Secretory Functions of the Alimentary Tract

Saliva & gastric secretion

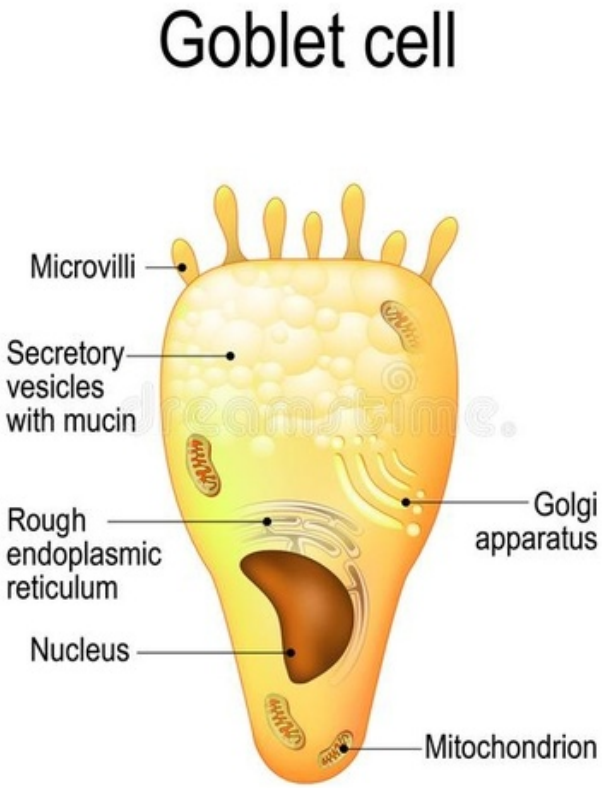
Dr. Iman Aolymat
imank@hu.edu.jo

Functions of Secretory Glands

- Digestive enzymes secretion - mouth → distal end of ileum
- Mucus secretion for lubrication & protection- mouth → anus

Types of Secretory Glands

- Single cell mucous glands/ mucous cells/goblet cells- extrude mucus → epithelial surface → lubrication & protection



The importance of mucus in GI

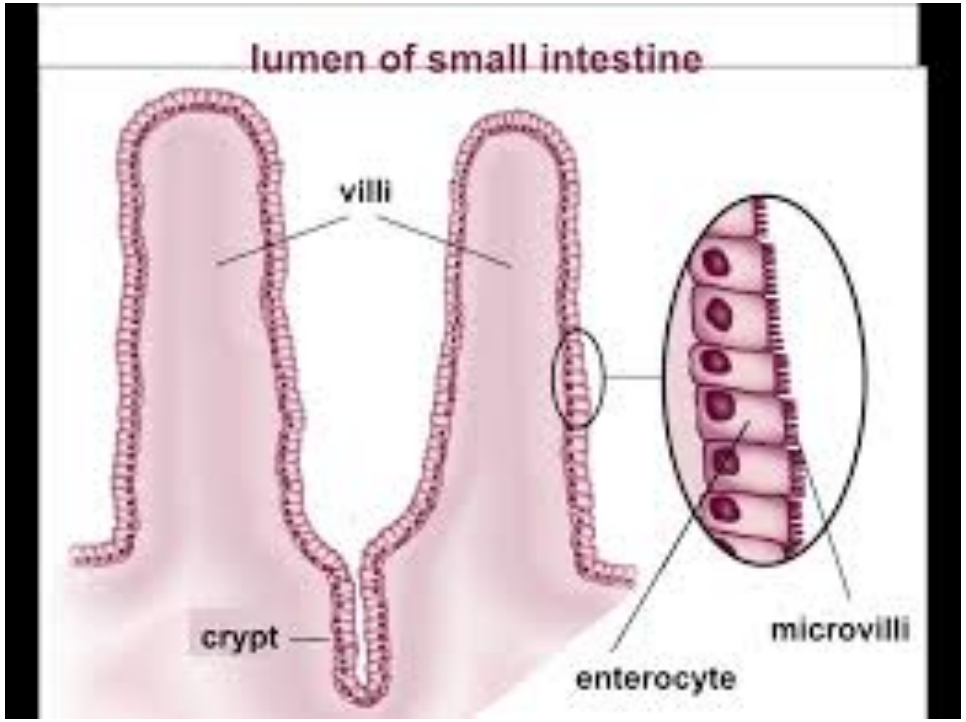
• Mucus is thick secretion composed mainly of water, electrolytes & glycoproteins.

• **Lubricant & protectant for wall of gut**

1. Has adherent qualities.
2. Coats gut wall & prevents contact of food with mucosa.
3. Sliding of food.
4. Adhering fecal particles together forming feces.
5. Resistant to digestion by GI enzymes.
6. Glycoproteins of mucus are capable of buffering small amounts of acids or alkalies.

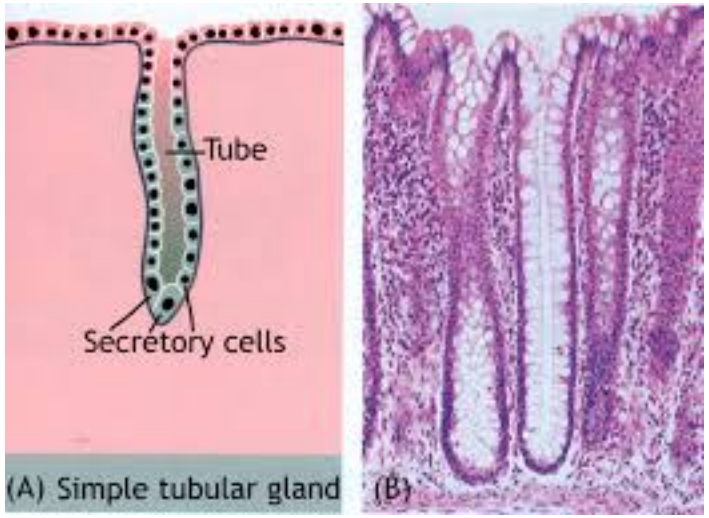
Types of Secretory Glands

Pits - invaginations of epithelium into submucosa (crypts of Lieberkühn)



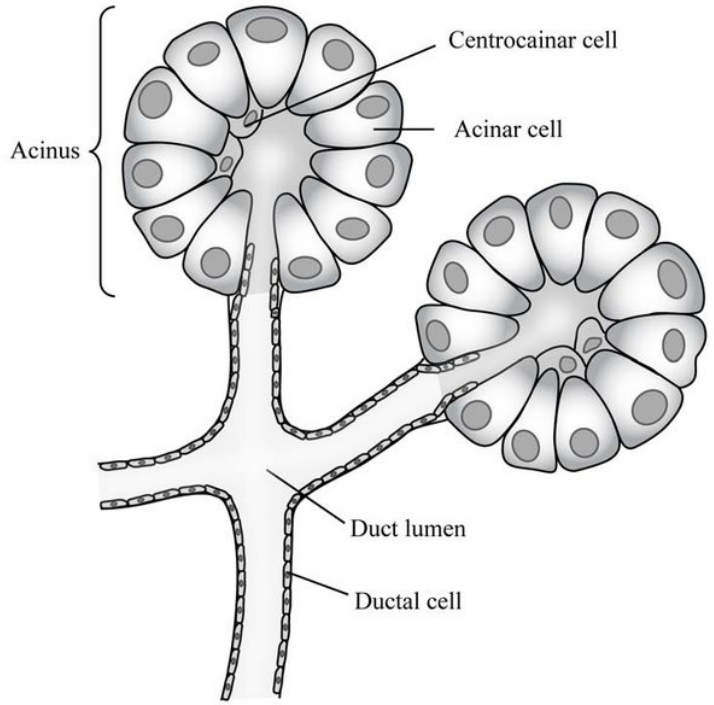
Types of Secretory Glands

- Tubular - acid & pepsinogen secreting oxyntic gland-stomach & upper duodenum



Types of Secretory Glands

- Complex - salivary, pancreas → compound acinous glands (acini+ducts)
  - liver



Control of Glandular Secretions

- Local - tactile, distention, irritation
- Reflex - nervous input
- Hormonal - G.I. hormones (stomach & intestine)→gastric & pancreatic juice secretion

Parasympathetic. ↑ rate of secretion

Glossopharyngeal, vagus →salivary, esophageal, gastric, pancreas & Brunner's glands in D

Pelvic n.→ glands of distal LI

Sympathetic - ↑ or ↓ (vasoconstriction) rate of secretion

Secretion of organic substance, Water and Electrolyte

1- Nutrient material from base.

