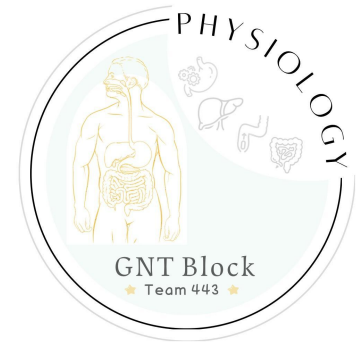
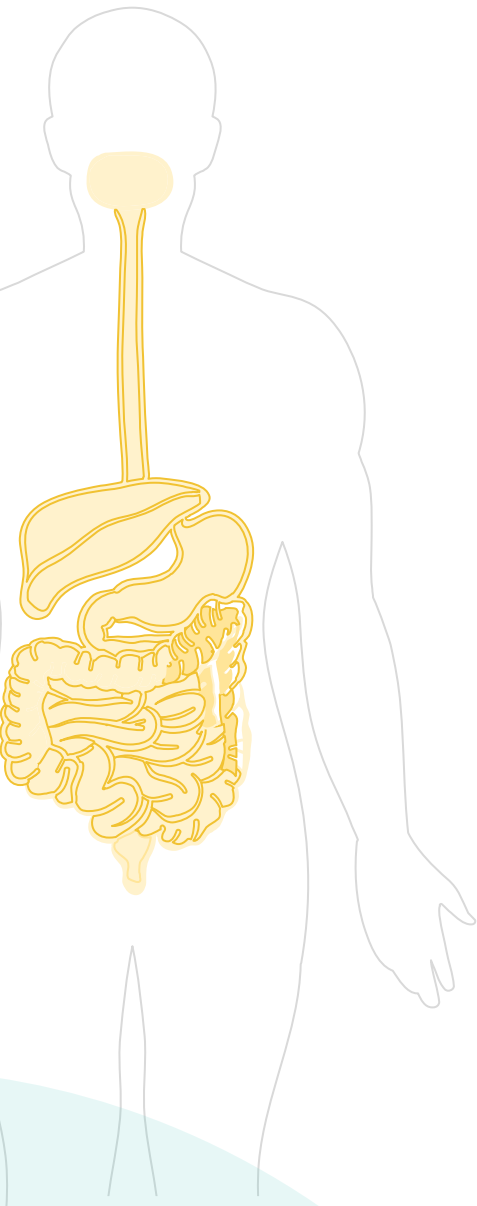
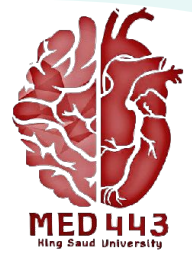


L5



Small Intestine Motility & Secretion

GNT Physiology

This lecture was presented by:
Prof. Mohammed Alzoghaibi & Dr. Hayam Gad

Color Index:

- Main text
- **Important**
- Female Slides
- Male Slides
- Notes
- Extra

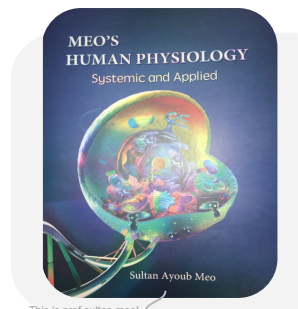
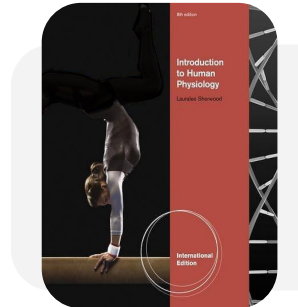
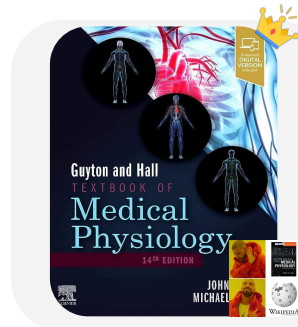
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Objectives

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

Resources

Only GI chapters included



This is prof sultan meo!



[Click here](#) for a helpful channel by the best physiology team!

الَّذِينَ يَذْكُرُونَ اللَّهَ قِيَامًا وَقُعُودًا وَعَلَىٰ جُنُوبِهِمْ وَيَتَفَكَّرُونَ فِي خَلْقِ السَّمَاوَاتِ
وَالْأَرْضِ رَبَّنَا مَا خَلَقْتَ هَذَا بَاطِلًا سُبْحَانَكَ فَقِنَا عَذَابَ النَّارِ (191)



Motility in the Small Intestine

The movements of the small intestine can be divided into :

Propulsive contractions (Peristalsis).

Migrating motor complex.

Peristaltic rush

Antiperistalsis

Segmenting (Mixing) contractions.

1 Propulsive Movement (Peristalsis)

- A contraction ring appears around gut, then moves forward.
- Usual stimulus is distention.
- Myenteric Plexus is important for these movements.
- They can be blocked by atropine.
- It organizes propulsion of material over variable distances within the intestinal lumen.
- Propulsive movements can occur in any part of small intestine at a velocity of 0.5 to 2 cm/sec.
- They normally are very weak and die after traveling only 3 to 5 centimeters, and the net movement along the small intestine normally averages only 1 cm/min. This means that 3 to 5 hours are required for passage of chyme from the pylorus to the ileocecal valve.
- They are faster in the proximal intestine and slower in the terminal intestine.

Male slides

Consist of:

Propulsive segment

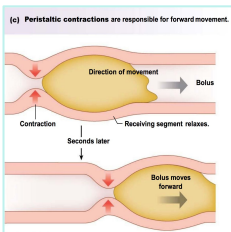
Contraction (circular M)

Relaxation (longitudinal M)

Receiving segment

Relaxation (circular M)

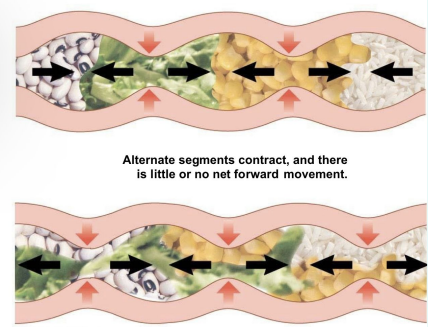
Contraction (longitudinal M)



2 Mixing (Segmentation) Contractions

- Usual stimulus is distention.
 - It is activated by enteric nervous system (ENS). (Myenteric plexus)
 - They can be blocked by atropine.
 - When a portion of small intestine becomes distended, the segmentation contraction (localized contractions of circular smooth muscle) is activated by ENS to divide the intestine into spaced segments which last for fraction of minute, and have the appearance of a chain of sausages.
 - As one set of segmentation contractions relaxes, a new set often begins at points between the previous ones. The segmentation contractions become weak when the excitatory activity of ENS is blocked by the drug atropine.
- Important**
- The significance/functions of segmentation contractions:
 1. Blend different juices with the chyme.
 2. Bring products of digestion in contact with absorptive surfaces.

(d) Segmental contractions are responsible for mixing.



3

Migrating motor complex (MMC)

It is **bursts of depolarization** accompanied by **peristaltic contraction** that begins in **empty stomach during inter-digestive period** (after absorption occurs), Travels along whole length of small intestine to reach **ileocaecal valve** after 1.5-2 h, where it **disappears**. Then a new wave of **MMC** starts.

The function of MMC is to **sweep material** (undigested food residues, dead mucosal cells and bacteria) / (to **propel any remnants in stomach & small intestine**) into colon **keeping the small intestine clean**, during the **interdigestive period**.

