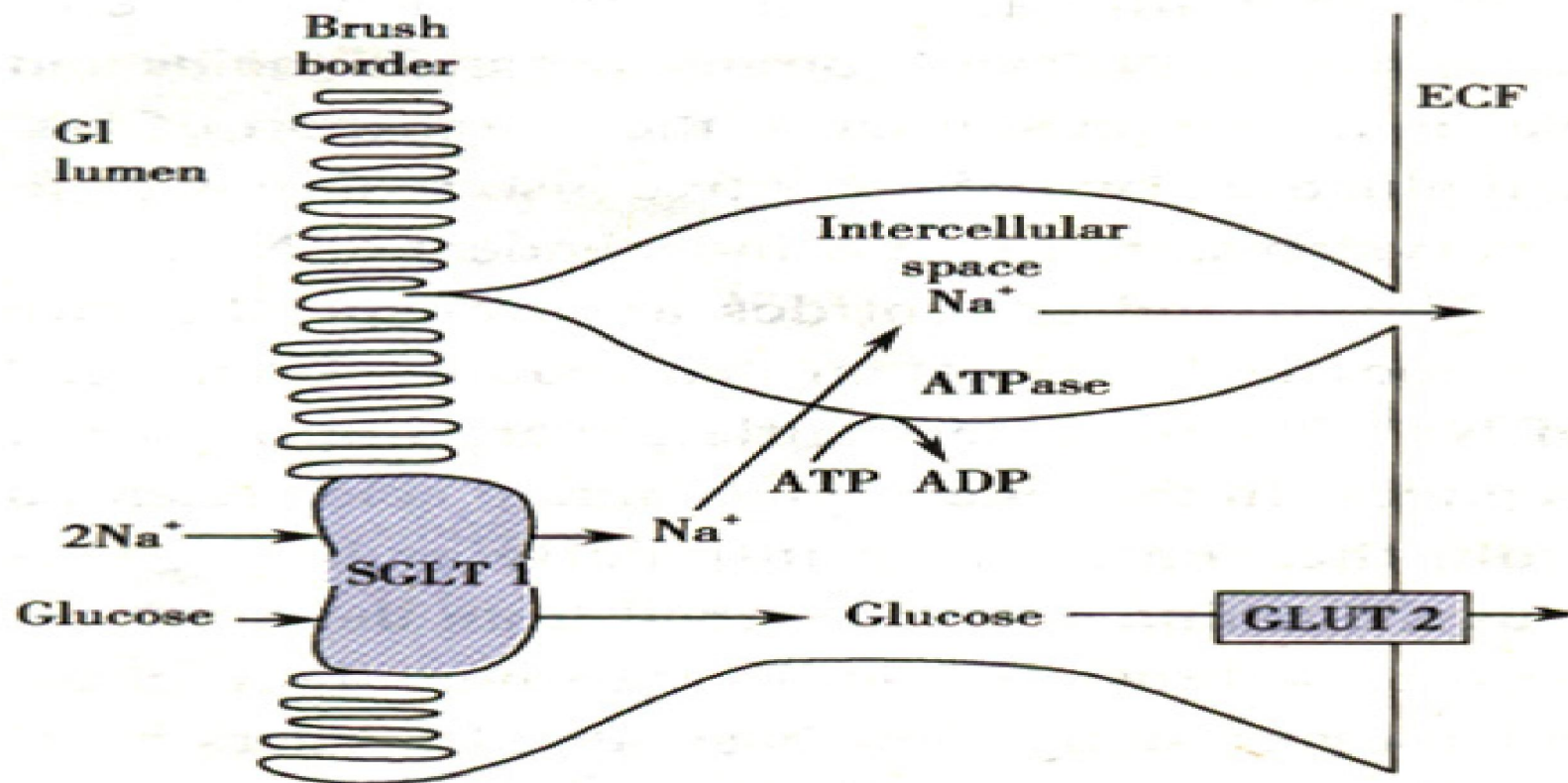
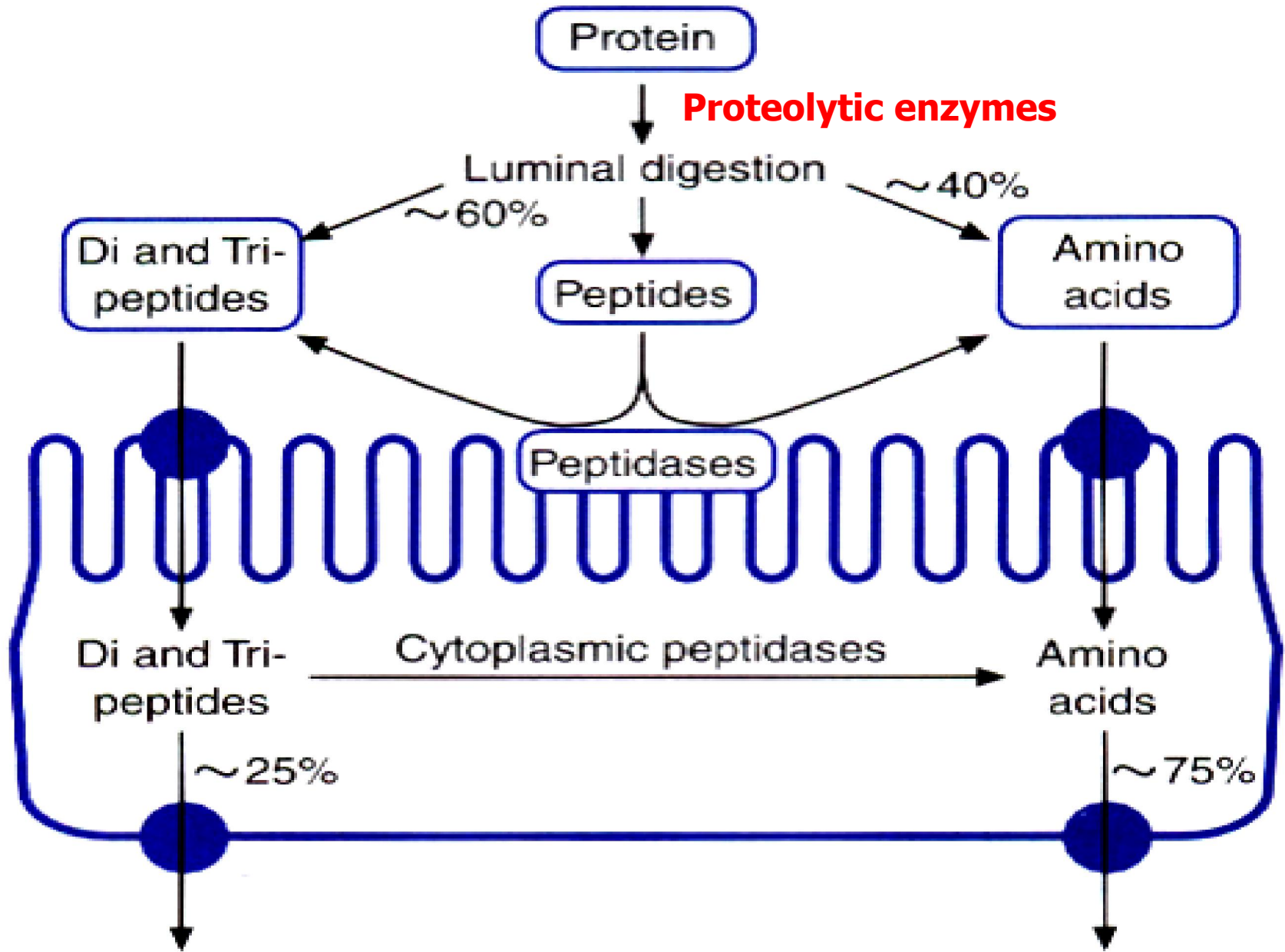


