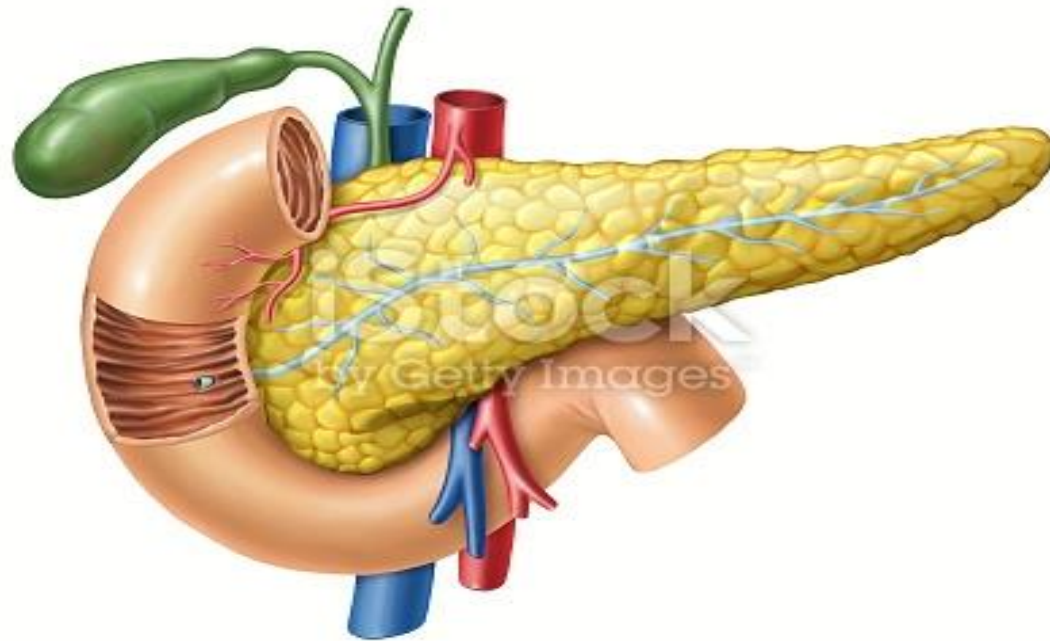


Composition & function of pancreatic secretion

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Learning objectives

- **Composition of the pancreatic secretion**
- **Enzymes of the pancreatic secretion**
- **Mechanism of action of pancreatic enzymes**
- **Mechanism of synthesis of bicarbonate rich pancreatic secretion**
- **Regulation of pancreatic secretion**

Composition of pancreatic secretion

- The pancreas is a dual gland having both exocrine and endocrine functions
- The exocrine part histologically resemble salivary glands and is represented by the acini , that contains zymogen granules which store and secrete digestive enzymes.
- A **small duct** arises from lumen of each alveolus, which unites with neighboring alveoli to form '**intra lobular duct**'.
- All the intra lobular ducts unite to form '**Wirsung duct**', which joins common bile duct to form '**ampulla of vater**'.

- The exocrine function involves the secretion of digestive juice, the pancreatic juice .
- The endocrine function involves the production of hormones .

Nerve supply:

Both sympathetic and para-sympathetic fibers.

Sympathetic fibers are supplied through **splanchnic nerve** and

Para-sympatheic fibers are supplied through **vagus nerve**.

Pancreatic juice:

The pancreatic juice is a clear, colorless ,watery solution that contains about 99.5 % of water and 0.5 % of solids .

The solids are the organic and inorganic substances .

- The inorganic matter consists mainly of HCO_3^- , Cl^- , Na^+ , K^+ and small amounts of phosphate , Ca^{++} and Mg^{++} are also present .
- The specific gravity of the pancreatic juice is usually between **1.010** and **1.018**
- The amount of pancreatic juice secreted per day is about is **1.5liters**

- The bicarbonate content of the pancreatic juice is very high which makes the pancreatic juice an alkaline fluid with a pH between **8 and 8.3**.