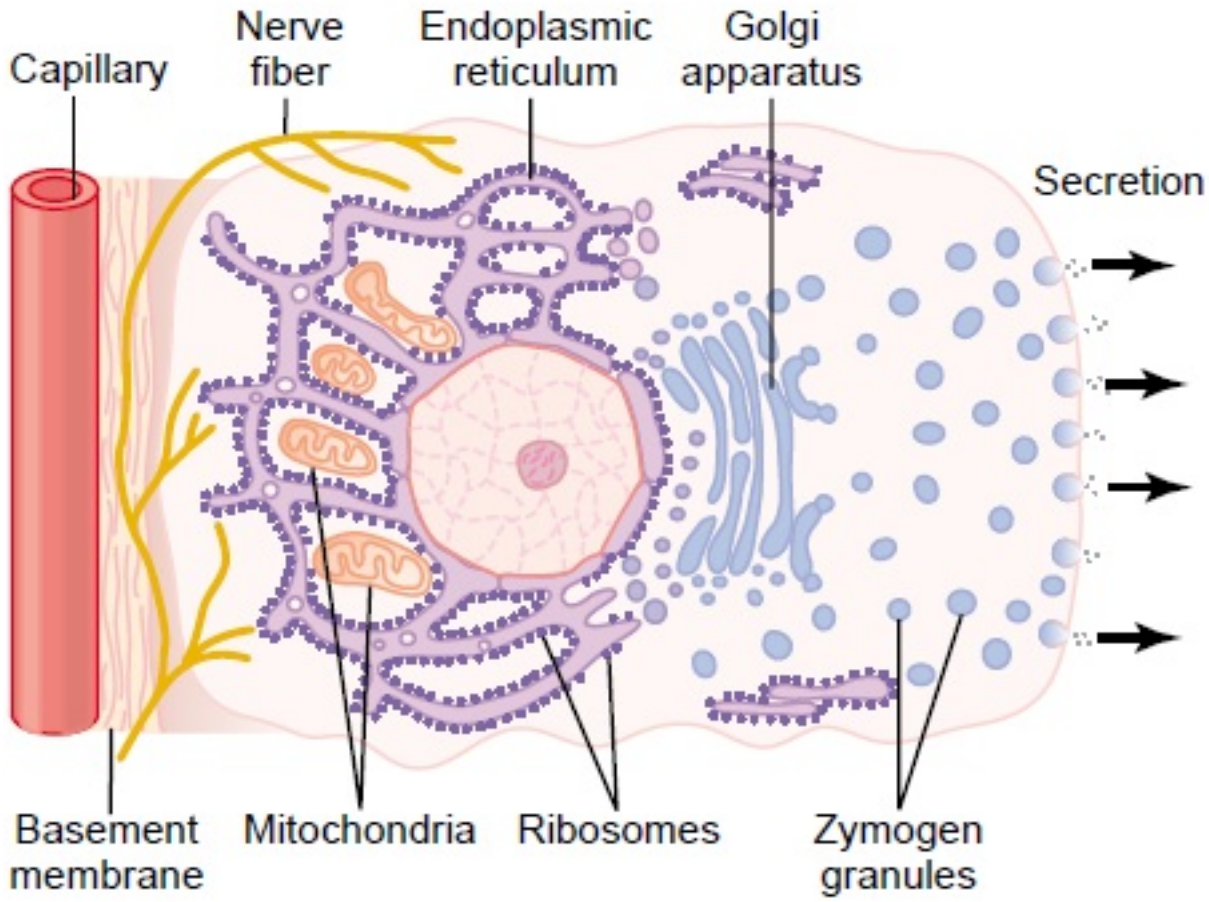
2- Mitochondria produce atp.

3- ATP is used for synthesis of protein by the help of er and ribosome.

4- This protein fuse with the golgi complex for processing then forming into a secretory vesicles.

5- This vesicle will rmain in the cell until hormonal and neural stimulation.

6- Ca will cause release of these vesicles by exocytosis.

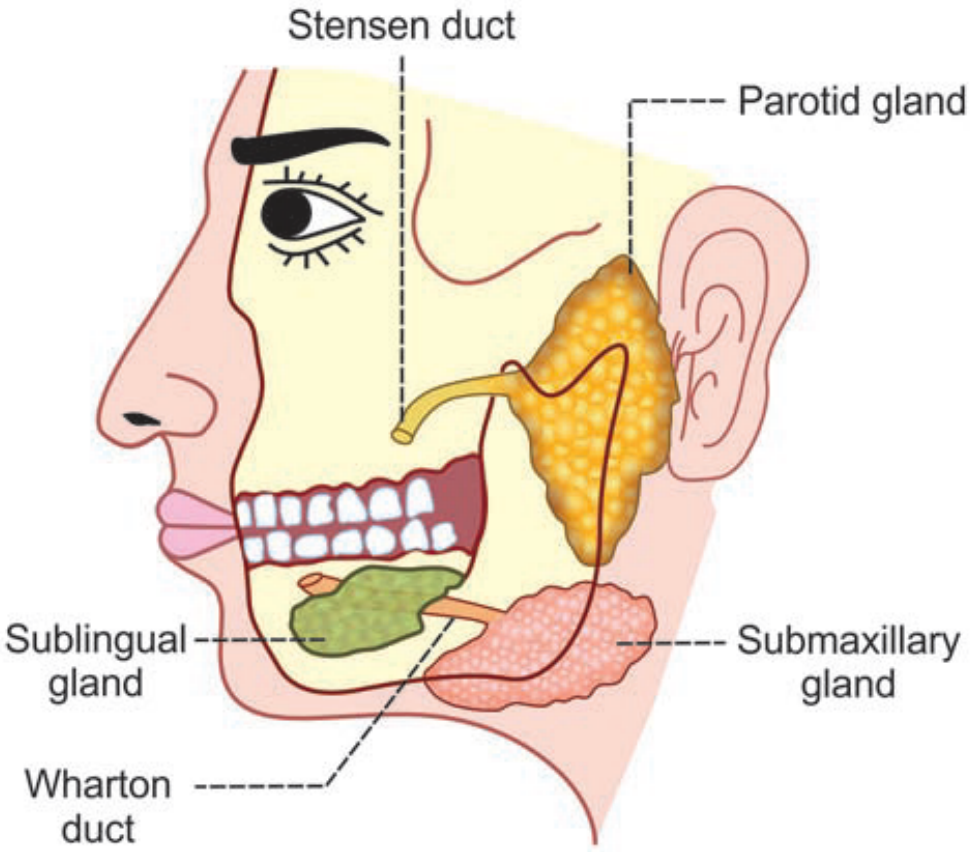


Nervous/hormonal stimulation → water and salts to pass through the glandular cells → washing organic substances through the secretory border of the cells at the same time.

MAJOR SALIVARY GLANDS

1. Parotid glands
2. Submaxillary or submandibular glands
3. Sublingual glands

Buccal glands



Secretion of saliva

- Two types of secretion -
  - Serous - watery secretion, contain α-amylase (ptyalin), starch digestion enzyme
  - Mucous - contains mucin – lubrication & surface protection

- Parotid (serous)
- Buccal (mucus)
- Submandibular + sublingual (mixed)

- Maximum rate of secretion: 4 ml/min
- Flow of saliva decreases during sleep
- Secrete 800-1500 ml/day (avg of 1000) of saliva
- pH 6-7