Figure 25-1 Mechanism for glucose transport across intestinal epithelium. Glucose transport into the intestinal cell is coupled to Na^+ transport, utilizing the cotransporter SGLT 1. Na^+ is then actively transported out of the cell, and glucose enters the interstitium by facilitated diffusion via GLUT 2. From there, it diffuses into the blood.





2. Absorption of Proteins

- **Amino acids & dipeptides/tripeptides**
 - **Co-transport with Na⁺ (Main)**
 - **Facilitated diffusion**
- **In infants, very small amounts of intact proteins (immunoglobulin) are absorbed by endocytosis & exocytosis**



3. Absorption of Lipids

- **Free fatty acids (FFA)**
 - **long chain FFA (16-18 C)**
 - **short chain FFA**
- **Monoglyceride**
- **Glycerol**
- **Lysolecithin**
- **Cholesterol**

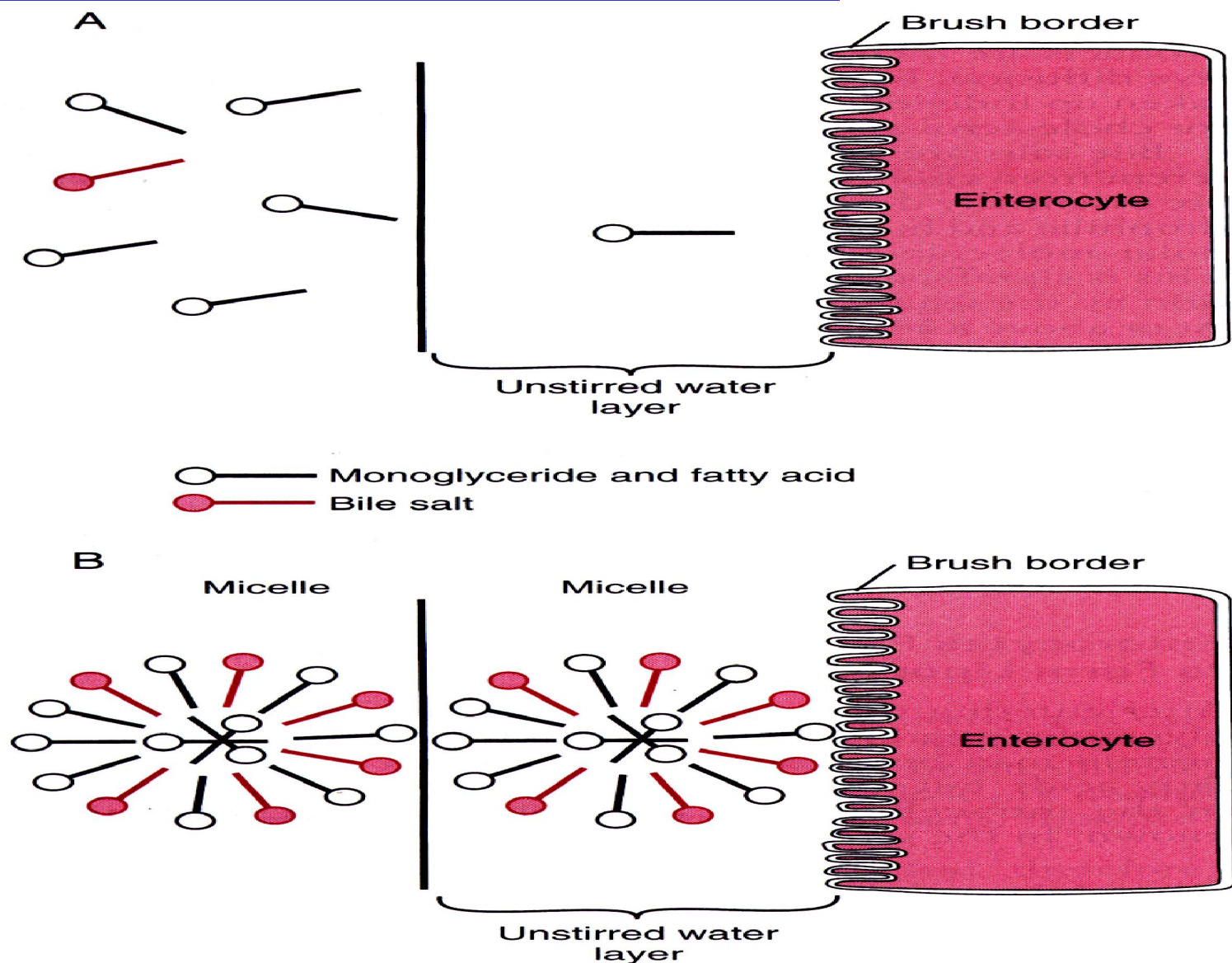
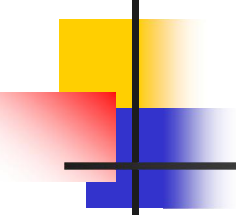


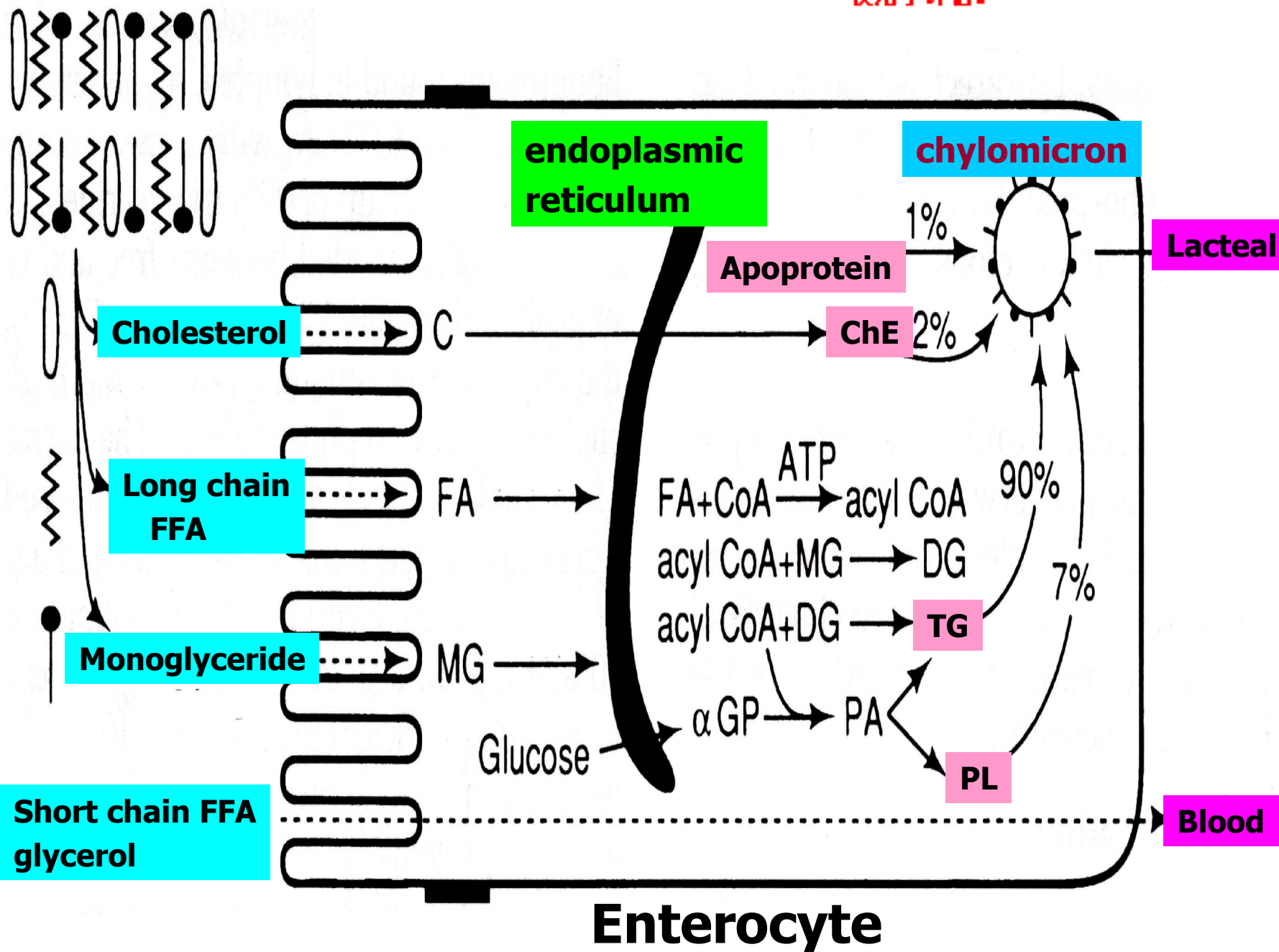
FIGURE 27.25 The micellar solubilization of lipids. Micellar solubilization enhances the delivery of lipid to the brush border membrane. **A**, In the absence of bile salts. **B**, In the presence of bile salts.

