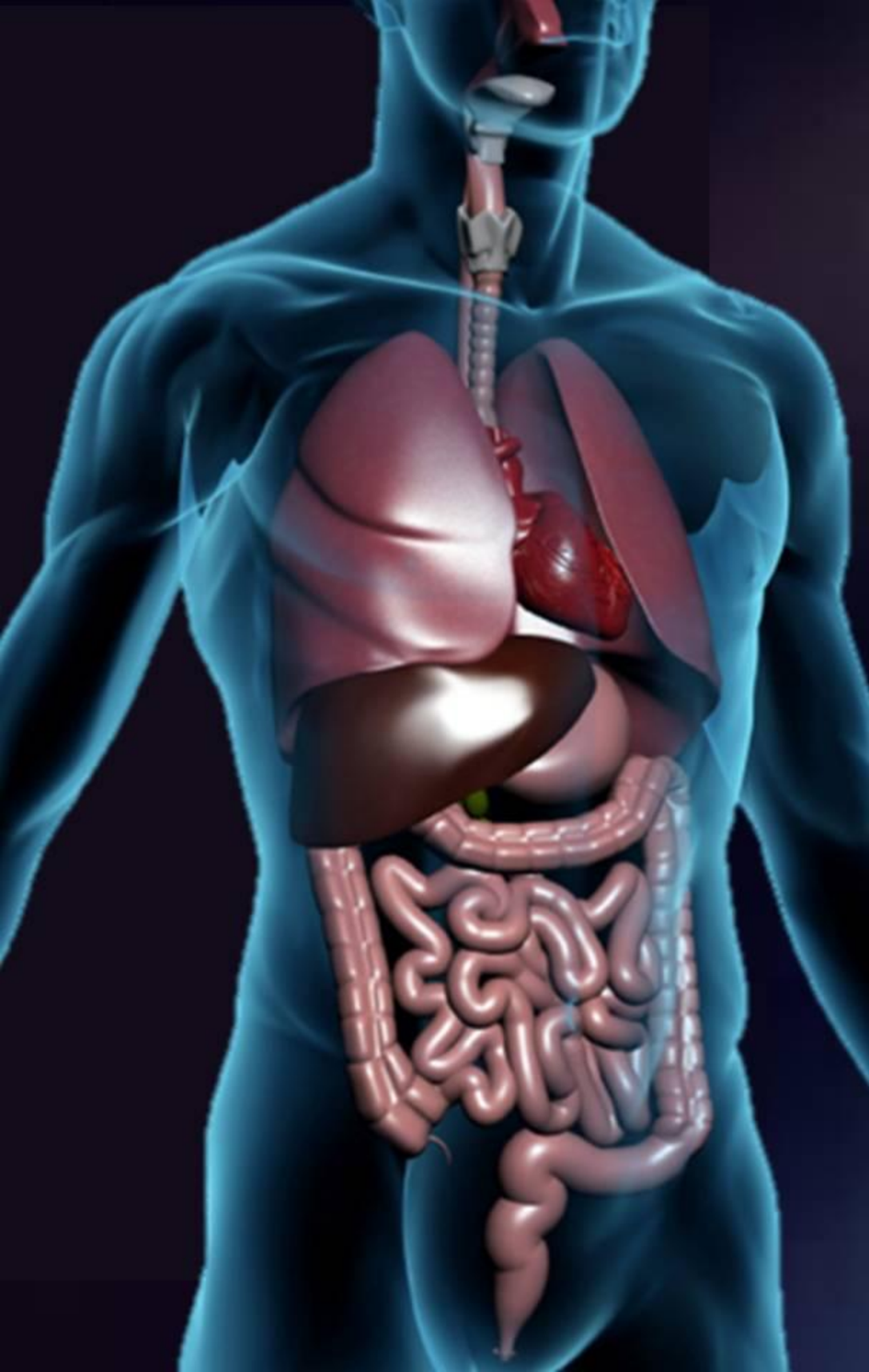


6 PHYSIOLOGY OF SMALL INTESTINE

MED 433 Teams

GIT

Objectives :

- Motility in the small intestine.
- Control of intestinal motility.
- Secretions of the small intestine
- Basic principles of gastrointestinal absorption.
- Digestion & absorption of carbohydrates, proteins and fats.
- Absorption of vitamins.
- Absorption and secretion of electrolytes and water.

Secretion and absorption is not a part of physiology's lectures. Rather it's a part of biochemistry's lectures (from slide 6 to the end) (Dr. M.alzoghaibi)

These videos might be helpful (from Areej AlWahaib):

fat :

digestion Digestion and Absorption of Fats Part 1/2

absorption Digestion and Absorption of Fat - Part 2/2

protein :

digestion Digestion and Absorption of Proteins - Part 1/2

Absorption https://www.youtube.com/watch?v=qDcvtOlaqZA

carbs :

digestion Digestion and Absorption of Carbohydrates PART 1/2

absorption Digestion and Absorption of Carbohydrates PART 2/2

Resources :

- Unit II, chapter 4, page 53 -55.

For more information about the transportation in absorption :

- Go back to physiology lecture of foundation block.