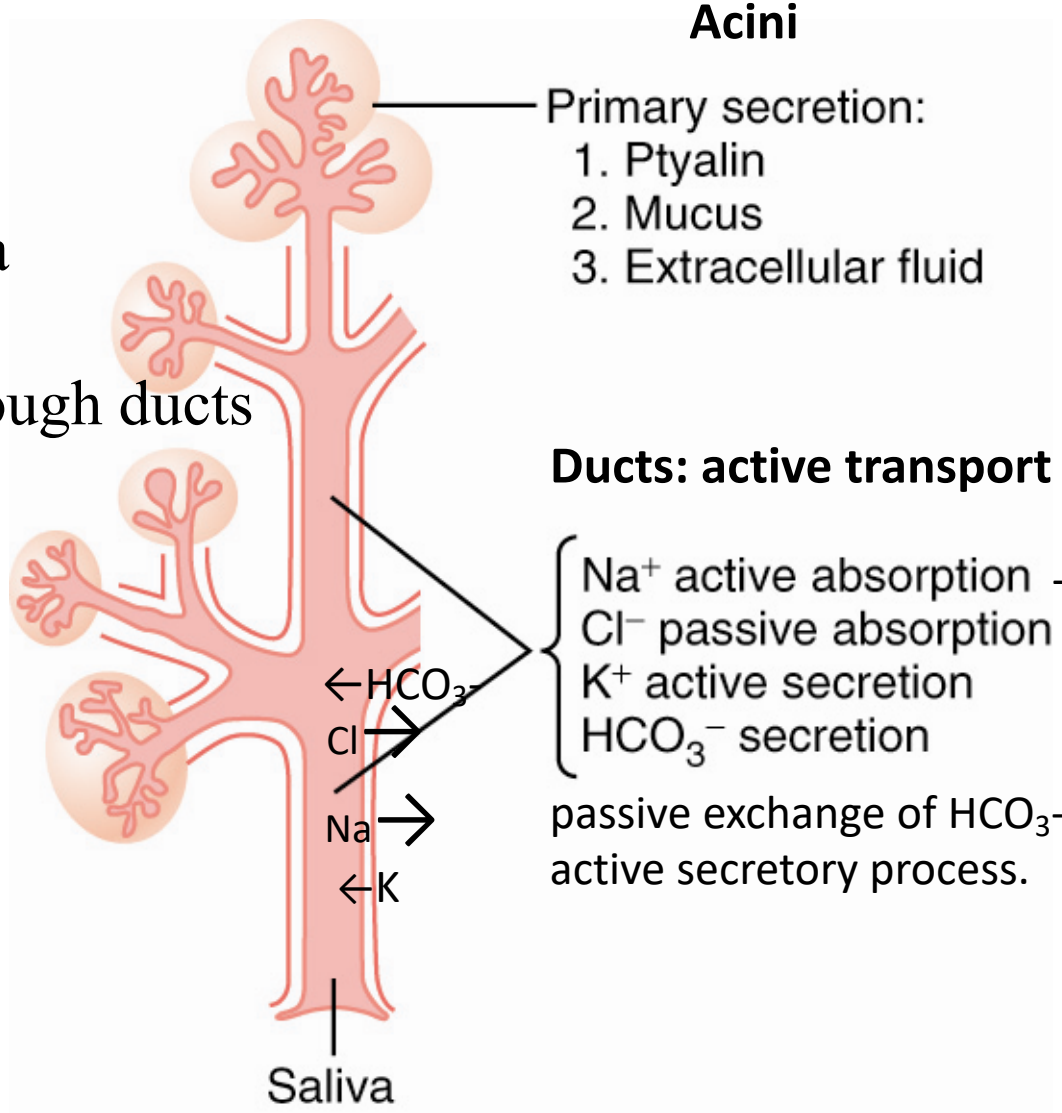
Functions of Saliva

- Lubrication
- Solubilizes dry food
- Oral hygiene
  - (wash bacteria, thiocyanate ions, lysozyme & antibodies destroy bacteria)
- Digestive function

Enzyme	Source of secretion	Activator	Action
Salivary amylase	All salivary glands	Acid medium	Converts starch into maltose
Maltase	Major salivary glands	Acid medium	Converts maltose into glucose
Lingual lipase	Lingual glands	Acid medium	Converts triglycerides of milk fat into fatty acids and diacylglycerol

Formation and Secretion of Saliva

- Two Stages -
  - Acini - primary secretion similar to plasma
  - Salivary Ducts - modified as it passes through ducts

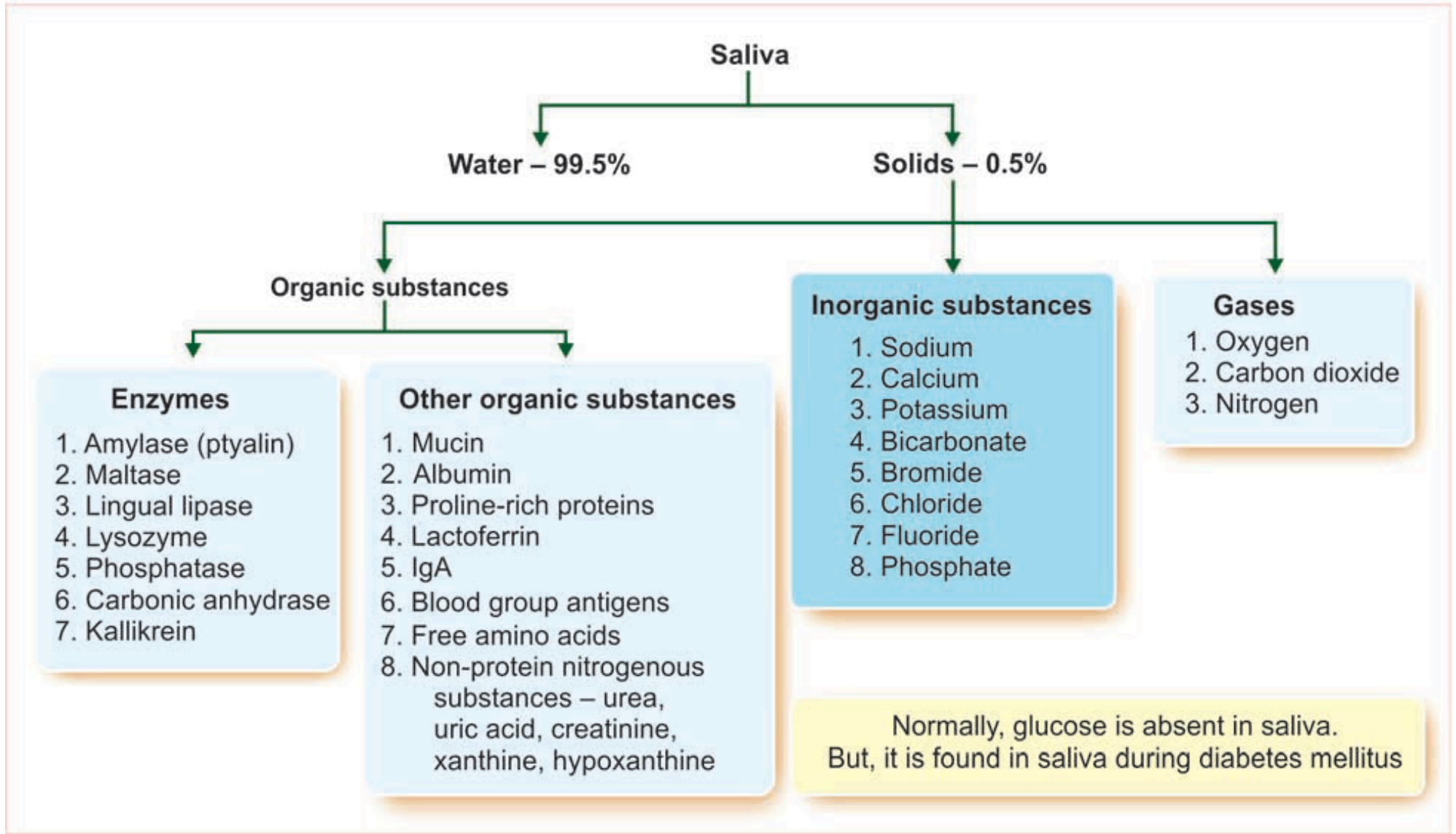


secretion of saliva by a submandibular salivary gland.

