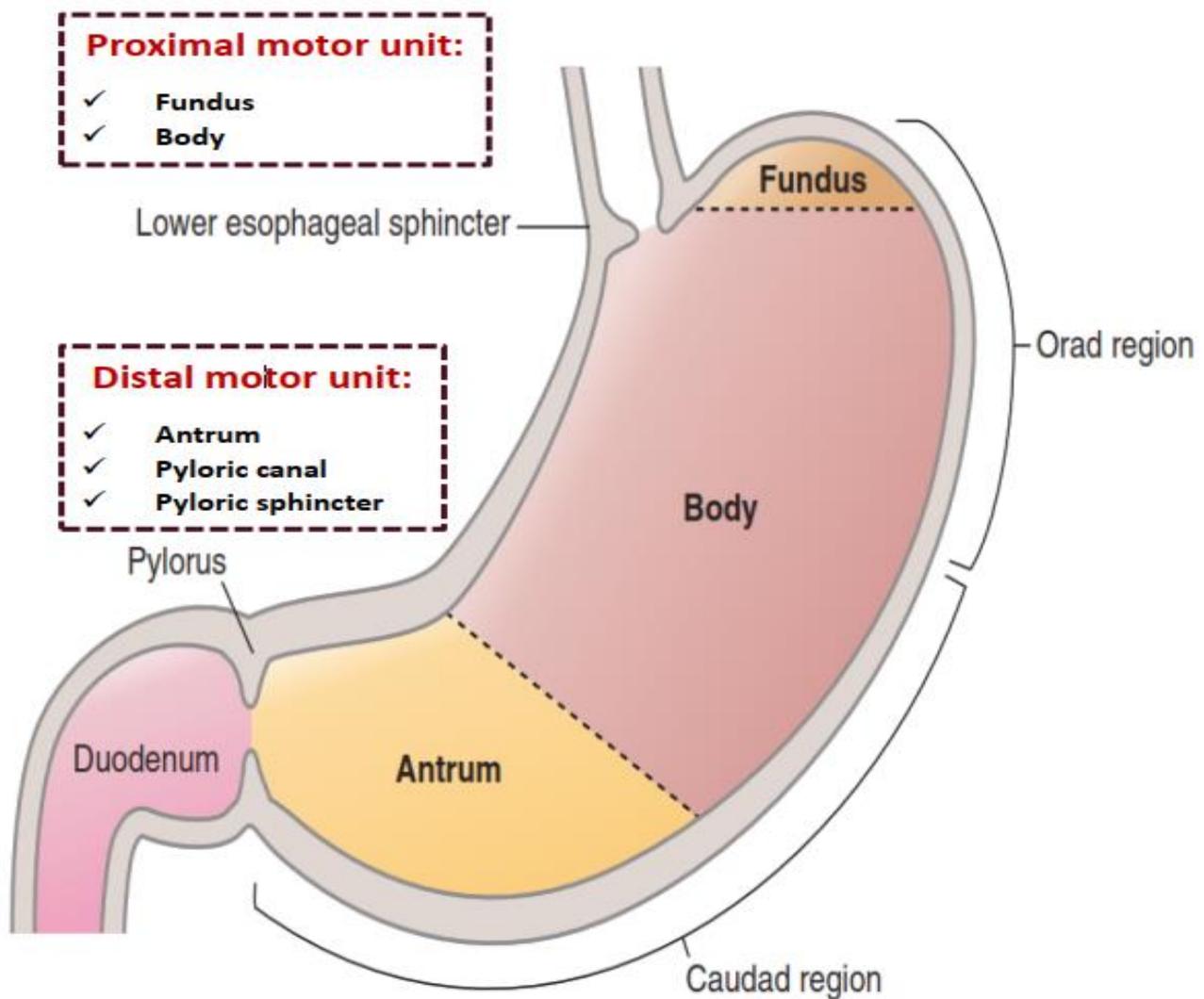


# Stomach

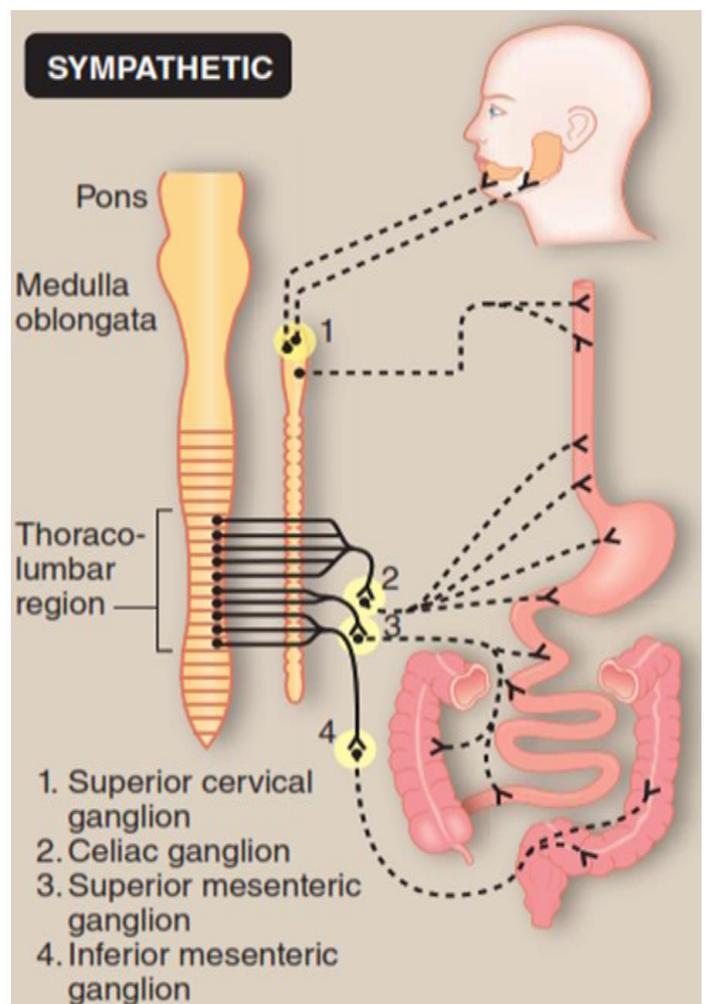
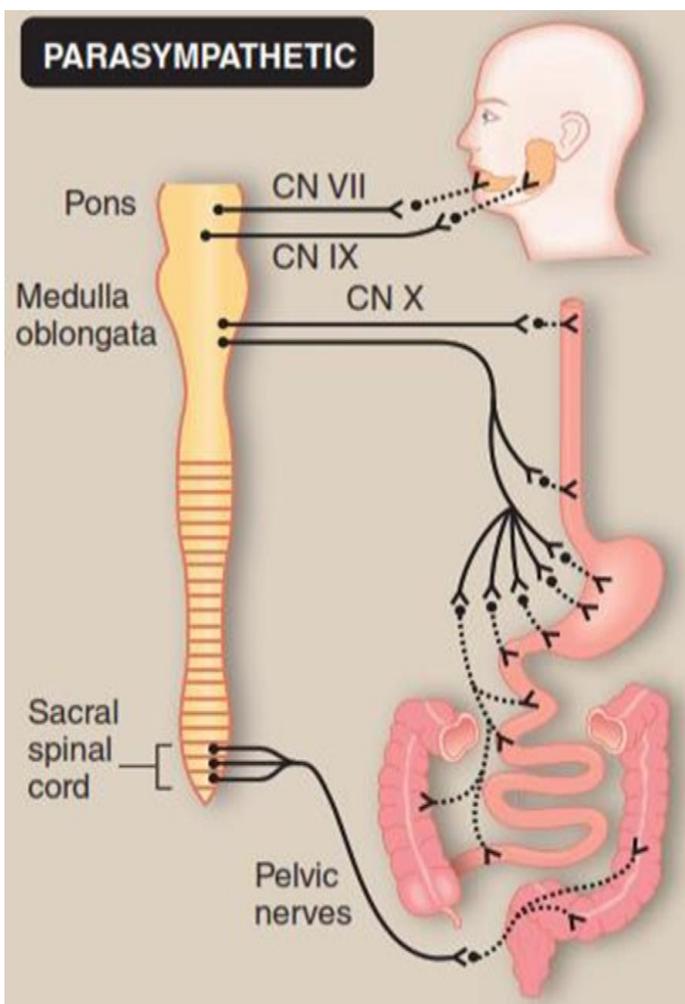
▪ Functionally, the stomach is divided into 2 parts:

	1- Proximal motor unit:	2- Distal motor unit:
<b>Consists of:</b>	<ul style="list-style-type: none"> <li>The <b>body and fundus</b>.</li> </ul>	<ul style="list-style-type: none"> <li>The <b>antrum, pyloric canal and pyloric sphincter</b>.</li> </ul>
<b>Thickness:</b>	<ul style="list-style-type: none"> <li>Has <b>thin musculature</b>.</li> </ul>	<ul style="list-style-type: none"> <li>Has <b>thick musculature</b>.</li> </ul>
<b>Function:</b>	<ul style="list-style-type: none"> <li>Acts as a <b>reservoir</b> for the swallowed food.</li> </ul>	<ul style="list-style-type: none"> <li><b>Mixing</b> the gastric contents and <b>emptying</b> them into the duodenum.</li> </ul>



▪ Nerve supply:

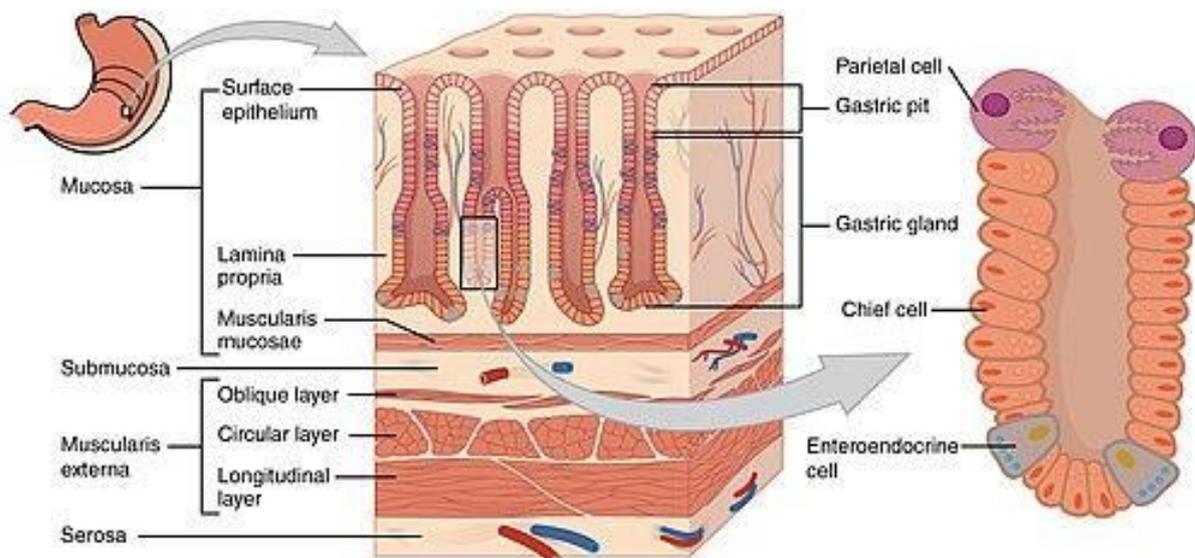
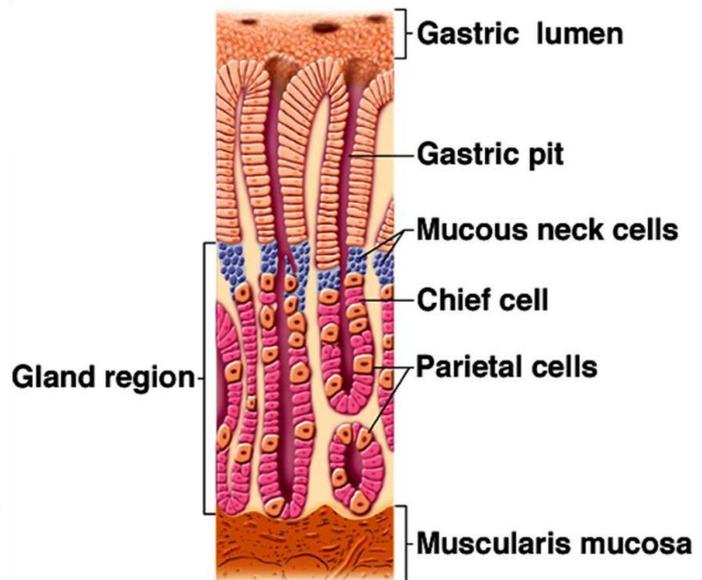
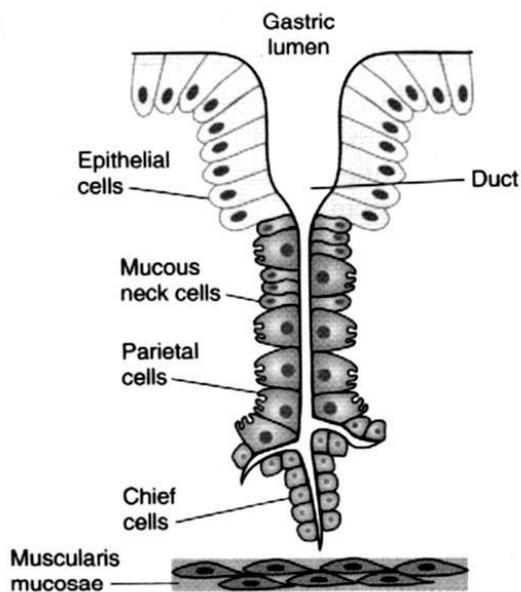
	A) Parasympathetic supply:	B) Sympathetic supply:
<b>Derived from</b>	Vagi	The greater splanchnic nerves
<b>Transmitter</b>	Acetyl choline	Noradrenaline
<b>Stimulation</b>	<ul style="list-style-type: none"> <li>• <b>Contraction of the wall of the stomach and relaxation of the pyloric sphincter</b> leading to acceleration of emptying.</li> <li>• <b>Secretion of juice rich in HCl and pepsinogens.</b></li> </ul>	<ul style="list-style-type: none"> <li>• Its stimulation leads to <b>Relaxation of the wall of the stomach and contraction of the pyloric sphincter</b>, leading to delayed emptying.</li> </ul>