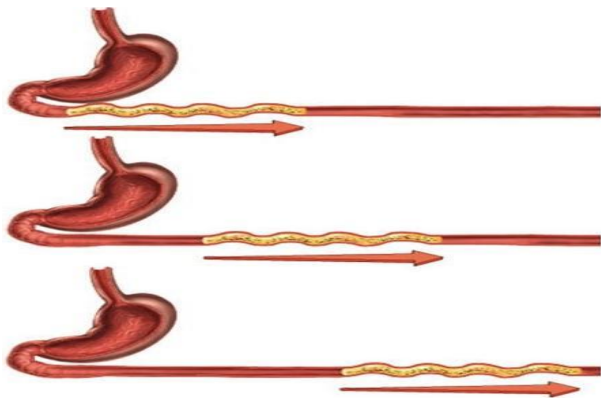
The activity of MMC **terminates** as soon as **food is ingested**.

End When the food is ingested, because it's in between meal.

Regulated by autonomic nerves and by **release of hormone "motilin"**.



تذكرون المحاضرة الأولى؟ أيد هو نفسه وقلنا انه مهم بعد..



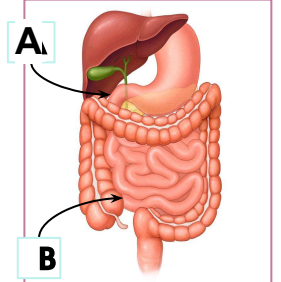
4

Antiperistalsis

A wave of contraction in the alimentary canal that passes in an **oral** (i.e. upward, **backwards**) direction and force **propel** the contents (chyme) in the **opposite direction**

Occurs between:

1. **Stomach** and **duodenum** to allow more time for **neutralization** of chyme. (A)
2. **Ileum** and **caecum** to allow time for **absorption** (B)



*this movement delay emptying

5

Peristaltic rush

- **Powerful rapid peristalsis** due to **intense irritation** of intestinal mucosa as in **infectious diarrhea**.

- Initiated mainly by **extrinsic** nervous reflexes through the **vagus nerve** to brain stem and back to gut.

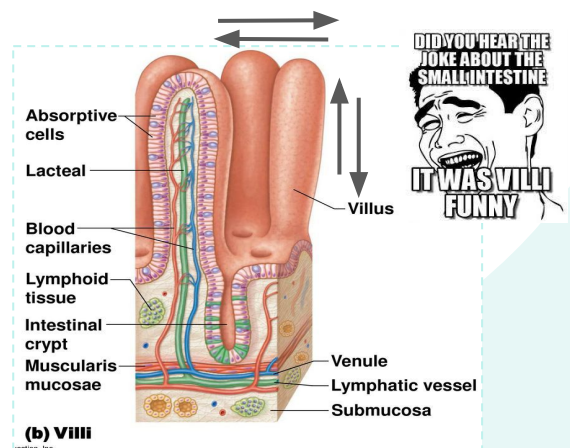
What's the function?

Sweeps the contents of intestine into the colon (without much absorption leading to diarrhea) and thereby relieving the small intestine of **irritative chyme** or **excessive distension**.



Movement of the villi

- **Villous contraction** is initiated by **local** nervous reflexes in response to **chyme** in small intestine.
- The villous movement consists of **fast shortening** and **slow lengthening** as well as side to side movements.
- Stimulated by **villikinin** hormone released by intestinal mucosa when it comes in contact with digestive products.
- **Function of villi movement?** Facilitate absorption and lymph flow from central lacteals into lymphatic system.



(b) Villi

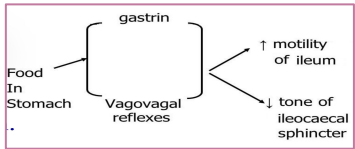
Control of intestinal motility

Control of intestinal motility

Neural control



-**Vagal** excitation **increases** intestinal and villous movements.
 -**Sympathetic** excitation **decreases** intestinal and villous movements
 -**Gastroileal reflex** :
 Initiated by gastric **distension**, Impulses are conducted through myenteric plexus to initiate a fast peristaltic wave passing to the ileum, The **ileoocaecal valve relaxes** allowing chyme to pass into cecum.
 This **reflex** is mediated by **vagus** nerve



Hormonal control



Gastrin, CCK, insulin and **serotonin**:
stimulate intestinal motility.
Gastrin and **CCK relax** ileocecal sphincter.
Motilin secreted from duodenum **stimulates** intestinal motility and regulate **MMC**.
Secretin and **glucagon** :
inhibits intestinal motility and contract ileocecal sphincter.
 -**Villikinin** stimulates movement of the villi.

Digestive enzymes in small intestinal secretions

Male slides

"The **enterocytes** of the mucosa contain digestive enzymes", they are:

Peptides

Splitting small Peptides to → amino acids by:
 1-Aminopeptidases
 2-Oligopeptidases
 3- Intracellular Di and Tri peptidases

Disaccharides

Splitting disaccharides to → monosaccharides by:
 1-Sucrase 2-Maltase
 3-Isomaltase 4-Lactase

Neutral fats

Splitting neutral fats to → glycerol and fatty acids by:
 Small amounts of intestinal lipase


Nucleotide

Nucleotides → Nucleotidases →
 purine base
 pyrimidine base
 phosphoric acid
 pentose sugar



Secretions of small intestine

Secretion of Mucus by Brunner's Glands in the Duodenum:

- Brunner's glands are located in the wall of the first few centimeters of the duodenum.
- They secrete large amounts of **alkaline mucus**, which contains a large amount of **bicarbonate ions**, **in response to/stimulated by**:
 - 1- **Irritating stimuli** on the duodenal mucosa
 - 2- **Vagal stimulation**
 - 3- **Secretin**  هرمون small intestine رقم واحد!
- Mucus **protects** the mucosa
- Brunner's glands are inhibited by sympathetic stimulation

Brunner's glands only found in duodenum

secretin

" Stimulus is highly acidic chyme "

Low pH -> Stimulate pancreatic secretions "rich in bicarb" and stimulate the Brunner's glands secretions "which rich in mucous and bicarb". Also stimulate bile secretion from liver which is alkaline.

Secretion of Intestinal Juices (**succus entericus**) by the Crypts of Lieberkühn

- Crypts of Lieberkühn are small pits which lie between intestinal villi.
- Volume: 1800 ml/day.
- pH: 7.5-8. It participates in the neutralization of acid chyme delivered from stomach.
- Composition: 0.6 % organic, 1 % inorganic substance.
- Most of the **enzymes** are found either in the **brush border** or in the **cytoplasm** of the enterocytes.
- The enzymes that are actually **secreted** into the **lumen** are **enteropeptidase and amylase**
- The surfaces of both the crypts and the villi are covered by an epithelium composed of 2 types of cells:
 - **1- Goblet cells :**
 - Secrete mucus+HCO₃
 - **2- Enterocytes :** نص حياتك
 - Secrete large quantities of H₂O and electrolytes and over the surfaces of adjacent villi Reabsorb H₂O, electrolytes & end products of digestion



Control of intestinal secretions

Intestinal juice	Brunner's glands
Secretion is stimulated by : <ol style="list-style-type: none"> 1. Distension, tactile , irritating stimuli and vagal stimulation. 2. Hormones : Gastrin , Secretin, CCK, glucagons, enterocrinin. Sympathetic system inhibits the intestinal secretion.	Secretion is stimulated by : <ul style="list-style-type: none"> - Secretin (Hormonal) - Tactile (Mechanical) - Vagal stimulation(Neural)



