

PHYSIOLOGY  
TEAM..

## PHYSIOLOGY OF PANCREAS ..

## Physiology of the Pancreas

The pancreas is composed of two portions:-

1-**The endocrine portion** (islets of Langerhans) which secrete hormones directly into blood stream. → we will take it in endocrine block , we will not talk about it now !!

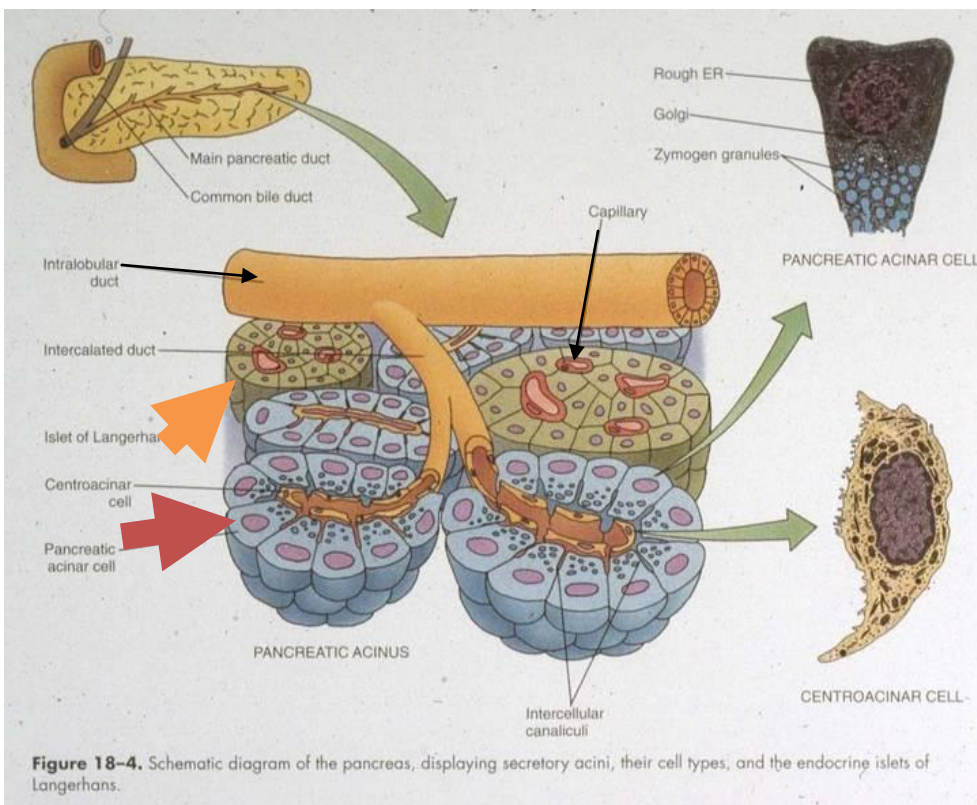
e.g: insulin, glucagone and somatostatin.

2-**The exocrine portion**( **acinar gland tissues**) which produce pancreatic juice into pancreatic duct then secreted into the intestine at major deudenal papilla.

-pancreatic juice = pancreatic enzymes.

- acinus : it is clusters "group" of cells "ball-like", secrete pancreatic enzymes OR :

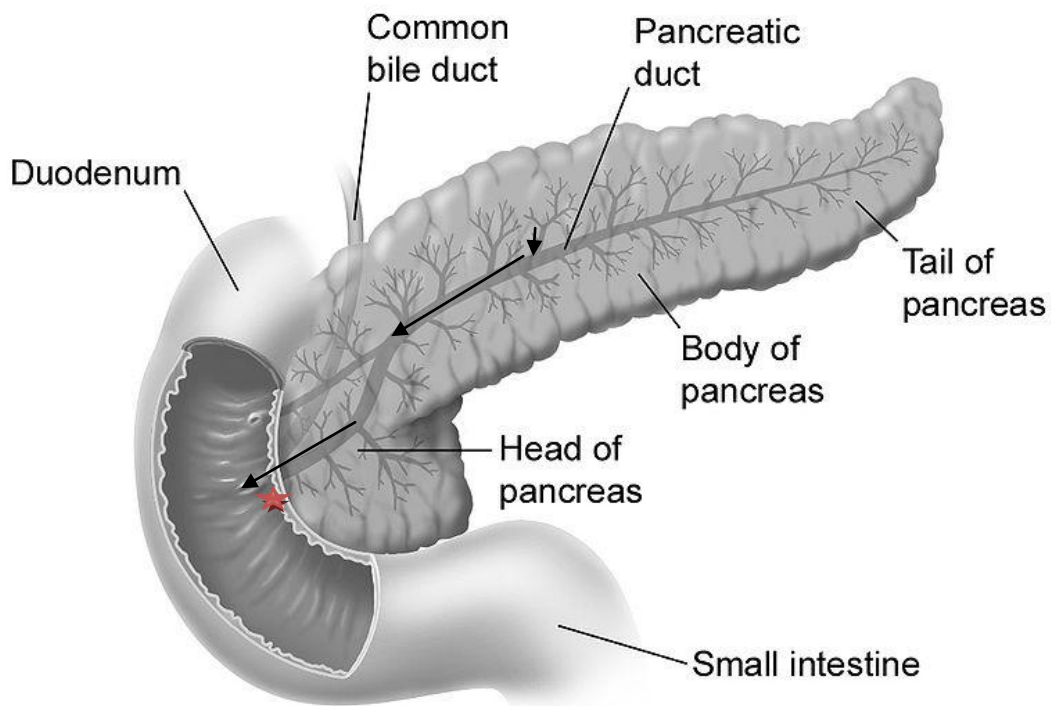
The cells lining the acini are serous cells containing zymogen granules (the precursors of pancreatic enzymes).