Absorption of digested fat product

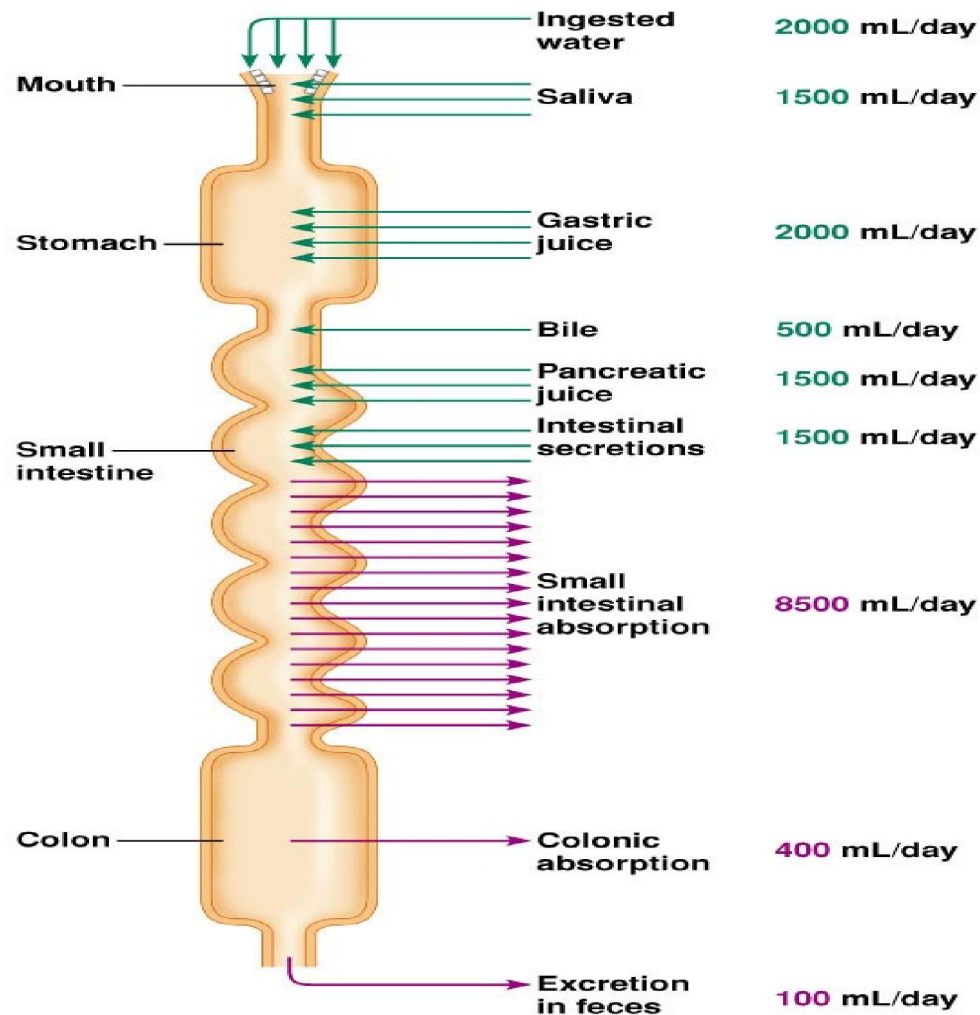


- Glycerol and short-chain FFA (< 10-12 carbon atoms) directly diffuse across the enterocyte into the portal blood.
- Long-chain FFA and monoglyceride are resynthesized to triglyceride (TG).
- cholesterol is esterified in the enterocyte

