

# **PRINCIPLES OF GI SECRETIONS/ MOTILITY**

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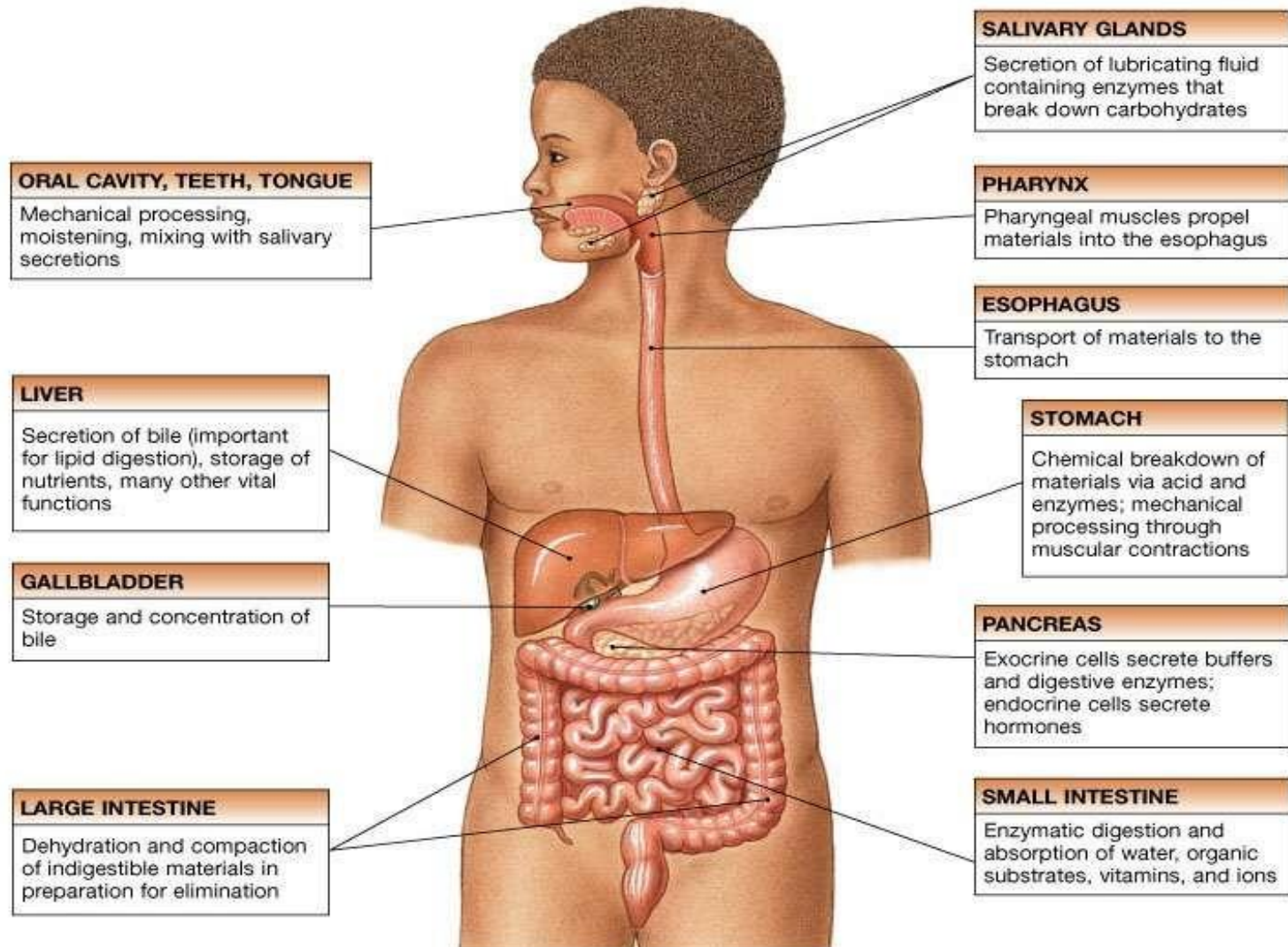
**BY  
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# LEARNING OBJECTIVES

To know the types of GI secretions generally, on the basis of their functions

1. Sites of secretion
2. Chemical composition
3. Nature of secretion
4. Functions
5. Mechanism of secretion

# GASTROINTESTINAL SECRETIONS



# GASTROINTESTINAL SECRETIONS

About 9 liters of fluid pass through the GI system each day, and only about 2 liters are ingested, the rest represent secretions from the system itself.

