# The Digestive System

Lecture 3

# Neutralisation of Acid in Duodenum

- Bicarbonate ($HCO_3$) secretion from Brunner's Gland duct cells (submucosal glands)

$$H^+ + HCO_3^- \leftrightharpoons H_2CO_3 \leftrightharpoons H_2O + CO_2$$

# Control of Duodenal $HCO_3$ Secretion

Acid in duodenum triggers…

A Long (vagal) & short (ENS) reflexes ⇒ $HCO_3$ secretion

B Release of secretin from S cells ⇒ $HCO_3$ secretion

- Secretin ⇒ $HCO_3$ secretion from pancreas & liver
- Acid neutralisation ⇒ inhibits secretin release (negative feedback control)

# Exocrine Pancreas

Responsible for digestive function of pancreas

- Anatomical Structure

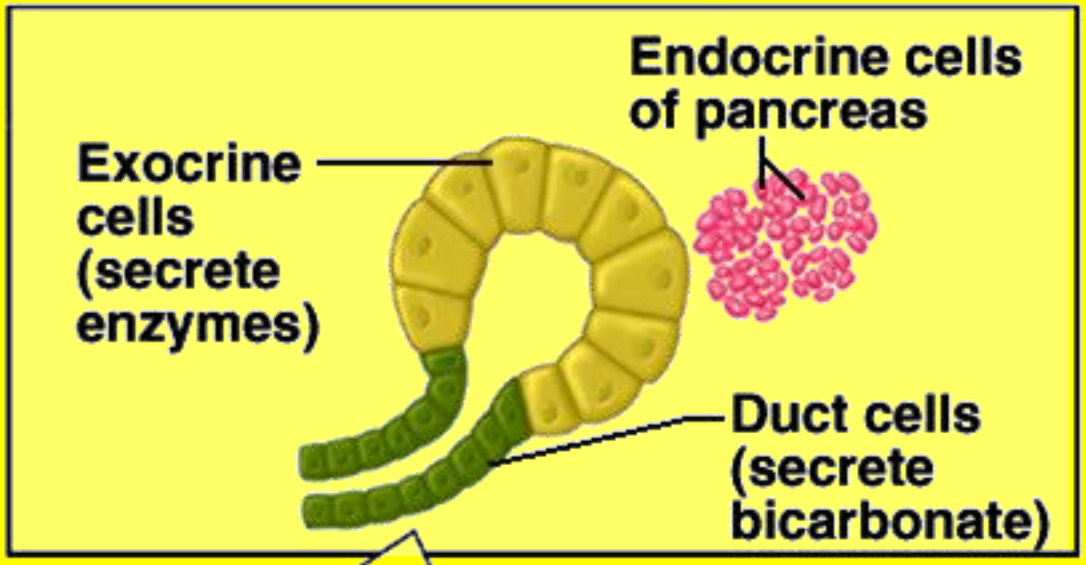
  Acini ⟶ Ducts ⟶ Pancreatic Duct

