PHYSIOLOGY OF THE STOMACH & REGULATION OF GASTRIC SECRETION

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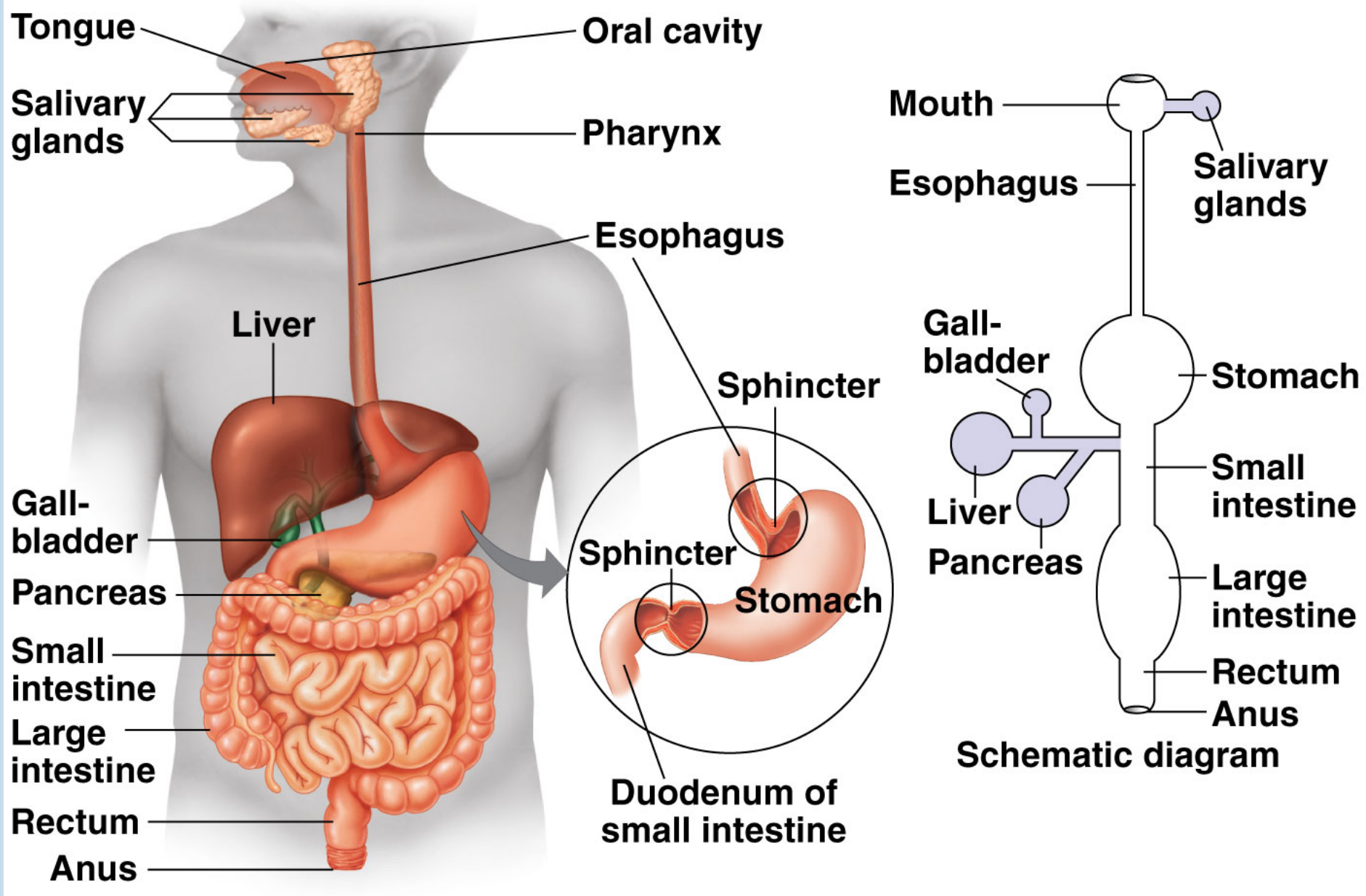
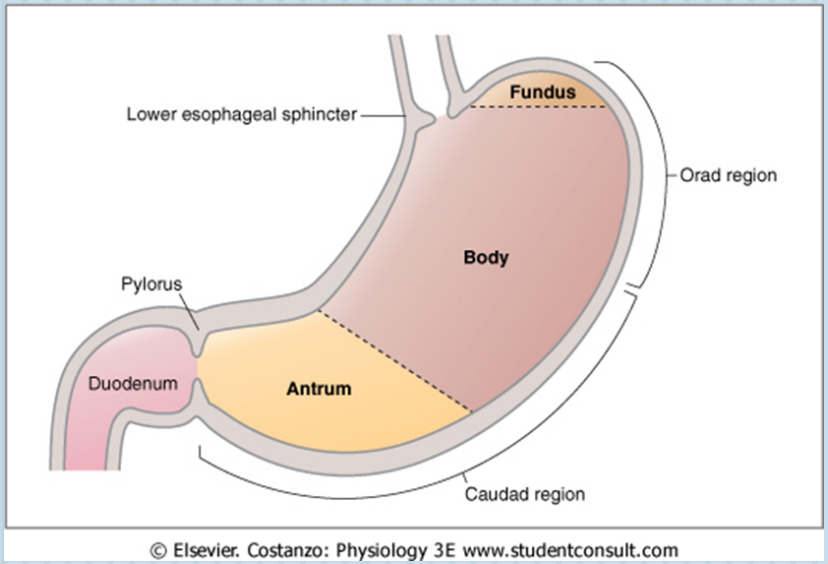
Objectives

- Functions of stomach
- Gastric secretion
  - ✓ Mechanism of HCl formation
  - ✓ Gastric digestive enzymes
  - ✓ Neural & hormonal control of gastric secretion
  - ✓ Phases of gastric secretion
- Motor functions of the stomach
- Stomach Emptying

