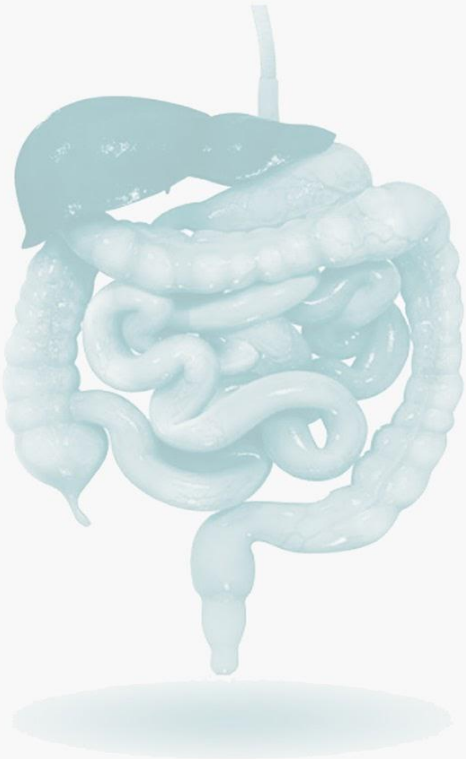


#5 Physiology of the small intestine (motility and secretion)

objectives :

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

Doctors' notes

Extra

Important

Revised by

خولة العماري & هشام الغفيلي

Resources: 435 Boys' & Girls' slides | Guyton and Hall 12th & 13th edition

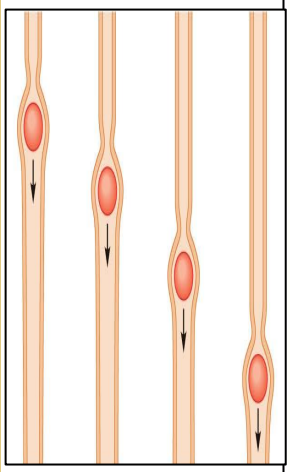
Editing file

Physiology435@gmail.com

Motility in the Small Intestine:

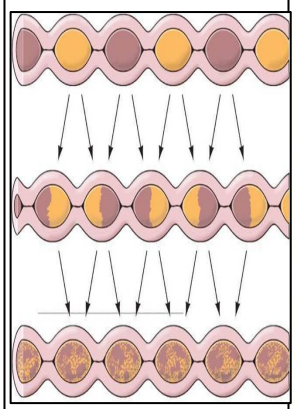
The movements of the small intestine can be divided into:

1. Propulsive contractions (Peristalsis):



- A contraction ring appears around gut, then moves forward.
- Usual stimulus is distention. "like finger movement, when you do constriction ring then propagate along the whole length"
- Organizes propulsion of material over variable distances. "We call it propulsive movement because the benefit of it is propulsion"
- They are faster in the **proximal** intestine and slower in the **terminal** intestine (velocity 0.5 to 2.0 cm/sec)
  (they get weaker after traveling 3 to 5 cm and the net movement average only 1 cm/min this means 3 to 5 hours are required for passage of chyme from the pylorus to the ileocecal valve).
- Myenteric "responsible for control or regulation of motility" plexus is important. (for contraction, can not occur without M.p.)
- They can be **blocked** by atropine
- **Receiving part** : contraction(longitudinal M) relaxation (circular M)
- **Propulsive part** : contraction(circular M) relaxation(longitudinal M)

2. Segmenting (Mixing) contractions:



- A localized contraction of circular smooth muscles that constricts the intestine into spaced segments, last for fraction of min. "The difference between it and the previous movement is this one include many constriction ring which divide the lobe of the intestine into segments(that's why we call it segmenting) and then those series of segment or contraction disappear and a new series start from the previous one"
- As one set of segmentation contractions relaxes, a new set often begins at points between the previous ones.
- Usual stimulus is distention.
- **The significance:**

1. Blend different juices with the chyme.
2. Bring products of digestion in contact with absorptive surfaces.

- It is activated by enteric nervous system.
- They can be **blocked** by atropine. "What's the function of this movement? Mixing or blinding of the contents, and also bring the products of digestion into the mucosa lining of the villi, which is the site of absorption, so it's facilitate the absorption"

3. Peristaltic rush:

- Powerful rapid peristalsis due to intense"severe" irritation of intestinal mucosa (as in infectious diarrhea).
- Initiated mainly by extrinsic nervous reflexes to brain stem and back to gut."it means by long vagal reflex"
- Sweeps the contents of intestine into the colon"so the function is rapid emptying of the irritating or the infectious substance from the small intestine to the colon to get rid to the outside through the defecation process, so this type occurs only in infectious condition during diarrhea, it's not physiologically, only if there's severe infection or severe irritation to the mucosa of the small intestine" without much absorption leading to diarrhea and thereby relieving the small intestine of irritative chyme or excessive distension.

Motility in the Small Intestine (cont..):

4. Antiperistalsis:

- "We know that the peristalsis always occur in a forward direction from the direction of the mouth to the villus, but her it occur in the opposite direction(physiologically it occurs), and pathologically it occurs during vomiting" A wave of contraction in the alimentary canal that passes in an oral (i.e. upward or backwards) direction and force the contents in the opposite direction to the normal.

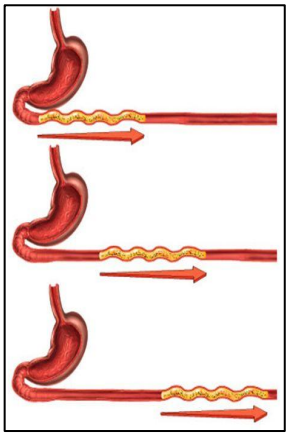
Occurs between:

- Stomach and duodenum to allow more time for neutralization of chyme."Between the stomach and the beginning of the small intestine, and the function here is allow(give time) neutralization of the chyme"
- Ileum and caecum to allow time for absorption."Between the end of the small intestine and the beginning of the colon of the large intestine, and the function here is facilitate(give sufficient time for) absorption"

5. Migrating motor complex:

- Bursts of depolarization "full with bi contraction, which start in an empty stomach during the enter digestion period, so this type of movement happen in between meals" accompanied by peristaltic contraction that begins in empty stomach "from the pyloric" during interdigestive period (after absorption occurs).(or when fasting)
- Travels along whole length of small intestine to reach ileocaecal valve (وهذا شيء مهم لأن لو كملت بعد الثالث بيبي يصير عندنا دايريا خلال الصيام) after 1.5-2 h, where it disappears. A new wave of MMC starts.
- Activity of MMC terminates as soon as food is ingested "because it's happen only in an empty stomach" so the function of MMC is "to sweep the remnant" propel material (undigested food residues, dead mucosal cells and bacteria) into colon and keeping the small intestine clean.
- Regulated by autonomic nerves and by release of motilin.

MMC start from the antral pump to the terminal ileum

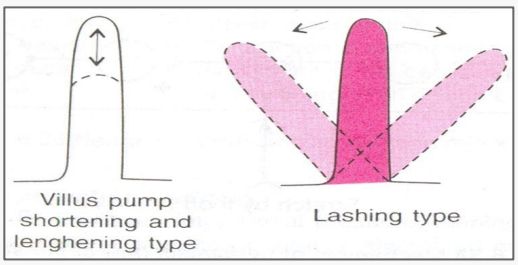


Movement of villi:

- Facilitate absorption and lymph flow from central lacteals into lymphatic system."the function is facilitation of absorption, and contain the lacteal (so it's facilitate(increase) the flow of the lymph from the lacteal to the lymphatic system"
- **Consists of two types of movement :**

1. fast shortening and slow lengthening "longitudinal"
2. side to side movements.

- Its initiated by local nervous reflexes in response to the present of the content of chyme in small intestine.
- **Stimulated** by villikinin hormone released by intestinal mucosa when it comes in contact with digestive products."the hormone takes the name from the villi, and it's facilitate or improve the movement of the villi"



Guyton corner : Movements Caused by the Muscularis Mucosae and Muscle Fibers of the Villi
The muscularis mucosae can cause short folds to appear in the intestinal mucosa. In addition, individual fibers from this muscle extend into the intestinal villi and cause them to contract intermittently. The mucosal folds increase the surface area exposed to the chyme, thereby increasing absorption. Also, contractions of the villi-shortening, elongating, and shortening again-"milk" the villi so that lymph flows freely from the central lacteals of the villi into the lymphatic system. These mucosal and villous contractions are initiated mainly by local nervous reflexes in the submucosal nerve plexus that occur in response to chyme in the small intestine.