# Gastric Glands

- Gastric mucosa contains several gastric glands which open on **the surface of gastric mucosa by gastric pits.**

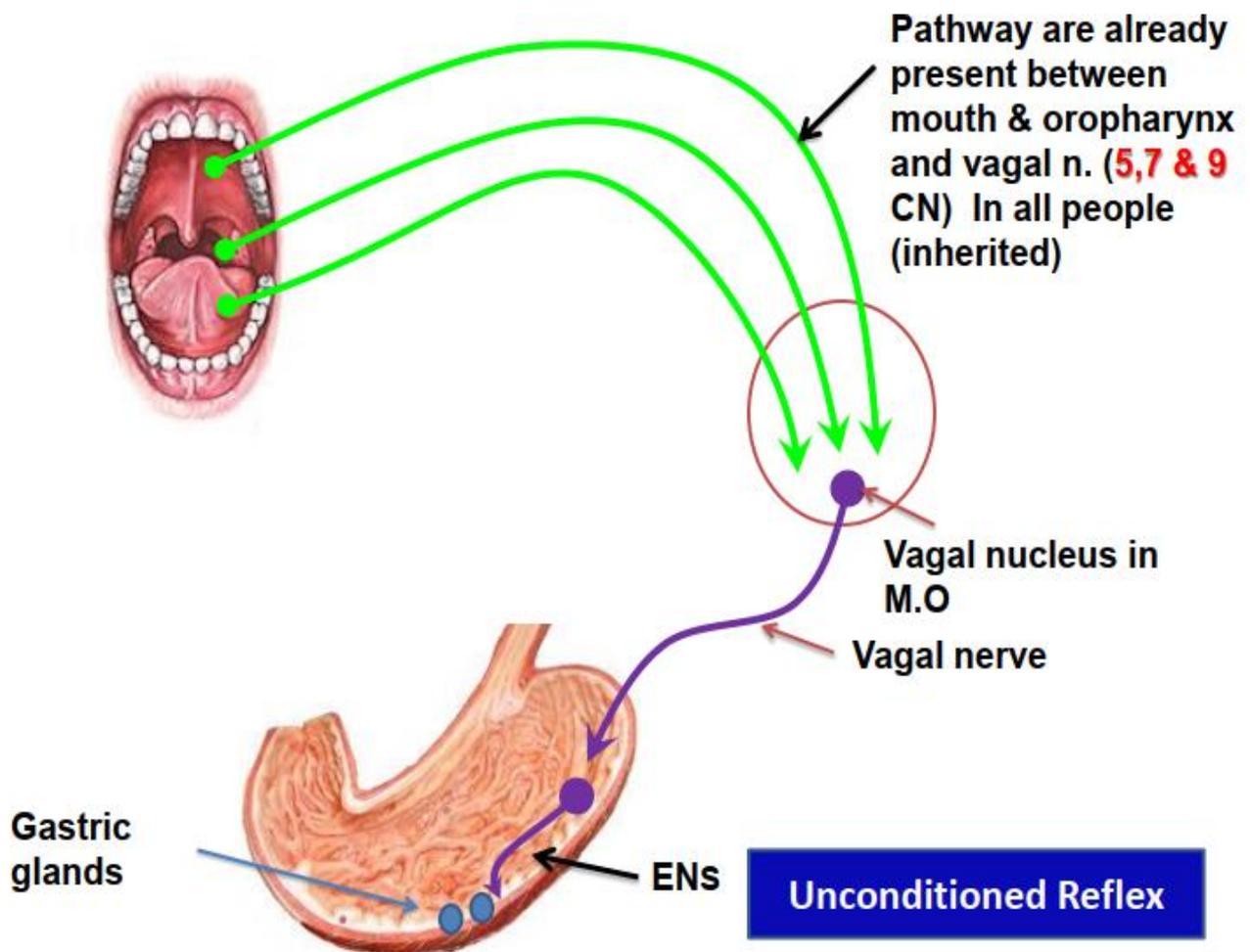
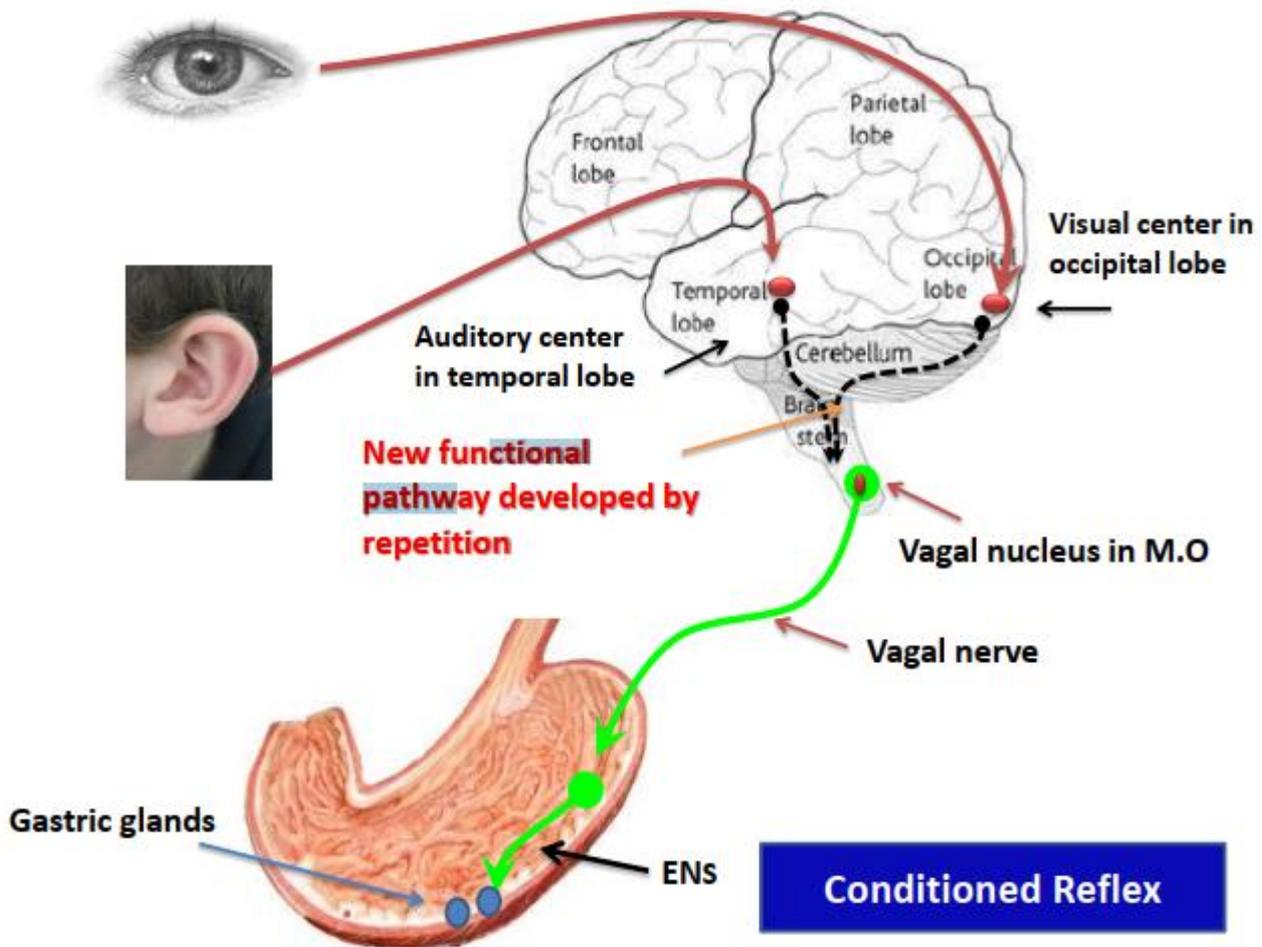
In the pyloric & cardiac regions	In the body and fundus
<p>The glands secrete <b>mucus</b>.</p>	<ul style="list-style-type: none"> <li>• <b>The glands have:</b> <ol style="list-style-type: none"> <li>1) <b>Parietal (oxyntic) cells:</b> which secrete HCl and intrinsic factor.</li> <li>2) <b>Peptic (chief) cells:</b> which secrete proteolytic enzymes pepsinogens.</li> </ol> </li> </ul>



