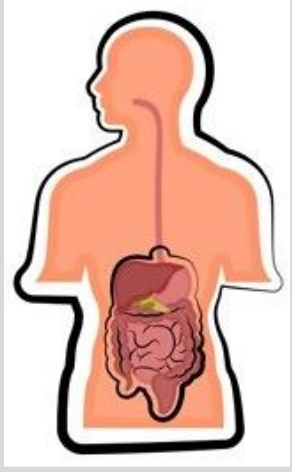

THE PANCREAS
PANCREATIC SECRETION

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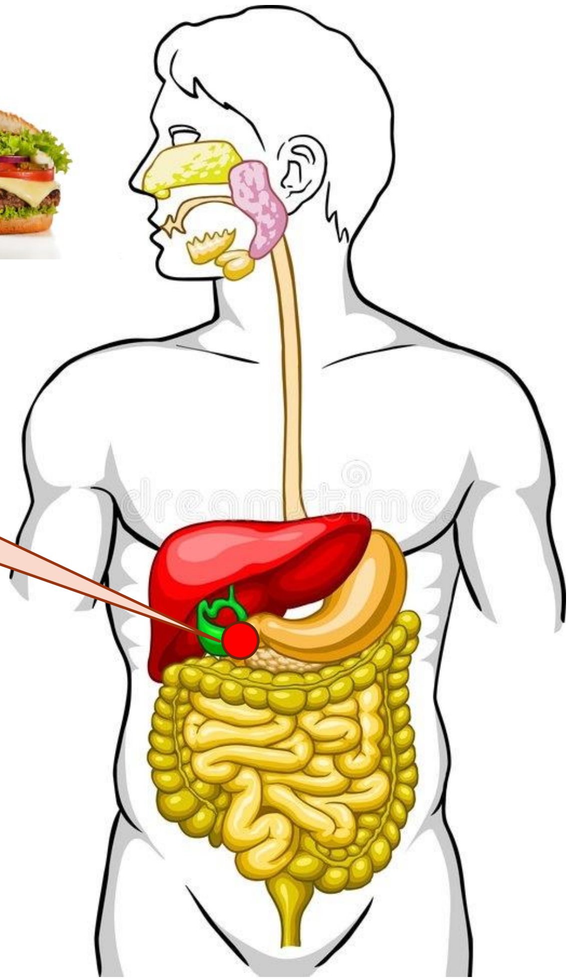
OBJECTIVES

- Discuss the functional anatomy of the pancreas, its division into endocrine and exocrine organ and the role of each.
- Describe the role of the pancreas in digestion.
- Discuss the components of pancreatic juice and their role in digestion.
- List the proteolytic enzymes synthesized by the pancreas and their target.
- Discuss the mechanism of secretion of bicarbonate-rich secretions by the pancreas.
- Describe the mechanism of activation of pancreatic enzymes.
- Discuss the hormonal & neural mechanisms regulating pancreatic secretion.
- Name and describe the phases of pancreatic secretion.

INTRODUCTION

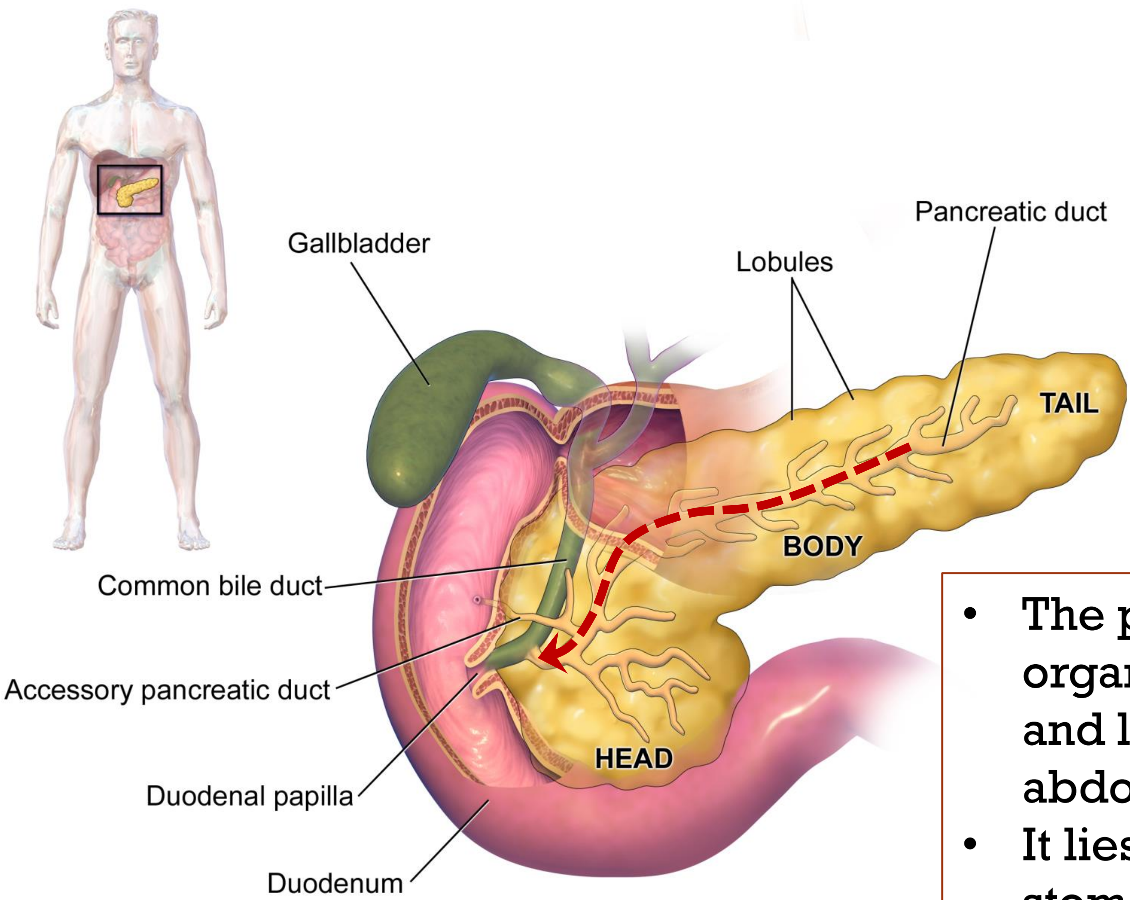
Chyme has arrived into duodenum



There it will be exposed to various secretions from biliary system and pancreas

Today we will discuss the pancreas

FUNCTIONAL ANATOMY OF PANCREAS



- The pancreas is an elongated organ that lies in the epigastric and left upper quadrant of the abdomen.
- It lies behind and below the stomach

