Biochemistry Team 435

جامعة الملك سعود
King Saud University

ROLE OF SALIVARY GLANDS AND STOMACH IN DIGESTION

* Please check out this link to know if there are any changes or additions.

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Color index: Important | Doctors notes | Further explanation.

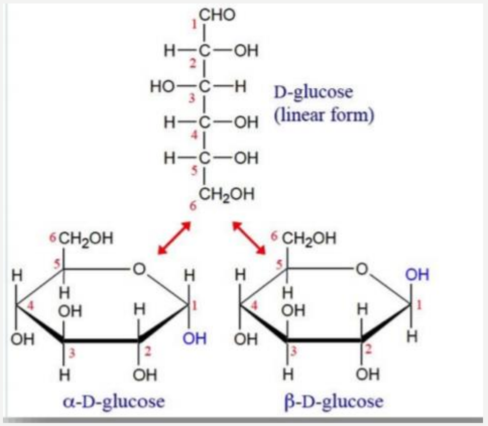
This slide is Extra .:

Carbohydrates isomers:

- Compounds with the same **chemical formula** but with a **different structural formula**.

Types:			
Aldo-Keto	Epimers	D- and L forms	α- and β- anomers
Same formula	Same formula	Same molecular formula	Same molecular formula
Different functional Group	Different configuration around a “single” carbon atom.	Different pposition of OH group on the “asymmetric carbon” farthest from carbonyl group	Different position of OH around anomeric carbon

Cyclization of Monosaccharides with 5 or more carbon are predominantly found in the ring form.
- The aldehyde or ketone group reacts with the –OH grp on the same sugar
- Cyclization creates an “anomeric carbon\ The carbon at which anomers rotate” (former carbonyl carbon) generating the α and β configurations.



OBJECTIVES:

1. Understand the principle and importance of dietary foodstuffs.

2. Understand the role of salivary glands in digestion.

3. Understand the role of stomach in digestion.

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The **breakdown** of the naturally occurring foodstuffs into **smaller, easily absorbable** forms .

Digestive Enzymes

Digestion:

1.What is "digestion"?

The **breakdown** of the naturally occurring foodstuffs into **smaller, easily absorbable** forms .

2.Processes of the digestive system:

- Motility
- Secretion
- Elimination
- Absorption

3.Digestion Effects:

Mechanical effects:

e.g., mastication

Enzymatic effects:

Digestive enzymes (*hydrolases)

4.End Products of Digestion:

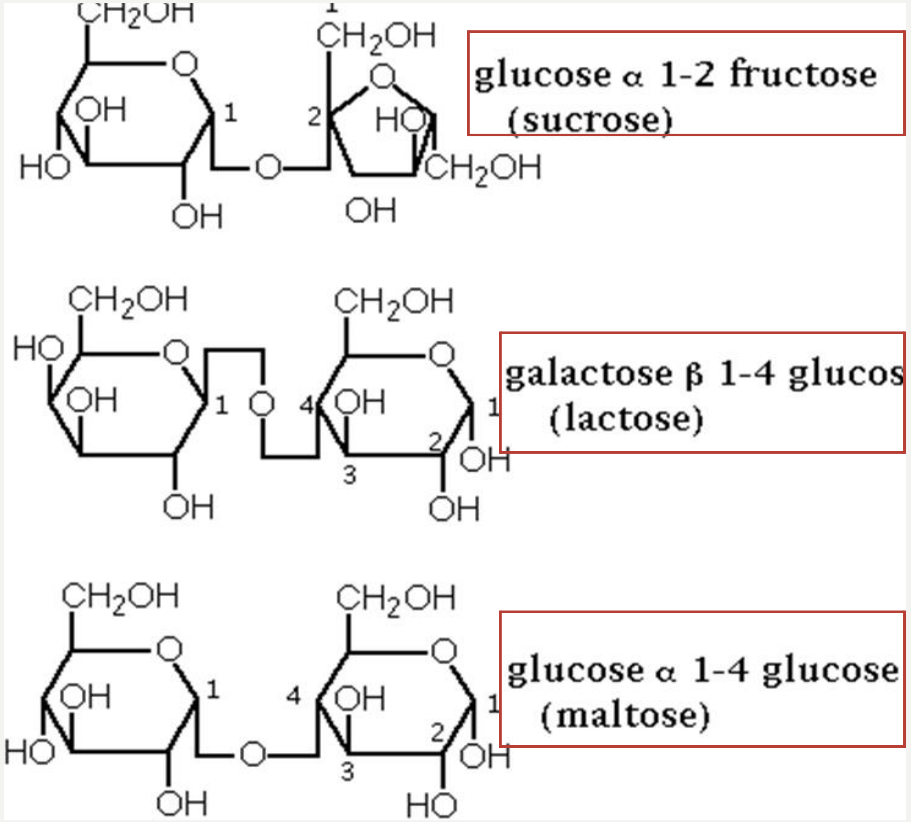
- **Carbohydrates** → **Monosaccharides**
- **Triacylglycerol (TAG)** → **Fatty acids & monoacylglycerols**
- **Proteins** → **Amino acids**

