Physiology of the Pancreas

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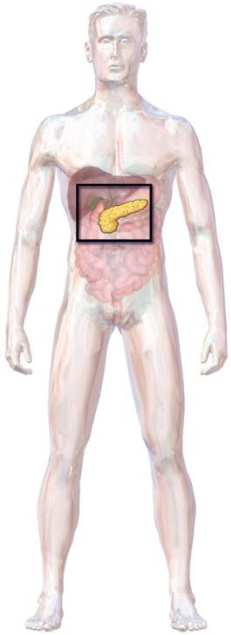
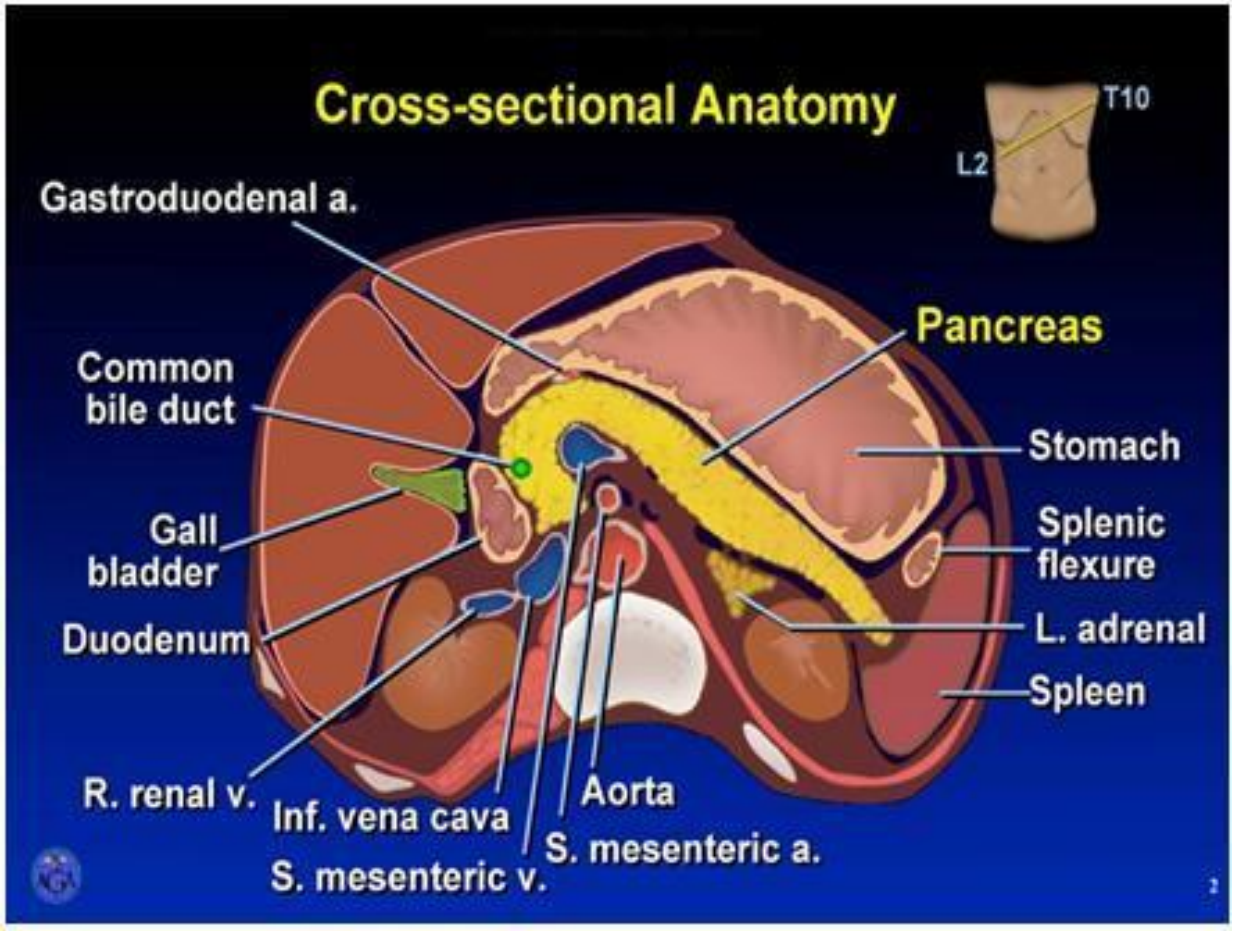
Functional Anatomy of the Pancreas



Functional Anatomy of the Pancreas



(https://www.pancreapedia.org/reviews/anatomy-and-histology-of-pancreas)