FUNCTIONAL ANATOMY OF PANCREAS

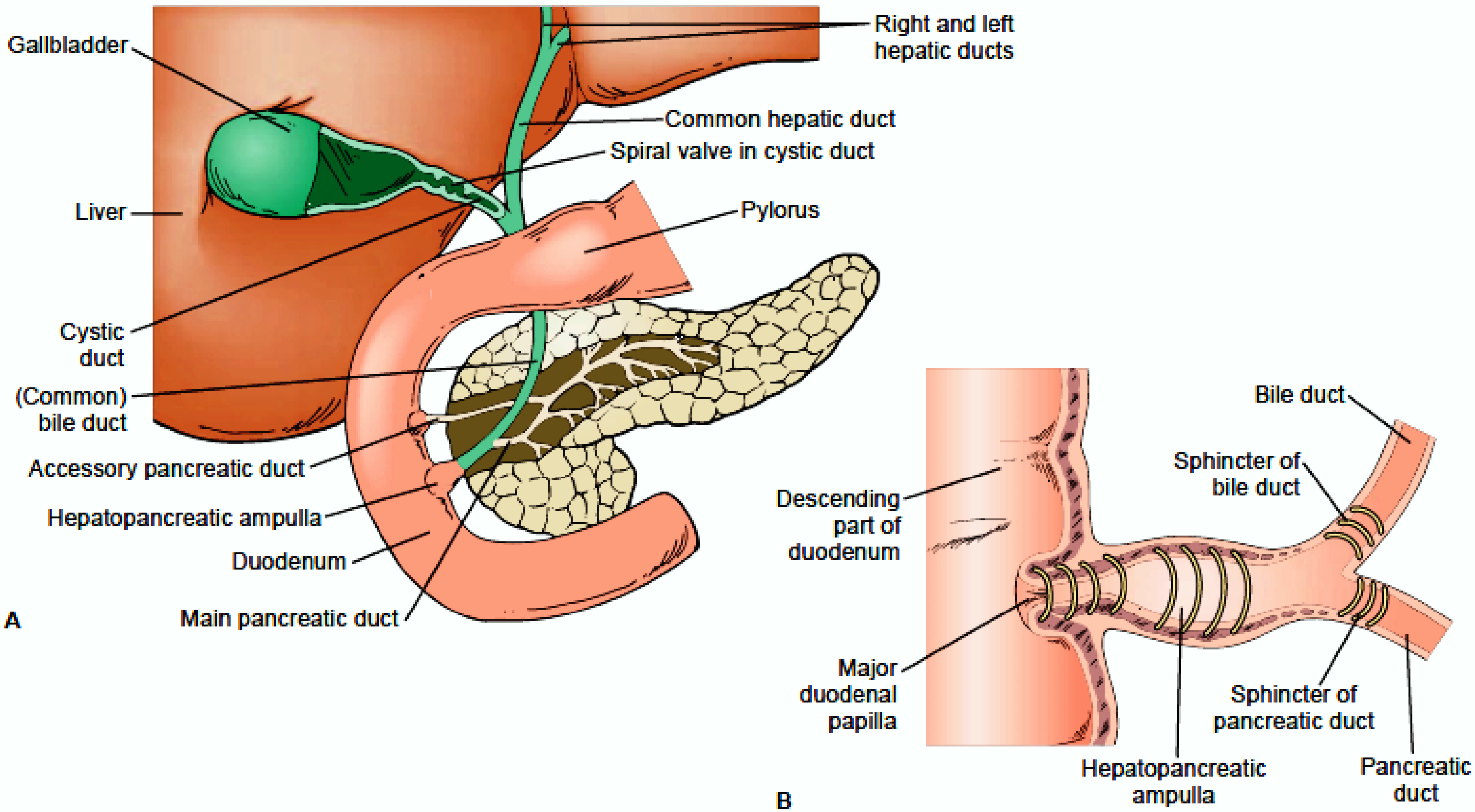
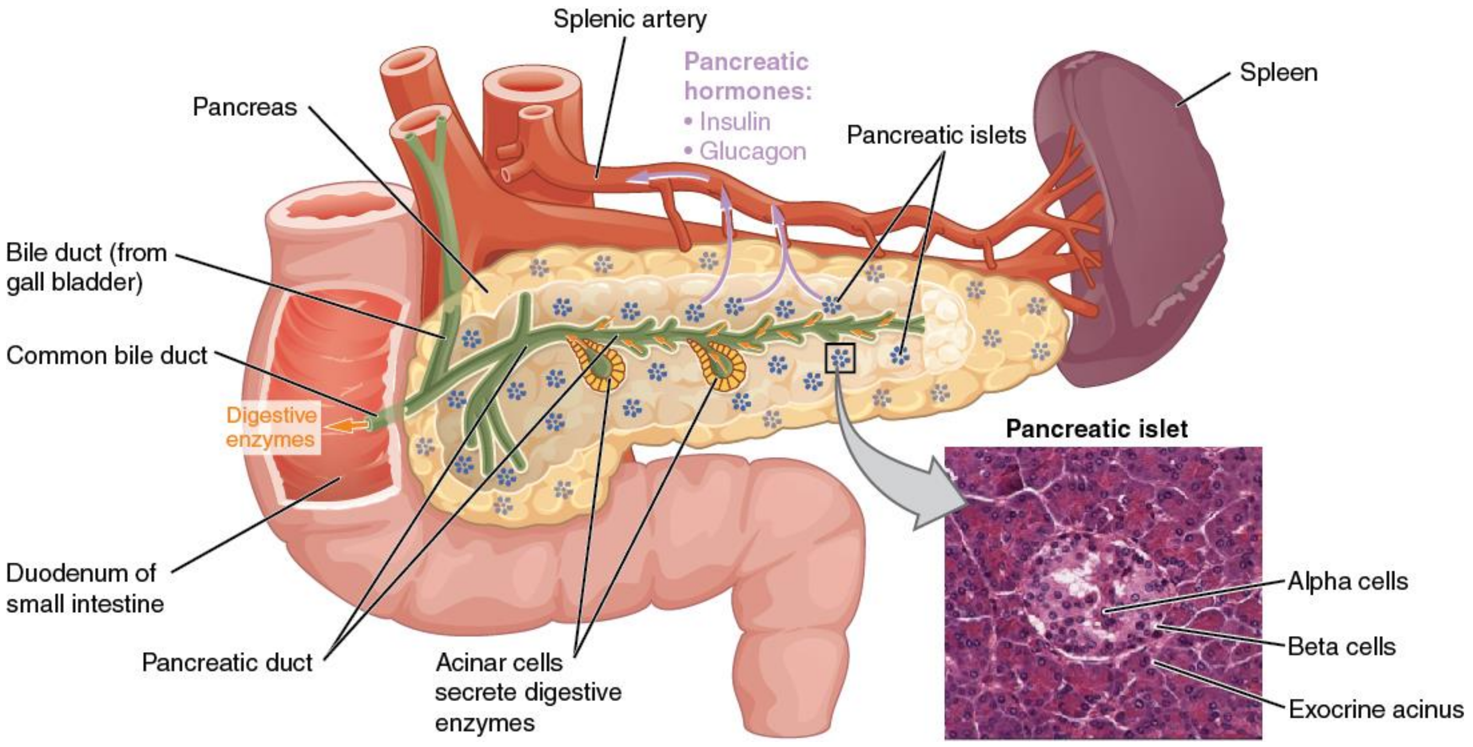


FIGURE 40-18 (A) Extrahepatic bile passages, gall bladder, and pancreatic ducts. (B) Entry of bile duct and pancreatic duct into the hepatopancreatic ampulla, which opens into the duodenum.

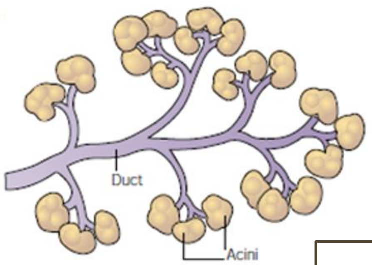
THE PANCREAS

The pancreas is a mixed gland; endocrine & exocrine… ***what does that mean?***

What is the difference between endocrine and exocrine glands?

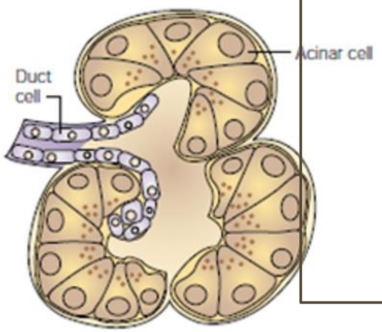


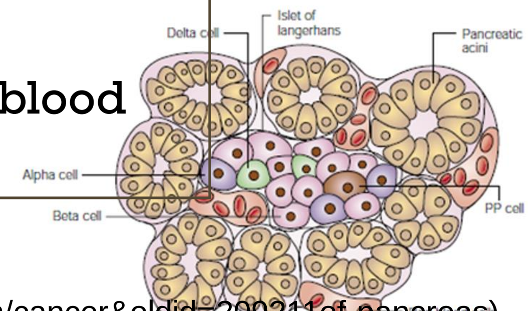
THE PANCREAS



The Pancreas

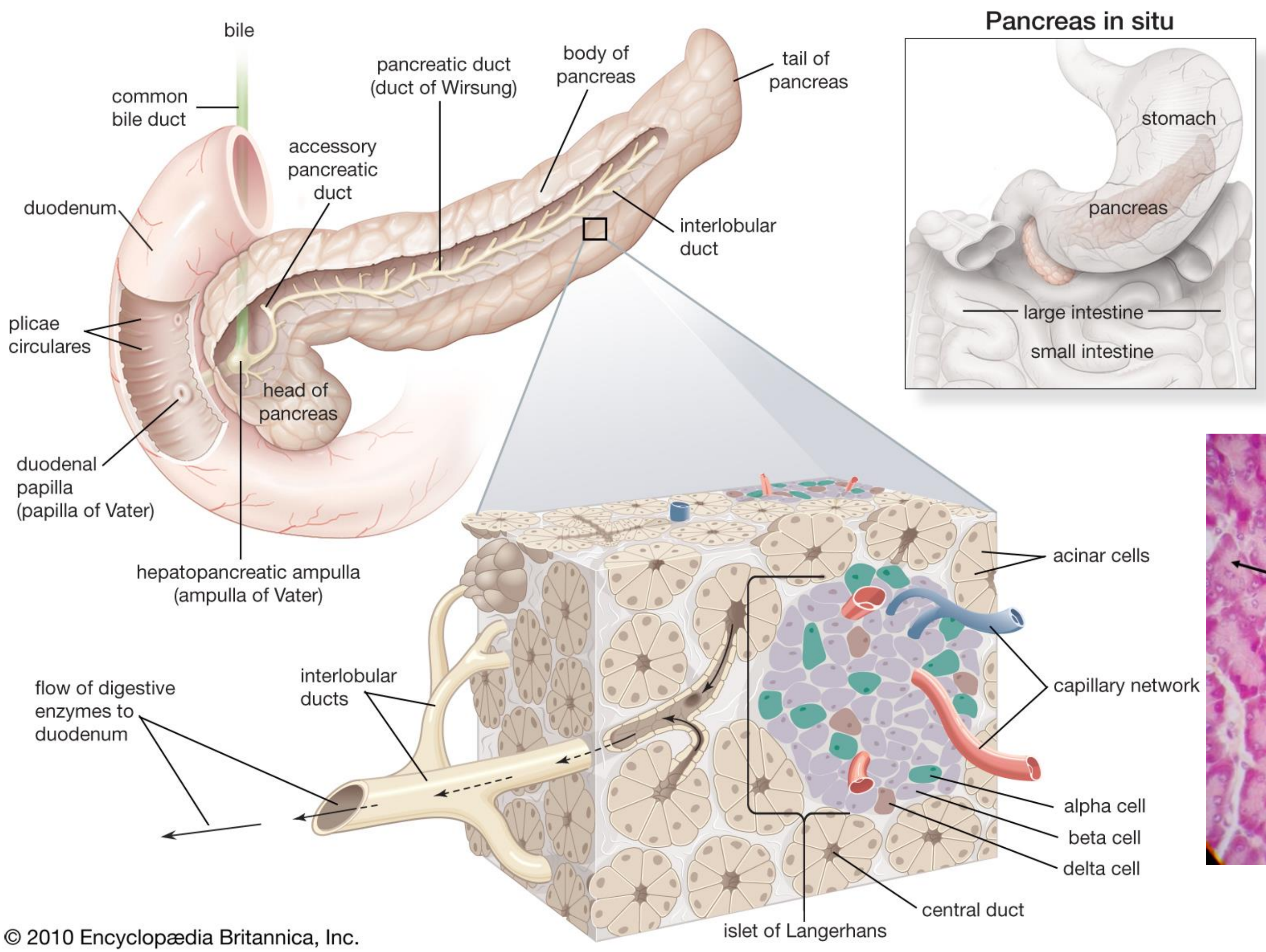
***Exocrine* pancreas**	***Endocrine* pancreas**
Constitute 90% of pancreas	Constitute 2% of pancreas
Made of acinar & ductal cells.	***Made of*** Islets of Langerhan's.
Secretes digestive enzymes, HCO_3^- and water.	***Secretes*** hormones.
Into duodenum	***Directly into*** blood