# Phases of Gastric Secretion

▪ Gastric secretion occurs in 3 phases:

	1-Cephalic (psychic) phase:	2- Gastric phase:	3-Intestinal phase:
<b>Time</b>	<ul style="list-style-type: none"> <li>Occurs <b>before</b> food reaches the stomach</li> </ul>	<ul style="list-style-type: none"> <li>Begins with food entering the stomach and continues for <b>3 hours</b>.</li> </ul>	<ul style="list-style-type: none"> <li>Occurs when food <b>reaches</b> the duodenum.</li> </ul>
<b>Accounts for</b>	<ul style="list-style-type: none"> <li>Accounts for <b>30%</b> of acid response to meal.</li> </ul>	<ul style="list-style-type: none"> <li>It is the <b>main phase</b> responsible for <b>60%-70%</b> of gastric secretion.</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for <b>10%</b> of total gastric secretions.</li> </ul>
<b>Mechanism</b>	<p><u>a) Conditioned reflex:</u></p> <ul style="list-style-type: none"> <li>Seeing the food, smelling, or sounds of food preparation stimulate gastric secretion.</li> <li>It is <b>acquired reflex</b>.</li> </ul> <p><u>b) Unconditioned reflex:</u></p> <ul style="list-style-type: none"> <li>Presence of food in the mouth stimulate gastric secretion.</li> <li>It is <b>inherent reflex</b>.</li> </ul>	<ul style="list-style-type: none"> <li>It occurs through <b>long and short reflexes</b>.</li> </ul>	<ul style="list-style-type: none"> <li>The presence of chyme in the duodenum causes <b>some gastric secretion</b>.</li> <li>This may be due to duodenal release of <b>Gastrin</b> from small intestine.</li> </ul>