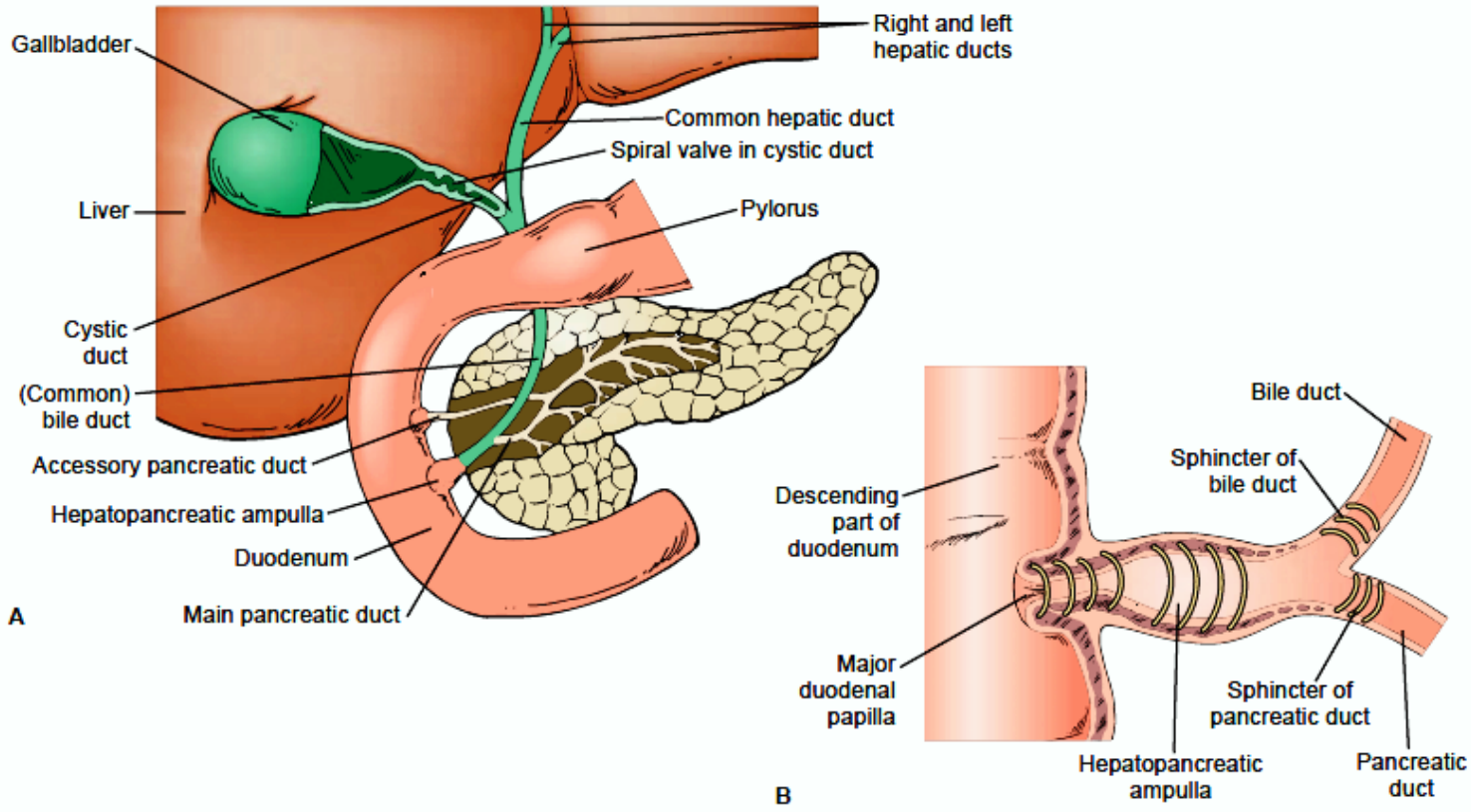


FIGURE 40-18 **(A)** Extrahepatic bile passages, gall bladder, and pancreatic ducts. **(B)** Entry of bile duct and pancreatic duct into the hepatopancreatic ampulla, which opens into the duodenum.

Histology of the Pancreas

The pancreas

Exocrine

95% of pancreas

Secretes digestive enzymes, HCO_3^- and water.

Into duodenum

Made of acinar & ductal cells.

Endocrine

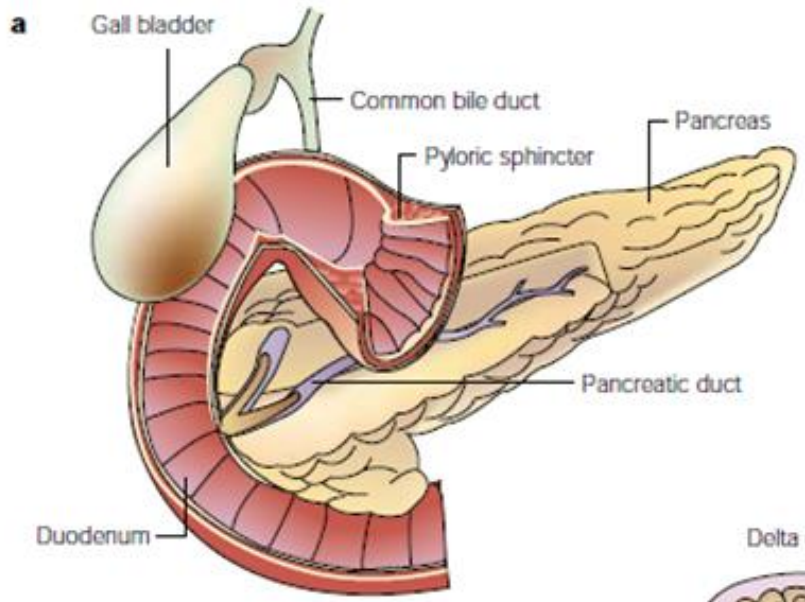
1-2% of pancreas

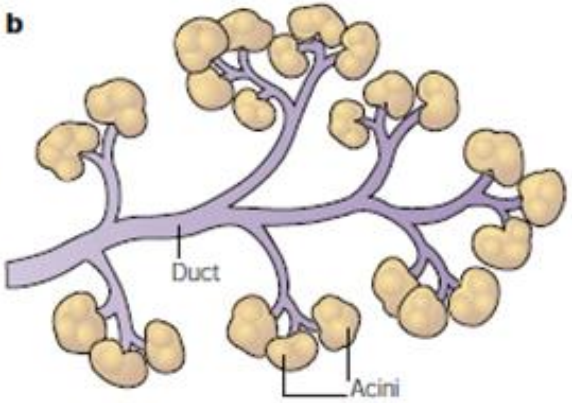
Secretes hormones.