(http://2010.igem.org/wiki/index.php?title=Team:ESBS-Strasbourg/proteolux/application/cancer&oldid=209211of-pancreas)

THE PANCREAS



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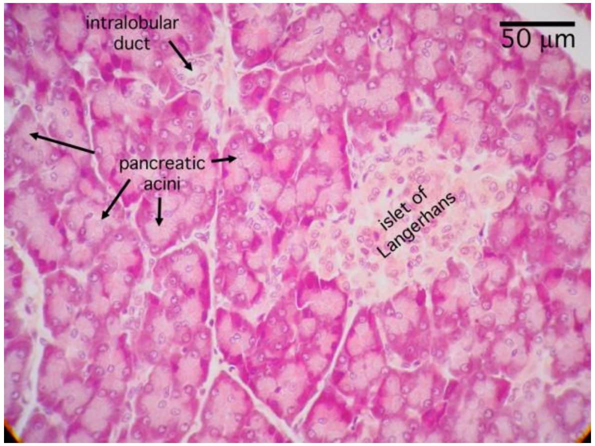


(http://2010.igem.org/wiki/index.php?title=Team:ESBS-Strasbourg/proteolux/application/cancer&oldid=209211of-pancreas)

PANCREATIC SECRETION

THE ROLE OF THE PANCREAS

- Digest dietary nutrients.
- Neutralize duodenal acidity arriving from stomach.
- ***Why is it important to neutralize acid arriving at the duodenum from the stomach?***

PANCREATIC SECRETION

- ***What are the constituents of pancreatic secretion "juice"?***

Pancreatic secretion (pH = 7.6 to 9.0)

Aqueous solution

Rich in bicarbonate
Water + bicarbonate
Alkaline

Enzymes

For protein digestion

Trypsin
Chemotrypsin
Carboxypolypeptidase

For fat digestion

Pancreatic lipase
Phospholipase
Cholesterol esterase

For carb digestion

Pancreatic amylase

For DNA & RNA

Nucleases

PANCREATIC SECRETION

Acini → secrete the pancreatic digestive enzymes

Ducts → secrete HCO_3 solution

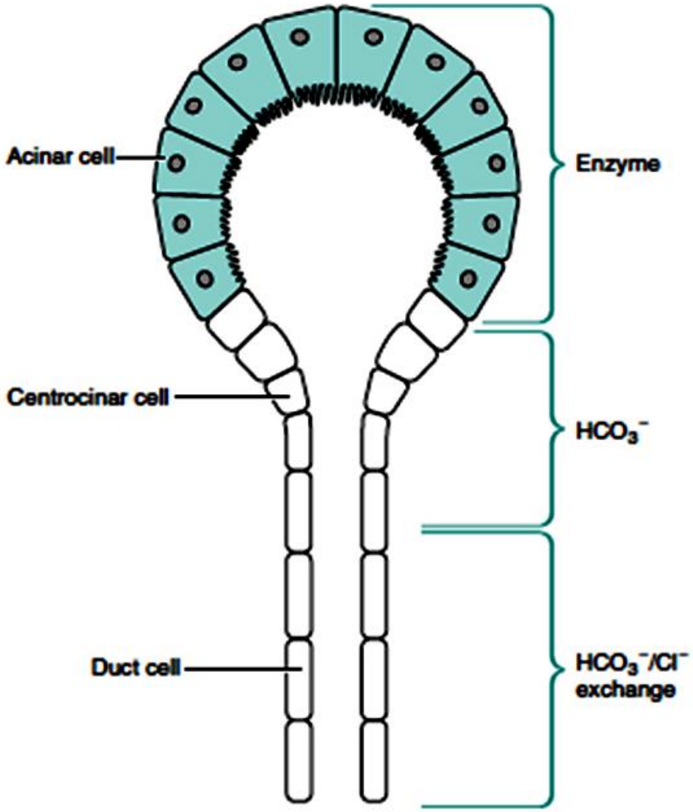
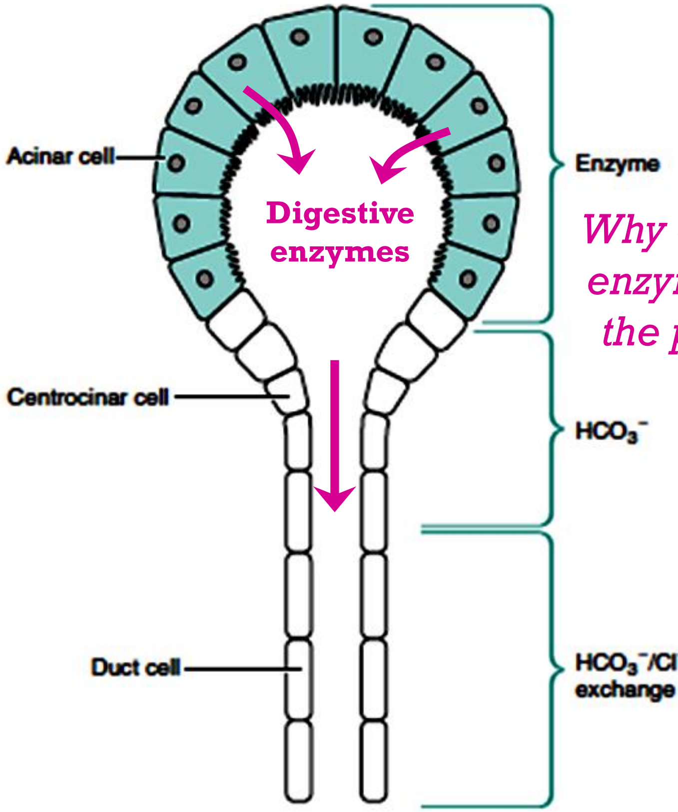


Fig. 5.4
Secretory unit showing the cellular locations of the different secretions.

ACINAR CELL SECRETION

- Secrete a protein-rich (digestive enzymes) secretion in an isotonic plasma-like fluid.
- Constitute 25% of total pancreatic secretion.
- Stimulated by ***CCK & Ach***.

1. Secreted as proenzymes (inactive form) which get activated in the lumen of the intestine.
2. The same cells secrete a substance "trypsin inhibitor".



Why don't these enzymes digest the pancreas?

Fig. 5.4
Secretory unit showing the cellular locations of the different secretions.