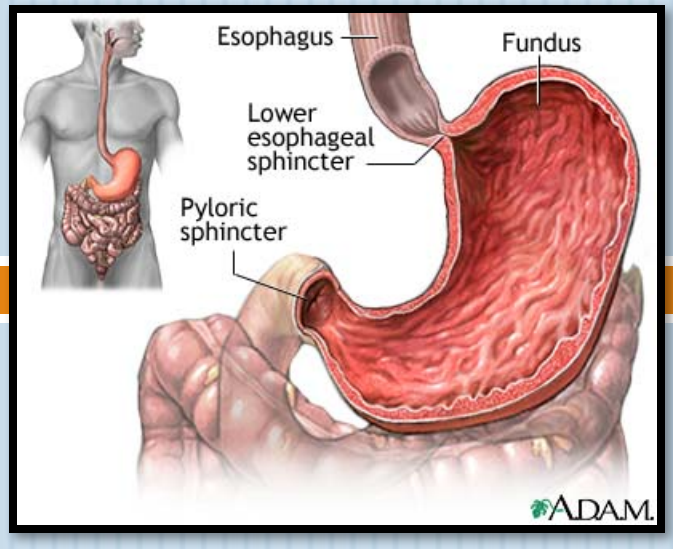


Anatomy & physiology of the stomach



- Anatomically :
  - Body
  - Antrum
- Physiologically
  - Orad
  - Caudad

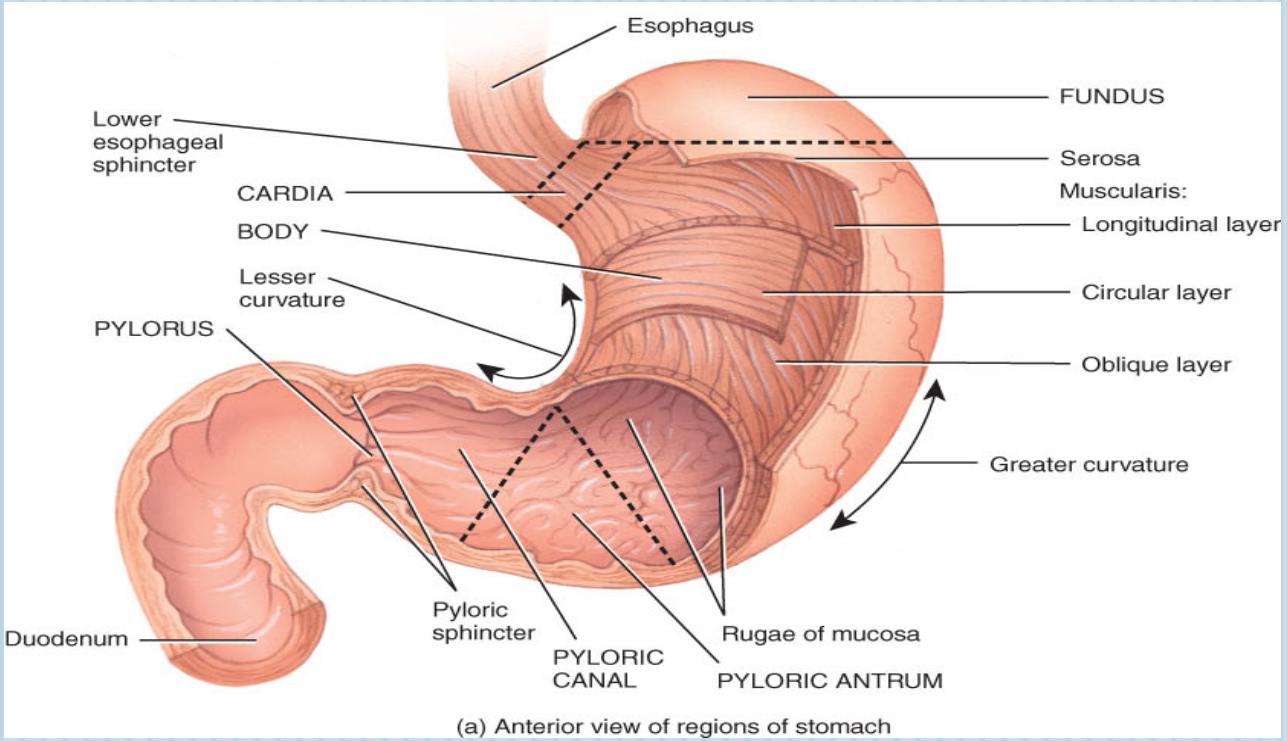
Stomach



- Stores food
- Digestion
  - Mechanical – churn, mix
  - Chemical – protein digestion
- Gastric juice: converts meal to acidic **chyme**
  - ***HCl***: pH 2, kills bacteria, denatures proteins
  - ***Pepsin***: enzyme breaks down proteins
- Rugae = large folds
- Mucus = protects lining of stomach

Anatomy & physiology of the stomach

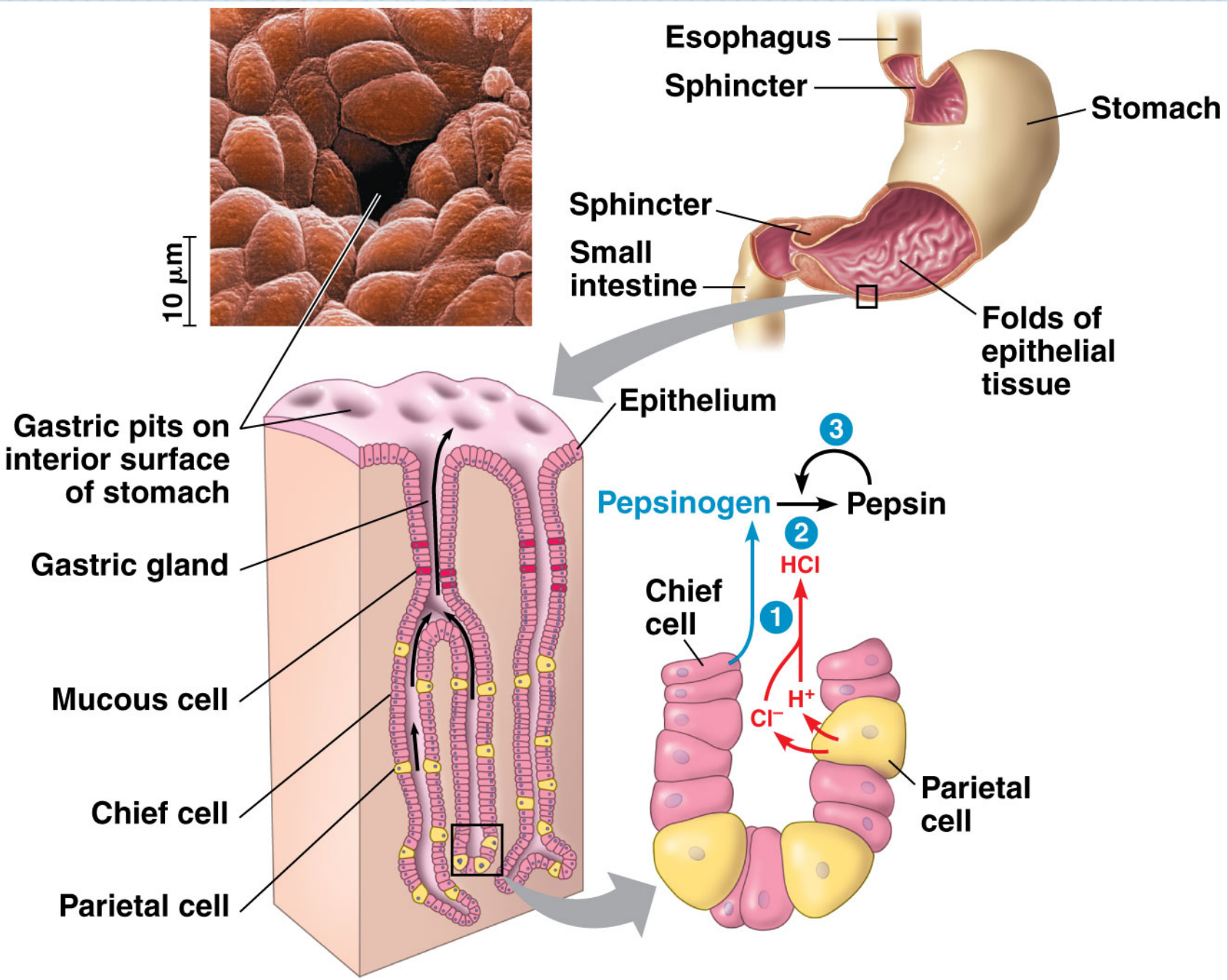
- Muscular wall
  - Longitudinal
  - Circular
  - Oblique