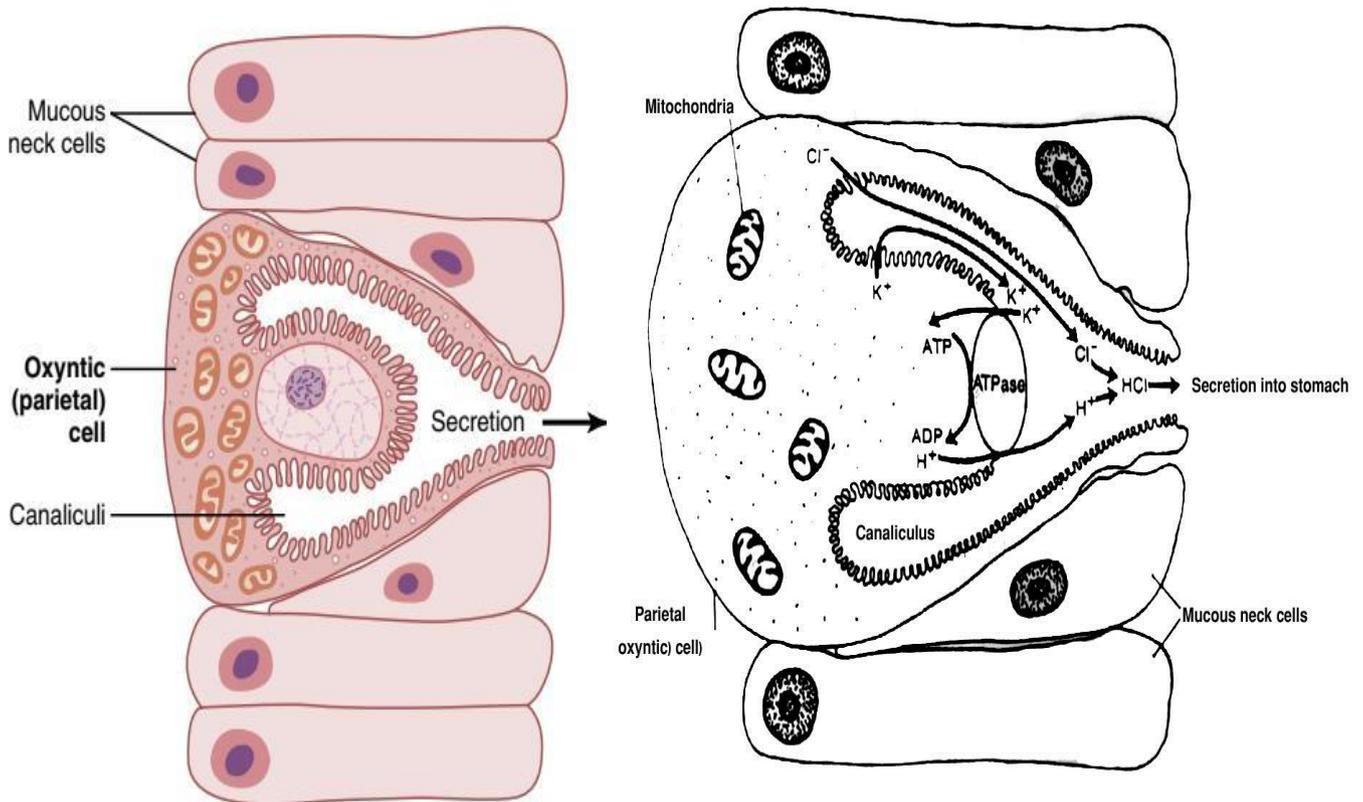
# Gastric Juice

## ▪ Composition:

<b>Volume</b>	<ul style="list-style-type: none"><li>• 2.5 - 3 L/day.</li></ul>
<b>pH</b>	<ul style="list-style-type: none"><li>• It is the <b>most acidic fluid</b> in the body.</li><li>• Its pH is <b>1</b>.</li></ul>
<b>Components:</b>	<ul style="list-style-type: none"><li>• <b>Water (99%)</b>.</li><li>• <b>HCl (0.5%)</b>.</li><li>• <b>Solids (0.5%) :</b><ul style="list-style-type: none"><li>➤ <b>Organic components (0.4%) e.g.,:</b><ul style="list-style-type: none"><li>- Enzymes: pepsinogen , amylase , gelatinase , lipase</li><li>- Mucus.</li><li>- Intrinsic factor.</li></ul></li><li>➤ <b>Inorganic components (0.1%) e.g.,:</b><ul style="list-style-type: none"><li>- Na, K.</li></ul></li></ul></li></ul>

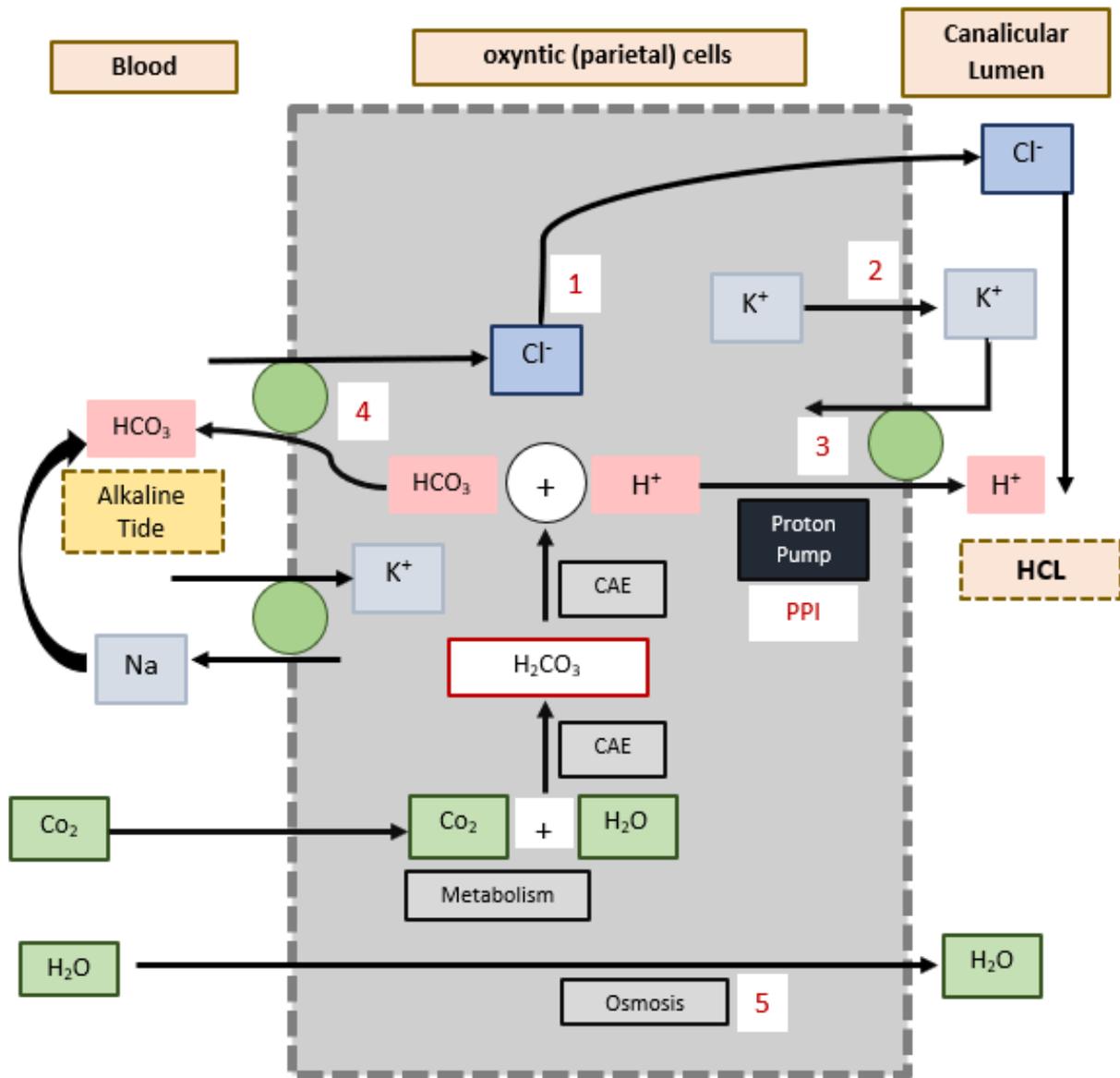
## **A) Hydrochloric acid (HCl)**

- Formed by the **Parietal cell**.
- **Parietal cells (Oxyntic cell) contain:**
  - 1- **Large number of mitochondria** (40% of cell volume).
  - 2- **System of canaliculi** communicating with the lumen of the gastric gland:
    - HCl is formed at the membrane of these canaliculus then **secreted**, so the **cytoplasm is not destroyed by this strong acid**.