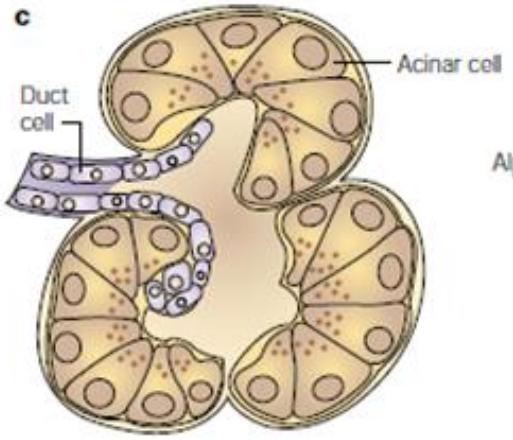
Into blood

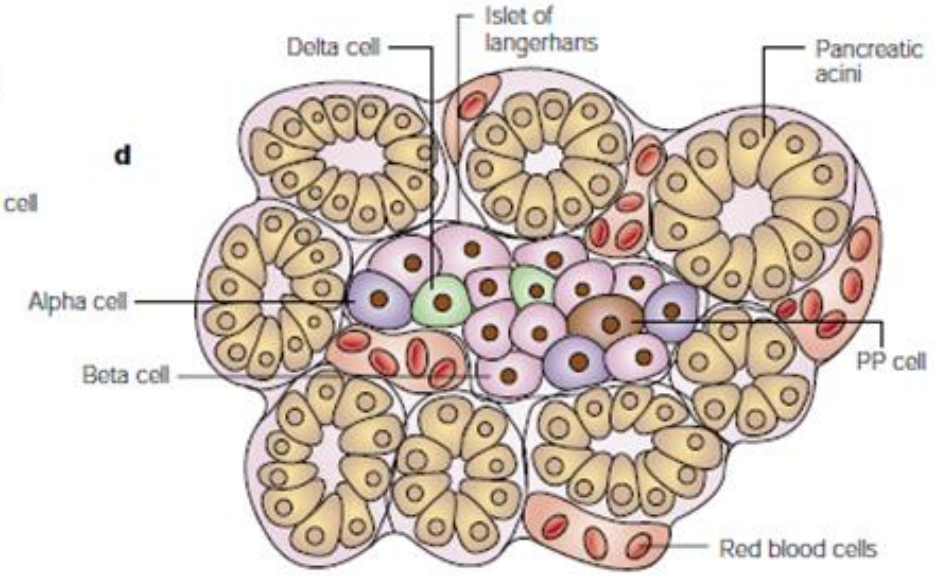
Made of Islets of Langerhan's.

Histology of the Pancreas

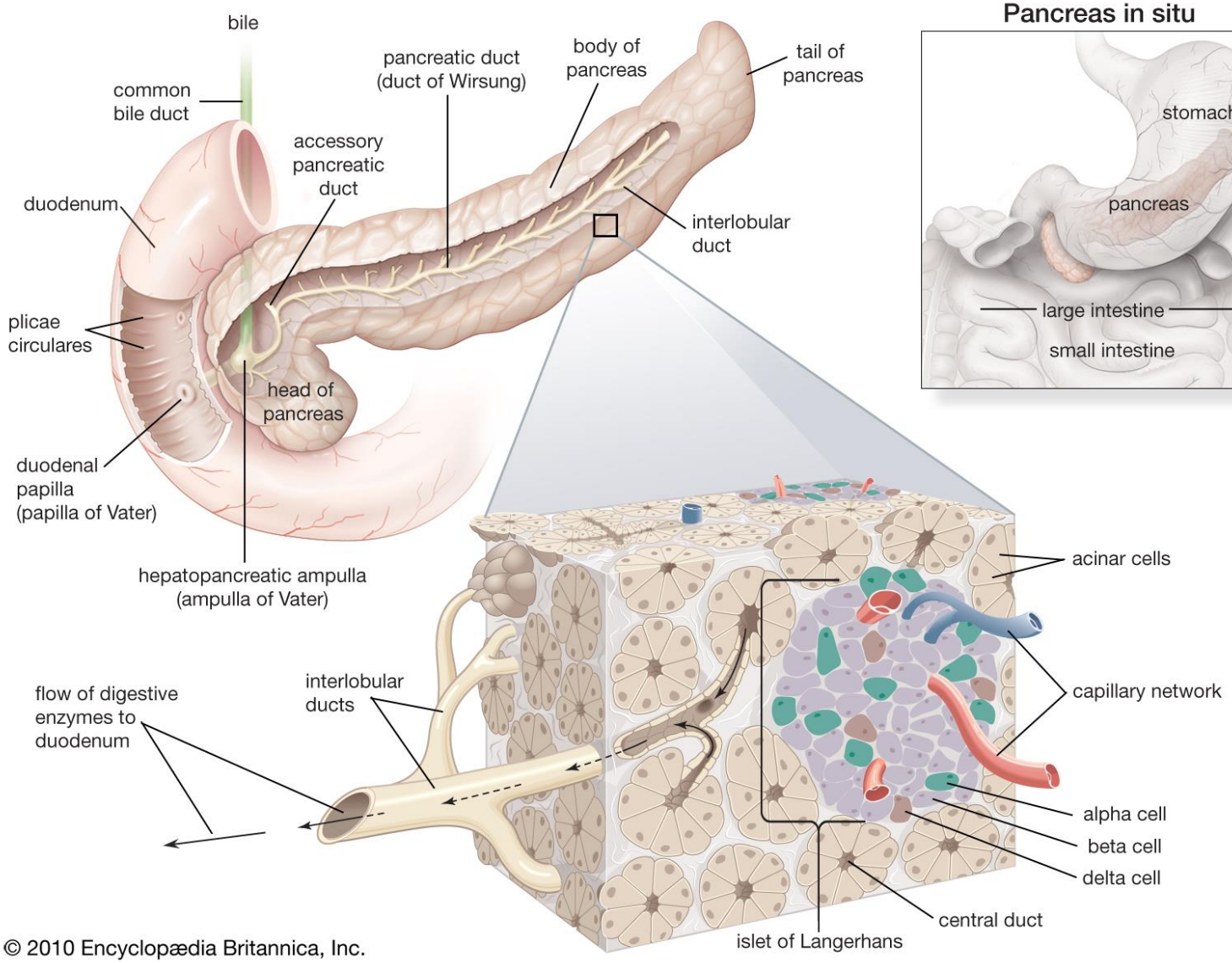








(http://2010.igem.org/wiki/index.php?title=Team:ESBS-Strasbourg/proteolux/application/cancer&oldid=209211of-pancreas)