(a) Anterior view of regions of stomach

Gastric secretion

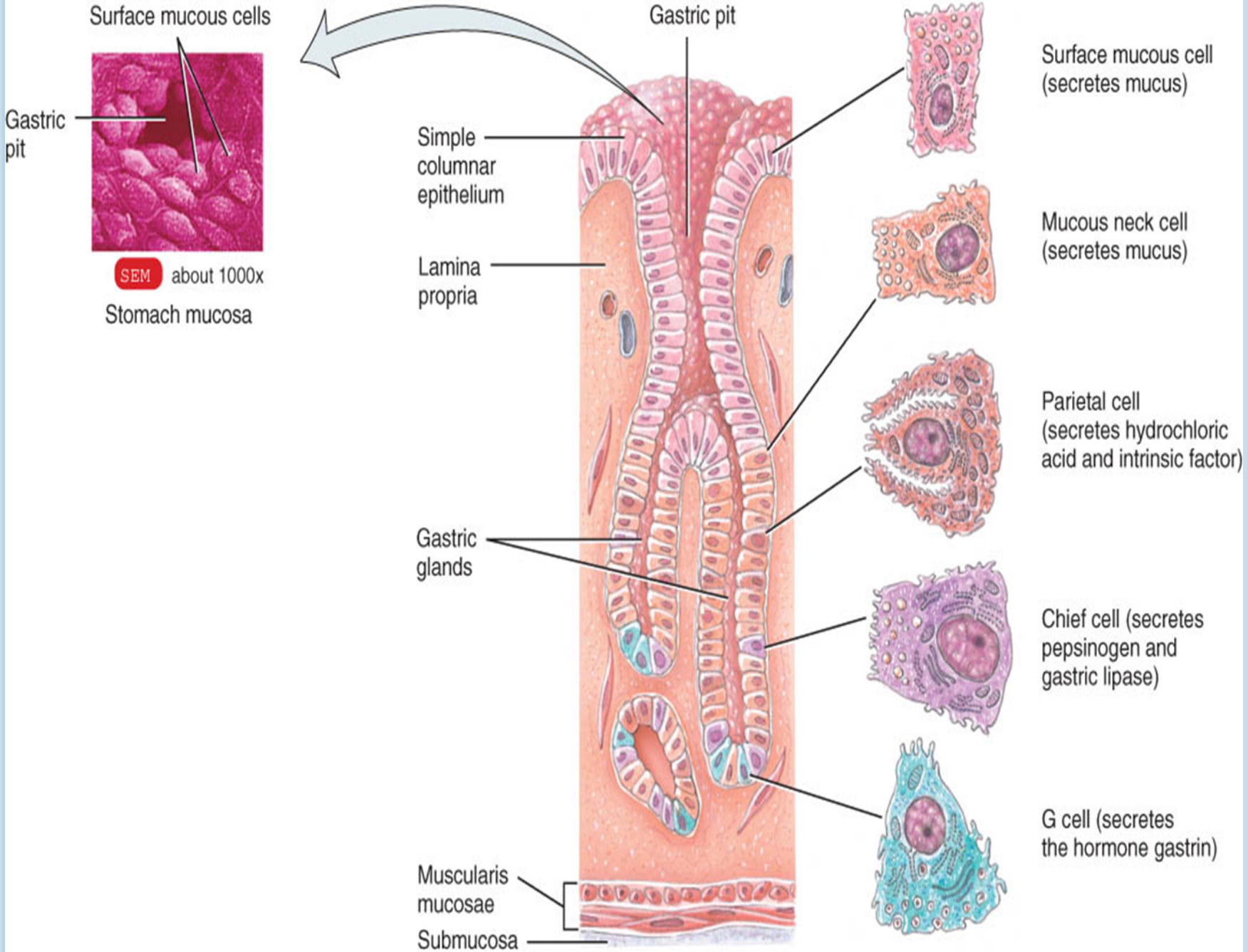
- Gastric mucosa has numerous openings called **gastric pits**
  - **Gastric glands** empty into bottom of pits
- 4 functionally different cell types compose glands
  - Mucous cells
  - Chief cells
  - Parietal cells
  - Enteroendocrine cells
  - Enterochromaffin-like cells (histamine)