Note that :

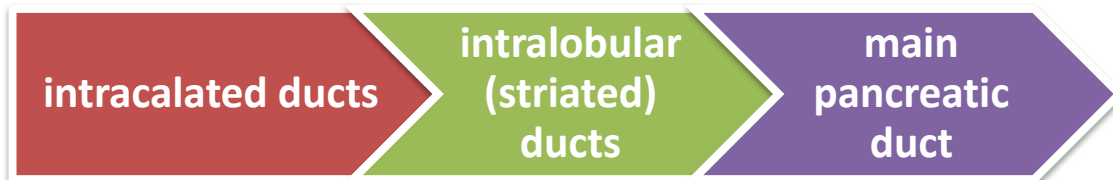
1-islets of langerhans  
beside the capillaries ..  
so they secrete  
hormones directly into  
blood!!

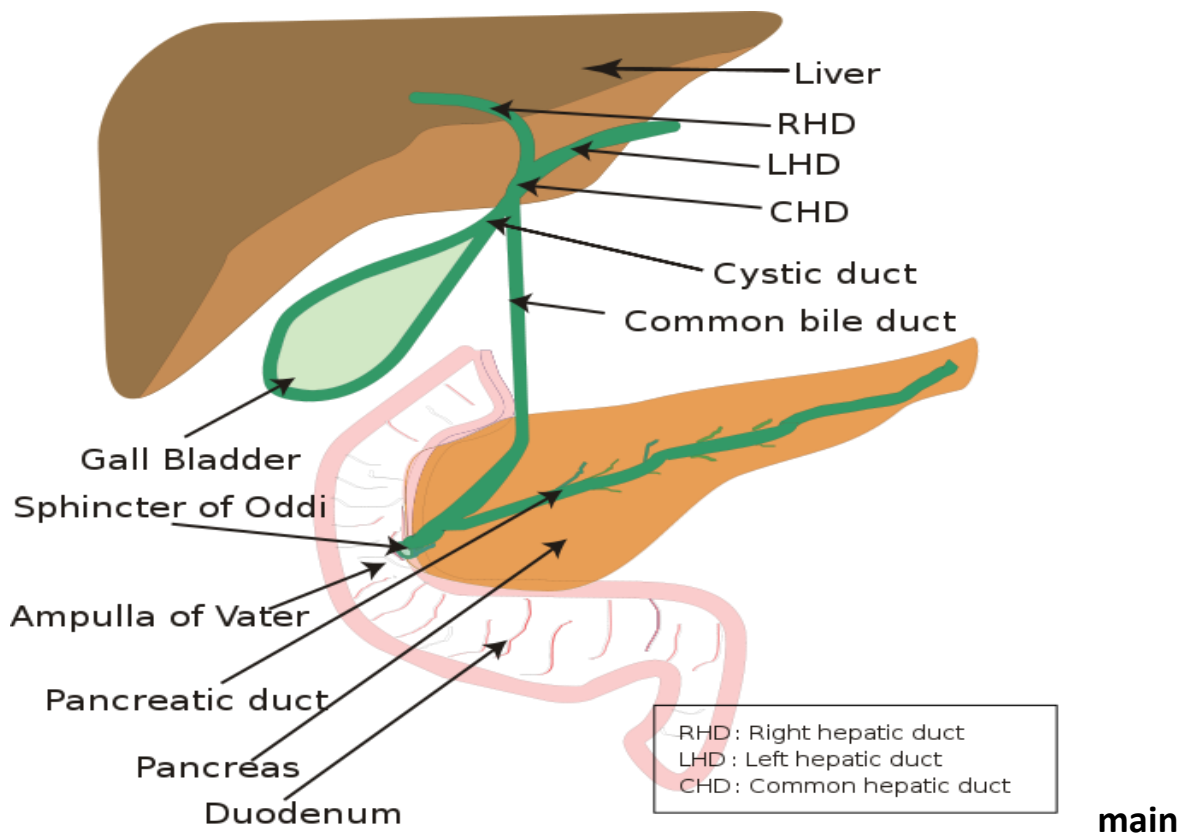
2-the acinus are  
directly open into  
pancreatic duct..