*Hydrolysis is the breaking of a bond in a molecule using water.

Carbohydrates types:

- **Mono-saccharides**
  - Glucose
  - Fructose
  - galactose
- **Di-saccharides**
  - Sucrose
  - Lactose
  - Maltose
- **poly-saccharides**
  - Glycogen
  - Starch
  - Cellulose

Di-saccharides



What do α & β refer to ?

α : is when both bonds are in the same side.(straight forward)

β : when one of the bonds are in the upper side and the other is in lower side.

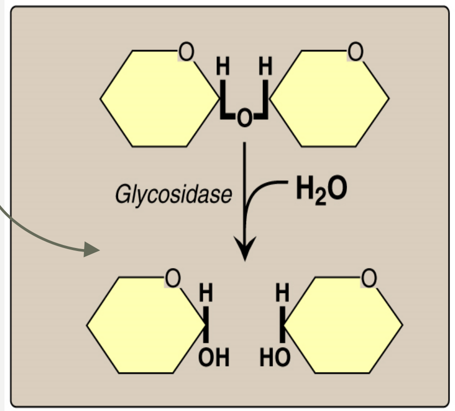
Salivary glands:

❖ **Salivary glands:** exocrine glands "glands with ducts", that produce **saliva**, which is formed of several things including amylase, a digestive enzyme that breaks down starch into maltose and glucose.

Role of salivary gland

Secrete **saliva**, which:

- Acts as **lubricant**
  - **lubricant** is a substance such as oil or grease, used for minimizing friction, especially in an engine or component.
  - Saliva coats the oral mucosa, mechanically protecting it from trauma during eating, swallowing and speaking.
  - In people with little saliva (xerostomia), soreness of the mouth is very common, and the food (especially dry food) sticks to the inside of the mouth.
- Contains **salivary α-amylase**
  - It is a digestive enzyme in mammals, and a member of the Glucosidases, which are enzymes involved in breaking down complex carbohydrates such as starch and glycogen into their monomers by hydrolyzing glycosidic bonds
- Contains **lingual lipase**



Salivary α-Amylase:

It's important to say "salivary" α-amylase. There is another enzyme called "pancreatic" α-amylase.

Secreted by:	**Parotid glands**	
Optimum pH:	**6.6 – 6.8**	- Salivary amylase is inactivated by the acidity of **stomach** (The enzyme is inactivated at pH 4.0 or less). - Activated in mouth.
Substrate:	**Starch and glycogen**	Its digestive action on the polysaccharides is of little significance because of the short time during which the enzyme can act on the food in the mouth.
Hydrolyzes:	**α(1,4) glycosidic bonds**	• Salivary α-amylase **does not** hydrolyze: α(1,**6**) glycosidic bonds (The branch points of starch and glycogen) • Salivary α-amylase **cannot** act on: **β**(1,4) glycosidic bonds of **cellulose** therefore, we can't digest cellulose. Because We don't have β-1,4 amylase in our body. • Salivary α-amylase **does not** hydrolyze disaccharides.
Produces:	**Short oligosaccharides** (oligo means few- from 3 to 20 -)	

- **Optimum pH means** the pH at which an enzymatic or any other reaction or process is most effective under a given set of conditions.