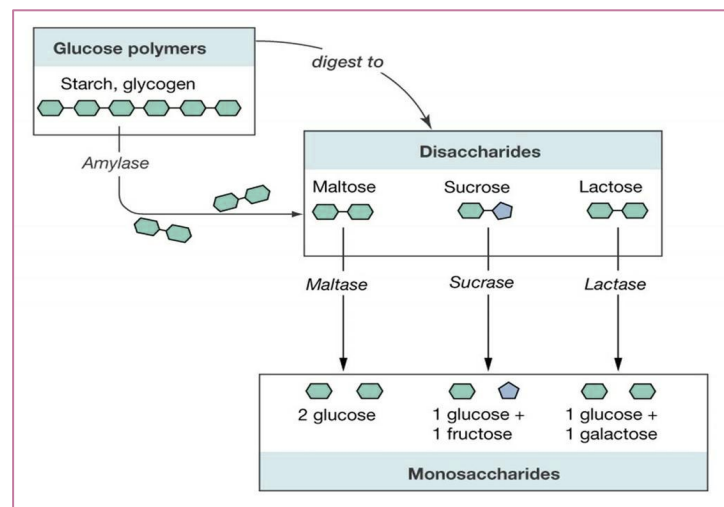
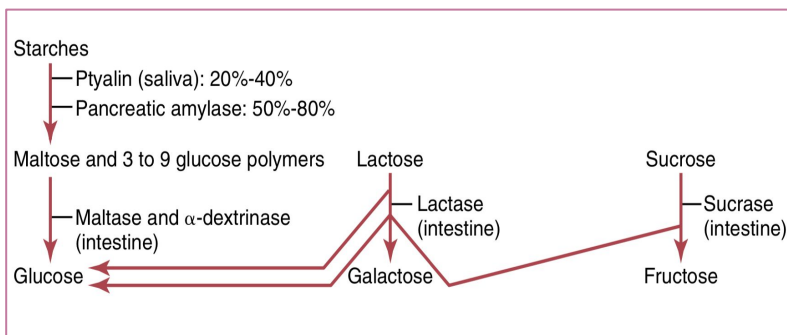
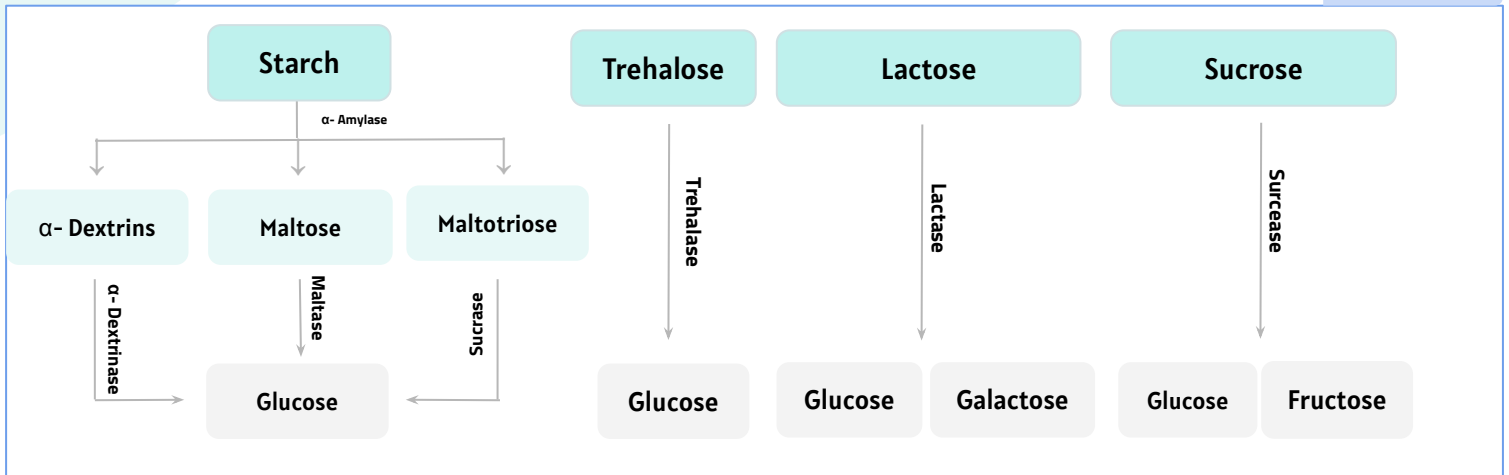
Digestion of carbohydrates

Site	Enzyme	Function	Notes
<p><i>Male slides</i></p> <p>1-In the mouth & stomach.</p>	<p>-Digestion by :</p> <p>The ptyalin (an α-amylase) enzyme in saliva.</p> <p>**No need for activation they are active.**</p> <p>-Stomach doesn't have enzymes To digest polysaccharides.</p>		<p>-The starch digestion sometimes continues in the fundus and body of the stomach for as long as 1 hour before the food becomes mixed with the stomach secretions.</p>
<p><i>Male slides</i></p> <p>2-In the small intestine (by pancreas)</p>	<p>-Digestion by :</p> <p><u>Pancreatic Amylase</u></p>	<p>- Hydrolyzes starch into the disaccharide (maltose) and other small polymers of glucose.</p> <p>Polysaccharides ->Disaccharides</p>	<p>-pancreatic secretion has (α-amylase) that is almost identical in its function with the α-amylase of saliva but is several times as powerful.</p> <p>-Therefore, within 15 to 30 minutes after the chyme empties from the stomach into duodenum and mixes with pancreatic juice, virtually all the Carbohydrates will have become digested.</p> <p>-The carbohydrates are almost totally converted into maltose and/ or other very small glucose polymers before passing beyond the duodenum or upper jejunum.</p>
<p>3- Hydrolysis of Disaccharides in intestine, by intestinal enzymes (In enterocytes)</p>	<p>-Digestion by :</p> <p>Disaccharidases, such as:</p> <p>1-Lactase. 2-Sucrase. 3-maltase . 4-α-dextrinase.</p> <p>Present in enterocytes lining the villi of the small intestine.</p>	<p>-Are capable of splitting the disaccharides lactose, sucrose and maltose, plus other small glucose polymers, into their constituent monosaccharides.</p> <p>Disaccharide ->Monosaccharide</p>	<p>- These enzymes are located in the enterocytes covering the intestinal microvilli brush border, so that the disaccharides are digested as they come in contact with these enterocytes.</p> <p>Becomes monosaccharide only if they touch the villi.</p>



Digestion of carbohydrates

Male slides



Digestion of carbohydrates (summary)

We highly recommend it for you.

Polysaccharides

Starch, Glycogen

Salivary and pancreatic \downarrow Amylase

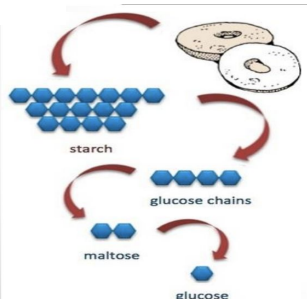
Disaccharides

Maltose

Enterocytes \downarrow Maltase

Monosaccharides

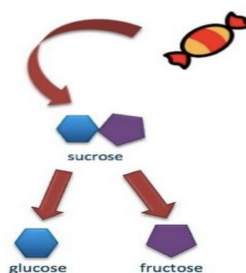
Glucose



Sucrose "sugar"

\downarrow Sucrase

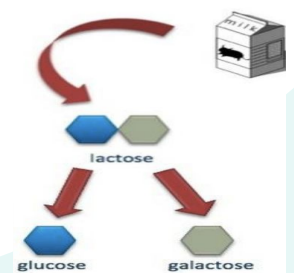
Glucose + Fructose



Lactose "milk"

\downarrow Lactase

Glucose + Galactose





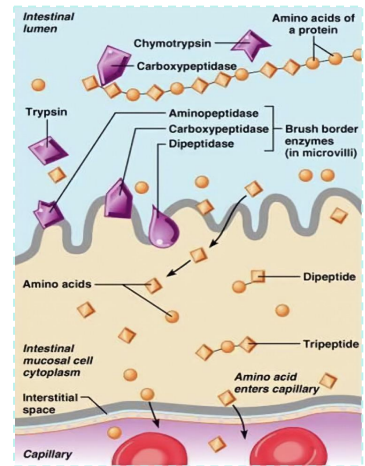
Digestion of Proteins

A small percentage of proteins are digested to free AA by the pancreatic enzymes.