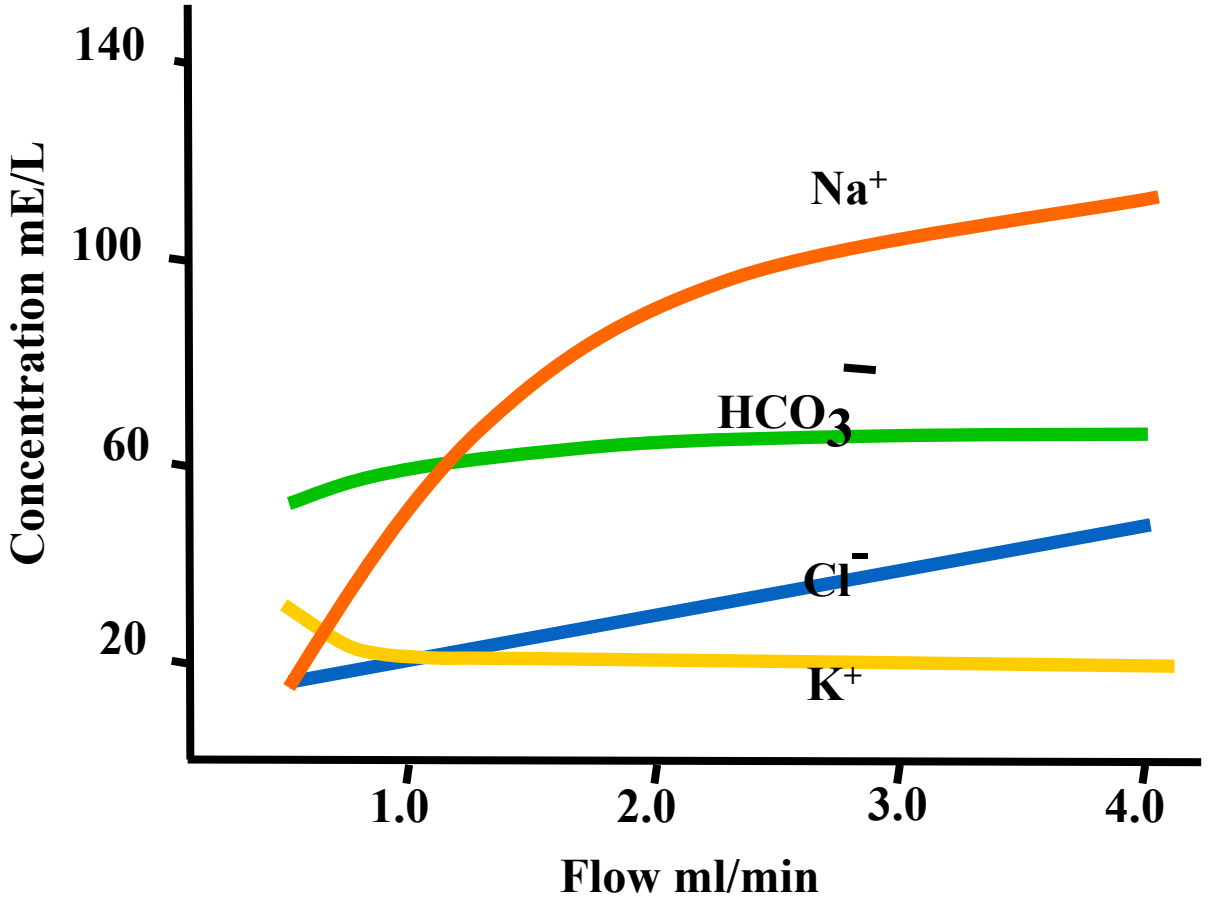
Ionic composition of Saliva

- Ionic composition depends upon rate of secretion.
- Resting composition are:
  - Na^+ & Cl^- - 1/7-10 x plasma (15 mEq/L)
  - K^+ - 7 x plasma (30 mEq/L)
  - HCO^-_3 - 2-3 x plasma (50-70 mEq/L)

- Saliva is hypotonic
- During maximal salivation rate ↑ by 20-folds (osmolarity increases →[Na^+& Cl^-] is 1/2 or 2/3 X plasma, [K^+] 4X plasma
- Loss of saliva from body can lead to K^+ depletion


Saliva
Water – 99.5%
Solids – 0.5%
Organic substances
Inorganic substances
1. Sodium
2. Calcium
3. Potassium
4. Bicarbonate
5. Bromide
6. Chloride
7. Fluoride
8. Phosphate
Gases
1. Oxygen
2. Carbon dioxide
3. Nitrogen
Enzymes
1. Amylase (ptyalin)
2. Maltase
3. Lingual lipase
4. Lysozyme
5. Phosphatase
6. Carbonic anhydrase
7. Kallikrein
Other organic substances
1. Mucin
2. Albumin
3. Proline-rich proteins
4. Lactoferrin
5. IgA
6. Blood group antigens
7. Free amino acids
8. Non-protein nitrogenous substances – urea, uric acid, creatinine, xanthine, hypoxanthine
Normally, glucose is absent in saliva.
But, it is found in saliva during diabetes mellitus

Saliva

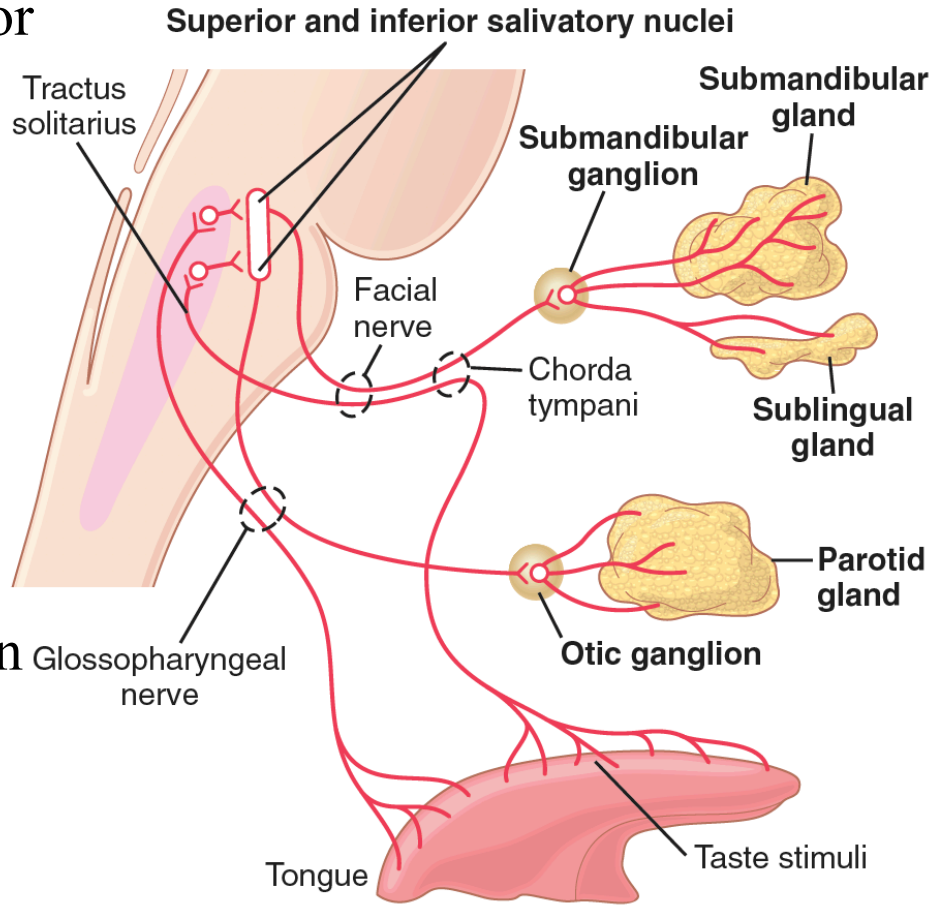

140
100
60
20
Concentration mE/L
Na^+
HCO_3^-
Cl^-
K^+
1.0
2.0
3.0
4.0
Flow ml/min

Nervous Regulation of Salivary Flow

- Controlled mainly by **PSN** signals from superior and inferior salivatory nuclei in BS (at juncture of M & P)

- Excited by taste & tactile stimuli from tongue, mouth & pharynx
- Appetite area in CNS control salivation

- Sour taste →↑ salivation (8-20 fold ↑)
- Smooth objects→ ↑ salivation, Rough objects→ ↓ salivation
- Reflexes in stomach and upper SI (irritation & nausea)→ ↑ salivation



Nervous Regulation of Salivary Flow

- **Sympathetic**→ ↑ salivation, weaker than parasympathetic stimulation.
- Sympathetic nerves originate from Superior Cervical G. and travel along surfaces of blood vessel walls to salivary glands.
- PSN → blood supply to glands (vasodilation) →↑ salivation
- ↑ Salivation →vasodilation (kallikrein splitting alpha2-globulin, forming VD bradykinin)