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- **Apoprotein, TG, cholesterol ester, phospholipids , fat-soluble vitamins , all were packed to form **chylomicrons**.**
 - **Chylomicrons leave the cell by exocytosis into lymphatic capillaries (**lacteals**)**



4. H₂O: Osmotic gradient



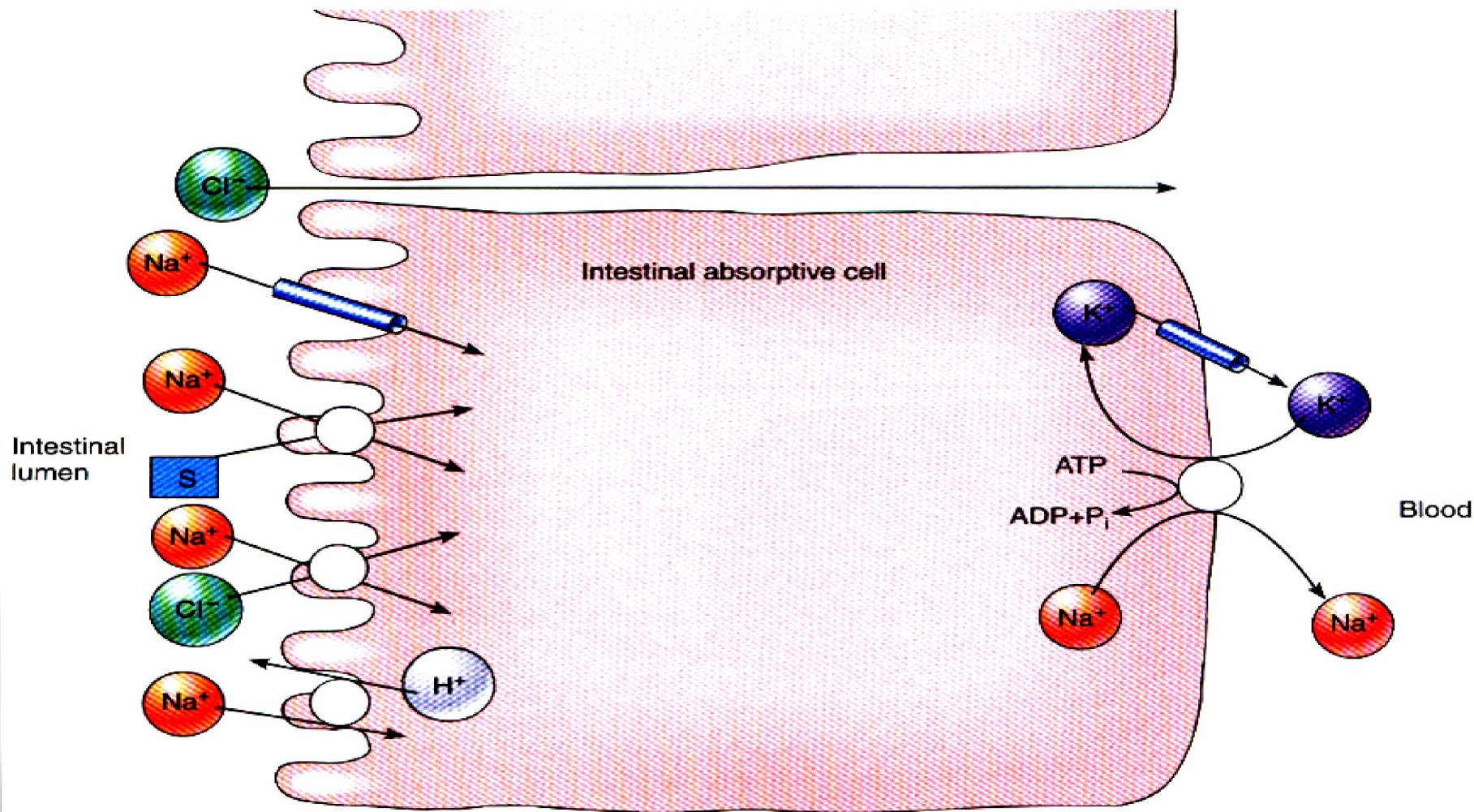
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Equal one-sixth of total body water volume (42L), more than twice the plasma volume (3L)

Solutes from the lumen are actively transported into the intestinal cells, creating an osmotic gradient which cause water to be absorbed.