Most protein digestion occurs in the **duodenum** and **jejunum** by aminopeptidases, oligopeptidases. (in the brush border)

Most proteins remain as dipeptides and tripeptides digested by intracellular di and tripeptidases To free AA.

Aminopeptidases And oligopeptidases digest proteins into amino acid and dipeptides and tripeptides, which then enter cells and digested intracellularly by di and tripeptidases. .



<p style="text-align: right; color: blue; font-size: small;">Male slides</p> <h2 style="text-align: center;">Digestion in the <u>stomach</u></h2>	<p style="text-align: right; color: blue; font-size: small;">Male slides</p> <h2 style="text-align: center;">Digestion by <u>pancreatic</u> secretion</h2>
<ul style="list-style-type: none"> ● Pepsin is the important peptic enzyme of the stomach . (active at PH=2.0-3.0 and is inactive at pH above about 5). ● Pepsin initiates the process of protein digestion, usually providing 10-20% of the total protein digestion. 	<ul style="list-style-type: none"> ● Most protein digestion occurs in the <u>duodenum</u> and <u>jejunum</u>. ● Both trypsin and chymotrypsin split protein molecules into <u>small polypeptides</u>. ● Carboxypolypeptidase then cleaves individual AA from the carboxyl ends of the polypeptides.
<ul style="list-style-type: none"> ● The pH of the stomach averages around 2.0-3.0. ● One of the most important feature of pepsin digestion is its ability to digest protein collagen. ● Collagen is a major constituents of the intracellular connective tissue of meats ; therefore, for the digestive enzymes of the digestive tract to penetrate meats and digest the other meat proteins, it is first necessary that the collagen fibers be digested. ● Digests proteins into proteoses , peptones & polypeptides. 	<ul style="list-style-type: none"> ● Proelastase is converted into elastase, which then digests elastin fibers that partially hold meats together. ● Only a small percentage of the proteins are digested all the way to their constituent AA by the pancreatic juices. ● Most remain as dipeptides and tripeptides to be digested by peptidases in the Enterocytes. (mainly in the duodenum and jejunum)

*Simply, we have got 4 sites to digest proteins :

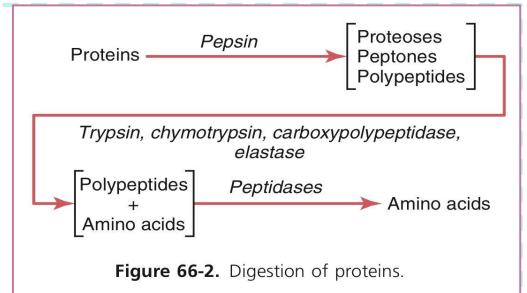
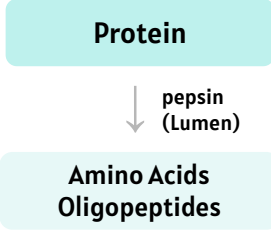
1-Stomach 2-Duodenum and jejunum 3-brush border 4-intracellular(Only (di-tri peptides)).



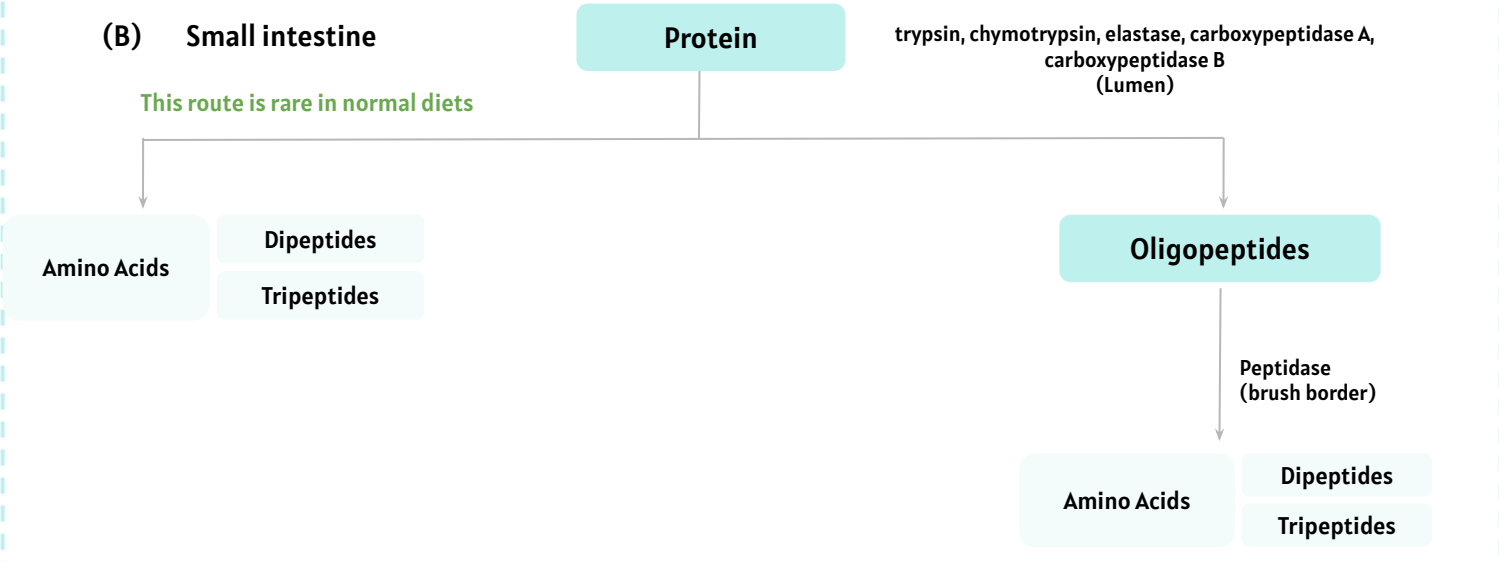
Digestion of Proteins

Male slides

(A) Stomach



(B) Small intestine

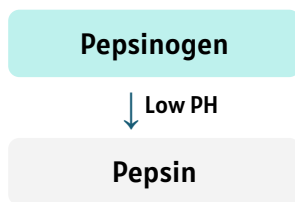


Activation of Gastrointestinal Proteases

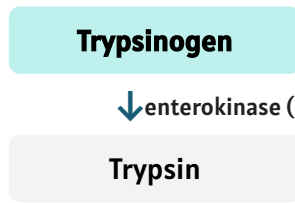
Same Diagrams but from Drs' slides

Male slides

(A) Stomach

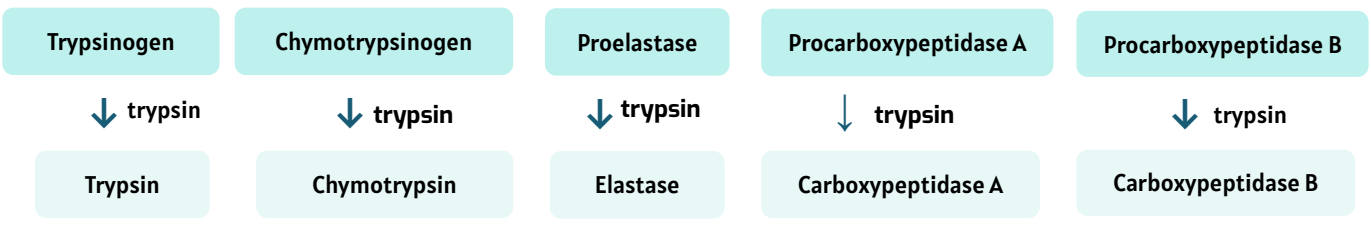


(B) Small intestine



-Enterokinase deficiency prevents activation of pancreatic enzymes and stops digestion of proteins. (M)important

-Protein can be absorbed in form of di-tri peptide as well as amino acids. Unlike polysaccharides must be absorbed into its smallest constituent (monosaccharides).