National Cancer Institute

the pancreatic enzymes will pass all parts of pancreatic ducts :





**pancreatic duct** join the bile duct(from liver and gallbladder) at ampulla of vater(in the second part of duodenum) that is surrounded by sphincter of Oddi “between duct and intestinal lumen”.

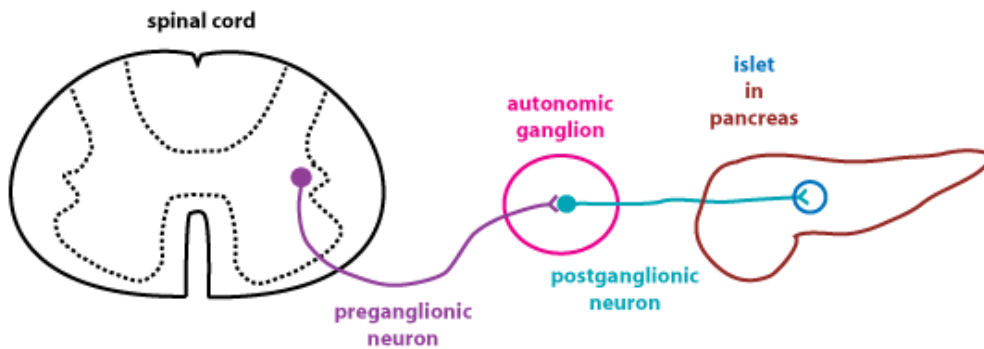


## Innervation of pancreas:

Has double innervations from:

a-sympathetic → decrease GIT function.

b-parasympathetic → increase GIT functions.



1-Preganglionic parasympathetic fibers arise in vagus nerve to synapse with ganglion cells around the large ducts. Postganglionic fibers supply the acini : see figure :

2-The sympathetic fibers accompany the blood vessels.

parasympathetic	sympathetic
Increase pancreatic secretion in acinus	Vasoconstriction of vessels , decrease hormonal secretion into blood !!

## Pancreatic juice:-

- **Volume:** 1.2-1.5 l/day.
- **Specific gravity**(الكثافة النوعية): 1008-1030.
- It is isotonic !!!
- **PH:** 8 \ alkaline
- **Composition:**
  - a- water.
  - b- 1 % **inorganic** materials (**electrolytes-** mainly  $\text{HCO}_3^-$  ).
  - c- 1-2 % **organic** materials **mostly enzymes**.

All GIT secretions are **isotonic** except saliva is (hypotonic).

**PH of pancreas is alkaline because it will secrete its enzymes into alkaline medium also "intestine"**

$\text{HCO}_3^-$  : alkaline .. is important electrolyte because it will **increase**

**Neutralize-** any acidic chyme coming from stomach .. so **enzymes can act on it.**

## I. The electrolytes:

They are produced by **duct cells** and include **cations**  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{++}$  and **anions**  $\text{HCO}_3^-$  and  $\text{Cl}^-$ .

The greater bulk of electrolytes are in the form of  $\text{NaHCO}_3$ .

It makes a major contribution to **neutralization of acid chyme** along with bile and duodenal secretion in order to **create a suitable medium for the action of pancreatic enzymes**.

Chyme entry to Duodenum will stimulate the pancreas secretion  
Duodenum has no Mucus protection from ACID  
the only protection is  $\text{HCO}_3^-$  for neutralizing the chyme

## II. The enzymes:

They are produced by acinar cells.

The pancreas secretes enzymes that act on all major types of food stuffs (**proteins, carbohydrates, fats, phospholipids, DNA and RNA**).