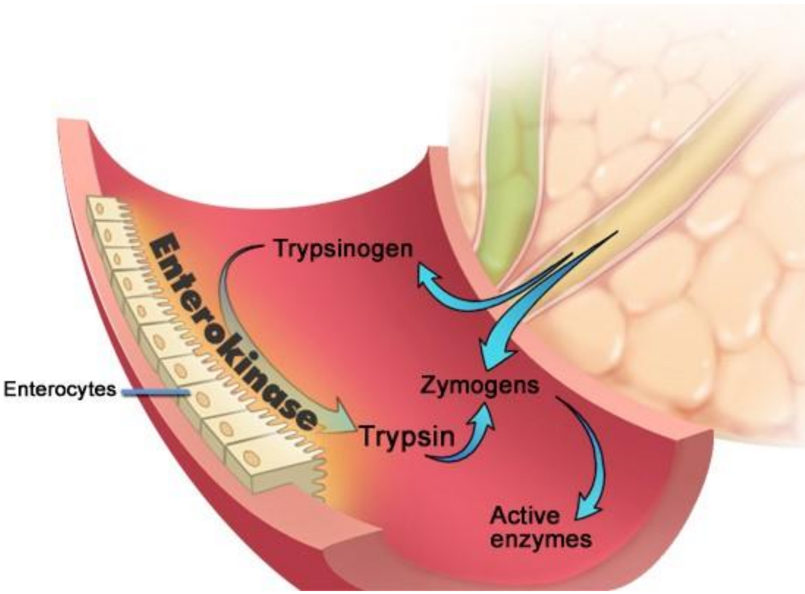
ACTIVATION OF PANCREATIC ENZYMES

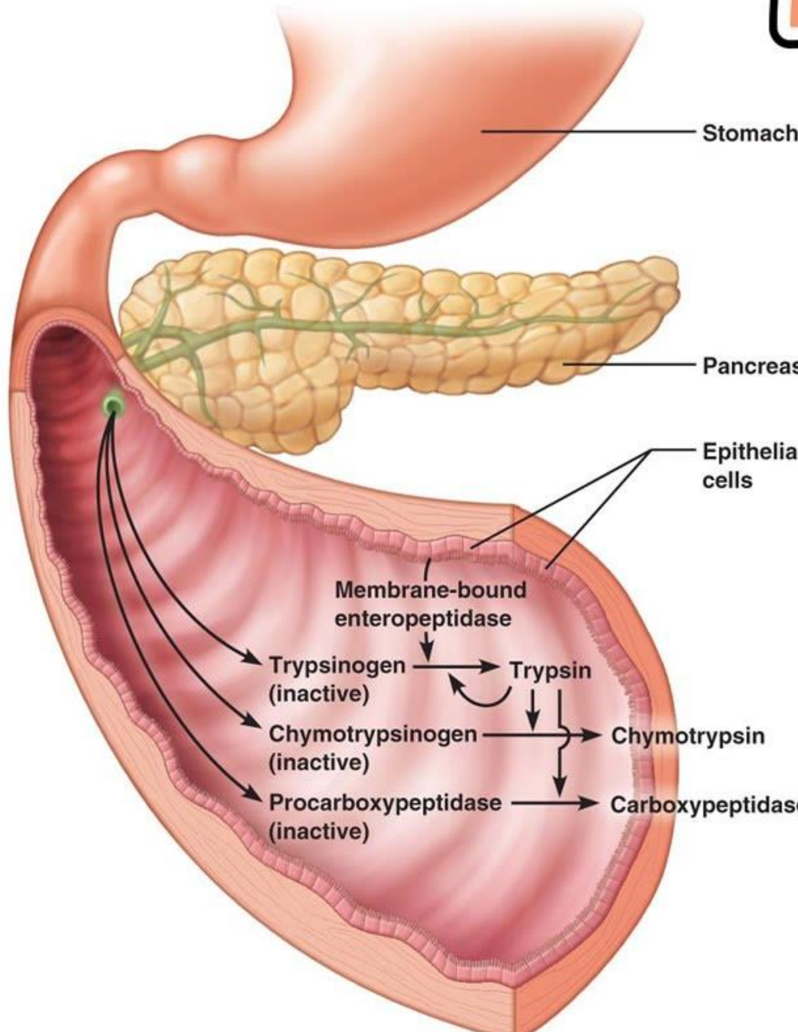
Table 5.1
Activation of enzyme precursors in the small intestine

Precursor		*Active enzyme*
Trypsinogen	*enterokinase, trypsin* →	trypsin + peptide
Chymotrypsinogen	*trypsin* →	chymotrypsin + peptide
Proelastase	*trypsin* →	elastase + peptide
Procarboxypeptidase	*trypsin* →	carboxypeptidase + peptide
Prophospholipase A	*trypsin* →	phospholipase A + peptide

Enterokinase is an enzyme that is secreted by brush border of small intestine and activate trypsinogen.

ACTIVATION OF PANCREATIC ENZYMES





DUCTAL CELL SECRETION

- Secretes a HCO_3^- -rich fluid that alkalinizes & hydrates the protein-rich secretion of acinar cells ([HCO3] =145mEq/L).
- Constitute 75% of pancreatic secretion.
- Stimulated by ***Secretin***.
- Effects of Secretin are potentiated by CCK & Ach.

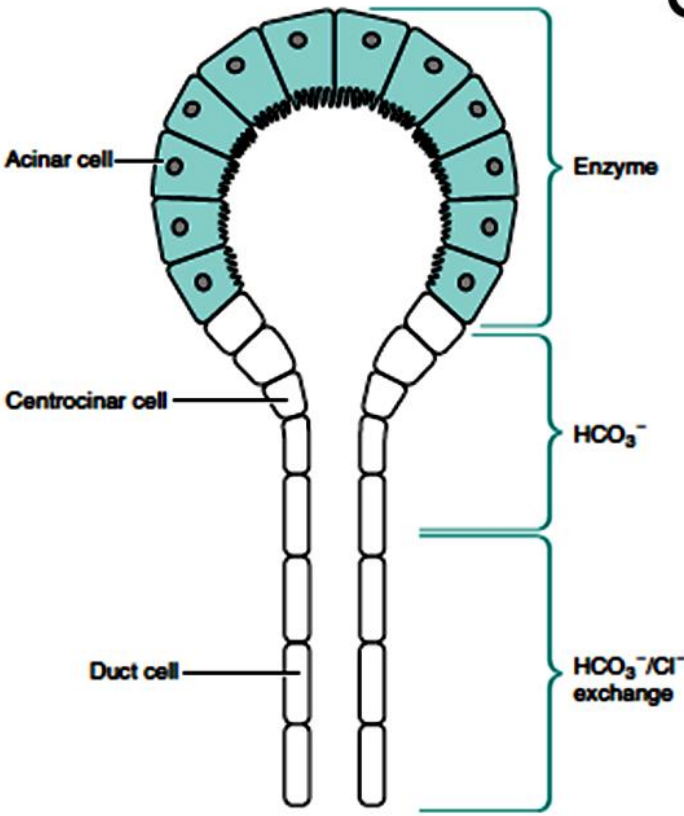
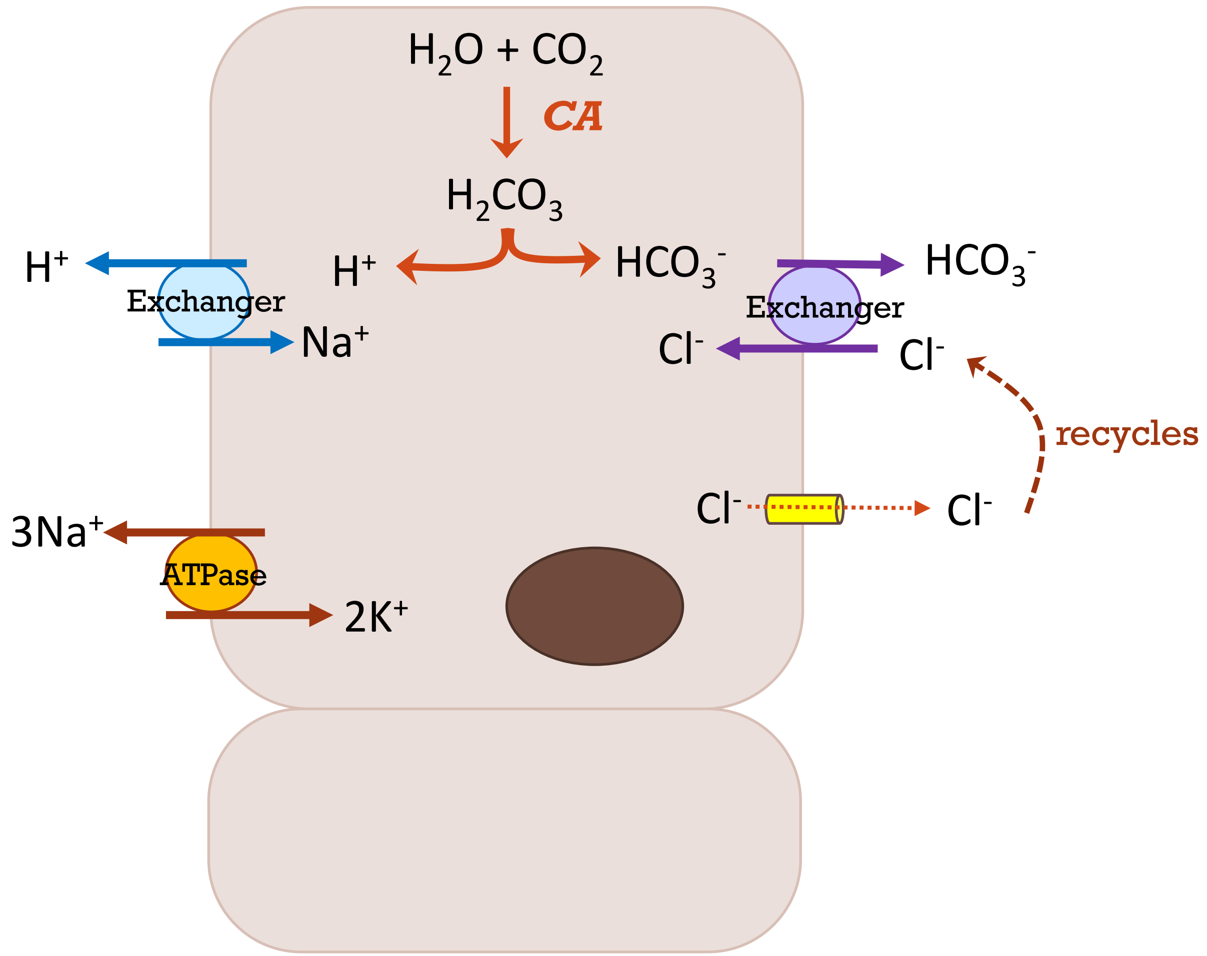


Fig. 5.4
Secretory unit showing the cellular locations of the different secretions.