Digestion of fat

- Less than 10% of triglycerides is digested in the stomach by lingual lipase.
- All fat digestion occurs in the **small intestine**. (Approximately all)

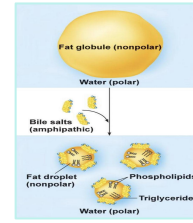
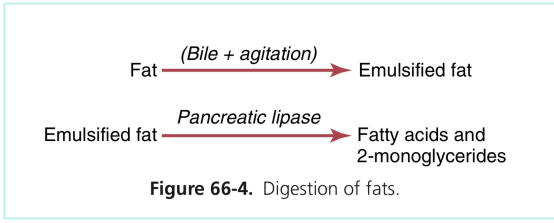
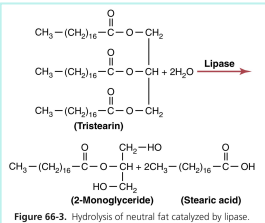
Emulsification of fat by bile acids :

Definition Break the fat globules into very small sizes under the influence of bile salts, so that the water-soluble digestive enzymes can act on the globule surfaces (**emulsification of the fat**).

Male slides

Information

- **What is the significance of Emulsification of fat ?**
-to increase the surface area of fat globule surfaces, so that water-soluble digestive enzymes can act on it. (**easily**)
- The polar parts (the points where ionization occurs in water) of the bile salts and lecithin molecules are highly soluble in water. So, they are **amphipathic** molecules.
- **Bile Salts and lecithin in the bile help fat digestion by making the fat globules readily fragmentable with water in the small intestine (emulsification of fat) .**
- The major function of the bile salts and lecithin, especially lecithin, in the bile is to make fat globules readily **fragmentable** by agitation with water in the small bowel.
- **CCK contracts the walls of gallbladder to help in digestion of fat.**

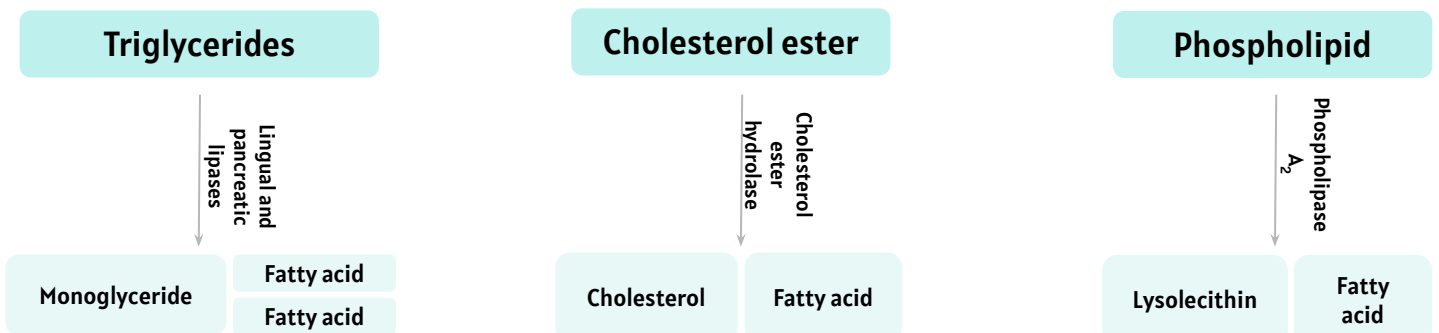


Digestion of Triglycerides by Pancreatic Lipase

Male slides

The most important enzyme for digestion of the triglycerides is **pancreatic lipase**. Reduction in pancreatic secretion leads to Steatorrhea.

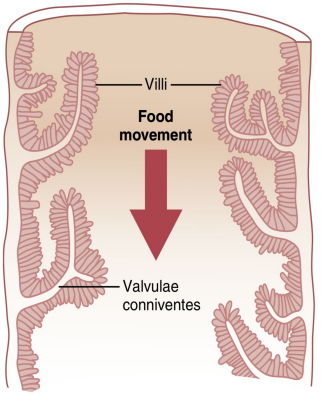
-End Products of Fat Digestion:



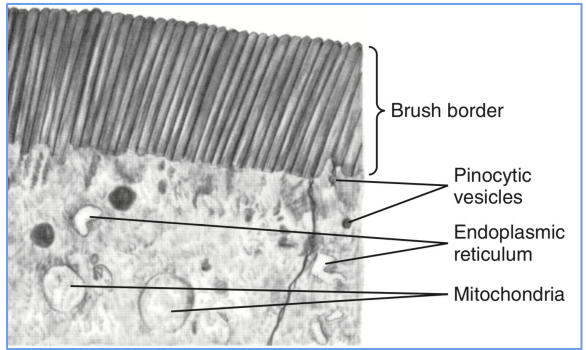


Basic Principles Of Gastrointestinal Absorption

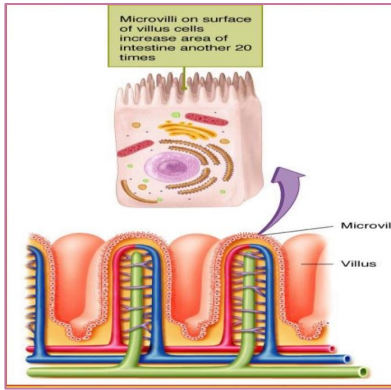
1	<p>The absorptive surface area of the small intestine is about 250m² (almost 2,700 square feet)- (provides the surface area equivalent to a tennis court).</p>
2	<p>The following increase the intestinal surface about 600 times: $3 \times 10 \times 20 = 600$</p> <p>a. Mucosal folds (<i>valvulae conniventes</i>) (kercking), well developed in the duodenum and jejunum (3 times/fold)</p> <p>b. The villi on the mucosal surface enhances (10 times/fold)</p> <p>c. The microvilli on the epithelial cells, the brush borders (20 times/fold)</p> <p>The epithelial cell on each villus is characterized by a brush border, consisting of as many as 1000 microvilli protruding into the intestinal chyme</p>



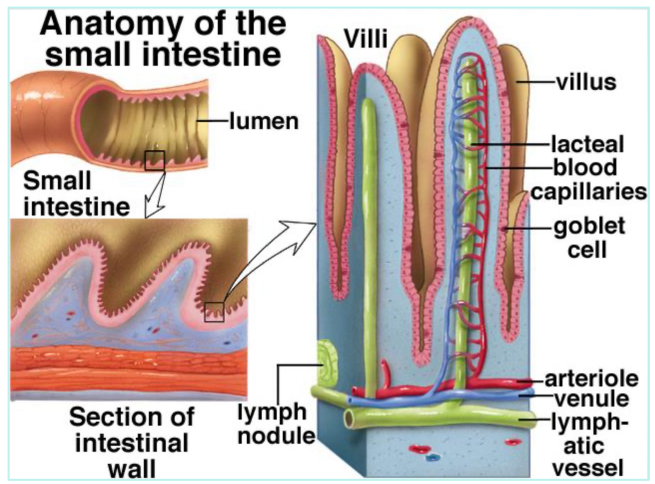
Longitudinal section of the small intestine, showing the valvulae conniventes covered by villi.



