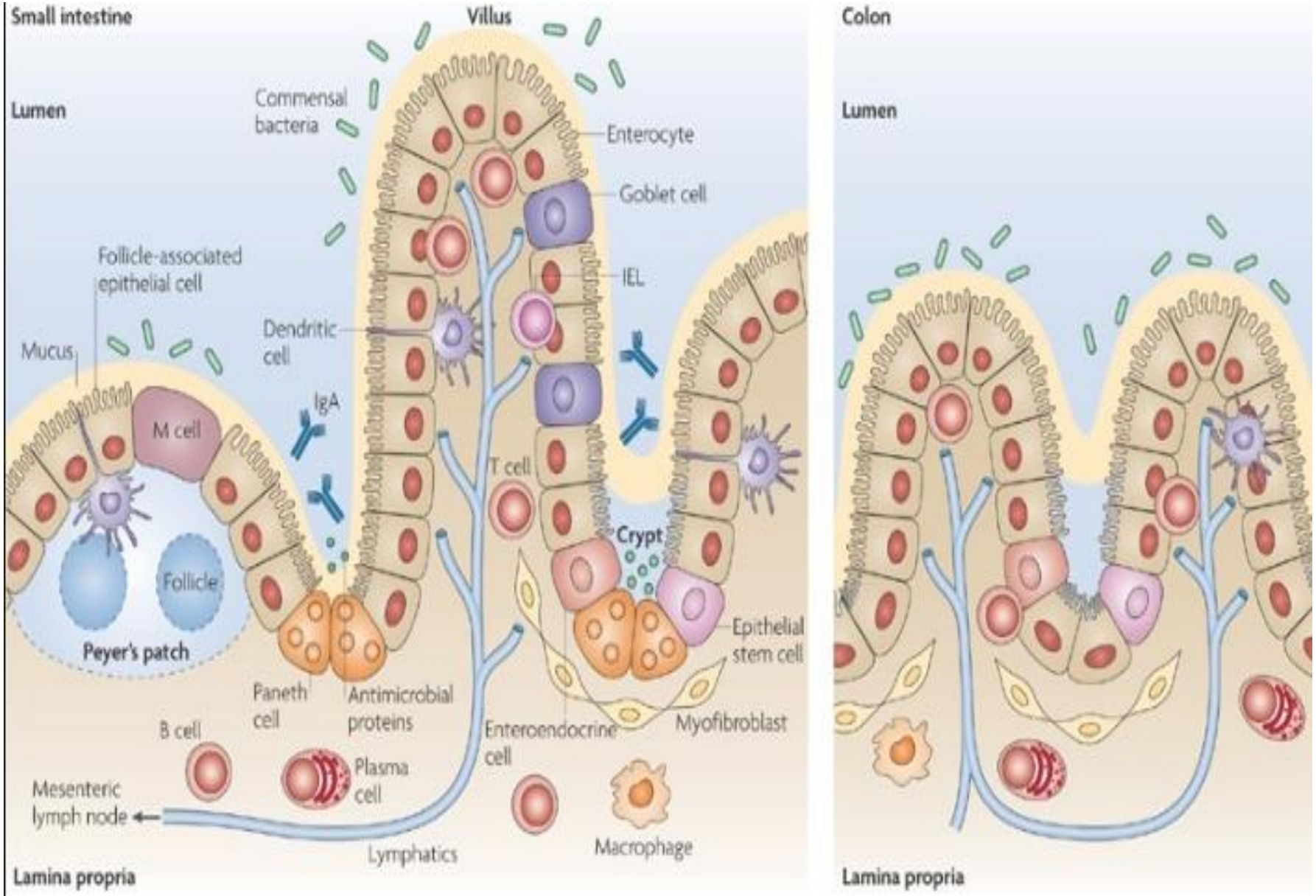
SECRETORY FUNCTION OF GIT

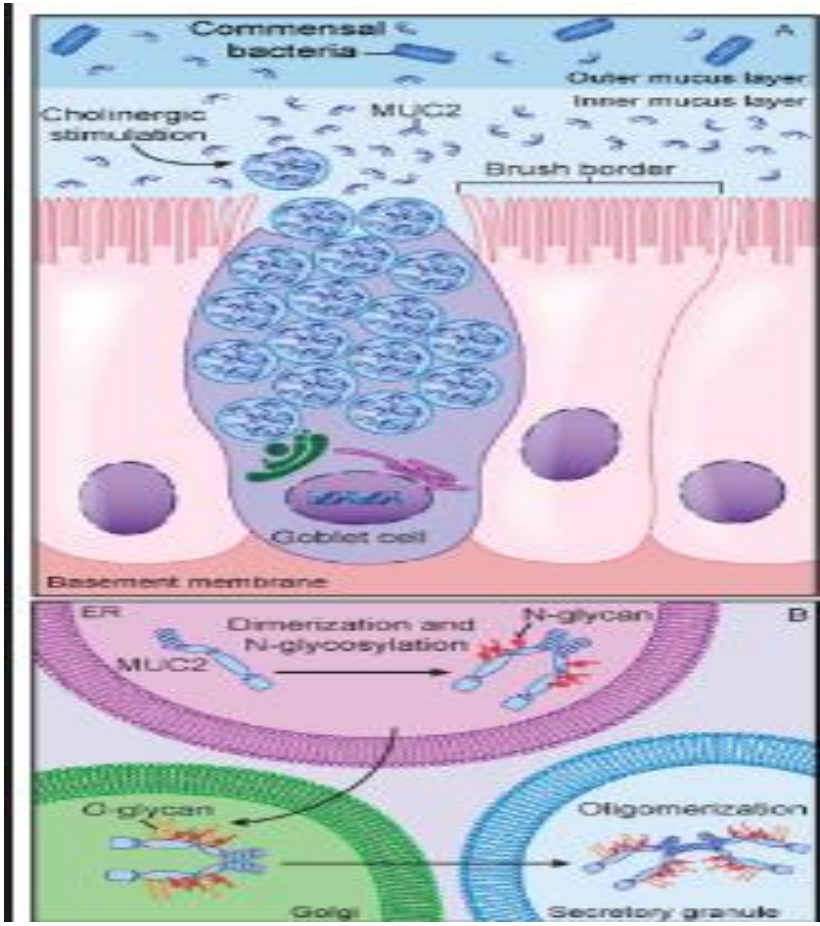
- ***Secretory glands*** **produce digestive enzymes present from mouth to terminal ileum.**

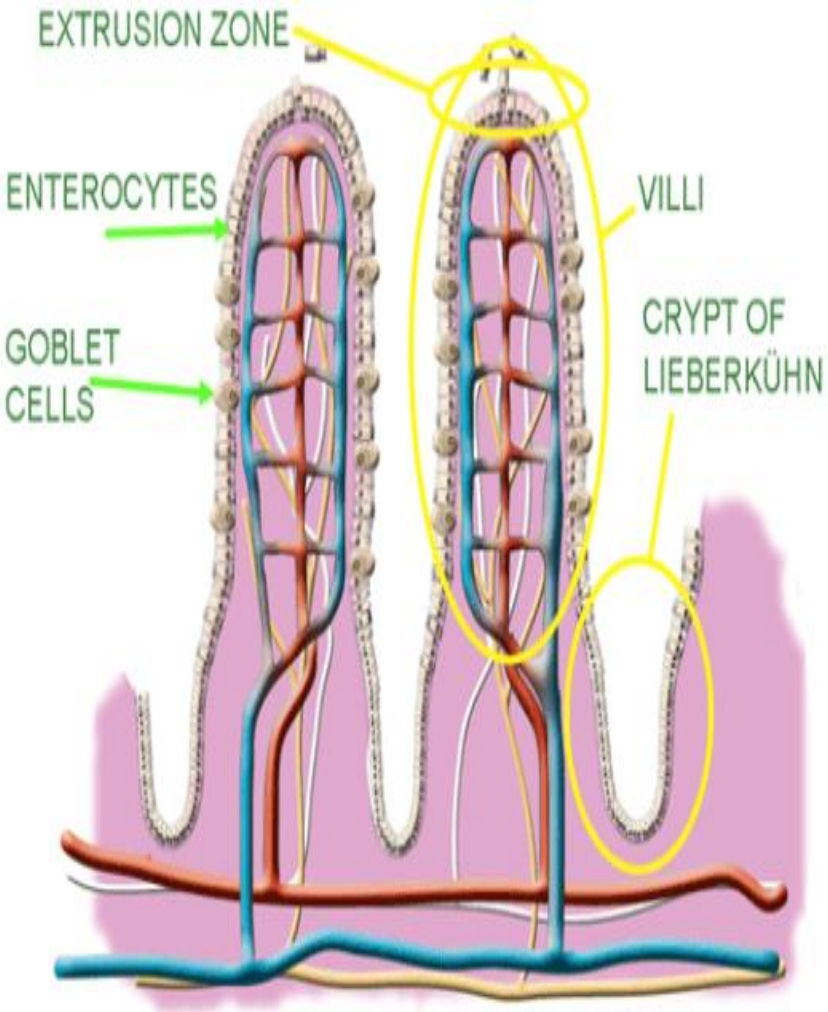
- ***Mucus glands*** **lubricants from mouth to anus.**

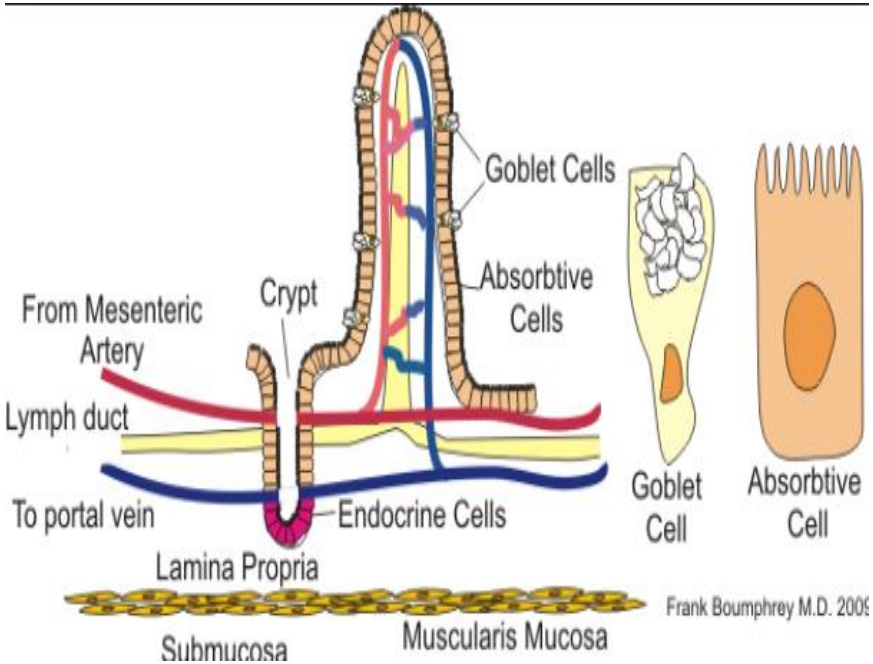

Small intestine
Villus
Lumen
Commensal bacteria
Enterocyte
Goblet cell
Follicle-associated epithelial cell
IEL
Dendritic cell
Mucus
IgA
M cell
T cell
Crypt
Follicle
Peyer's patch
Epithelial stem cell
Paneth cell
Antimicrobial proteins
Enteroendocrine cell
Myofibroblast
B cell
Plasma cell
Mesenteric lymph node
Lymphatics
Macrophage
Lamina propria
Colon
Lumen
Lamina propria

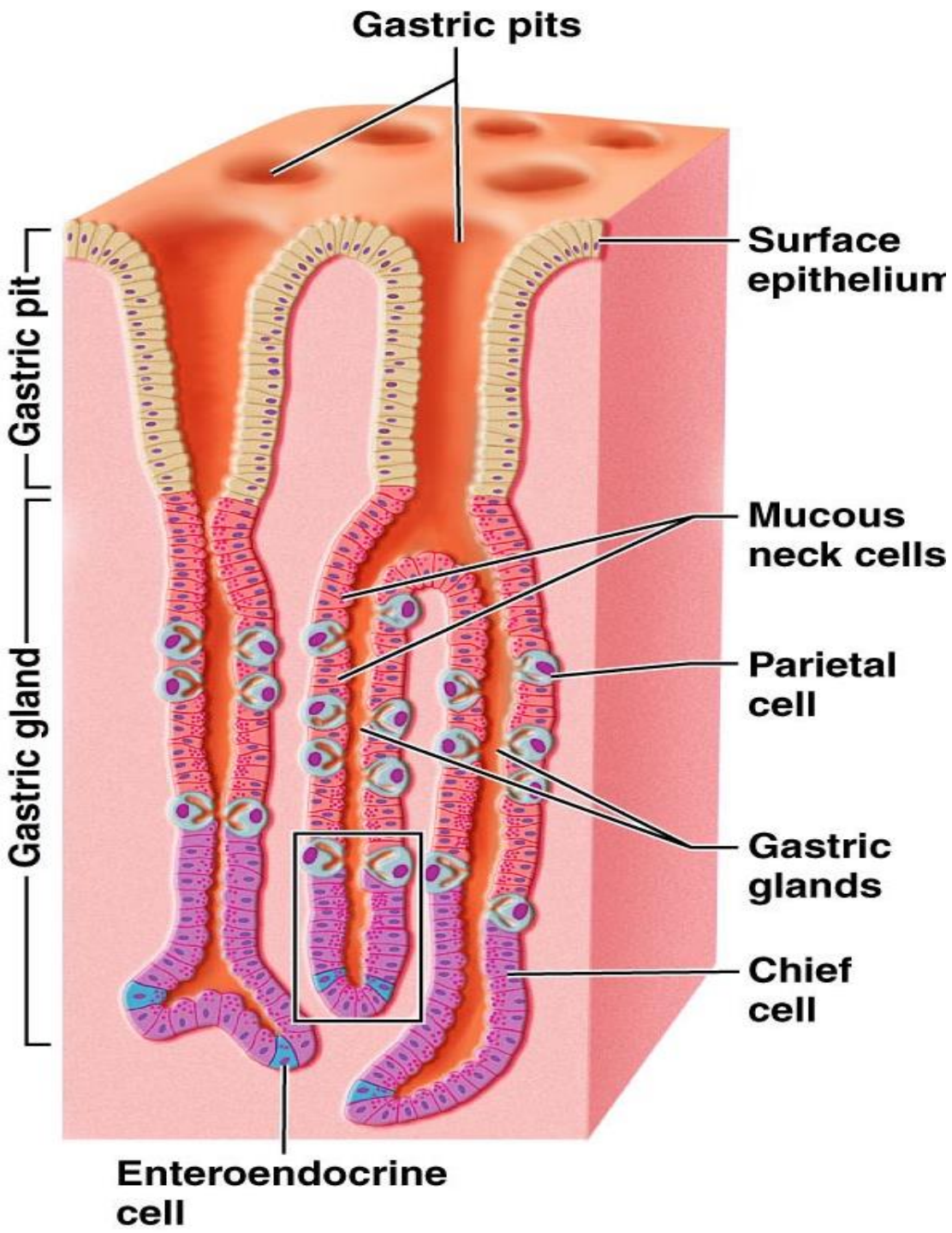
Anatomical type of glands

- *Goblet cells* **single mucus secretion gland.**
- **Specialized glands lie in pits like crypts of Lieberkühn.**
- **Deep tubular glands oxyntic cells.**
- **Several complex glands salivary ,pancreas liver.**




EXTRUSION ZONE
ENTEROCYTES
GOBLET CELLS
VILLI
CRYPT OF LIEBERKÜHN


Goblet Cells
Absorbtive Cells
Crypt
From Mesenteric Artery
Lymph duct
To portal vein
Endocrine Cells
Lamina Propria
Submucosa
Muscularis Mucosa
Goblet Cell
Absorbtive Cell
Frank Boumphrey M.D. 2009


Gastric pits
Surface epithelium
Gastric pit
Gastric gland
Mucous neck cells
Parietal cell
Gastric glands
Chief cell
Enteroendocrine cell

Basic mechanism of stimulation of alimentary tract glands

- **Mechanical stimulation by presence of food especially mucus gland *Direct contact***
- ***Function of Enteric Nervous Stimuli.***
  - **Tactile stimulation.**
  - **Chemical irritation.**
  - **Distention of the gut wall.**
- ***Autonomic Stimulation of Secretion***
- **Parasympathetic Stimulation.**
- **sympathetic Stimulation.**
- ***Regulation of Glandular Secretion by Hormones***
- **Chemically, the gastrointestinal hormones are polypeptides or polypeptide derivatives.**

Importance of Mucus in the Gastrointestinal Tract

- **Mucus is a thick secretion composed mainly of**
- **Water Electrolytes, Mixture of several glycoproteins, (large polysaccharides bound with much smaller quantities of protein).**

- **Mucus is slightly different in different parts of the gastro-intestinal tract.**
- **But everywhere it has several important characteristics that make it both an excellent *Lubricant and a Protectant* for the wall of the gut.**

- Mucus has Adherent qualities that make it adhere tightly to the food or other particles and to spread as a thin film over the surfaces.
- It has *Sufficient body* that it coats the wall of the gut and prevents actual contact of most food particles with the mucosa.
- Mucus has a *low resistance for slippage*, so that the particles can slide along the epithelium with great ease.
- Mucus causes *fecal particles to adhere to one another* to form the feces that are expelled during a bowel movement.
- Mucus is *Strongly resistant to digestion* by the gastrointestinal enzymes.
- The glycoprotein of mucus have ***amphoteric properties***, which means that they are capable of Buffering small amounts of either acids or alkalis.
- Also, mucus often contains moderate quantities of bicarbonate ions which specifically *Neutralize acids*.