<u>*فى حالة الالفا اميليز:</u>
- عند بي اتش ٦,٦ – ٦,٨ الإنزايم بيكون أكثر فعالية.
- عند بي اتش ٤ أو اقل الإنزايم بيصير غير فعال وماراح يشتغل.

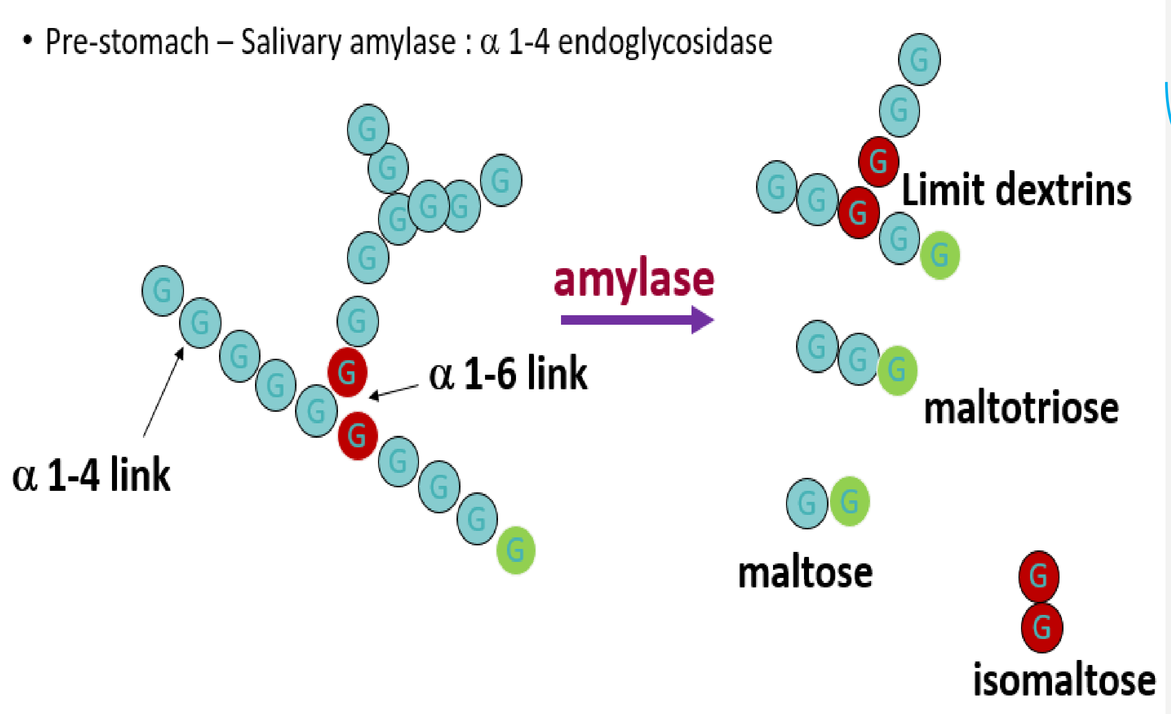
<u>*وش ممكن نستنتج من الكلام السابق؟</u>
الالفا اميايلز ماراح يشتغل بالمعدة وبيشتغل بالفم

<u>* طيب ليش؟</u>
المعدة وسط حامضي والبي اتش فيها تقريبا تقريبا بين ٢-٤ وانزايمنا حبيبنا مايشتغل من ٤ وتحت

Starch (from plants) & glycogen(from animals) are both carbohydrates that have α-(1,4) glycosidic bonds. They are targeted and cleaved by salivary alpha-amylase, to short oligosaccharides. So, only carbohydrates are digested in mouth!
- Why oligosaccharides? Why it didn't produce monosaccharides?
Because the food doesn't last long enough in the mouth to be converted to monosaccharides, also the stomach acidity inhibit the salivary amylase, thus the pancreatic amylase do the rest of digestion of these saccharides.