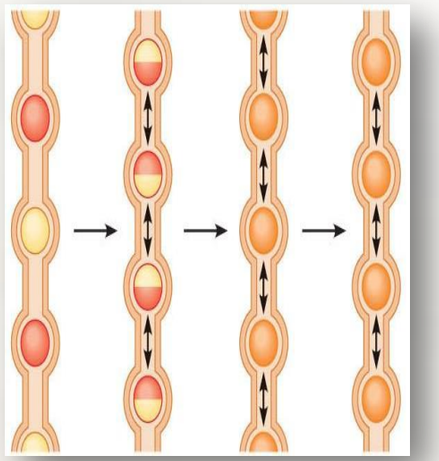
Motility in the Small Intestine

- Segmenting contractions (Mixing)
- Propulsive contractions (Peristalsis)
- Antiperistalsis
- Peristaltic rush
- Migrating motor complex

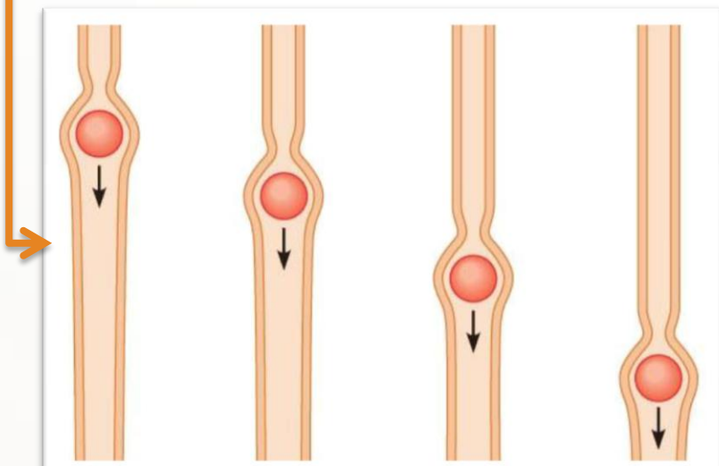
- **stimulus :** distention.
- **Mechanism:** The intestine is divided into spaced segments, last for fraction of min, As **one** set of segmentation contractions relaxes, a **new** set often begins at points between the previous ones.
- **Activated** by ENS.
- **Blocked** by atropine.
- **The significance:**

(1) Blend different juices with the chyme.

(2) Bring products of digestion in contact with absorptive surfaces



- **stimulus :** distention.
- They are faster in the proximal intestine and slower in the terminal intestine (velocity 0.5 to 2.0 cm/sec),
- (Note : 3 to 5 hours are required for passage of chyme from the pylorus to the ileocecalvalve).
- blocked by atropine
- **Myenteric** plexus is important.



Motility in the Small Intestine

Segmenting contractions (Mixing)

Propulsive contractions (Peristalsis)

Antiperistalsis

- In the **opposite** direction.
- Occurs : (1) between stomach and duodenum to **allow** more time for neutralization of chyme.
(2) between ileum and caecum to **allow** time for absorption.

Peristaltic rush

- It is bursts of **depolarization** accompanied by **peristaltic contraction** that begins in empty stomach.
- **Mechanism:** (1)during **interdigestive period**, travels a long whole length of small intestine to reach ileocaecal valve after 1.5-2 h. (2)where it disappears. A **new** wave of MMC starts.
- **Termination of activity: as soon as** food is ingested
- **Function** : **propel any remnants in stomach & small intestine into colon**

Migrating motor complex

IMPORTANT

- Powerful rapid peristalsis due to→ **intense irritation of intestinal mucosa as in infectious diarrhea.**
- **initiated** mainly by **extrinsic nervous reflexes** to brain stem and back to gut.
FUNCTION:It **sweeps** the contents of intestine **into the colon** and thereby relieving the small intestine **of irritative chyme or excessive distension**

Movement of the villi:

It consists of three patterns of movements:

1- fast shortening

2- slow lengthening

3- side to side movement.

The movement of the villi is initiated by local nervous reflexes in response to chyme.

(villikinin) is the hormone released by intestine when it comes in contact with digestive products.

The movement of the villi facilitates:

absorption (١

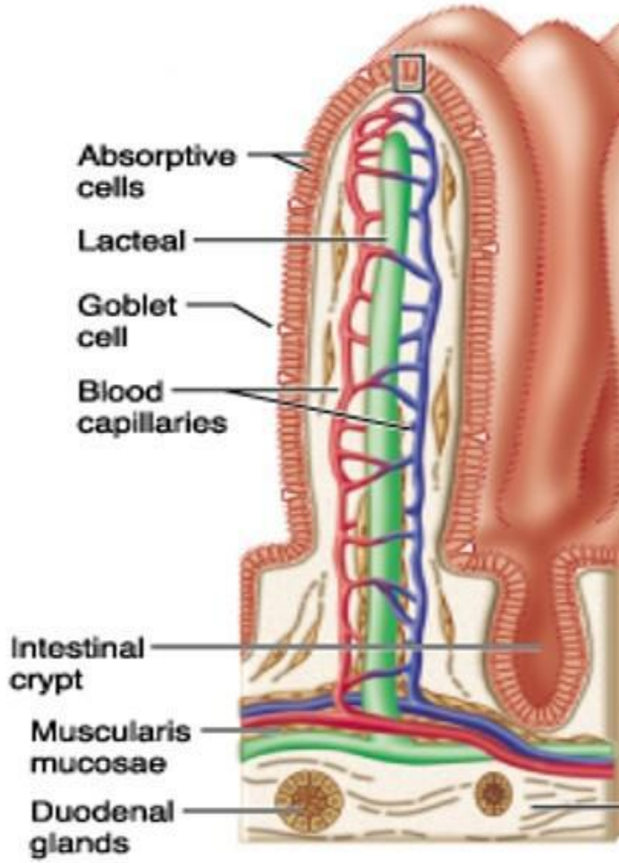
Lymph flow from central lacteal into lymphatic system (see absorption of the long-chat fatty acid) (٢

