جامعة الملك سعود
King Saud University

"اللَّهُمَّ لا سَهْلَ إلاَّ ما جَعَلْتَهُ سَهْلاً، وأنْتَ تَجْعَلُ الحَزْنَ إذَا شِئْتَ سَهْلاً "

Biochemistry437

Role of Salivary Gland and Stomach in Digestion

Biochemistry Team 437

Color index:
Doctors slides
Doctor's notes
Extra information
Highlights

GNT block

Revised By: Hodeel Awartani & Abdullah AlOmar

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Objectives:

- Understand the principle and importance of digestion of dietary foodstuffs
- Understand the role of salivary glands in digestion
- Understand the role of stomach in digestion

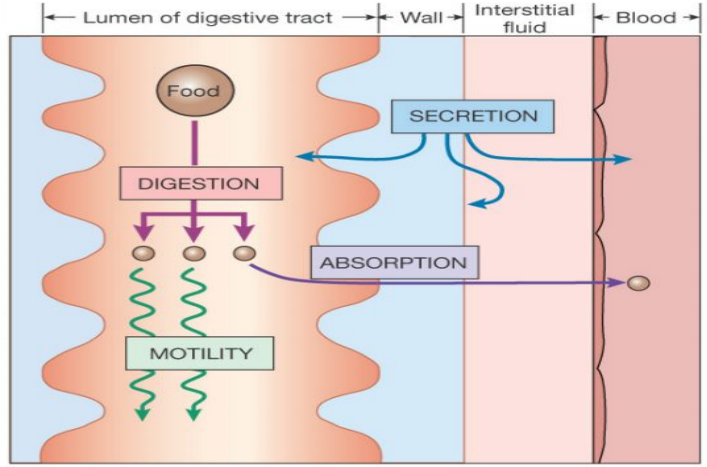
Background

- Most of dietary foodstuffs are ingested in the form that cannot be readily absorbed from the digestive tract.
- **Digestion:** The breakdown of the naturally occurring foodstuffs into smaller, easily absorbable forms.

To be able to absorb the nutrients we need, we first ingest then digest our food

Processes of the Digestive System

Only in Female's slides



1. Motility
2. Secretion
3. Digestion of enzymes and other molecules
4. Absorption of nutrients via blood
5. Elimination

Digestion End Products and Role of Salivary glands

Digestion Effects: "how do we digest our food?"

- Mechanical effects: e.g., mastication (chewing)
- Enzymatic effects: Digestive enzymes (hydrolases)[1]

End Products[2] of Digestion:

- Carbohydrates broken down into → Monosaccharides
- Triacylglycerol (TAG) → Fatty acids and monoacylglycerols
- Proteins → Amino Acids

Role of Salivary Glands in Digestion:

- **They secrete <u>saliva</u>, which:**
  - Acts as lubricant
  - Contains salivary α-amylase
  - Contains lingual lipase

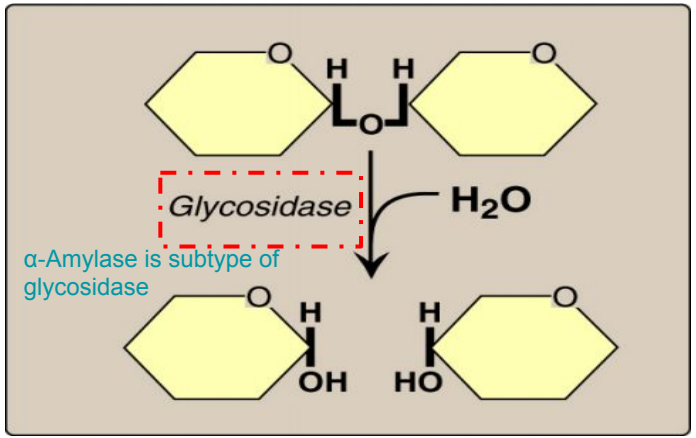
1- Enzymes that use water to cleave bonds.
2- Smallest and absorbable forms of each macronutrient.