### *1- Pancreatic proteolytic enzymes:*

Ribonuclease = RNA  
Deoxyribonuclease = DNA

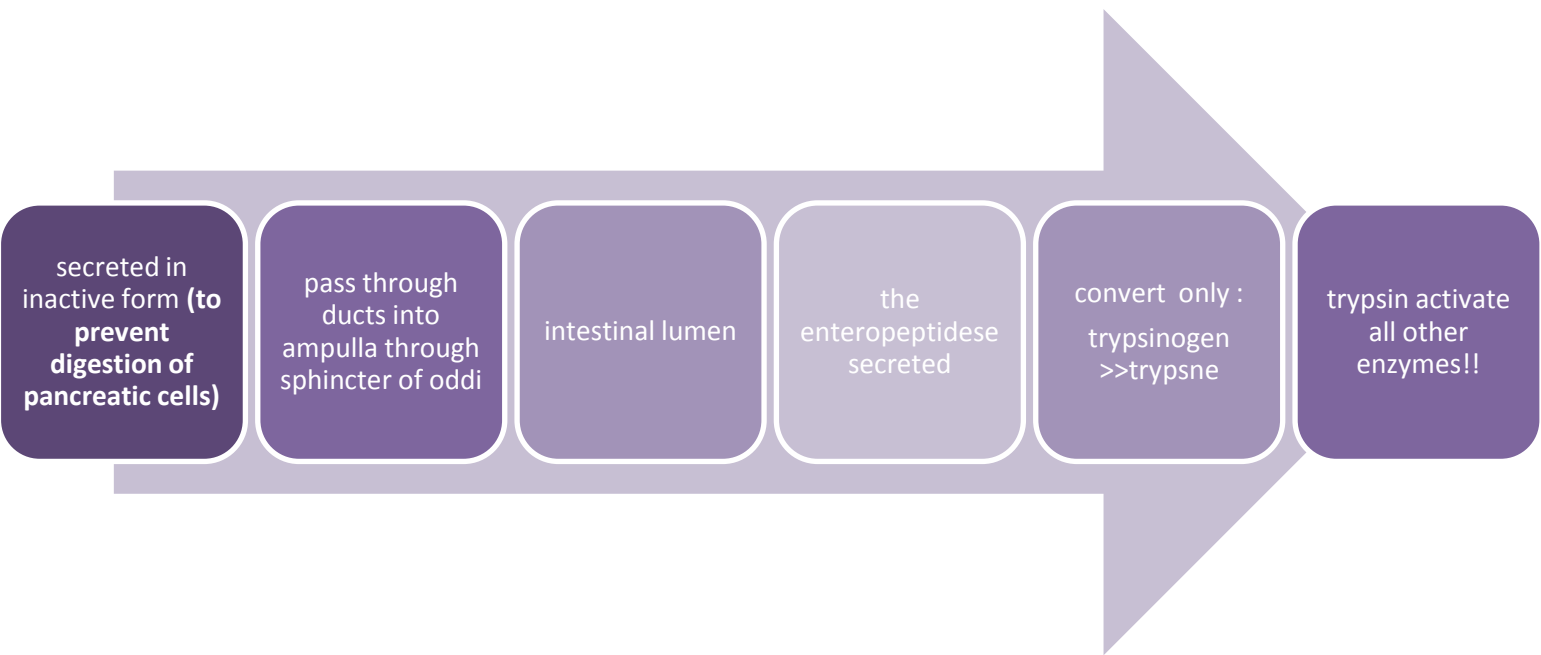
The first proteolytic enzyme is pepsin in the stomach.

-Trypsin,

chymotrypsin, elastase, carboxypeptidase, ribonuclease and deoxyribonuclease.

CCK stimulate Acinar cells to release Enzymes

Secretin stimulate Ductal cells to release  $\text{HCO}_3^-$



So, trypsin activate:

chymotrypsinogen → chymotrypsin

proelastase → elastase

procarboxypeptidase → carboxypeptidase

so,

**activation of trypsinogen by enteropeptidase is the key to activation of pancreatic proteases.**

**Enteropeptidase is considered the most important intestinal enzyme.**

**Entero**peptidase =  
enterokinase : secreted by  
**duodenal mucosal cells.**

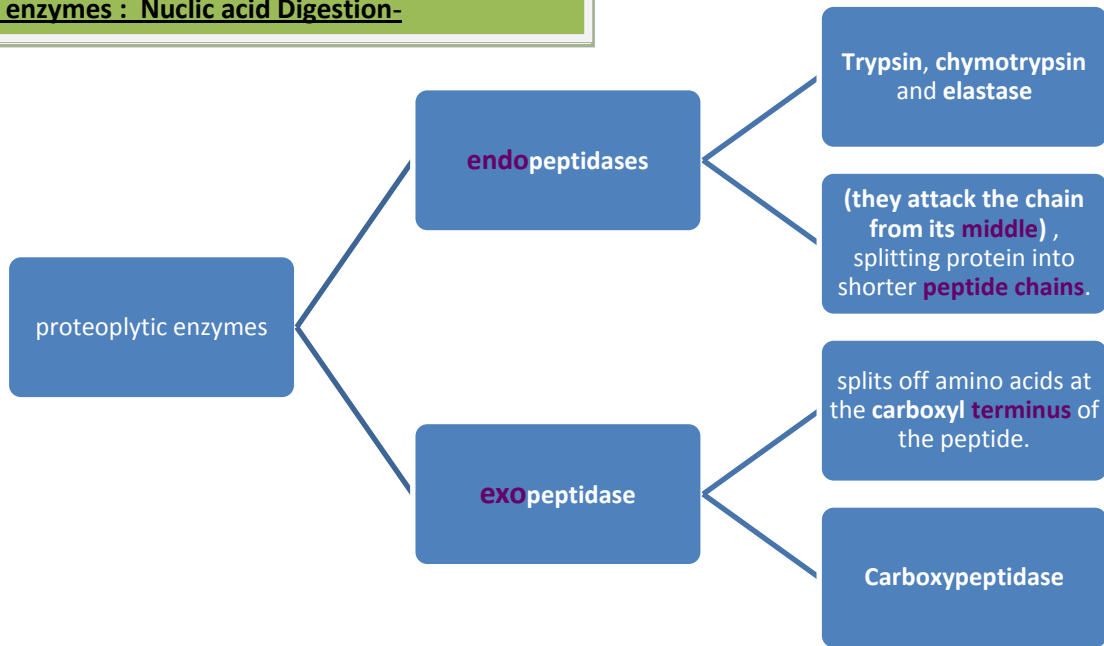
-**Trypsin inhibitor** is present  
in cytoplasm of glandular  
cells "in acinus".