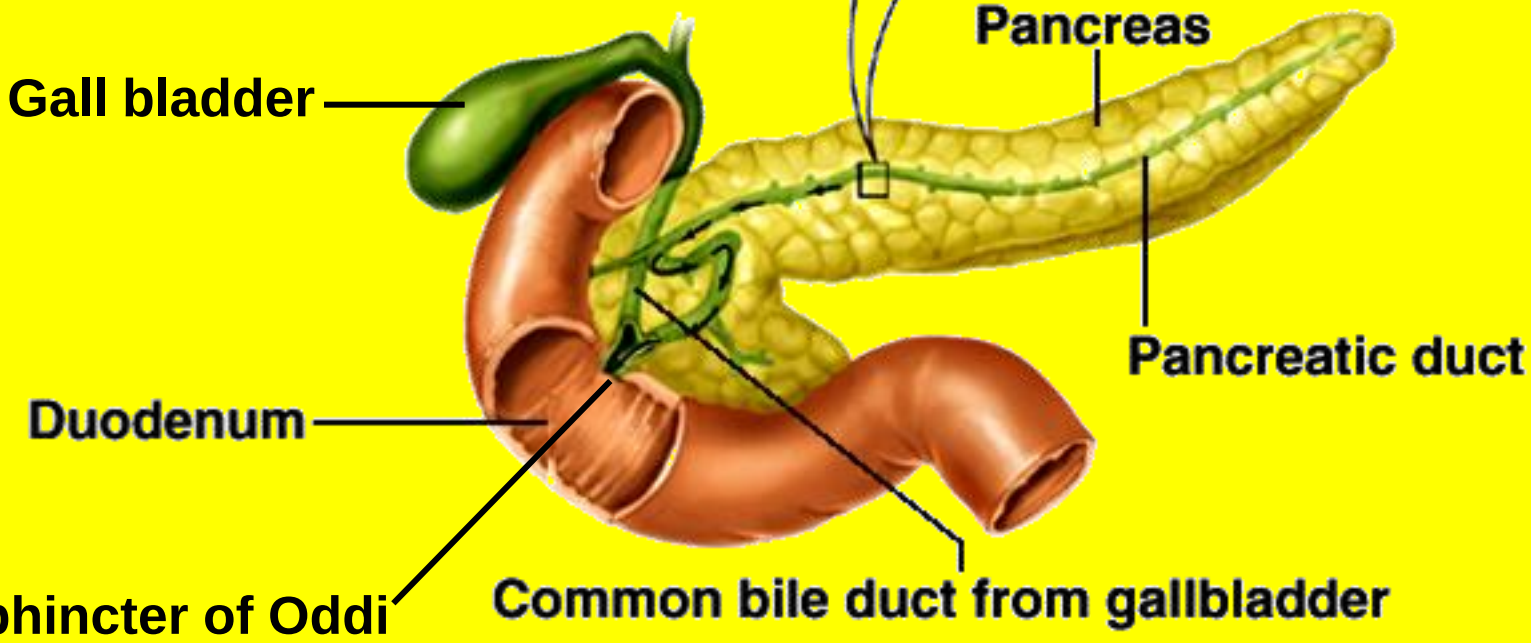
- Function

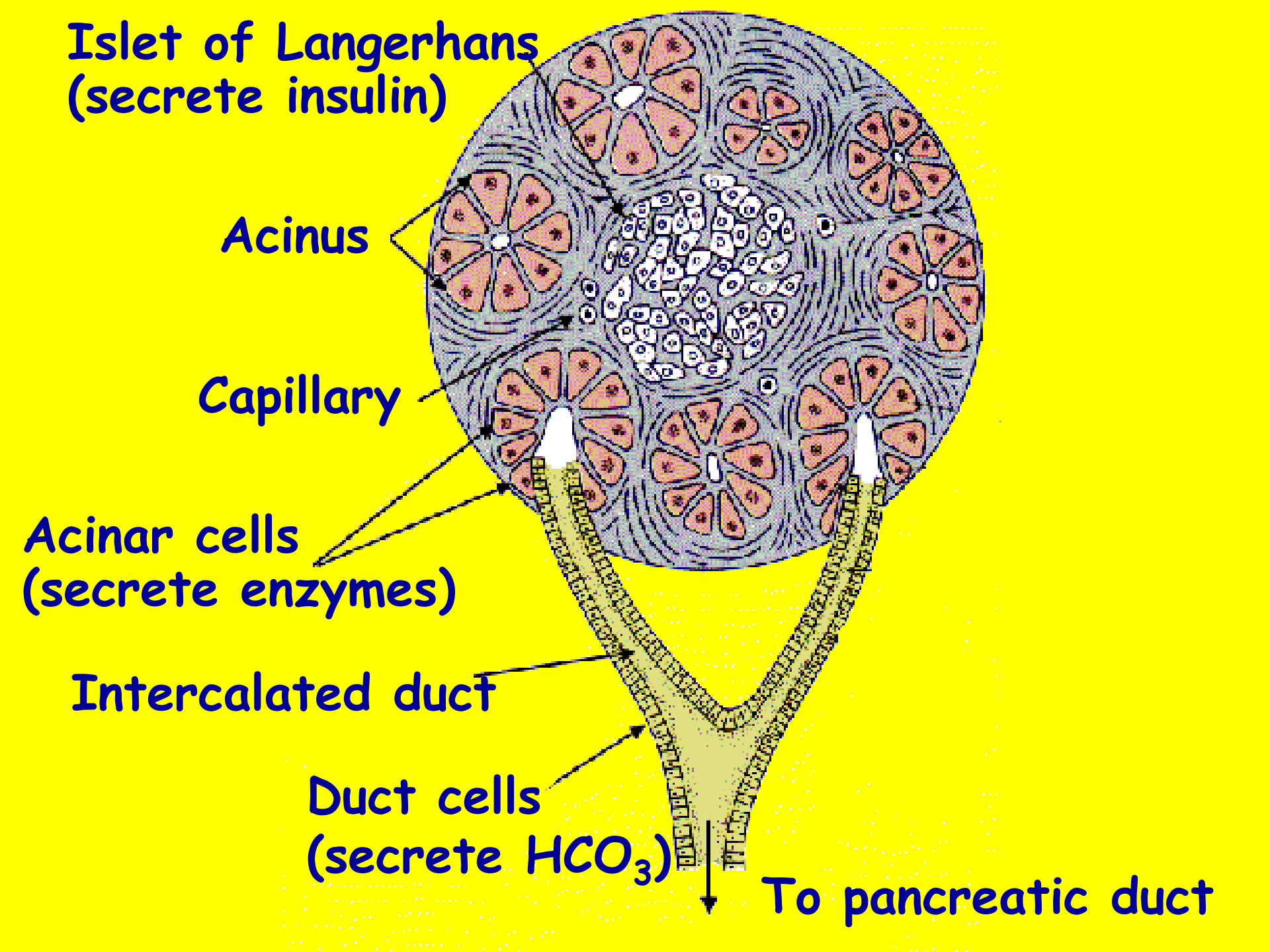
  Secretion of bicarbonate by duct cells

  Secretion of digestive enzymes by acinar cells

# Structure of the pancreas




Islet of Langerhans
(secrete insulin)
Acinus
Capillary
Acinar cells
(secrete enzymes)
Intercalated duct
Duct cells
(secrete $HCO_3$)
To pancreatic duct

# Composition of the pancreatic juice:

- The volume is 1-1.5 liter per day.
- PH is 8
- It contains water and different electrolyte –
- CATIONS ($Na^{+}$, $K^{+}$, $Ca^{++}$, $Mg^{++}$)
- ANIONS ($HCO3^{-}$, $Cl^{-}$, $SO4^{=}$, $HPO4^{=}$)

- neutralizing acid chyme emptied by stomach

- organic constituents: different digestive enzymes for digestion of protein, fat and CHO.