We are going to talk about 3 enzymes in this lecture:
1- Amylase for carbohydrates
2- Lipase for lipids
3- Pepsin for proteins

Salivary[1] α-Amylase

Secreted by:	Parotid glands
Optimum pH[2]:	6.6 – 6.8
Substrate:	Starch (plant polysaccharide) and glycogen (animal polysaccharide)
Hydrolyzes[3]:	α(1,4) glycosidic bonds "only"
Produces: *"End product"*	Short oligosaccharides

Hydrolysis of α(1,4) Glycosidic Bonds



1- There are two types of amylase :
- Salivary
- Pancreatic

In this lecture we will focus on salivary amylase .
- Clinically the pancreatic is more important and it is the one measured from the blood in the lab, it is used to diagnose patients with acute pancreatitis, While Salivary amylase has very short half life and is not usually measured.

2- Optimum pH: it means that this enzyme will not work in pH less or more than this. salivary α-Amylase works in an almost neutral PH. So, when salivary α-Amylase reach down to the stomach (highly acidic), it will be inactive or denatured. That is why carbohydrate digestion will start in the mouth then stop in the stomach and finally continue in the small intestine.

3- Break down by water. *** make sure you know it works only α(1,4) glycosidic bonds, many students make this simple mistake.**

*The doctor said this is **for your own knowledge,** to know the meaning of glycosidic bond*

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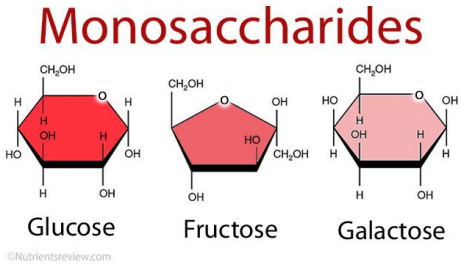
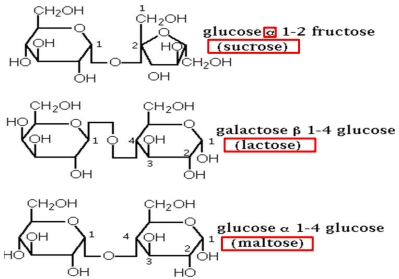
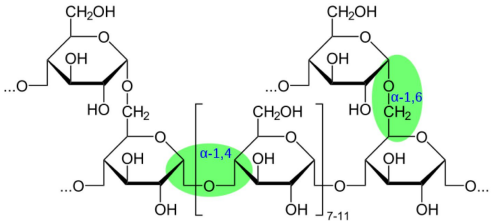
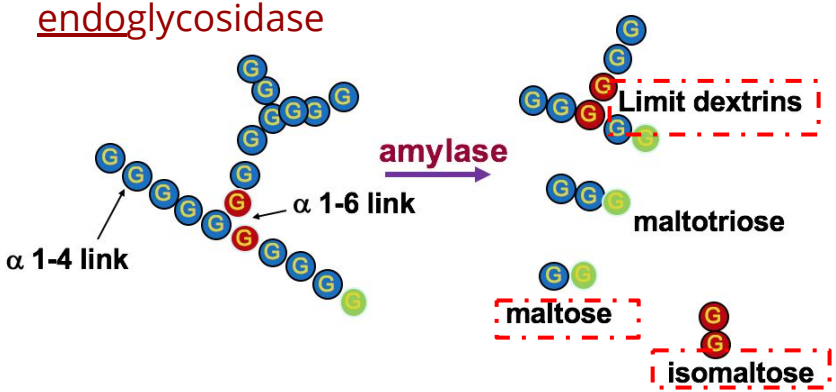
Types of carbohydrates

Simple Sugars	Disaccharides	Polysaccharides
		
Glucose (6 carbon) Galactose (6 carbon) fructose (6 carbon)	- Compounds made by 2 monosaccharides - Maltose يسمى أيضا الشعير : Glucose+Glucose - Lactose: Glucose + Galactose - Sucrose: Glucose + Fructose	A compound made by 3 or more monosaccharides - Glycogen (more branched) - Starch (flat)