Esophageal secretions

- Main body of esophagus → simple mucous glands
- Gastric end & initial portion of esophagus → compound mucous glands
- Mucous secretions only →lubrication for swallowing & protect mucosa (food & acid reflux)

Gastric Secretion

- **Glands of stomach:**

1- **Mucus**-secreting cells

2- **Oxyntic / gastric/ parietal** (acid-forming) glands

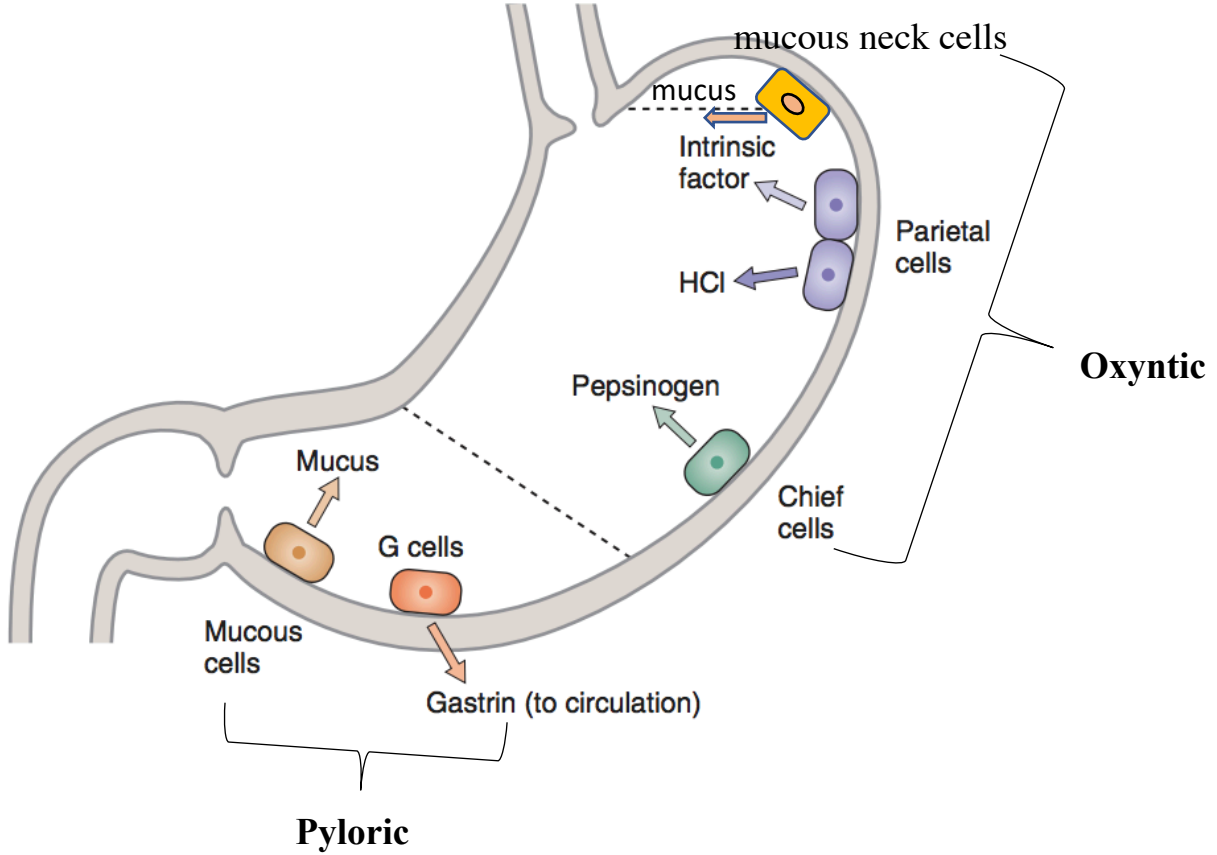
✓ -Located on inside surfaces of body & fundus (proximal 80%)

✓ -Secrete HCl, Pepsinogen, Intrinsic factor, Mucus.

3- **Pyloric glands**

✓ Located in antrum (distal 20%)

✓ Secrete mucus, gastrin

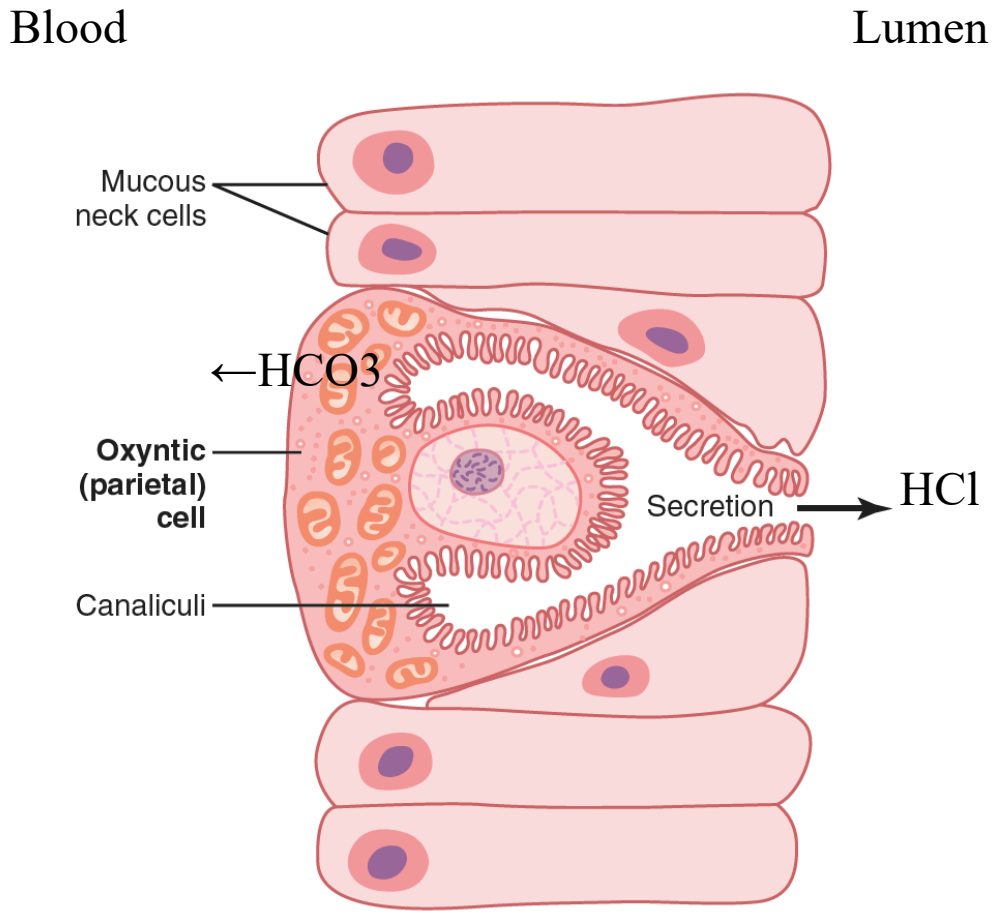


Gastric Acid

- Three major functions -
  - Bacteriostatic
  - Converts pepsinogen to pepsin
  - Begins protein digestion (with pepsin)