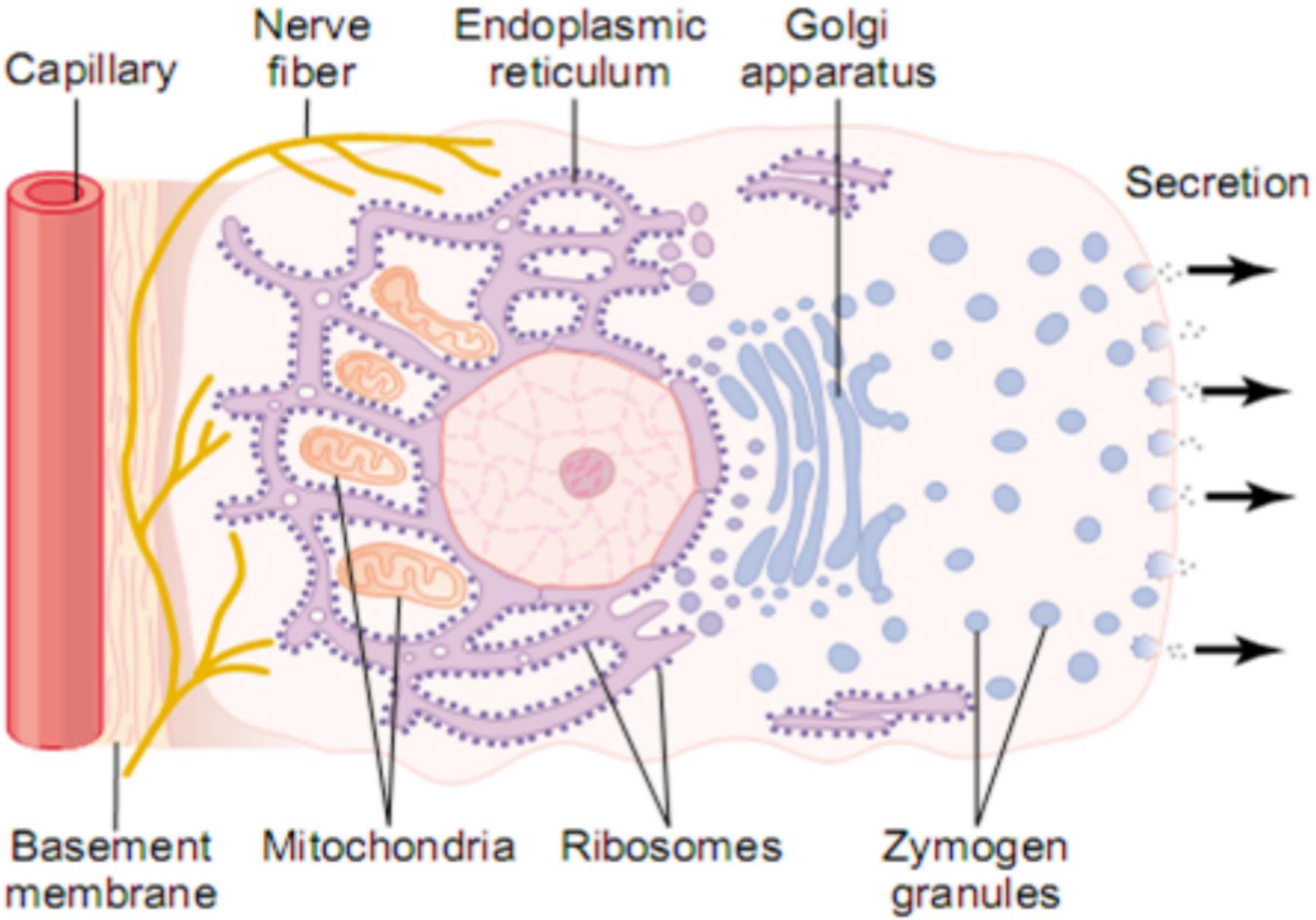

Capillary
Nerve fiber
Endoplasmic reticulum
Golgi apparatus
Secretion
Basement membrane
Mitochondria
Ribosomes
Zymogen granules

Figure 64–1

Composition of gastrointestinal secretions

Type of secretion	Volume	Na^+	K^+	Cl^-	Hco_3
Salivary	1000	20	26	50	50
Stomach	1500	70	10	100	0
Small bowel	2500	140	20	104	30
Bile	1000	140	5	100	35
Pancreas	1000	140	5	70	115

Chemical composition of body fluids

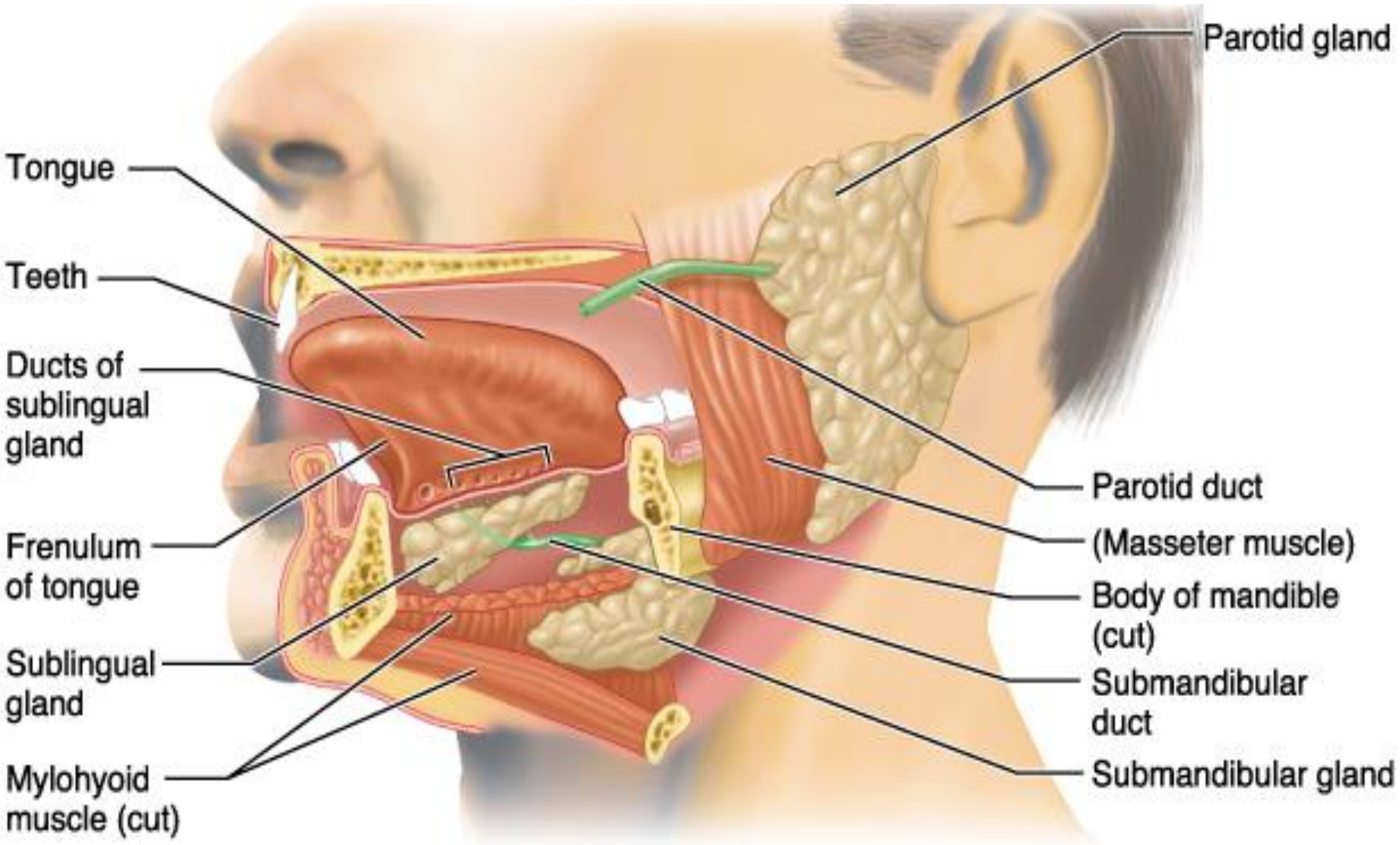
Fluid	Na	K	Mg	Hco3	Protein	PO4	CL
Intracellular	10	150	40	10	40	120	3
Interstitial	144	4	2	30	1	3	114
Plasma	142	4	3	27	16	3	103
Ringer lactate	130	4	-	28	-	-	109

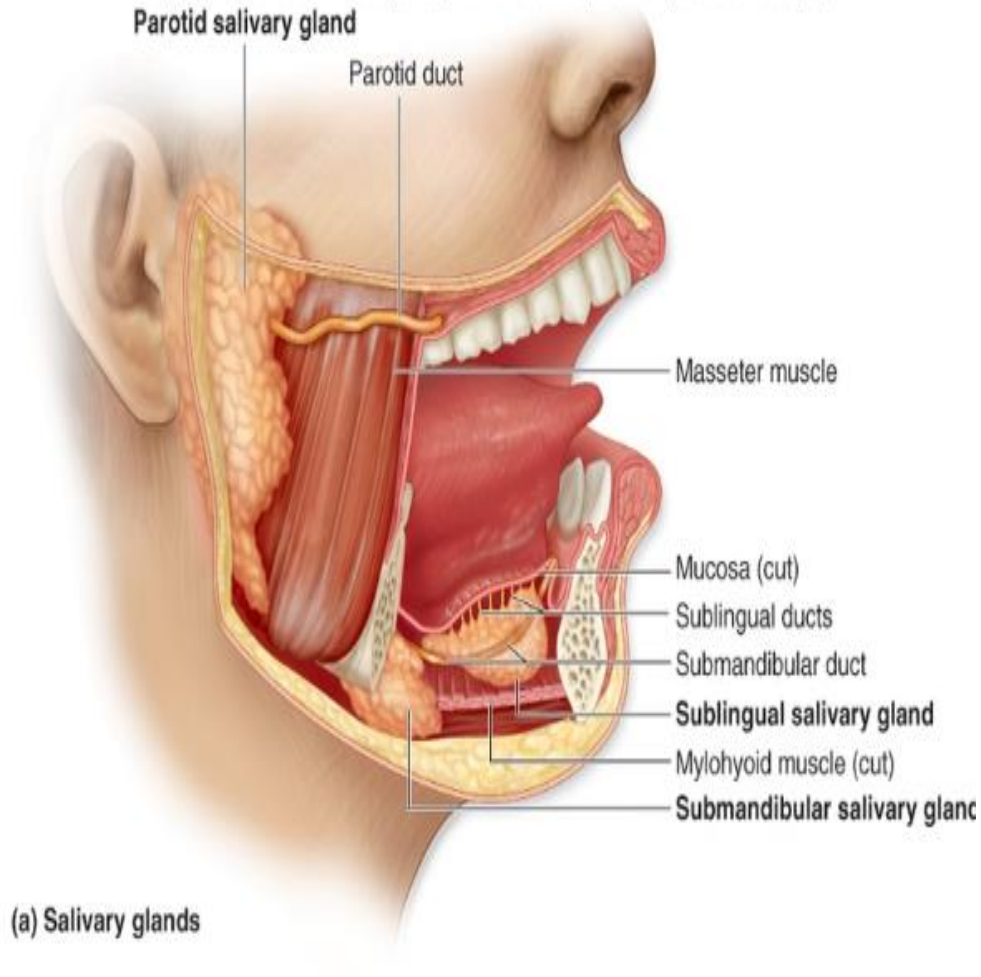
2-Secretion of Saliva

Daily Secretion of Intestinal Juices

	Daily Volume (ml)	pH
Saliva	1000	6.0–7.0
Gastric secretion	1500	1.0–3.5
Pancreatic secretion	1000	8.0–8.3
Bile	1000	7.8
Small intestine secretion	1800	7.5–8.0
Brunner's gland secretion	200	8.0–8.9
Large intestinal secretion	200	7.5–8.0
Total	6700	

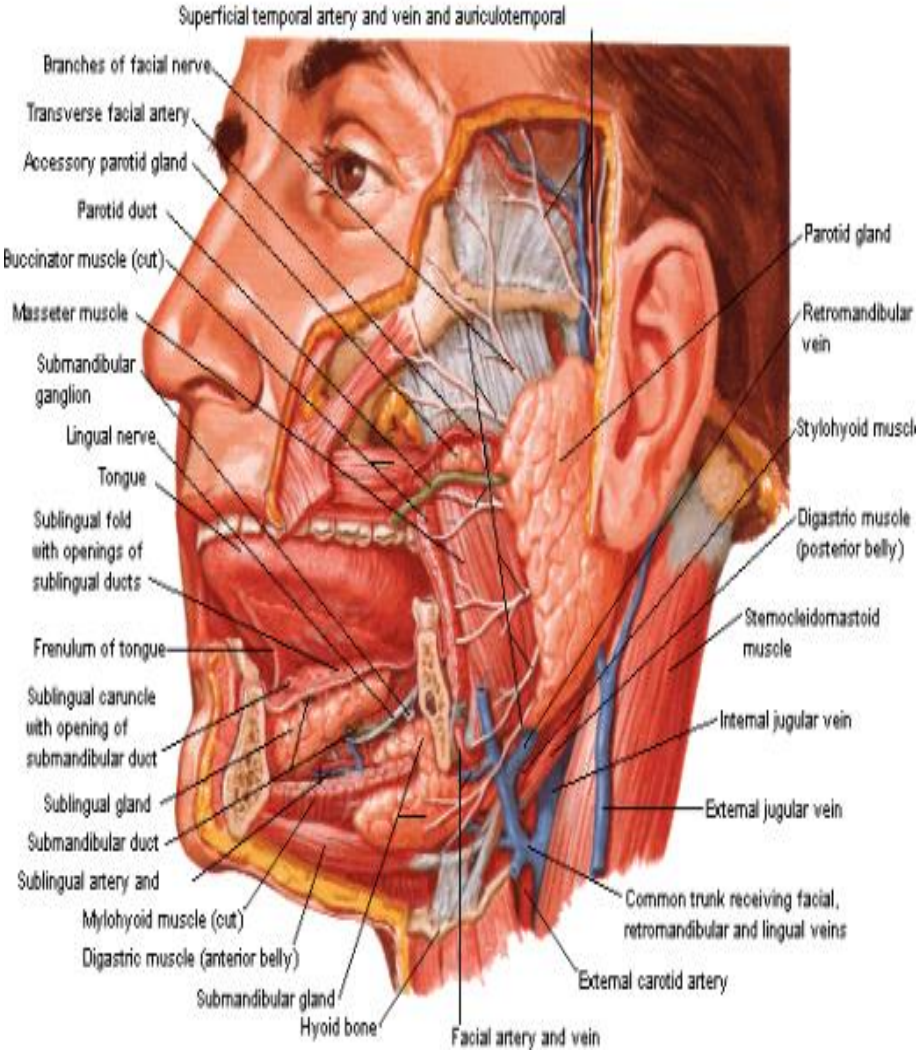
- **Saliva Contains a *Serous Secretion* and a *Mucus Secretion***
- **The principal glands of salivation are the**
- **Parotid: Serous type of secretion**
- **Submandibular: Serous secretion and Mucus(70)%**
- **Sublingual :serous secretion and mucus.**
- **Buccal glands: only mucus**
- **Daily secretion of saliva normally ranges between 800 and 1500 milliliters, as shown by the average value of 1000 milliliters**


Parotid gland
Tongue
Teeth
Ducts of sublingual gland
Frenulum of tongue
Sublingual gland
Mylohyoid muscle (cut)
Parotid duct
(Masseter muscle)
Body of mandible (cut)
Submandibular duct
Submandibular gland