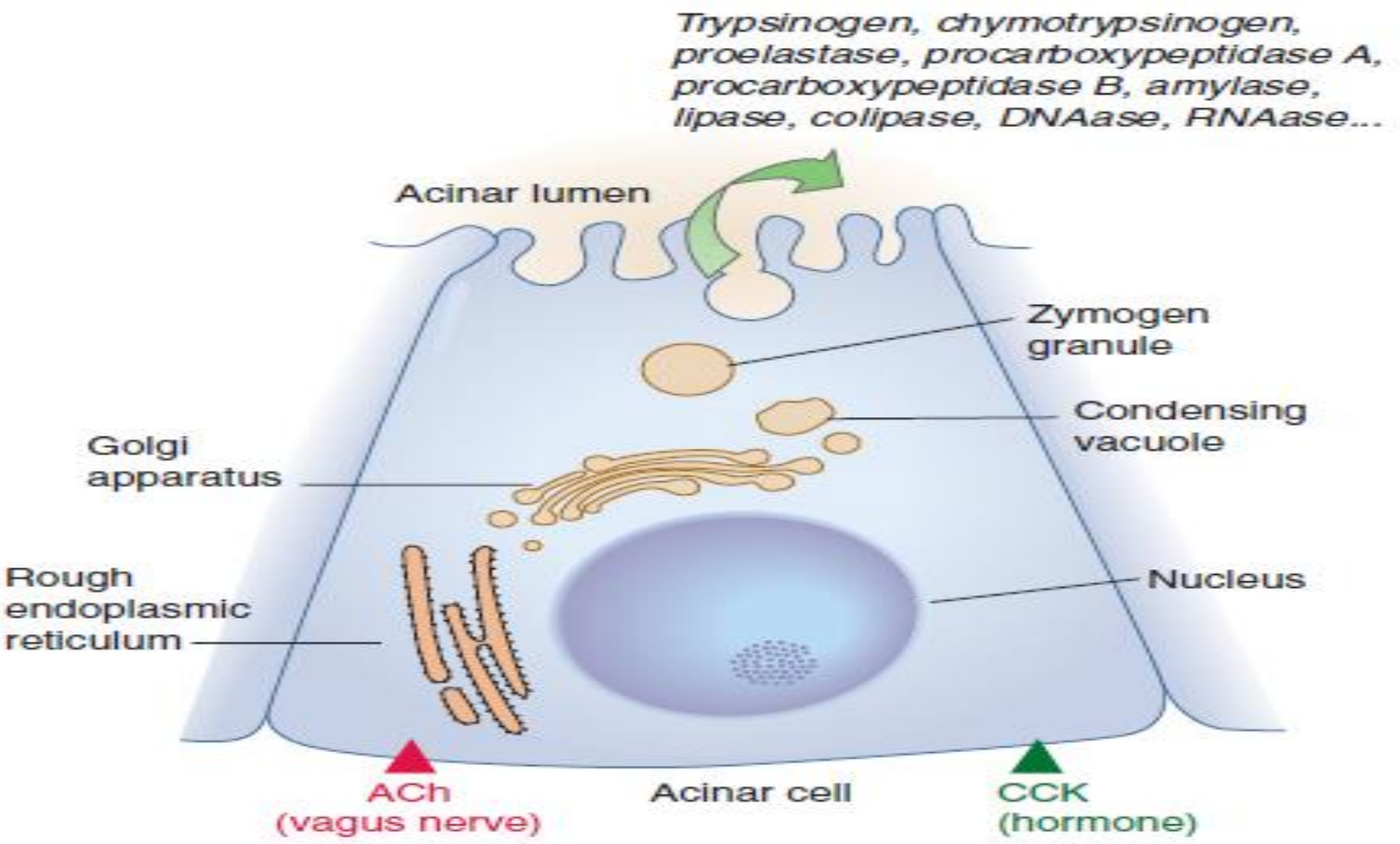
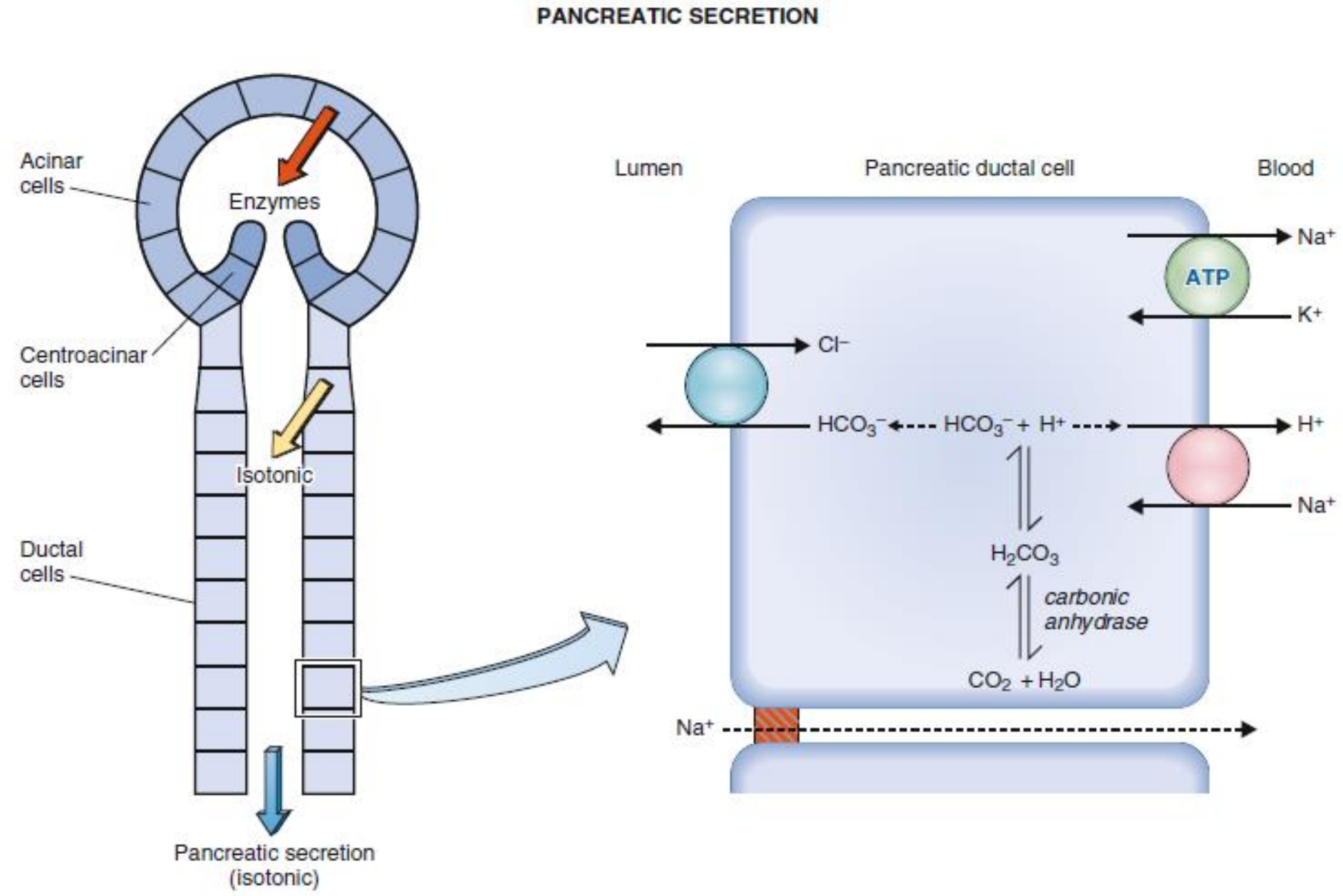