MECHANISM OF DUCTAL CELL SECRETION

Blood side

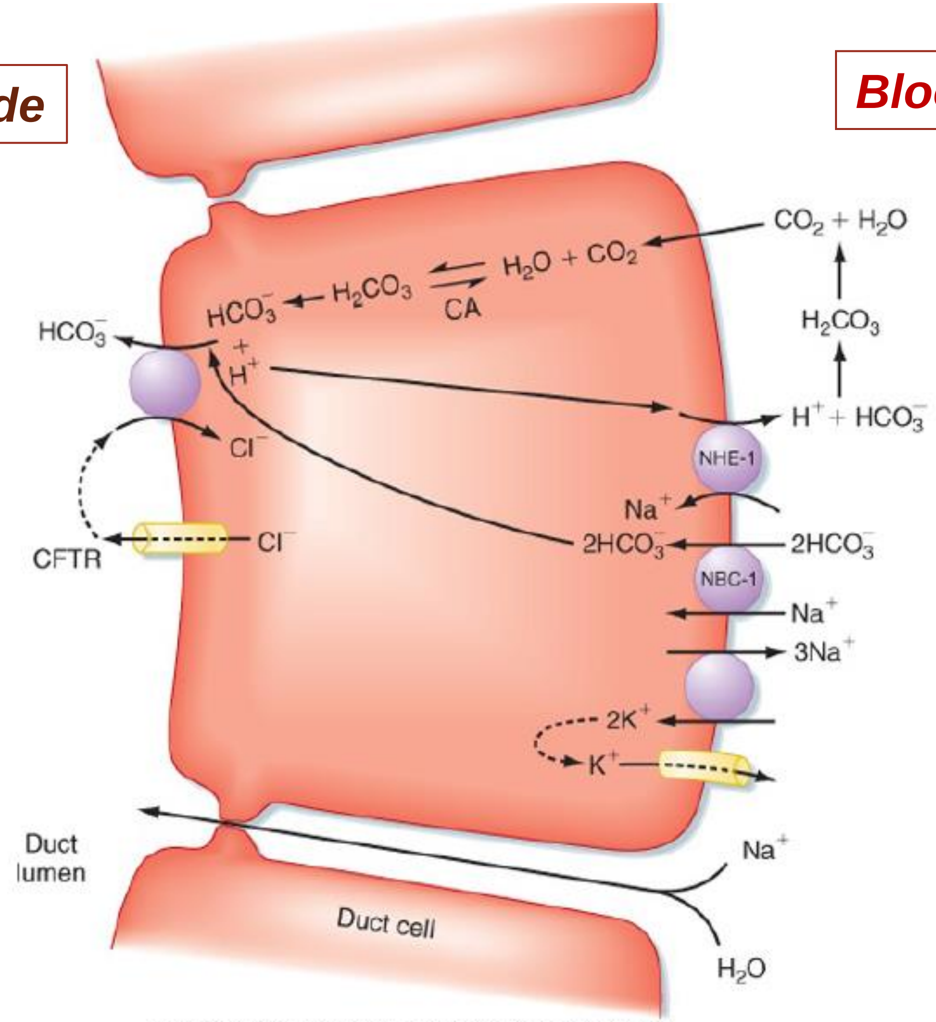
Luminal side



MECHANISM OF DUCTAL CELL SECRETION

Luminal side

Blood



Koeppen & Stanton: Berne and Levy Physiology, 6th Edition.