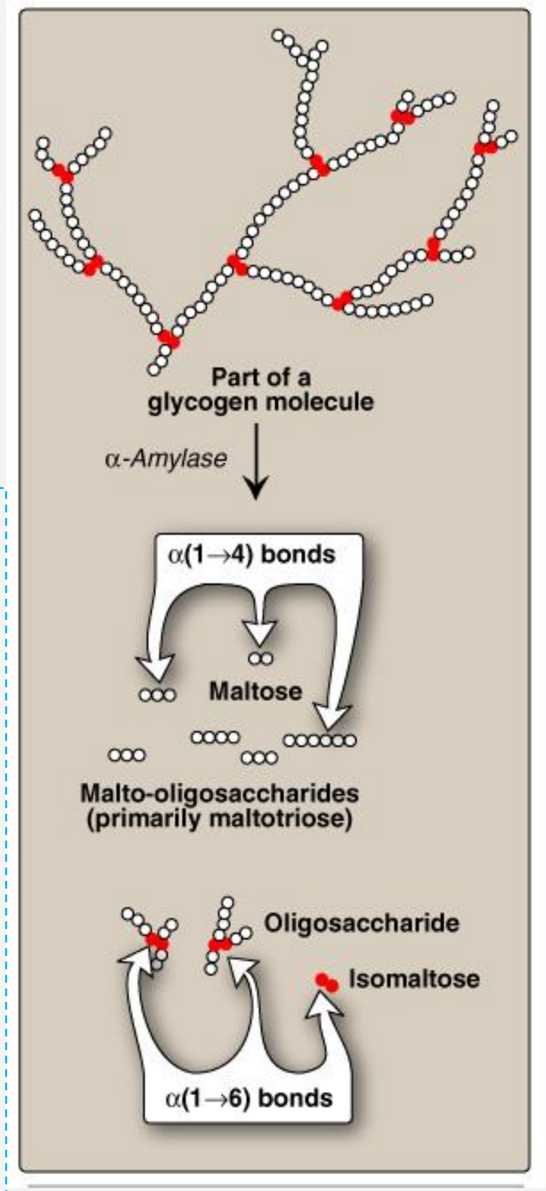
Effects of α-Amylase on glycogen

- ❖ **Hydrolysis of:** **α(1,4) glycosidic bonds**.
- ❖ **Products:***
  1. **Mixture of short oligosaccharides:** (both branched & unbranched).
  2. **Disaccharides:** Maltose and isomaltose.



Endoglycosidase: meaning that the enzyme works on the interior bonds. Doesn't work peripherally.
Limit dextrin: short more branched oligosaccharide
Isomaltose: same as maltose, but we say "iso" to know its in branch point.

* Those products can't be absorbed unless converted to smaller products(glucose, fructose..)