■ **Hydrochloric acid (HCl) secretion:**

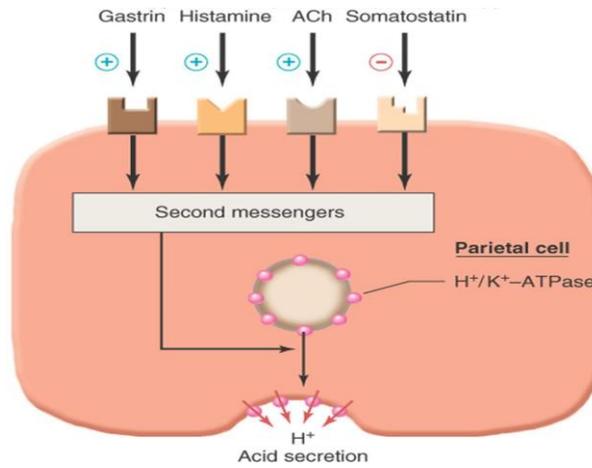
- **Cl<sup>-</sup>** is actively transported into the lumen of the canaliculus.
- This creates -ve potential which helps passive diffusion of **K<sup>+</sup>** to the canaliculus.
- **H<sub>2</sub>CO<sub>3</sub>** is dissociated by carbonic anhydrase enzyme into **H<sup>+</sup>** and **HCO<sub>3</sub><sup>-</sup>** :
  - a) **H<sup>+</sup>** is actively pumped into the canaliculus in exchange with **K<sup>+</sup>** by the aid of **H<sup>+</sup>-K<sup>+</sup> ATPase** enzyme (proton pump).
  - b) **HCO<sub>3</sub><sup>-</sup>**, in exchange with **Cl<sup>-</sup>**, diffuse out of the cell to the extracellular fluid  
 → raise the pH of blood and this is called **alkaline tide**.
    - For every **H<sup>+</sup>** pumped there is one **HCO<sub>3</sub><sup>-</sup>** found as an alkaline tide.
- **Water** diffuses through the cell into the canaliculus by **osmosis**.



▪ **Receptors on parietal cell wall:**

➤ There are 5 types of receptors on the parietal cell wall

Receptor	Stimulated by	Effect on HCL
<b>1) Muscarinic receptors:</b>	Acetylcholine	Stimulate HCL secretion
<b>2) Gastrin receptors:</b>	Gastrin	Stimulate HCL secretion
<b>3) Histamine receptors: (H2 receptors)</b>	Histamine	Stimulate HCL secretion
<b>4) Prostaglandin receptors:</b>	Prostaglandin	Inhibit HCL secretion
<b>5) Somatostatin receptor:</b>	Somatostatin	Inhibit HCL secretion



**NB:**

- **Anti-inflammatory drugs** inhibit prostaglandin synthesis so, it increase the incidence of **peptic ulcer**.

▪ **Control of HCL secretion:**

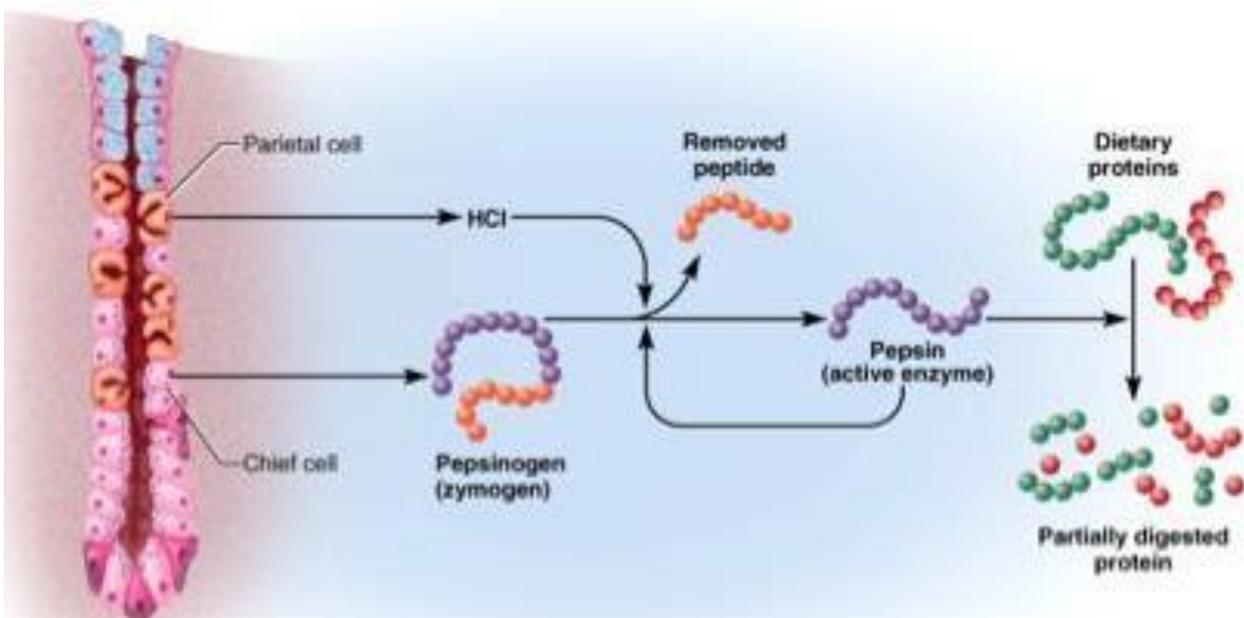
<i>Stimulatory factors:</i>	<i>Inhibitory factors:</i>
<ul style="list-style-type: none"> <li>• Acetyl-choline.</li> <li>• Gastrin.</li> <li>• Histamine.</li> </ul>	<ul style="list-style-type: none"> <li>• Somatostatin.</li> <li>• Prostaglandins E2.</li> <li>• GIP, VIP, secretin.</li> </ul>

▪ **Functions of HCl:**

- 1) **Anti-bacterial.**
- 2) **pepsinogens** activation into **pepsin** and provides the acidic medium needed for their actions.
- 3) It helps **milk clotting**.
- 4) It helps **Ca<sup>++</sup>** and **iron absorption**.
- 5) Stimulates CCK & secretin release → the **flow of bile and pancreatic juice**.
- 6) **Control rate of gastric emptying:** So excessive duodenal acidity delays gastric emptying

## B) Pepsinogens secretion:

<b>Nature:</b>	<ul style="list-style-type: none"><li>• Proteolytic enzyme.</li></ul>
<b>Secreted:</b>	<ul style="list-style-type: none"><li>• in an <i>inactive</i> form.</li></ul>
<b>Activated by:</b>	<ul style="list-style-type: none"><li>• <b>HCL</b> (Pepsinogen to pepsin) + <b>Autoactivation</b> by pepsin.</li></ul>
<b>Inactivated by:</b>	<ul style="list-style-type: none"><li>• <b>Alkaline secretion</b> in duodenum which neutralize acidity</li></ul>
<b>Stimulated by:</b>	<ul style="list-style-type: none"><li>• Histamine</li><li>• Acetylcholine</li><li>• Gastrin</li></ul>