It is about **110-150meq/L** against the plasma level **24meq/L**.

High HCO_3^- content of pancreatic juice is important because of two reasons;

- i) It makes pancreatic juice highly alkaline, it protects the intestinal mucosa from acid chyme.
- ii) It provides the required pH(7-9) for the activation of pancreatic enzymes.

Pancreatic juice

Water – 99.5%

Solids – 0.5%

Organic substances

Inorganic substances

Enzymes

Other organic substances

Proteolytic enzymes

1. Trypsin
2. Chymotrypsin
3. Carboxypeptidases
4. Nuclease
5. Elastase
6. Collagenase

Amylolytic enzyme

Pancreatic amylase

Lipolytic enzymes

1. Pancreatic lipase
2. Cholesterol ester hydrolase
3. Phospholipase A
4. Phospholipase B
5. Colipase
6. Bile salt-activated lipase

1. Albumin
2. Globulin

1. Sodium
2. Calcium
3. Potassium
4. Magnesium
5. Bicarbonate
6. Chloride
7. Phosphate
8. Sulfate

Bicarbonate content = 110 to 150 mEq/L

Enzymes of pancreatic juice

- The pancreas produces proteins at a rate highest in the body on per gram tissue basis .
- Many of the enzymes are produced ,stored , and released as their inactive precursors ,so that these do not digest and destroy the pancreas itself .There are also enzymes inhibitors present in the acinar cells.
- These inactive precursors are later activated .

Enzymes of pancreas are

- 1) Trypsin
- 2) Chymotrypsin
- 3) Carboxy peptidases A and B
- 4) Elastase
- 5) Pancreatic lipase and Co lipase
- 6) Collagenase
- 7) Bile salt acid lipase

Enzymes of pancreas are

- 8) Pancreatic alpha amylase
- 9) Deoxy ribonuclease
- 10) Ribonuclease
- 11) Phospholipase A
- 12) Cholesteryl ester hydrolase
- 13) Non specific esterase
- 14) Miscellaneous enzymes

Functions of Pancreatic juice:

1. Digestive functions of pancreatic juice
2. Neutralization action of pancreatic juice
3. Digestion of proteins
4. Digestion of lipids
5. Digestion of carbohydrates

Functions of Pancreatic juice:

1.Digestive functions of pancreatic juice:

Pancreatic juice plays an important role in the digestion of proteins and lipids . It also digests the carbohydrates.

2.Neutralization action of pancreatic juice:

Because of the high HCO_3^- content, it makes pancreatic juice highly alkaline, it protects the intestinal mucosa from acid chyme.

Functions of Pancreatic juice:

3.Digestion of proteins

The major proteolytic enzymes of pancreatic juice are Trypsin and Chymotrypsin . Other enzymes are carboxypeptidases , nucleases, elastase and collagenase.

Trypsin:

This enzyme is secreted in the inactive or zymogen form called trypsinogen. When the pancreatic juice enters the duodenum the trypsinogen is activated to trypsin by an enzyme called enteropeptidase secreted by the upper small intestine especially the duodenum .

It has an alkaline optimum pH, between **8.0 and 9.0**

Trypsin has the following actions:

1) Digestion of proteins

Trypsin is the most powerful protein digesting enzyme .

It is an endopeptidase and hydrolyzes preferably the centrally situated peptide linkages of the protein molecules.

By means of hydrolysis, it converts proteins into proteoses and polypeptides.

Though trypsin is a strong proteolytic enzyme, it cannot hydrolyze any peptide bond with proline residue.

2) It greatly accelerates the clotting of blood

3) It converts caseinogen in the milk into casein

4) It activates other enzymes of pancreatic juice

▪
-It activates chymotrypsinogen , proelastase , procarboxypeptidase A and B , prophospholipaseA , pro colipase to their active form .

a) An inhibitor of trypsin activity occurs in the pancreatic juice . It appears to have the function of protecting tissue from the proteolytic effects of trypsin , in case trypsin is produced from trypsinogen within the pancreatic tissue.