Control of intestinal movement :

Neural control	Hormonal control
• Vagal"parasympathetic" excitation"stimulatory" **increases** intestinal and villous movements."it's stimulate the contraction of the wall and the relaxation of the sphincter" • **(Gastroileal reflex)**"always when there's reflex, the 1st part of the name it indicate the location of the stimulus, and the 2nd part it indicate the effective organ" is initiated by gastric distension. Impulses are conducted through myenteric plexus to initiate a fast peristaltic wave passing to the ileum. The ileocaecal valve relaxes allowing chyme to pass into cecum This reflex is mediated by **vagus nerve**."it's initiate by present of food in the stomach, this will initiate impulses or send impulses to stimulate certain receptor(any reflex is a stimulus then receptor) the stretch receptor in the wall of the stomach then the the impulses are conducted along the myenteric plexus to initiate a long efferent to the small intestine to initiate peristalsis, which stimulate the motility(the propulsive or peristaltic contraction, and at the same time it also decrease the tone of the ileocecal sphincter, it also sweeping of the content from the terminal of the small intestine to the colon" يعني اذا صارت المعدة مليانه ترسل اشارة للامعاء الدقيقة انه استعدي ترى جايتك دفعة اكل تروح الامعاء الدقيقة تستوعب وتفضي كل اللي باقي فيها عالامعاء الغليظة عشان تقدر تستقبل الدفعة الجاية • Sympathetic excitation **decreases** intestinal and villous movements."the opposite effect, stimulate the contraction of the sphincter and relaxation of the wall(motor function)"	• Gastrin, CCK, insulin and serotonin stimulate intestinal motility. Gastrin and CCK relax ileocaecal sphincter. • Motilin secreted from duodenum **stimulates** intestinal motility and **regulate** MMC. • Secretin and glucagon **inhibits** intestinal motility and contract ileocaecal sphincter. • Villikinin **stimulates** movement of the villi.

Secretion and control of the small intestine :

1. Brunner's Glands in the Duodenum

- **Brunner's glands:** (submucosal glands in the first few cm of duodenum) secrete large amounts of alkaline mucus"this type of secretion from brunner's gland doesn't contain any digestive enzymes"

(Contains large amounts of bicarbonate ions)"why it called alkaline mucus? Alkaline=large amounts of bicarbonate and mucus=submucosal gland"

This mucus protects the mucosa from the acidic chyme coming from the stomach.

- Brunner's glands are **stimulated** by :

1. irritating (tactile) stimuli on the duodenal mucosa."present of the chyme"
2. **vagal stimulation.**
3. Secretin hormone."this hormone stimulate by acidity to secret pancreatic secretion which is alkaline, and also from this gland" يعني حموضة المعدة تحفز افراز هذا الهرمون وهذا الهرمون يحفز افراز هذي الغدة للمخاط القاعدي اللي يحمي الغشاء من حموضة المعدة

Brunner's glands are **inhibited** by sympathetic stimulation.

Secretion and control of the small intestine cont. :

2. Intestinal crypts secretion

- Intestinal Juice (Succus Entericus) is secreted by the **intestinal crypts** "are the intestinal glands which are between the bases of the villi" (Crypts of Lieberkühn) which are small pits between the villi.
- **Volume:** 1800 ml/day. pH: 7.5-8"the only highly acidic secretion is stomach, slightly acidic saliva, and the rest are alkaline
- It participates in the neutralization of acid Chyme delivered from stomach."means with the pancreatic secretion and biles + water, and like any secretion in the gastrointestinal system it's contain of water and dissolved(organic or inorganic, organic(enzymes or mucus or antibodies like in saliva) or inorganic(electrolytes, Na, K..) substance"
- **Composition:** 0.6 % organic, 1 % inorganic substance.
- Most of the enzymes are found either in the brush border"site of absorption" or in the cytoplasm of the enterocytes."most of the enzymes are not found in the lumen"
- The only enzymes that are actually secreted into the lumen are Enteropeptidase"entero=intestinal" and amylase"secreted from the pancreas, these two function on the peptides"
- **Stimulated** by:

1. Distension, tactile"present of chyme come in contact with the gland" and **vagal stimulation**.
2. Hormones as gastrin, secretin,CCK, glucagon, enterocrinin.
3. Sympathetic stimulation exerts an inhibitory effect.

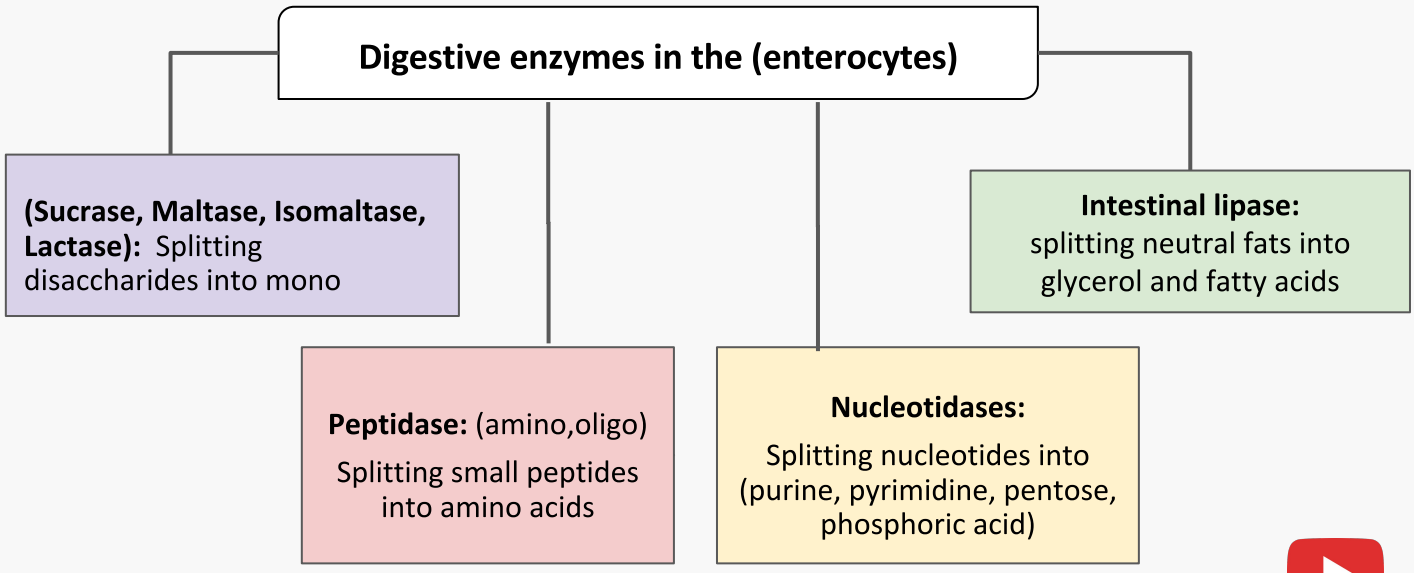
❖ Intestinal crypts secretion cont':

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

(2) enterocytes: 1- secrete large quantities of H2O and electrolytes

2- over the surfaces of adjacent villi, reabsorb H2O, electrolytes & end products of digestion.



Digestion:

1) Digestion of Carbohydrate:

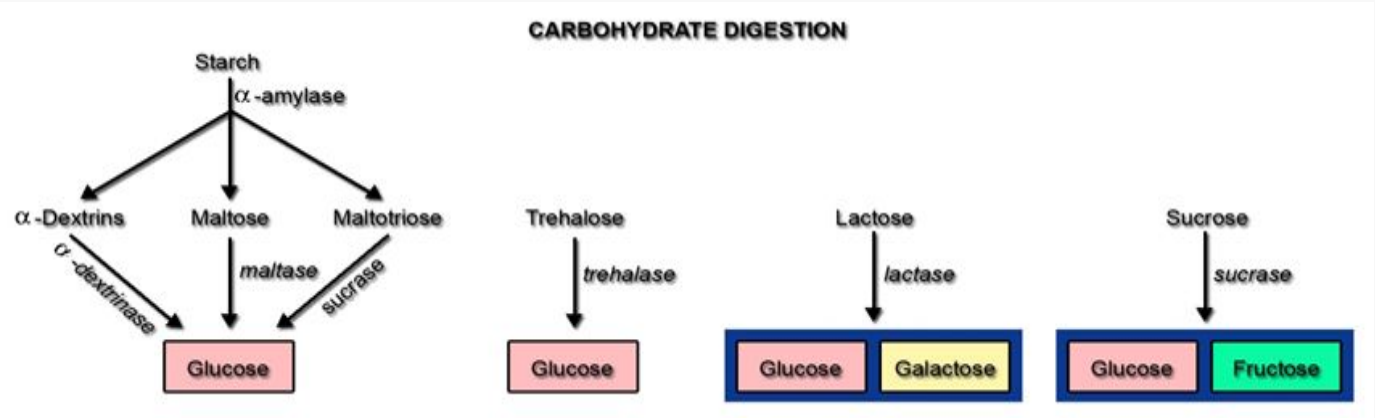
- The ptyalin (an α-amylase) enzyme in saliva hydrolyzes starch into the disaccharide maltose "two molecule of glucose" and other small polymers of glucose.
- The starch digestion sometimes continues in the fundus and body of the stomach for as long as 1 hour before the food becomes mixed with the stomach secretions.