Final product of carbohydrate metabolism	- Between the two monosaccharides making up this molecule:
	  - maltose : has α1-4 glycosidic bond
	  - lactose : has β 1-4 glycosidic bond
	  - Sucrose has α 1-2 glycosidic bond
	- So if you noticed ,**α** Amylase will not break down these disaccharides, so we need special enzymes to digest them. for example to digest lactose, we need lactase "the enzyme that is deficient in people with lactose intolerance
		- The bonds between the monosaccharides here are α1-4 glycosidic bonds, so **α** Amylase can work on them. Except at the branch points where the bonds are α(1,6) glycosidic bonds.
		- Cellulose is a polysaccharide with β bonds, so α amylase cant break it down

Salivary α-Amylase

Pre-stomach – Salivary amylase : **α** 1-4 endoglycosidase



Endoglycosidase : means enzyme that works on bonds inside the molecule and not on the ends

When salivary alpha amylase works on a polysaccharide, it can break all the bonds in between the polysaccharides (α1-4) except 'the 1-6 bond at the branch, and the bond between the disaccharides, so we get:

- **Limit Dextrin**: short oligosaccharides, branched
- **Maltose** : disaccharide of glucose with alpha 1-4 linkage
- **Isomaltose** : disaccharide of glucose with alpha 1-6 linkage

Effect of α-Amylase on Glycogen imp.

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

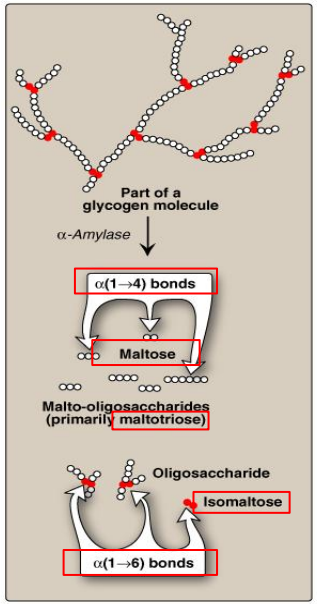
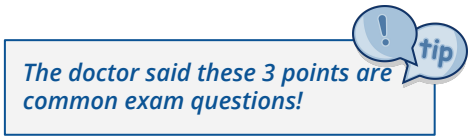


Figure 7.9
Degradation of dietary glycogen by salivary or pancreatic α-amylase.

Salivary α-Amylase

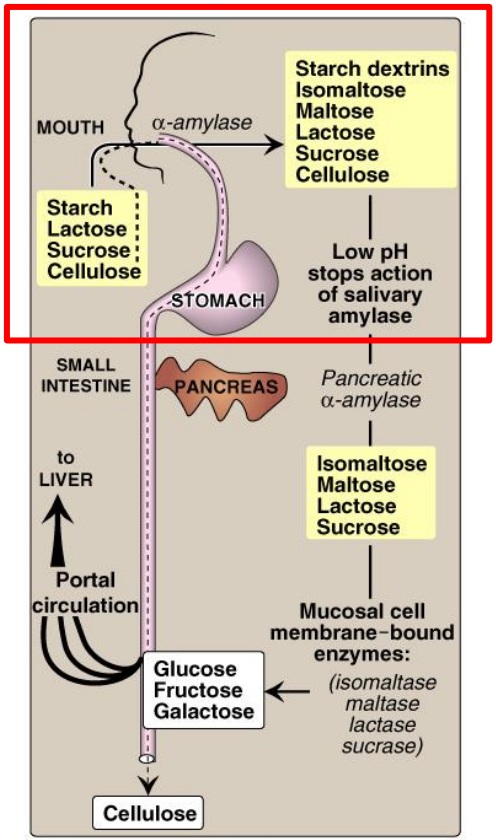
- Its digestive action on the polysaccharides is of little significance because of the short time during which the enzyme can act on the food in the mouth.
- Salivary amylase is inactivated by the acidity of stomach (The enzyme is inactivated at pH 4.0 or less).