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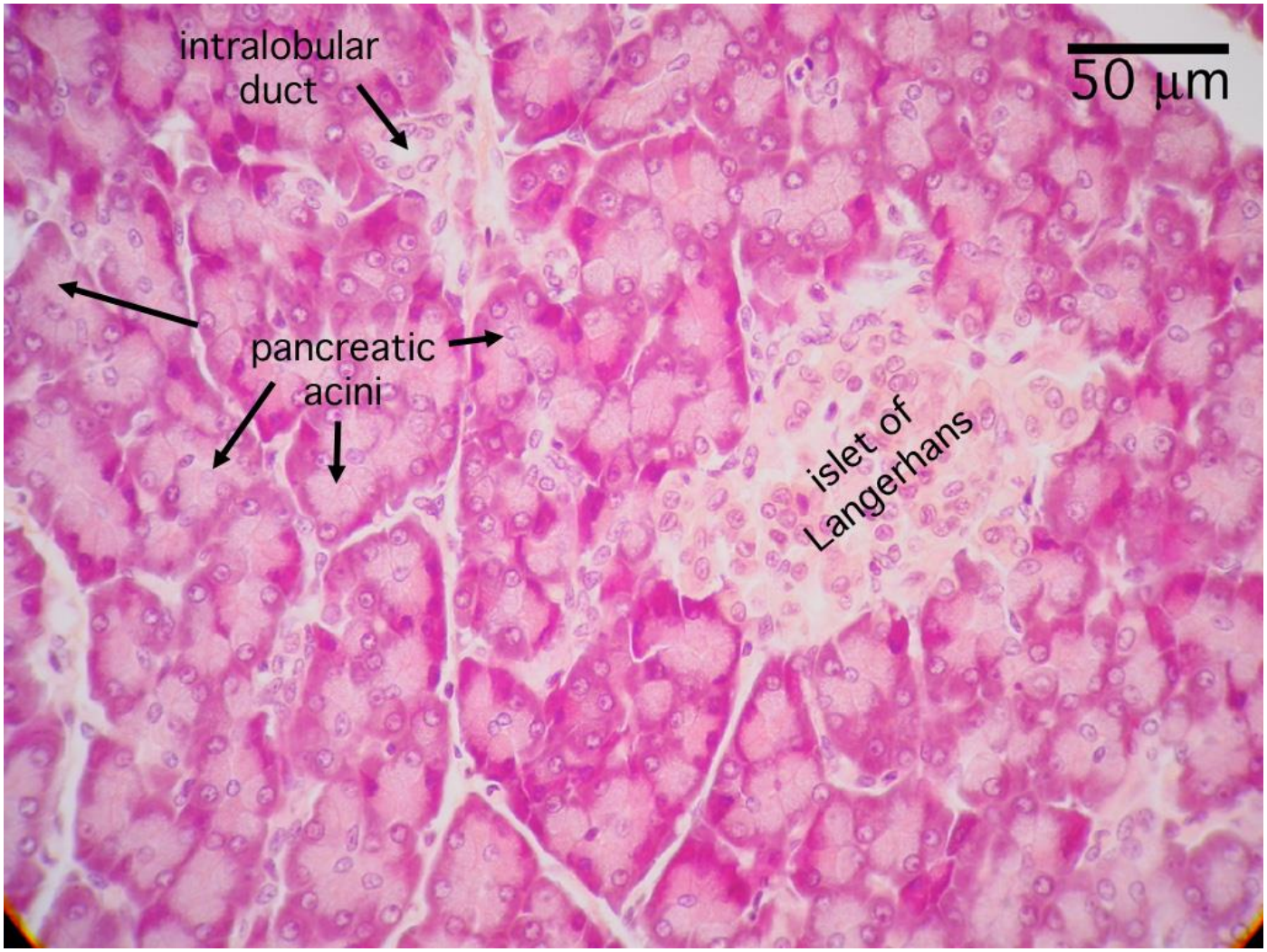
Histology of the Pancreas



Pancreatic Secretion

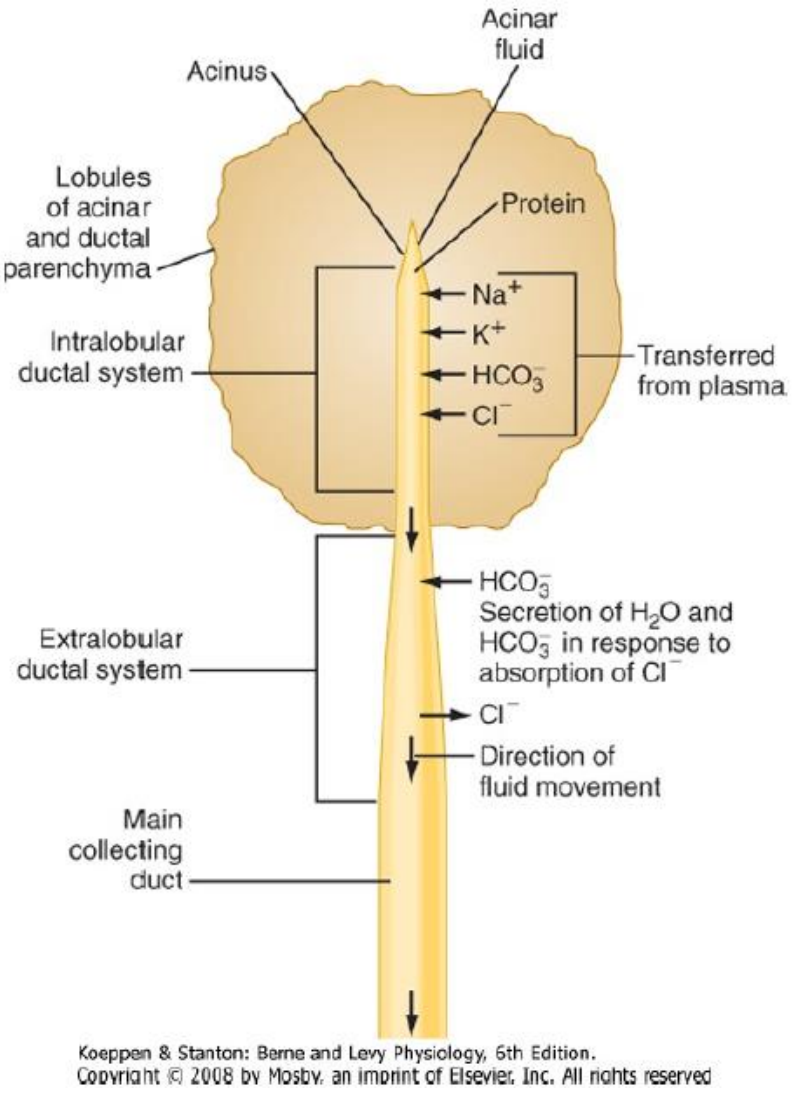
Function of Pancreatic Secretion

- 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

Acini provide the primary secretion → organic constituents (digestive juices) in a solution with similar composition to plasma.

Ducts dilute & alkalinize the pancreatic juice.