(b) Trypsin-inhibitors: Our food may contain trypsin inhibitors.

For example:

- Egg–white contains water soluble muco protein, a very potent trypsin inhibitor

- Human and bovine colostrum and raw soya beans have also been shown to contain trypsin inhibitors.

- Trypsin inhibitors have also been reported recently from lung tissues and blood.

- Experimentally, trypsin can be inhibited by di iso propyl fluoro-phosphate(DFP).

Chymotrypsin

This enzyme is first secreted as the inactive chymotrypsinogen ,which is activated to chymotrypsin by trypsin .

Actions of Chymotrypsin

i)Digestion of proteins

Chymotrypsin is also an endopeptidase and it hydrolyses the proteins into polypeptides.

ii)Digestion of milk

Chymotrypsin digests casein faster than trypsin .The combination of both enzymes causes more rapid digestion of milk

- no action blood clotting

It has no action on blood clotting.

Like trypsin , chymotrypsin is also an **endopeptidase** and has the same optimum pH but unlike trypsin it can bring about clotting of milk but not of blood.

Carboxy peptidase A and B

These enzymes are first secreted as pro carboxypeptidase and are activated to carboxypeptidase by trypsin .

Actions of carboxypeptidases

Carboxypeptidases break the terminal bond of protein molecules therefore these enzymes are called exopeptidases

Carboxypeptidase A splits the protein into amino acids having aromatic or aliphatic side chains .

Carboxypeptidase B converts the proteins into amino acids having basic side chains .

Unlike trypsin and chymotrypsin these are exopeptidases and split off specific carboxyl _ terminal amino acids from protein molecules .

Elastase

It is first secreted as proelastase and is then activated to elastase by trypsin .It is not specific for elastins but can hydrolyze other proteins as well .

Elastase digest the elastic fibres .

Collagenase

This enzyme specifically hydrolyze collagen .

Nucleases

The nucleases of pancreatic juice are **ribonuclease** and **deoxyribonuclease** , which are responsible for the digestion of nucleic acids

These enzymes convert the deoxyribonucleic acid and ribonucleic acid into mononucleotides.

3.DIGESTION OF LIPIDS

The lipolytic enzymes present in pancreatic juice are

- pancreatic lipase
- Cholesterol ester hydrolase , phospholipase A and phospholipase B.

- **Pancreatic lipase**

Pancreatic lipase is a powerful lipolytic enzyme .It hydrolyses the triglycerides into monoglycerides and fatty acids .The activity of pancreatic lipase is accelerated in the presence of bile .

- Digestion of fat by pancreatic lipase requires two more factors
- Bile salt and co lipase

- The end products of lipase action on fats are mainly diglycerides and monoglycerides and fatty acids along some glycerol may be liberated .
- The lipase acts only in the presence of bile salts.
- Apart from bile salts , soaps & synthetic detergents activate this enzyme.
- The activity of pancreatic lipase is also increased by some proteins and amino acids .
- Its optimum pH is **8.2 to 9.2**
- Enzyme pro co lipase present in pancreatic juice is activated to co lipase by trypsin .It acts as a cofactor for lipase by binding itself to bile salt triglyceride.

- **Cholesterol ester hydrolase**

Cholesterol ester hydrolase or cholesterol esterase hydrolyses cholesterol ester into free cholesterol and fatty acids .

- **Phospholipase A**

Phospholipase A digests phospholipids namely lecithin and cephalin

and converts them into lysophospholipids , lecithin into lysolecithin

cephalin into lysocephalin .

- **Phospholipase B**

This enzyme converts the lysophospholipids to **phosphoryl choline** and **free fatty acids**.

- **Co lipase**

Colipase is a small protein cofactor which facilitates the efficient hydrolysis of fats by pancreatic lipase .