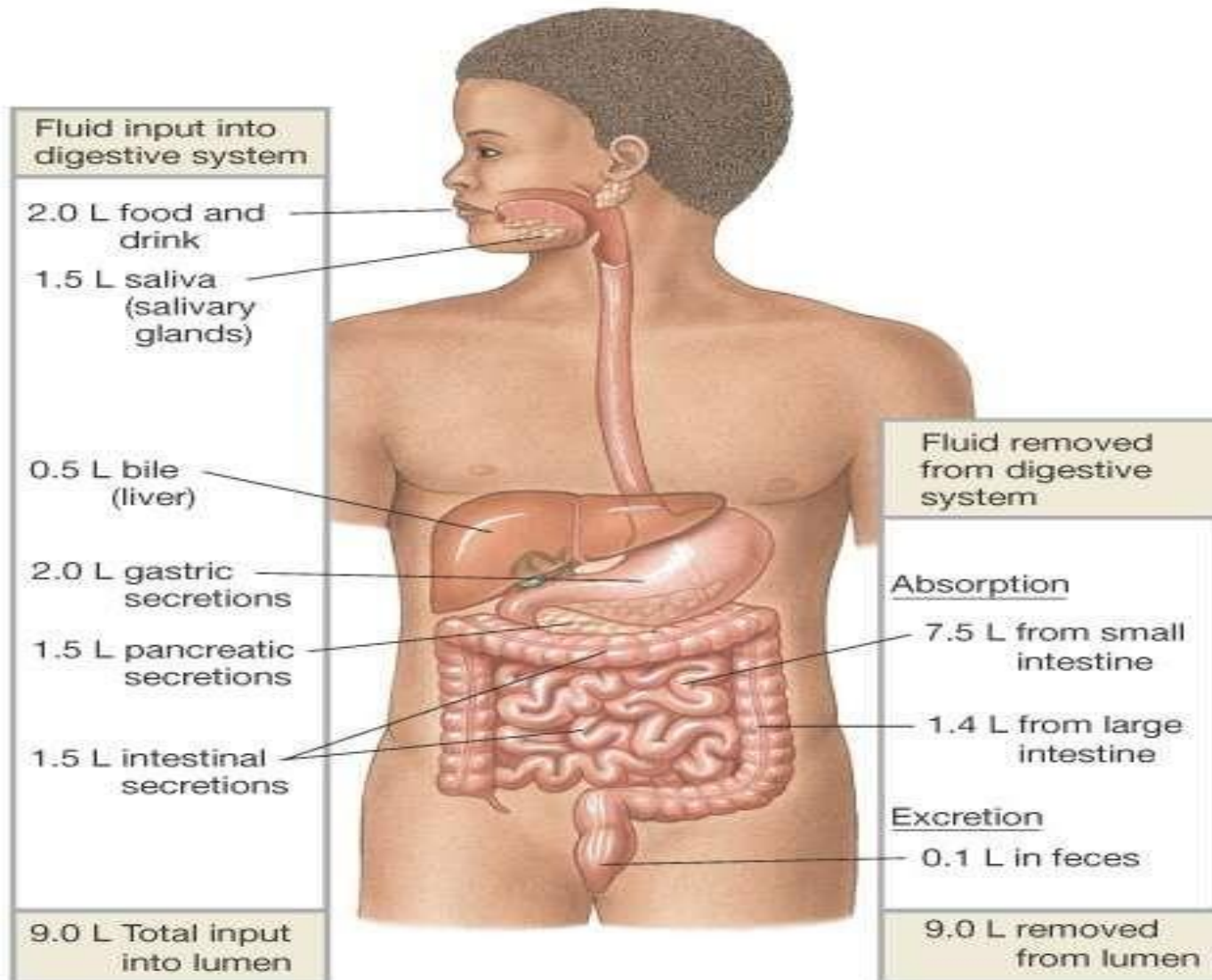
- About half of the total secreted amount  
Secreted from the exocrine glands, the salivary gland, the pancreas and the liver,
- The other half is secreted by the epithelial cells of the digestive tract itself.
- **Nearly all this fluid is absorbed**

# GASTROINTESTINAL SECRETIONS

To put this in perspective a 70 Kilogram man has about 42 liters of fluid, so the secretions represent about a sixth of the body's volume.

- The circulation contains about 3.5 liters, so these secretions represent twice the bodies circulating volume!
- Failures of absorption of the intestinal secretions can thus lead to rapid dehydration and electrolyte imbalance.

# GASTROINTESTINAL SECRETIONS



# GASTROINTESTINAL SECRETIONS

## Types of gastrointestinal glands

1. **Single cell mucous** glands and **goblet cells**.
2. **Pit glands**: Invaginations of the epithelia into the submucosa. In the small intestine these are called **Crypts of Lieberkuhn**.
3. **Deep tubular glands**. These are found in the stomach - the gastric glands, and the upper duodenum - **Brunners glands**.
4. **Complex glands**, the salivary glands, pancreas and liver.

# Components of gastrointestinal secretions

## Electrolytes and Fluids

A large portion of the 7 liters is composed of water and ions. The ionic composition varies from region to region.

- The **acini of the salivary glands** secrete a sodium and chloride rich secretion, this is then turned to a potassium, bicarbonate rich secretion as it travels down the lumen and ducts of the glands
- The **Oxyntic cells of the stomach** secrete Hydrochloric acid
- The **mucous cells of the stomach** secrete a mucous rich in bicarbonates
- The **pancreatic ducts and ductules** secrete a solution rich in bicarbonate
- The **Crypts of Liberkuhn of the small intestine** secrete a solution almost indistinguishable from interstitial fluid.



# Components of gastrointestinal secretions

## Digestive Enzymes

LOCATION	ENZYME NAME	ACTION
Buccal Cavity	Alpha amylase	Splitting of 1-4 linkages in starch
	Lingual Lipase	Triglyceride digestion especially in bacterial wall (immune function)
Stomach	Pepsin	Digestion of tertiary proteins into simpler forms
	Gastric Lipase	Splitting of fatty acids from triglycerides

# Components of gastrointestinal secretions

## 2- Digestive Enzymes

LOCATION	ENZYME NAME	ACTION
Exocrine Pancreas	Pancreatic Amylase	Digestion of starch remnants into disaccharides and glucose
	Pancreatic Lipase	Digestion of dietary triglycerides
	Phospholipase	Digestion of any phospholipids
	Trypsin	Long peptide digestion
	Chemotrypsin	Splitting of chemical bonds between polypeptides