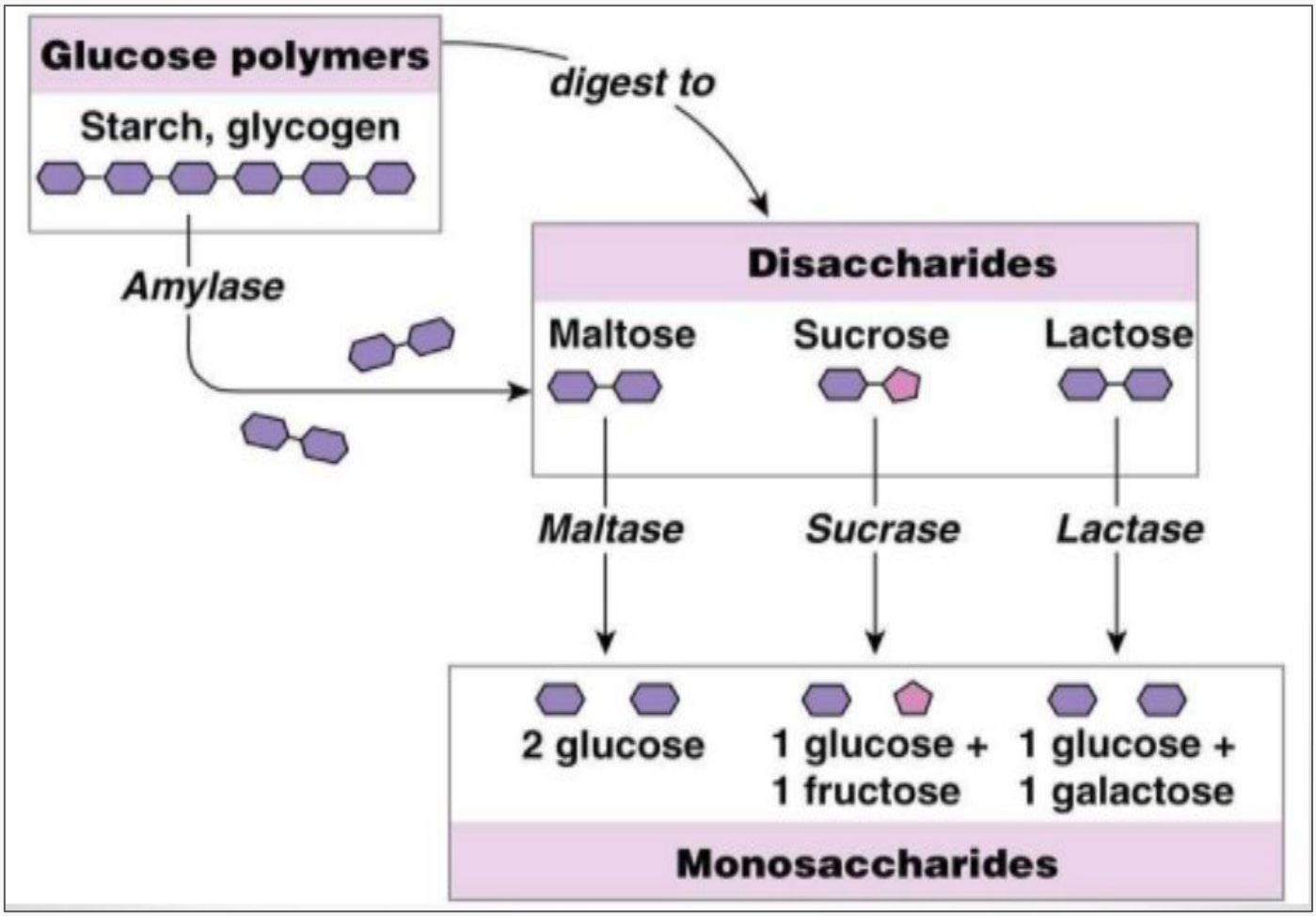
"in the stomach there's no digestion of carbohydrates, and in the intestine the digestion start by the pancreatic amylase, so we have 3 type of disaccharide, maltose(from starch), saccharose(from the usual sugar), lactose(from milk) then there's 3 enzymes will break them down, maltase will break maltose into 2 molecule of glucose, sucrase will break saccharose into 1 glucose & 1 fructose, lactase will break lactose into 1 glucose & 1 galactose, aal the end products are monosaccharides"

Digestion by Pancreatic Amylase:

- Pancreatic secretion has α-amylase that is almost identical in its function with the α-amylase of saliva but is several times as powerful. Therefore, within 15 to 30 minutes after the chyme empties from the stomach into the duodenum and mixes with pancreatic juice, virtually all the carbohydrates will have become digested.
- The carbohydrates are almost totally converted into maltose and/or other very small glucose polymers before passing beyond the duodenum or upper jejunum.

❖ The enterocytes contain four enzymes (lactase, sucrase, maltase, and a-dextrinase)	
• **Their function:**	they are capable of splitting the disaccharides lactose, sucrose, and maltose, plus other small glucose polymers, into their constituent monosaccharides.
• **Their location:**	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.





Guyton corner :

Digestion of Carbohydrates in the Small Intestine:

Digestion by Pancreatic Amylase. Pancreatic secretion, like saliva, contains a large quantity of α-amylase that is almost identical in its function with the α-amylase of saliva but is several times as powerful. Therefore, within 15 to 30 minutes after the chyme empties from the stomach into the duodenum and mixes with pancreatic juice,virtually all the carbohydrates will have become digested.

In general, the carbohydrates are almost totally converted into maltose and/or other small glucose polymers before passing beyond the duodenum or upper jejunum.

Hydrolysis of Disaccharides and Small Glucose Polymers into Monosaccharides by Intestinal Epithelial Enzymes. The enterocytes lining the villi of the small intestine contain four enzymes (lactase, sucrase, maltase, and α-dextrinase), which are capable of splitting the disaccharides lactose, sucrose, and maltose, plus other small glucose polymers, into their constituent monosaccharides. These enzymes are located in the enterocytes covering the intestinal microvilli brush border, so the disaccharides are digested as they come in contact with these enterocytes.

Lactose splits into a molecule of galactose and a molecule of glucose. Sucrose splits into a molecule of fructose and a molecule of glucose. Maltose and other small glucose polymers all split into multiple molecules of glucose. Thus, the final products of carbohydrate digestion are all monosaccharides. They are all water soluble and are absorbed immediately into the portal blood.

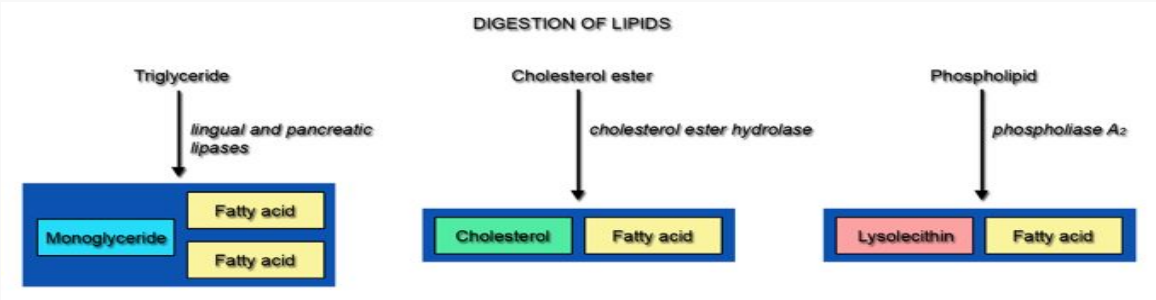
In the ordinary diet, which contains far more starches than all other carbohydrates combined, glucose represents more than 80 percent of the final products of carbohydrate digestion, and galactose and fructose each represent seldom more than 10 percent.