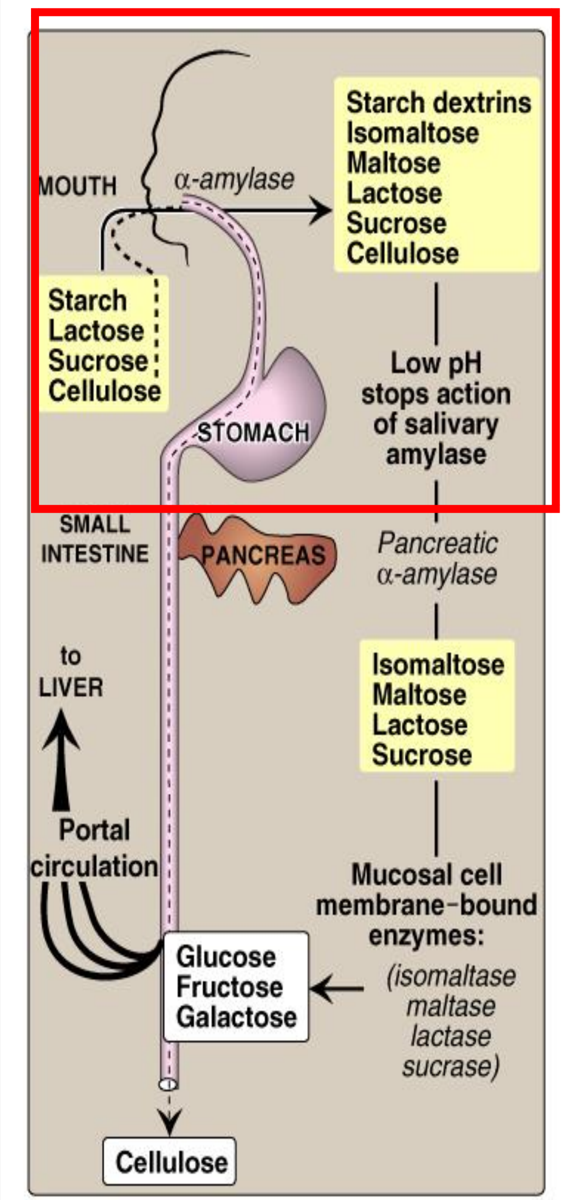


Digestion of carbohydrates in the mouth:

Extra Explanation:

The major dietary polysaccharides are of plant (starch, composed of amylose and amylopectin) and animal (glycogen) origin.
During mastication, α-amylase acts on dietary starch and glycogen, hydrolyzing random **α(1,4) glycosidic bonds**.
- Because branched amylopectin and glycogen also contain **α(1,6)** glycosidic bonds, which amylase cannot hydrolyze, the digest resulting from its action contains a mixture of: short, branched, and unbranched oligosaccharides known as dextrins.
- Disaccharides are also present as they, too, resistant to amylase.
- Carbohydrates digestion halts temporarily **in the stomach**, because the high acidity inactivates salivary **α-amylase.**

Starch dextrins, isomaltose, maltose, lactose, sucrose and cellulose are oligosaccharides (you should memorize them).



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Role of stomach in digestion:

- **No** further digestion of **carbohydrates**.
- **Lipid digestion** begins by lingual and gastric lipases.
- **Protein digestion** begins by pepsin and rennin. (which means the chemical digestion of proteins begins in the stomach).

Lingual lipase

Secreted by: the dorsal surface of the tongue (Ebner's glands)

Acts in: the **stomach** for the digestion of **TAG**

Produces: **fatty acids** and **mono-acylglycerols**

Its role is of: **little** significance in adult humans

More in infants and neonate, why?
Because they get their calories from milk which contain medium to short fatty acid chains (digested by this enzyme) . As for adults they consume a lot of meat containing long fatty acid chains that can't be digested by lingual lipase.

Lingual and Gastric Lipases (Acid-Stable Lipases)