Colipase binds to the C- terminal , the non catalytic domain of lipase so that there is an overall increase in the hydrophobic binding site of lipase

- **Bile salt activated lipase**

This enzyme has a weak lipolytic action than pancreatic lipase but it hydrolyses a variety of lipids like phospholipids , cholesterol ester, and triglycerides .

4.DIGESTION OF CARBOHYDRATES

Like salivary amylase , the pancreatic amylase also converts starch into dextrin and maltose .

Secretion of bicarbonate ions :

The bicarbonate ions of pancreatic juice are secreted from the cells of pancreatic ductules and released into the pancreatic duct

Mechanism of bicarbonate secretion

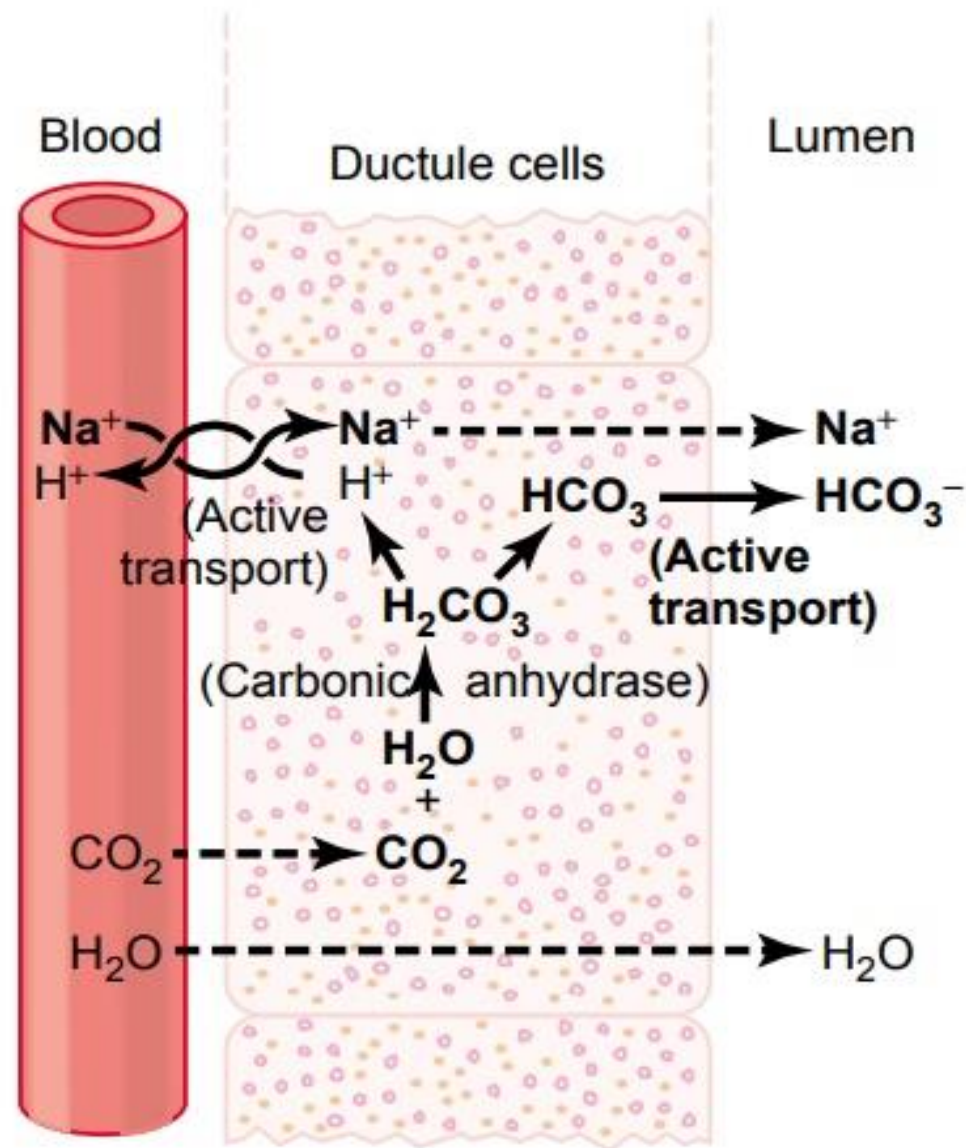
1. The carbon dioxide derived from blood or metabolic processes combines with water inside the cell to form carbonic acid in the presence of carbonic anhydrase.
2. Carbonic acid dissociates into hydrogen and bicarbonate ions .
3. Bicarbonate ions are actively transported out of the cell into lumen.
4. Hydrogen ion is actively transported into blood in exchange for sodium ions.