Control of intestinal motility

Neural control	Hormonal control	
Parasympathetic ↑ motility	↑ intestinal motility:	Gastrin, CCK, insulin, Motilin & serotonin
Sympathetic ↓ motility	Relaxing ileocaecal sphincter:	gastrin & CCK
Gastroileal reflex: Gastric distension → impulses through myentric plexus → ileum and initiates peristaltic movement →open ileocaecal valve → food passes to colon	Regulating MMC (during fasting):	Motilin
	Inhibits intestinal motility:	secretine& glucogon
	Contracts ileocaecal sphincter:	Secretine & glucogon
	Stimulating movement of villi:	villikinin

Secretions of small intestine :

Secretion of mucus	Secretion of intestinal juices (succus entericus)
- By **Brunner's Glands .** - They secrete large amounts of alkaline mucus, which contains a large amount of bicarbonate ions. - They are stimulated by: (1) irritating stimuli on the duodenal mucosa. (2) vagal stimulation. (3) secretin. - They are inhibited by sympathetic stimulation.	- By **the Crypts of Lieberkühn.** - The Crypts of Lieberkühn are small pits lie between intestinal villi. - Their epithelium composed of: (1) Goblet cells, secrete mucus. (2) Enterocytes, secrete large quantities of H2O and electrolytes. (Note :Enterocytes over the surfaces of adjacent villi reabsorb H2O, electrolytes & end products of digestion)
Mucus	**Succus enericus**
Protect the mucosa	- Volume: 1800 ml/day. - PH: 7.5-8. It participates in the neutralization of chyme acidity delivered from stomach. - Composition: 0.6 % organic, 1 % inorganic substance. - The enzymes that are actually secreted into the lumen are enteropeptidase and amylase. - Most of them are found either in the in the brush border or in the cytoplasm of enterocytes.



- Intestinal juice secretion is stimulated by:
A. Distension, tactile & vagal stimulation.
B. Hormones as gastrin, secretin, CCK, glucagons, enterocrinin.
- **Inhibited by**
Sympathetic stimulation.

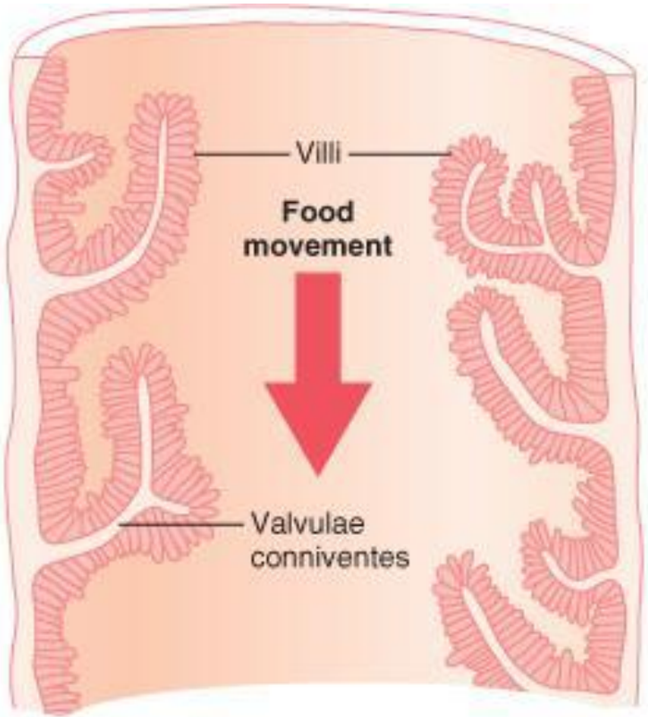
Absorption of small intestine :

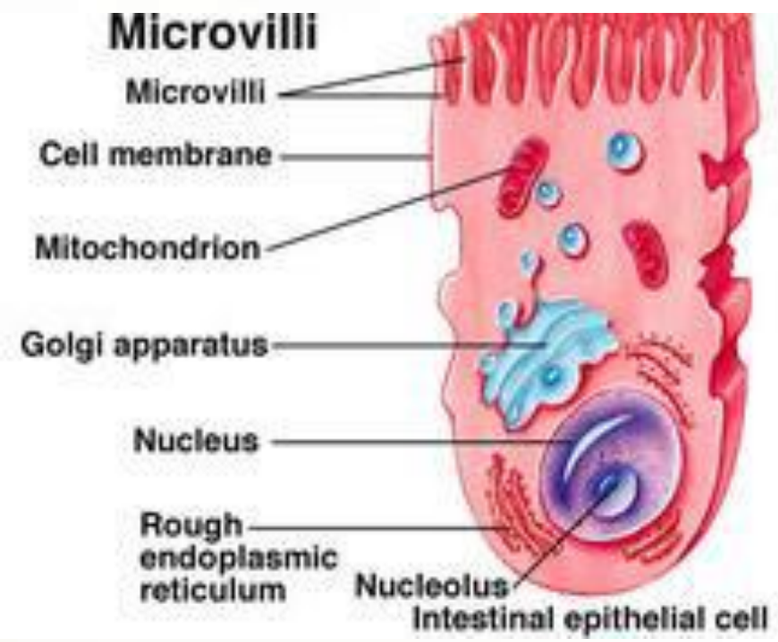
- Absorptive surface of the small intestinal mucosa contains structures that **increase its surface area** in order to enhance the absorption of digestive molecules.