# Components of gastrointestinal secretions

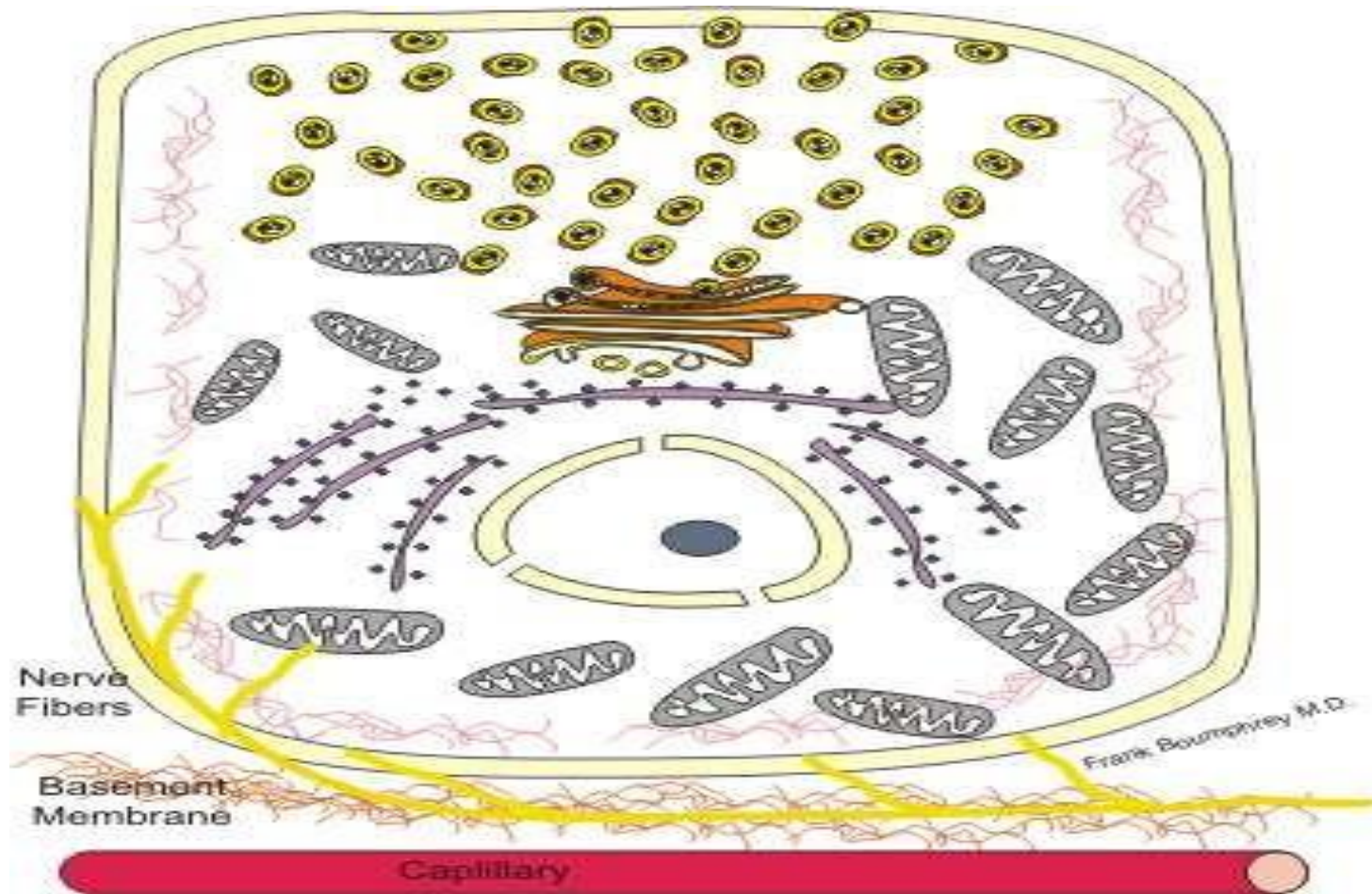
## Digestive Enzymes

LOCATION	ENZYME NAME	ACTION
Intestinal Epithelium	Enterokinase	Activation of intestinal proteolytic enzymes
	Endopeptidases	Splitting of bonds inside a polypeptide
	Exopeptidases	Splitting of terminal bonds
	Aminopeptidase	Splitting of amine end from a polypeptide
	Carboxypeptidase	Splitting of carboxyl end from a polypeptide
	Sucrase	Splitting of sucrose into two glucose molecules
	Maltase	Splitting of maltose
	Lactase	Splitting of lactose

# Mechanism of formation and secretion of Digestive Enzymes

- Digestive enzymes are secreted by glandular cells which will store the enzyme in **secretory vesicles** until they are ready to be released.
- These cells are characterised by a robust rough endoplasmic reticulum and numerous mitochondria.
- Passage of materials from the ribosomes, through the endoplasmic reticulum and Golgi body to the secretory vesicles takes about 20 minutes.

# Mechanism of formation and secretion of Digestive Enzymes



# Components of gastrointestinal secretions

## A- Mucous Secretions

- Mucous is a viscous secretion used for protection and lubrication.
- It consists mainly of **Glycoproteins**.
- In the mouth about 70% of the mucous is secreted by the **minor salivary glands**.
- **Mucous cells** in the stomach.
- **Goblet cells** in the small intestine. Up to 25% of the intestinal epithelial cells are goblet cells.

# Mucous Secretions

Mucous has the following properties:

1. Adherent properties, it sticks well to surfaces
2. to prevent contact of most food particles with tissue
3. Lubricates well - has a low resistance to slippage
4. Strongly resistant to digestive enzymes
5. Neutralizing properties. As well as a buffer like effect, mucous can also contain large quantities of bicarbonate.

# B- Hormonal Secretions

HORMONE	SECRETING CELL	TARGET TISSUE	RELEASING STIMULI	RESULTING EFFECTS
<b>GASTRIN</b>	G-cells in the gastric antrum	<ol style="list-style-type: none"> <li>1. Histamine-secreting cells</li> <li>2. Gastric acid secreting cells</li> </ol>	<ul style="list-style-type: none"> <li>•Chemical stimuli as peptides in chyme</li> <li>•Neural stimuli through Cr-X and ENS</li> </ul>	Increases acid secretion in stomach
<b>CHOLECYSTOKININ (CCK)</b>	Endocrine cells of small intestine	<ul style="list-style-type: none"> <li>-Gall bladder</li> <li>-Pancreas</li> <li>-gastric muscle</li> </ul>	Fat in the duodenal chyme	<ol style="list-style-type: none"> <li>1. gallbladder contraction</li> <li>2. inhibits gastric emptying;</li> <li>3. stimulates secretion of Pancreatic Enzymes</li> </ol>