By 2 reasons there is limited action of salivary amylase:
1- We do not keep it long in the mouth (short time for mastication)
2- When it reaches the stomach (high acidity\low pH) it will become inactive



1. Salivary α-amylase does not hydrolyze: α(1,6) glycosidic bonds (The branch points of starch and glycogen) ((that is why it gives us isomaltose))
2. Salivary α-amylase cannot act on: β(1,4) glycosidic bonds of cellulose
3. Salivary α-amylase does not hydrolyze: Disaccharides (Maltose- Lactose-Sucrose)

Digestion of Carbohydrates in the Mouth



So How would carbohydrates end in our stomach?

1- Starch > converted to dextrin (تصغر) and the rest will be converted to isomaltose because we can't break α(1,6) glycosidic bonds, and maltose

2- Lactose and sucrose> will remain the same because we can't break disaccharides

3- Cellulose > will remain the same because we cannot break beta bonds and it has other functions such as facilitating digestion

Quick recap by Dr. Rana !

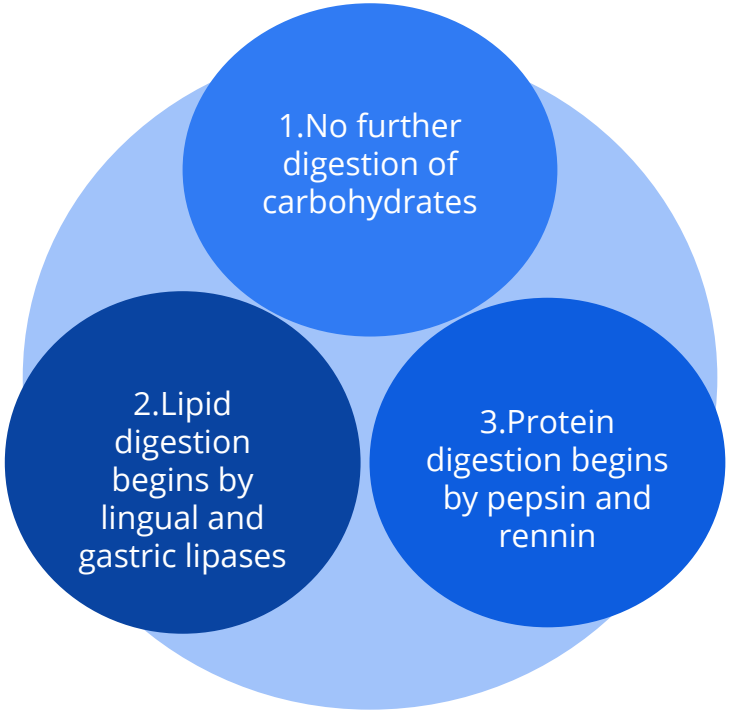
- Salivary alpha Amylase works on carbohydrates either from starch (comes from plants and is more flat in structure) or glycogen (from animals and is more branched)
- It is secreted from parotid gland.
- It will be inactive in stomach because it cant handle its acidity, so The main action of digestion of carbohydrate will be in the mouth at the beginning.
- The action of amylase is breaking of α(1,4) glycosidic bonds in the polysaccharides.
- It is an endo-glycosidase enzyme (يشتغل على الروابط الداخلية) so it cannot break disaccharides (maltose\sucrose\lactose). Also it cannot break α(1,6) glycosidic bonds (isomaltose) , and it cannot break beta bonds (cellulose).