- These structures are :
  1. **Valvulae conniventes** (folds in small intestinal mucosa) → increase surface area 3-folds.

  2. **Villi** (found on the mucosal surface) → increase the surface area another 10-fold.

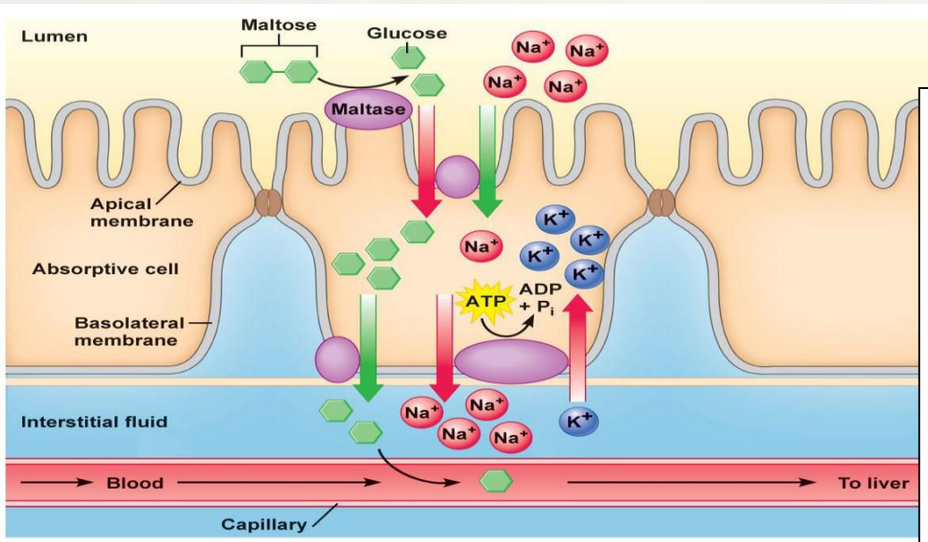
  3. The epithelial cell on each villus is characterized by a **brush border** (consisting of as many as 1000 microvilli) → increases the surface area another 20-fold.

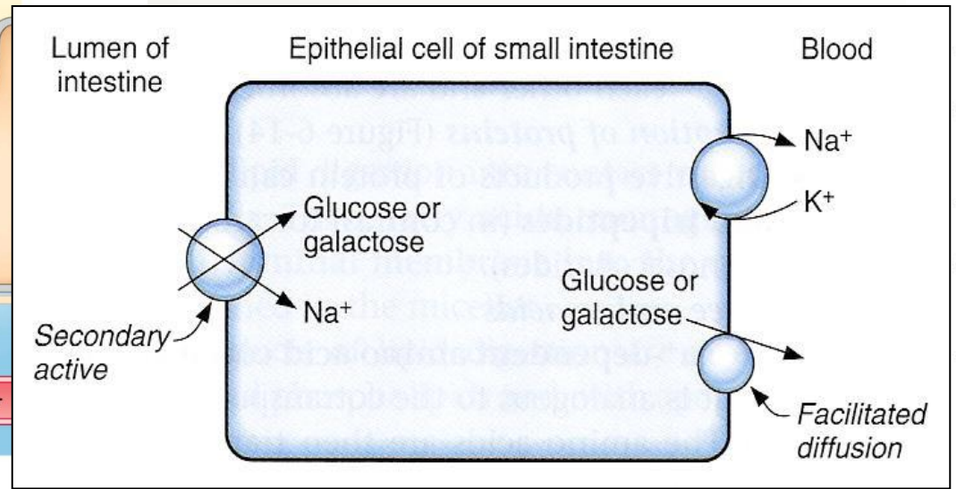


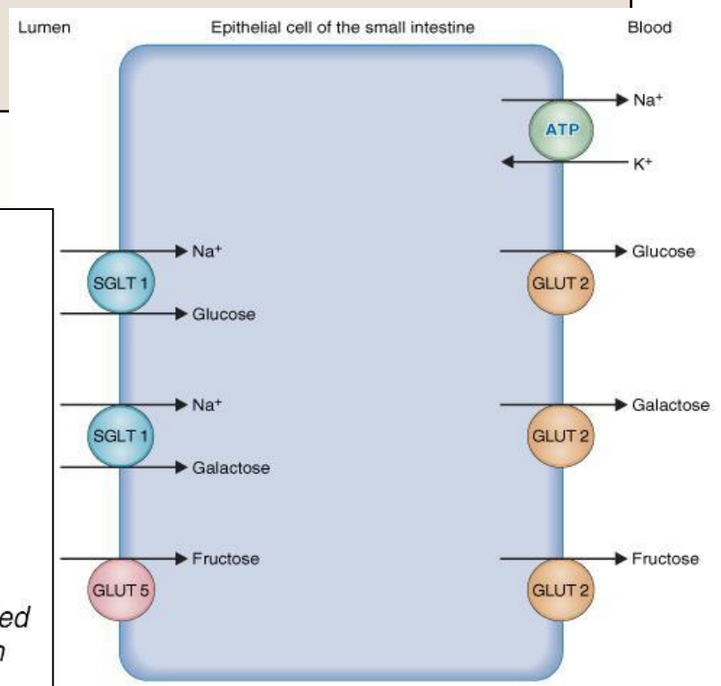


Digestion & absorption of carbohydrates :