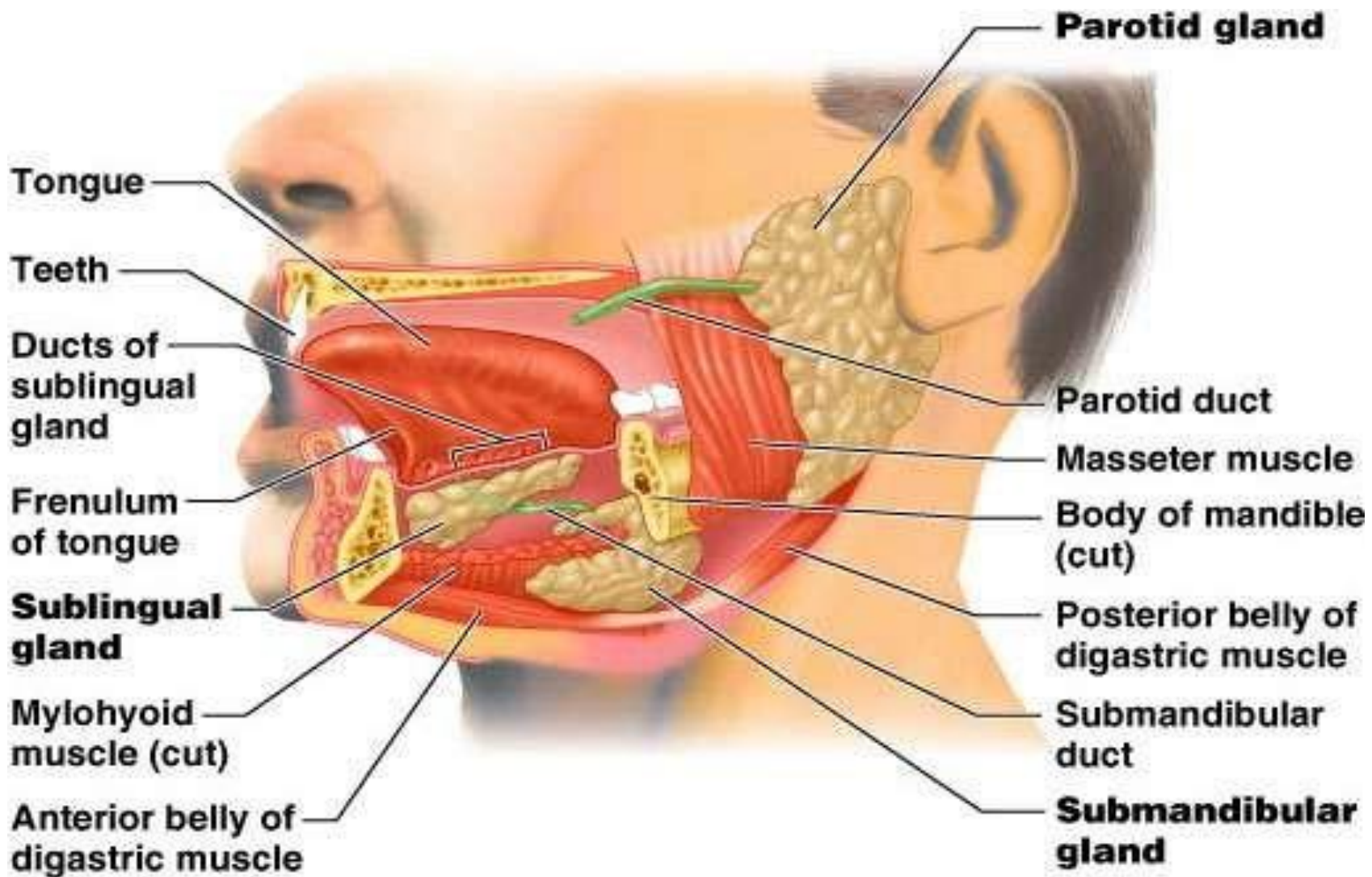
# Hormonal Secretions

HORMONE	SECRETIN G CELL	TARGET TISSUE	RELEASIN G STIMULI	RESULTIN G EFFECTS
<b>SECRETIN</b>	Endocrine cells of small intestine	<ol style="list-style-type: none"> <li>1. Exocrine Pancreas</li> <li>2. Gastric acid secreting cells</li> <li>3. Pyloric Musculature</li> <li>4. LES</li> </ol>	<ul style="list-style-type: none"> <li>•Chemical stimuli as peptides in chyme</li> <li>•Neural stimuli through Cr-X and ENS</li> </ul>	<ol style="list-style-type: none"> <li>1. Increase bicarbonate secretion</li> <li>2. Inhibit acid secretion</li> <li>3. Stimulatory for sphincters</li> </ol>
<b>MOTILIN</b>	Endocrine cells of small intestine	<p>-Gastric antral musculature</p> <p>-Duodenal musculature</p>	Fasting	Evokes hungar pangs

# ORAL CAVITY SECRETION OF “SALIVA”

- The Salivary glands consist of the **parotid, submandibular, and sublingual** glands as well as numerous smaller **buccal** glands secreting both *serous* and *mucoïd* secretions.
- The parotid secretions are mainly serous, the buccal glands mucus, and the sublingual and submandibular are a mixture of the two.
- The acini secrete proteins and a fluid similar in consistency to interstitial fluid, and the ducts exchange the sodium for potassium and Bicarbonate for chlorine leaving saliva that is rich in Potassium and bicarbonate ions.
- The glands secrete between 800-1500 ml per day

# SALIVARY GLAND



# SALIVARY GLAND

Primary secretions  
(Ptyalin, Mucous, Extracellular fluid)



F.B.2009

Secondary Secretions  
( $K^+$  &  $HCO_3^-$ )

Schematic Diagram of Salivary Gland

# SALIVARY SECRETIONS

- The sodium ions are actively reabsorbed, and the potassium ions are actively secreted at the luminal side of the cell with an excess of sodium reabsorption causing a -70mV gradient.
- This causes passive reabsorption of chlorine ions.
- Bicarbonate ions are both passively exchanged , and actively secreted in exchange for chlorine.