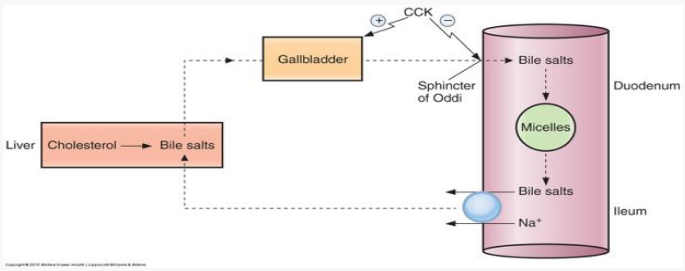
2) Digestion of Fat :

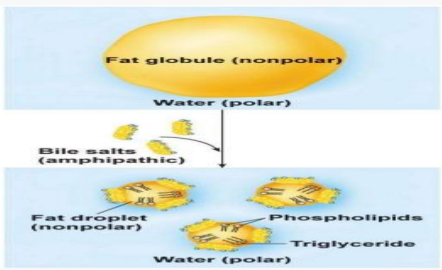
"How chyme digestion in presence of bile salts and lecithin helps in fat digestion? The help the emulsification of fat(fat problem is they're water insoluble, so since the bile salts are amphipathic they have polar and nonpolar ends, and they have water soluble and fat soluble portion, so they arrange themselves with the fat soluble portion to the interior, and water soluble portion to the outside"

"How does bile salt emulsification the fat? The fat has high attraction force(like when you put a drop of oil in water globule, so the bile salts intersperses in between the fat molecules and decrease the surface tension move the fat molecule away from each other(breaking the large fat molecule into small portions)which will increase the surface area for the action of lipase enzyme(this emulsification process make the fats homogeneous with the media around it)"

- Bile salts are not enzymes, they only help emulsification of fat
- The enzyme which digests the fat is the lipase.
- End products are fatty acids & monoglyceride.
- 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.
- Fat digestion start in the stomach by gastric(weak) lipase then pancreatic lipase then intestinal lipase, the most powerful fat splitting enzyme is the pancreatic lipase(deficiency of this enzyme cause steatorrhea)
- All fat digestion occurs in the small intestine.







Guyton corner: FAT

The First Step in Fat Digestion Is Emulsification by Bile Acids and Lecithin. The first step in fat digestion is physically to break the fat globules into small sizes so that the water-soluble digestive enzymes can act on the globule surfaces. This process is called emulsification of the fat, and it begins by agitation in the stomach to mix the fat with the products of stomach digestion.

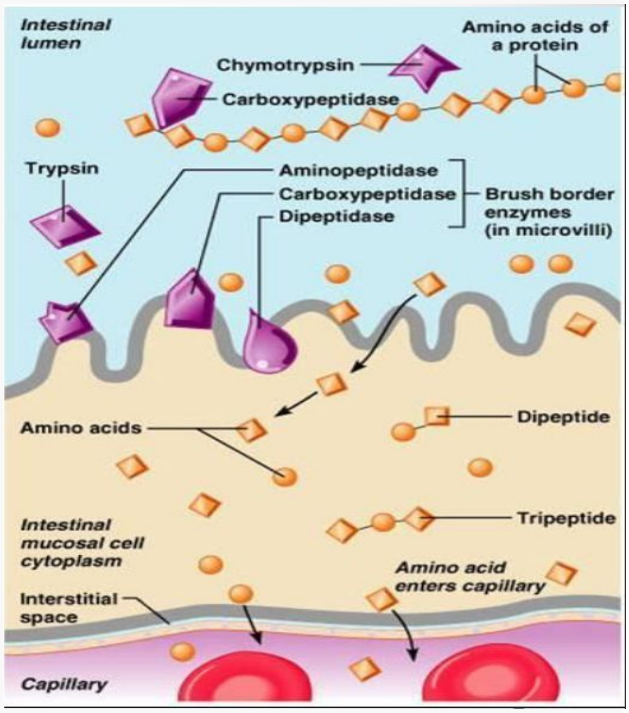
Then, most of the emulsification occurs in the duodenum under the influence of bile, the secretion from the liver that does not contain any digestive enzymes. However, bile does contain a large quantity of bile salts, as well as the phospholipid lecithin. Both of these, but especially the lecithin, are extremely important for emulsification of the fat. The polar parts (the points where ionization occurs in water) of the bile salts and lecithin molecules are highly soluble in water, whereas most of the remaining portions of their molecules are highly soluble in fat. Therefore, the fat-soluble portions of these liver secretions dissolve in the surface layer of the fat globules, with the polar portions projecting. The polar projections, in turn, are soluble in the surrounding watery fluids, which greatly decreases the interfacial tension of the fat and makes it soluble as well.

When the interfacial tension of a globule of nonmiscible fluid is low, this nonmiscible fluid, on agitation, can be broken up into many tiny particles far more easily than it can when the interfacial tension is great. Consequently, a major function of the bile salts and lecithin, especially the lecithin, in the bile is to make the fat globules readily fragmentable by agitation with the water in the small bowel. This action is the same as that of many detergents that are widely used in household cleaners for removing grease.

Each time the diameters of the fat globules are significantly decreased as a result of agitation in the small intestine, the total surface area of the fat increases manyfold. Because the average diameter of the fat particles in the intestine after emulsification has occurred is less than 1 micrometer, this represents an increase of as much as 1000-fold in total surface areas of the fats caused by the emulsification process. The lipase enzymes are water-soluble compounds and can attack the fat globules only on their surfaces. Consequently, this detergent function of bile salts and lecithin is very important for digestion of fats.

3) Digestion of protein:

- A **small** percentage of proteins are digested to Amino Acid by the pancreatic juices."no enzymes of digestion of protein in the mouth, it's start digeste in the stomach by hcl enzyme, breaks polypeptide chain into smaller oligopeptide chain"
- Pepsin is important enzyme of stomach active at pH=2, has an important feature it's the ability to digest the protein collagen.
- Both trypsin and chymotrypsin split protein molecules into small polypeptides
- **Most proteins** remain as dipeptides and tripeptides. To be digested by **peptidase in the enterocytes.**
- **Most protein** digestion occurs in the duodenum and jejunum by aminopeptidases"like carboxypeptidase, but it's work on the peptide chain with amino acid terminal(free amino acids)" , oligopeptidases, intracellular by di and tripeptidases."this 2 enzymes are inside the cytoplasm"
- All the enzymes are proteolytic enzymes acts on protein chains.



Guyton corner : PROTIEN

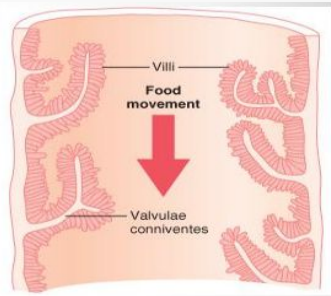
Digestion of Peptides by Peptidases in the Enterocytes That Line the Small Intestinal Villi. The last digestive stage of the proteins in the intestinal lumen is achieved by the enterocytes that line the villi of the small intestine, mainly in the duodenum and jejunum. These cells have a brush border that consists of hundreds of microvilli projecting from the surface of each cell. In the membrane of each of these microvilli are multiple peptidases that protrude through the membranes to the exterior, where they come in contact with the intestinal fluids.Two types of peptidase enzymes are especially important, aminopolypeptidase and several dipeptidases. They succeed in splitting the remaining larger polypeptides into tripeptides and dipeptides and a few into amino acids. Both the amino acids plus the dipeptides and tripeptides are easily transported through the microvillar membrane to the interior of the enterocyte Finally, inside the cytosol of the enterocyte are multiple other peptidases that are specific for the remaining types of linkages between amino acids. Within minutes, virtually all the last dipeptides and tripeptides are digested to the final stage to form single amino acids; these then pass on through to the other side of the enterocyte and thence into the blood.