Digestion	Absorption
- Lactase, sucrase, maltase & a-dextrinase → these enzymes can split the disaccharides (such as lactose, sucrose & maltose) and other small glucose polymers into their constituent monosaccharides. - These 4 enzymes located in enterocytes which covering the intestinal microvilli brush border → so, once the disaccharides come in contact with these enterocytes , the digestion will occur.	- All the carbohydrates are absorbed in the form of monosaccharides except a small fraction of disaccharides. - **At brush border :** (1) Glucose & Galactose → secondary active transport (Na - glucose/galactose co-transport "SGLT1") (2) Fructose → facilitated diffusion (Na+ independent "GLUT 5"). (3) Pentose → passive diffusion. - **At basolateral membrane :** Glucose, galactose & fructose → facilitated diffusion (Na+ independent "GLUT 2").

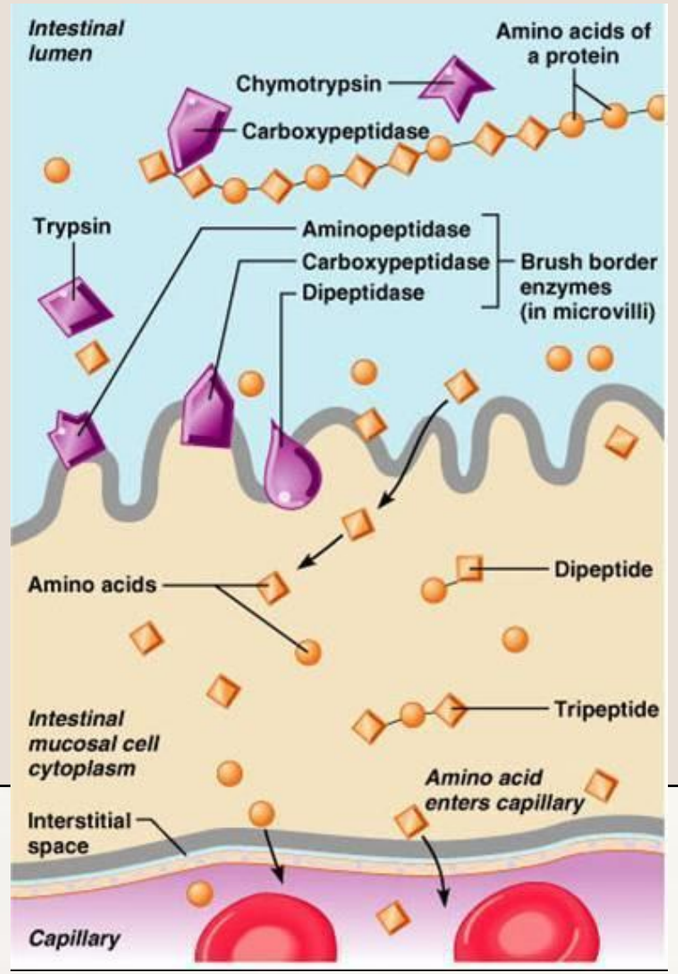


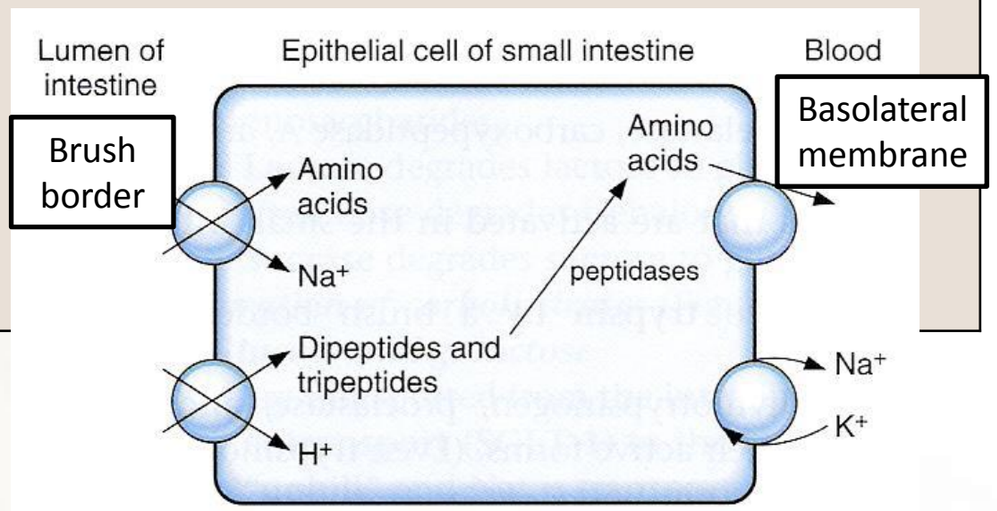




Digestion & absorption of protein:

Digestion	Absorption
- Most proteins remain as dipeptides and tripeptides . - small percentage of proteins are digested to amino acids by the **pancreatic juices**. - Most protein digestion occurs in the **duodenum and jejunum** by aminopeptidases, oligopeptidases, intracellular dipeptidase and tripeptidases.	- Proteins are absorbed in the form of dipeptides, tripeptides, and a few free amino acids. - **At Brush border :** 1- D-amino acids are transported by passive diffusion . 2- L-amino acids are transported by secondary active transport (Na – amino acids co-transport). 3- dipeptides & tripeptides cross by active transport protein carrier (then it hydrolyzed by brush border & cytoplasmic oligopeptidases to amino acids). - **At Basolateral membrane :** amino acids leave the cell by facilitated transport.



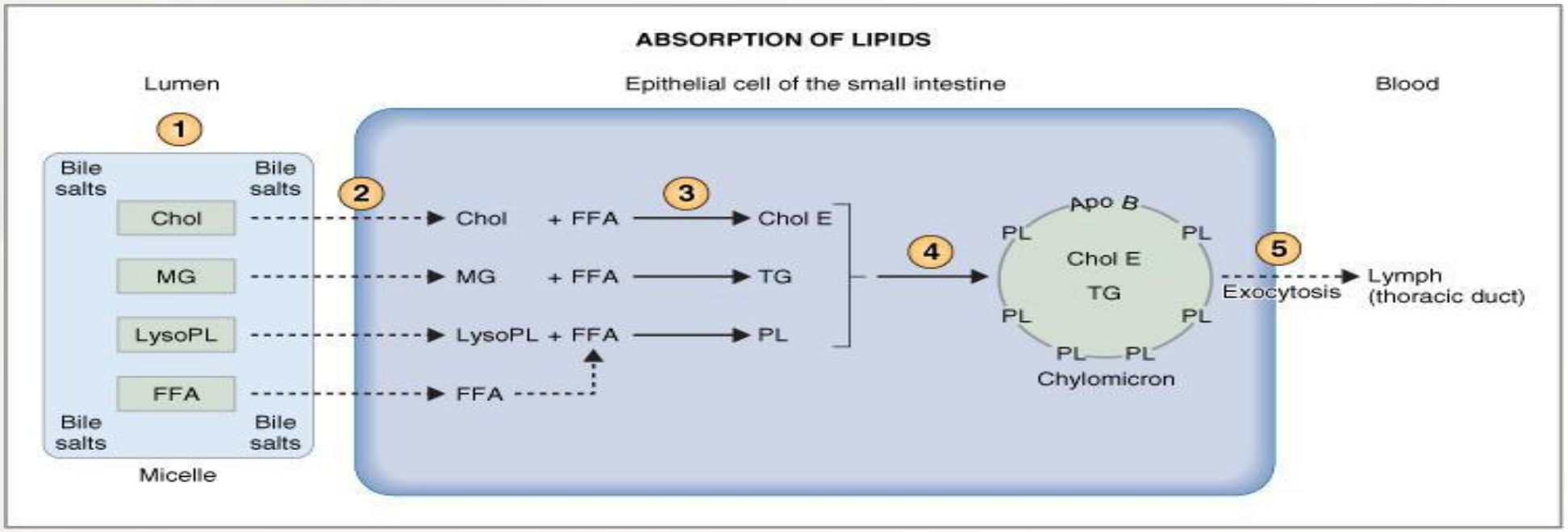


Digestion & absorption of fat :

Bile salts and lecithin in the bile help fat digestion by make the fat globules readily fragmentable with the water in the small intestine (**emulsification of fat**).

Bile salts break the fat globules into **very small sizes**, so that the water-soluble digestive enzymes **can** act on the globule surfaces

In the presence of an abundance **of bile micelles**, about **97**% of the fat is absorbed; in the absence of the bile micelles, only 40 to 50% can be absorbed



Formation of micelles

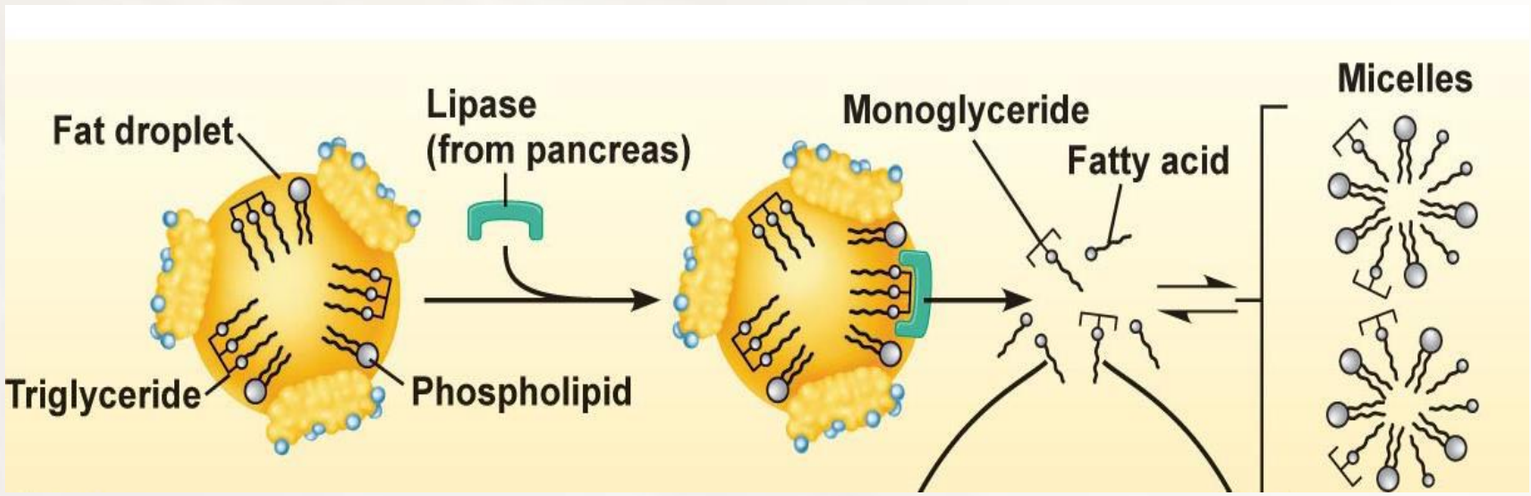
Bile salt are **amphipathic** molecules,
each composed of a sterol nucleus **(fat-soluble)** + a polar group (water-soluble).