**Figure 7-15:** Enzyme synthesis and secretion by the pancreatic acinar cells. Enzymes are synthesized and stored in zymogen granules in the apical region of the cell. Acetylcholine (ACh) and cholecystokinin (CCK) are secretagogues that stimulate exocytosis of zymogens into the acinar lumen.




**igure 8-21 Mechanism of pancreatic secretion.** The enzymatic component is produced by acinar cells, and the aqueous compo-ent is produced by centroacinar and ductal cells. ATP, Adenosine triphosphate.

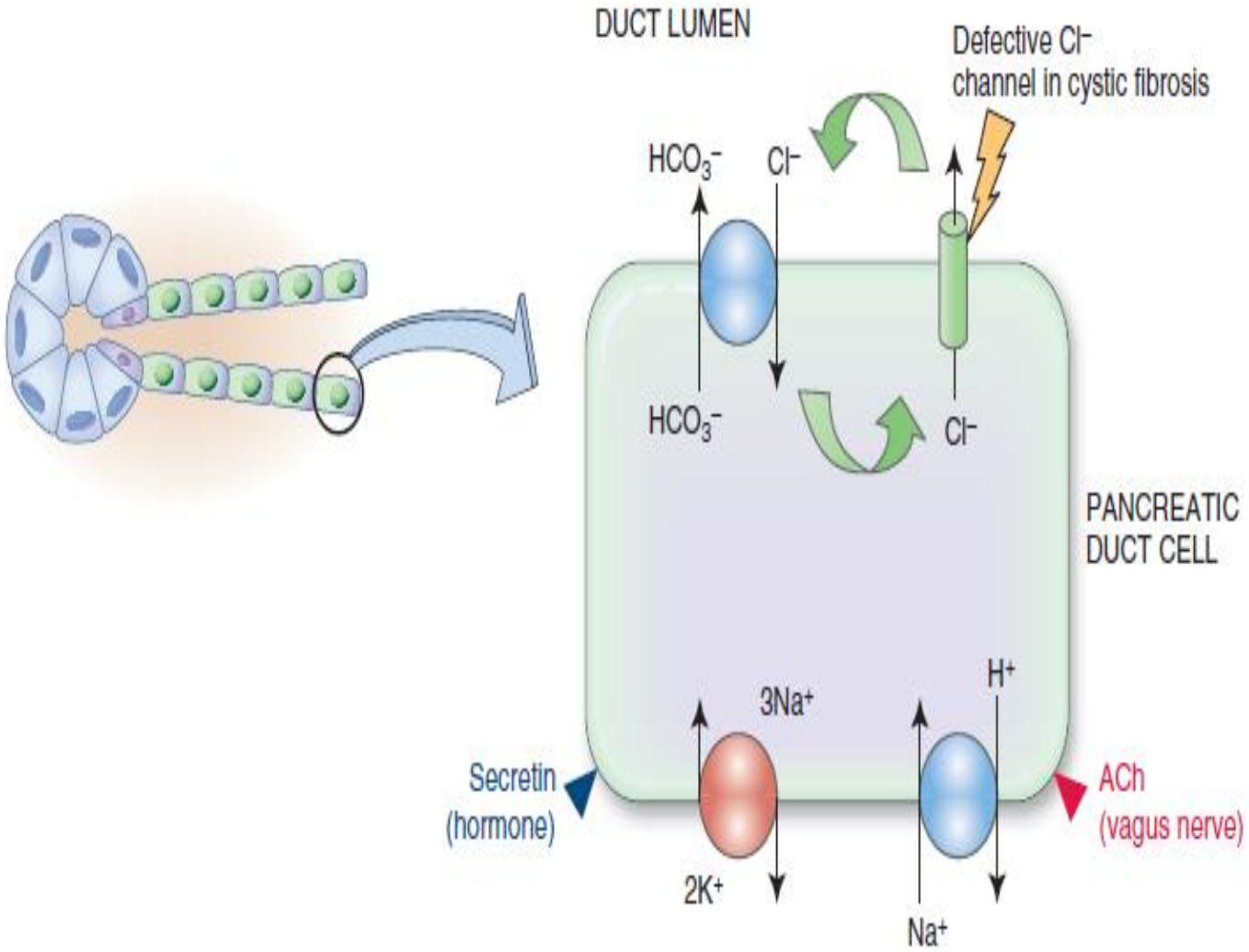
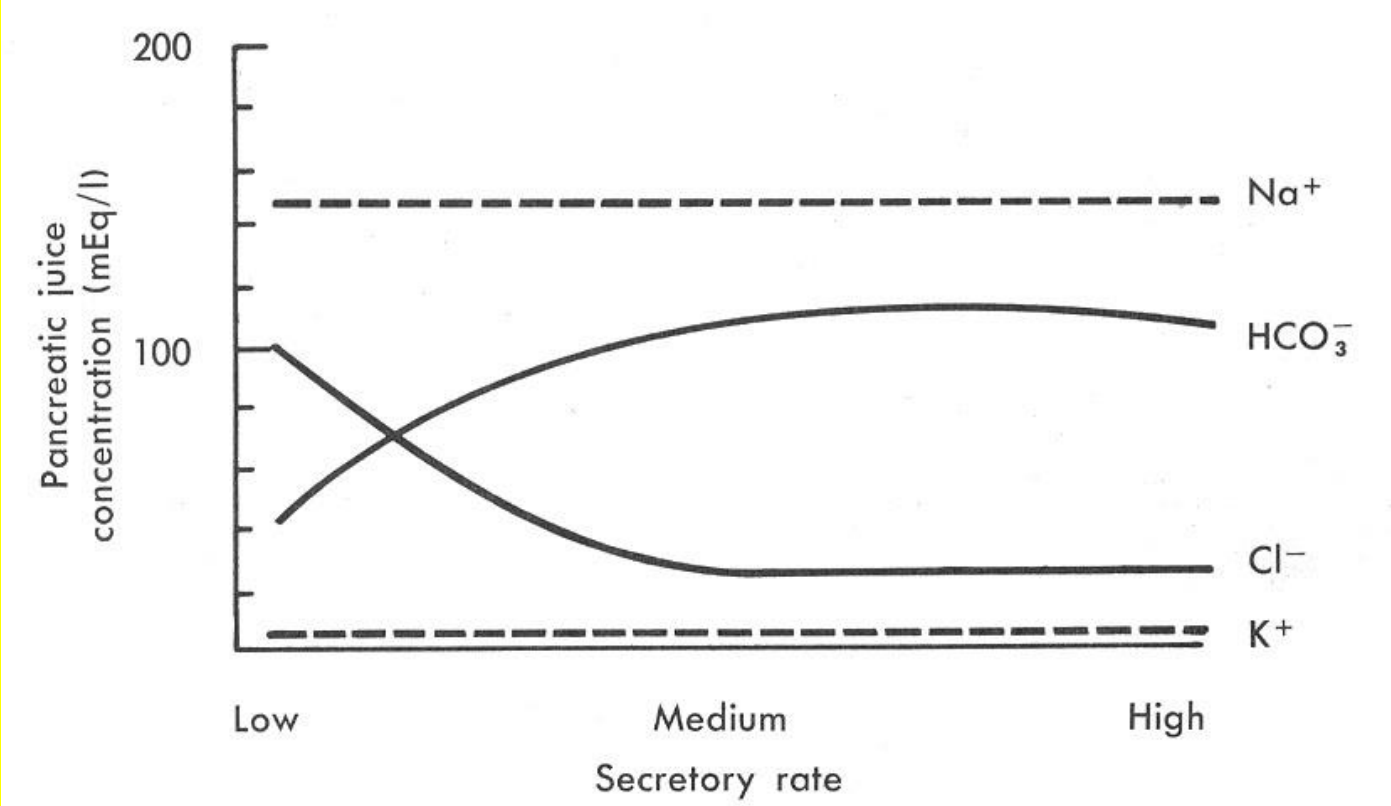



**Figure 7-16:** Cellular model of pancreatic duct cell secretion. $HCO_3^-$ secretion requires $Cl^-$ recycling via a $Cl^-$ channel in the apical cell membrane. The channel is missing or defective in patients with cystic fibrosis, causing failure of $NaHCO_3^-$ and fluid secretion by the pancreatic ducts. ACh, acetylcholine.