# Stomach

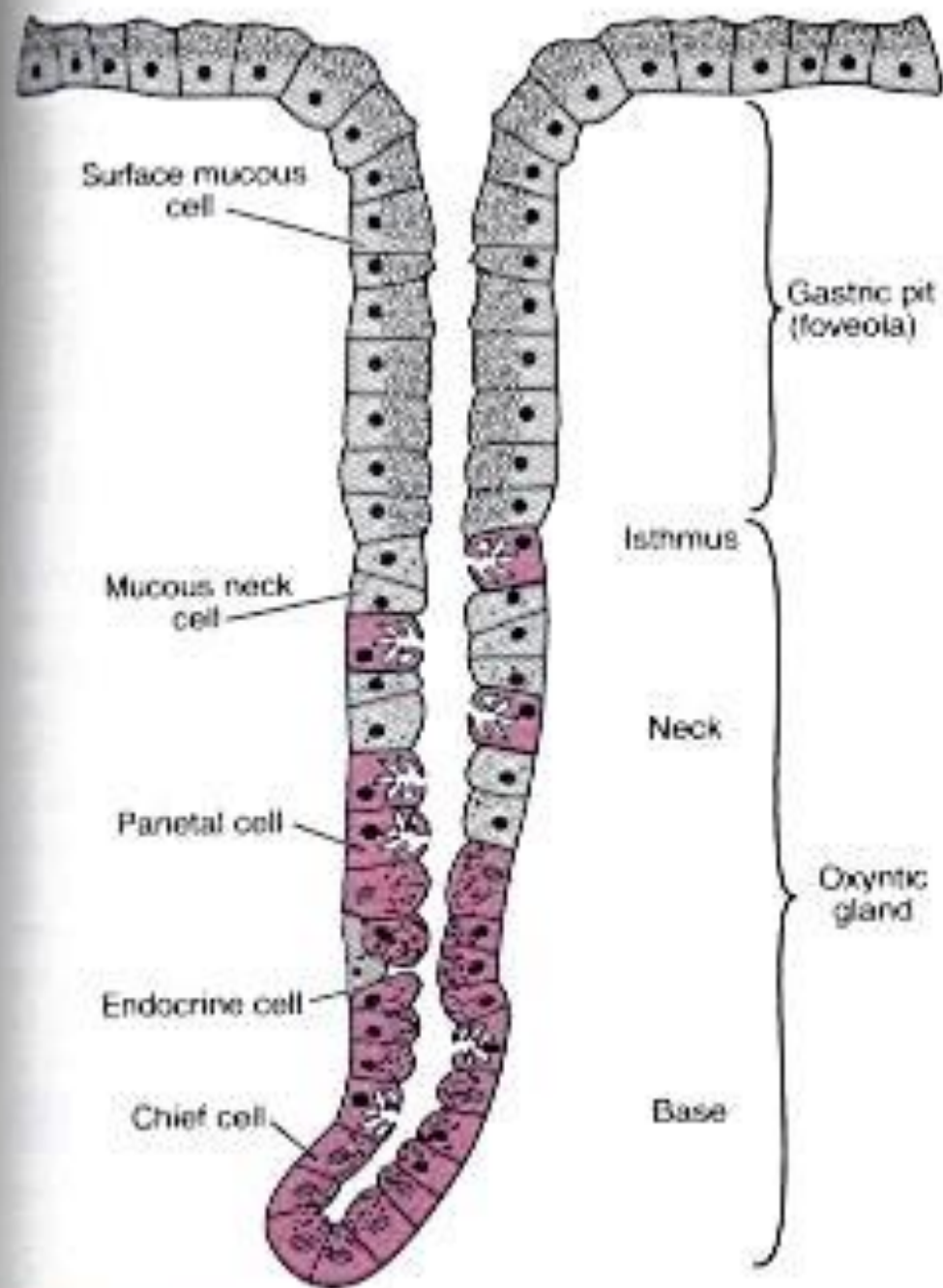
- Types of Gland

(located in gastric mucosa):

- Cardiac Glands

- Pyloric glands (many G cells)

- Oxyntic glands (most abundant, found in fundus and corpus)



A simplified diagram of the gastric gland

# Types of Cell

- Parietal cells
- most distinctive cells in stomach (HCl & intrinsic factor)
- Chief cells
- pepsinogen
- Mucus neck cells:
  - $\text{HCO}_3^-$
  - Mucus