5. The sodium ion from the cell is transported into the lumen where it combines with bicarbonate to form sodium bicarbonate .

6. Because of the loss of sodium and bicarbonate ions from the blood there is some disturbance in the osmotic equilibrium of the blood .

To maintain the osmotic equilibrium ,water leaves the blood and enters the lumen of pancreatic duct by osmosis.

- In the lumen, bicarbonate combines with water forming the solution of bicarbonate

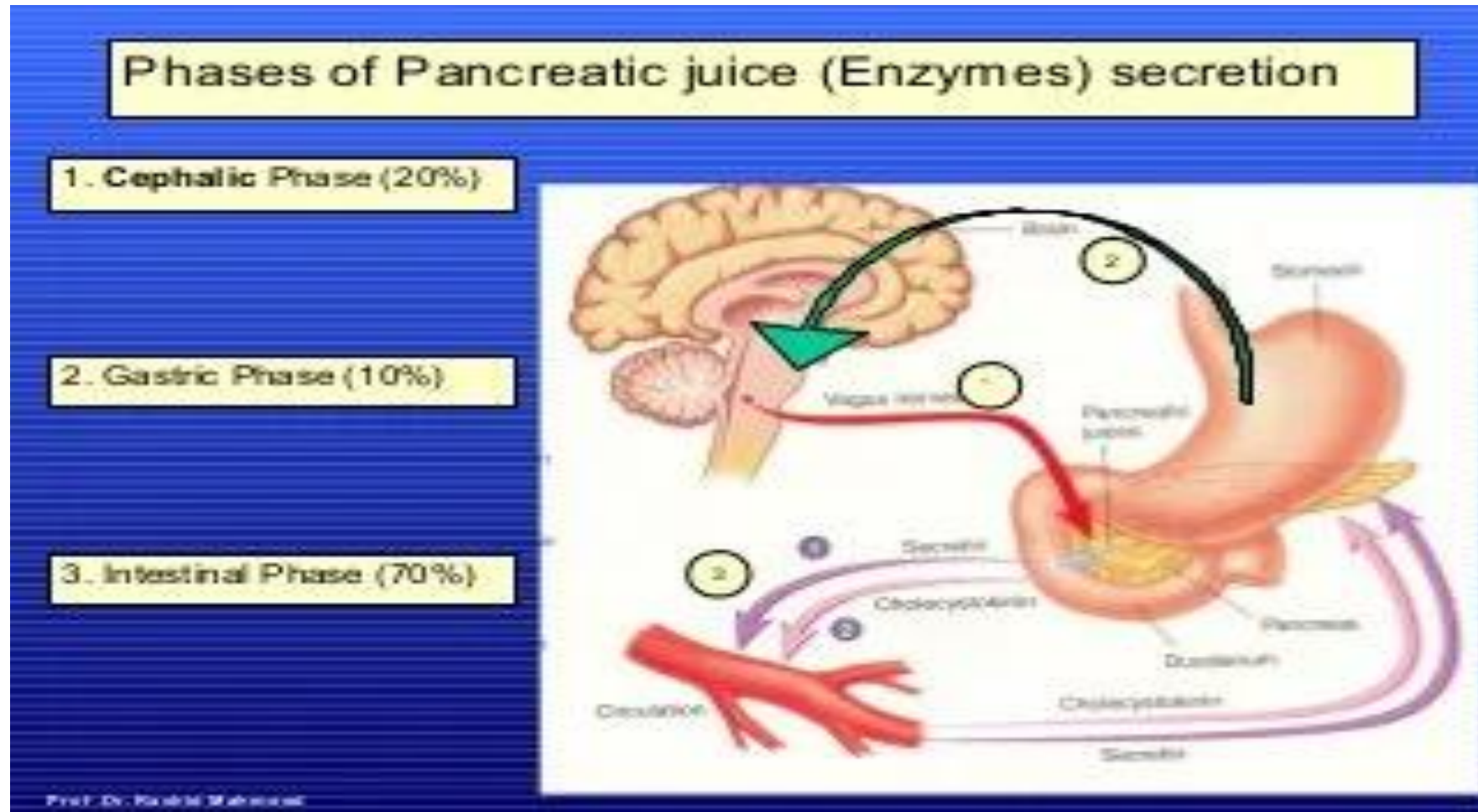


Mechanism of pancreatic secretion

- The pancreatic enzymes are synthesized in ribosomes ,which are attached to the endoplasmic reticulum of acinar cells in pancreas.
- The raw materials for the synthesis of pancreatic enzymes are the amino acids which are derived from blood.