It inhibits activation of  
trypsin in acini and ducts of  
the pancreas → so , prevent  
any conversion of these  
enzymes inside pancreas →  
to prevent digestion of  
pancreatic cells..!!

proteolytic enzymes : Protein Digestion

Amylolytic Enzymes : Fat Digestion-

nucleolytic enzymes : Nucleic acid Digestion-



## 2-Pancreatic amylase:

**For carbohydrate “polysaccharide = starch !!**

It splits **starch** to maltose, maltotriose and dextrins → see BIO lecture\ same as salivary amylase ..

## 3-Enzymes for fat digestion: as BIO lecture..

**Secreted from pancreas into intestinal lumen to act on lipids:**

a-Pancreatic **lipase** is the most important fat splitting enzyme. It breaks TG into MG and FA in the presence of bile salts and colipase.

b- **Cholesterol esterase** which liberates cholesterol.

c- **Phospholipase A<sub>2</sub>** which splits phospholipids into lysophospholipids & FA.

**floating stools indicate high fat content ( fat malabsorption)**

## Control of pancreatic secretion

### Control mean “ which increase or decrease pancreatis secretion”

#### 1- hormonal

- it is the more important for pancreatic secretion..!!

#### 2- neural

- it is a reflex:
- A- vagovagal reflex
- B- short ENS reflex

Depending on the food position in your GIT , there will be three phases :

- 1- Cephalic → كيف رح يؤثر وجود الطعام في الفم على افرازات البنكرياس
- 2- Gastric → كيف رح يؤثر وجود الطعام في المعده على افرازات البنكرياس
- 3- Intestinal → كيف رح يؤثر وجود الطعام في الامعاء على افرازات البنكرياس  
في كل الثلاث مراحل .. السؤال هو : ماذا سيحدث في البنكرياس ؟

Simply :  
Control of all GIT :

- 1- BY : Hormonal - Neural
- 2- In all three phases what will happen to the organ you talk about ??

رح اجمع بين البنكرياس والمعدة لانهم نفس الطريقة .. ☺ In english

A) Cephalic phase :

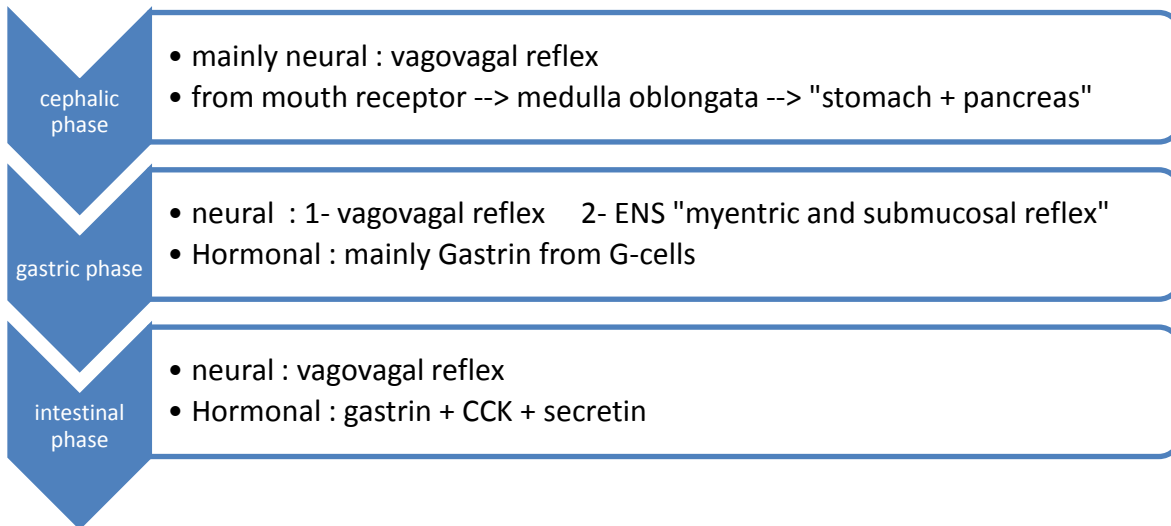
When food is in your mouth → what will happen to you stomach and pancreas??