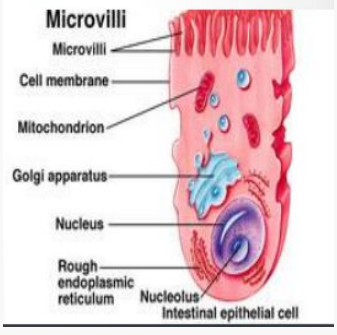
More than 99 percent of the final protein digestive products that are absorbed are individual amino acids, with only rare absorption of peptides and very, very rare absorption of whole protein molecules. Even these few absorbed molecules of whole protein can sometimes cause serious allergic or immunologic disturbances

Basic principles of G.I. absorption:

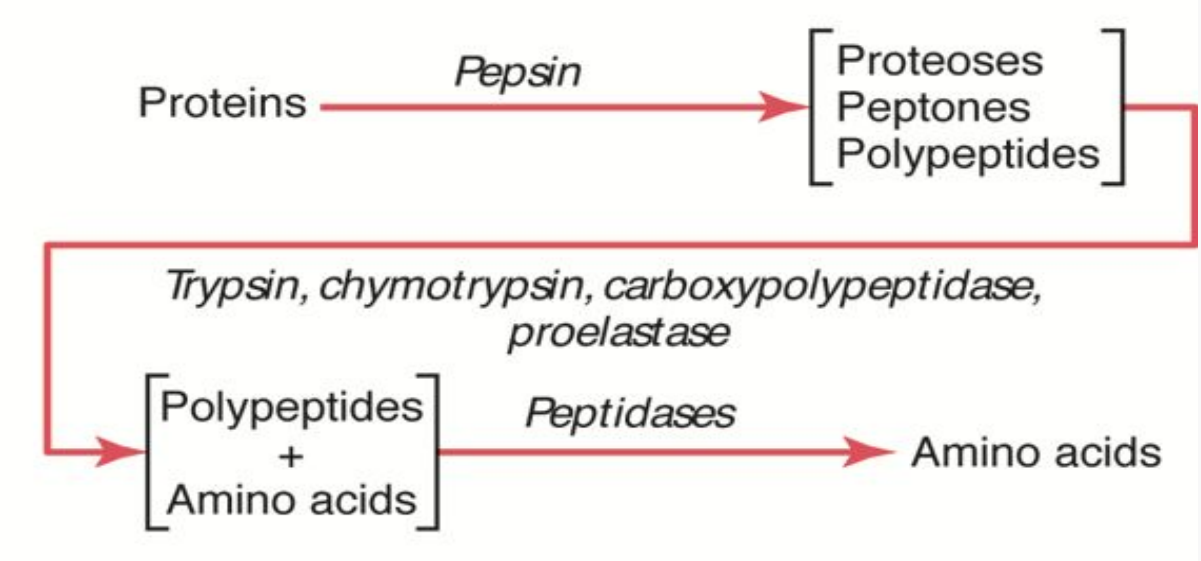
❖ Absorptive surface of the small intestine

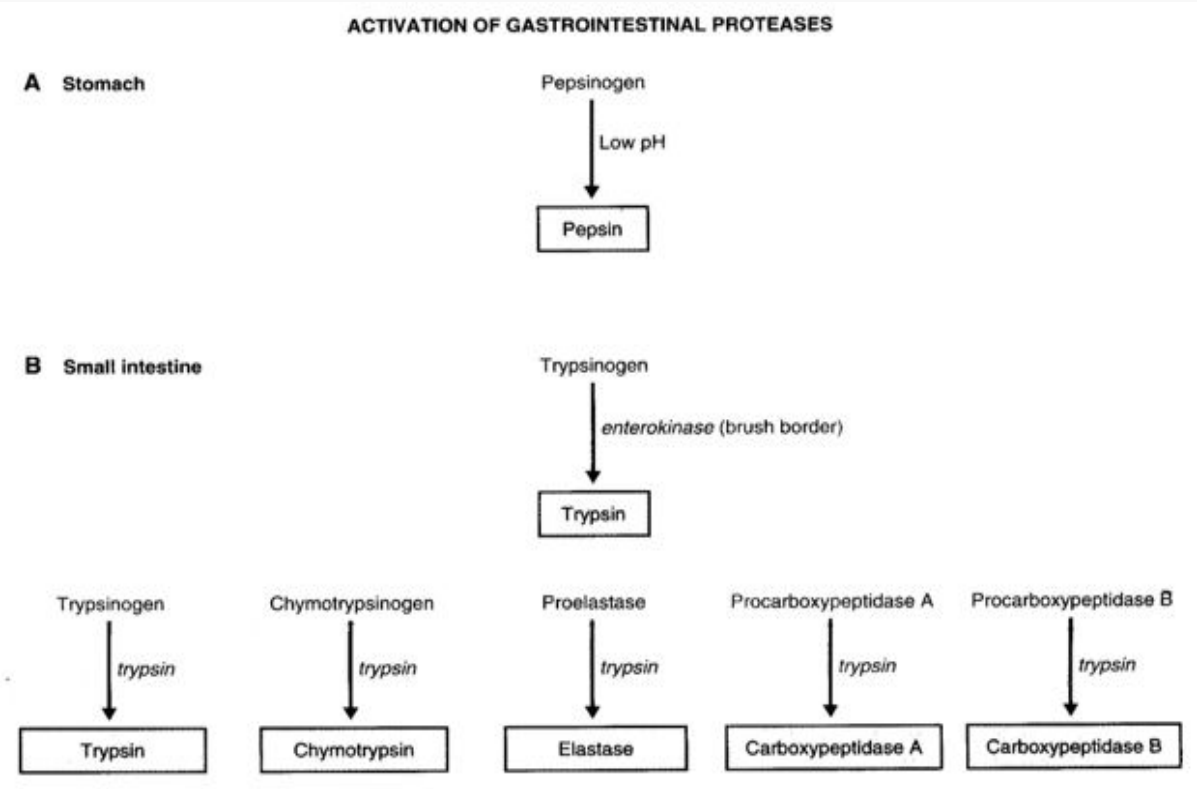
- The absorptive surface of the small intestinal mucosa, showing many folds called valvulae conniventes, well developed in the duodenum and jejunum. They increase the surface area of the absorptive mucosa about 3-fold.
- The presence of villi on the mucosal surface enhances the total absorptive area another 10-fold.
- 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).





- EXtra diagrams for the Digestion of protein:





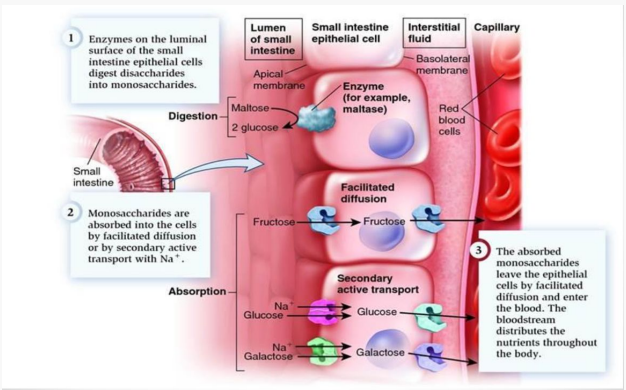
Absorption of carbohydrate :

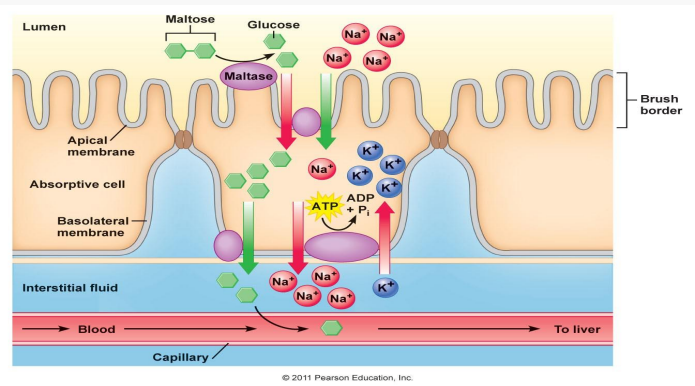
- The small intestine is the main site of absorption * there's some absorption happen in the mouth(drug absorption) and some happen in the stomach(food, alcohol, drug,water) some happen in the colon(water), but more than 90% absorbed in the small intestine
- So the small intestine surface(mucosa) adducted to absorption, how does that happen? By the presence of villi & microvilli & mucosal folds يعني الفيلاي عبارة عن ثنيات على سطح الطبقة المخاطية ولكن في الامعاء الدقيقة يوجد ثنيات في السطح نفسه -عشان كذا يقولون ان الامعاء يوصل طولها لسبعة متر بس لما نشوفها نحسها قصيرة لانها كلها ثنيات - ثنيات الغشاء المخاطي تضاعف طول السطح ثلاث مرات(لو طوله متر يصير ثلاث امتار) والفيلاي ثنياتها تضاعف الطول عشر مرات والمايكرو فيلاي تضاعف طول السطح 24 مره يعني مجموع جميع الثنيات في الامعاء الدقيقة يصل لمضاعفة طول السطح لـ600 مره

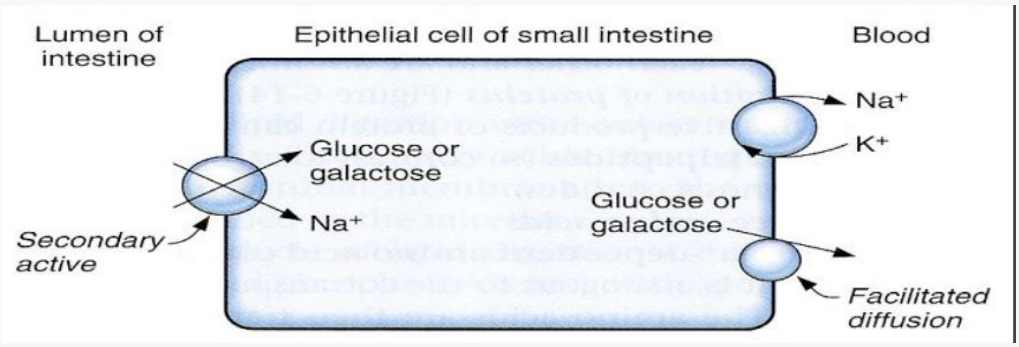
- All the carbohydrates in the food are absorbed in the form of **monosaccharides(glucose, galactose, fructose, pentose from DNA)** ; only a small only a small fraction are absorbed as disaccharides.
- Glucose and galactose absorption occurs in a cotransport mode with active transport of Na+(sodium dependent or sodium mediated) (2ry active transport) .