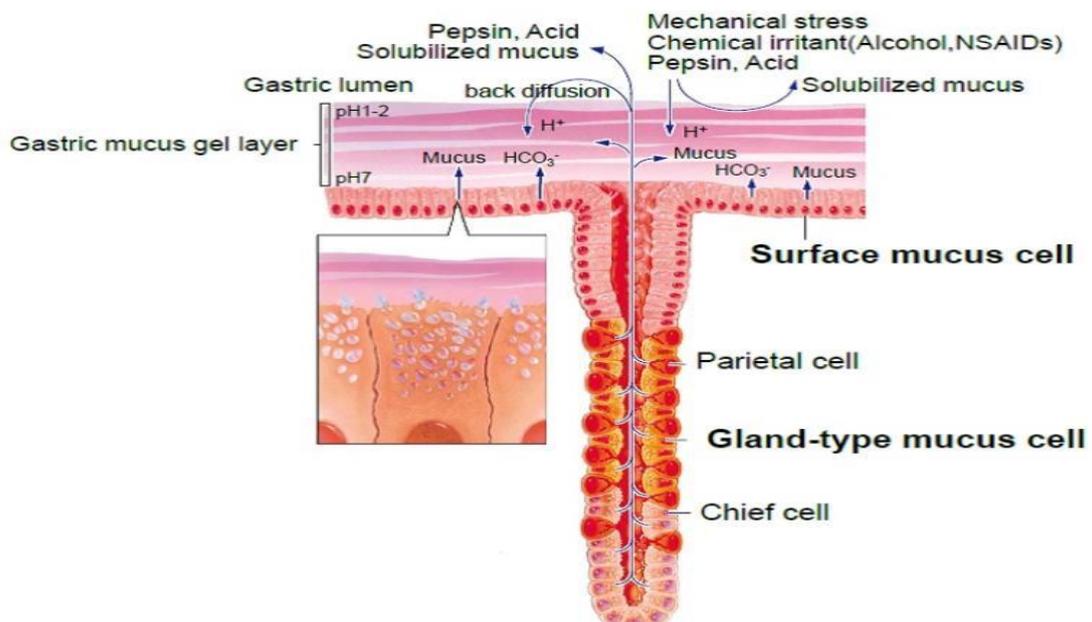
### C) Intrinsic factor:

<b>Source</b>	<ul style="list-style-type: none"> <li>It is secreted by the <b>parietal cells</b>.</li> </ul>
<b>Function</b>	<ul style="list-style-type: none"> <li>It is essential for absorption of <b>vitamin B12</b>.</li> <li>B12 is essential for <b>maturation of RBCs</b>.</li> <li>Atrophy of the oxyntic cells leads to <b>achlorhydria and pernicious anemia</b>.</li> </ul>

### D) Mucus secretion:

- There are 2 types of mucus secreting cells in the stomach:

<b>1- Mucus secreting cells present in neck of gastric glands:</b>	<b>2- Mucous secreting cells present on surface of gastric mucosa between glands.</b>
<ul style="list-style-type: none"> <li>They secrete large quantities of <b>thin mucus</b>.</li> </ul>	<ul style="list-style-type: none"> <li>They secrete large quantities of <b>more viscid mucus</b> which forms a gel that coats the mucosa.</li> <li>They also secrete <b>HCO<sub>3</sub><sup>-</sup></b> which is trapped in the mucous gel.</li> </ul>



# Gastric Mucosal Barrier (GMB)

## ▪ Significance:

➤ Protects the stomach from the harmful effects of **HCl** and **pepsin**.

## ▪ Formed of:

1) The **thick mucus gel coat**, which is more than 1 mm thick, containing  $\text{HCO}_3^-$  provides major protection.

2) HCl secreted cross this barrier in **finger-like channels** leaving the gel layer intact.

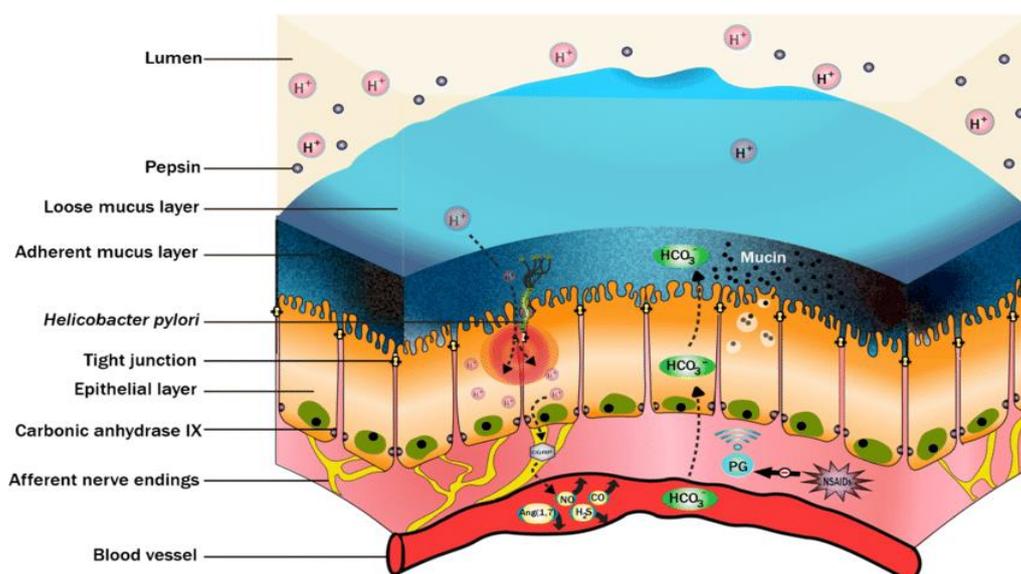
3) The gastric mucosal cells are tightly joined by **tight junction**.

4) **Integrity of the membrane** of the mucosal cells.

5) The presence of **trefoil peptides** in the mucosa , These peptides resist acid effect and autodigestion of gastric mucosa.

## ▪ Factor affecting:

Strengthened by	Weakened by
<ul style="list-style-type: none"> <li>• <u>Prostaglandins strengthens the GMB by:</u> <ol style="list-style-type: none"> <li>1) It stimulates mucus secretion.</li> <li>2) It inhibits HCl secretion.</li> <li>3) Increases the mucosal blood flow.</li> </ol> </li> </ul>	<ul style="list-style-type: none"> <li>• Alcohol, aspirin and anti-inflammatory drugs.</li> <li>• salts, sugar at high concentration.</li> <li>• vinegar</li> </ul>