Inorganic salts

- (1) Na^+ : 25~35 g/day
- (2) Cl^- : electrical gradient





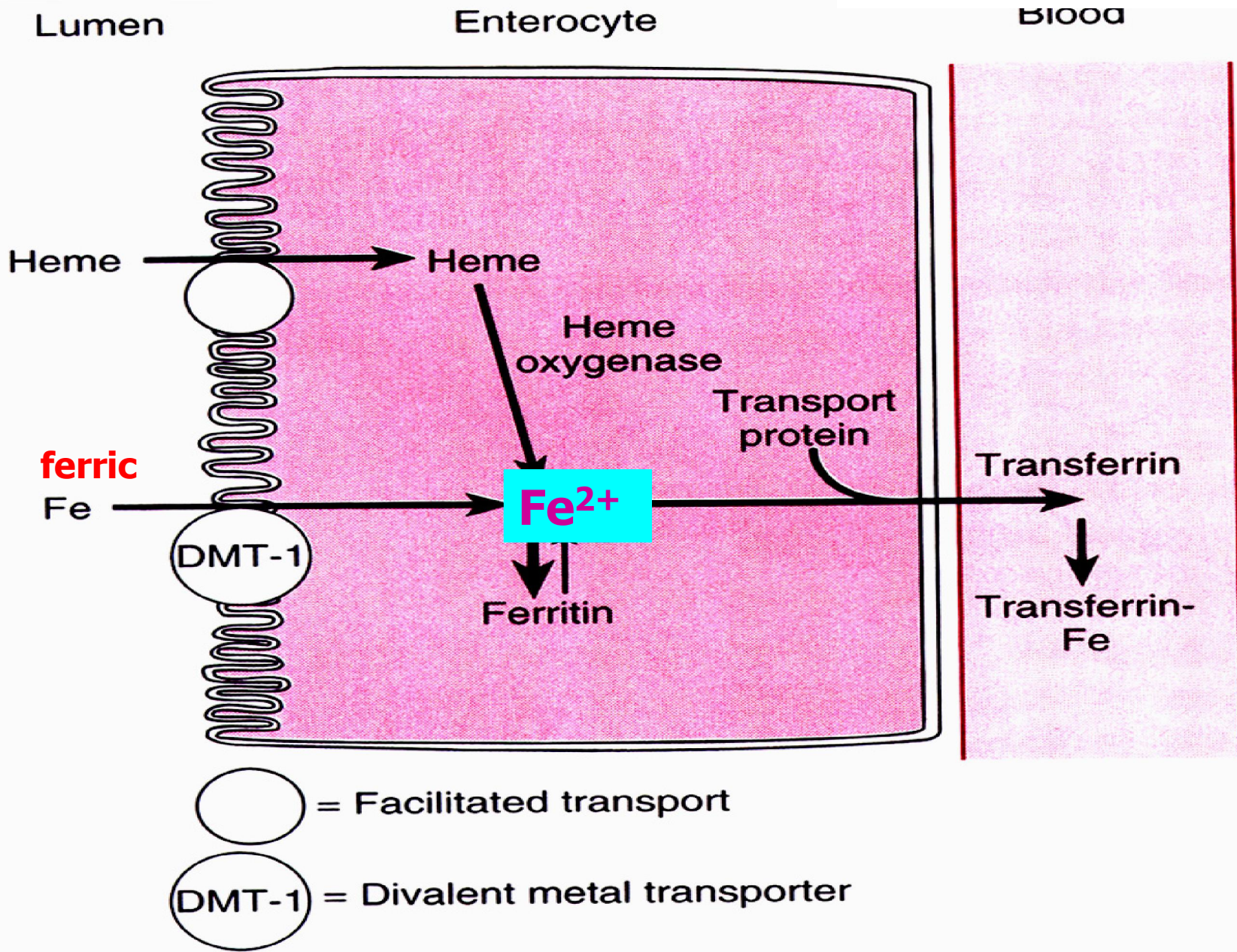
5. Absorption of Vitamins

- **Water-soluble vitamins**
 - carrier-mediated transport
 - Vit B₁₂ absorbed in ileum
- **Fat-soluble vitamins A, D, E, K**
 - in the same pathway for fat absorption