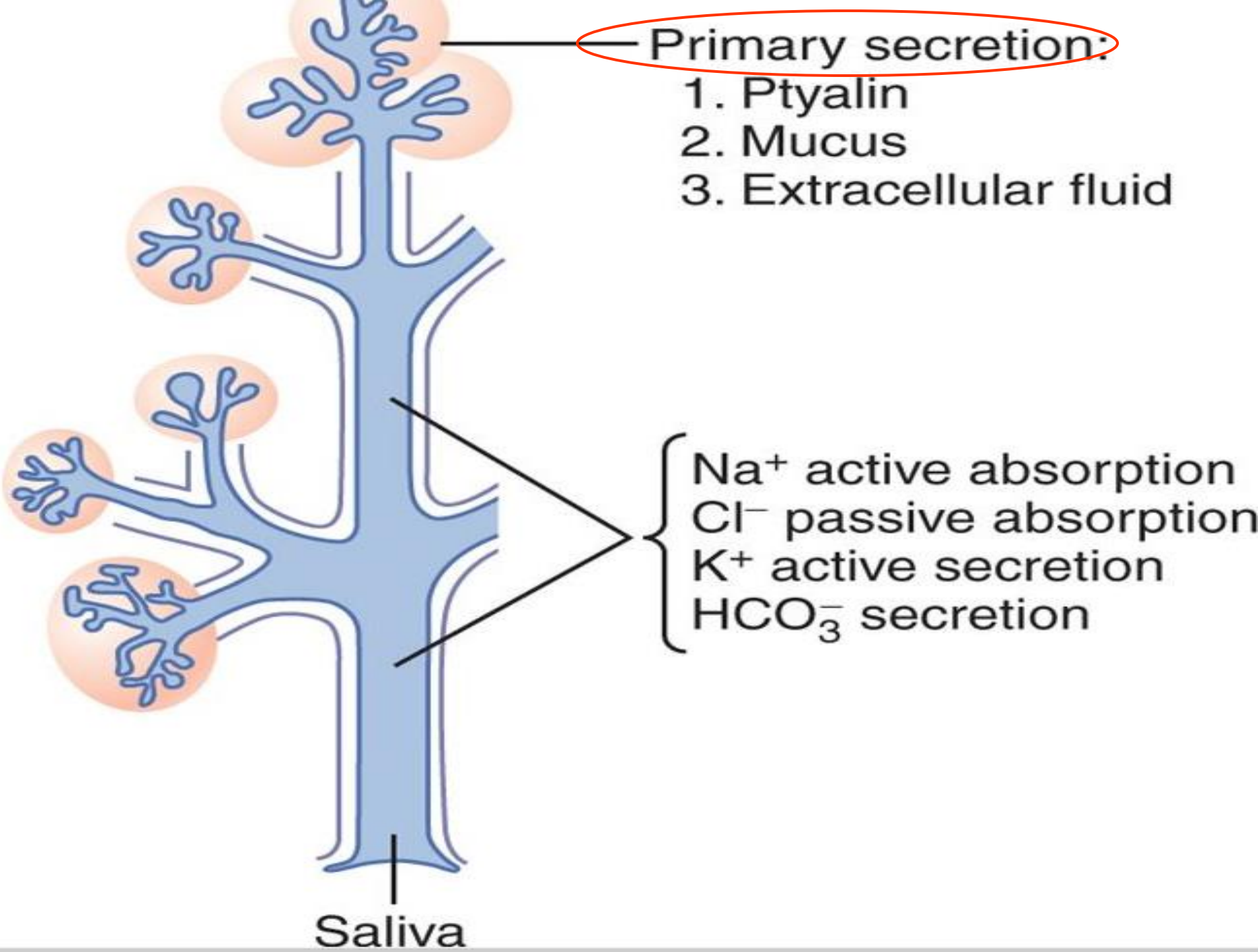


(a) Salivary glands

Salivary Glands



- **Saliva contains two major types of protein secretion:**
- **(1) *Serous secretion* that contains ***Ptyalin*** (an α-amylase), which is an enzyme for digesting starches.**
- **(2) *Mucus secretion* that contains ***Mucin*** for lubricating and for surface protective purposes.**
- **Saliva has a pH between 6.0 and 7.0, a favorable range for the digestive action of ptyalin.**


Primary secretion:
1. Ptyalin
2. Mucus
3. Extracellular fluid
Na^+ active absorption
Cl^- passive absorption
K^+ active secretion
HCO_3^- secretion
Saliva

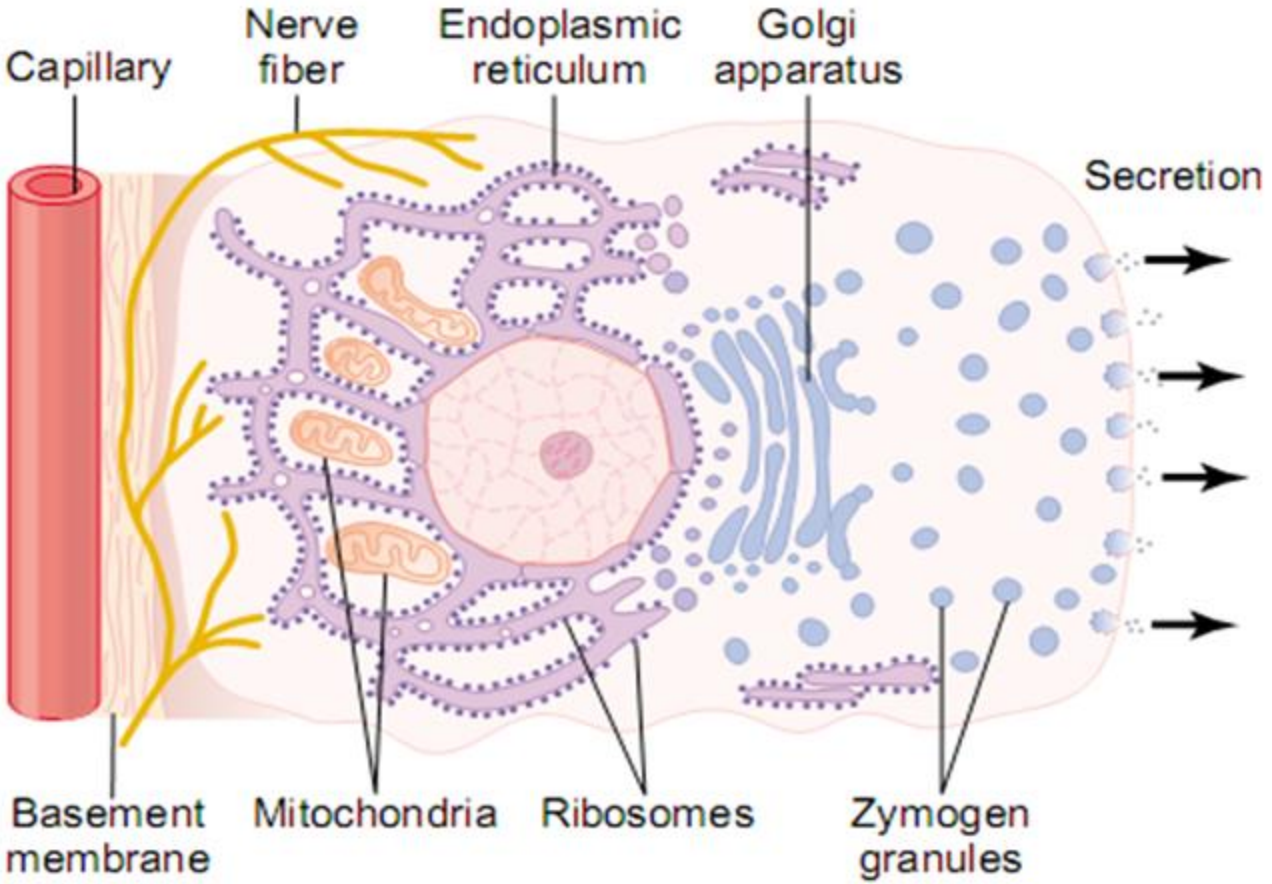
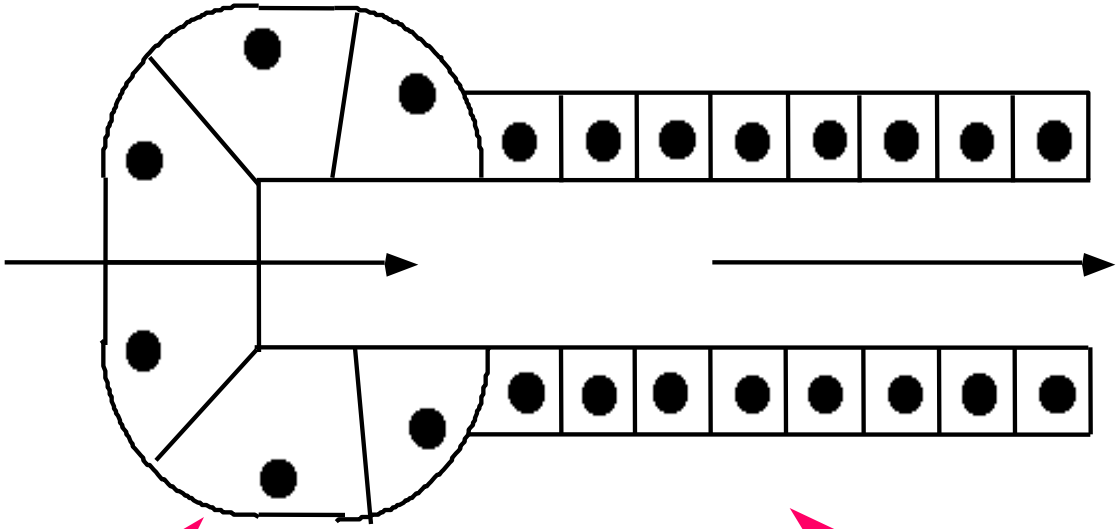

Capillary
Nerve fiber
Endoplasmic reticulum
Golgi apparatus
Secretion
Basement membrane
Mitochondria
Ribosomes
Zymogen granules

Figure 64–1

THE SECRETORY UNIT

The basic building block of all salivary glands



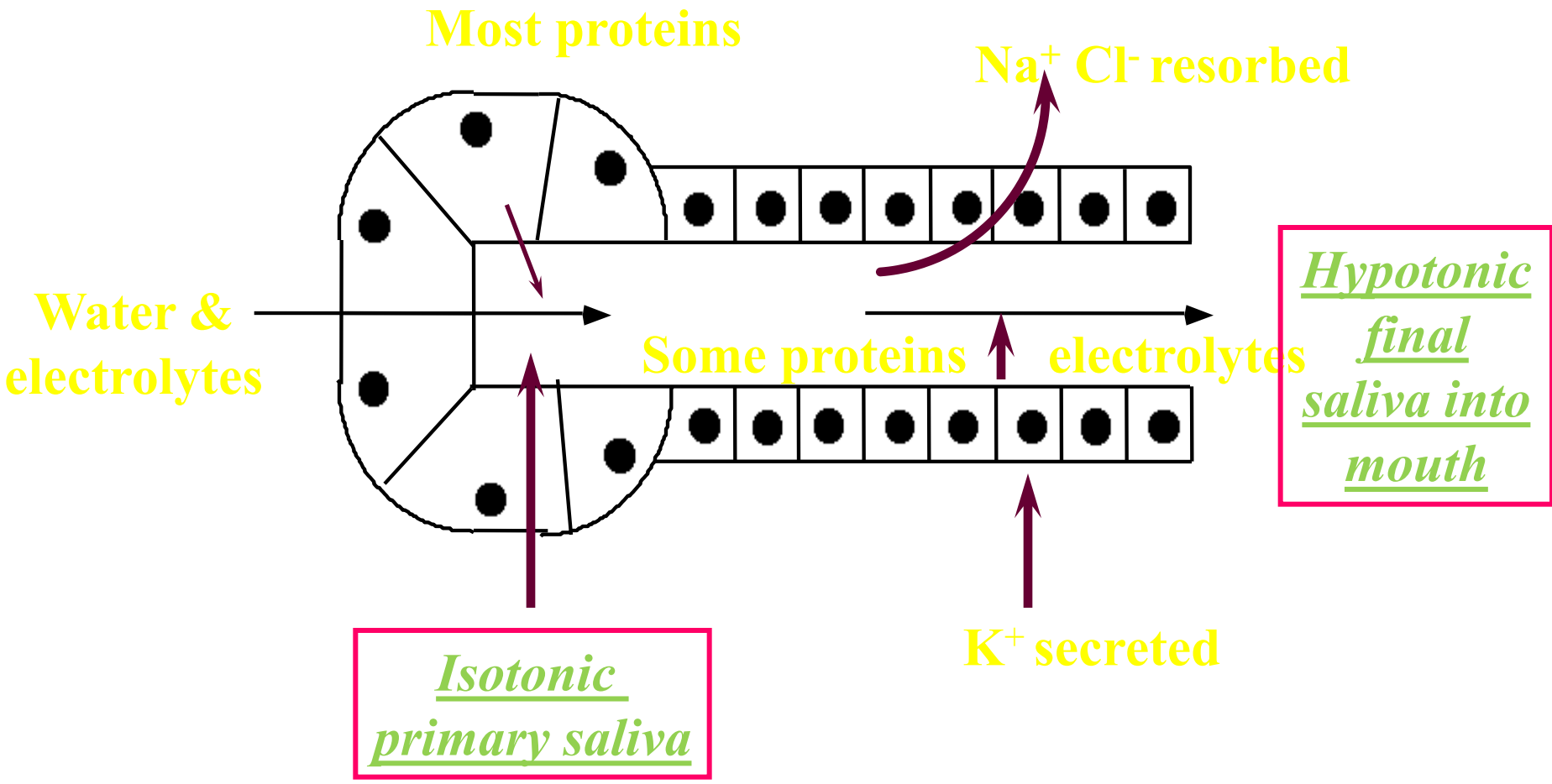
- **ACINI - water and ions derived from plasma.**
- **Saliva formed in acini flows down DUCTS to empty into the oral cavity.**

Secretion of Ions in Saliva :

- Saliva contains especially *large* quantities of Potassium and Bicarbonate ions.
- *Sodium and Chloride* ions are several times *less* in saliva than in plasma.
- Mechanism of saliva secretion:
- The *Acini* secrete a *primary secretion* that contains ptyalin and/or mucin in a solution of ions in concentrations not greatly different from those of typical extracellular fluid.
- As the primary secretion flows through the *Ducts*, *two major active transport processes take place* that markedly modify the ionic composition of the fluid in the saliva.

- First, ***sodium*** ***ions*** are ***actively reabsorbed*** from all the salivary ducts and ***potassium*** ***ions*** are ***actively secreted*** in exchange for the Na
- Second, ***bicarbonate*** ***ions*** are secreted by the ductal epithelium into the lumen of the duct
- Under resting conditions***:***
- ***Sodium and chloride:*** ions in the saliva are only about 15 mEq/L each, about one-seventh to one-tenth their concentrations in plasma.
- Conversely, the concentration of potassium ions is about 30 mEq/L, seven times as great as in plasma, and the concentration of bicarbonate ions is 50 to 70 mEq/L, about two to three times that of plasma.