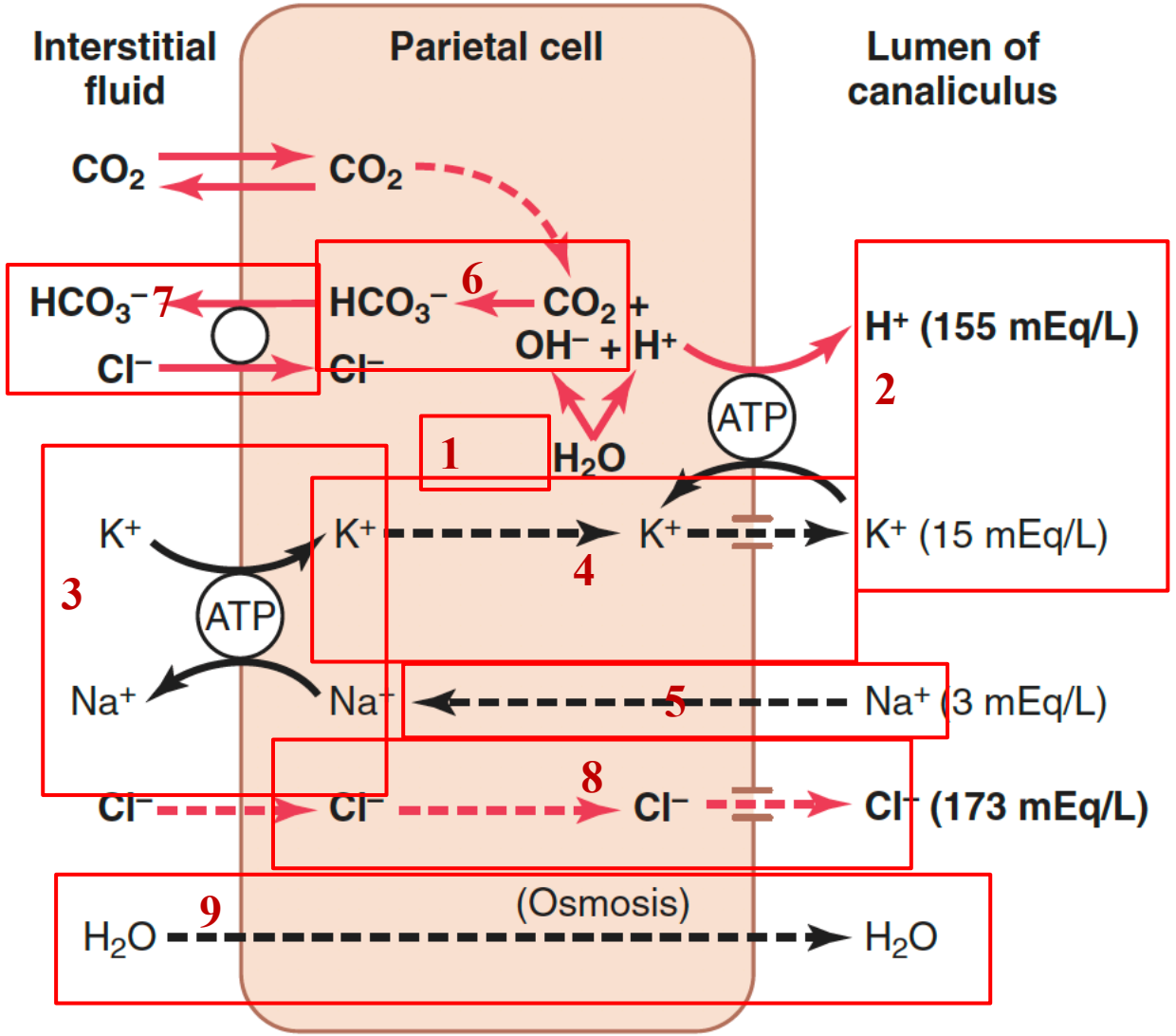
Parietal Cell

- Gastric juice contains 160 mmol/L of HCl (isotonic with body fluid)
- pH= 0.8, [H^+] 3 million * arterial blood
- HCl is formed at the villus-like membranes of the canaliculi which are continuous with the lumen

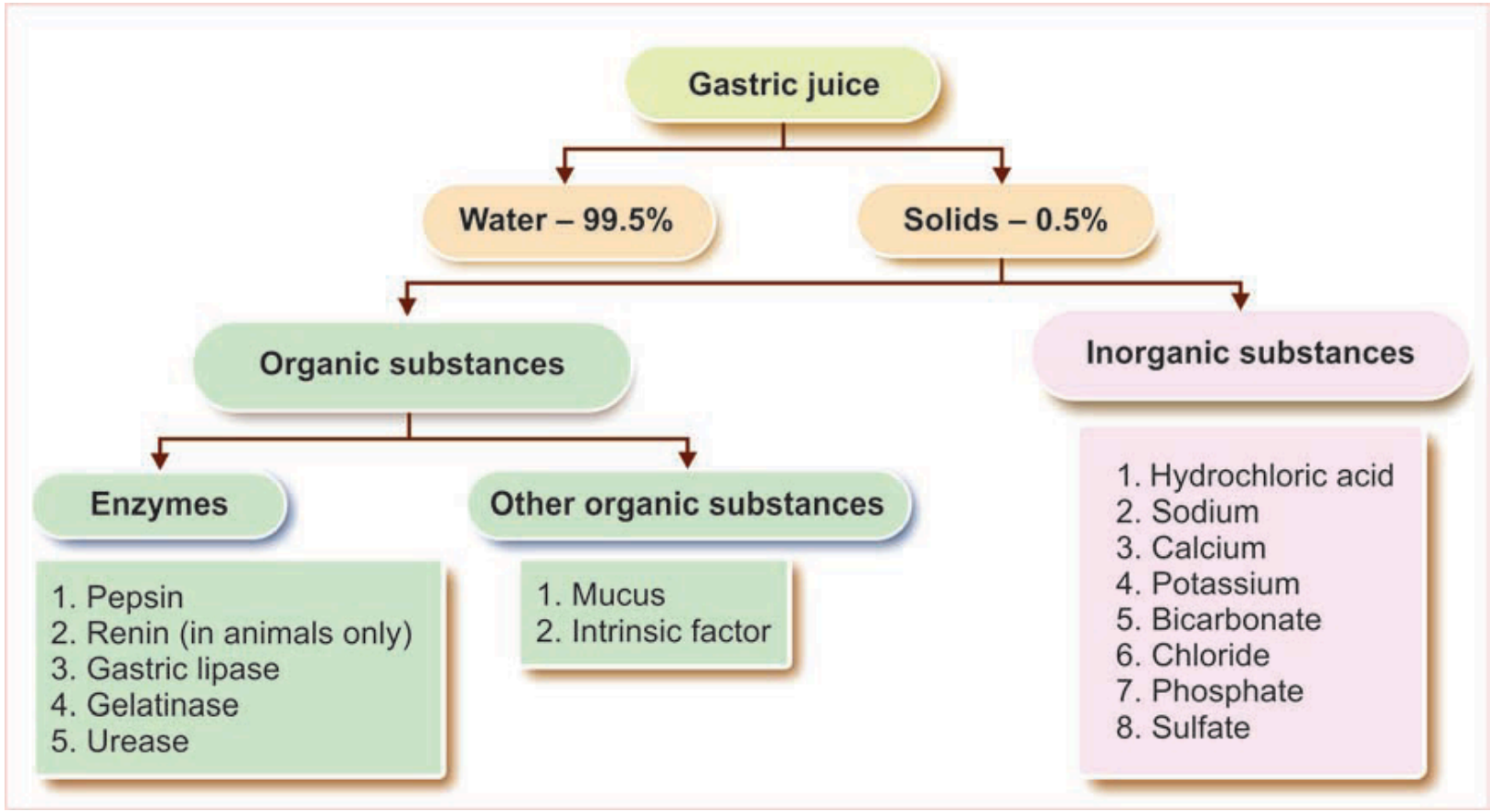


Mechanism of HCl Secretion

1. H2O inside parietal dissociate → H+ & OH−
2. H+ is actively secreted into canaliculus in exchange for K+ (catalyzed by H+-K+ ATPase).
3. K+ transported into cell by Na+-K+ ATPase pump on the basolateral side
4. K+ leak into lumen but recycled back into cell by H+-K+ ATPase.
5. Basolateral Na+-K+ ATPase creates low intracellular Na+ → Na+ reabsorption from lumen of canaliculus.
6. Pumping of H+ out of cell → OH− accumulation +CO2(carbonic anhydrase) →HCO3
7. HCO3 is transported into ECF in exchange for Cl→
8. Cl secreted by Cl channels → canaliculus → Cl+H →HCl secreted to lumen.
9. H2O passes into the canaliculus by osmosis.