B) Gastric phase :

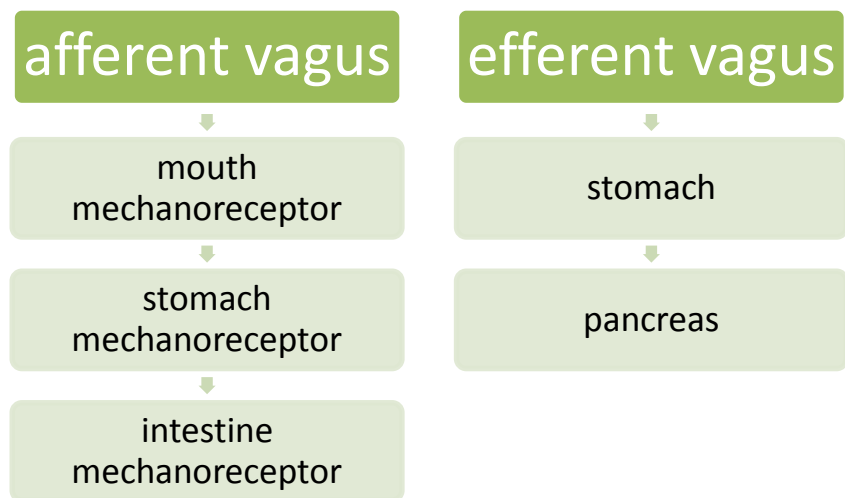
When food “chyme” is in your stomach → what will happen to you stomach and pancreas??

C) Intestinal phase :

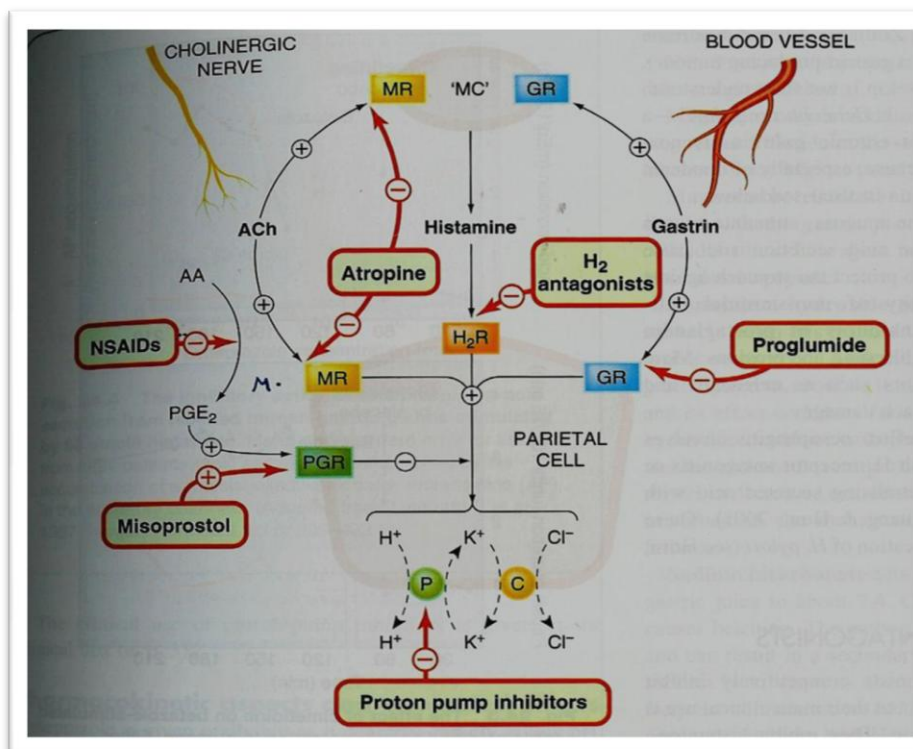
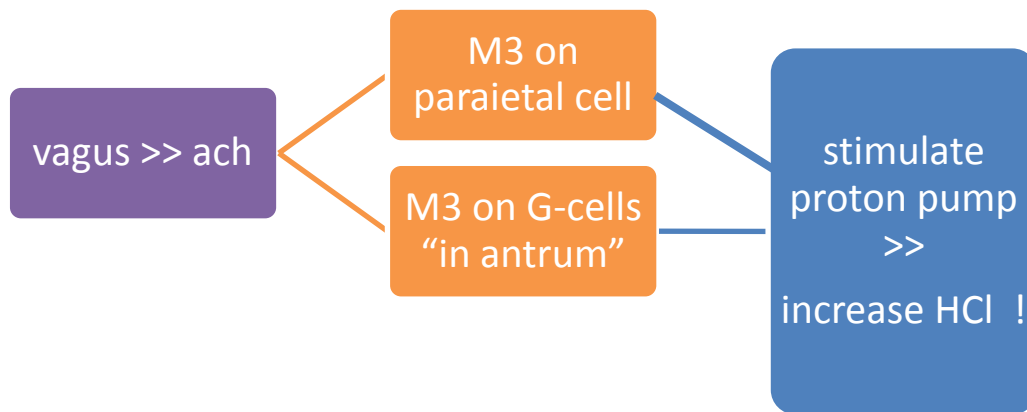
When food “chyme” in your intestine “mainly in deudenum” → what will happen to you stomach and pancreas??