- **Target substrate for acid-stable lipases is:**

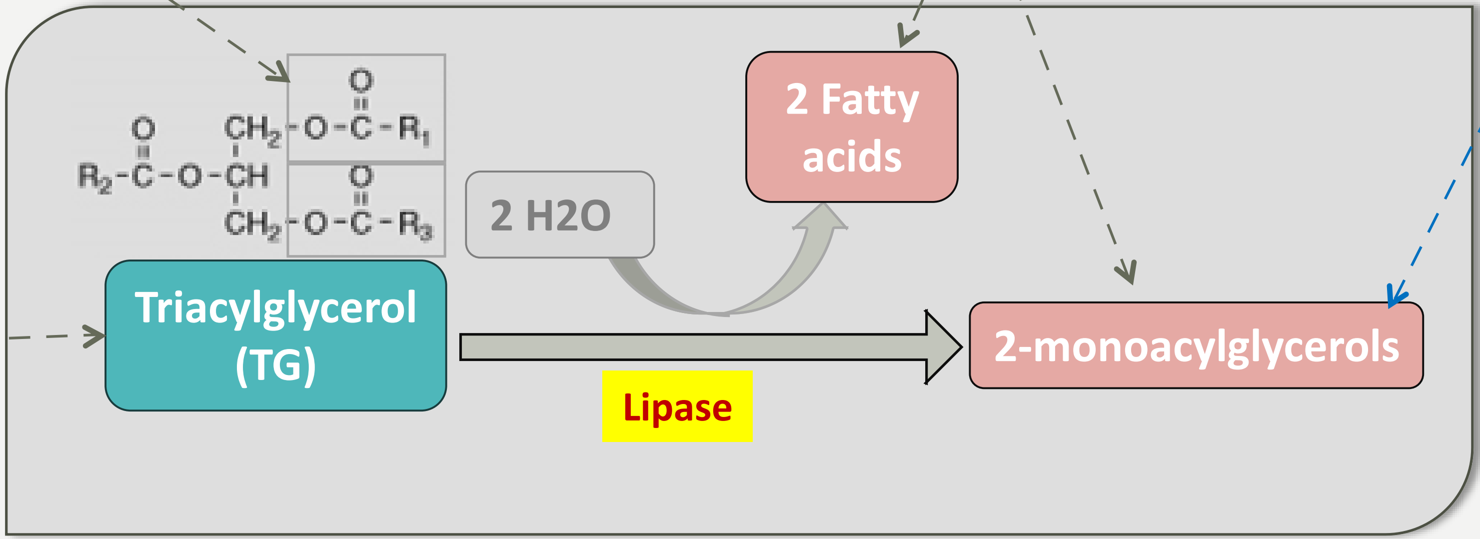
TAG containing:
short- or **medium**-chain fatty acids

- **The end products are:**

2-monoacylglycerols 2 **Fatty acids**

- **Substrate:**

TAG molecules, containing **medium**- and **short**-chain fatty acids; such as found in **milk fat.**



Please note that 2-monoacylglycerol doesn't mean "2 molecules of monoacylglycerol"!!
It means glycerol linked to fatty acid by ester bond on the second carbon.

- **The role of both lipases in lipid digestion is of little significance in adult human. Why?**

The lipids in the stomach are not yet emulsified. *Emulsification occurs in duodenum.

*Emulsification: The breaking down of large fat globules in the intestine into smaller, uniformly distributed particles, largely accomplished through the action of bile acids, which lower surface tension.

Lingual and Gastric Lipases (Acid-Stable Lipases)

They are important in

- **neonates** and **infants** for the digestion of TAG of **milk**
- Patients with **pancreatic insufficiency** where there is absence of pancreatic lipase

Digestion of Lipids in Stomach

In adults:

No significant effects because of lack of emulsification that occurs in duodenum.

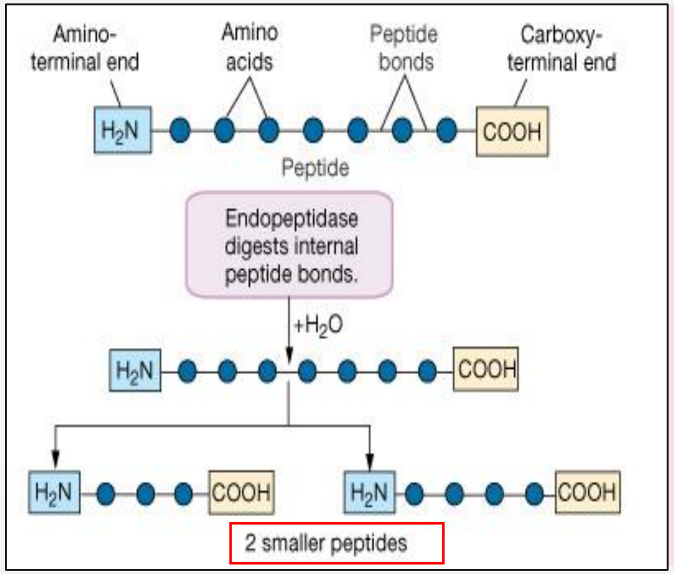
In neonates and infants:

Digestion of milk TAG and production of short- and medium-chain fatty acids

PEPSIN

What is "pepsin"?	Acid-stable, **endo**peptidase.
Secreted by:	Secreted by **chief cells** of stomach as inactive proenzyme, **pepsinogen**.
Activated by:	- **HCl** - **Auto-catalytically by pepsin** molecules that have already been activated. First pepsinogen gets activated by HCL, then the activated pepsinogen "pepsin" and HCL activate other pepsingens.
Substrate:	**de**natured dietary proteins (**by HCl**)
Produces:	Smaller polypeptides

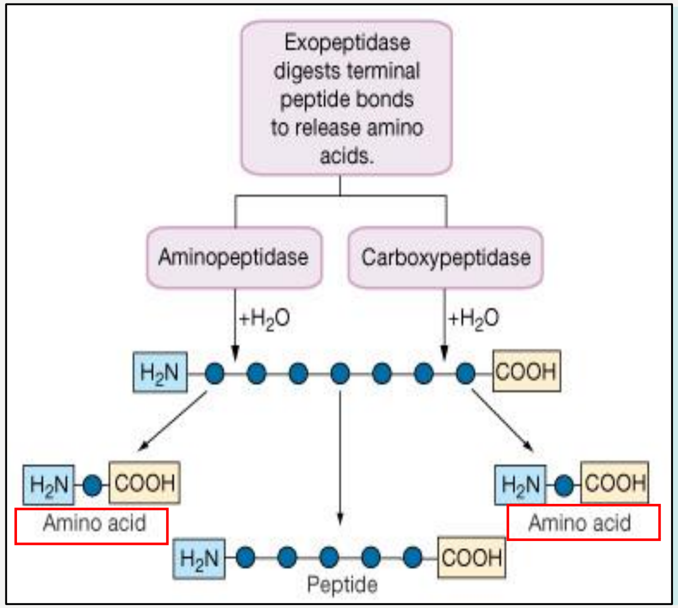
Pepsinogen has to be activated outside the cell. Why?
Because when it gets activated within the cell it will digest it. Because the cell contains polypeptide. Which is the target of pepsin



Endopeptidase

- Proteolytic peptidases that break peptide bonds of nonterminal amino acids (i.e. within the molecule).

- Break protein into 2 smaller peptides.



Exopeptidase

- break peptide bonds from end-pieces of terminal amino acids.

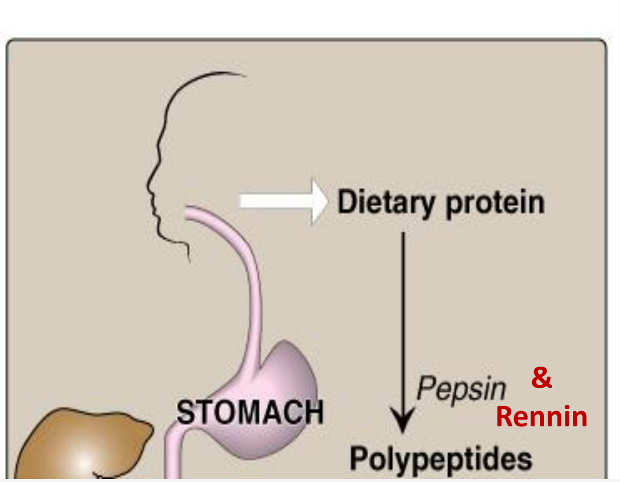
- Break protein into amino acids and peptides.