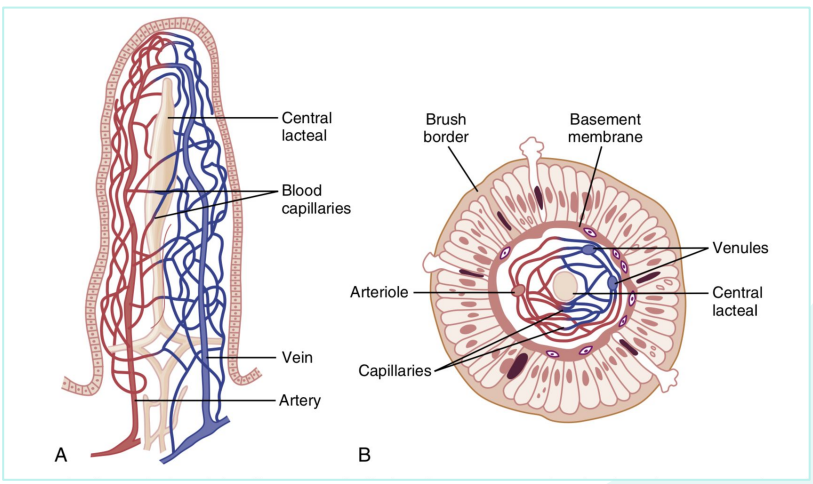
Brush border of a gastrointestinal epithelial cell



Anatomy of small intestine



Microvasculature of the villus



Inside each villus there is a lymph vessel and blood vessel (arterioles and venules). Most of the different type of the end products of digestion of carbohydrates, protein and fat are absorbed into the bloodstream (into the capillary blood, then to the portal circulation to the liver, EXCEPT the fatty acids specially long chain fatty acids goes to the central lacteal then lymphatic vessels.



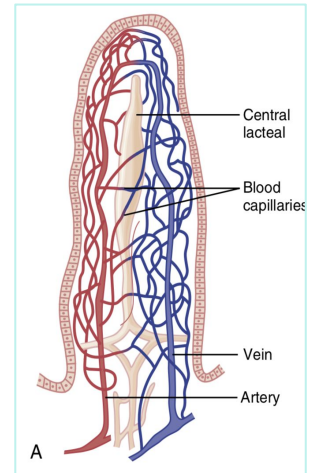
Absorption in the Small Intestine

The small intestine

It is about 5-7 meters, extends from the pyloric sphincter to the ileocecal valve, consists of:-

- Duodenum (0.5 meters)
- Jejunum (2-3 meters)
- Ileum (3-4 meters)

- Approximately 90% of protein & CHO digestion (and essentially all lipid digestion) takes place in the first two sections of the small intestine.
- The small intestine has the key role in absorption.



End products of digestions:	
Carbohydrates	Monosaccharides
Proteins	Amino acids
Fat	Fatty acids + monoglycerides
Vitamin, minerals & water	No digestion



Overview of the Absorption Mechanisms

<p>High concentration Nutrient Cell membrane Low concentration</p>	<p>Nutrient Carrier protein Low concentration High concentration</p>	<p>Low concentration Nutrient Carrier protein ATP High concentration</p>	<p>Nutrient</p>	<p>Extracellular fluid Molecules to be secreted Secretory vesicle Cytoplasm</p>
<p>a Passive diffusion: Nutrients pass through the cell membrane.</p>	<p>b Facilitated diffusion: Requires a specific carrier but no energy is needed to cross the membrane.</p>	<p>c Active transport: Requires both a carrier protein and energy to cross the cell membrane.</p>	<p>d Endocytosis: Whole molecules are engulfed by the cell membrane.</p>	<p>e Exocytosis: Whole molecules enclosed in a vesicle, then extruded outside the cell</p>



Absorption in the Small Intestine



1

Absorption of Carbohydrates

All the carbohydrates in the food are absorbed in the form of **monosaccharides**; only a small fraction are absorbed as disaccharides.

- **Glucose and galactose** absorption occurs in a co-transport mode with active transport of Na⁺ (**2ry active transport**) **Na⁺ dependence**.
- **Fructose** is independent on Na⁺ but it transports in luminal membrane **via facilitated diffusion**.
- **Pentose** (comes from DNA and RNA digestion) is transported by **passive diffusion**

2

Absorption of proteins

- **Proteins are absorbed in the form of dipeptides, tripeptides, and a few free amino acids**
- L-AA are transported by **secondary** active transport.
- D- AA are transported by **passive diffusion**.
- **Di and tripeptides** cross the brush border by active transport protein carrier. Di and tripeptides are hydrolyzed by brush border and cytoplasmic **oligopeptidase**.
- AA leaves the cell at the **basolateral** membrane by **facilitated** transport.

3

Absorption of Vitamins

-Vitamins are absorbed mainly in the jejunum & ileum. A, D, E, and K are fat soluble vitamins, absorbed in the jejunum in combination with fat.

The B's and C vitamins are water soluble vitamins, absorbed in the jejunum and upper ileum.

-**Fat-soluble vitamins (A, D, E, & K)** (KADE=كادي) are incorporated into micelles and absorbed along with other lipids.

-**Most water-soluble vitamins (C, B1, B2, B6, and folic acid)** are absorbed by Na⁺- dependent cotransport mechanisms

-Vitamin B12 is absorbed in the **terminal** part of **ileum** and requires intrinsic factor.

Important

-Vitamin B12 is absorbed in the terminal ileum and needs intrinsic factor (secreted from the stomach). Ileal resection can cause vitamin B12 deficiency (pernicious anemia) due to? *Only site of absorption.*

Gastrectomy / **Atrophy of gastric mucosa** results in the loss of parietal cells and loss of intrinsic factor → **pernicious anemia**

4

Absorption of Fats

-Bile salts have the ability to form micelles, (**Bile salt are amphipathic molecules**, each bile salt molecule is composed of a sterol nucleus that is fat-soluble and a polar group that is water-soluble).

-Micelles are small spherical, cylindrical globules **3 to 6 nm in diameter** composed of 20 to 40 molecules of bile salt. Long chain FA, MG, cholesterol and fat soluble vitamins are incorporated into the interior of the micelle.

-The polar groups are (-) charged, they allow the entire micelle globule to dissolve in the water of the digestive fluids and to remain in stable solution.

the micelles perform a "ferrying" function that is highly important for fat absorption

-**The micelles act as a transport medium to carry the monoglycerides and free fatty acids to the brush borders of the intestinal epithelial cells** (The micelles carry FA & MG to the luminal borders of the intestinal epithelial cells).

-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.**

Failure to synthesize Apo B results in

abetalipoproteinemia. • **Abnormality at any one of lipid dig & absorption steps will interfere with lipid absorption and results in Steatorrhea (fat excreted in feces).**

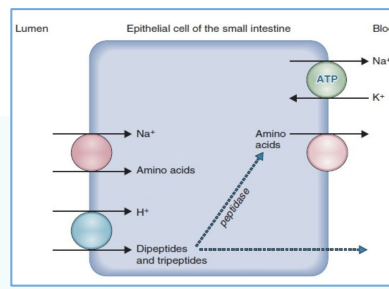
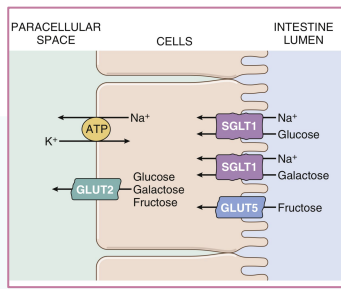
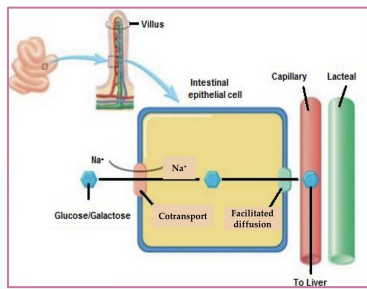
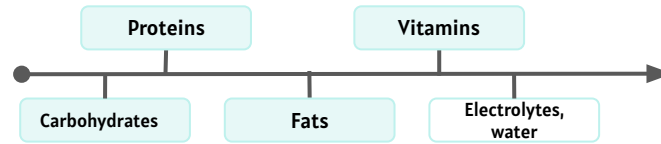
4. The ileum and distal jejunum of a 34-year-old man are ruptured in an automobile accident. The entire ileum and a portion of the jejunum are resected. What is most likely to occur in this man?