- how does glucose enter the cell? By 2ry active transport In the basal border sodium potassium pump(pump the sodium to outside and potassium to inside) this will decrease sodium concentration(decreased comparing to the sodium in the lumen) so the sodium diffuse from the lumen into the cell, during that the carrier which carry glucose will take advantage to transport glucose with sodium, now the glucose enter the cell against it's concentration of gradient(because glucose inside the cell more than outside) نستخدم هالتكنيك اذا صار جفاف بسبب الاسهال او الاستفراغ عند الاطفال نعطيهم محلول فيه ملح صوديوم وجلكوز
- How glucose exit the cell? By facilitated diffusion with another carrier
- The absorption into the bloodstream not to the lymph, and this time is the fastest rate one to transport, why? Because it has sodium and carrier and energy to facilitate, the second is the fructose because it has only carrier to facilitate, the slowest one is the pentose because nothing facilitate it's process .

- Fructose is independent on Na+ but it transports in lumenal membrane via facilitated diffusion.
- Pentose is transported by passive diffusion



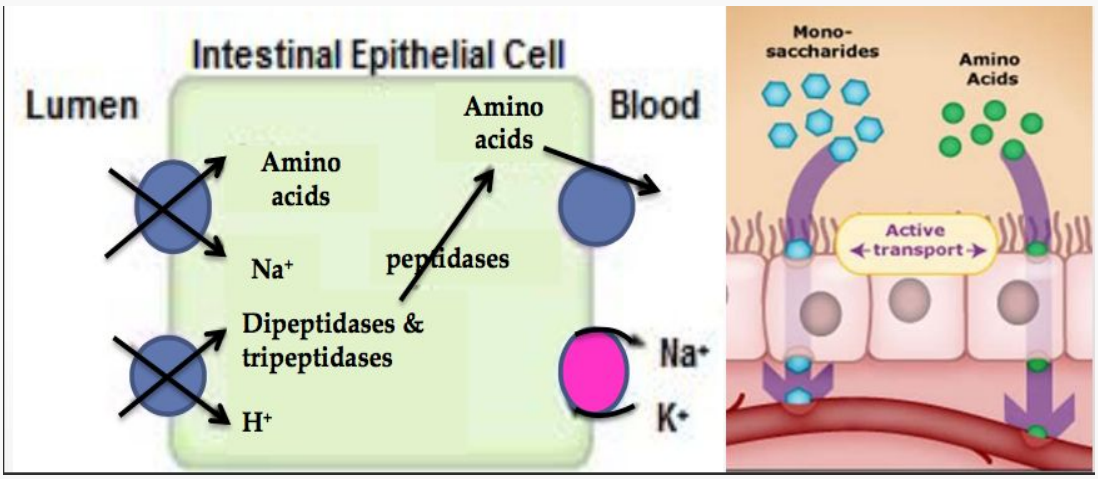




Absorption of protein :

Proteins are absorbed in the form of dipeptides, tripeptides,"because there's di and tripeptidase intracellular" and a few free amino acids.

- D- AA are transported by passive diffusion.
- L- AA are transported by 2ry active transport."like the glucose and galactose"
- Di and tripeptides cross the brush border by active transport protein carrier. They are hydrolyzed by"intracellular di and tripeptidase into free amino acids, the free amino acids will leave the cell through the basal border into bloodstream" brush border and cytoplasmic oligopeptidases.
- AA leaves the cell at the basolateral membrane by facilitated transport.

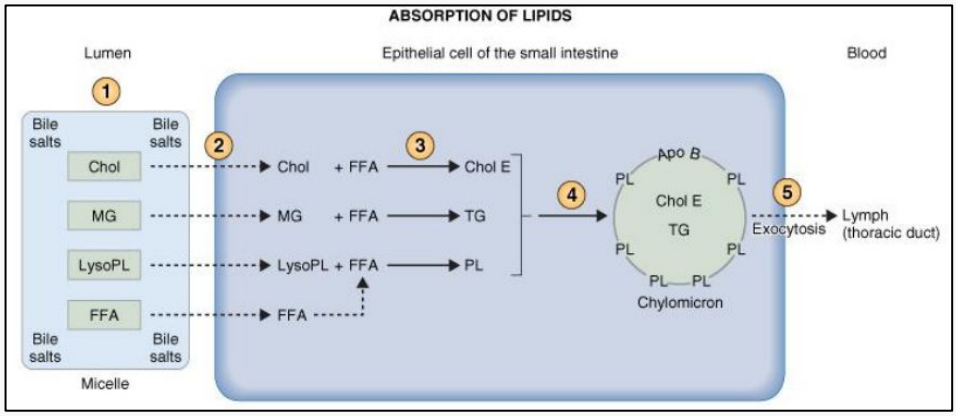


Guyton corner : page 797

Absorption of Proteins as Dipeptides, Tripeptides, or Amino Acids
As explained earlier in the chapter, most proteins, after digestion, are absorbed through the luminal membranes of the intestinal epithelial cells in the form of dipeptides, tripeptides, and a few free amino acids. The energy for most of this transport is supplied by a sodium cotransport mechanism in the same way that sodium co-transport of glucose occurs. That is, most peptide or amino acid molecules bind in the cell's microvillus membrane with a specific transport protein that requires sodium binding before transport can occur. After binding, the sodium ion then moves down its electrochemical gradient to the interior of the cell and pulls the amino acid or peptide along with it. This is called co-transport (or secondary active transport) of the amino acids and peptides

A few amino acids do not require this sodium co-transport mechanism but instead are transported by special membrane transport proteins in the same way that fructose is transported, by facilitated diffusion.
At least five types of transport proteins for transport- ing amino acids and peptides have been found in the luminal membranes of intestinal epithelial cells. This multiplicity of transport proteins is required because of the diverse binding properties of different amino acids and peptides.

Absorption of Fats:



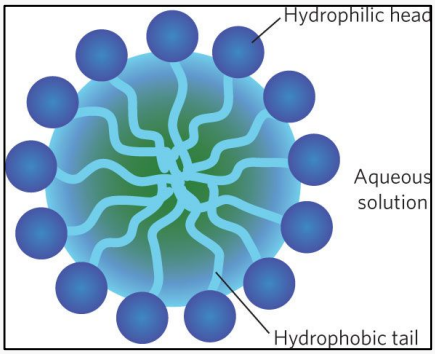
- The same problem they're water insoluble, so they need a carrier to carry them through the lumen into the brush border(needed to be dissolved in water of small intestine, who's the carrier here? Is the bile salts(amphipathic)

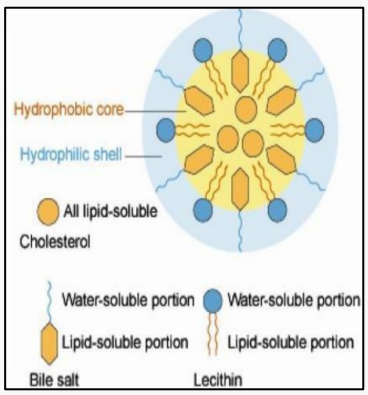
- In the **presence** of an abundance of bile micelles, about 97 % of the fat is absorbed.
- In the **absence** of the bile micelles, only 40 to 50 % can be absorbed.