# Secretion of water and electrolytes




- Na, K – the same as in plasma
- Bicarbonate concentration – up to 5 times higher than in plasma

# Composition and Function of Pancreatic Juice

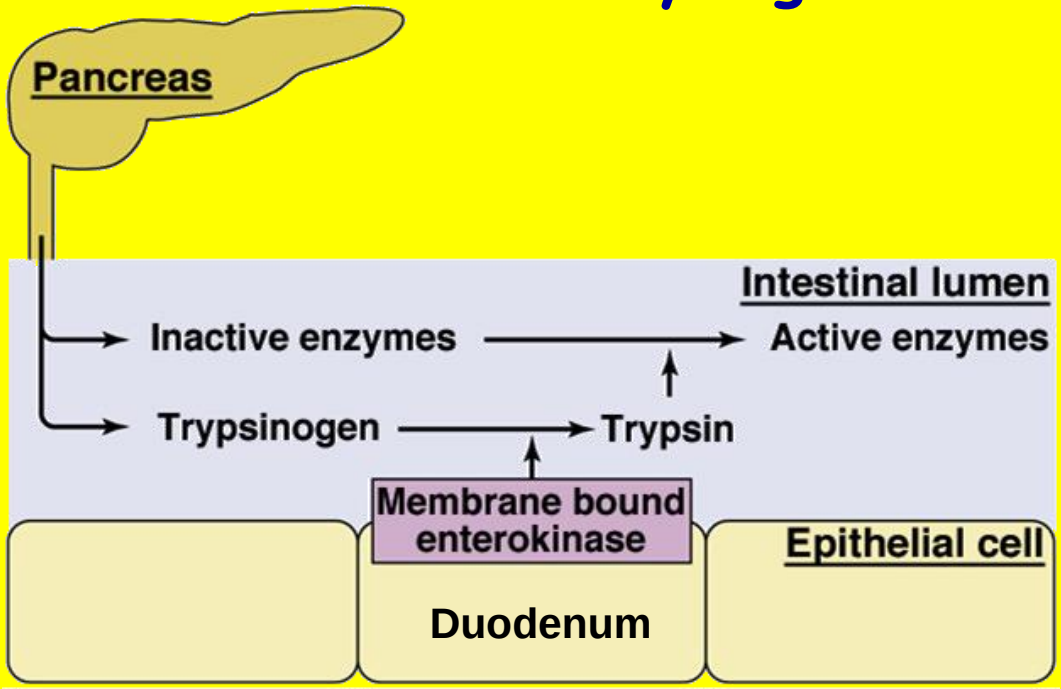
- Water solution of enzymes and electrolytes (primarily $HCO_3$)
  - Neutralizes acid chyme
  - Provides optimal environment for pancreatic enzymes
- Enzymes are released in inactive form and activated in the duodenum

# Composition and Function of Pancreatic Juice

- Examples include
  - Trypsinogen is activated to trypsin
  - Procarboxypeptidase is activated to carboxypeptidase
- Active enzymes secreted
  - Amylase, lipases, and nucleases
  - These enzymes require ions or bile for optimal activity

# Zymogens

- Acinar cells contain digestive enzymes stored as inactive zymogen granules
- Prevents autodigestion of pancreas
- Enterokinase (bound to brush border of duodenal enterocytes) converts trypsinogen to trypsin
- Trypsin converts all other zymogens to active forms