# Types of Cells

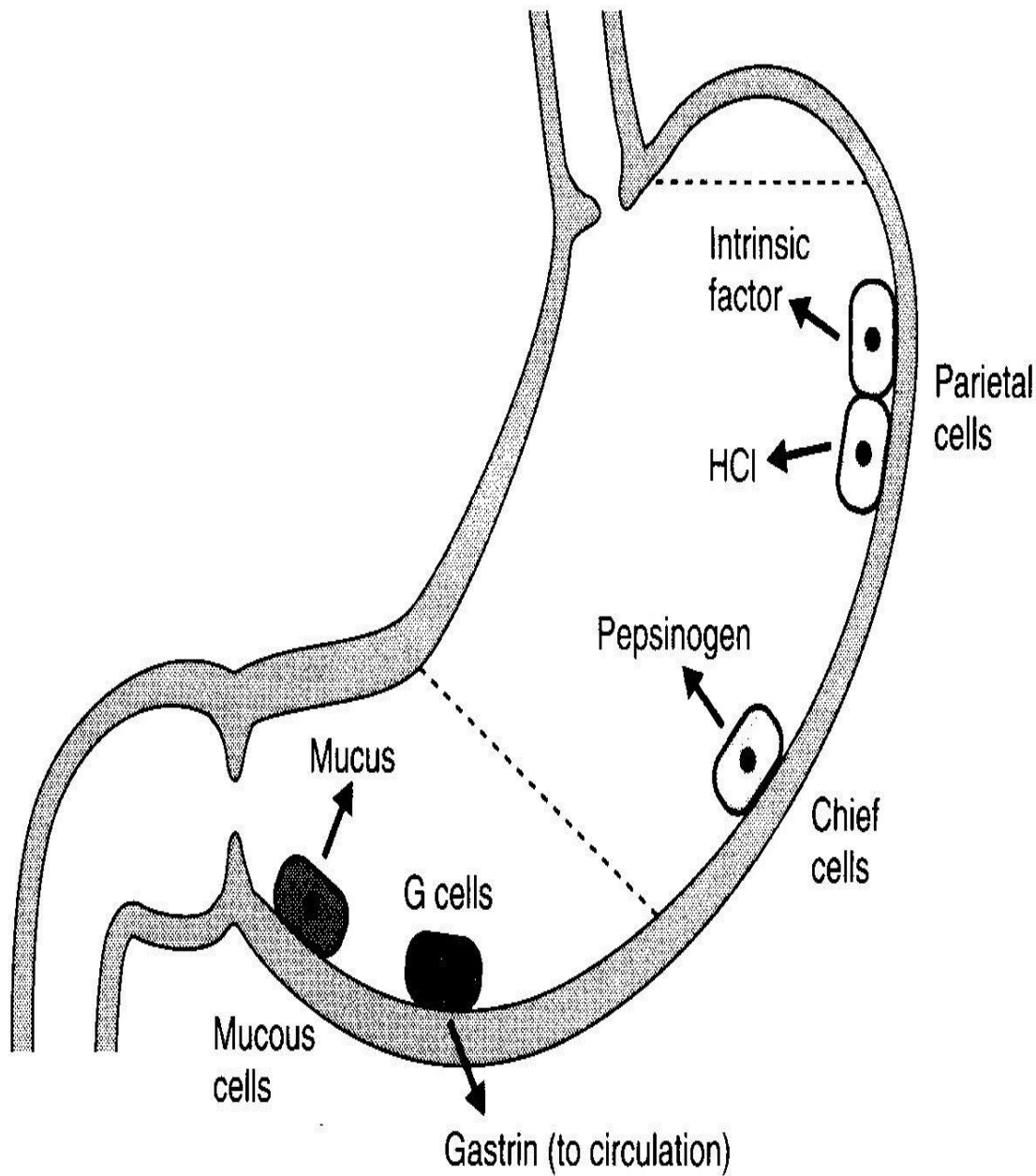
□ G Cells: Gastrin (hormone) - ↑ -->

HCl secretion

□ D Cells: Somatostatin (antrum)

□ Enterochromaffin-like cell:

Histamine



Cell Type	Location	Secretion
Parietal cells	Body	HCL Intrinsic factor
Chief cells	Body	Pepsinogen
G cells	Antrum	Gastrin
Mucous cells	Antrum	Mucus Pepsinogen

# Gastric juice

- HCL
- Pepsinogen
- Electrolytes
- Intrinsic factor
- Mucus (mucus gel layer)

- GI Hormones - secreted from the endocrine cells
- especially in stomach & small intestine
- endocrine cells
  - Enteroendocrine - GI hormones
  - Enterochromaffin - serotonin
  - APUD – amines & polypeptides (neuroendocrine cells)



1. Gastrin family-gastrin & CCK
2. Secretin family-secretin, glucagon, GLI, VIP & GIP
3. Other polypeptides



# Gastrin

- pyloric glands (G Cells)-antral portion of the stomach
- also found in the pancreatic islets in fetal life
- *anterior & intermediate lobes of the pituitary gland, in the hypothalamus, medulla oblongata, & in the vagus & sciatic nerves*



# Functions

- stimulation of gastric acid & pepsin secretion
- stimulates growth of gastric mucosa & mucosa of intestine
- ↑gastric motility
- contraction of muscles at the gastro-esophageal junction
- exocrine pancreatic secretion
- insulin secretion
- stimulates mass movement of large intestine
- colonic contraction that initiates gastrocolic reflex after a meal



# Factors that ↑gastrin secretion

## ○ Luminal

- Peptides & amino acids
- Distension

## ○ Neural

- ↑vagal discharge via GRP (gastrin releasing peptides)

## ○ Blood-borne

- Calcium
- Epinephrine





# Factors that ↓ gastrin secretion

- Luminal
  - Acid
  - Somatostatin
- Blood-borne
  - Secretin, GIP, VIP, Glucagon



# Cholecystokinin-Pancreozymin (CCK-PZ or CCK)

- I cells in the upper intestine
- nerves in the distal ileum & colon
- neurons in brain ( cerebral cortex) & in nerves in many part of the body
- peptides & amino acids, & long chain fatty acids



# Functions

- pancreatic secretion rich in enzymes
- augments the action of secretin to produce alkaline pancreatic secretion
- relaxation of sphincter of Oddi
- stimulate growth of pancreas
- inhibits gastric acid secretion
- inhibits gastric motility-delays gastric emptying

- causes contraction of gall bladder
- ↑secretion of enterokinase
- enhance motility of small intestine
- stimulates colonic movements
- augments contraction of pyloric sphincter
- stimulates glucagon secretion



# Secretin

- S cells located in the mucosa of the upper part of small intestine (duodenum & jejunum)
- polypeptide hormone (27 AA)
- acid chyme ( $\downarrow$  4.5-5.0)- secretin



# Functions

- ↑secretion of pancreatic juice rich in bicarbonate
- ↑alkaline bile secretion
- augments the action of CCK to produce pancreatic secretion rich in enzymes
- ↓gastric acid secretion & motility
- contraction of pyloric sphincter