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Pancreatic Secretion

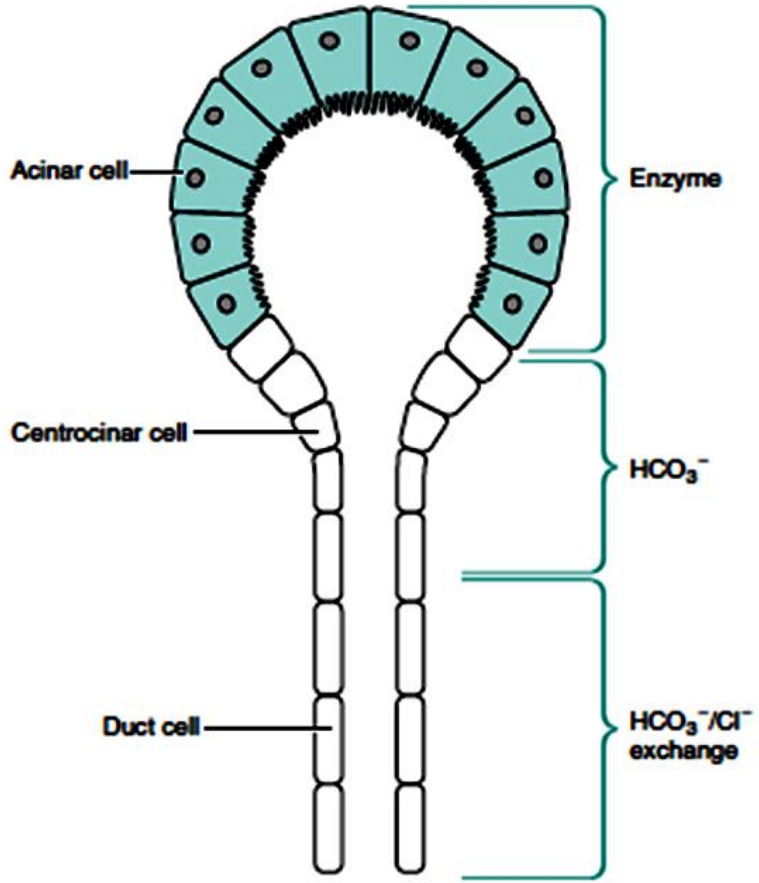


Fig. 5.4
Secretory unit showing the cellular locations of the different secretions.

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.

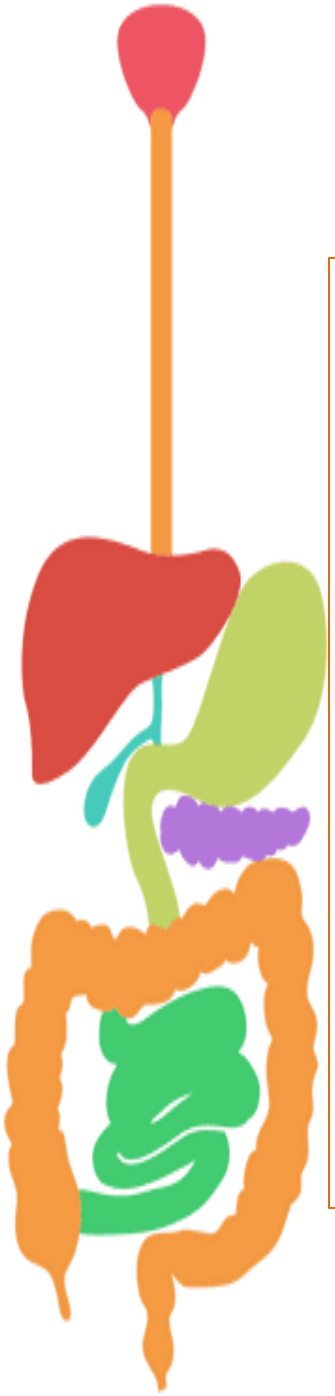
Cholecystokinin (CCK)

- 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.

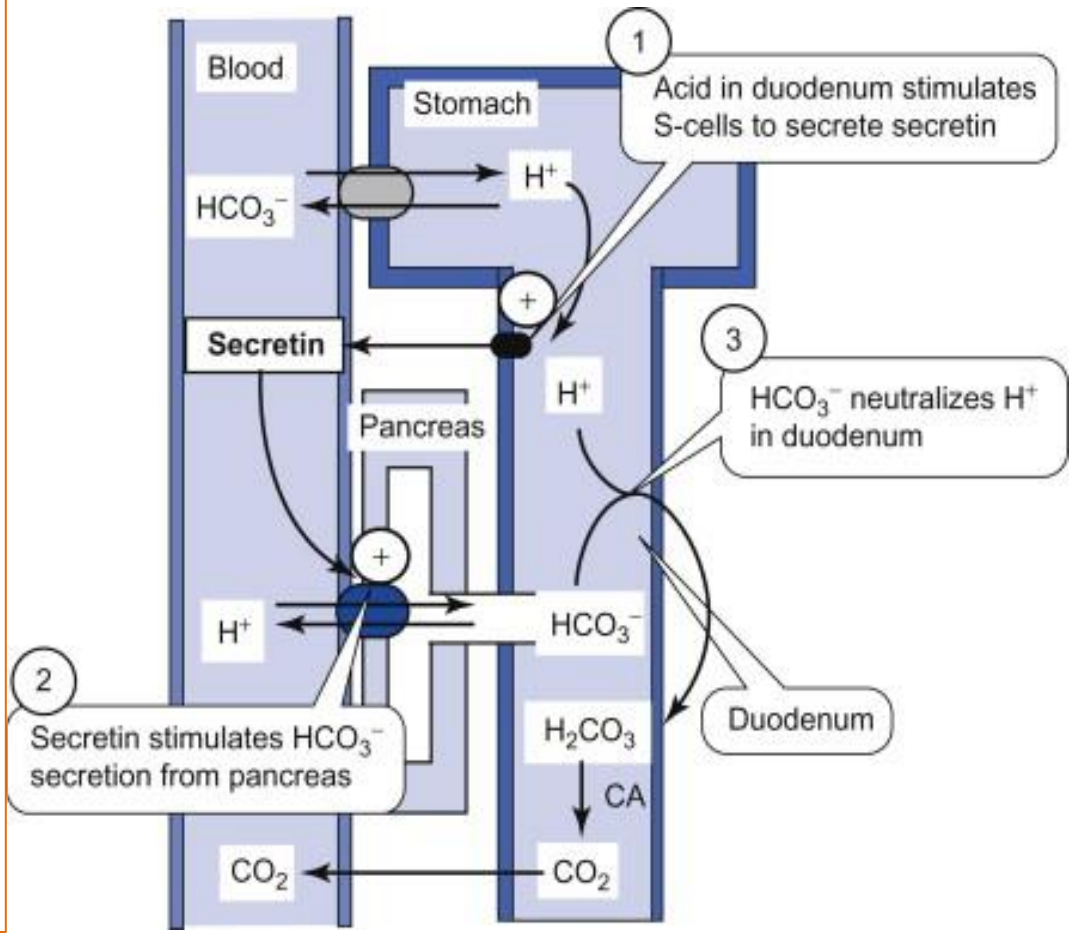
Ductal Cell Secretion

- Secretes a HCO_3^- -rich fluid that alkalinizes & hydrates the protein-rich secretion of acinar cells.
- Constitute 75% of pancreatic secretion.
- Stimulated by Secretin.
- Effects of Secretin are potentiated by CCK & Ach.