First , the vagovagal is :



In stomach → any vagus efferent will cause:



Any vagus in pancreas will cause :

Vagus → acinus → secrete pancreatic enzyme

*Innervation of pancreas:*

*Parasympathetic:*

*Preganglionic nerve → "ganglion in pancreatic duct" → postganglionic nerve "in acinus"*

=====

*As we said before : acinus is clusters of cells that are secreting pancreatic enzymes !!*

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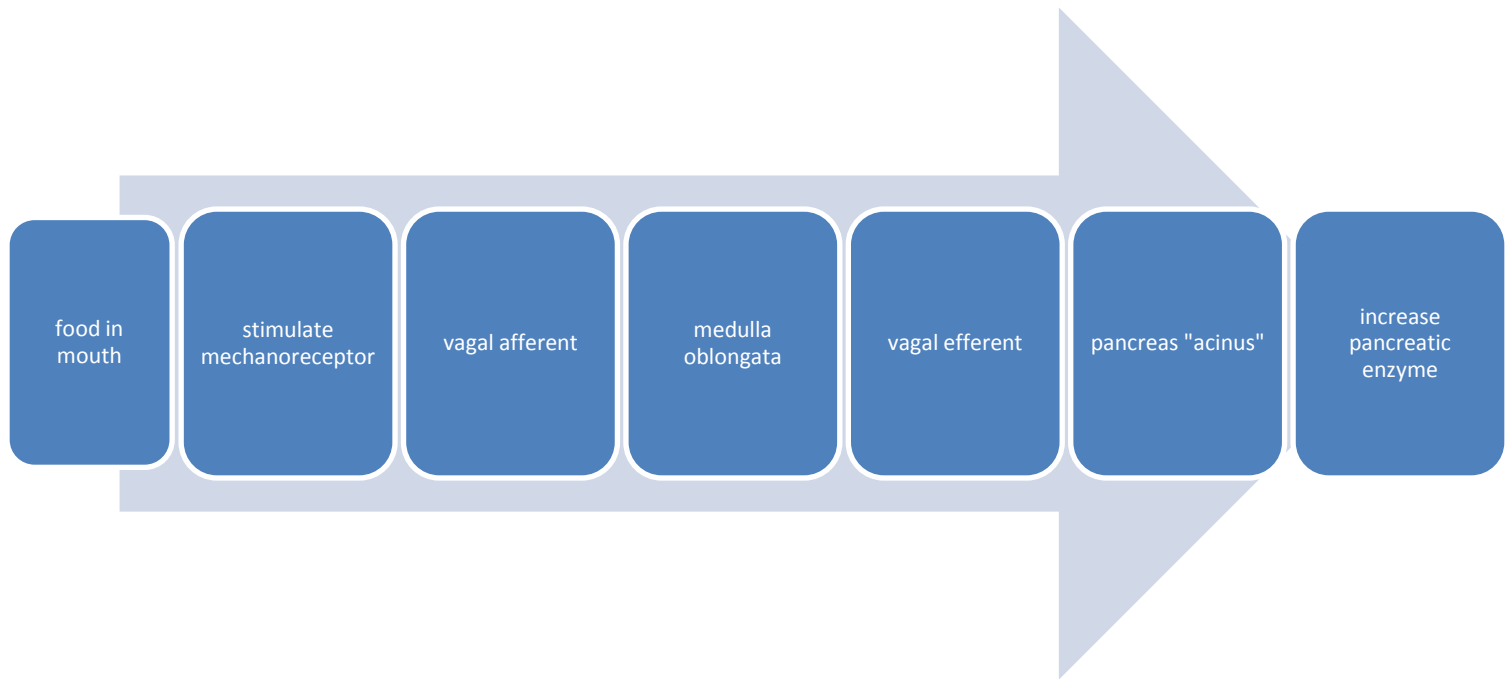
*So, any parasympathetic stimulation → stimulate secretion of pancreatic enzyme ☺*

Now I will talk about CONTROL OF PANCREAS as in lecture :