### GIT Secretions summarization

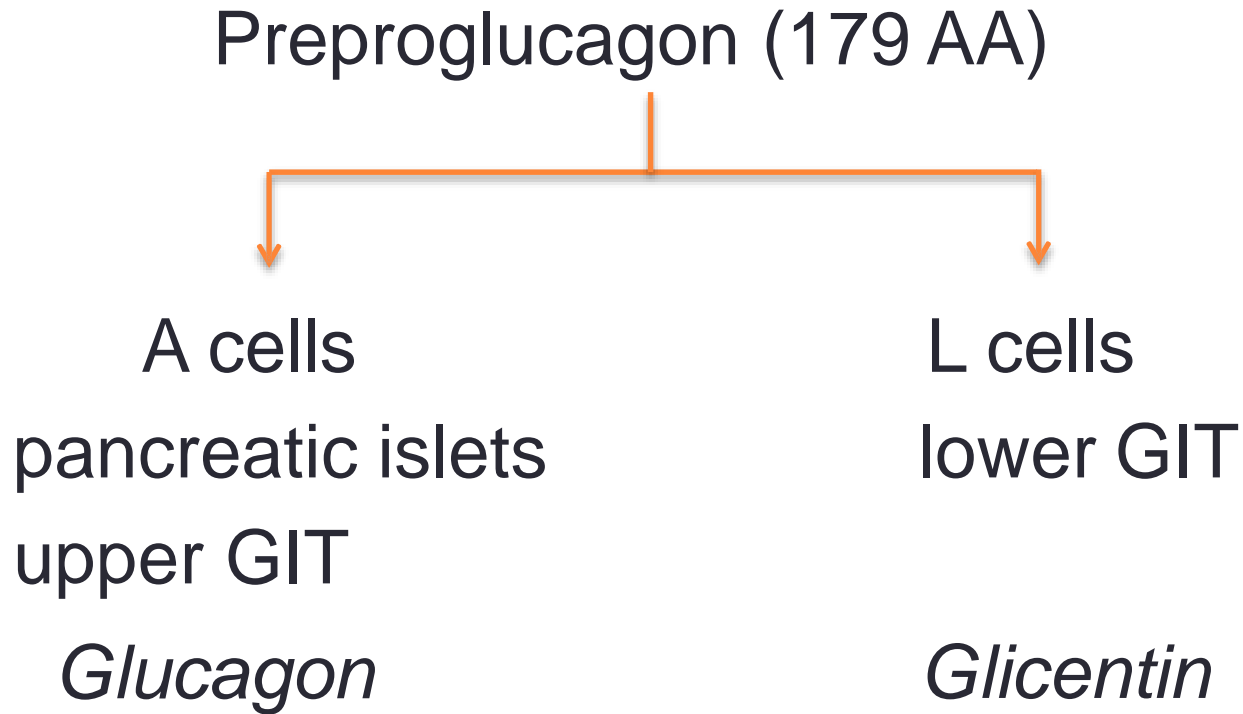
By: Olla BaEissa

Secretion	saliva	Gastric juice	Pancreatic juice	Hepatic bile	Gall bladder bile
Amount	1.0 – 1.5 L/ day	2-3 L/ day	1500 ml/ day	500 ml/ day	
PH	pH – 6.8 – 7.2	pH is 1-3 (highly acidic)	pH – 7.8 – 8.4 (alkaline )	pH 7.8 – 8.6 color is golden yellow	pH 7.0 – 7.4 color is dark green
Composition	99.5 % water & 0.5% others includes: Electrolytes, glycoproteins (mucins), antibodies, Enzymes, Lysozyme, Lactoferrin, kallikrein	97 – 99 % water contains inorganic salts, & Others organic components include: <u>mucin</u> , <u>digestive enzymes</u> and <u>hormones</u> .	- Water solution of enzymes & electrolytes (primarily HCO <sub>3</sub> <sup>-</sup> )	- water, bile salts, neutral fats, phospholipids and electrolytes, & Cholesterol and bile pigments from the breakdown of hemoglobin.	
The glands produce it	- the parotid, - the submandibular - the sublingual glands.	- Enteroendocrine cells - Chief cells: pepsinogen - Parietal cells: HCl & IF - mucus neck cells: mucus	- Pancreas (exocrine secretion)	- liver hepatocytes	
Functions	3- Stimulate taste buds 4- contain IgA 5- Contain Lysozyme and Lactoferrin to protect the mouth from excess bacteria. 6- contain Proline rich proteins to protect tooth enamel 7- Buffering 8- neutralizes gastric acid 9- reduces heart burn 10- Initiate digestion of carbohydrates by salivary amylase 1- Lubricating the mouth and mucus for protection of oral mucosa, mastication & swallowing. 2- Moistening – speech	- secrete hormones that regulate stomach functions, peristalsis, and secretions. - initiate digestion of proteins - converts hormones - chemical digestion - provides optimal pH - destroys some bacteria - Stops carbohydrate digestion - secrete a mucus protect the epithelium from chemical insults. - secrete a mucus that coats and lubricates the gastric surface	- Neutralizes acidic chyme - Provides optimal pH for pancreatic enzymes in digestion	- important for digestion and absorption of fats & fat-soluble vitamins in the small intestine. - Many waste products, including bilirubin, are eliminated from the body by secretion into bile. - acts to some extent as a surfactant - helping to emulsify the lipids in food. - neutralizing any excess stomach acid in the duodenum.	