EFFECT OF FLOW RATE ON PANCREATIC SECRETION

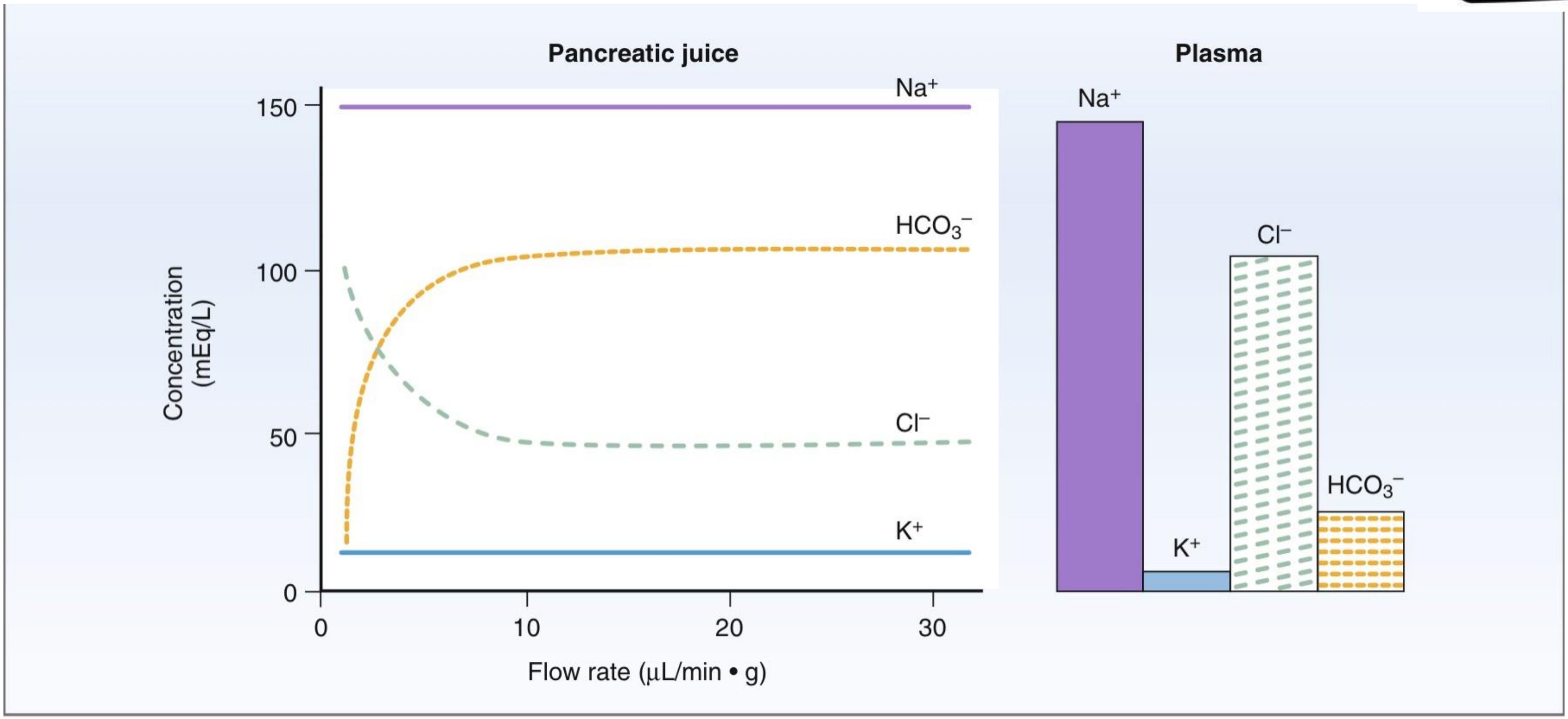


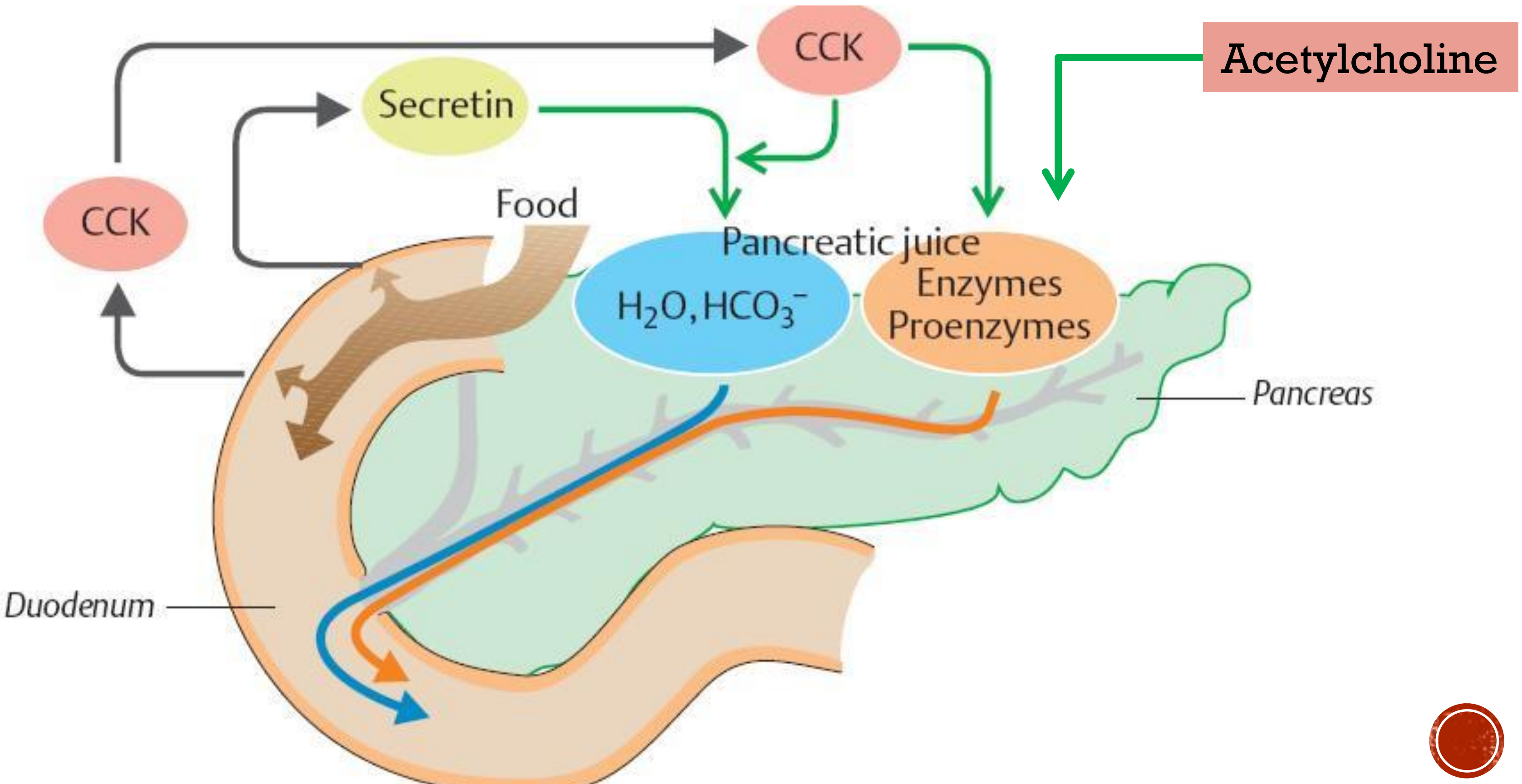
Figure 8-22 Relationship between the composition of pancreatic juice and the pancreatic flow rate. The ionic composition of pancreatic juice is compared with that of plasma.

REGULATION OF PANCREATIC SECRETION

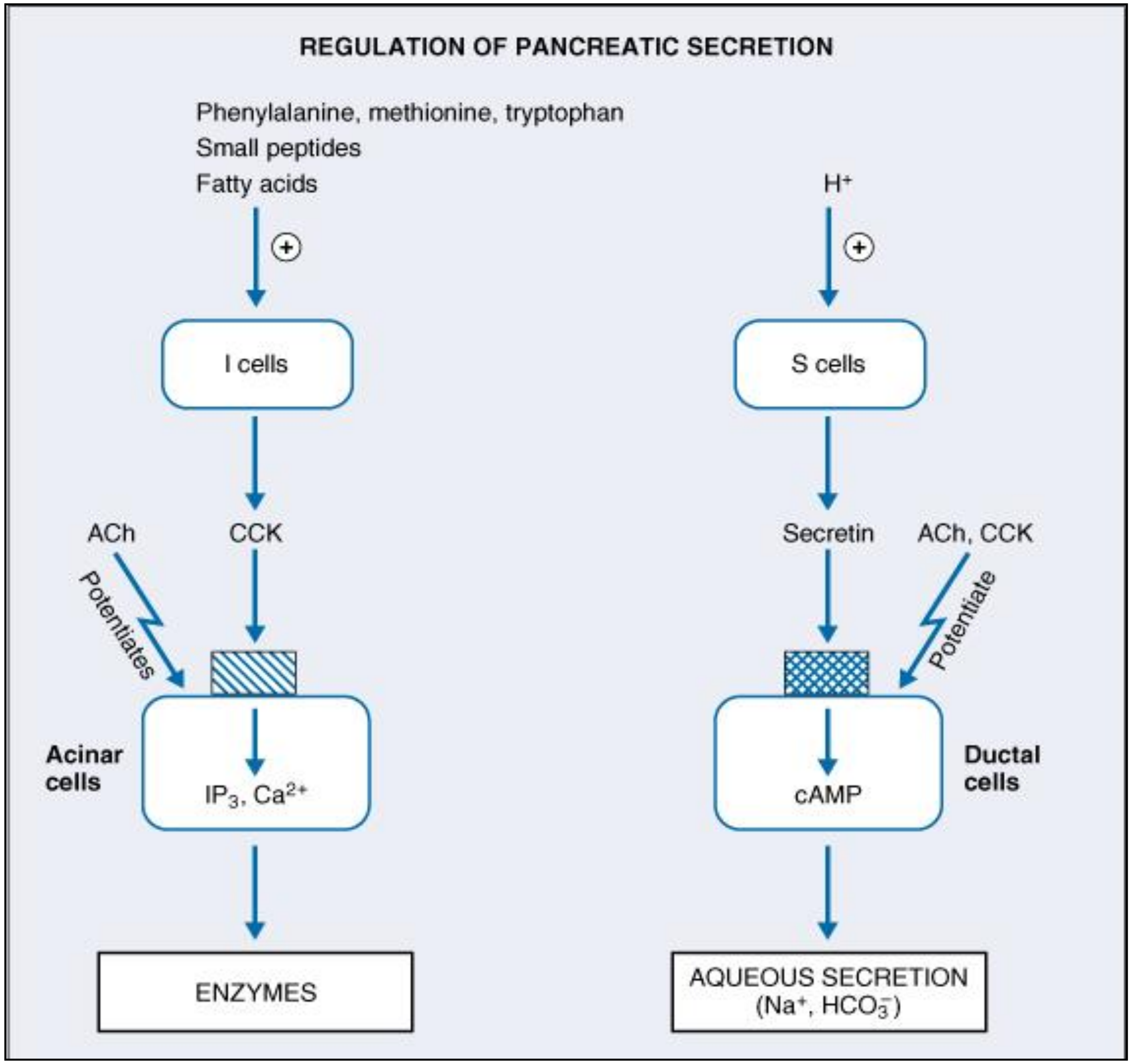
REGULATION OF PANCREATIC SECRETION

Three basic stimuli:

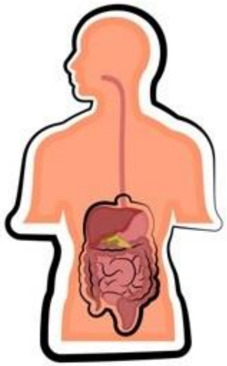
- Ach
- CCK
- Secretin



REGULATION OF PANCREATIC SECRETION



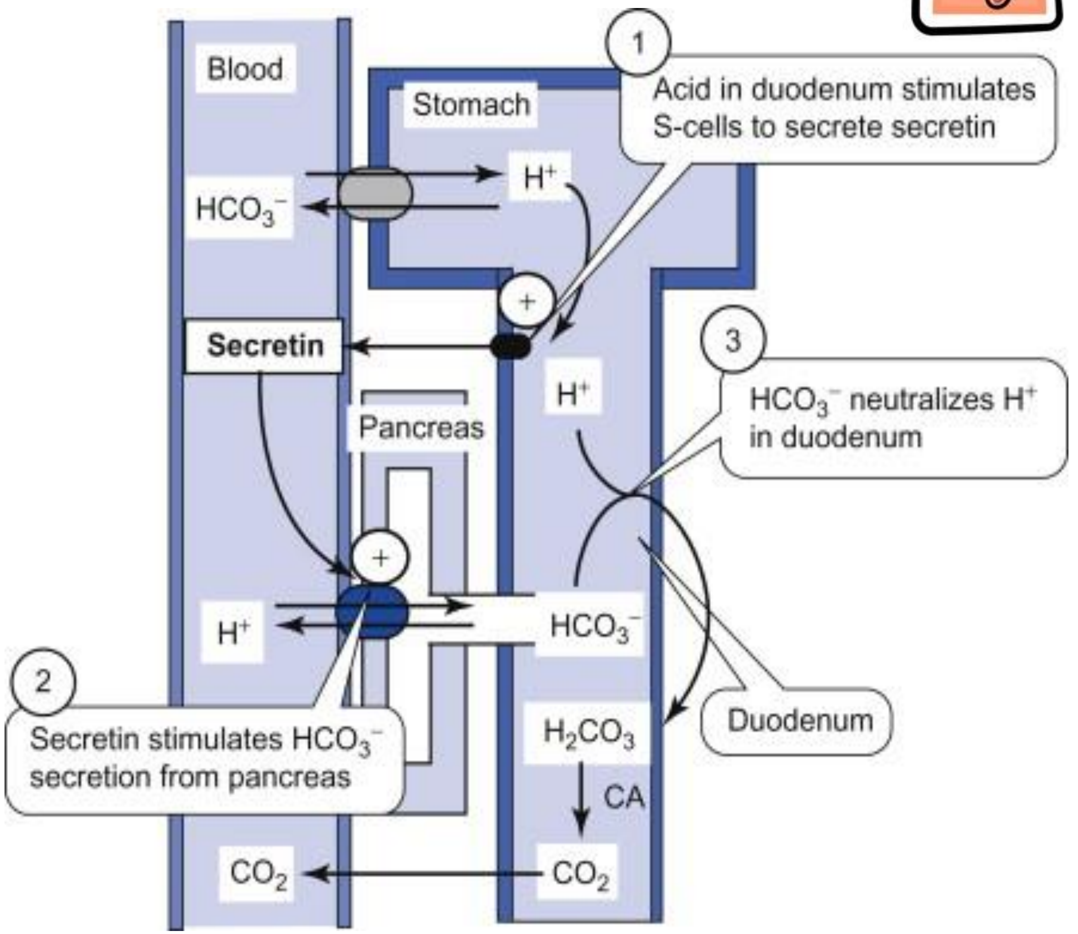
CHOLECYSTOKININ (CCK)



- A 33-amino acid polypeptide.
- Secreted by enteroendocrine cells "***I cells***" in duodenum & upper jujenum.
- Stimulated by the presence of fat and protein degradation products (proteoses & peptides).
- CCK → ↑ pancreatic digestive enzyme secretion.

SECRETIN

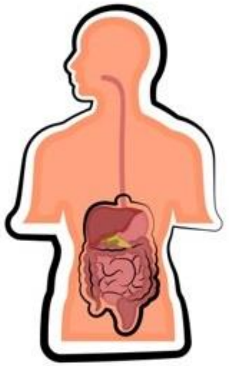
- 27 amino acid polypeptide.
- Secreted by "S cells" in the duodenum & upper jujenum.
- When luminal pH<4.5
- HCO_3^- concentration in pancreatic secretion = 145mmol/L



Joseph Feher. Pancreatic and Biliary Secretion. Editor(s): Joseph Feher. Quantitative Human Physiology, Academic Press, 2012, Pages 721-730.

PHASES OF PANCREATIC SECRETION

PHASES OF PANCREATIC SECRETION



- ***Cephalic phase***
  - Through vagus nerve.
  - 20% of pancreatic enzymes
- ***Gastric phase***
  - Through vagus nerve.
  - 5-10 %
- ***Intestinal phase***
  - Through hormonal stimulation (secretin & CCK).
  - 70-75 %

PHASES OF PANCREATIC SECRETION

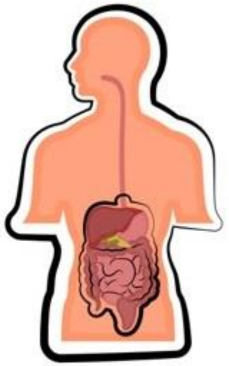


Table 43-2 The Three Phases of Pancreatic Secretion

Phase	Stimulant	Regulatory Pathway	Percentage of Maximum Enzyme Secretion
Cephalic	Sight Smell Taste Mastication	Vagal pathways	25%
Gastric	Distention Gastrin?	Vagal-cholinergic	10%-20%
Intestinal	Amino acids Fatty acids H^+	Cholecystokinin Secretin Enteropancreatic reflexes	50%-80%

SUMMARY

TABLE 8–2. Summary of Gastrointestinal Hormones

Hormone	Hormone Family	Site of Secretion	Stimuli for Secretion	Actions
Gastrin	Gastrin-CCK	G cells of the stomach	Small peptides and amino acids Distention of the stomach Vagal stimulation (GRP)	↑ Gastric H^+ secretion Stimulates growth of gastric mucosa
Cholecystokinin (CCK)	Gastrin-CCK	I cells of the duodenum and jejunum	Small peptides and amino acids Fatty acids	↑ Pancreatic enzyme secretion ↑ Pancreatic HCO_3^- secretion Stimulates contraction of the gallbladder and relaxation of the sphincter of Oddi Stimulates growth of the exocrine pancreas and gallbladder Inhibits gastric emptying
Secretin	Secretin-glucagon	S cells of the duodenum	H^+ in the duodenum Fatty acids in the duodenum	↑ Pancreatic HCO_3^- secretion ↑ Biliary HCO_3^- secretion ↓ Gastric H^+ secretion Inhibits trophic effect of gastrin on gastric mucosa
Gastric inhibitory peptide (GIP)	Secretin-glucagon	Duodenum and jejunum	Fatty acids Amino acids Oral glucose	↑ Insulin secretion from pancreatic β cells ↓ Gastric H^+ secretion

SUMMARY OF DIGESTION OF FOOD TYPES

DIGESTION OF CARBOHYDRATES
FROM MOUTH TO DUODENUM

Carbohydrates in diet

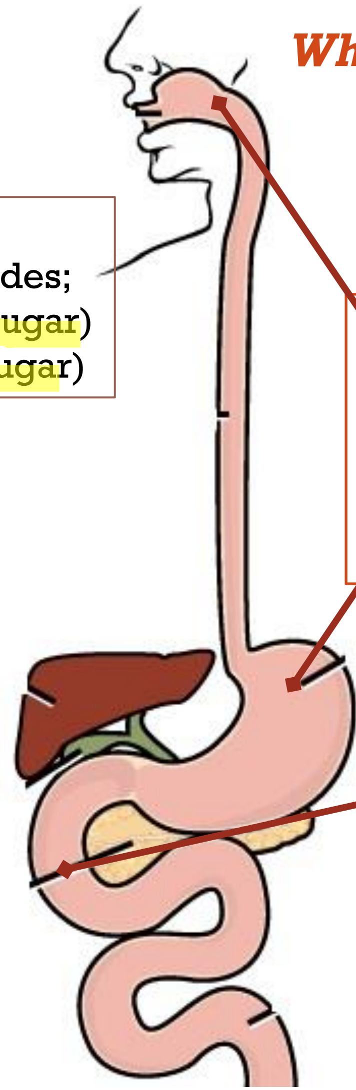
Most (2/3) Plant polysaccharides "Starch"

Remaining Are disaccharides; Sucrose (table sugar) Lactose (milk sugar)

Glycogen
Cellulose "fiber"-not digested by humans

Dietary carbohydrates

Absorbed form; Monosaccharides



What are sucrose & lactose made of??

Sucrose = glucose + fructose
Lactose = glucose + galactose

Mouth ***20-40%***

Starch $\xrightarrow[\text{amylase}]{\text{Salivary}}$ Oligosaccharides Maltose

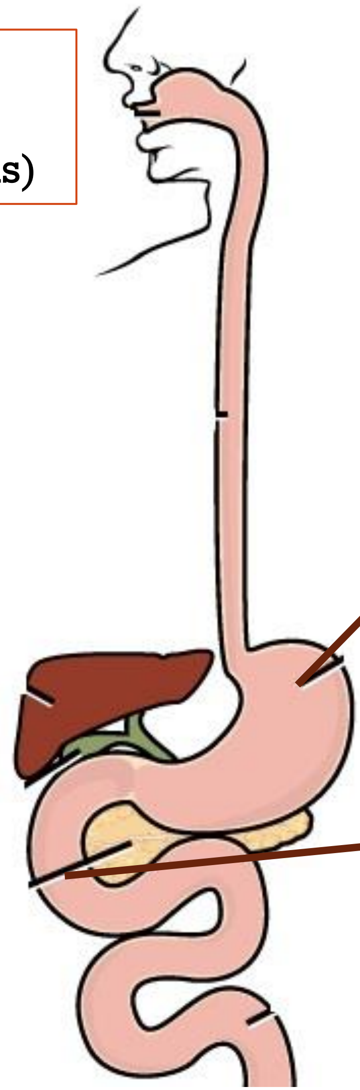
Duodenum ***50-80%***

Starch Oligosaccharides $\xrightarrow[\text{amylase}]{\text{pancreatic}}$ small glucose polymers Maltose

DIGESTION OF PROTEINS
FROM MOUTH TO DUODENUM

Exogenous protein (diet)
+ endogenous proteins
(digestive enzymes & mucus)

Absorbed form;
Amino acids
Dipeptides
tripeptides



What is the difference between a protein and a peptide??