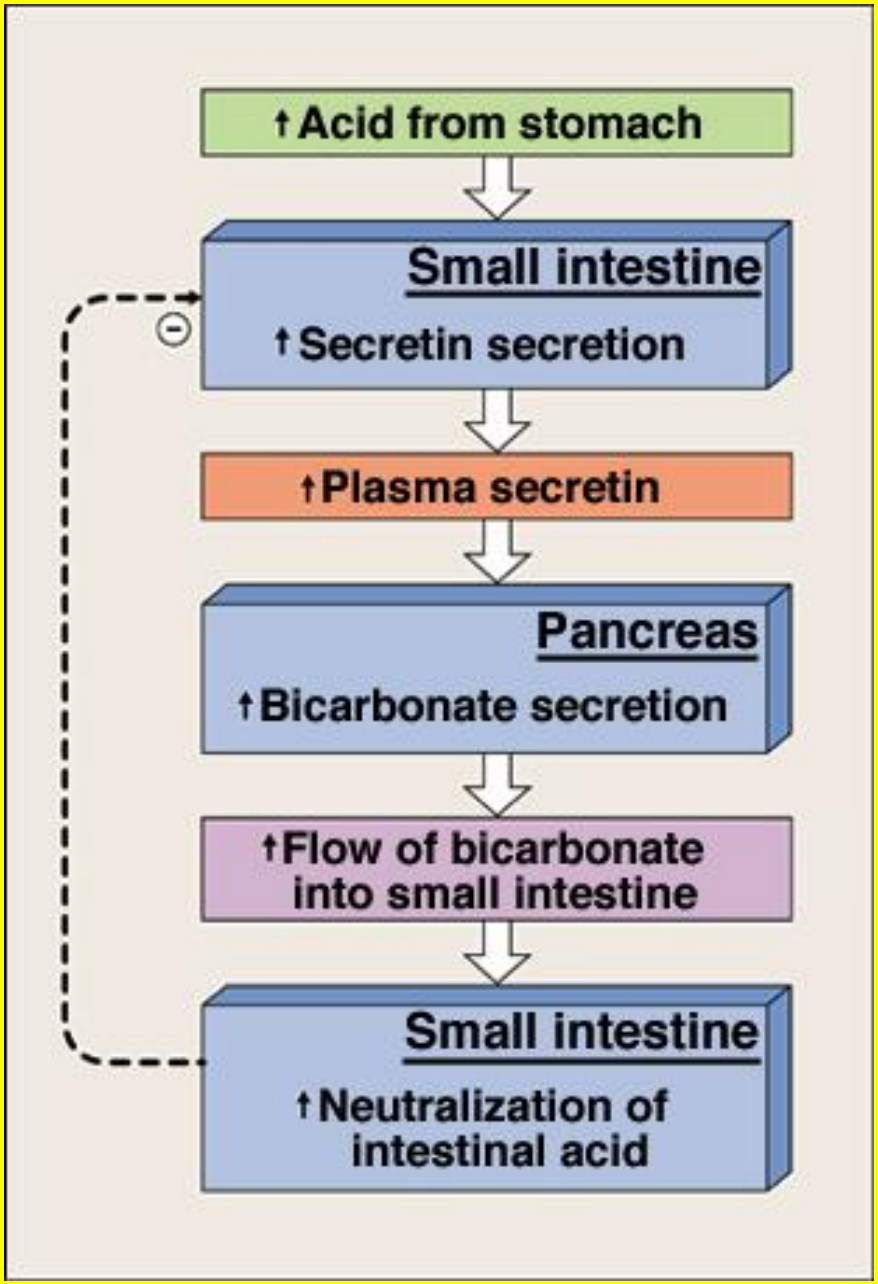
# Categories of Pancreatic Enzymes

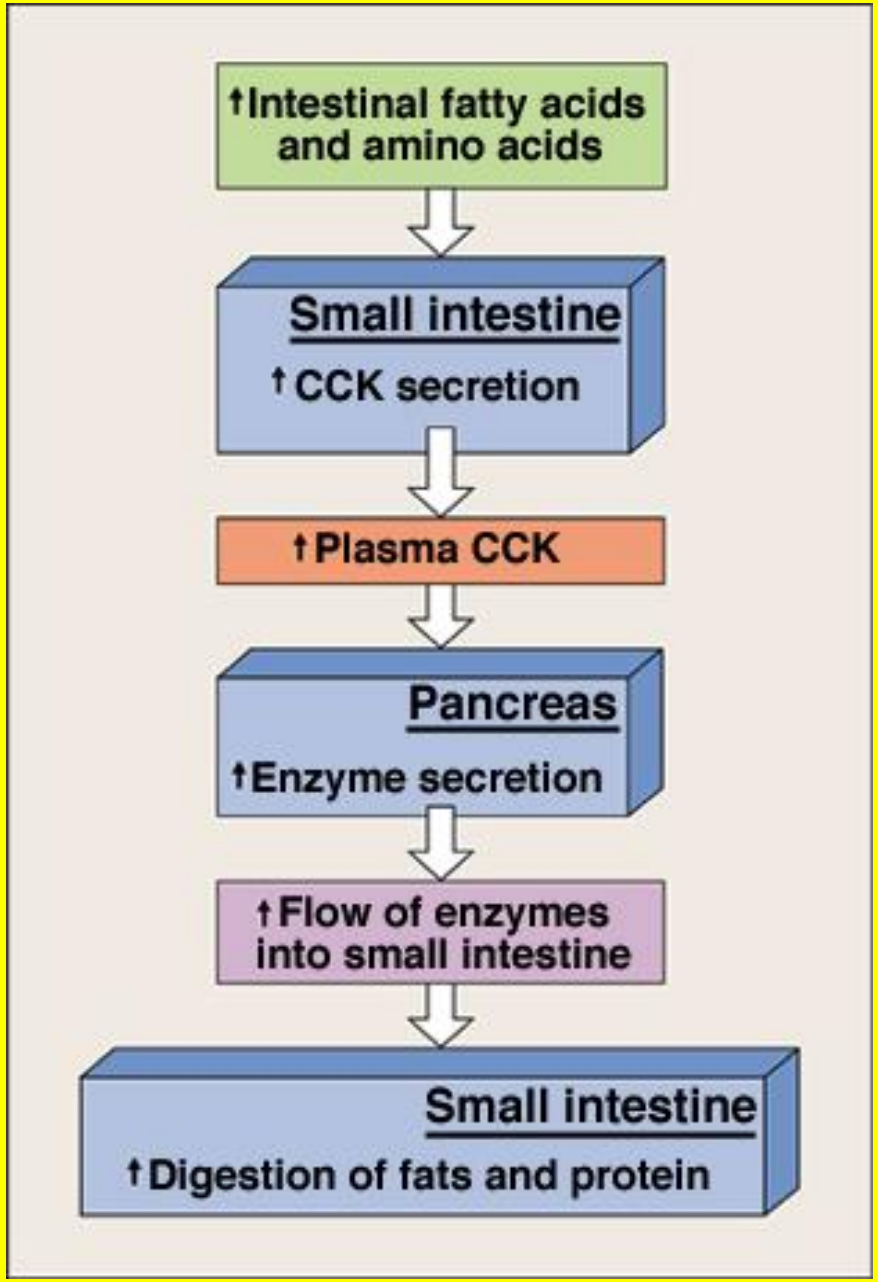
| | |
|---|---|
| Proteases | Cleave peptide bonds |
| Nucleases | Hydrolyse DNA/RNA |
| Elastases | Collagen digestion |
| Phospholipases | Phospholipids to fatty acids |
| Lipases | Triglycerides to fatty acids+ glycerol |
| α-Amylase | Starch to maltose + glucose |