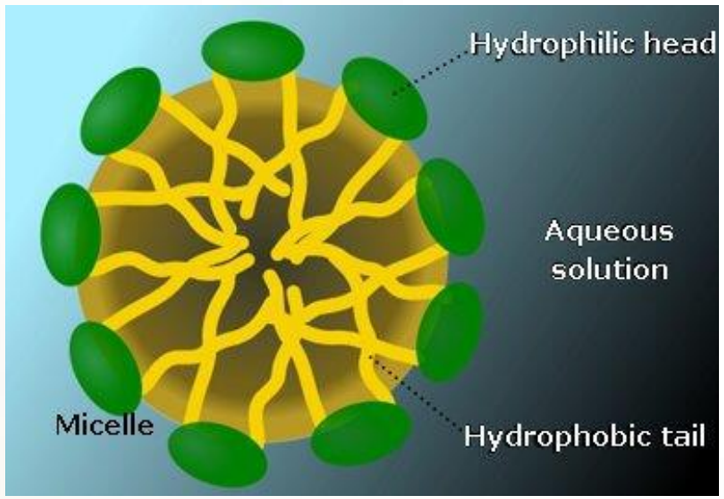
- Micelles are small spherical, cylindrical ,globules 3 - 6 nm in diameter
- composed of 20 - 40 molecules of

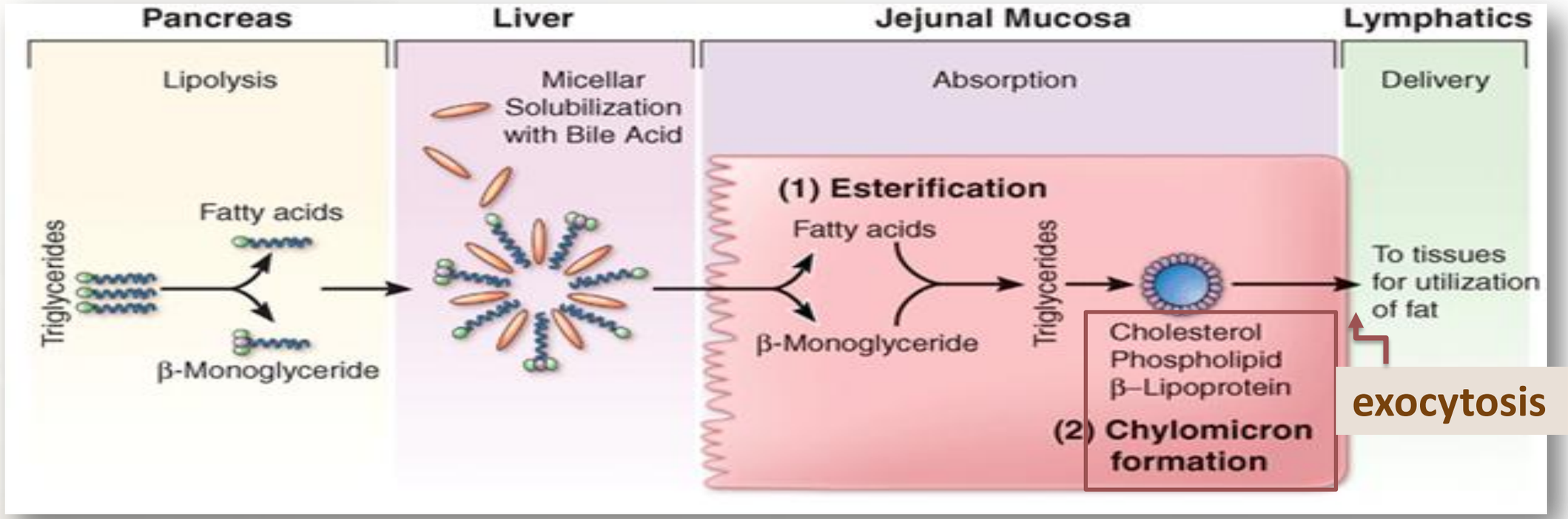
bile salts.