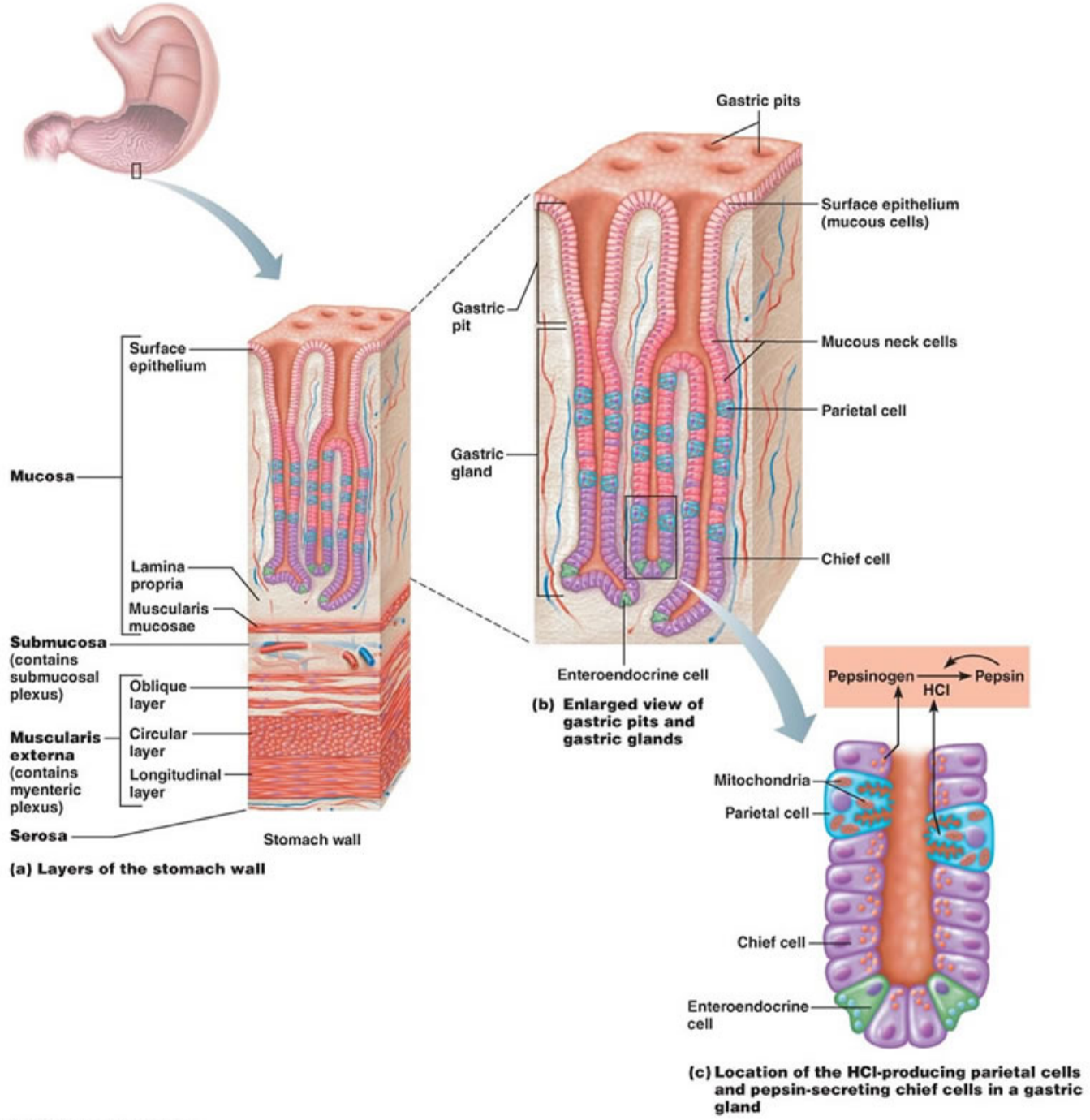
Secretory functions of the stomach

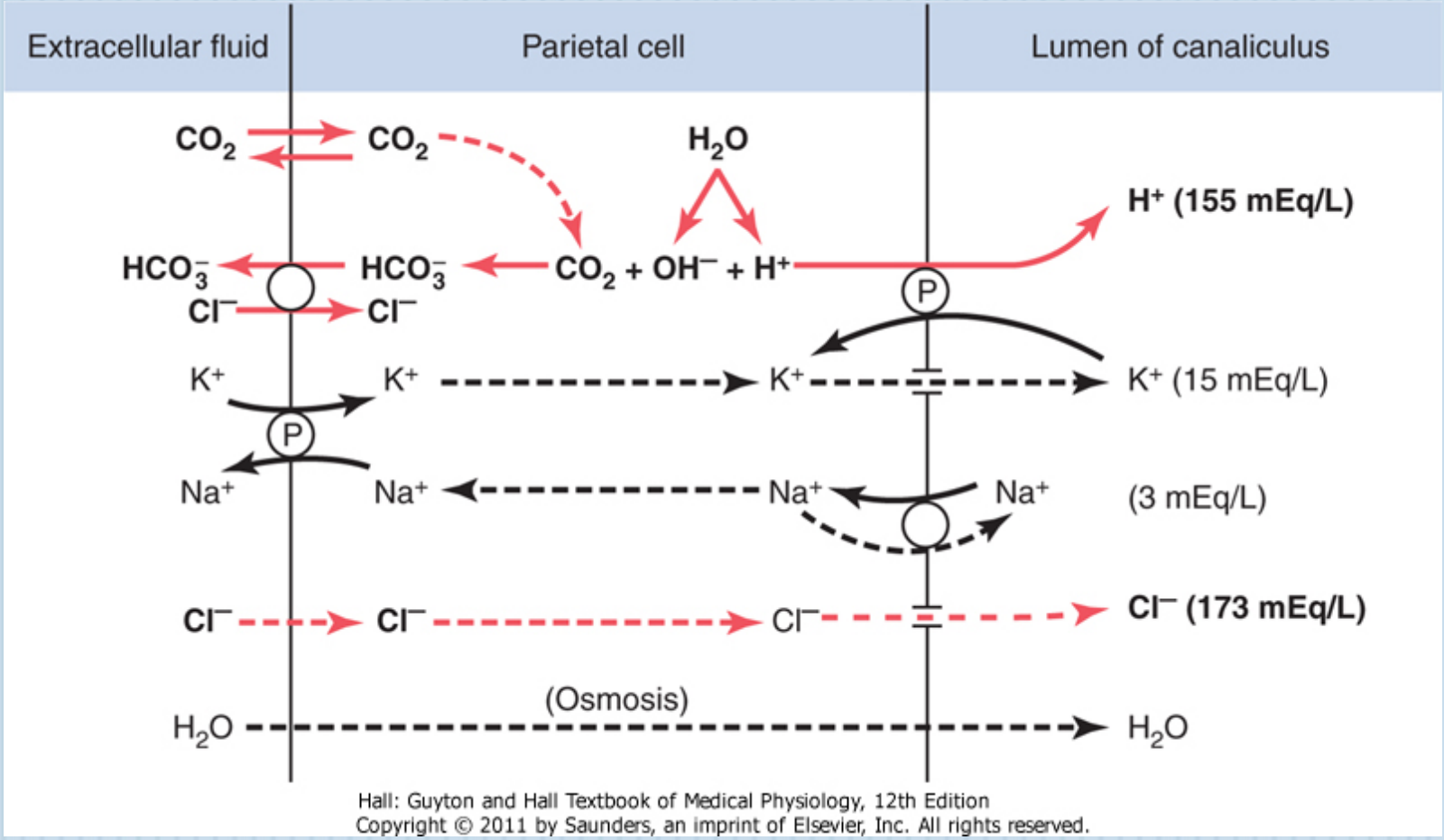
- In addition to mucus secreting cells that line the stomach and secrete alkaline mucus there is two important types of tubular glands:

oxyntic (gastric) glands	Pyloric glands
Secrete: Hydrochloric acid Pepsinogen Intrinsic factor Mucus Located in body & fundus In proximal 80%of stomach	Secrete: Mucus- protection Gastrin Pepsinogen Located in the antrum In the distal 20% of stomach



(b) Sectional view of the stomach mucosa showing gastric glands and cell types





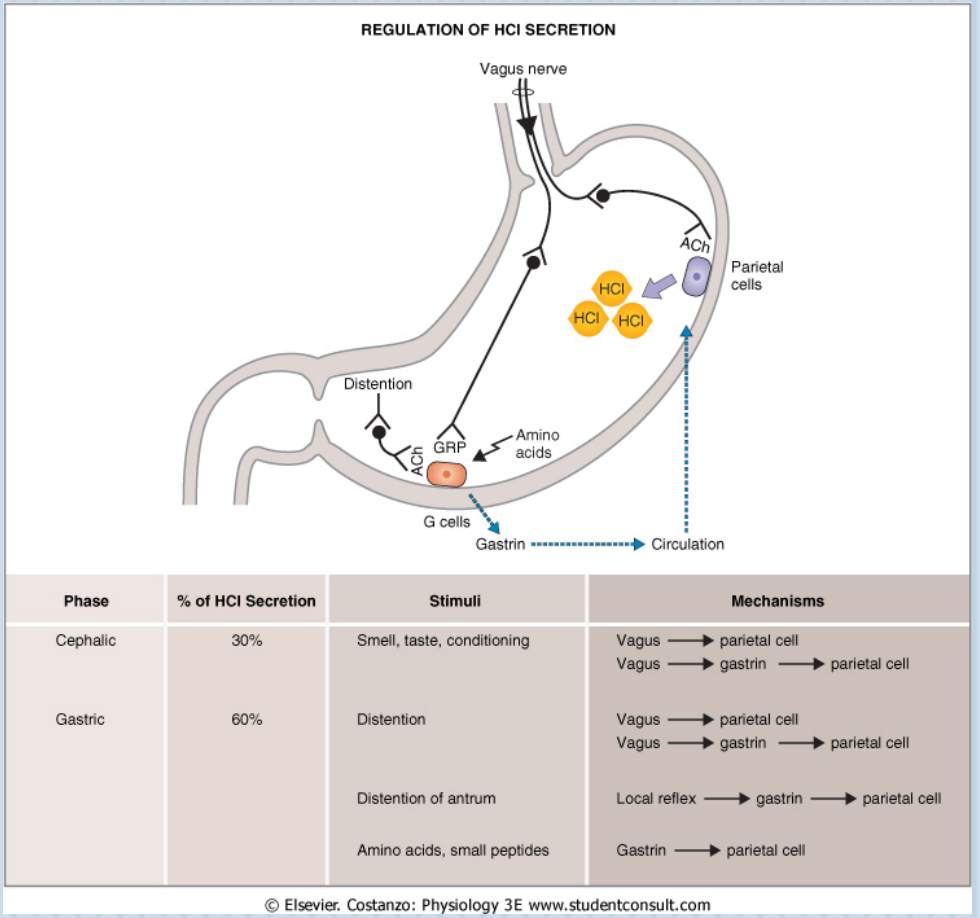
Postulated mechanism for secretion of hydrochloric acid. (The points labeled *"P"* indicate active pumps, and the *dashed lines* represent free diffusion and osmosis.)