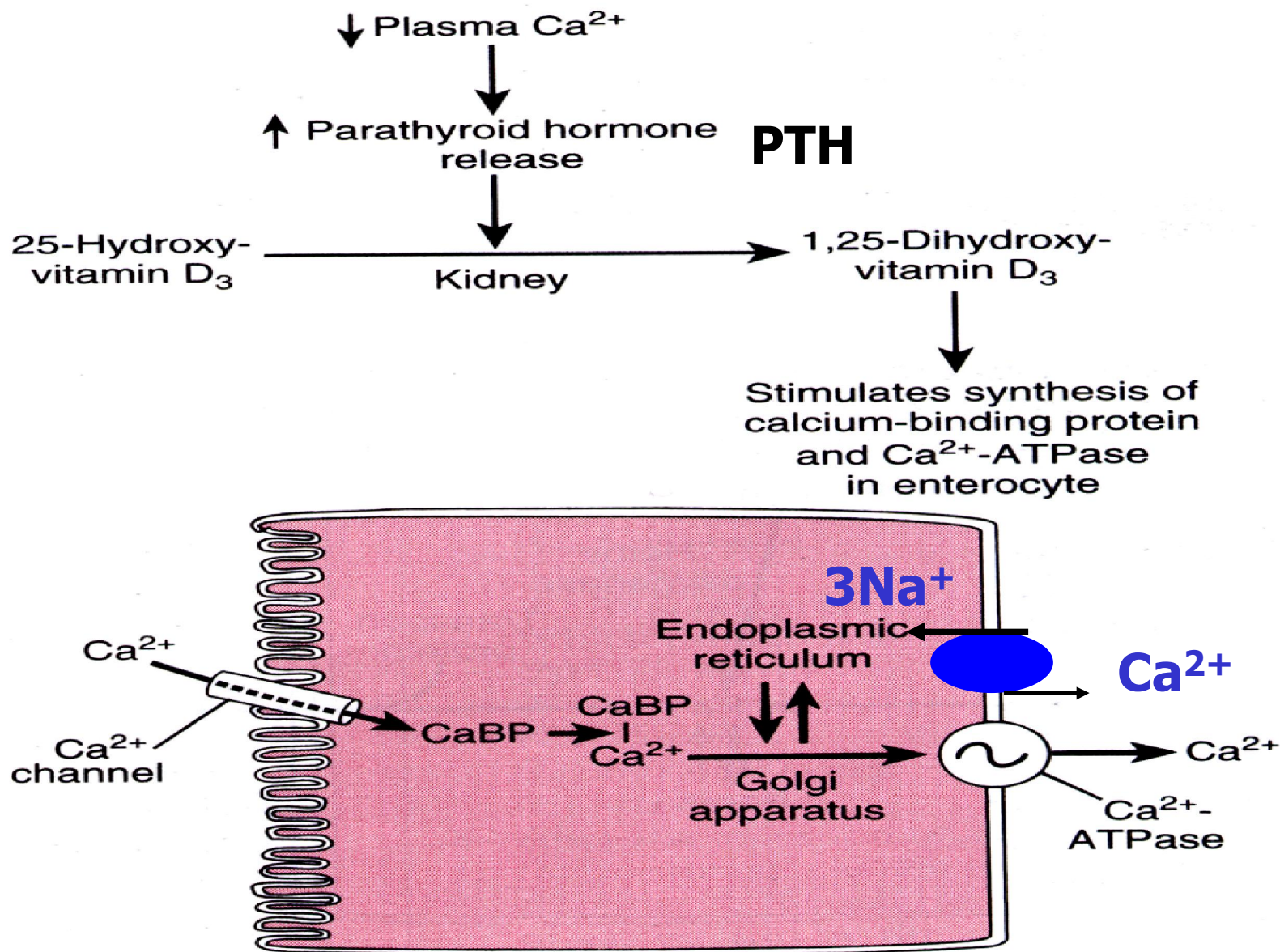


6. Absorption of Iron

- **Daily absorption : 1 mg/day**
- **Iron is absorbed in two forms:**
 - **Fe²⁺** or ferrous
 - **Heme** from hemoglobin and myoglobin
- **HCl & Vit C facilitate the conversion of Fe³⁺ (ferric) to Fe²⁺**



7. Ca^{2+} absorption



Zollinger-Ellison Syndrome (Gastrinoma)

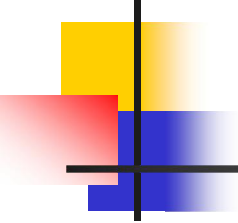
- Abe is a 40-year-old teacher. For several months, he had a number of symptoms, including **indigestion**, **loss of appetite**, **abdominal pain**, and **diarrhea**. He also found his feces looked **oily**. The abdominal pain was relieved by eating and by taking over-the-counter antacids. In hospital, Abe underwent fiberoptic endoscopy, which showed an ulcer in the duodenal bulb. To determine the cause of ulcer, additional tests were performed, including a serum gastrin level, analysis of gastric acid, a pentagastrin stimulation test, and a secretin stimulation test.



Laboratory tests

- **Serum gastrin: 800 pg/ml (0-130 pg/ml)**
- **Basal H⁺ secretion: 100 mEq/h (10 mEq/h)**
- **Pentagastrin stimulation test:**
 - **no increase in H⁺ secretion**
- **Secretin stimulation test:**
 - **serum gastrin increased to 1100 pg/ml**