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 monoacylglycerols
Role:	Its role is of little significance in adult humans

*It works in the stomach that means it likes acidity, Ph of stomach = 2
- **Secreted** from the dorsal surface of the **tongue** but **works** in the **stomach**

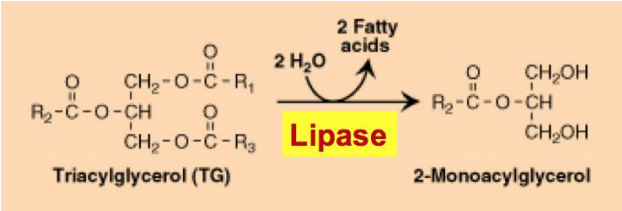
Role of Stomach in Digestion



Lingual and Gastric Lipases [Acid-Stable Lipases]

Substrate:	TAG molecules, containing medium- and short-chain fatty acids; such as found in milk fat*
The end product:	2-monoacylglycerols and fatty acids
Role:	The role of both lipases in lipid digestion is of little significance in adult human* *(The lipids in the stomach is not yet emulsified. Emulsification* (To turn big droplets of fat to small droplets) *occurs in duodenum)*
Importance:	They are important in neonates and infants for the digestion of TAG of milk. Also important in patients with pancreatic insufficiency where there is absence of pancreatic lipase.

*Medium and short chains fatty acids can be found in milk, so this enzyme is specially important in babies, whereas other fatty foods have long chain fatty acids digested by another enzymes, so lipases are in little significance for adults



Target substrate for acid-stable lipases is TAG containing:

R1 – C – O and R3 – C – O
as short- or medium-chain fatty acids

What you need to know from here:
- Acid stable Lipases work on short and medium fatty acids to give us:
  - 2 fatty acid chain
  - and 2-monoacylglycerol

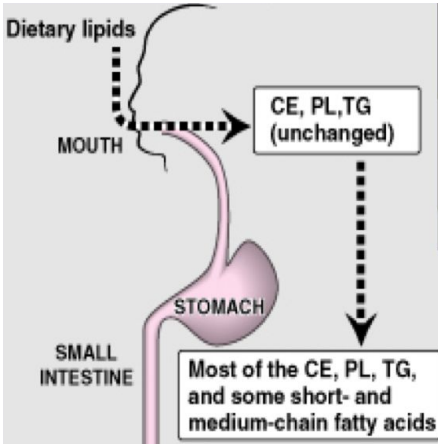
Digestion of Lipids in Stomach

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



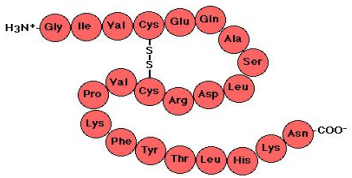
Quick recap by Dr. Rana !

- Lipase is acid stable (can work in acidic environment). It works in the stomach
- Two types of lipases: Lingual and Gastric.
- Act on short and medium chain fatty acids, especially for babies and patients with pancreatic insufficiency.
- Convert lipids to form 2-monoacylglycerols and 2 fatty acids.

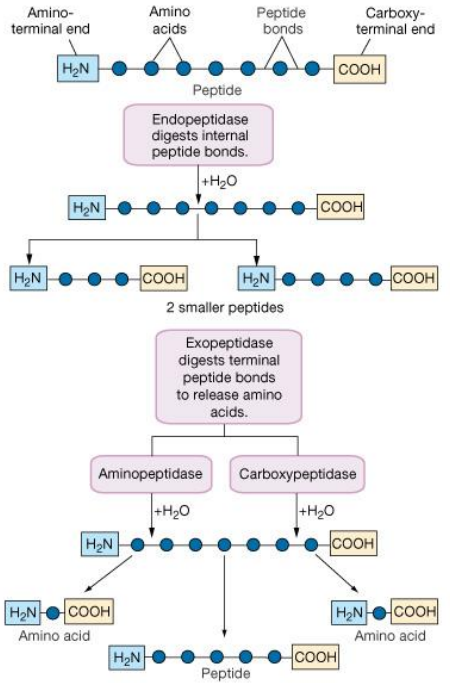
Pepsin
[Acid-stable Endopeptidase]

Secreted by:	Chief cells of stomach as inactive proenzyme, pepsinogen
Activated by:	HCl and autocatalytically by pepsin
Properties	Acid stable, endopeptidase **Dr.s emphasize this**
Substrate:	Denatured dietary proteins (by HCl)
End product:	Smaller polypeptides

- Inside the cell we don't want pepsin to be active so it doesn't ruin the cell from the inside.
- When pepsinogen is secreted to start digestion, the previous remaining active pepsin and HCL in the stomach will activate it by breaking it down.