Mechanism of HCL secretion

- https://youtu.be/XhB7WNJVg3U

Neural & Hormonal Control of Gastric Secretion

- **Vagus nerve (neural effector)** either by releasing Ach (direct activation of parietal cells) or by releasing Gastrin releasing peptide, GRP (indirect activation).
- **Gastrin (hormonal effector)**
- **Enterochromaffin-like cells** release Histamine→ activates H_2 receptor (parietal cells) → increases acid secretion
- **Cimetidine (H_2 receptor blocker)→ peptic ulcer and gastroesophageal reflux**

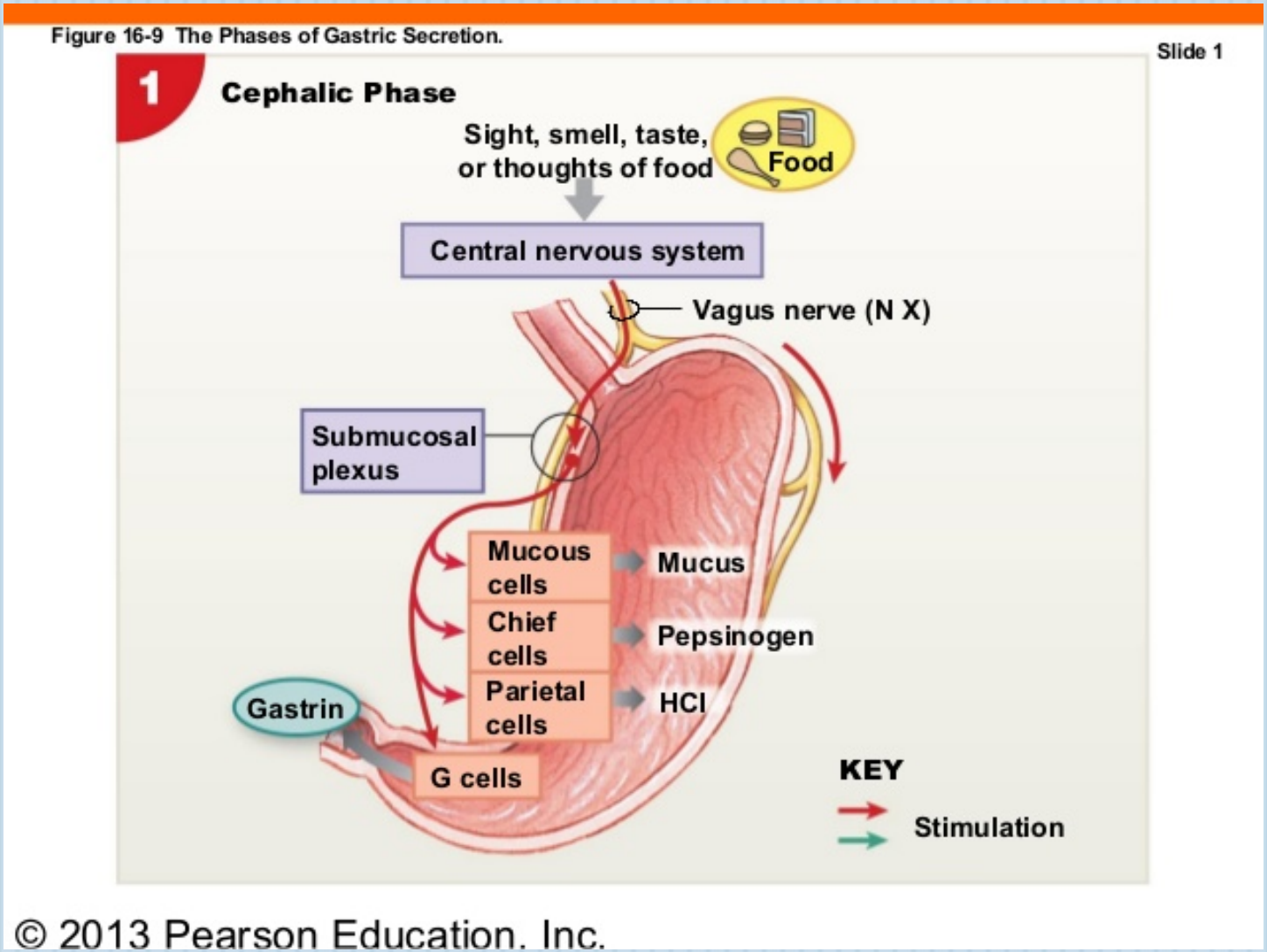


Phase	% of HCl Secretion	Stimuli	Mechanisms
Cephalic	30%	Smell, taste, conditioning	Vagus → parietal cell Vagus → gastrin → parietal cell
Gastric	60%	Distention	Vagus → parietal cell Vagus → gastrin → parietal cell
		Distention of antrum	Local reflex → gastrin → parietal cell
		Amino acids, small peptides	Gastrin → parietal cell