1- Cephalic phase : إعادته للسابق ذكره ☺

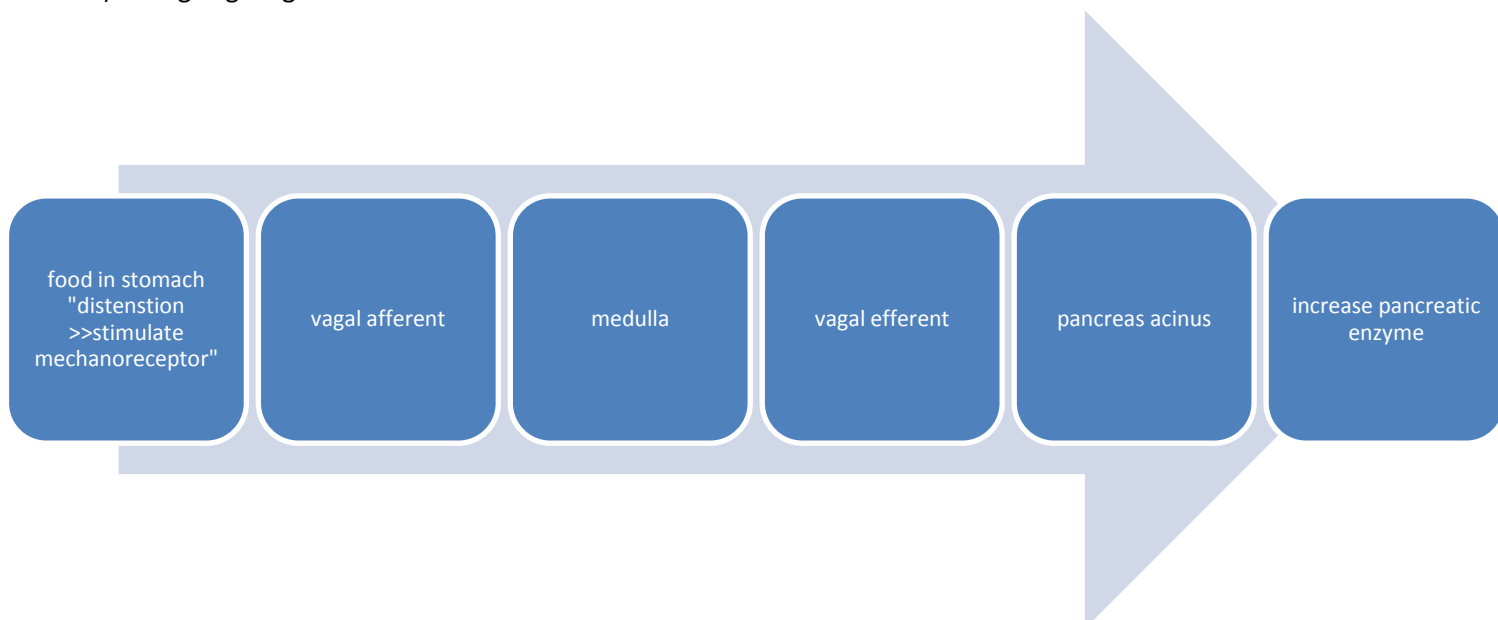
Conditioned → by smelling and thinking about food

Non-conditioned → by presence of food



2- Gastric phase :

A) Long vagovagal :



B) Short ENS "enteric" :

(( gastropancreatic reflex )) :

Stomach myentric plexus → stimulate submucosal plexus in panceas → increase local secretion

C) Intestinal phase :

It is the most important phase in controlling PANCREATIC SECRETION !!

Because this phase , the chyme is in intestine where the pancreatic enzyme will act !!!!

The hormonal control is more important than neural ..

Because hormones from intestine will act directly on pancreatic secretion !!

So, Hormonal control of pancreatic secretion is :

BY 2 main hormones : “ we took it in BIO – digestion of lipid”

*Until now we know that Upper intestine “deudenum” has three types of cells secreting hormones:*

1- G-cell → gastrin

2- I – cells → CCK

3- S-cells → secretin

4- M – cells → for phagocytosis

	secretin	CCK
stimulus	Acidic chyme “low PH”	Presence of aminoacid and fatty acid “
Main funtion	1- Act on duct cells → $H_2O + HCO_3^-$ secretion. 2- Act on biliary duct cells → increase hepatic flow and $HCO_3^-$ secretion • <u>To increase PH to optimum level that pancreatic enzyme can act on .. !!</u>	1- Act on acinus cells → pancreatic enzymes 2- Increase gall bladder contraction → bile salt
Other functions:		
1- Gastric motility and secretion	1- Inhibit	1- stimulate
2- Pyloric sphincter	2- Contract	2- contract
3- LES sphincter	3- Relax	3- relax
4- Intestinal motility and iliocaecal sphincter	4- Inhibit and contract 5- Stimulate pepsin secretion	4- stimulate 5- it may concerned with the mechanism of staitety

- CCK : it may concerned with the mechanism of staitety → it give sensation of fullness : in staitety center in hypothalamus
- CCK : cholecystokinin :cholecysto → gall bladder \ kinin → increase motility
- In BIO : the lipid must be emulsified BY bile salt → to make micelles “ outer hydrophilic + inner hydrophobic” → so ezymed can act on it ..
- These two hormones are augmented each other !!

-Rate of flow of secretion of pancreas: affected mainly by ( $\text{HCO}_3$ , CL)

-if the rate of flow is high  $\rightarrow$  increased  $\text{HCO}_3$  , Decreased CL ,

NA + K Remain the same

-If the rate of flow is low  $\rightarrow$  Decreased  $\text{HCO}_3$  , Increased CL

NA+K Remain the same

-Regulaion: if CCK Increased  $\rightarrow$  Ca intracellular Increased