- Atrophic gastritis
- Constipation
- Gastric ulcer
- Gastroesophageal reflux disease (GERD)
- Vitamin B₁₂ deficiency

Guyton Review 2e

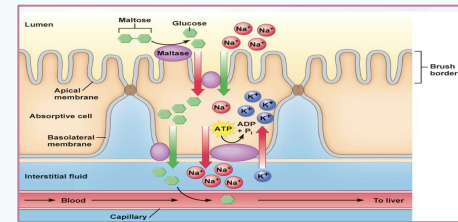
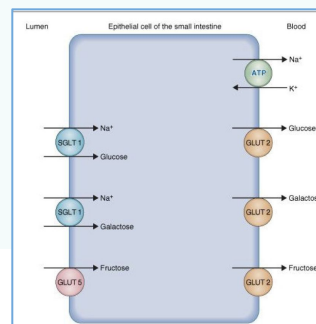
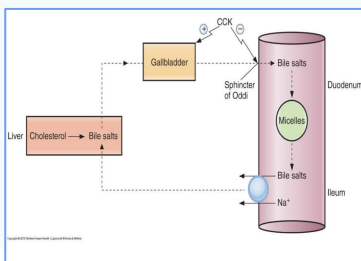
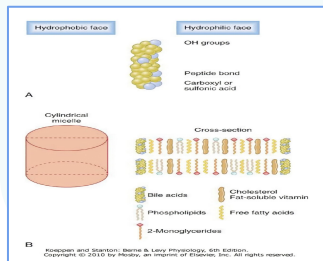


Absorption in the Small Intestine



STOMACH	Alcohol (20% of total) Calcium, magnesium, iron
SMALL INTESTINE	Glucose Water-soluble vitamins Alcohol (80% of total) Sodium, potassium Vitamin B-12
COLON	Sodium, potassium Acids and gasses
RECTUM	Water

Feces

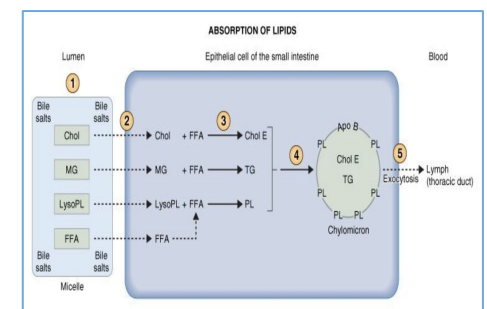
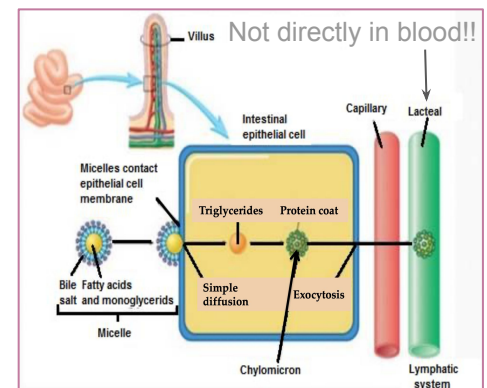


Steps of Fat Absorption

Female slides

Fatty acids (FA) & monoglycerides (MG) associated with the micelles in lumen of intestine.

- 1 FA & MG leave micelles and enter epithelial cell by **diffusion**.
- 2 FA are used to synthesis triglycerides in agranular endoplasmic reticulum.
- 3 Fatty globules are combined with proteins to form **chylomicrons** within Golgi apparatus. Triglycerides (from RER) partially covered by protein
- 4 Vesicles containing chylomicrons leave epithelial cells by **exocytosis** (Because it is bigger than the pores in cell membrane) and enter a lacteal (lymph capillary).
- 5 Lymph in the lacteal transport chylomicrons away from the intestine.



Disorders of Carbohydrate Digestion and Absorption:

- **Lactose intolerance** (lactase deficiency) causes **osmotic diarrhea**

Important

Male slides

Disorders of Proteins Digestion and Absorption:

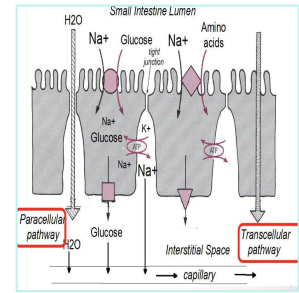
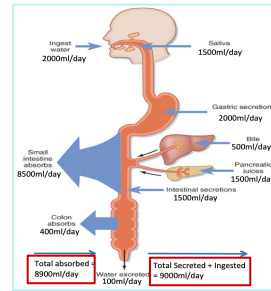
Cystinuria: is a genetic disorder in which the transporter **Na-AA** is absent in small intestine and kidney.



Absorption in the Small Intestine



- ❖ Electrolytes and H₂O cross intestinal epithelial cells by either **transcellular** or **paracellular** route
- ❖ The permeability of the tight junctions varies with the type of epithelium
 - Leaky epithelia are in the small intestine and gallbladder
 - A tight epithelium is in the colon

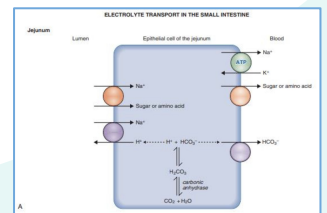
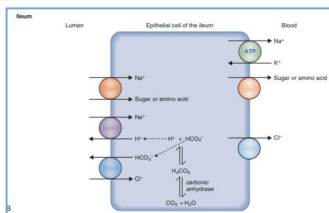


<p>Absorption of Na+</p>	<ol style="list-style-type: none"> 1) passive diffusion. 2) Na⁺-Glucose or Na⁺-Amino acid Cotransport 3) Na⁺-Cl Cotransport 4) Na⁺-H⁺ exchange <ul style="list-style-type: none"> - The next step is osmosis of water into the paracellular space, because a large osmotic gradient has been created by the elevated concentration of ions in the paracellular space. - Aldosterone Greatly Enhances Na⁺ Absorption. This effect is especially important in the colon because it allows virtually no loss of NaCl and water. 	<p>ELECTROLYTE TRANSPORT IN THE COLON</p>
<p>Absorption of Cl-</p>	<p>Cl⁻ absorption accompanies Na⁺ absorption by the following mechanisms:</p> <ol style="list-style-type: none"> 1. Passive diffusion 2. Na⁺-Cl⁻ cotransport 3. Cl⁻-HCO₃⁻ exchange 	
<p>Absorption and Secretion of K+</p>	<ul style="list-style-type: none"> - K⁺ is absorbed in the small intestine by passive diffusion - K⁺ secretion (active) in the colon is stimulated by aldosterone - Excessive loss of K⁺ in diarrheal fluids causes hypokalemia (metabolic acidosis also happen in sever diarrhea-loss of HCO₃⁻) 	
<p>Secretion of Bicarbonate Ions in the Ileum</p>	<ul style="list-style-type: none"> ❖ The epithelial cells on the surfaces of the villi in the ileum and large intestine have a special capability of secreting bicarbonate HCO₃⁻ in exchange for absorption of chloride ions Cl⁻. ❖ This provides alkaline bicarbonate HCO₃⁻ that neutralize acid products formed by bacteria in the large intestine. 	
<p>Ca⁺⁺ Absorption by Enterocytes</p>	<ul style="list-style-type: none"> ❖ 1,25 dihydroxy-vitamin D₃ stimulates synthesis of Ca⁺⁺-binding protein and Ca⁺⁺-ATPase in enterocytes 	