Phases of gastric secretion

- https://youtu.be/ifDp57pvKOg
- https://youtu.be/pqgcElaXGME

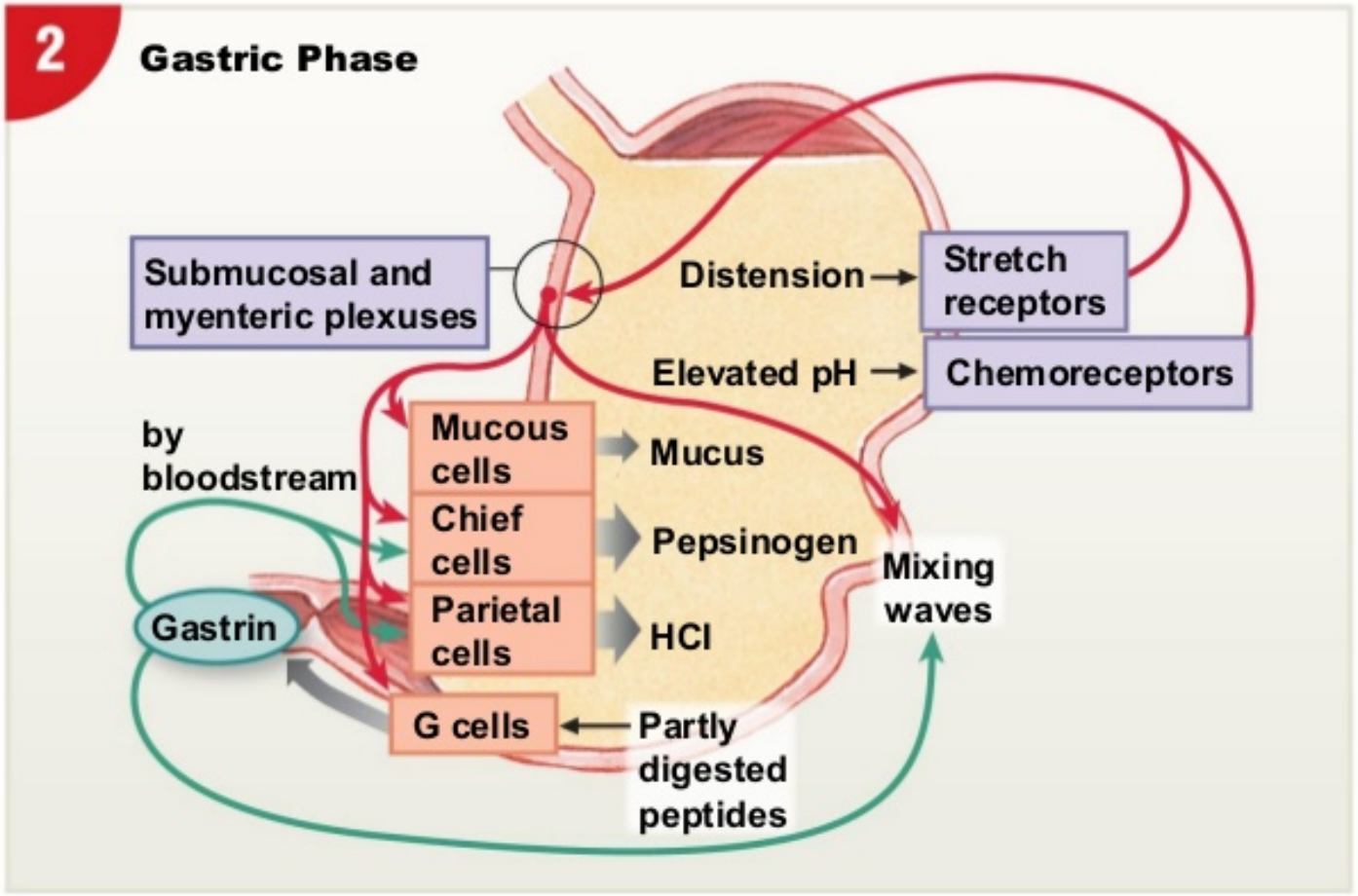
Phases of gastric secretion



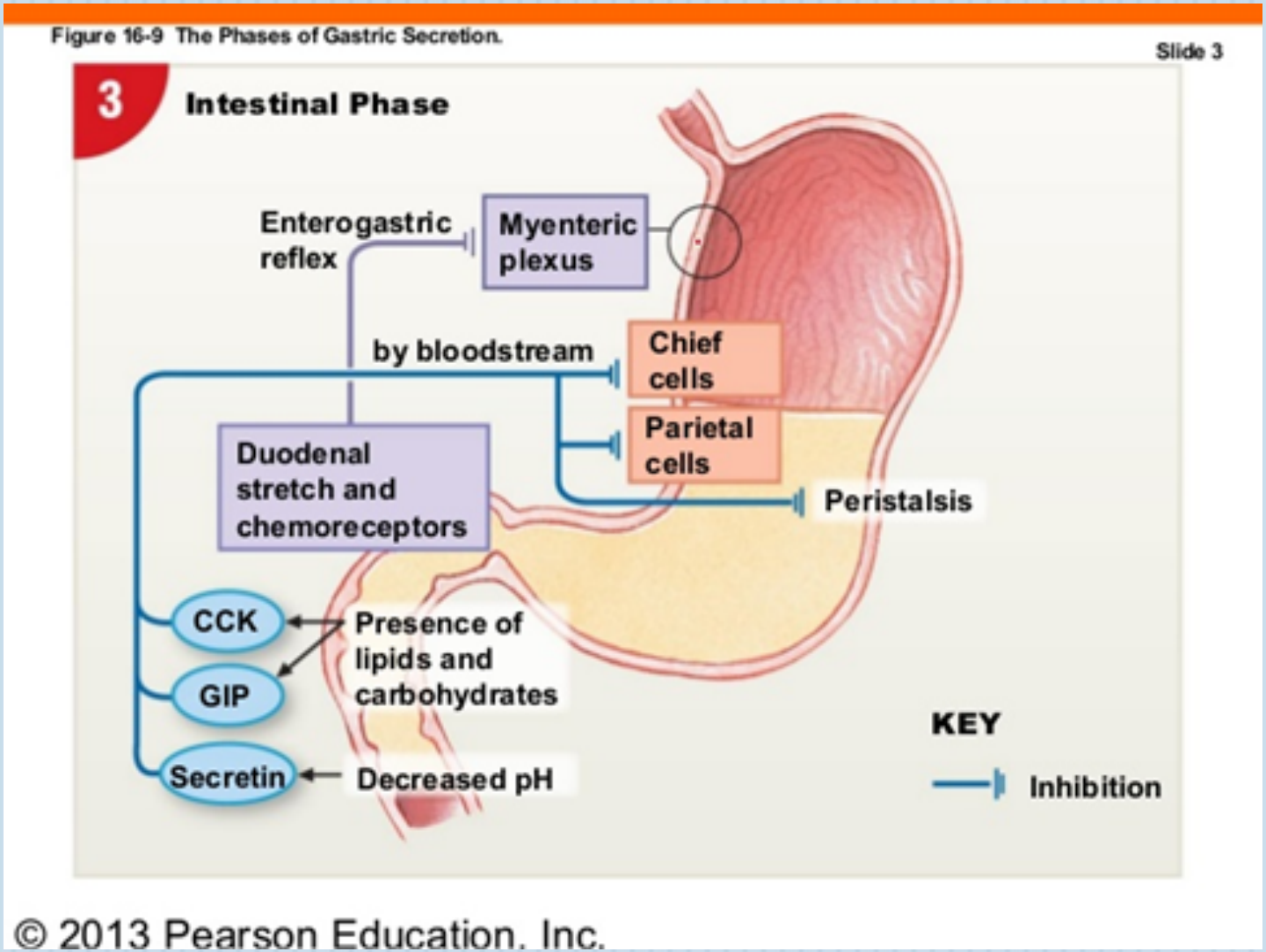
Phases of gastric secretion

Figure 16-9 The Phases of Gastric Secretion.