Secretin

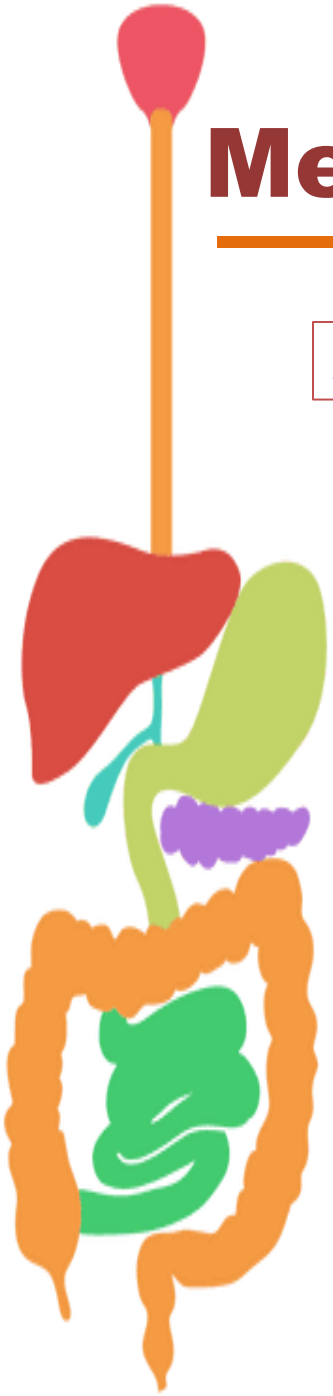


- 27 amino acid polypeptide.
- Secreted by S cells in the duodenum & upper jujenum.
- When luminal pH<4.5
- HCO_3^- concentration in pancreatic secretion = 145mmol/L



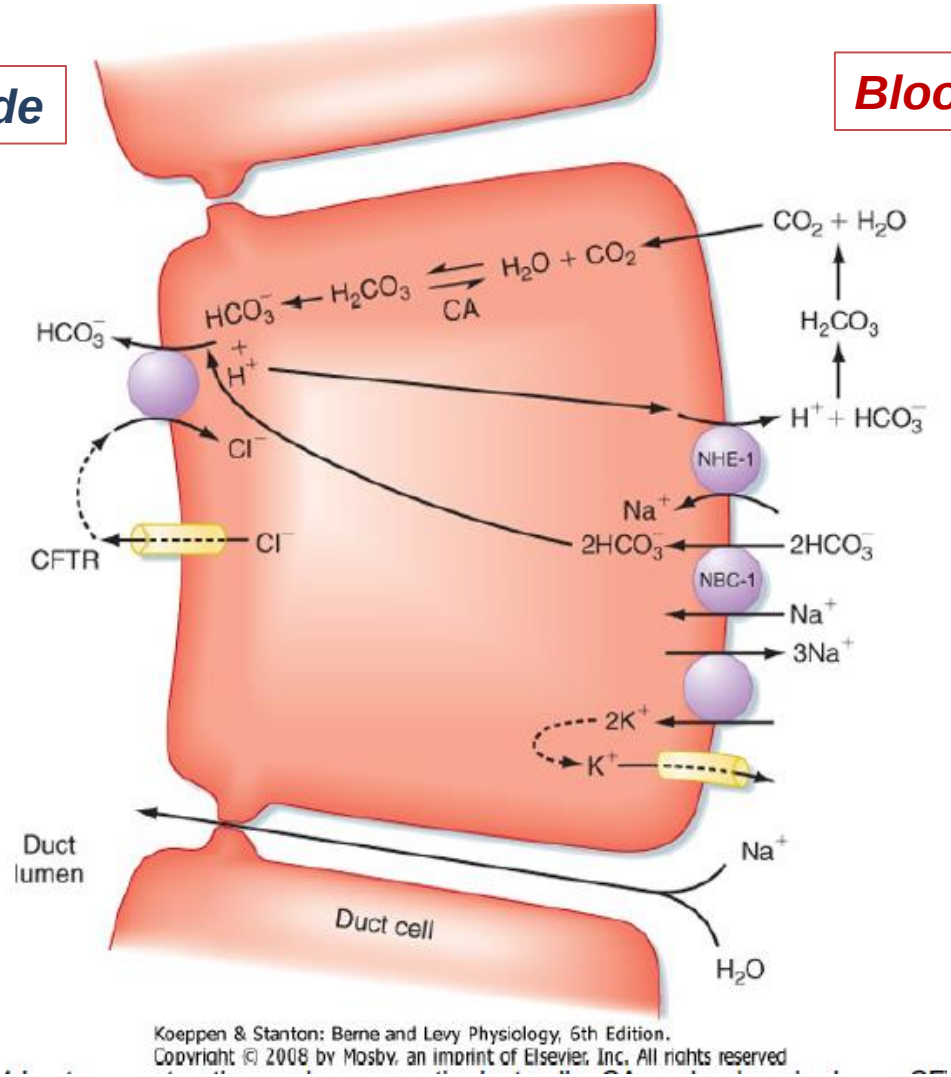
Joseph Feher. Pancreatic and Biliary Secretion. Editor(s): Joseph Feher. Quantitative Human Physiology, Academic Press, 2012, Pages 721-730.