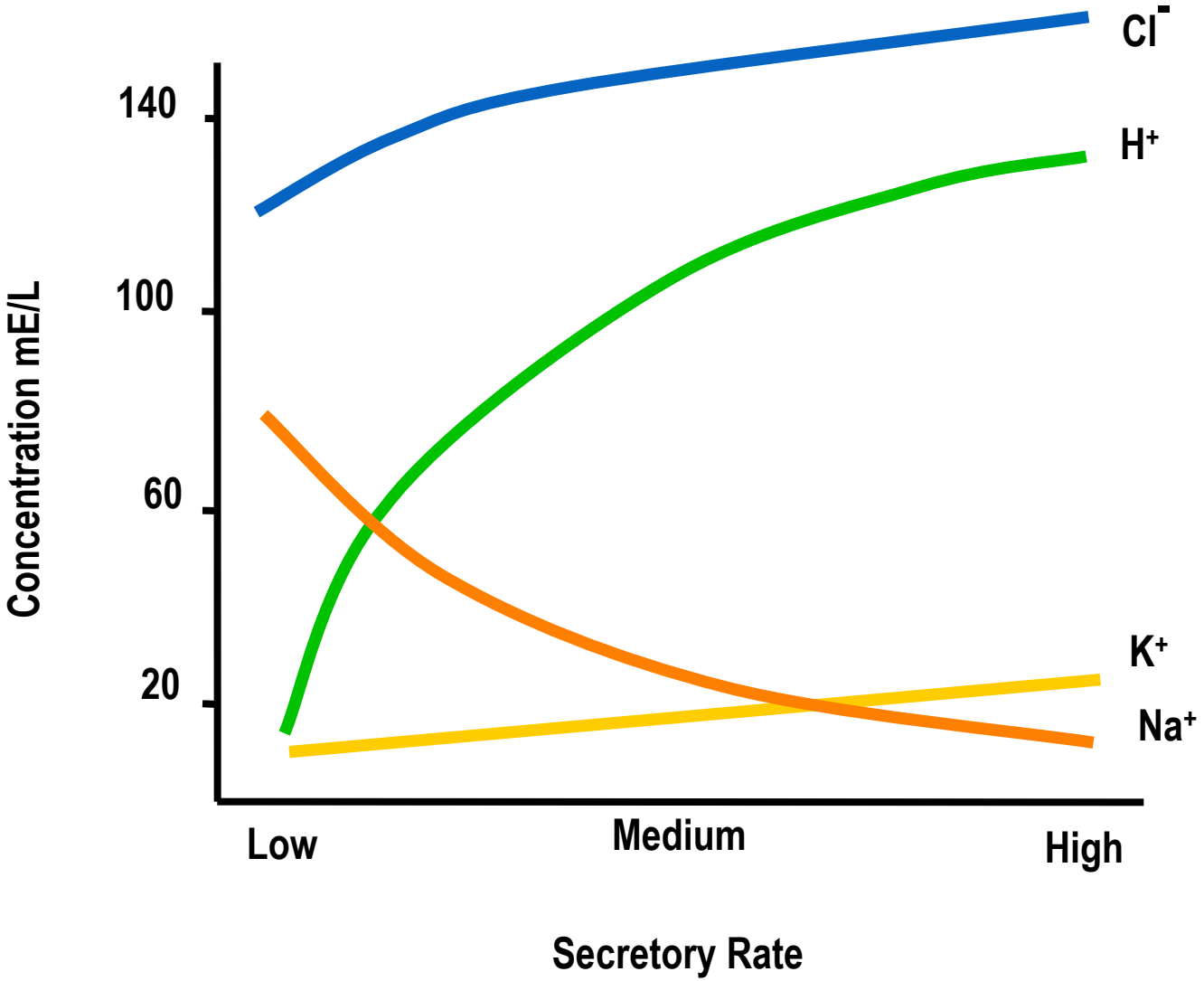


Gastric Secretion



Effect of Secretory Rate on Ionic Composition of Gastric Juice

- Low secretion rate (between meals)
  - high NaCl
- High secretion rate (after a meal)
  - high HCl
- Always isotonic


Cl-
H+
K+
Na+
140
100
60
20
Concentration mE/L
Low
Medium
High
Secretory Rate

Regulation of Gastric Secretion

- Gastric secretion is stimulated by neural, paracrine and endocrine mechanisms
  - Acetylcholine - HCl secretion
    - mucus, pepsinogen, and gastrin
  - Histamine - HCl secretion
  - Gastrin - HCl secretion (1500x more powerful compared to histamine)

Pepsinogen

- Secreted by peptic and mucous cells of gastric glands
- Pepsinogen is an inactive, secreted form of pepsin -
  - HCl converts pepsinogen to pepsin
  - Pepsin (35 kDa) converts more pepsinogen to pepsin

- proteolytic enzyme
- optimal pH 1.8 - 3.5
- reversibly inactivated >pH 5.0
- irreversibly inactivated >pH 7-8

Intrinsic Factor

- Secreted by parietal cells
- Essential for absorption of vit. B12 in ileum.

- When the acid-producing parietal cells of the stomach destroyed (Ileal disease, resection, atrophic gastritis) → achlorhydria & pernicious anemia.

- Pernicious anemia → failure of maturation of RBC in absence of vit. B12

Intrinsic Factor

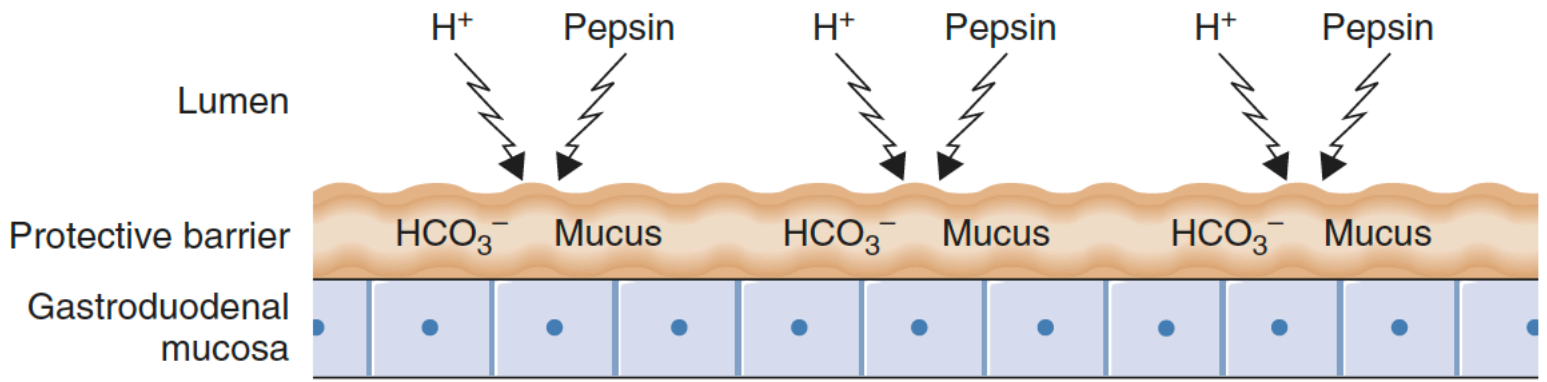
- Stomach - Dietary vitamin B_{12} bound by B_{12} -binding proteins present in gastric juice
- Duodenum - pancreatic proteases digest binding proteins, releasing vitamin B_{12} which binds to intrinsic factor
- Ileum - intrinsic factor - vitamin B_{12} complex absorbed

Secretion from pyloric glands

- Structurally similar to the oxyntic glands.
- Few peptic cells, no parietal cells.
- Contain mostly mucous cells, identical with mucous neck cells of oxyntic glands.
- Secrete small amount of pepsinogen
- Secrete large amount of thin mucus → lubricate food & protect stomach wall from digestion by gastric enzymes
- Secrete Gastrin→ controlling gastric secretion.

Gastric barrier

- Surface mucous cells → thick (1 ml), alkaline, viscid mucus
- Alkaline mucus & tight junctions between epithelia cells→ protect stomach mucosa from acidic gastric juice
- Barrier is damaged by excessive use of aspirin or alcohol → causing stomach mucosal damage.