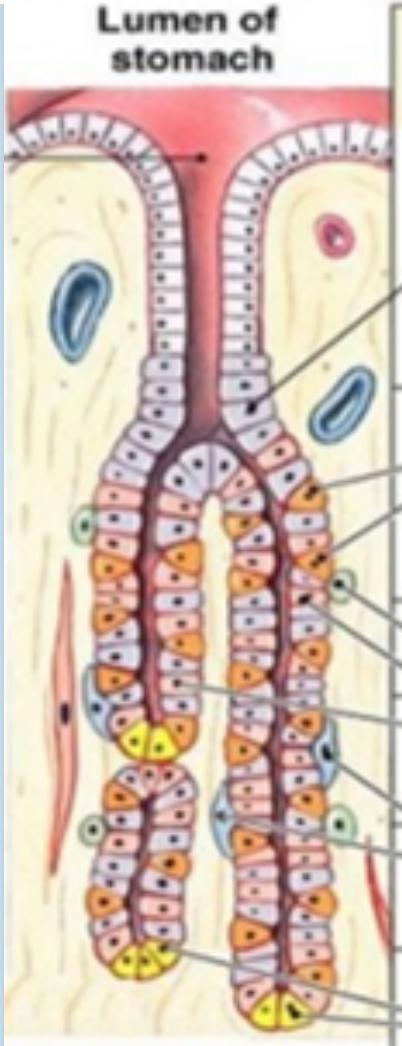
Slide 2



Phases of gastric secretion

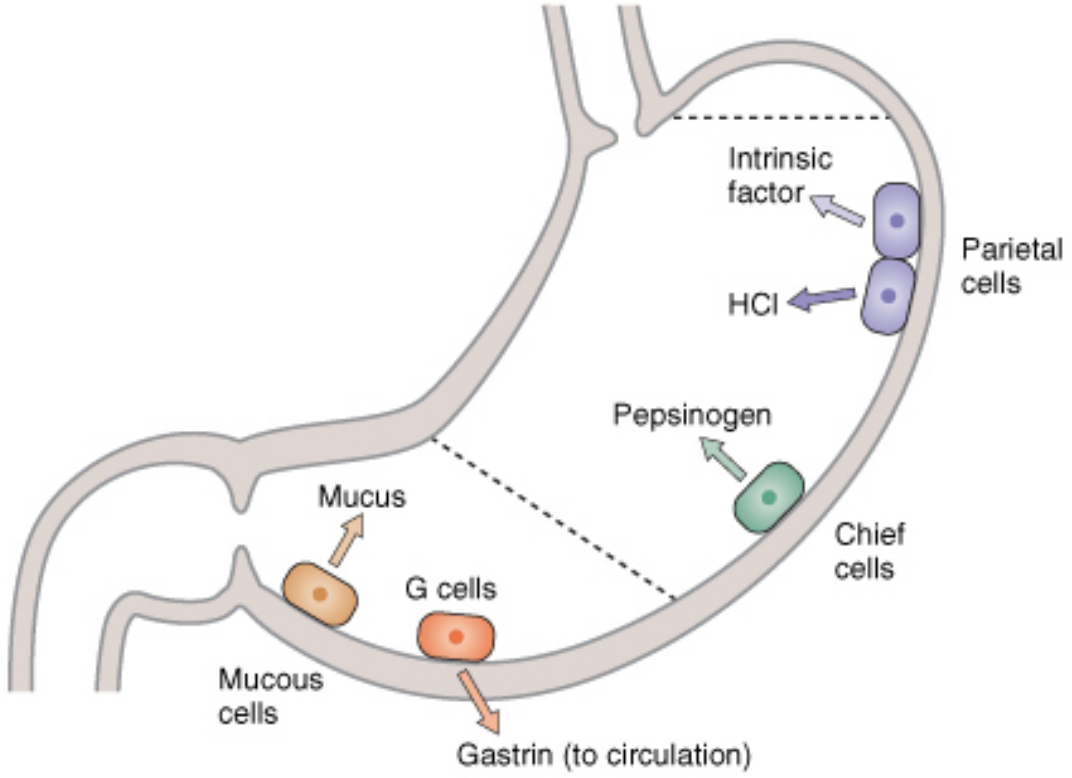


Gastric secretion



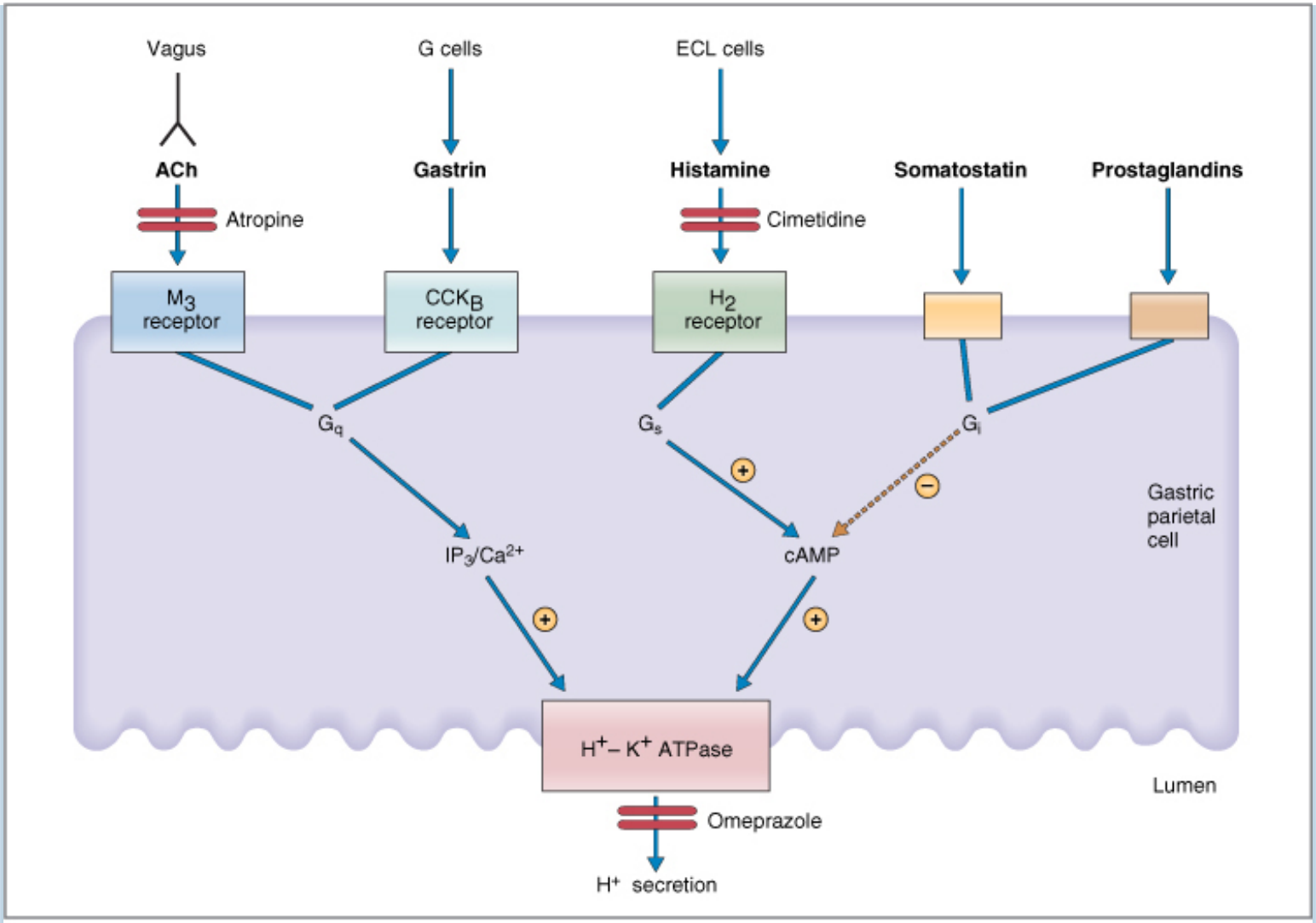
Cell Types	Substance Secreted
Mucous neck cell	Mucus (protects lining)
	Bicarbonate
Parietal cells	Gastric acid (HCl)
	Intrinsic factor (Ca++ absorption)
Enterochromaffin-like cell	Histamine (stimulates acid)
Chief cells	Pepsin(ogen)
	Gastric lipase
D cells	Somatostatin (inhibits acid)
G cells	Gastrin (stimulates acid)