SALIVA FORMATION



During maximal salivation:

- **The rate of formation of primary secretion by the acini can increase as much as *20-fold.***
- **This acinar secretion then flows through the ducts so rapidly that the ductal reconditioning of the secretion is considerably reduced. Therefore, when copious quantities of saliva are being secreted, *NaCl* concentration is about *One-half or two-thirds* that of plasma, and the *K* concentration rises to only *Four times* that of plasma.**

MAJOR FUNCTIONS OF SALIVA

- Solvent
- Buffering
- Lubrication
- Remineralization
- Digestion
- Anti-bacterial
- Anti-fungal
- Temperature regulation
- Production of growth factors and other regulatory peptides

Function of Saliva for Oral Hygiene

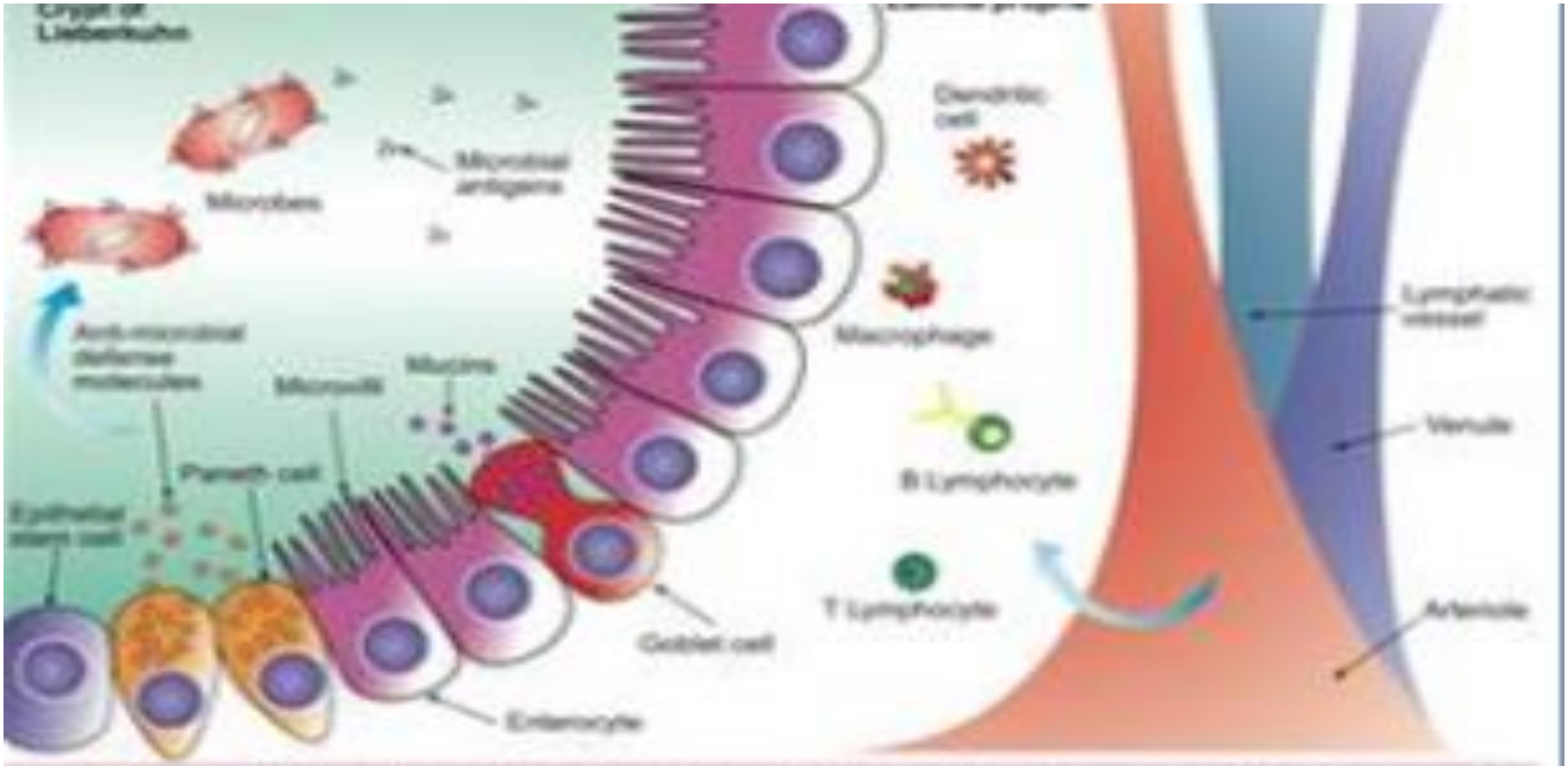
About *0.5 milliliter* of saliva, almost entirely of the mucous type, is secreted each minute.

- The flow of saliva itself helps wash away pathogenic bacteria, as well as food particles
- Saliva contains several factors that destroy bacteria. One of these is *thiocyanate ions* and another is several *proteolytic enzymes*-most important, *lysozyme.*
- Saliva often contains significant amounts of *Protein antibodies* that can destroy oral bacteria.

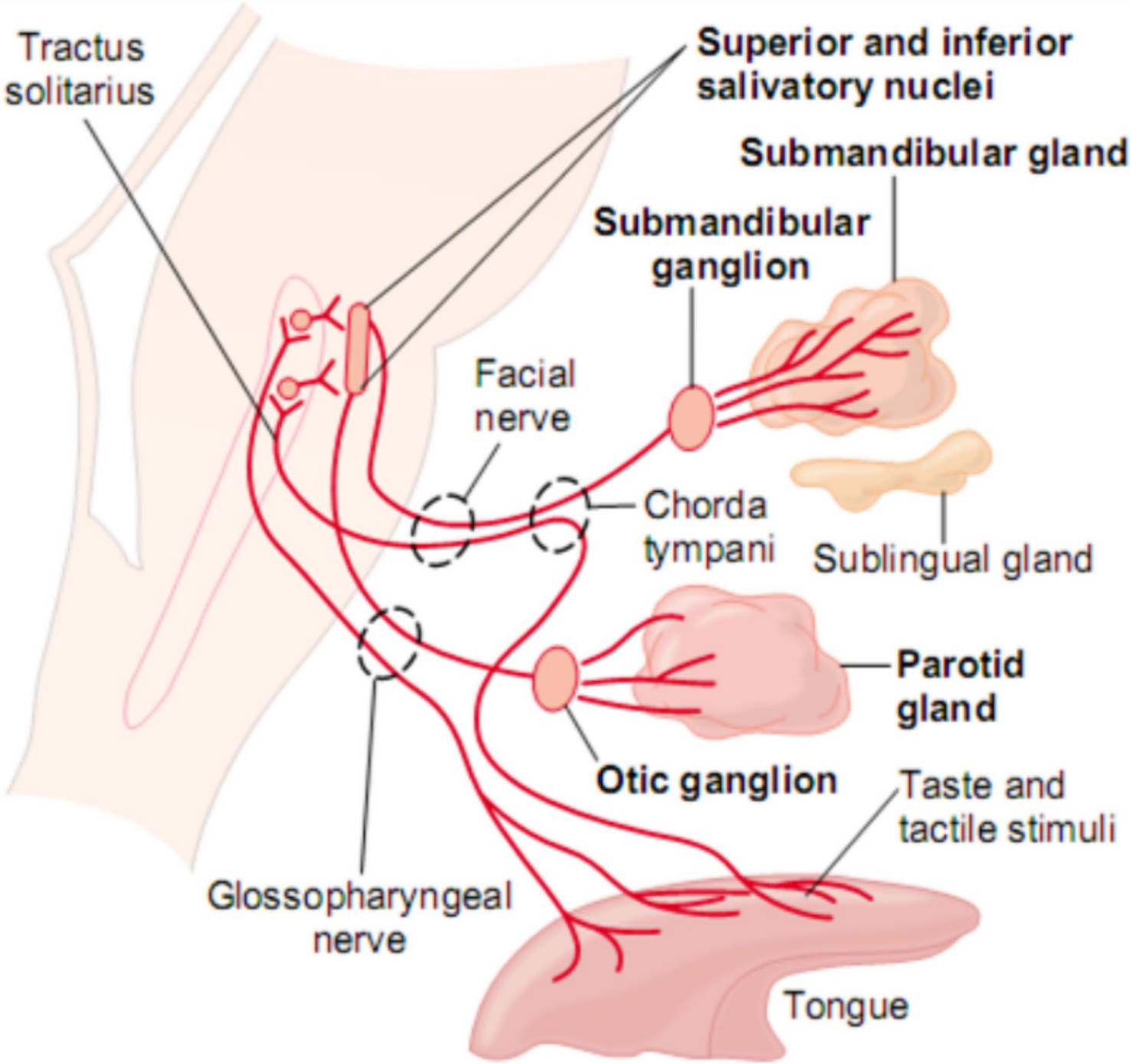
Nervous Regulation of Salivary Secretion

- The salivary glands are controlled mainly by *parasympathetic nervous signals* all the way from the *superior* and *inferior salivatory nuclei* in the brain stem.
- Taste and tactile stimuli from the tongue and other areas of the mouth and pharynx.
- Many *Taste stimuli*, especially the Sour taste (caused by acids), elicit copious secretion of saliva-often *8 to 20* times the basal rate of secretion.
- *Tactile stimuli*, such as the presence of smooth objects in mouth causes marked salivation.

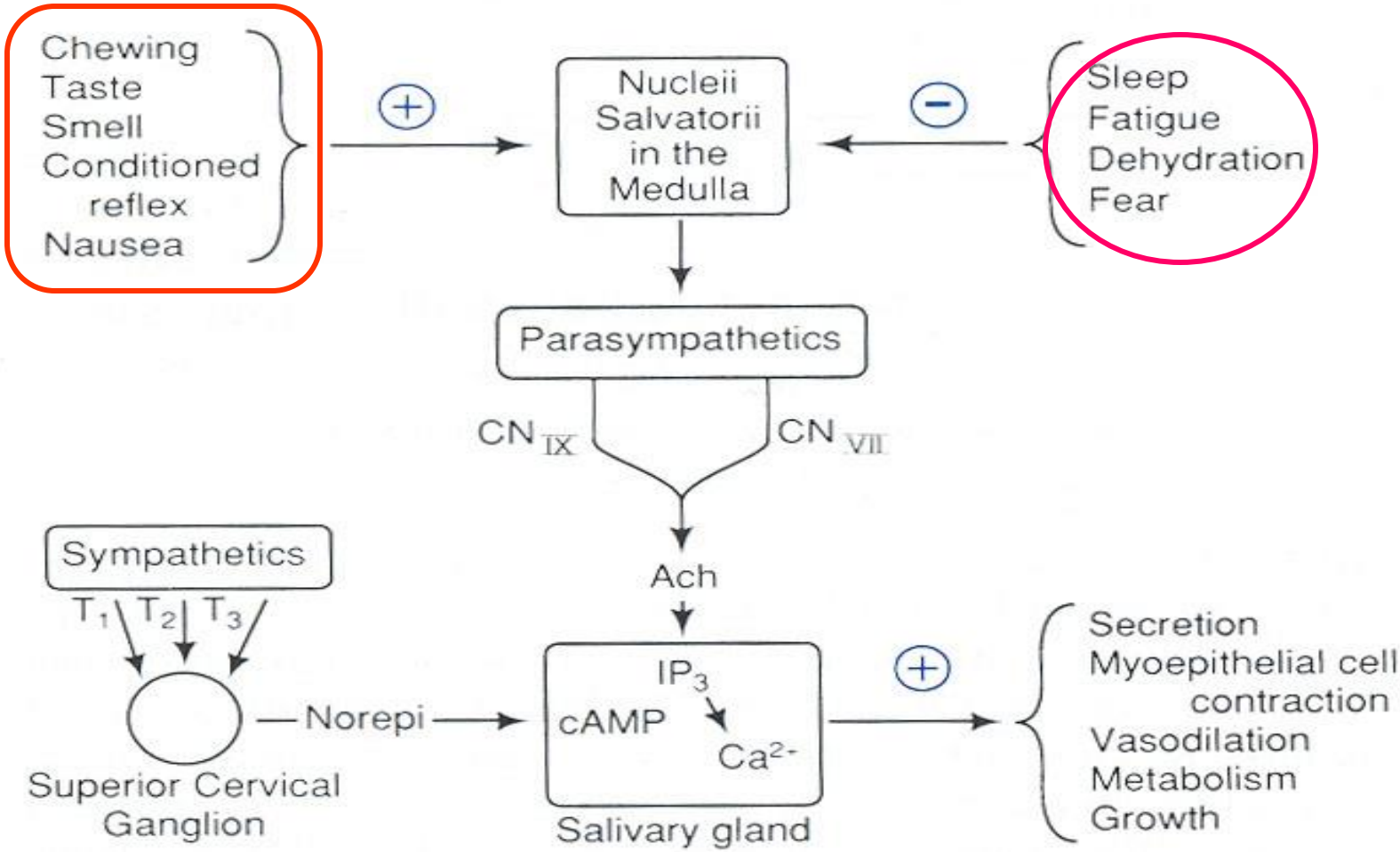
- ***Higher* centers control:** when a person smells or eats favorite foods, salivation is greater than when disliked food is smelled or eaten(*appetite area* of the brain) .
- ***Reflexes originating in the stomach and upper small intestines-*** particularly when irritating foods are swallowed or when a person is nauseated .The saliva, when swallowed, helps to remove the irritating factor in the GIT by diluting or neutralizing the irritant substances.
- ***Sympathetic stimulation*** can also increase salivation a slight amount
- ***Blood supply to the glands kallikrein, bradykinin.***



absorption of nutrients is done by enterocytes that have specialized microvilli on there luminal surfaces (also known as brush ...der cells). To lubricate and protect the epithelial cells, mucous is produced by goblet cells. The crypts contain the epithelial ...m cells that generate new enterocytes and other cell types. They are protected by Paneth cells that secrete antimicrobial ...defense molecules. The Lamina propria contains immune cells that monitor invasion of the epithelial lining by microorganisms.


Tractus solitarius
Superior and inferior salivatory nuclei
Submandibular gland
Submandibular ganglion
Facial nerve
Chorda tympani
Sublingual gland
Parotid gland
Otic ganglion
Taste and tactile stimuli
Glossopharyngeal nerve
Tongue

Neural regulation of secretion



3-Esophageal Secretion

- **The esophageal secretions are *Entirely Mucous* and mainly provide lubrication for swallowing.**

- ***Simple mucous glands: main body.***

- ***Compound mucous glands :At lower end& to lesser extent the* initial portion ,which prevent peptic ulceration.**

4-Gastric Secretion

Characteristics of the Gastric Secretions

- ***Oxyntic glands*** **(also called *Gastric* glands) and *Pyloric glands.***
- ***The Oxyntic*** **(acid-forming) glands**
- **Secrete *hydrochloric acid.***
- ***Pepsinogen.***
- ***Intrinsic factor.***
- **M*ucus***
- **located at the body and fundus.**
- **Constituting the proximal 80 % of stomach.**

Pyloric glands

- Secrete mainly ***mucus*** for protection of the pyloric mucosa from the stomach acid.
- They also secrete the hormone ***Gastrin***.
- located in the Antral portion of the stomach, the distal 20 %of the stomach.

Types of Cells

- ***Parietal(oxyntic) cells***
  - **Most distinctive cells in stomach (HCl & intrinsic factor).**
- ***Chief(peptic) cells***
  - **pepsinogen**
- **Mucus neck cells:**
  - **- HCO_3^-**
  - **- Mucus**

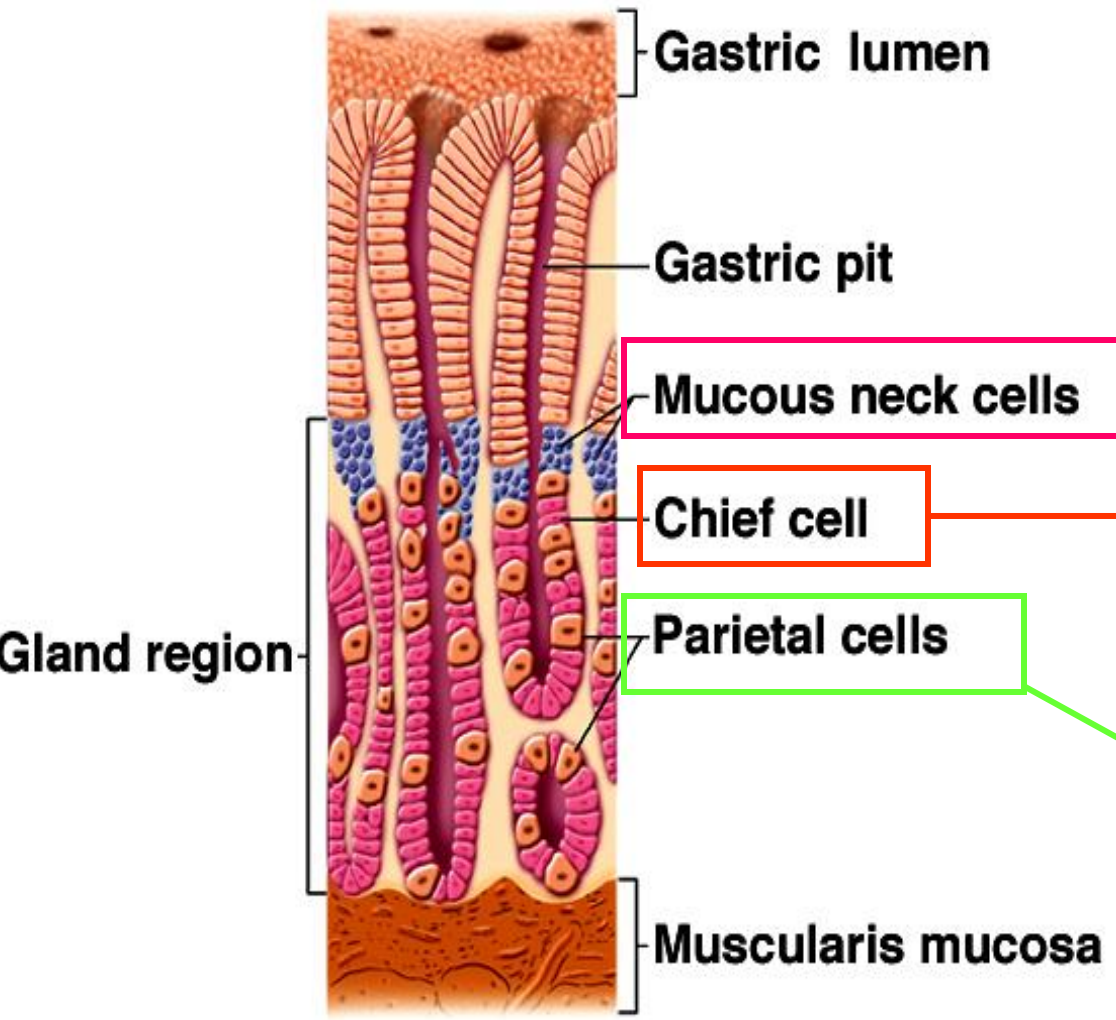
Types of Cells

- ***G Cells:*** **Gastrin (hormone) ---> ↑ HCl secretion**
- ***D Cells:*** **Somatostatin (antrum).**
- ***Enterochromaffin-like cell:*** **Histamine**
- **Present in a recess in deep part of gastric pits**