Mechanism of HCO3 secretion



Luminal side

Blood



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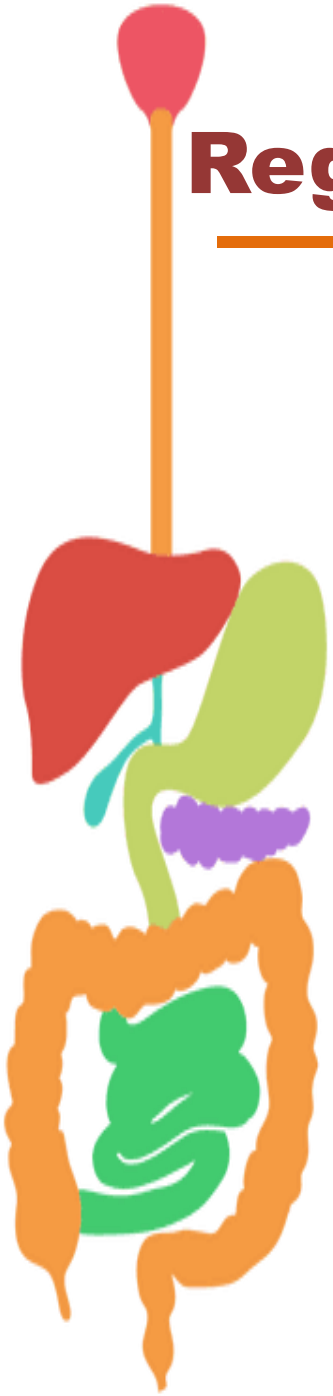
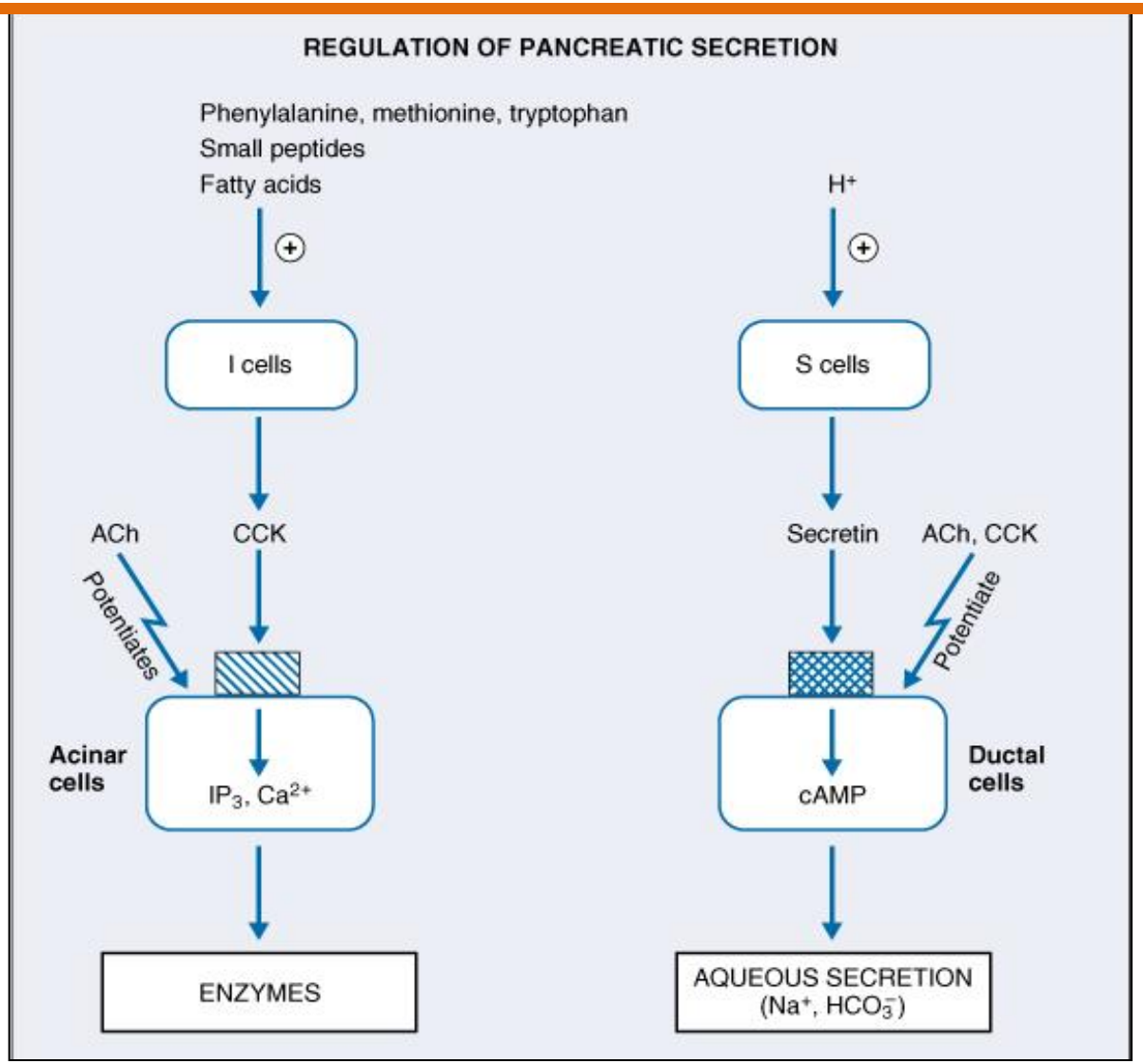
Mechanism of HCO3 secretion