- The absorption can occur with and without the presence of bile salts, facilitate but not dependent

❖ Formation of Micelles:

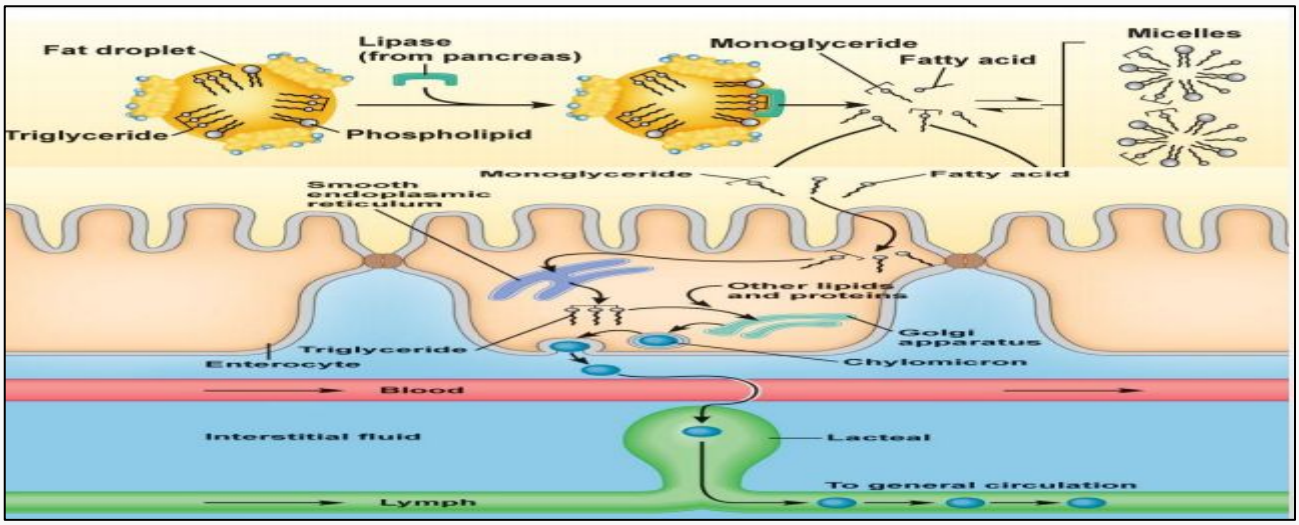
- Bile salt are amphipathic Having both hydrophilic and hydrophobic parts molecules, each composed of a sterol nucleus (fat-soluble) and a polar group (water-soluble).
- Micelles are small spherical, cylindrical globules 3-6 nm in diameter composed of 20-40 molecules of bile salts.
- The polar parts are (-) charged, they allow the entire micelle globule to dissolve in the water of the digestive fluids.





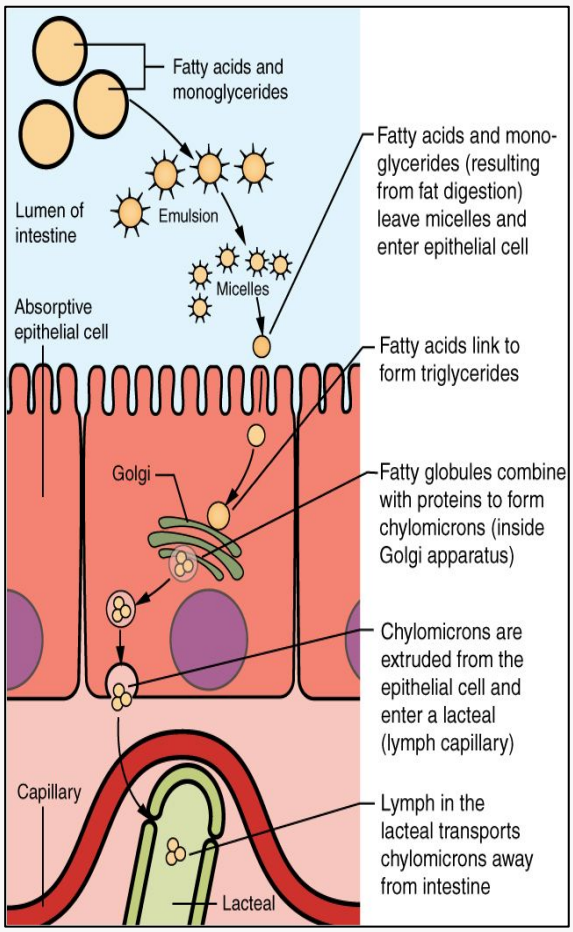
Guyton corner : when fats are digested to form monoglycerides and free fatty acids, both of these digestive end products first become dissolved in the central lipid portions of bile micelles. Because the molecular dimensions of these micelles are only 3 to 6 nanometers in diameter, and because of their highly charged exterior, they are soluble in chyme. In this form, the monoglycerides and free fatty acids are carried to the surfaces of the microvilli of the intestinal cell brush border and then penetrate into the recesses among the moving, agitating microvilli. Here, both the monoglycerides and fatty acids diffuse immediately out of the micelles and into the interior of the epithelial cells, which is possible because the lipids are also soluble in the epithelial cell membrane. This leaves the bile micelles still in the chyme, where they function again and again to help absorb still more monoglycerides and fatty acids. Thus, the micelles perform a "ferrying" function that is highly important for fat absorption. In the presence of an abundance of bile micelles, about 97 per cent of the fat is absorbed; in the absence of the bile micelles, only 40 to 50 per cent can be absorbed. After entering the epithelial cell, the fatty acids and monoglycerides are taken up by the cell's smooth endoplasmic reticulum; here, they are mainly used to form new triglycerides that are subsequently released in the form of chylomicrons through the base of the epithelial cell, to flow upward through the thoracic lymph duct and empty into the circulating blood.

• The micelles act as a transport medium to carry the monoglycerides and free fatty acids to the brush borders of the intestinal epithelial cells.



❖ Steps of Fat Absorption:

- Fatty acids and monoglycerides are associated with micelles in lumen of intestine.
  - "1st in the brush border fatty acids and monoglycerides leaves the micelles become free and they enters the cell, how they enter? Diffusion(passive), because they're fat soluble and the membrane in bilayer "
  - "2nd inside the agranular endoplasmic reticulum fatty acids and monoglycerides are reformed as a triglyceride"
  - "3rd this triglyceride(fatty globule) are combined with protein(partially cover with protein) to form what's called chylomicrons"
  - "How chylomicrons leaves the basal border? By forming vesicle and the vesicle come with contact with basal border then fusion occurs then ruptured in the site of fusion and they're extruded to the outside, but her the absorption into the lymph the lacteal"



1- Fatty acids and monoglycerides resulting from fat digestion leave micelles and enter epithelial cell by diffusion.

2- Fatty acids are used to synthesize triglycerides in agranular endoplasmic reticulum.

3- Fatty globules are combined with proteins chylomicrons (within golgi apparatus).

4- Vesicles containing chylomicrons migrate to the basal membrane where they are extruded from the epithelial cell and enter a lacteal (lymph capillary).

5- Lymph in the lacteal transports chylomicrons away from intestine.

Absorption of Vitamins:

Vitamin B12	Is absorbed in the ileum and requires intrinsic factor."secreted from the parietal cells" • Gastrectomy results in the loss of parietal cells and loss of intrinsic factor -> pernicious anemia.
Most water-solubl e vitamins:	(C, B1 , B2 , B6 , and folic acid) are absorbed by Na+ dependent cotransport mechanisms."2ry active transport"
Fat-soluble vitamins	(A, D, E, & K) are incorporated into micelles and absorbed along with other lipids."the same mechanism as the fat absorption in the previous slide"

Absorption and secretion of electrolytes and water:

- Electrolytes and H2O cross intestinal epithelial cells by either cellular or paracellular(tight junction) route."in between the cells" من الجمب
- The permeability of the tight junctions varies with the type of epithelium:
  - Leaky(free permeable)خفيفة epithelia are in the small intestine and gallbladder.
  - A tight epithelium is in the colon.

❖ Absorption of Na+:

1- Na+ moves into the intestinal cells by the following mechanisms:

1. Passive diffusion."high to low concentration"
2. Na+-glucose or Na+-amino acid co-transport.
3. Na+-Cl- exchange.
4. Na+-H+ exchange.

2- The next step in the transport process is osmosis

" in result of sodium increased in the cell or in the opposite side in the lumen, it increase the concentration(osmotic gradient) in result of absorption of sodium, the sodium will absorb the chloride, which mean the osmotic pressure increasing in this side and this will increase the osmosis of water(water will follow this osmotic gradient)

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.