Gastric juice

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

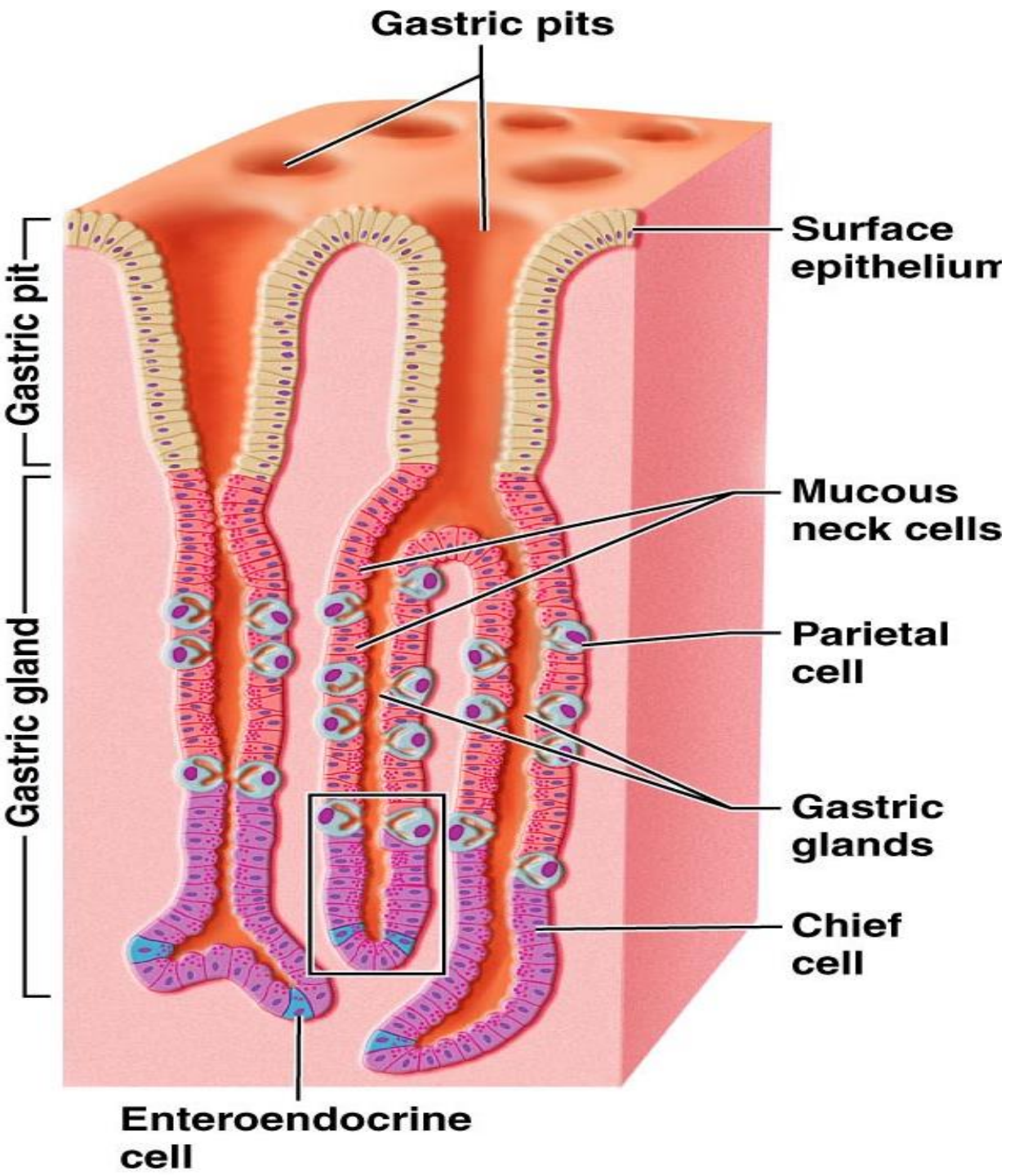
Exocrine gland cells of gastric pits

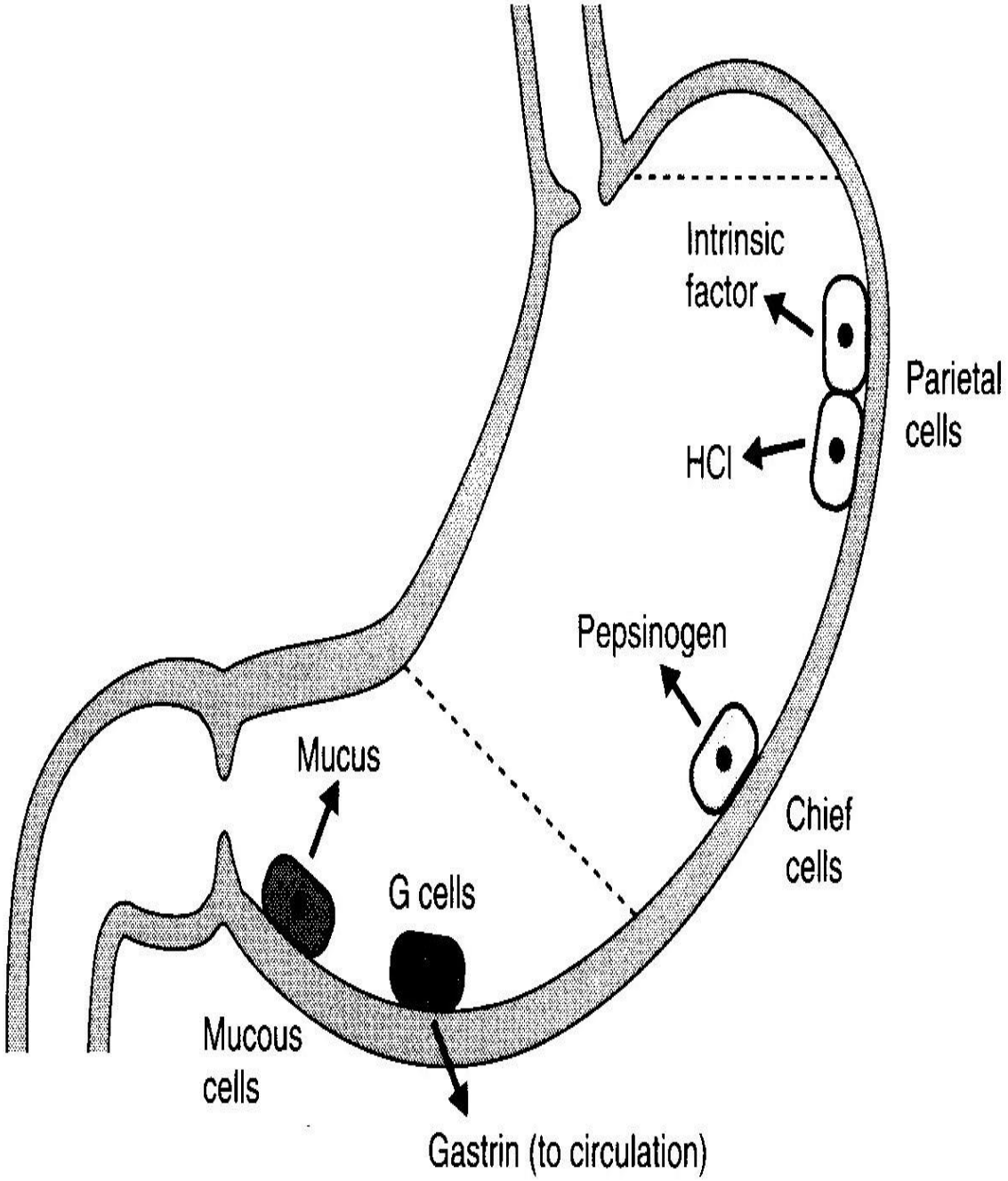


Produce alkaline mucus that covers mucosa layer

Synthesize and secrete the protease precursor known as pepsinogen.

Synthesize and secrete the HCl acid responsible for the acidic pH in the gastric lumen.


Gastric pits
Surface epithelium
Gastric pit
Gastric gland
Mucous neck cells
Parietal cell
Gastric glands
Chief cell
Enteroendocrine cell



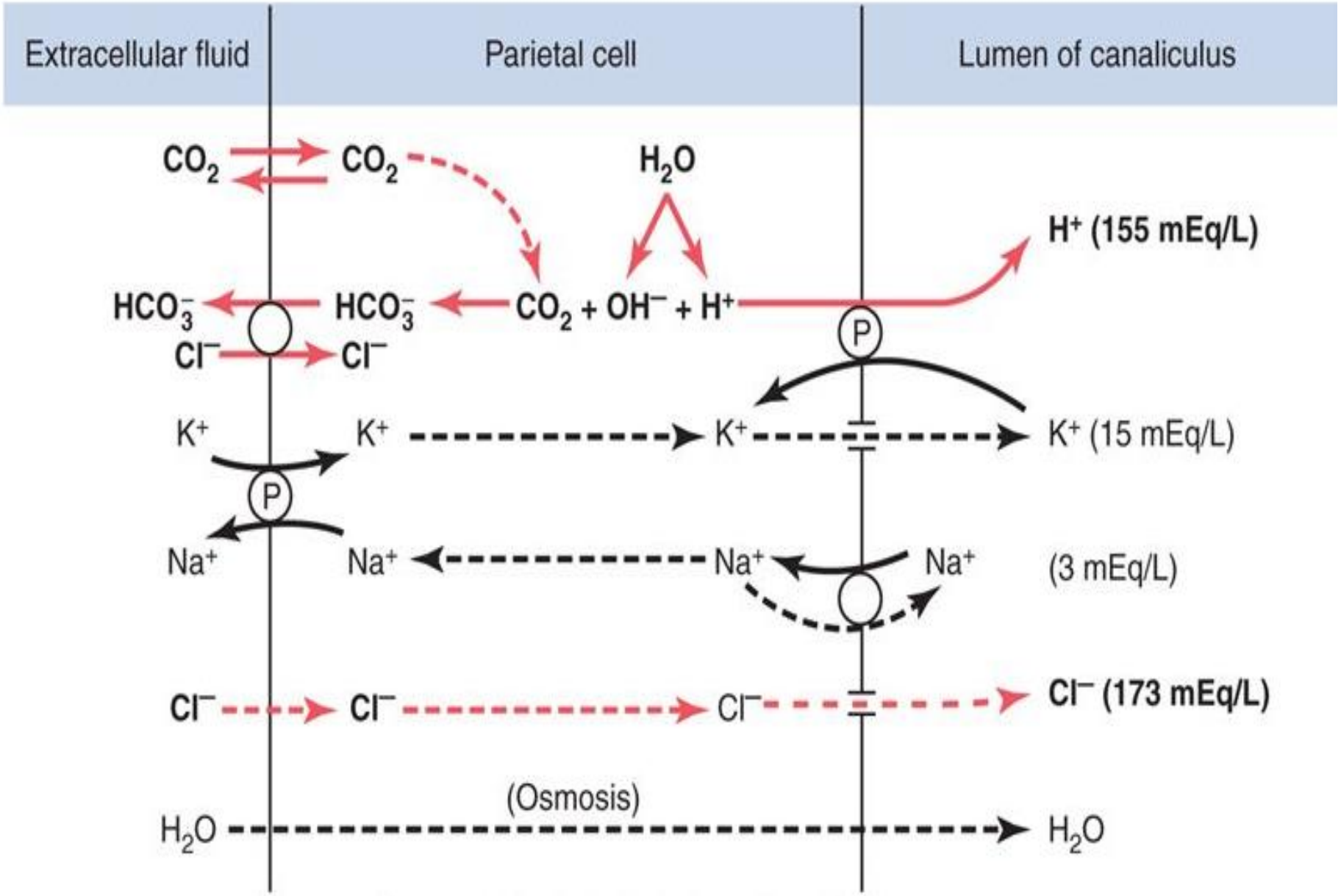
Cell Type	Location	Secretion
Parietal cells	Body	HCL Intrinsic factor
Chief cells	Body	Pepsinogen
G cells	Antrum	Gastrin
Mucous cells	Antrum	Mucus Pepsinogen

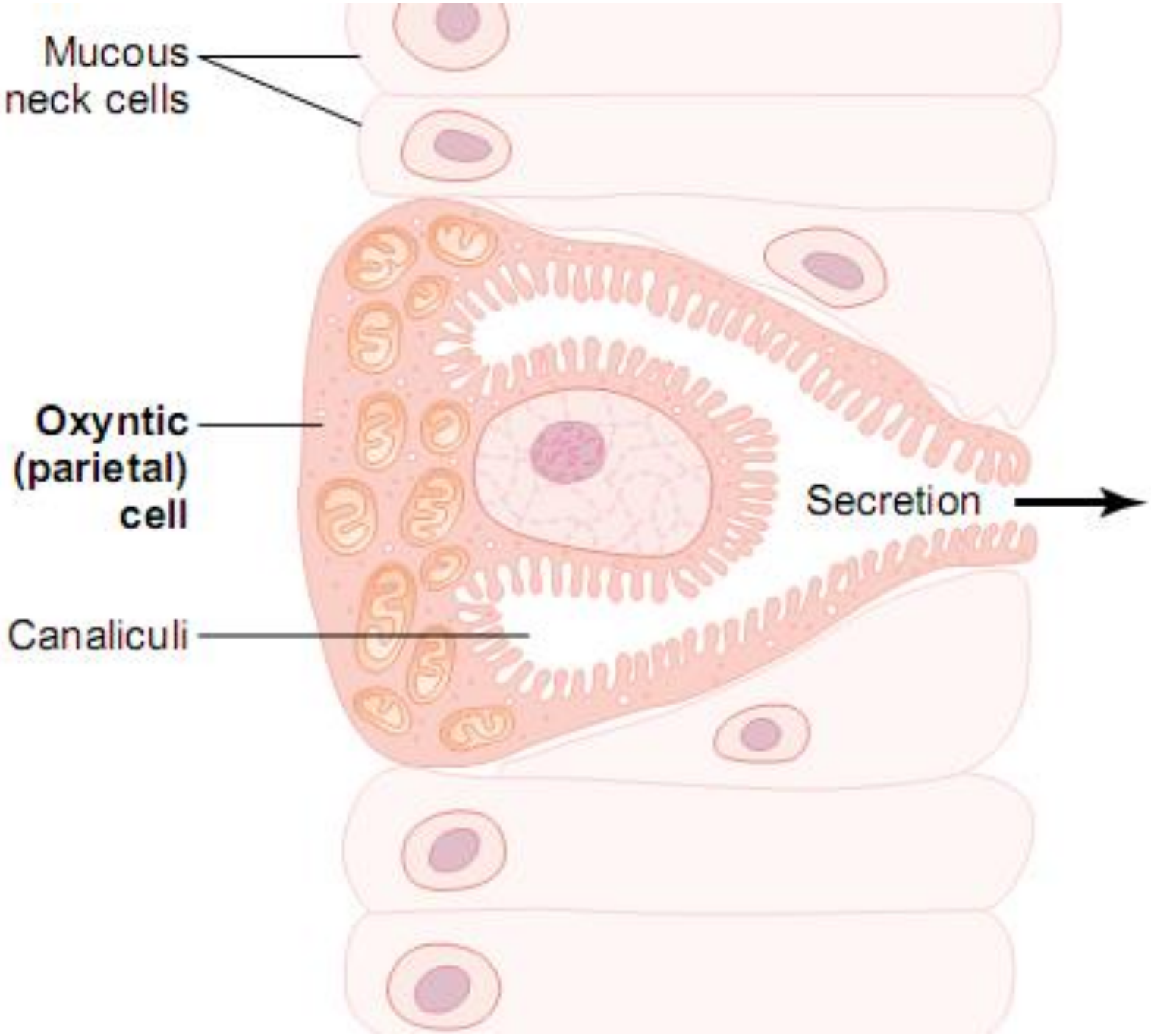
Secretion of hydrochloric acid

- Parietal cells secrete an isotonic acid solution that contains about 160 mmol/L of hydrochloric acid.
- This has pH about 0.8, which is extreme acidic. At this pH, the hydrogen ion concentration is about 3 million times that of the arterial blood. At the same time that hydrogen ions are secreted, bicarbonate ions diffuse into the blood so that gastric venous blood has a higher pH than arterial blood when the stomach is secreting acid *(alkaline tide.)*