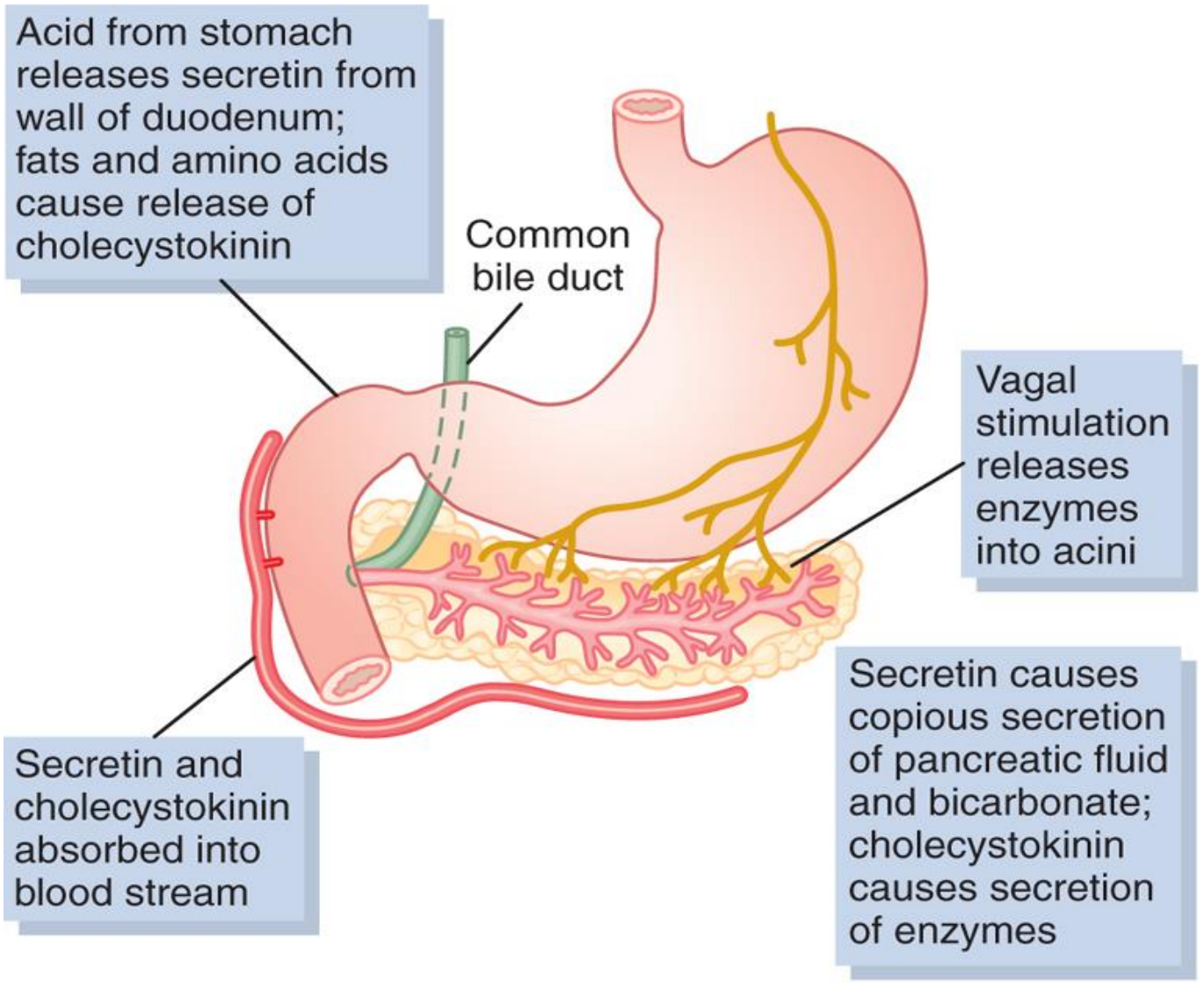
- Apical membrane of ductal cells contains a Cl^--HCO_3^- exchanger.
- Basolateral membrane contains Na^+-K^+ ATPase and a Na^+-H^+ exchanger.

1. CO_2 and H_2O combine in cells to form H+ and HCO_3^-
2. HCO_3^- is secreted into pancreatic juice by Cl^--HCO_3^- exchanger.
3. H^+ is transported into blood by Na^+-H^+ exchanger

Regulation of Pancreatic secretion







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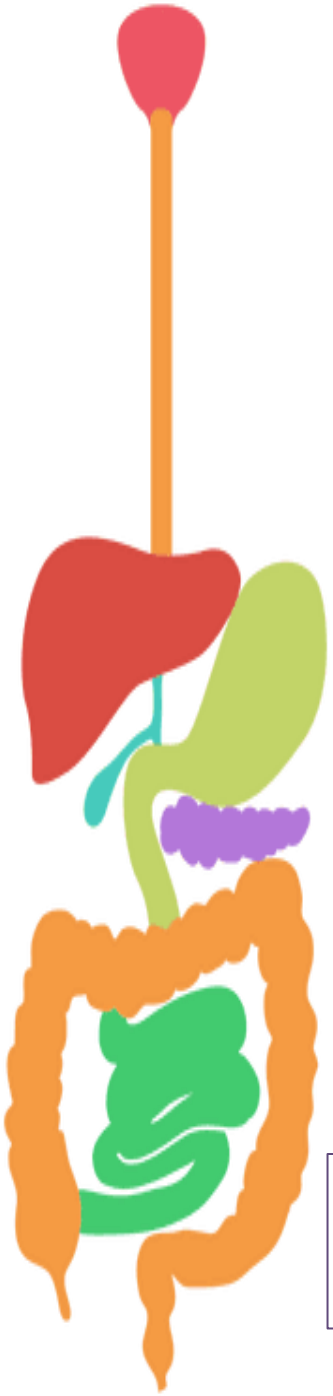
Regulation of pancreatic secretion



Pancreatic Juice

- Refers to the final combined product secreted by the exocrine pancreas.

- It contains;
  1. An electrolyte solution rich in HCO_3^-
  2. Digestive enzymes

Pancreatic digestive enzymes

For proteins	For lipids	For carbohydrates	For DNA & RNA
Trypsin Chymotrypsin Carboxypeptidase	P. Lipase Esterase Phospholipase	P. Amylase	Nucleases

Pancreatic Secretion

- Amount ≈ 1.5/day in an adult human.
- pH from 7.6 to 9.0.
- Digestive enzymes are secreted in an inactive form… ***why?***
- How do these enzymes get activated?

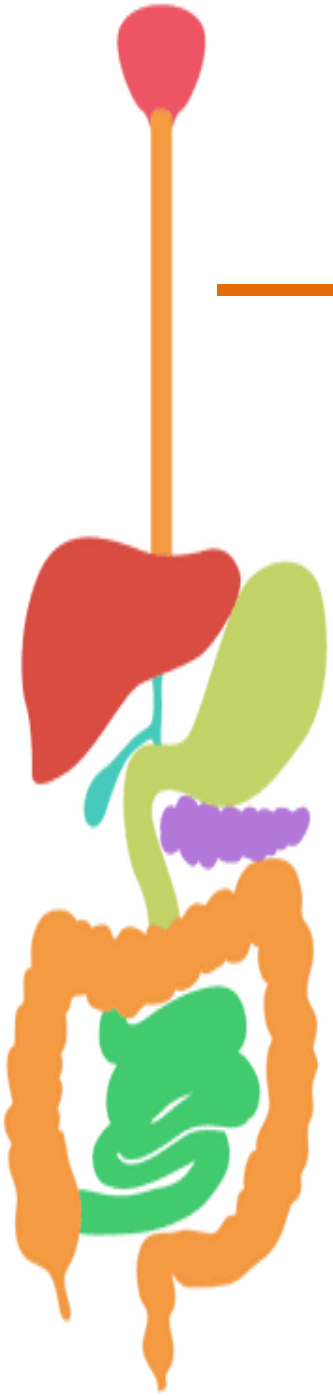
Table 5.1
Activation of enzyme precursors in the small intestine

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.

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%

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

Thank you