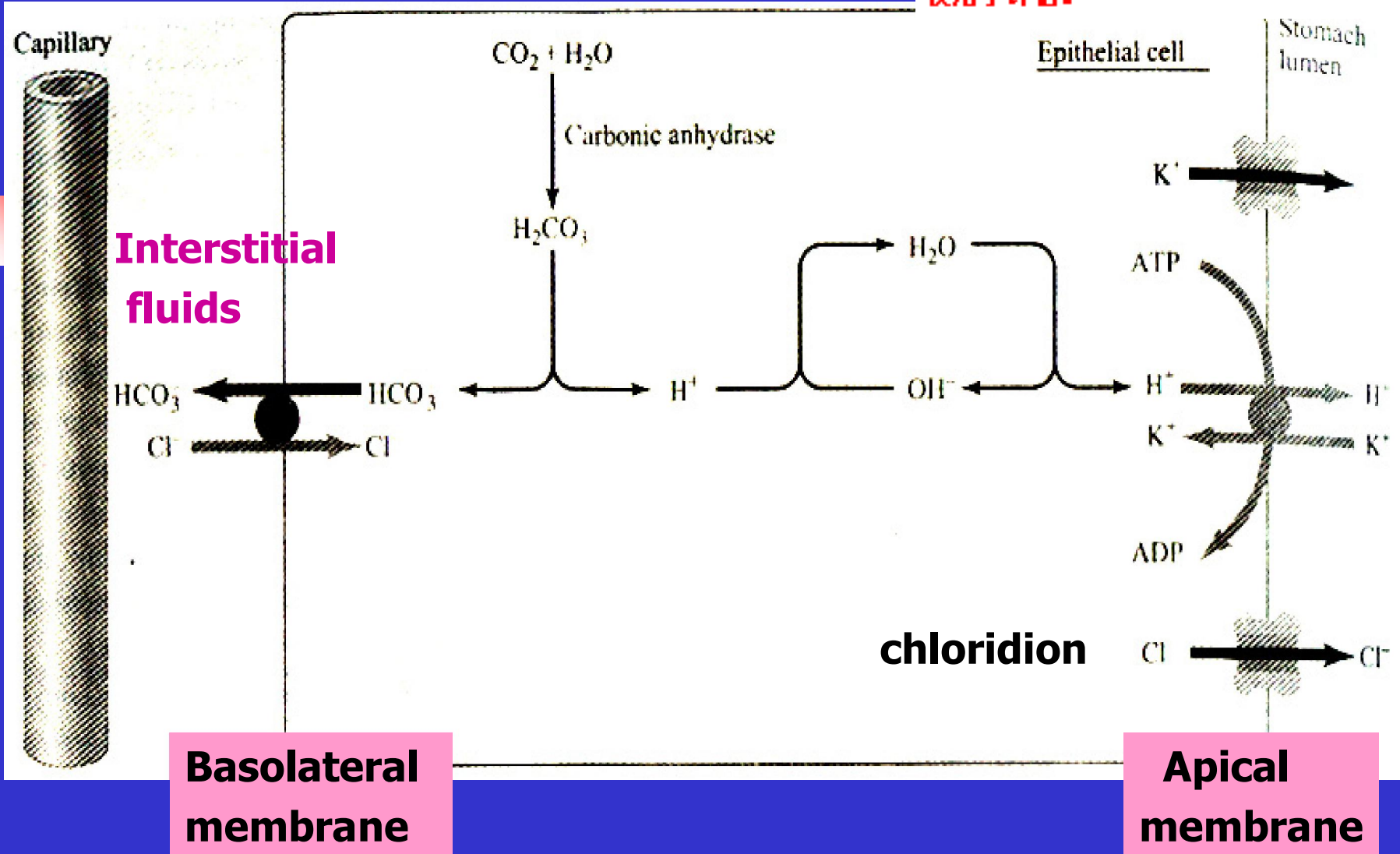
Pg=picogram ; mEq = milliEquivalent

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- **A computed tomography scan showed a 3-cm mass on the head of the pancreas. The mass was thought to be a **gastrinoma**. While awaiting surgery to remove the mass, Abe was treated with a drug called **omeprazole**. After surgery, his symptoms disappeared.**



Questions

- 1. What is the mechanism of H^+ secretion by parietal cells?**



Acid secretion by parietal cells is an active process mediated by H⁺-K⁺-ATPase (proton pump)



2. Why did Abe have a duodenal ulcer?

- **Abe's duodenal developed because acid delivered from the stomach to the duodenum was greater than could be buffered. As a result, the acidic contents of duodenum digested a portion of the duodenal mucosa.**

3. Pentagastrin in Abe did not stimulate acid secretion, why?

- **Abe had such high circulating levels of gastrin from the tumor that acid secretion was already maximally stimulated. Therefore, the small additional amount of gastrin in the test could not further stimulate acid secretion.**



4. Explain the results of secretin stimulation test

- **For reasons that are not understood, secretin directly stimulates gastrin secretion by gastrinoma cells, but not by antral G cells.**
- **When a healthy person is challenged with secretin, the serum gastrin level is decreased or is unchanged.**



5. Why did Abe have diarrhea?

- **Because a large volume of gastric juice was secreted . When the volume of gastrointestinal secretions exceeds the absorptive capacity of the intestine, diarrhea occurs.**



6. Why Abe have steatorrhea?

- **Abe had fat in his stool (steatorrhea) because he had three major defects in lipid digestion and absorption.**
 - 1) **Pancreatic enzymes are inactivated at acidic pH (the optimal pH for lipase is 6)**
 - 2) **At acidic pH, bile salts are absorbed too early in the small intestine.**
 - 3) **Acid damages the mucosa of the small intestine, thereby reducing the surface area for lipid absorption.**



7. Abe felt better when he ate. Why?

- **Some of the excess H^+ was buffered by the food in his stomach, reducing the load of free H^+ delivered to the small intestine.**