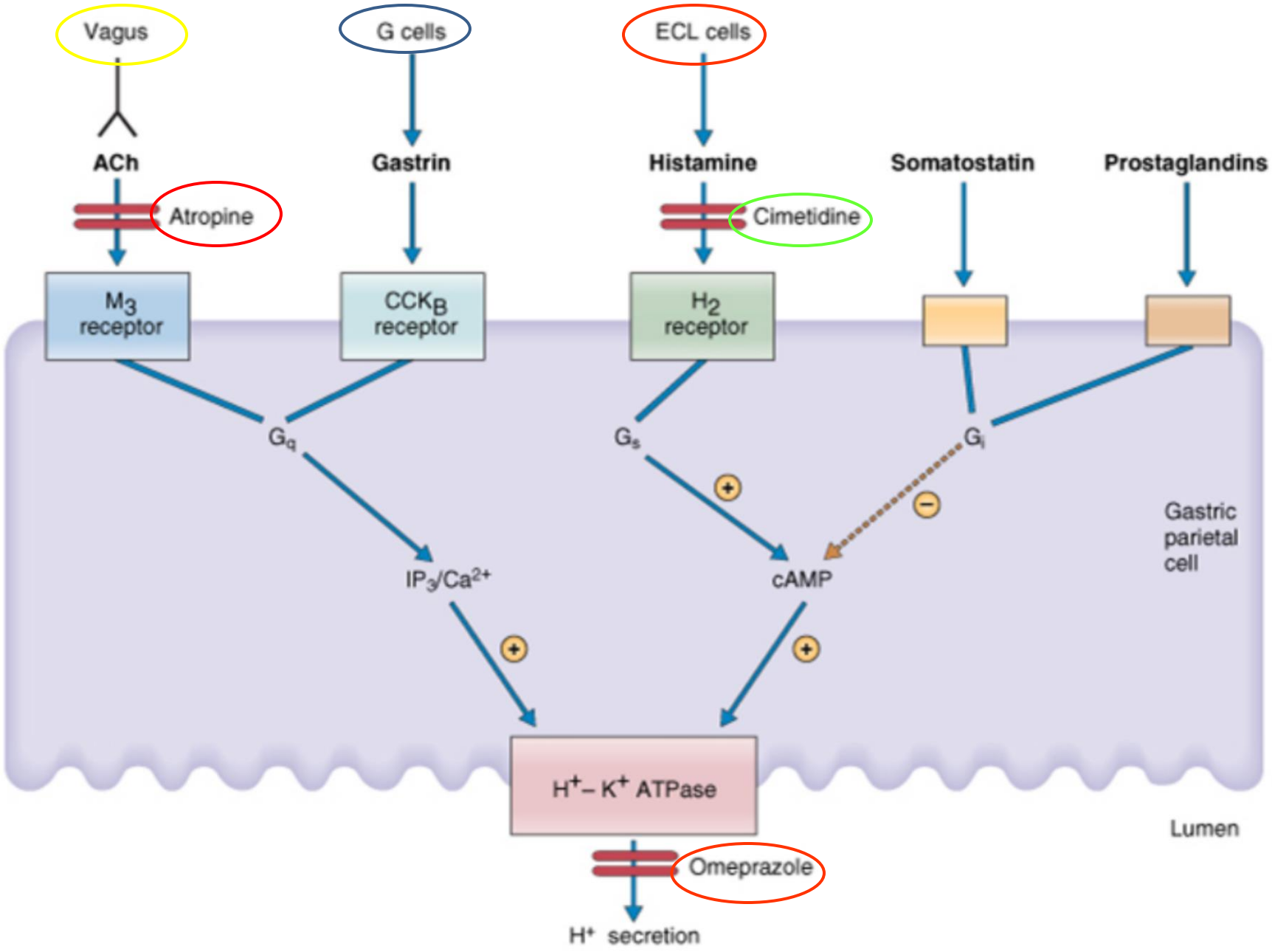
Basic mechanism of HCL secretion

- Water is dissociated in cytoplasm into H^+,OH^-,H+ is actively secreted into (Can),in exchange of K^+ by H-K ATPase shunt.
- CL^- is actively transported from cytoplasm of cell into lumen of canaliculus (Can)
- Na^+ is actively transported in other direction
- K^+, and few Na+ ions passively diffuse as a result to lumen of (Can)
- Na^+ is actively reabsorbed by separate shunt
- Water pass to (Can) by osmosis
- CO2 in cytoplasm combine with OH^- by carbonic anhydrase in to Hco_3 which diffuse to plasma in exchange of CL^-

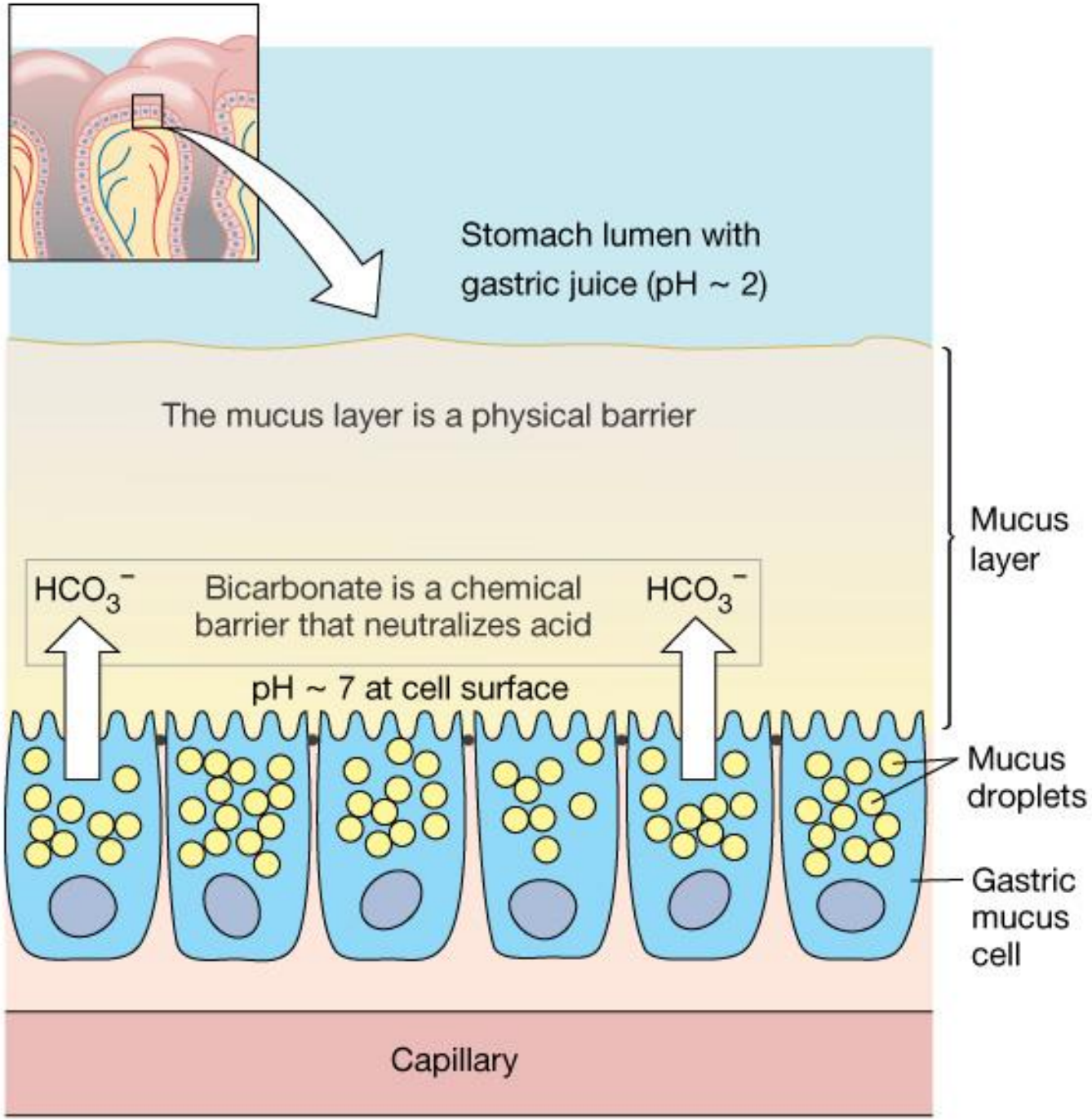

Extracellular fluid
Parietal cell
Lumen of canaliculus
CO_2
CO_2
H_2O
H^+ (155 mEq/L)
HCO_3^-
HCO_3^-
$CO_2 + OH^- + H^+$
Cl^-
Cl^-
P
K^+
K^+
K^+
K^+ (15 mEq/L)
P
Na^+
Na^+
Na^+
Na^+
(3 mEq/L)
Cl^-
Cl^-
Cl^-
Cl^- (173 mEq/L)
(Osmosis)
H_2O
H_2O


Mucous neck cells
Oxyntic (parietal) cell
Canaliculi
Secretion

- **Basic Factors That Stimulate Gastric Secretion *Are Acetylcholine, Gastrin, and Histamine***
  - **Secretion and Activation of Pepsinogen.**
  - **Secretion of Intrinsic Factor by Parietal Cells .**
  - **Pyloric Glands-Secretion of Mucus and Gastrin .**
  - **Surface Mucous Cells :They secrete large quantities of *viscid mucus(it is alkaline)* that coats the stomach mucosa with a gel layer of mucus often more than *1 millimeter thick*, thus providing a major shell of protection for the stomach wall, as well as contributing to lubrication of food transport**



- **The stomach's ability to prevent back leak of acid can be attributed to the Gastric barrier due to the formation of alkaline mucus and to tight junctions between epithelia cells .**
- **If this barrier is damaged by toxic substances, such as occurs with excessive use of *Aspirin or NSAIDS, Steroids,Alcohol*, *Vinegar, Bile salts* the secreted acid does leak down an electrochemical gradient into the mucosa, causing stomach mucosal damage.**



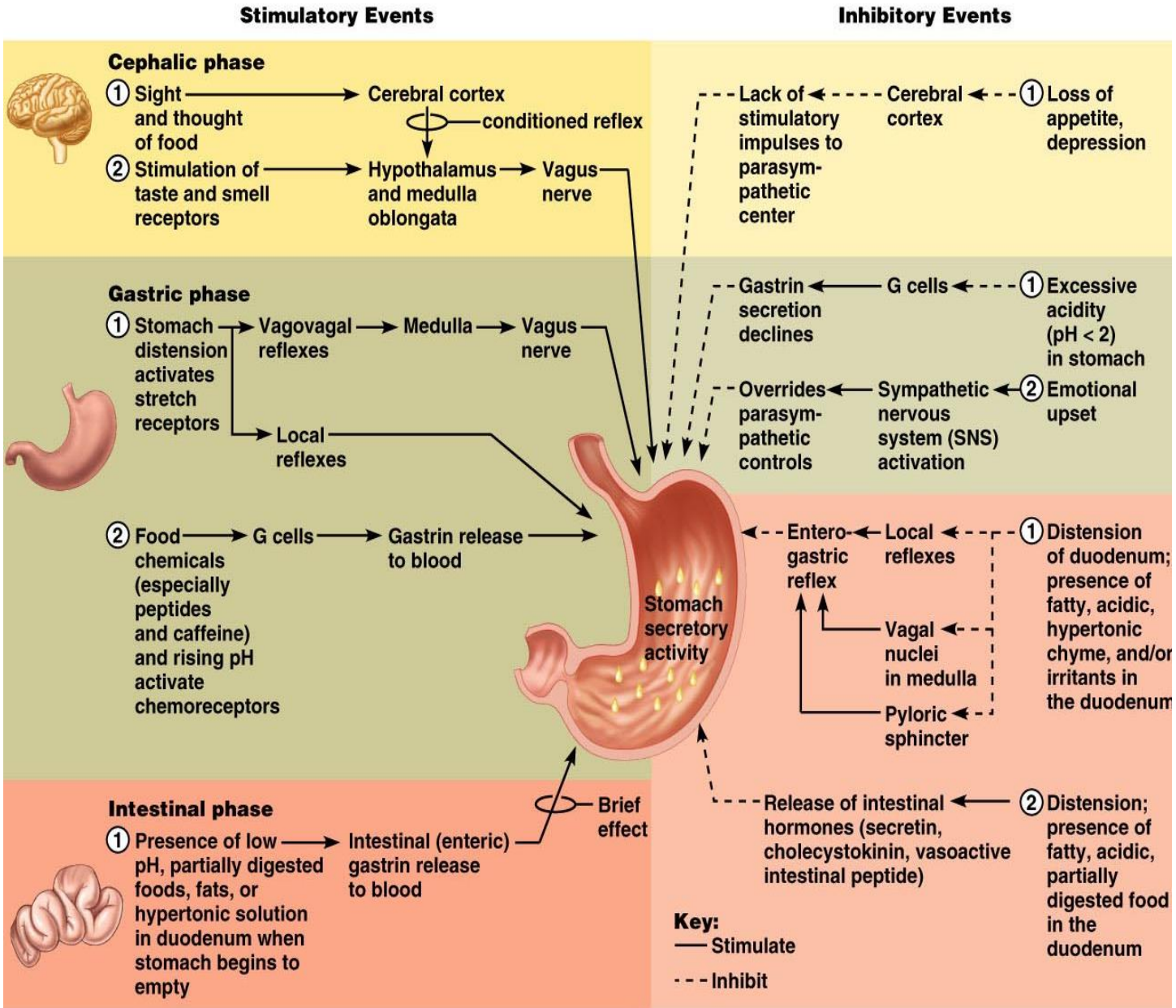
Neural & Hormonal Control of Gastric Secretion

- Vagus nerve (neural effector).
- Gastrin (hormonal effector).
- Enterochromaffin-like cells Histamine ---→H_2 receptor (parietal cells) → acid secretion.

Stomach: Regulation of Secretion and Motility

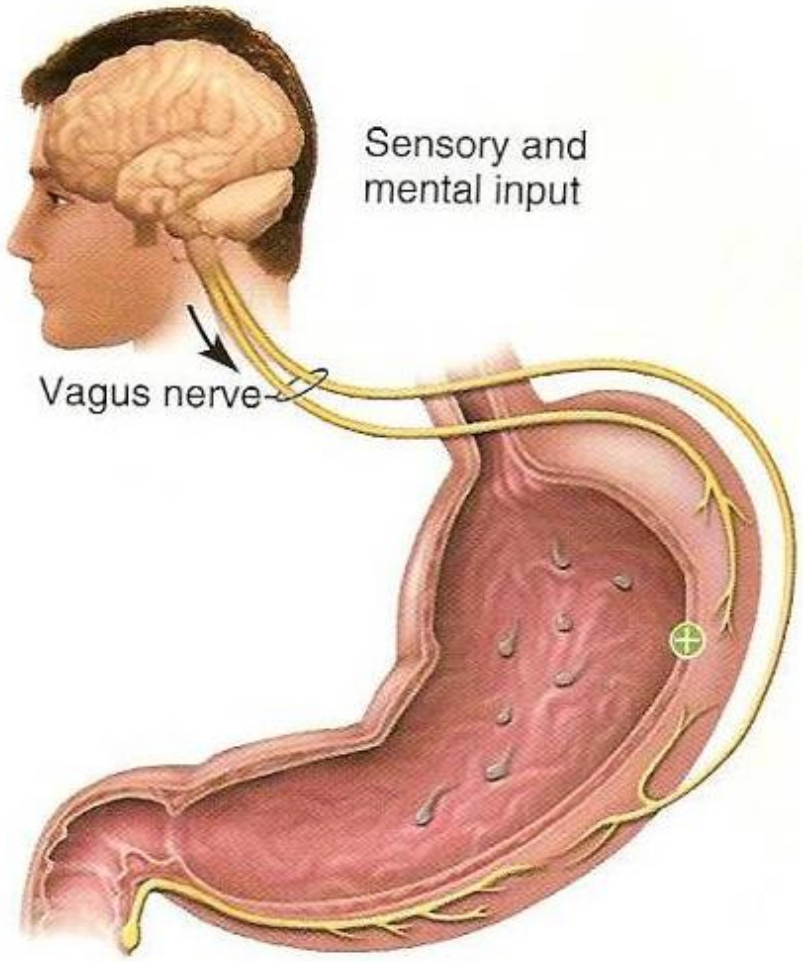
3 phases

- ***Cephalic***
- ***Gastric***
- ***Intestinal***



Stomach: Regulation of Secretion and Motility

1. *Cephalic phase*
   - Stimuli
     - Sight
     - Smell
     - Taste
     - Thoughts/Memories
   - Effect
     - Parasympathetic impulses increase gastric secretion