Regulation of Secretion	Sympathetic and parasympathetic are stimulatory	1- Sympathetic and parasympathetic 2- hormonal regulation	1- hormonal regulation CCK & Secretin	1- hormonal regulation choleterics and cholagogues
Conditions where saliva is more	Chewing, Taste, Smell Conditioned reflex, Nausea			
Conditions where saliva is less	Sleep, Fatigue, Dehydration, fear			



# Glucagon & Glicentin



- produces hyperglycemia

## **VIP (*vasoactive intestinal peptide*)**

- polypeptide containing 28 AA
- nerves in the GIT
- also found in blood
- also found in the brain & autonomic nerves



# Functions

- ↑intestinal secretion rich in electrolytes & water
- causes vasodilation
- ↓GI motility
- potentiates the action of acetylcholine on salivary glands
- inhibits gastric acid secretion



## **GIP** (*gastric inhibitory peptide*)

- polypeptide hormone containing 42 AA
- K cells present in the mucosa of duodenum & jejunum
- inhibits gastric acid secretion & motility
- stimulate insulin secretion



# Motilin

- polypeptide hormone containing 22 AA
- enterochromaffin cells & Mo cells present in the mucosa of GIT
- ↑GI motility (interdigestive phase)



# Neurotensin

- a polypeptide hormone containing 13 AA
- neurons & mucosal cells of ileum
- inhibits gastric acid secretion but ↑ ileal blood flow



# Substance P

- Endocrine & nerve cells in the GIT
- ↑intestinal motility of the small intestine



# Somatostatin

- a polypeptide containing either SS 14 or SS 28
- D cells in GIT, *hypothalamus*, *D cells of pancreas*
- inhibits secretion of gastrin, VIP, secretin & motilin
- inhibits pancreatic exocrine secretion; gastric acid secretion & motility; gall bladder contraction; & absorption of glucose, amino acids & triglycerides



## **GRP** (*gastrin releasing peptide*)

- polypeptide containing 27 AA
- vagal nerve endings that terminate on G cells
- ↑gastrin secretion



# Guanylin

- polypeptide hormone containing 15 AA
- secreted from the paneth cells
- ↑secretion of Cl<sup>-</sup> into the intestinallumen



# Peptide YY

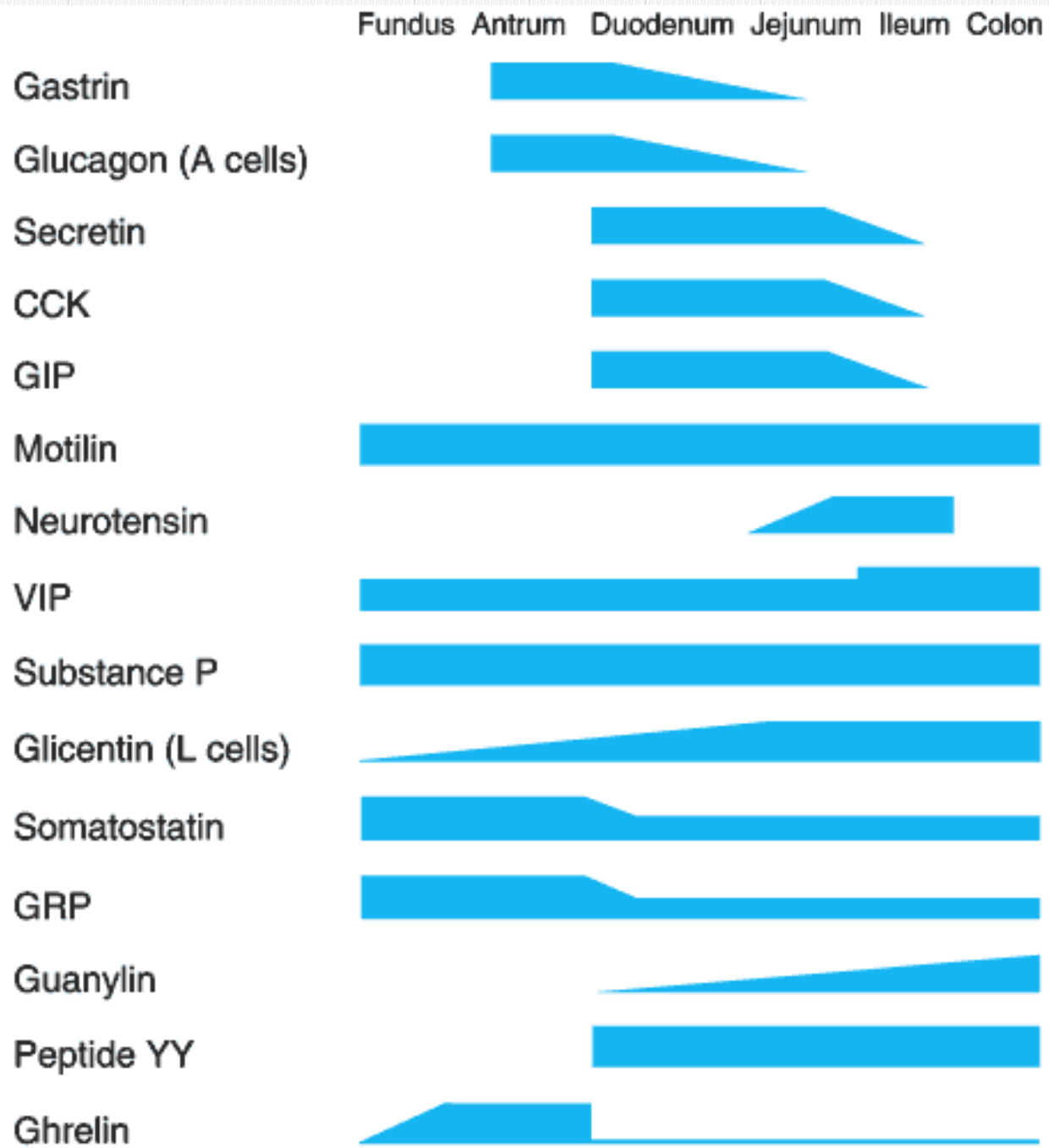
- entire GIT (ileum & colon)
- inhibits the food intake
- inhibits gastric acid secretion & motility



# Ghrelin

- polypeptide (28 AA)
- oxyntic cells of stomach (intestine)
- ↓when food is eaten & ↑during fasting





# References

Guyton and Hall, text book of medical physiology-11/E

Ganong Review of Medical Physiology, 22/E



**THANK YOU**