Starts at stomach **10-20%**

Proteins $\xrightarrow[\text{HCL}]{\text{Pepsin}}$ Partially digested proteins
Polypeptides

Duodenum

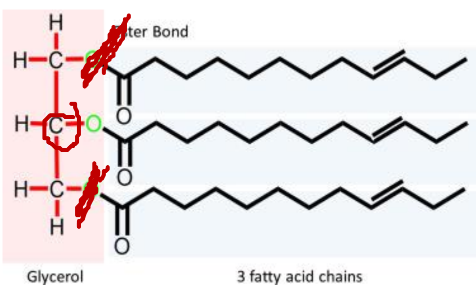
Proteoses
Peptones $\xrightarrow[\text{Chemotrypsin}]{\text{Trypsin}}$ Polypeptides

Polypeptides $\xrightarrow{\text{Carboxypeptidase}}$ Releases some a.a.
Smaller peptides
(some Tri- & di-peptides)

DIGESTION OF FAT
FROM MOUTH TO DUODENUM

Fat in diet

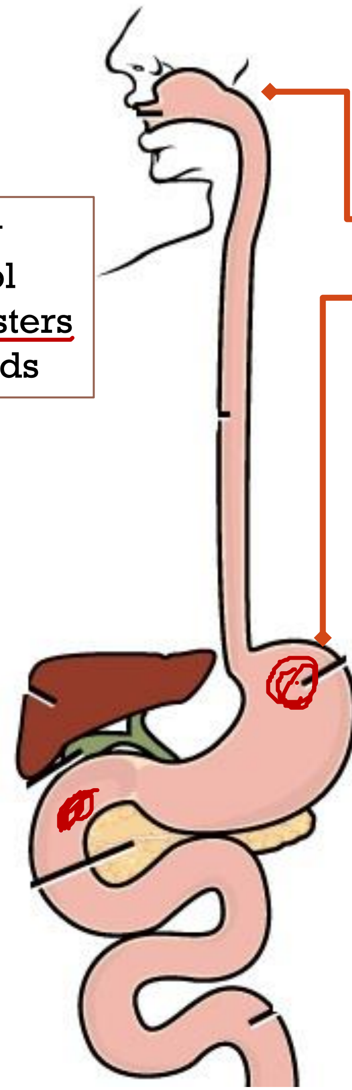
- Mostly triglycerides
- Remaining: Cholesterol, Cholesterol esters, phospholipids



Dietary fat

↓

Absorbed form:
2-monoglycerides
Cholesterol
Fatty acids



10%

Mouth & stomach

TGs $\xrightarrow{\text{Lingual lipase}}$ Diglycerides, Fatty acids

Intestine

TGs, DAGs $\xrightarrow{\text{Pancreatic lipase}}$ 2-MG, Fatty acids

CE $\xrightarrow{\text{Cholesterol esterase}}$ Chol, FA

Phospholipids $\xrightarrow{\text{Phospholipase A2}}$ Lysoph., FA

END OF PANCREAS

MIGRATORY MOTOR COMPLEXES

WHAT HAPPENS TO OUR GI SYSTEM IN BETWEEN MEALS?

- We understood that the GI tract motility is involved in mixing and moving food along the tract in an orad to caudad direction.

- ***But what happens when there is no food in the system? During fasting for example?***

- The intestine is relatively quiescent during fasting but exhibit a certain pattern of electric and motor activity

Interdigestive myoelectric complexes

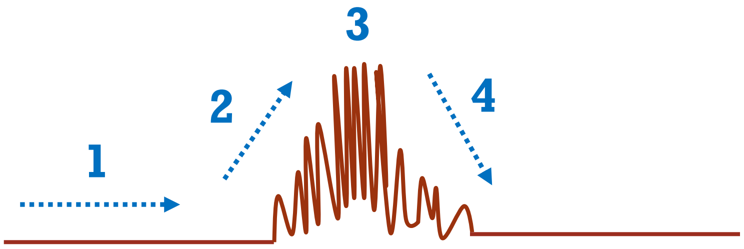
"Migrating Motor Complexes (MMC)"

MIGRATING MOTOR COMPLEXES

- ***MMC*** is a term that describes the rhythmic contractions of the small intestine during the fasting state.

- Starts at the stomach and moves down to terminal ilium.

- At intervals of 90-120 min.



- Consists of four main phases:
  1. Prolonged quiescent period.
  2. A period of increasing AP and contractility.
  3. A period of peak electrical and mechanical activity.
  4. A period of declining activity.

Walter F. Boron, Emile L. Boulpaep- Medical Physiology, Updated Edition.

MIGRATING MOTOR COMPLEXES

- These are though to clear the intestine of its contents.
- Allows particles > 2mm to pass from stomach to duodenum.
- *Motilin* is thought to play a role in their generation.

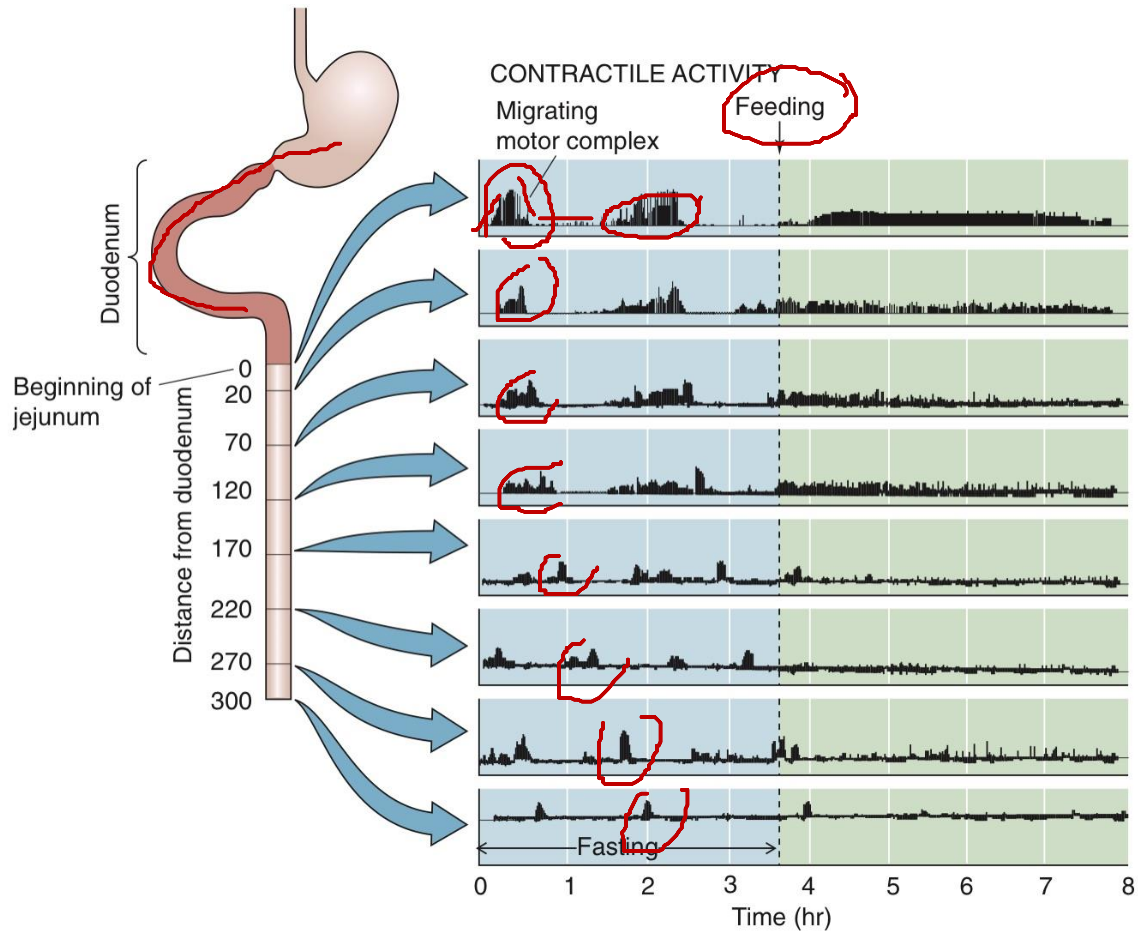


Figure 41-6 Mechanical activity in the fasting and fed states. Shown are records of intraluminal pressure along the small intestine of a conscious dog. Before feeding (*left side*), the pattern is one of MMCs. Feeding triggers a switch to a different pattern, characterized by both segmental contractions that churn the contents and peristaltic contractions that propel the contents along the small intestine. *(Data from Itoh Z, Sekiguchi T: Scand J Gastroenteral Suppl 1983; 82:121-134.)*

Disappear upon feeding

Walter F. Boron, Emile L. Boulpaep- Medical Physiology, Updated Edition.

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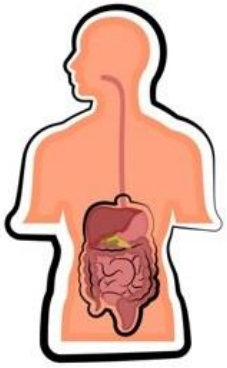

Thank you