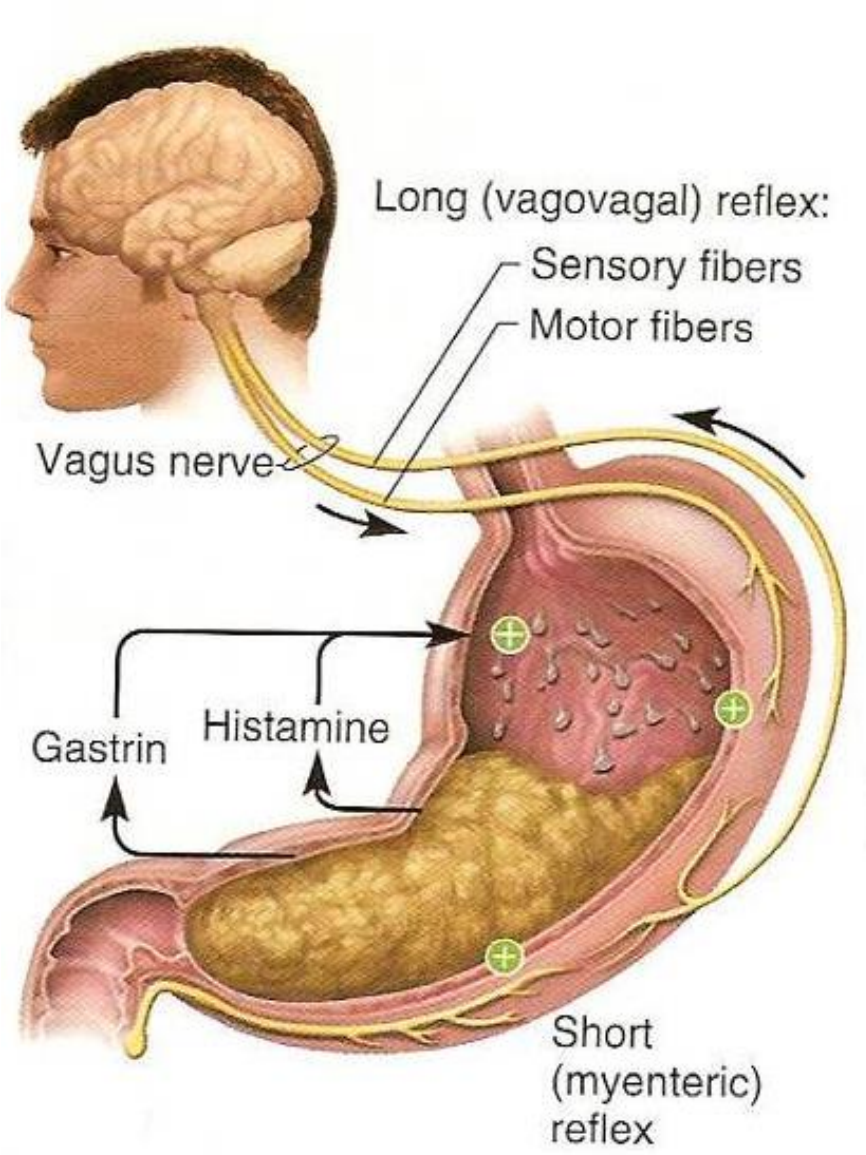


Stomach: Regulation of Secretion and Motility

2. Gastric phase

- ***Neural negative feedback mechanisms***

- **Distension activates stretch receptors causing Myenteric and vago-vagal reflexes to release Ach**
  - **Ach stimulates gastric juice secretion**
- **Chemoreceptor's respond to partially digested proteins, caffeine and rising pH**
  - **Stimulate gastric secretion from G cells**

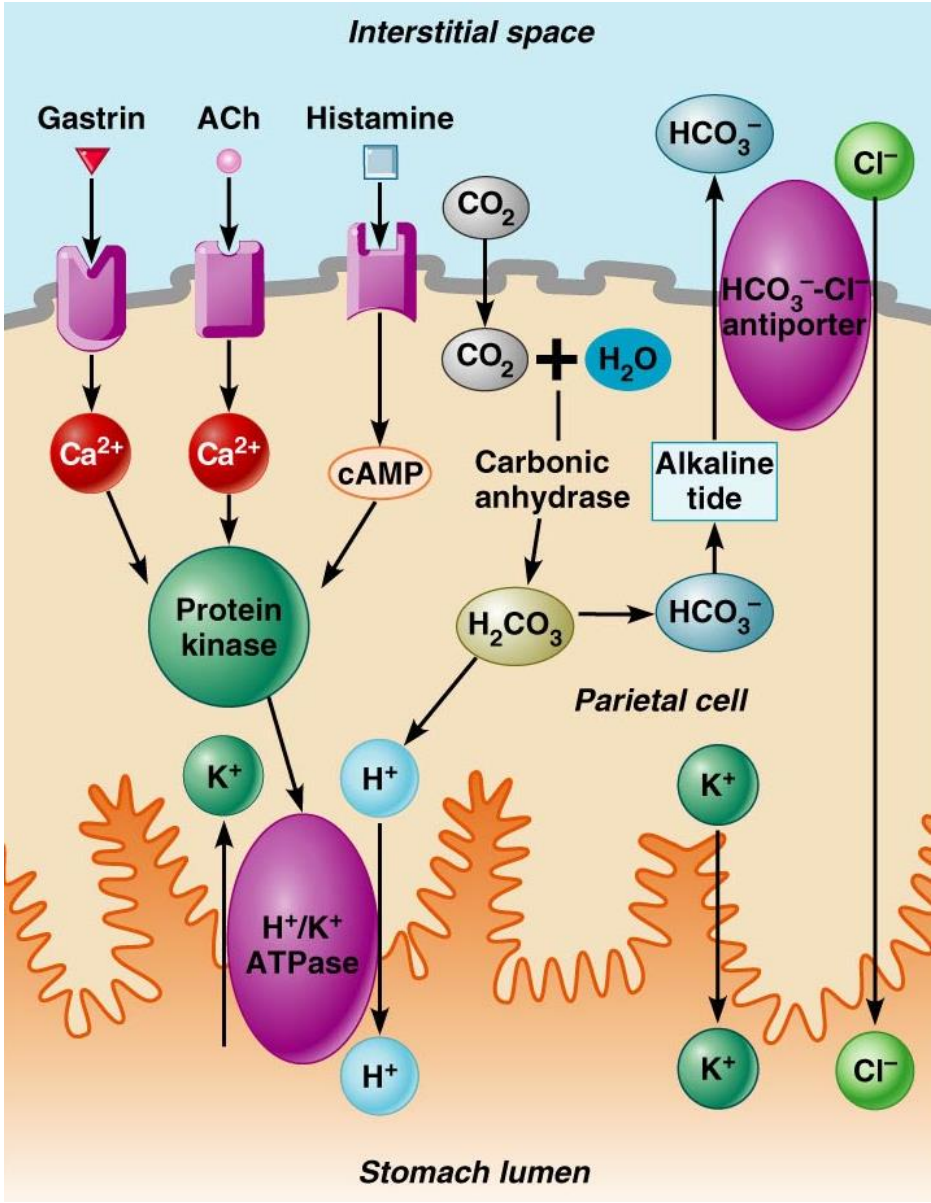


Stomach Regulation of Secretion and Motility

2. Gastric phase (cont.)

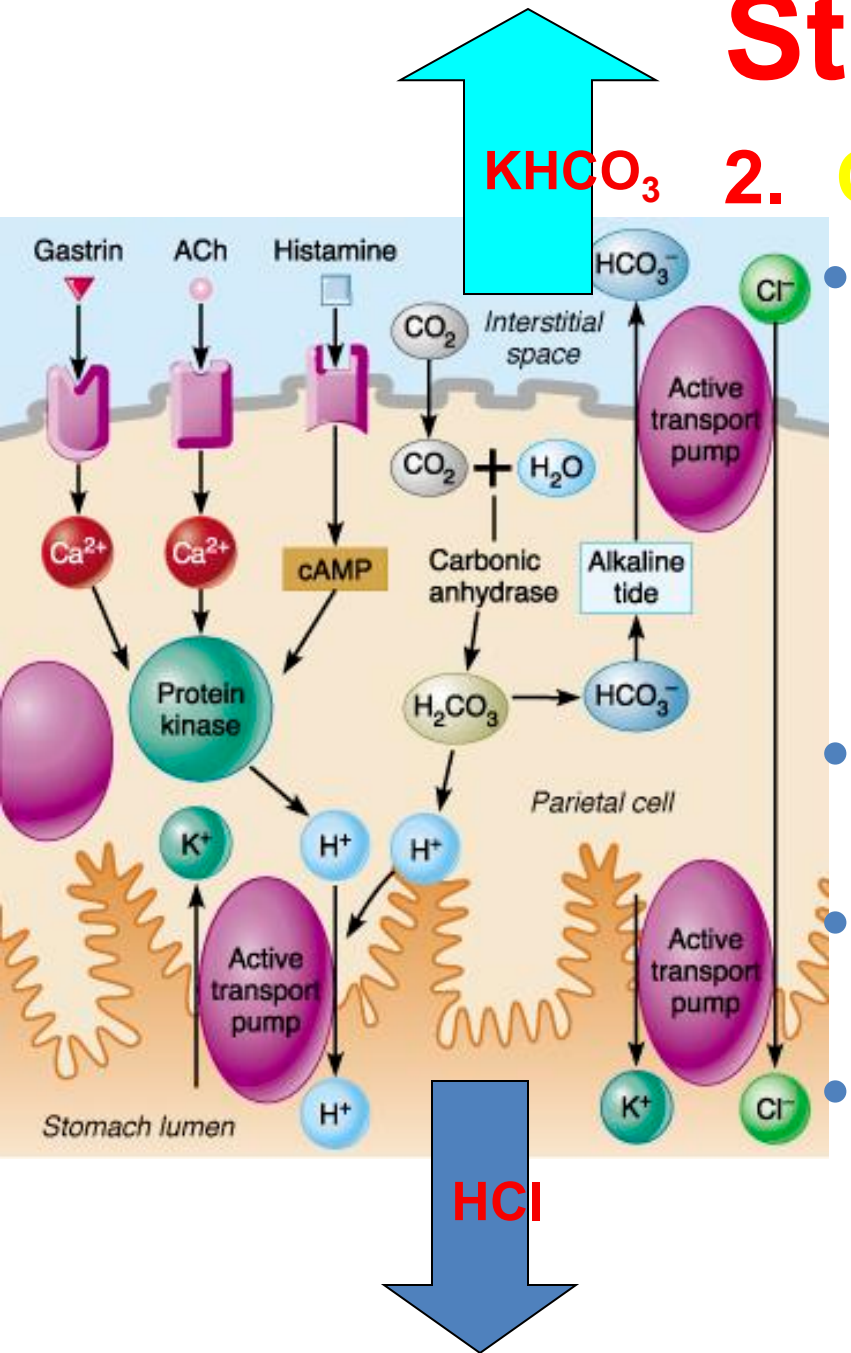
- ***Gastrin***

- Inhibited at pH less than 2
- Gastrin transported in the blood to the gastric glands
- Greatly stimulates HCl secretion
- Stimulates histamine secretion
- Slightly stimulates pepsinogen secretion
- Contracts lower esophageal sphincter
- Relaxes pyloric sphincter
- Increases gastric motility



Stomach

2. Gastric phase (continued)



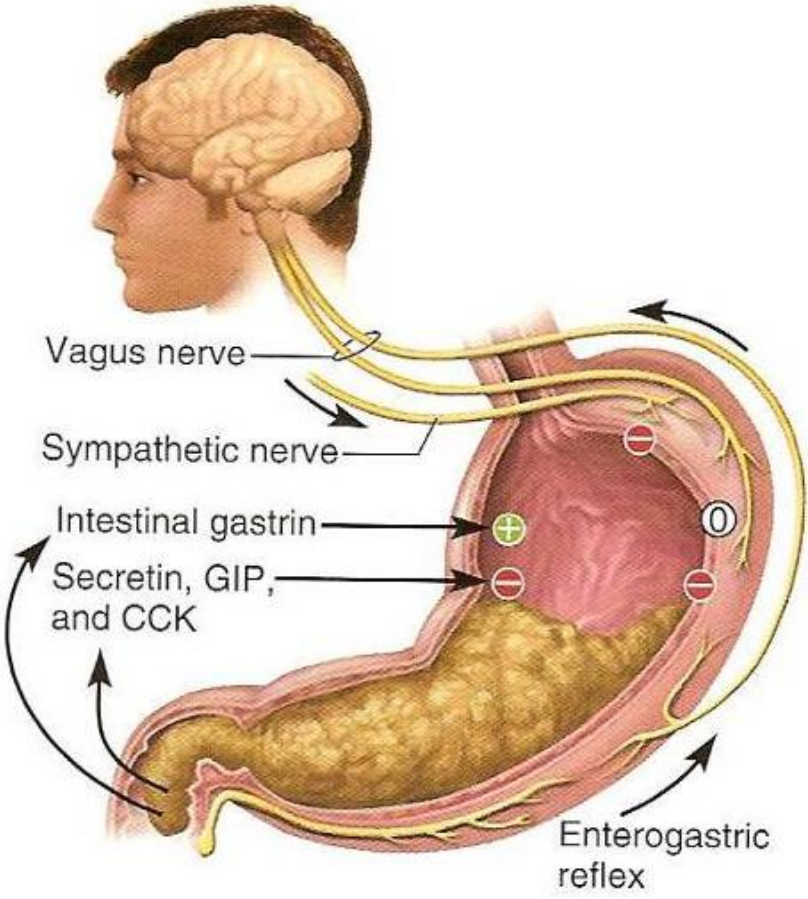
- Control of HCl secreting parietal cells
  - stimulation by three signal chemicals
    - **gastrin**
    - **acetylcholine**
    - **histamine**
- All three needed for strong H^+ secretion
- H^+ pumps work in conjunction with carbonic anhydrase
- blockage of the histamine H_2 receptor decreases HCl secretion
  - Tagamet
  - Zantac

Stomach: Regulation of Secretion and Motility

3. Intestinal phase has excitatory and inhibitory components:

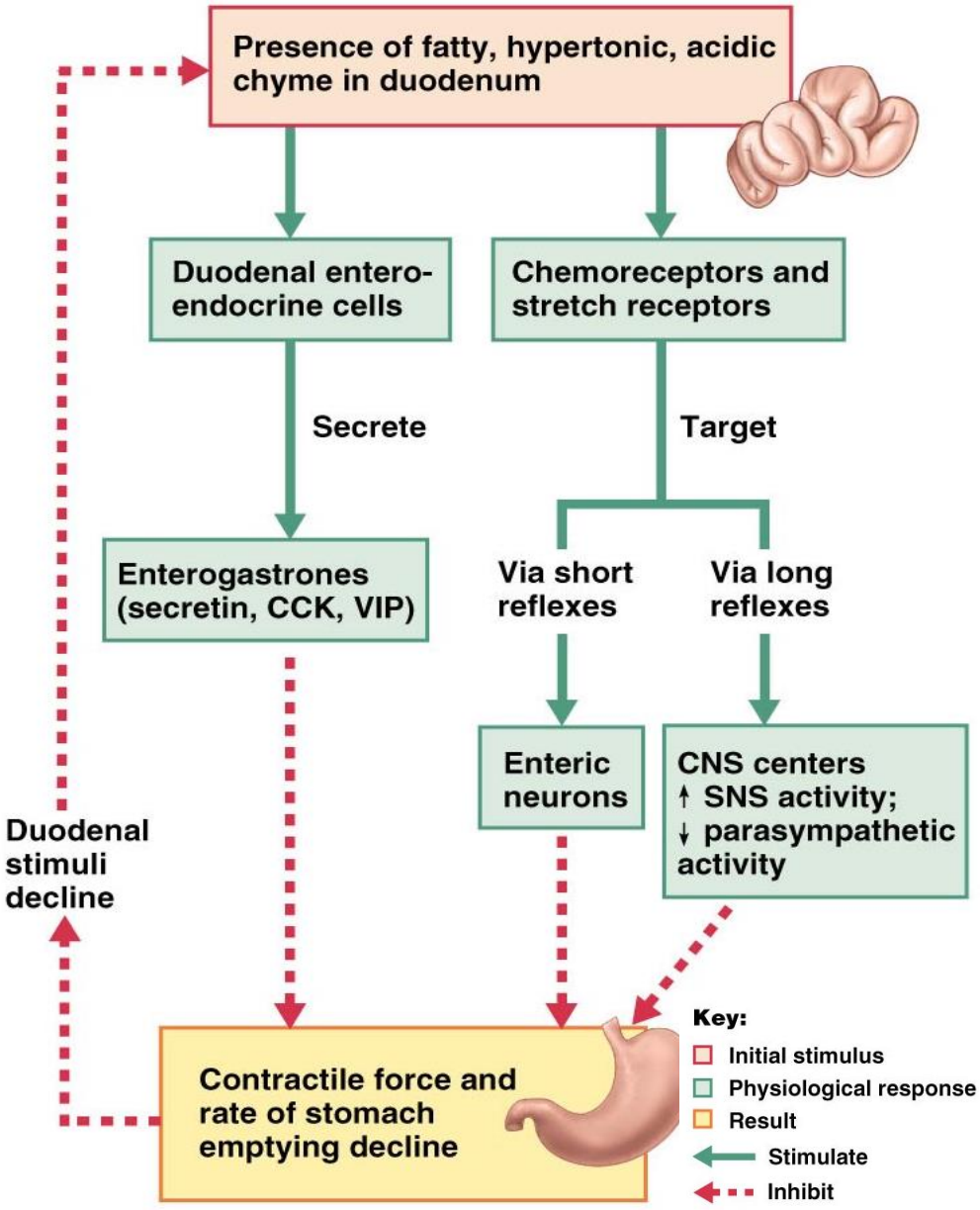
- ***Excitatory***

- **Very short phase**
- **Initiated by chyme entry into duodenum**
- **Stretch receptors stimulate release of intestinal (enteric) gastrin**
- **Chemoreceptor's detect fatty acids, & glucose in the duodenum**
- **Stimulate enteric gastrin release**



Emptying

- Food normally passes through stomach in *4 hours*
- Hormonal/neuronal reflexes regulate gastric emptying
- Large meals and large amounts of liquid increase stomach distension → increasing rate of emptying
- Stomach emptying inhibited by the Enterogastric reflex, enterogastrones, and fat in the duodenum.