- After synthesis , the enzymes are packed into different zymogen granules by golgi apparatus and stored in cytoplasm.
- When stimulated , the acinar cells release the zymogen granules into the pancreatic duct . From the granules the enzymes are liberated into intestine.

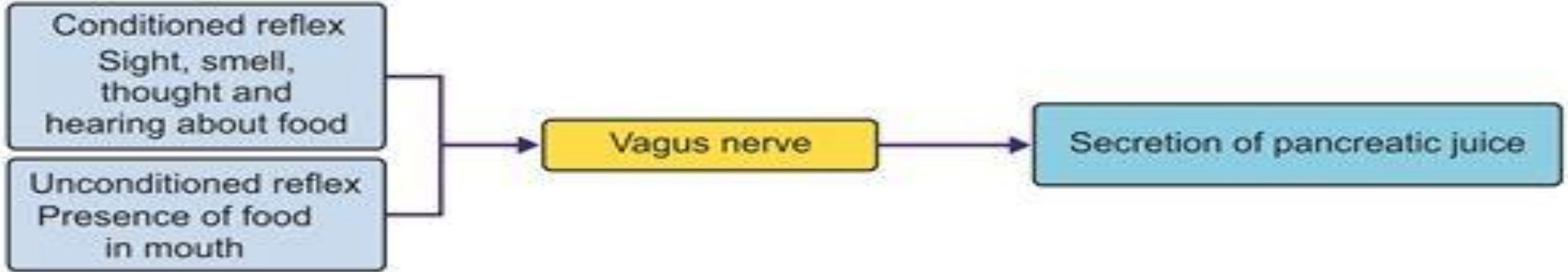
Regulation of Pancreatic secretion

- Both nervous and hormonal factors.
- Pancreatic juice secreted in three phases
 - 1) Cephalic phase
 - 2) Gastric phase
 - 3) Intestinal phase

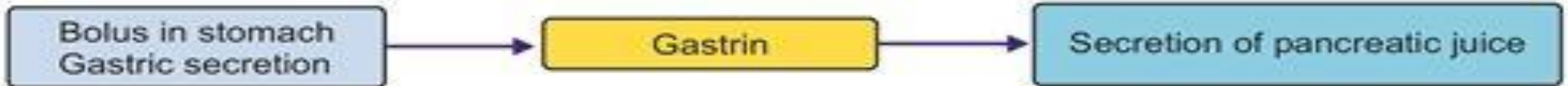


Three phases of Pancreatic secretion

Cephalic phase: Nervous



Gastric phase: Hormonal



Intestinal phase: Hormonal



Hormones inhibiting Pancreatic secretion

- 1) pancreatic poly peptide
- 2) Somatostatin
- 3) Peptide YY
- 4) Ghrelin
- 5) Leptin

Thank You