Electrolytes transport in small intestine

Male slides

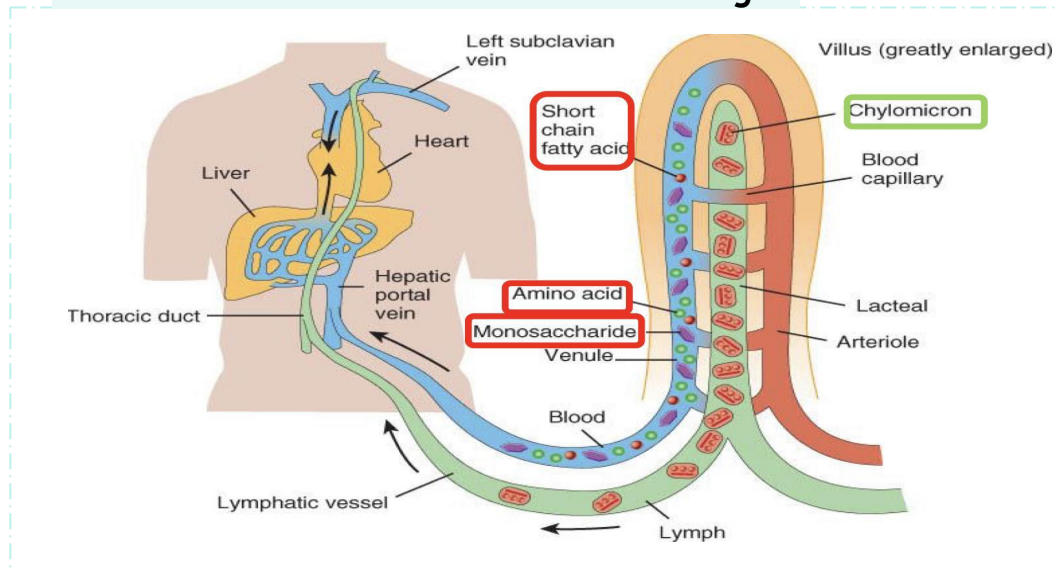
- Jejunum: Net absorption of NaHCO₃.
- Ileum: Net absorption of NaCl



Absorption of nutrients (summary)

Site	Absorbed Nutrient
Duodenum and upper jejunum	Most minerals
Jejunum and upper ileum	Carbohydrates, amino acid, water-soluble vitamins
Jejunum	Lipids and fat-soluble vitamins
Terminal ileum	Vitamin B12. (M)

Where will the absorbed nutrients go ?



Hormonal control of Absorption and secretion

Glucocorticoid	= ↑ Absorption of H ₂ O & ions (small & large intestine)
Somatostatin	= ↑ H ₂ O & ions absorption (ileum & colon)
Epinephrine	= ↑ NaCl absorption (ileum)
Aldosterone	= ↑ Synthesis of Na ⁺ channels (colon)

تَحَدِّي!

قدھا؟ إضغط هنا.



Doctors' Notes

1: Propulsive movement, هي اللي تنزل للقولون ويتغير اسمها الى -> mass movement

2: I can inhibit mixing movement by ATROPINE "cholinergic blocker" because vagus nerve -> cholinergic neurone.

- (Parasympathetic is usually excitatory) BUT 'during swallowing' it's inhibitory for (LES) sphincter only during swallowing so between swallows, it increase the tone.
- While sympathetic is inhibitory to gut body, while excitatory to sphincters.

2: Migratory Motor Complex:

هي propulsive movement بالحقيقة ولكن ما نشوفها الا بالinterdigestive periods (وقت الصوم مثلاً)

- MMC **only** seen during **fasting**, when **motilin** hormone goes up
وهو أيضاً مسؤول عن جزء من Hunger sensation
- Also Responsible for pushing remnants in stomach/small intestines down into colon, Starts at middle of the stomach it steps at terminal ileum.

When this movement stops?

وجود الأكل بالstomache هو اللي يعطي أوامر انها توقف، بمعنى أن **smelling** of food بحد ذاته مش حيوقف MMC.

Immediately stops when is ingest, even if it didn't reach ilem.

3: Peristaltic rush

دايماً نشوفها بالdiarrhoea

- Toxic Substances or any kind of infection that activates the wall of the small intestine to **maximum power** to push materials down to large intestines.

4: movement of villi :

يسموها -> fast shortening, slow lengthing

- Villikin hormone is not considered main GI hormone, but it activates aslo muscularis mucosa.

5: control of intestinal motility:

In neural,

small intestine باللي نشوفها بالGastroileal reflex also called (Gastrocolic)

it' **vagovagal reflex

In Hormonal, (secretin, GIP, Glucagon) these are **inhibitory**.

- Gastrin, CCK they work together in increasing **motility in small intestine** but they work against each other in terms of **gastric motility**.

Brunner's glands:

القلائد هادي صديقتنا الروح بالروح، لان عندها القدرة على انتاج HCO_3 بشكل كبير مما يساهم في عملية neutralization بمعنى، اذا فيه acid solution in duodenum لن يتم هضمه ولا امتصاصه!

How brunner's gland/crypts of lieberkuhn is controlled?

By hormones(secretin), vagal stimulation

والمحفز لهم سواء secretin or vagus هو destention/tactile

Carbohydrates digestion starts in mouth (a amylase), stopped in stomach (because of high acidity), and completed by pancreatic Amylase 15 to 30 m ↓

ماتاخذ وقت طويل خصوصاً لو كانت disaccharide وهاذي majority اللي ناخذها.

Digestion of proteins start in stomach, but real digestion is in the **small intestine**

If pepsin doesn't get released in stoma, what do you think will happen?

-والله ما حيصير اي disorder in protein digestion and absorption

السبب أن bulk of protein يتم هضمه في duodenum وتحت تصرف البنكرياس لأن عنده "الشلة حقت trypsin/chymotrypsin"..

TEST YOURSELF !

MCQ:

Q1) Mixing Contraction can be blocked by?

A) Heparin

B) Atropine

C) NSAIDs

D) Warfarin

Q2) What's the most important enzyme that digest Triglycerides

A) pancreatic lipase

B) Pancreatic amylase

C) Aminopeptidase

D) Phospholipase A₂

Q3) Amino acids leave the cell at the basolateral border via:

A) Primary active transport

B) Facilitated diffusion

C) Secondary active transport

D) passive diffusion

Q4) it's Powerful rapid peristalsis due to intense irritation

A) Antiperistalsis

B) Propulsive contractions

C) Peristaltic rush

D) segmenting contractions

Answers: Q1:B | Q2:A | Q3:B | Q4:C

SAQ:

Q1) Mention the site of absorption for each of the following:

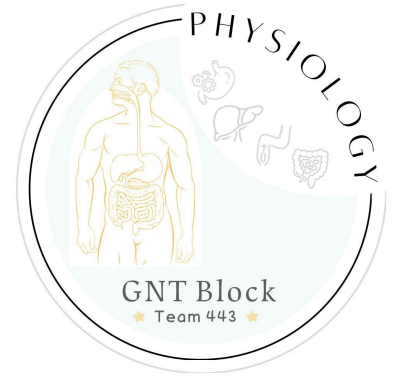
Absorbed Nutrient	Site
Most minerals	Duodenum and upper jejunum
Carbohydrates, amino acid, water-soluble vitamins	Jejunum and upper ileum
Lipids and fat-soluble vitamins	Jejunum
Vitamin B12. (M)	Terminal ileum

Q2) What are the mechanisms of Na⁺ absorption?

- 1) passive diffusion.
- 2) Na⁺-Glucose or Na⁺-Amino acid Cotransport
- 3) Na⁺-Cl Cotransport
- 4) Na⁺-H⁺ exchange



Well done! You've just finished the last midterm physiology lecture!
Here's a gift for you!



 The BEST
Team Leaders
EVER..


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