# Motor functions of the stomach

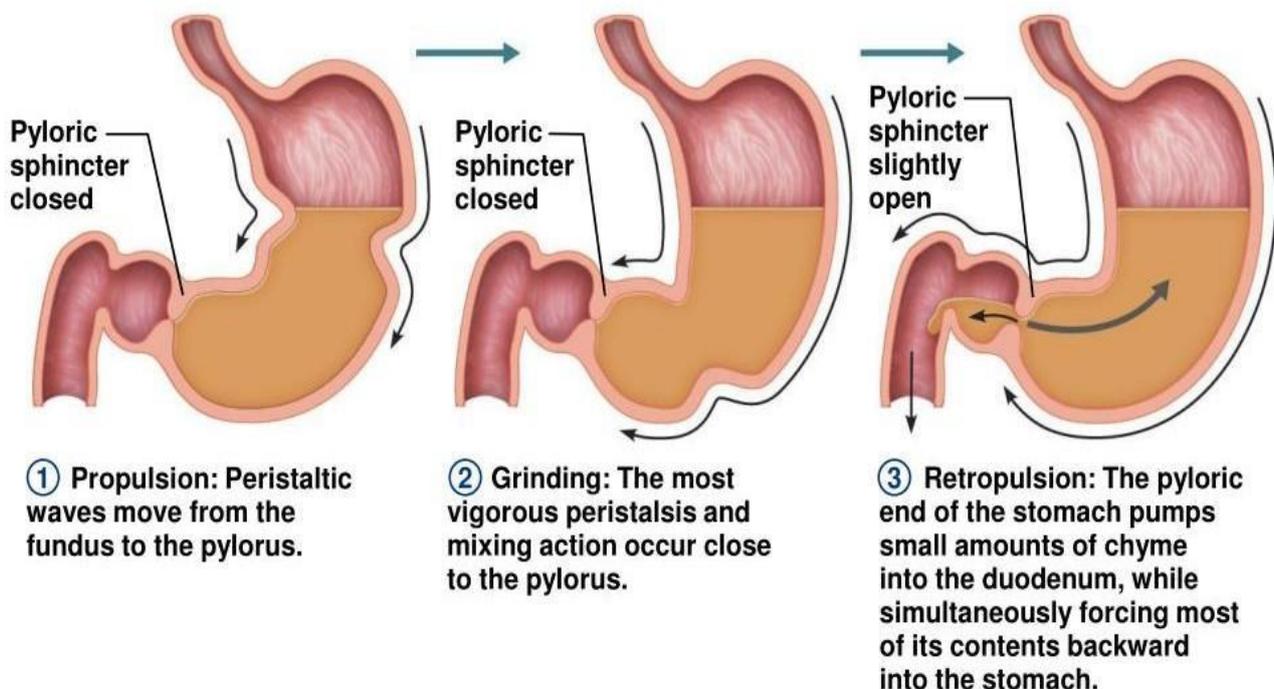
## ▪ Gastric movements (motility) after meals:

### 1) Storage functions:

- When food enters the stomach, the fundus and upper part of its body **relax** to **accommodate** the food with little increase in pressure.
- This is called **receptive relaxation**.
- Receptive relaxation is **vagally mediated** and is synchronized with the primary peristaltic waves in the esophagus.

### 2) Gastric peristalsis:

- When the stomach is filled, weak peristaltic waves (pyloric mill) move along the stomach towards the antrum causing **complete grinding and mixing** of food with gastric juice.
- The resulting mixture is a semifluid called "**chyme**"



### 3) Emptying of the stomach:

- Once peristalsis occurs, the pressure in the pyloric antrum **exceeds** that in the duodenum. So, the gastric contents pass to the duodenum (**pyloric pump**) then the pylorus closes.
- This is repeated with the **new peristalsis wave**.
- Gastric emptying is **Slow process, small amount** of chyme passes to duodenum each time to prevent **sudden stretch** of duodenum which causes abdominal distension, nausea even vomiting because duodenum has low capacity.

#### **NB:**

- **Pyloric mill:** Repeated **propulsion & retropulsion** which cause complete grinding & mixing of food with gastric juice.
- **Chyme:** Resulting mixture of peristaltic wave which is **characterized by** murky, milky & semi fluid.

## Regulation of gastric emptying:

	I) Gastric factors:	II) Duodenal factors:
<b>Action</b>	<ul style="list-style-type: none"> <li>Promote gastric emptying</li> </ul>	<ul style="list-style-type: none"> <li>Inhibit gastric emptying</li> </ul>
<b>Nervous signals:</b>	<p style="text-align: center;"><u>Short reflex &amp; long vago-vagal reflex</u></p> <ul style="list-style-type: none"> <li><b>Stimulus:</b> Distension of stomach by food</li> <li><b>Response:</b> <ul style="list-style-type: none"> <li>➤ Increase pyloric pump.</li> <li>➤ Inhibit pyloric sphincter.</li> </ul> </li> </ul>	<p style="text-align: center;"><u>Enterogastric reflex</u></p> <ul style="list-style-type: none"> <li><b>Stimulus:</b> Distension &amp; acidity of duodenum (by presence of gastric contents).</li> <li><b>Response:</b> inhibits gastric emptying.</li> <li><b>This reflex is mediated by</b> extrinsic (vagovagal reflex) and intrinsic (ENS).</li> </ul>
<b>Hormonal signals:</b>	<ul style="list-style-type: none"> <li>Gastrin hormone.</li> <li><b>Response:</b> as nervous</li> </ul>	<ul style="list-style-type: none"> <li><b>GI hormone</b> GIP, VIP, CCK, secretin are responsible for this inhibitory effect.</li> </ul>
<b>Consistency of food:</b>	<ul style="list-style-type: none"> <li>Soft food <b>emptied quicker</b> than hard food.</li> </ul>	

▪ Enterogastric reflex is elicited by:

<b>Mechanical:</b>	<ul style="list-style-type: none"> <li><b>Distension or irritation</b> to the duodenal mucosa.</li> </ul>
<b>Chemical:</b>	<ul style="list-style-type: none"> <li><b>Decrease pH</b> of the duodenum as it inhibit gastric emptying until the acidity is neutralized by pancreatic secretion.</li> </ul>
<b>Products of protein digestion:</b>	<ul style="list-style-type: none"> <li>To insure sufficient for its digestion.</li> </ul>

## Motility of Fasted Stomach

	<b>Migrating Motor Complex (MMR)</b>	<b>Hunger Contractions</b>
<b>Def</b>	<ul style="list-style-type: none"> <li>• Periodic episodes of contractions in <b>fasted stomach</b></li> </ul>	<ul style="list-style-type: none"> <li>• Rhythmic peristaltic contractions in empty stomach after <b>long time of fasting</b></li> </ul>
<b>character</b>	<ul style="list-style-type: none"> <li>• Once every <b>90 minutes</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>Starts:</b> after <b>12-24h.</b> after the last meal</li> <li>• <b>Maximum intensity:</b> in <b>3-4 days</b> then <b>decreases</b> gradually and fasting can be continued without pain.</li> </ul>
<b>Function:</b>	<ul style="list-style-type: none"> <li>• <b>Clears</b> the stomach and the small intestine from the <b>undigestible residues.</b></li> <li>• Inhibit migration of <b>colonic bacteria</b> into the terminal ileum.</li> </ul>	