# Control of Pancreatic Function

- Bicarbonate secretion stimulated by secretin
- Secretin released in response to acid in duodenum
- Zymogen secretion stimulated by cholecystokinin (CCK)
- CCK released in response to fat/amino acids in duodenum
- Also under neural control (vagal/local reflexes) – triggered by arrival of organic nutrients in duodenum

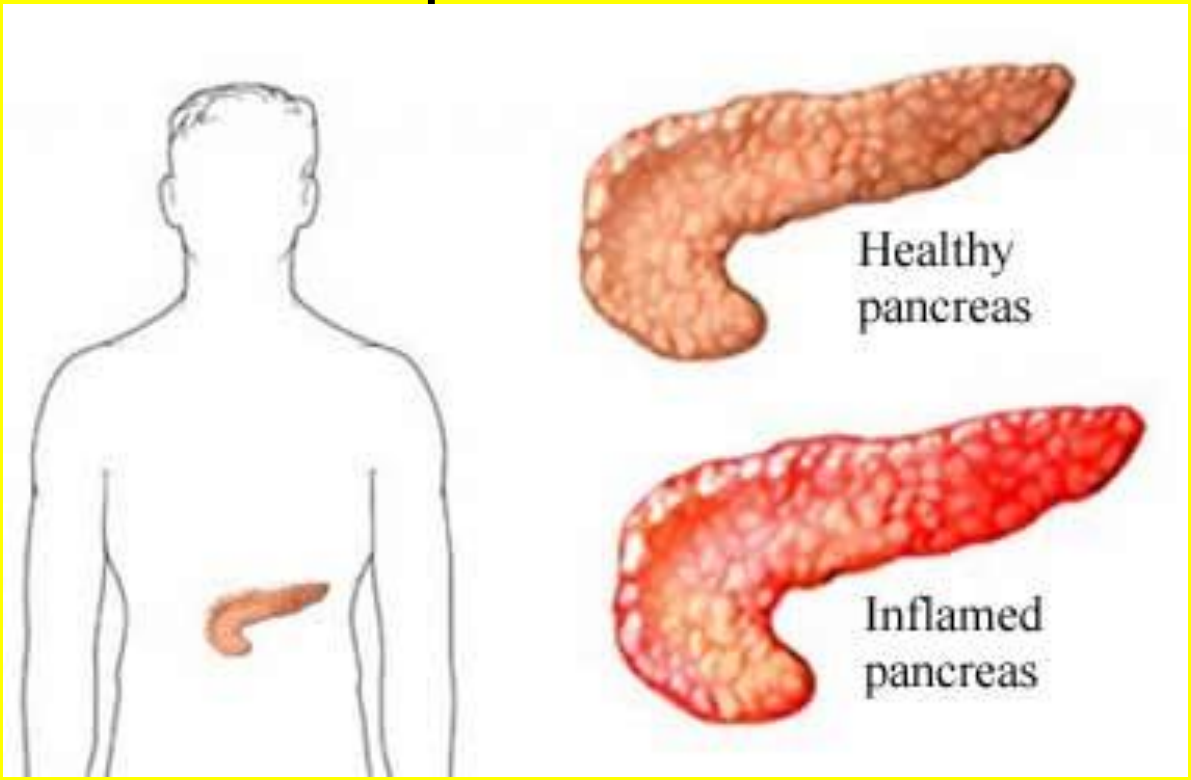
# Control of Pancreatic Function



# Pancreatitis

- Inflammation of the pancreas



# Acute pancreatitis

- Pancreas suddenly becomes inflamed
- Causes: **G**allstones
  **E**thanol
  **T**rauma
  **S**teroids
  **M**umps
  **A**utoimmune
  **S**corpion venom
  **H**yperlipidaemia, hypothermia ↑$Ca^{2+}$

  **D**rugs

## Symptoms

- epigastric and central abdominal pain
- vomiting and nausea
- swollen and tender abdomen
- fever
- dehydration and low blood pressure

## Diagnosis

- medical history and physical exam
- blood test: ↑ amylase, lipase
- abdominal ultrasound, Endoscopic ultrasound, CT scan

# Chronic pancreatitis

- inflammation of the pancreas - gets worse over time and leads to permanent damage

**Causes**: chronic use of alcohol

hereditary disorders of the pancreas

cystic fibrosis

haemochromatosis

autoimmune conditions

## Symptoms

- nausea and vomiting
- weight loss
- diarrhea
- steatorrhea

## Diagnosis

- medical history and physical exam
- abdominal ultrasound, CT scan, MRCP (**Magnetic resonance cholangiopancreatography) ,**

, ERCP (**endoscopic retrograde cholangiopancreatography)**

# Steatorrhea

- It is the presence of excess fat in feces. Stools may be bulky and difficult to flush, have a pale and oily appearance and can be especially foul-smelling
- Causes include exocrine pancreatic insufficiency, with poor digestion from lack of lipases, loss of bile salts, which reduces micelle formation, and small intestinal disease producing malabsorption.