Just for illustration



Endopeptidases and exopeptidases

Rennin

Secreted by:	Chief cells of stomach in neonates and infants
Substrate:	Casein of milk (in the presence of calcium)
End product:	Paracasein with the formation of milk clot
Effect:	It prevents rapid passage of milk from stomach, allowing more time for action of pepsin on milk proteins

tip

Don't confuse it with Renin, the enzyme that's involved in regulation of blood pressure !

Rennin turns the liquid form of milk to solid so the milk can stay for a longer duration in the body.
It is found in higher amounts in infants

Digestion of Dietary Proteins in Stomach

HCL:	Pepsin:	Rennin:
• Denatures proteins • Activates pepsin	Cleaves proteins into polypeptides	Formation of milk clot

Take Home Messages

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Read it, it is a good summary of some concepts

- Digestion involves both mechanical and enzymatic processes.
- Digestion makes dietary foodstuffs readily absorbable by the digestive tract.
- Salivary α-amylase is of limited, but initial effect on digestion of starch and glycogen in the mouth.
- Salivary α-amylase converts starch and glycogen into short, branched oligosaccharides.
- Limited digestion of TAG begins in the stomach by both lingual and gastric lipases producing 2-monoacylglycerols and fatty acids.
- Digestion of proteins begins in the stomach by pepsin producing smaller polypeptides.
- In neonates and infants, digestion of milk occurs in stomach by:
  Acid-stable lipases for digestion of milk fat.
  Rennin and pepsin for digestion of milk proteins.

Summary

Special Thanks to Dimah Alaraifi♡

	Secreted by	Substrate	Action	Produces	PH	Notes
Salivary α-Amylase	Parotid glands	Starch and glycogen	Hydrolyzes of α(1,4) glycosidic bonds	- Short oligosaccharides (brached, unbranched) - Disaccharides (Maltose, isomaltose)	6.6 – 6.8 (inactivated at pH 4.0 or less)	**Can't act on:** - α(1,6) glycosidic bonds - β(1,4) glycosidic bonds of cellulose - disaccharides
Lipase	Lingual from dorsal surface of the tongue	TAG containing medium- and short-chain fatty acid	Acts in the stomach for the digestion of TAG	- 2-monoacylglycerols - fatty acids	Acid-stable	- important in neonates and infants for digestion TAG of milk - important in patients with pancreatic insufficiency - In adults, no significant effects because of lack of emulsification that occurs in duodenum
Pepsin	chief cells of stomach	denatured dietary proteins (by HCl)		Smaller polypeptides	Acid-stable	Secreted As inactive proenzyme pepsinogen, Activated by HCl and another pepsin
Rennin	chief cells of stomach in neonates and infants	Casein of milk (in the presence of Ca)	prevents rapid passage of milk from stomach, allowing more time for action of pepsin on milk proteins	- Paracasein - milk clot	-	-

MCQs:

Q1\ What is Salivary α-Amylase Optimum pH ?

A. 2.5 - 4 PH
B. 6.6 - 6.8 PH
C. 9 - 10.5 PH
D. 8 - 12 PH

Q2\ what is the end product of renin ?

A. Paracasein
B. polypeptides
C. Monoacylglycerols
D. Short oligosaccharides

Q3\ Lingual and Gastric Lipase is secreted by

A. Ebner's glands
B. Chief cells of stomach
C. Parotid glands
D. Pituitary gland

Q4\ Which of these is hydrolyzed by alpha amylase ?

A. cellulose
B. Maltose
C. sucrose
D. glycogen

1- B
2- A
3- A
4- D

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Girls team

- غادة الحيدري
- لجين عبد الرحمن
- نورة بن حسن
- عبير العبدالجبار
- العنود المنصور
- ريناد الغريبي

Boys team

Team leaders

- رهام الحلبي
- عبدالحكيم العنيق

@biochemistry437

teambiochem437@gmail.com