RENIN

Secreted by:	**chief cells** of stomach in **neonates** and **infants**
Substrate:	Casein of milk (**in the presence of calcium** as a cofactor).
Produces:	**Paracasein** with the formation of milk clot ماله أي دور في الهضم، فقط يحول قوام الحليب من سائل الى جبني
Effect:	It prevents rapid passage of milk from stomach, allowing more time for action of pepsin on milk proteins

Digestion of dietary proteins in stomach:

HCl:	Denatures proteins - Activates pepsin
Pepsin:	Cleaves proteins into polypeptides
Rennin:	Formation of milk clot



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Summary: click here to check out the complete summary

	Salivary α-Amylase	Lingual and gastric lipase	Pepsin	Rennin
Secreted by:	**Parotid glands**	The dorsal surface of the tongue (**Ebner's glands**)	**chief cells** of stomach as inactive proenzyme, pepsinogen	**Chief cells** of stomach in neonates and infants
Optimum pH:	**6.6 – 6.8** **"in mouth"** Salivary amylase is inactivated by the acidity of stomach (The enzyme is inactivated at pH 4.0 or less)	Acts in the **stomach** Acid-Stable Lipases	**Acid-stable**	
Substrate:	• **Starch and glycogen** • Its digestive action on the polysaccharides is of little significance because of the short time during which the enzyme can act on the food in the mouth	**TAG molecules**, containing medium- and short-chain fatty acids; such as found in milk fat	**denatured dietary proteins** (by HCl)	**Casein of milk** (in the presence of calcium)
How they act on the substrate (IMP)	❖ **Hydrolyzes**: α(1,4) glycosidic bonds (α 1-4 endoglycosidase) ❖ Salivary α-amylase does not hydrolyze: 1. α(1,6) glycosidic bonds (The branch points of starch and glycogen) 2. Salivary α-amylase cannot act on: β(1,4) glycosidic bonds of cellulose 3. Salivary α-amylase does not hydrolyze disaccharides	-	**Endopeptidase**	-
Produces:	**Short oligosaccharides**	**2-monoacylglycerols and fatty acids**	**Smaller polypeptides**	**Paracasein with the formation of milk clot**
Comment	-	- Its role is of little significance in adult humans , The lipids in the stomach is not yet emulsified. Emulsification occurs in **duodenum .** -They are important in **neonates** and infants for the digestion of TAG of milk and production of short- and medium-chain fatty acids . - They are also important in patients with **pancreatic insufficiency** where there is absence of pancreatic lipase	**Activated by** **1.HCl** **2.autocatalytically by pepsin**	**Effect:** It prevents rapid passage of milk from stomach, allowing more time for action of pepsin on milk proteins

Check your understanding!

Q1: The product of alpha amylase:
A. Maltose
B. Isomaltose.
C. Dextrine.
D. All of the above.

Q2: what is the end product of renin?
A. Paracasein.
B. Casein of milk.
C. Monoacylglycerols.
D. None of the above.

Q3: Salivary α-amylase hydrolyzes :
A. β(1,4) glycosidic bonds of cellulose.
B. disaccharides.
C. α(1,4) glycosidic bonds.
D. α(1,6) glycosidic bonds.

Q4: Lingual and gastric lipases are important in:
A. Neonates.
B. Pancreatic insufficiency.
C. Cystic fibrosis.
D. A & B.

Q5: which one of the following is true regarding stomach role in digestion ?
A. No further digestion of carbohydrates.
B. Lipid digestion begins by pepsin and rennin.
C. Protein digestion begins by lingual and gastric lipases.
D. Digestion of carbohydrates continues by α-amylase .

Q6: α-amylase works best at:
A. 6.6-6.8 PH
B. 2-4 PH.
C. Short chain TAG.

Q7: Acid-stable lipases target TAG, to produce:
A. 2 molecules of monoacylglycerol.
B. 2 fatty acids.
C. A & B .

1.D 2.A 3.C 4.D 5.A 6.A 7.B

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–- رهف بن عباد.

Resources:

- 435’s slides and 434’s notes.
- Lippincott’s illustrated reviews: Biochemistry – sixth edition.

PAIN MAKES YOU STRONGER, TEARS MAKE YOU BRAVER AND HEARTBREAK MAKES YOU WISER, SO THANK THE PAST FOR A BETTER FUTURE.

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