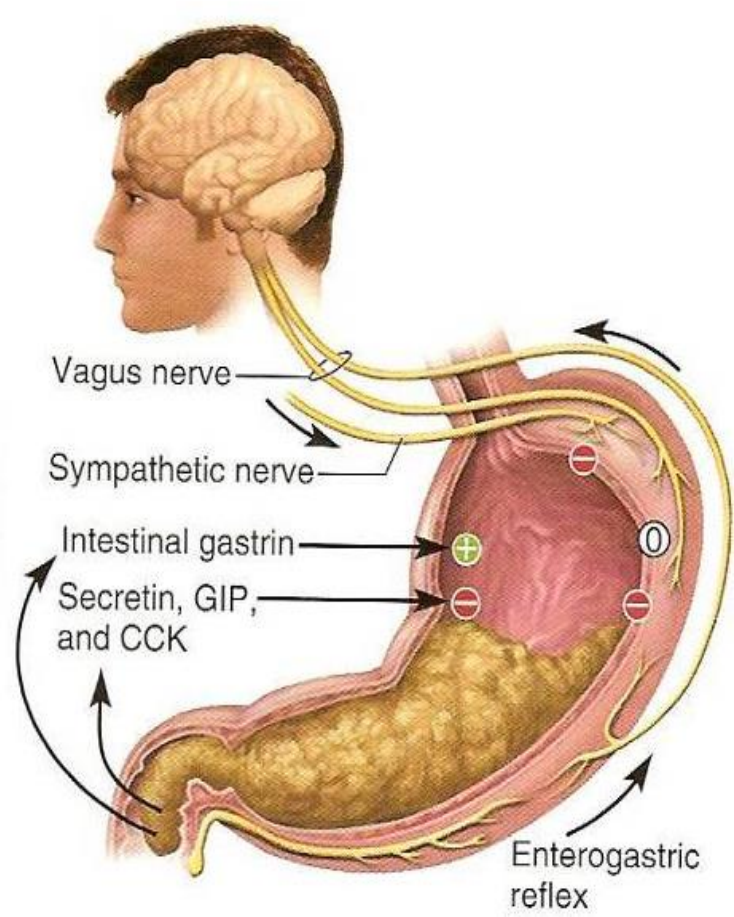


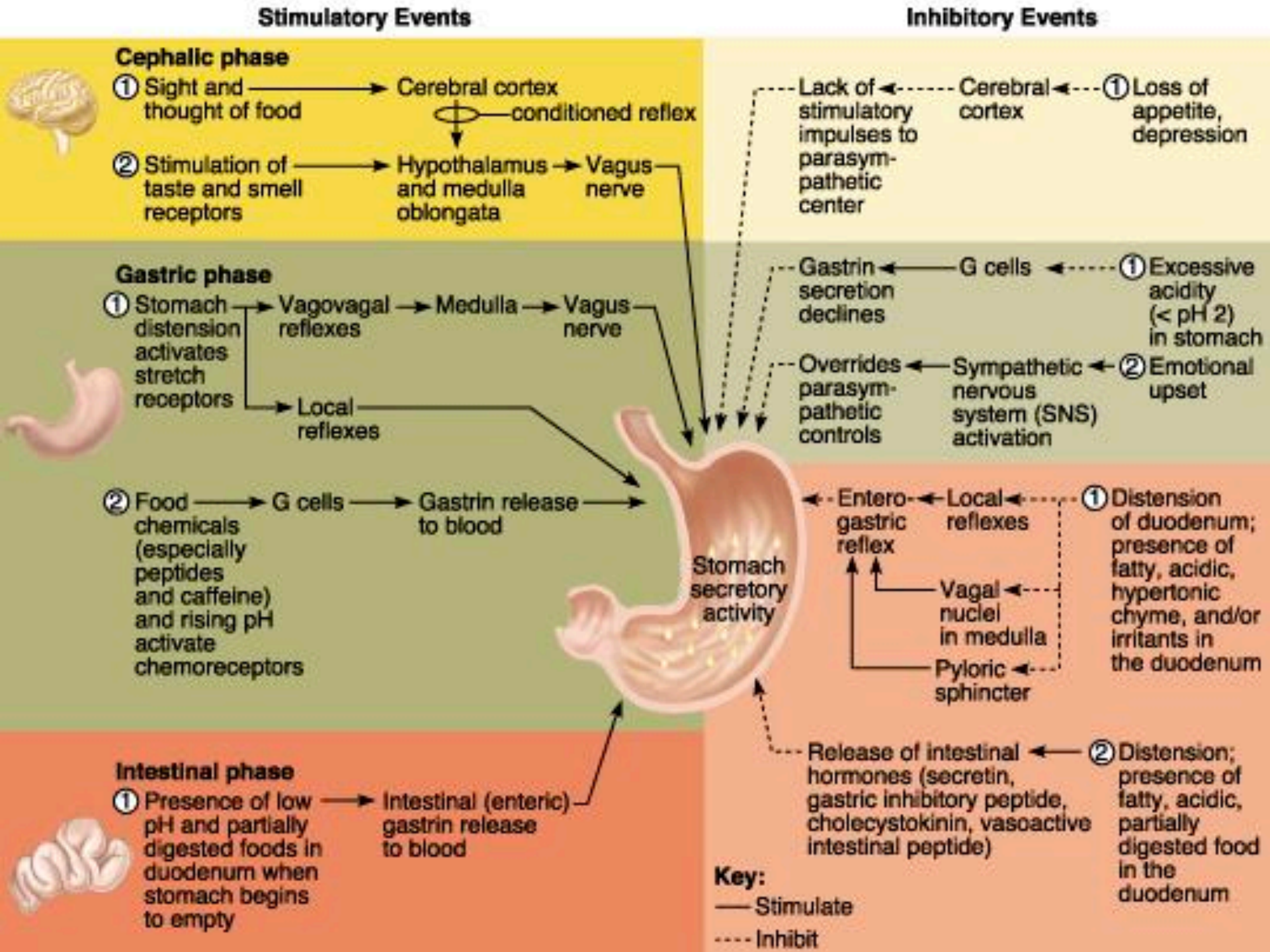
Stomach: Regulation of Secretion and Motility

3. Intestinal phase (cont.)

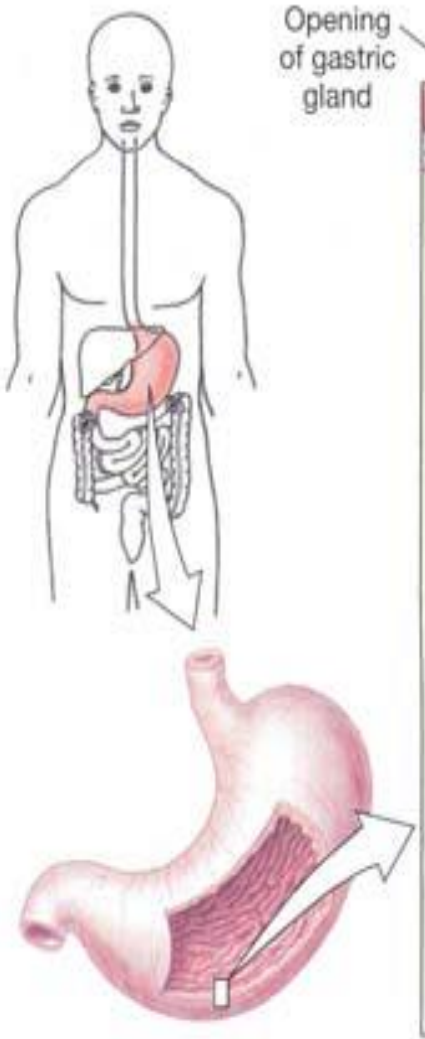
- ***Inhibitory***

- ***Enterogastric reflex:*** **stretch receptors, chemoreceptors trigger 3 reflexes that**
  1. **Inhibit vagovagal reflex**
  2. **Inhibit myenteric reflex**
  3. **Activate sympathetic nervous syste close pyloric sphincter**
  - **Inhibit gastric secretion**
  - **Enterogastrone secretion**
- **Enteroendocrine cells in the small intestine release:**
  - **Cholecystokinin (CCK)**
  - **Gastric inhibitory peptide (GIP)**
  - **Secretin**
  - **Vasoactive intestinal peptide (VIP)**
  - **Hormones inhibit gastric secretion**



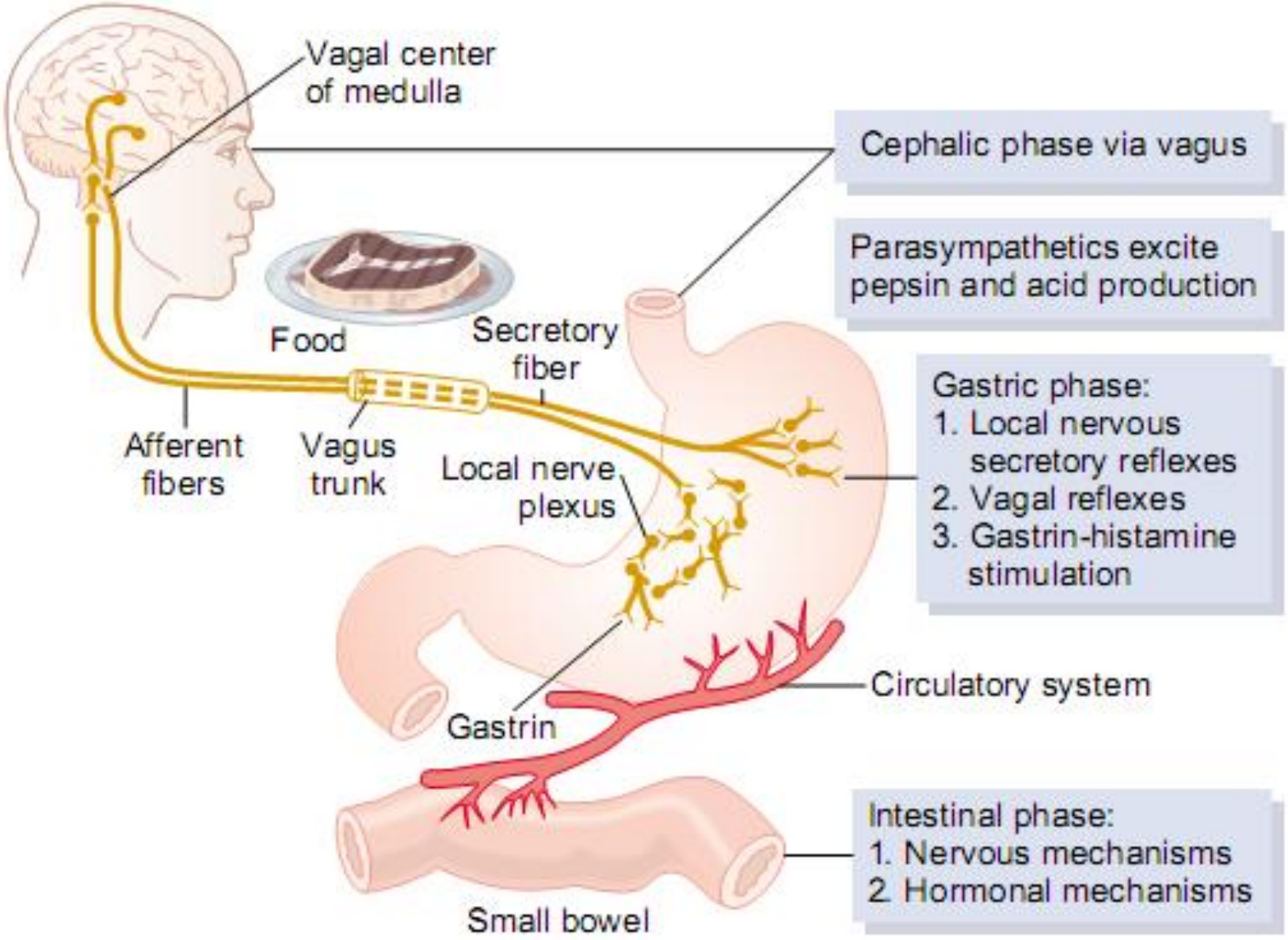

Stimulatory Events
Inhibitory Events
Cephalic phase
① Sight and thought of food
Cerebral cortex
conditioned reflex
② Stimulation of taste and smell receptors
Hypothalamus and medulla oblongata
Vagus nerve
Lack of stimulatory impulses to parasym-pathetic center
Cerebral cortex
① Loss of appetite, depression
Gastric phase
① Stomach distension activates stretch receptors
Vagovagal reflexes
Medulla
Vagus nerve
Local reflexes
Gastrin secretion declines
G cells
① Excessive acidity (< pH 2) in stomach
Overrides parasym-pathetic controls
Sympathetic nervous system (SNS) activation
② Emotional upset
② Food chemicals (especially peptides and caffeine) and rising pH activate chemoreceptors
G cells
Gastrin release to blood
Stomach secretory activity
Entero-gastric reflex
Local reflexes
① Distension of duodenum; presence of fatty, acidic, hypertonic chyme, and/or irritants in the duodenum
Vagal nuclei in medulla
Pyloric sphincter
Intestinal phase
① Presence of low pH and partially digested foods in duodenum when stomach begins to empty
Intestinal (enteric) gastrin release to blood
Release of intestinal hormones (secretin, gastric inhibitory peptide, cholecystokinin, vasoactive intestinal peptide)
② Distension; presence of fatty, acidic, partially digested food in the duodenum
Key:
Stimulate
Inhibit

Gastric Glands and secretions



Source	Substance Secreted	Stimulus for Release	Function
Mucous neck cell	Mucus	Tonic secretion; increased with irritation of mucosa	Physical barrier between lumen and epithelium
	Bicarbonate	Secreted with mucus	Buffers gastric acid to prevent damage to epithelium
Parietal cells	Gastric acid (HCl)	Acetylcholine, gastrin, histamine	Activates pepsin; kills bacteria
	Intrinsic factor		Complexes with vitamin B_{12} to permit absorption
Enterochromaffin-like cell	Histamine	Acetylcholine, gastrin	Stimulates gastric acid secretion
Chief cells	Pepsin(ogen)	Acetylcholine, acid, secretin	Digests proteins
	Gastric lipase		Digests fats
D cells	Somatostatin	Acid in the stomach	Inhibits gastric acid secretion
G cells	Gastrin	Acetylcholine, peptides, and amino acids	Stimulates gastric acid secretion

■ Figure 20-16 Cell types of the gastric mucosa



Figure

Phases

Secretion and Activation of Pepsinogen

- **Secreted by the peptic and mucous cells of the gastric glands**
- **When pepsinogen is first secreted, it has no digestive activity. However, as soon as it comes in contact with hydrochloric acid, it is activated to form active *pepsin*.**
- **Pepsin functions as an active Proteolytic enzyme in a highly acid medium (optimum pH 1.8 to 3.5), but above a pH of about 5 it has almost no Proteolytic activity and becomes completely inactivated in a short time.**

Regulation of Pepsinogen Secretion

- **(1) stimulation of the *peptic cells* by *acetylcholine* released from the *Vagus nerves* or from the *gastric enteric nervous plexus.***
- **(2) stimulation of peptic cell secretion in response to acid in the stomach. The acid probably does not stimulate the peptic cells directly but instead elicits additional enteric nervous reflexes that support the original nervous signals to the peptic cells.**