- **Aldosterone Greatly Enhances Na+ Absorption:** This effect of aldosterone is especially important in the colon because it allows virtually no loss of NaCl and water(sever diarrhea).
  - "the aldosterone increase the formation of sodium channel and help absorption of sodium"

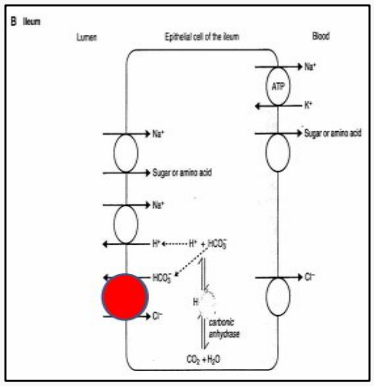
❖ Absorption of Cl-:

- Cl- absorption accompanies Na+ absorption by the following mechanisms:
  1) Passive diffusion. **2) Na+-Cl- cotransport.** **3) Cl^--HCO_3^- exchange.**

❖ Absorption and secretion of K+:

- K+ is absorbed in the small intestine by passive diffusion.
- K+ secretion"by sodium potassium pump" in the colon is stimulated by aldosterone.
- Excessive loss of K+ in diarrheal fluids causes hypokalemia.

Secretion of Bicarbonate Ions in the Ileum:



- The epithelial cells on the surfaces of the villi in the ileum and large intestine have a special capability of secreting HCO3 - in exchange for absorption of Cl- .
- This provides alkaline HCO3 "this's very important in the colon" - that neutralize acid products formed by bacteria "which normal inhabitants" in the large intestine."in the colon bacterial flora which produced acids, these acids can be neutralized by secretion of bicarbonate in exchange with chloride"

Ca++ Absorption by Enterocytes:

- **Decreased Plasma Ca++ ⟶ INCREASED Parathyroid hormone :**
  Conversion of 25-hydroxy-vitamin D3 into :
  1,25 dihydroxy-vitamin D3.
  (1,25 dihydroxy-vitamin D3 stimulates synthesis of Ca-binding protein and Ca-ATPase in enterocytes).

Hormonal control of absorption & secretion:

Hormone	Effect
Glucocorticoid	INCREASE absorption of H2O & ions (small & large intestine).
Somatostatin	INCREASE H2O & ions absorption (ileum & colon).
Epinephrine	INCREASE NaCl absorption (ileum).
Aldosterone	INCREASE synthesis of Na+ channel (colon)."also increase the K+ secretion
Catecholamines	Decrease intestinal secretion

Guyton corner :

The mucosa of the large intestine, like that of the small intestine, has a high capability for active absorption of sodium, and the electrical potential gradient created by absorption of the sodium causes chloride absorption as well. The tight junctions between the epithelial cells of the large intestinal epithelium are much tighter than those of the small intestine. This prevents significant amounts of back-diffusion of ions through these junctions, thus allowing the large intestinal mucosa to absorb sodium ions far more completely—that is, against a much higher concentration gradient—than can occur in the small intestine. This is especially true when large quantities of aldosterone are available because aldosterone greatly enhances sodium transport capability. In addition, as occurs in the distal portion of the small intestine, the mucosa of the large intestine secretes bicarbonate ions while it simultaneously absorbs an equal number of chloride ions in an exchange transport process that has already been described. The bicarbonate helps neutralize the acidic end products of bacterial action in the large intestine. Absorption of sodium and chloride ions creates an osmotic gradient across the large intestinal mucosa, which in turn causes absorption of water.

SUMMARY

Motility of small intestine

Propulsive contraction (Peristalsis)	Segmenting (Mixing) contraction	Migrating motor complex	Antiperistalsis	Peristaltic rush
A contraction ring appears around gut, then moves forward. Usual stimulus is distention.	A localized contraction of circular smooth muscles that constricts the intestine into spaced segments, last for fraction of min.	Bursts of depolarization accompanied by peristaltic contraction that begins in empty stomach during interdigestive period	A wave of contraction in the alimentary canal that passes in an oral	Powerful rapid peristalsis due to intense irritation of intestinal mucosa (as in infectious diarrhea).

Control intestinal motility

Neural control	Hormonal control
• Vagal excitation increases intestinal • Sympathetic excitation decreases intestinal	• Gastrin, CCK, insulin and serotonin stimulate intestinal • Motilin secreted from duodenum stimulates intestinal motility and regulate MMC. • Villikinin stimulates movement of the villi

Secretion and control of the small intestine

Brunner's Glands in the Duodenum	Intestinal crypts secretion
secrete large amounts of alkaline mucus This mucus protects the mucosa	Intestinal Juice is secreted by the intestinal crypts

SUMMARY

Digestion		
Carbohydrate	**Fat**	**protein**
Pancreatic secretion has α-amylase. The enterocytes contain enzymes (lactase, sucrase, maltase, and a-dextrinase) they are capable of splitting the disaccharides lactose, sucrose, and mltose, into monosaccharides.	Bile salts and lecithin in the bile help fat digestion,Bile salts break the fat globules into very small sizes, so that the water-soluble digestive enzymes can act on the globule (emulsification of fat)	- proteins remain as dipeptides and tripeptides. To be digested by peptidase in the enterocytes. -protein digestion occurs in the duodenum and jejunum by -Both trypsin and chymotrypsin split protein molecules into small polypeptides
Absorption		
Carbohydrate	**Fat**	**protein**
All the carbohydrates absorbed in the form of monosaccharides -Glucose and galactose absorption with active transport of Na+ -Fructose is transported in lumenal membrane via facilitated diffusion. -Pentose is transported by passive diffusion	- 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.	-Proteins are absorbed in the form of dipeptides, tripeptides, and a few free amino acids. -Di and tripeptides cross by active transport protein carrier. They are hydrolyzed by oligopeptidases in the enterocyte -AA leaves the cell at the basolateral membrane by facilitated transport.

MCQ

1- Which of the following contractions occur mainly in inter-digestive period:

A- Segmentation contraction

B- Propulsive contraction

C- Antiperistalsis contraction

D- Migrating motor complex

2- Antiperistalsis contraction for neutralizing chyme occur between:

A- Stomach and jejunum

B- Jejunum and stomach

C- Stomach and duodenum

D- Cecum and duodenum

3- intense irritation of intestinal mucosa result in:

A- Mixing contraction

B- Propulsive contraction

C- Antiperistalsis

D- Peristaltic rush

4- Gastroileal reflex is initiated mainly by:

A- Gastric distention

B- Ileum distention

C- Gastric irritation

D- Ileum irritation

5- Which of the following effect is true regarding gastrin and CCK on intestinal motility:

A- Relax ileocecal sphincter and stimulate the motility

B- Contract ileocecal sphincter and stimulate the motility

C- Relax ileocecal sphincter and inhibit the motility

D- Contract ileocecal sphincter and inhibit the motility

6- Intestinal juice secretion is stimulated by all of the following except:

A-Distention
B-CCK
C-Sympathetic
D-Gastrin

7-Most protein digestion occurs in:

A – stomach
B –duodenum and jejunum
C –eilum and cecum
d- non of them

8- Glucose and galactose absortion at enterocytes occure by:

A –Na-dependant transporter
B - secondary active transport
C - against the conc
D – all of them

9- which of the following is most likely with patient who had removed gallbladder:

A –decrease fat absorption 50%
b – complete loss of fat absorption
c – decrease carbohydrates absorption 50%
d- no effect on absorption

10 - increase parathyroid hormone level lead to :

A - Stimulates synthesis of Ca+2-binding protein
B – stimulate synthesis of Ca+2-ATPase
C - stimulate synthesis of NA+-ATPase
D – a&b

answer key: 1.D, 2.C, 3.D, 4.A, 5.A, 6.C , 7.B , 8.D, 9.A , 10. D

خولة العمَّاري
نجود الحيدري
نورة الطويل
لولوة الصغير
لجين السواط
رزان السبتي
ربى السليمي
ديما الفارس
خولة العريني
ملاك الشريف
منيرة الحسيني
مروج الحربي
أفنان المالكي
دلال الحزيمي
رناد القحطاني
سارة الخليفة
فرح مندوزا
مي العقيل
نورة الخراز
سارة الخليفة
نورة الخيال
رغد النفيسة
منيرة السلولي
نوف العبدالكريم
سها العنزي
نورة القحطاني

عمر آل سليمان
عبدالعزيز الحماد
عبدالرحمن السياري
محمد أبونيان
عبدالرحمن البركه
إبراهيم النفيسه
محمد البشر
عمر العتيبي
حمزة الفعر
عبدالله الجعفر
عبدالله الضحيان
حسن البلادي
حسن الشماسي
عبدالله الضبيب
محمد الفواز
محمد السحيباني
وائل العود
رواف الرواف
عمر الشهري