Stimulation of gastric acid secretion

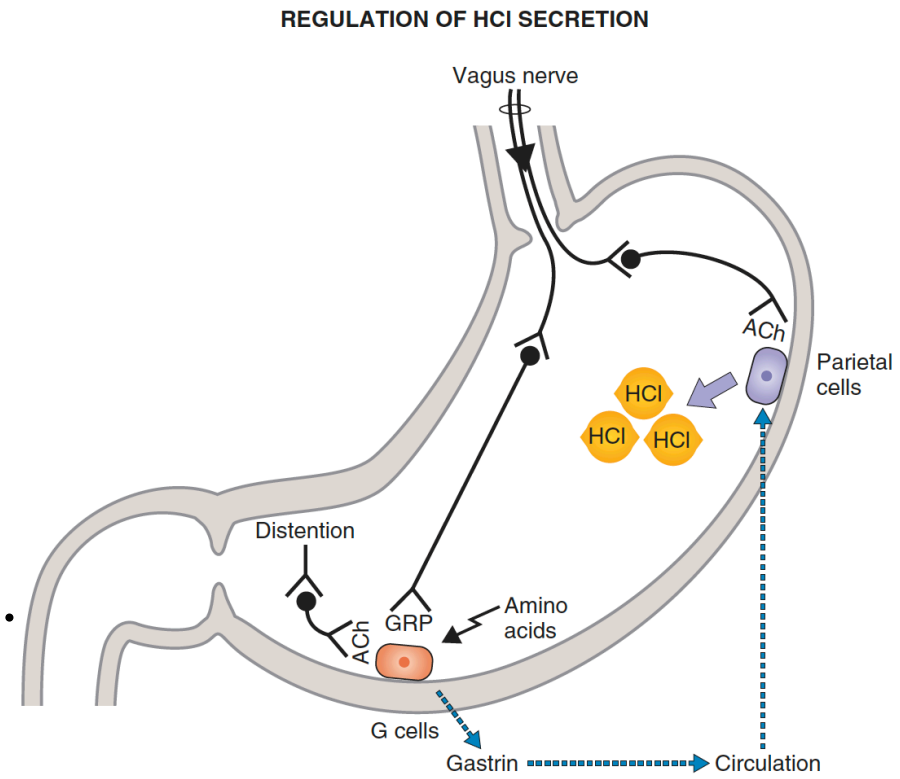
- Secretion of gastric acid is controlled by endocrine and nervous signals.

- Enterochromaffin-like (ECL) cells

✓ Lie in deep recesses of oxyntic glands

✓ Stimulated by gastrin

✓ Secrete histamine → partial cells → HCl.



Regulation of pepsinogen secretion

Stimulation of pepsinogen secretion:
(1) Acetylcholine released from vagus nerves/ENS
(2) Acid in stomach (indirect effect-ENS reflexes)

Enzyme	Activator	Substrate	End products
Pepsin	Hydrochloric acid	Proteins	Proteoses, peptones and polypeptides
Gastric lipase	Acid medium	Triglycerides of butter	Fatty acids and glycerols
Gastric amylase	Acid medium	Starch	Dextrin and maltose (negligible action)
Gelatinase	Acid medium	Gelatin and collagen of meat	Peptides
Urase	Acid medium	Urea	Ammonia

Phases of Gastric Secretion/Cephalic Phase

- Seeing, smelling and anticipating food is perceived in CC & appetite center)→vagus → stomach

- Accounts for 30% of acid response to meal -

  – Stimuli - Mechanoreceptors
    Chemoreceptors (smell and taste)
    Central pathway (thought)
    Hypoglycemia

  – Blocked entirely by vagotomy

Gastric Phase

- When meal enters stomach.
- Accounts for 60% of acid response (1500 ml) to a meal
- Stimuli

(1) Vagovagal reflexes from stomach →brain → stomach
(2) Local enteric reflexes
(3) Gastrin mechanism

Intestinal Phase

- Accounts for 10% of acid response to a meal
  - presence of food in upper portion of SI (esp. D)
  - small amounts of gastric juice
  - Stimulated by gastrin release by D mucosa.

CEPHALIC PHASE: Only nervous

Conditioned reflex
Sight, smell, thought of and hearing about food

Unconditioned reflex
Presence of food in mouth

→ Stimulation → Vagus nerve → Secretion of gastric juice

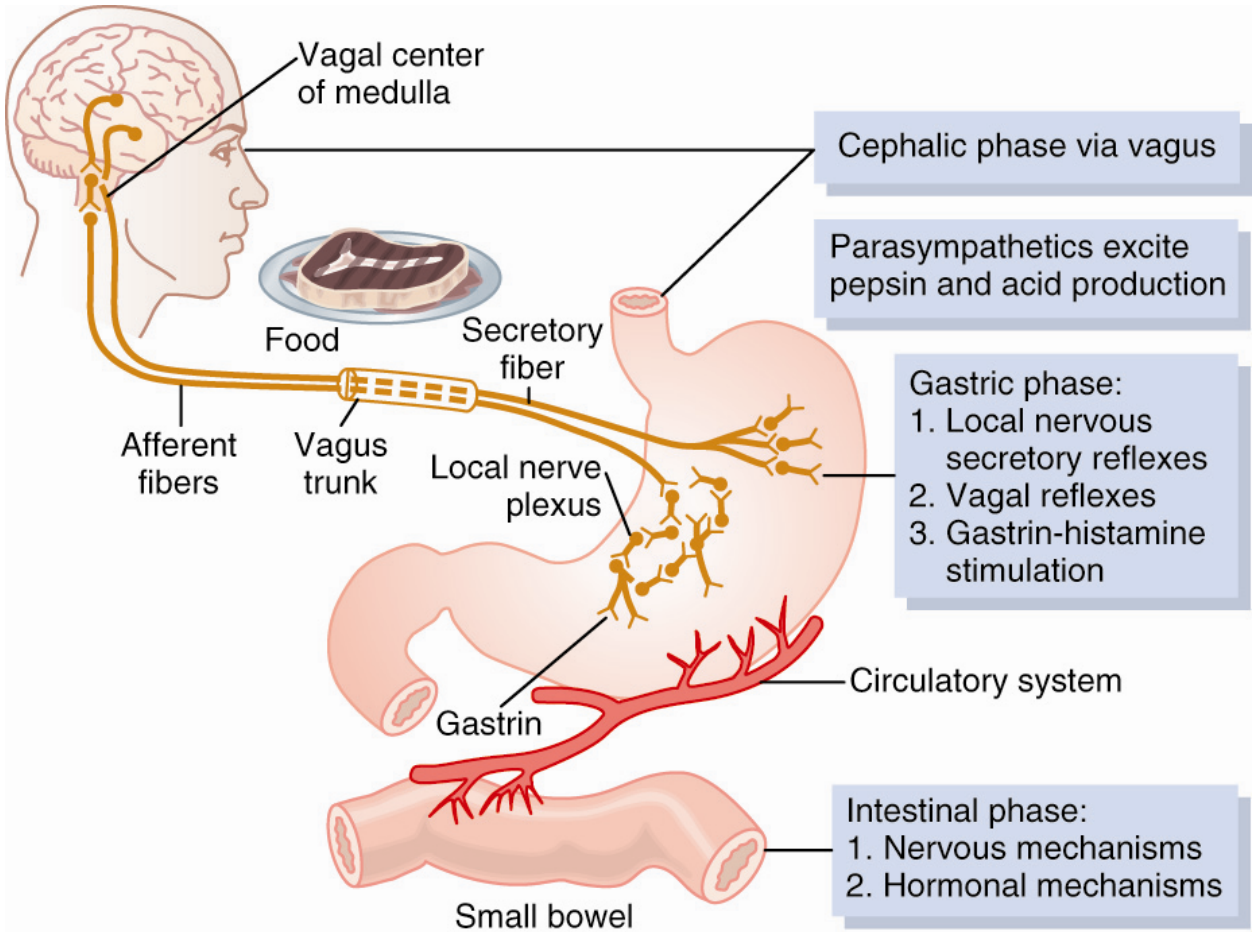
GASTRIC PHASE: Nervous and hormonal

Bolus in stomach → Vagus nerve, Local nerves, Gastrin → Stimulation → Secretion of gastric juice

INTESTINAL PHASE: Mostly hormonal

Chyme in intestine

- Gastrin → Stimulation → Secretion of gastric juice
- Secretin, CCK-PZ, Somatostatin, GIP, VIP → Inhibition → Secretion of gastric juice



Inhibition of Gastric Secretion by Other Intestinal Factors

- **Enterogastric reflex:** transmitted through MNS, sympathetic and vagus nerves→ ↓stomach secretion.
- Stimuli for enterogastric reflex:

(a)SI distention
(b)Presence of acid in upper I
(c) Protein breakdown products
(d) Irritation of mucosa

- **Acid, fat, protein breakdown products, hyperosmotic or hypo-osmotic fluids, irritating factor in upper I** → secretin → pancreatic secretion control & ↓stomach secretion.

- **Glucose-dependent insulinotropic peptide (gastric inhibitory peptide), vasoactive intestinal polypeptide, and somatostatin** ↓stomach secretion.