Amphipathic;
both hydrophilic (*water-loving*, polar) and lipophilic (*fat-loving*) properties

• The polar parts are **(-) charged**, they allow the entire micelle globule to dissolve in the water of the digestive Fluids.
The micelles act as a **transport medium** to carry
the **monoglycerides and free fatty** acids to the→ **brush borders** of the intestinal epithelial cells







Triglycerides aggregate into globules along with +the **absorbed cholesterol and phospholipids.**
B-lipoprotein coat part of the surface of each globule to form →**chylomicrons**.
-**Chylomicrons** diffuses to side of the cell and is excreted by **exocytosis** into the central lacteal of villi, to lymph, then to thoracic duct.

Absorption Of Vitamins

Fat soluble

{A-K-E-D}

)أكيد(

incorporated

into micelles and absorbed along with other lipids

Water soluble

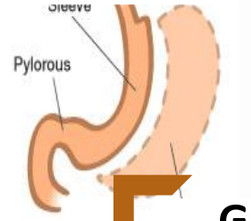
B1-B2-B6-C-Folic acid

*B12

absorbed by Na+ dependent

cotransport mechanisms

* B12 is absorbed in the ileum and requires intrinsic factor



Gastrectomy results in the loss of parietal cells and loss of intrinsic factor which will lead to pernicious anemia

Secretions Of Electrolytes And Water

Electrolytes and H2O cross intestinal epithelial cells by either:

1- cellular or

2-paracellular route

The permeability of the tight junctions varies with the type of epithelium

Leaky epithelium are in the small intestine and gallbladder

A tight epithelium is in the colon

Absorption Of Electrolytes

Electrolytes	Absorption mechanism
Na+	1-Passive diffusion 2-Na+-glucose or Na+-amino acid co-transport 3-Na+-Cl- exchange 4-Na+-H+ exchange (The next step in the transport process is osmosis of water into the paracellular spaces because a large osmotic gradient has been created by the elevated concentration of ions in the paracellular space) NOTE : Aldosterone Greatly Enhances Na+ Absorption, so almost no NaCl & water loss
Cl-	accompanies Na+ absorption by mechanisms: 1-Passive diffusion 2-Na+-Cl- cotransport 3- Cl- HCO3- exchange
K+	Passive diffusion (loss of K+ in diarrhea causes Hypokalemia)
Ca++ absorption by enterocytes.	↑Plasma Ca++ → Parathyroid hormone (it goes to kidney & activate Vit. D in order to absorb more Ca++ in intestine) 25-hydroxy-vitamin D3 (inactive) > In kidney> 1,25 dihydroxy-vitamin D3 (active). → Stimulates synthesis of Ca-binding protein and Ca-ATPase in enterocytes.

Secretion Of Electrolytes

K+

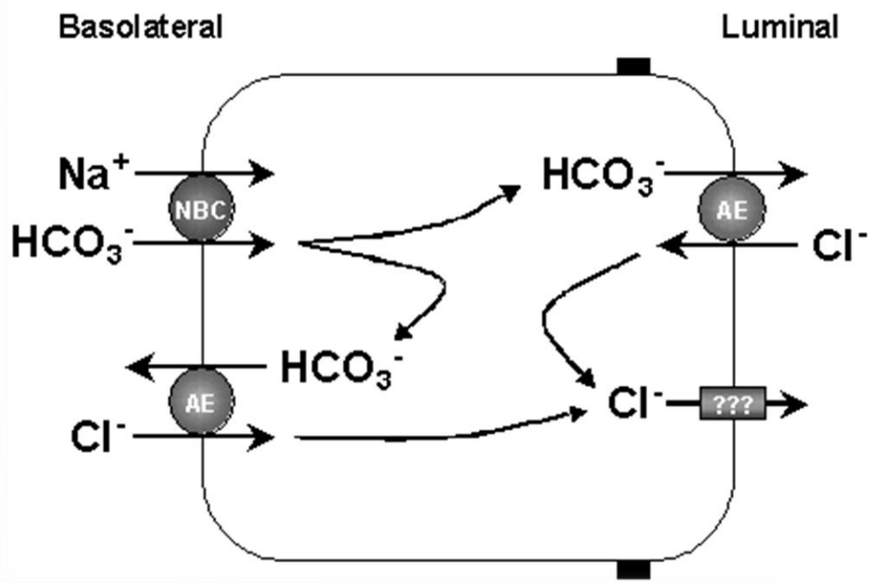
- K+ secretion in the colon is stimulated by aldosterone

HCO3-

- The epithelial cells on thesurfaces of the villi in the ileum and large intestine have a specialcapability of secreting HCO3-in exchange for absorption of Cl-
- { this provides alkaline HCO3- thar neutralize acid products formed by bacteria in larg intestine }

Hormonal Control Of Absorption & Secretionsof Electrolytes

Hormones	Action
Glucocorticoid	absorption of H2O & ions (small & large intestine)
Somatostatin	H2O & ions absorption (ileum & colon)
Epinephrine	NaCl absorption (ileum)
Aldosterone	synthesis of Na+ channel (colon)
Catecholamines	intestinal secretion



@PhysiologyTeam

Pht433@gmail.com

Physiology team

Done by :

Areej Alalwan

Areej Alwahaib

Fatimah Alqarni

Revised by :

Ahmed Alhussien

Rahma Alshehri

GOOD LUCK