Secretory products of various gastric cells



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

Agents that stimulate and inhibit H^+ secretion by gastric parietal cells



Motor functions of the stomach

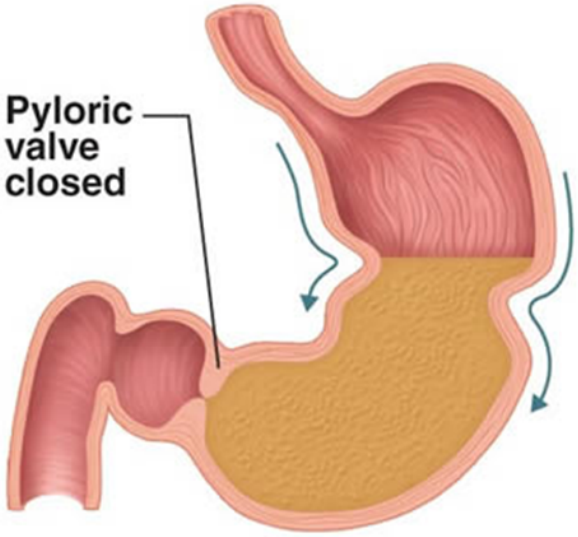
- 3 motor functions of the stomach:
  - **Storage** of large quantities of food
  - **Mixing** of food with gastric secretions to produce chyme
  - **Slow emptying** of chyme into the small intestine at a suitable rate for proper digestion & absorption

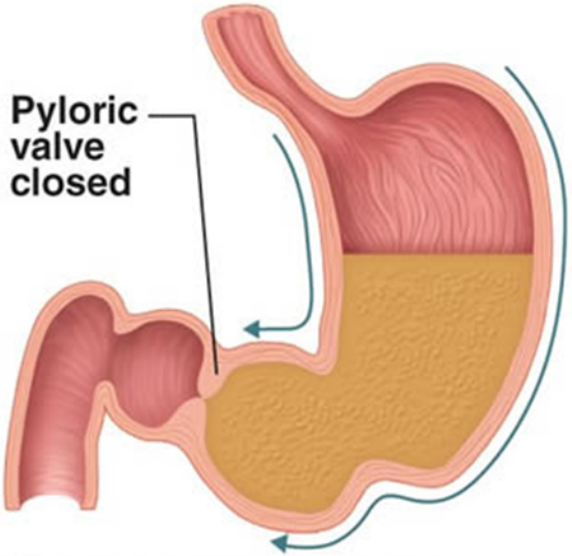
Motor functions of the stomach

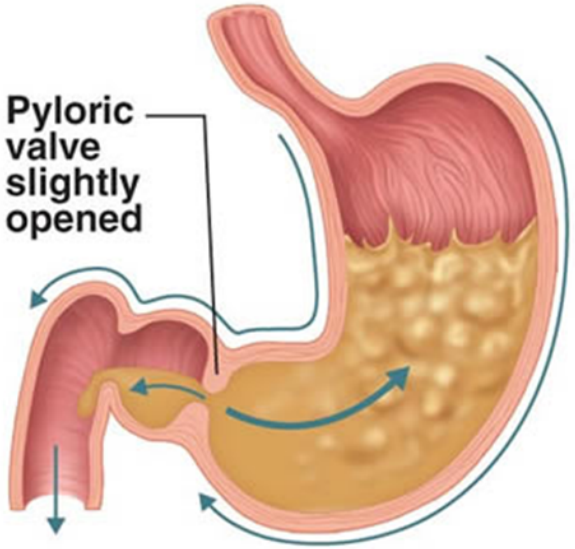
- Storage function:
  - When food stretch the stomach a vagovagal reflex from the stomach to the brain stem Back to the stomach to reduce the tone in the muscular wall in the body of the stomach
  - Stomach wall bulges progressively
  - Stomach will accommodate up to 0.8-1.5 liters
  - Pressure in the stomach remains low

Motor functions of the stomach

- Mixing and propulsion function:
  - As long as food is in the stomach , weak peristaltic constrictor waves (mixing waves) begin in the mid to upper portions of the stomach wall and move toward the antrum once every 15-20 seconds
  - It is initiated by the gut wall basic electrical rhythm (slow waves)
  - As the constrictor waves move into the antrum they become more intense
  - Some become extremely intense providing peristaltic action potential-driven constrictor rings that force antral contents under higher pressure toward the pylorus







① **Propulsion:** Peristaltic waves move from the fundus toward the pylorus.

② **Grinding:** The most vigorous peristalsis and mixing action occur close to the pylorus.

③ **Retropulsion:** The pyloric end of the stomach acts as a pump that delivers small amounts of chyme into the duodenum, simultaneously forcing most of its contained material backward into the stomach.

Motor functions of the stomach

- Mixing and propulsion function:
  - Constrictor rings play an important role in mixing the stomach contents:
    - Each time it digs deeply into the food contents in the antrum
    - The opening of the pylorus allows only a few mls of antral contents to be expelled into the duodenum with each wave
    - As each wave approaches the pylorus the pyloric muscle contracts
    - Most of the antral content are squeezed upstream through the peristaltic ring toward the body
    - The moving peristaltic ring + upstream squeezing action called Retropulsion is an important mixing mechanism

Motor functions of the stomach

- Hunger Contractions:
  - Occurs when stomach is empty for several hours
  - They are rhythmical peristaltic contractions in the body of the stomach
  - When successive contractions become extremely strong they fuse into a continuing tetanic contractions that lasts for 2-3 min
  - Sometimes they cause mild pain (hunger pangs)
  - They begin 12-24 hrs after last meal
  - In starvation they reach greatest intensity in 3-4 days

Motor functions of the stomach

- Stomach Emptying
  - Promoted by intense peristaltic contractions in the antrum
  - Empting is opposed by resistance to passage of chyme at the pylorus
- Pyloric pump:
  - Most of the time contractions are weak and cause mixing of food with gastric secretions
  - 20% of the time contractions in the form of tight ringlike constrictions cause stomach emptying
  - They are 6 times as powerful as mixing waves

Motor functions of the stomach

- Role of pylorus in controlling emptying
  - Pylorus is the distal opening of the stomach
  - Thickness of circular muscles is 50-100% greater than in the antrum
  - It is slightly tonically contracted almost all the time
  - It is named the pyloric sphincter
  - It is usually open enough to allow water & fluids
  - It is controlled by nervous and humoral reflexes from the stomach and duodenum

Motor functions of the stomach

- Regulation of stomach emptying:
  - Emptying of the stomach is regulated by :
    - Stomach
    - Duodenum (more potent)
  - Gastric factors:
    - Gastric food volume: when volume increased it increased emptying due to stretch of stomach wall which initiate local myenteric reflexes causing:
      - Increase activity of pyloric pump
      - Inhibit the pylorus
    - Gastrin released from antral mucosa and enhance the activity of pyloric pump

Motor functions of the stomach

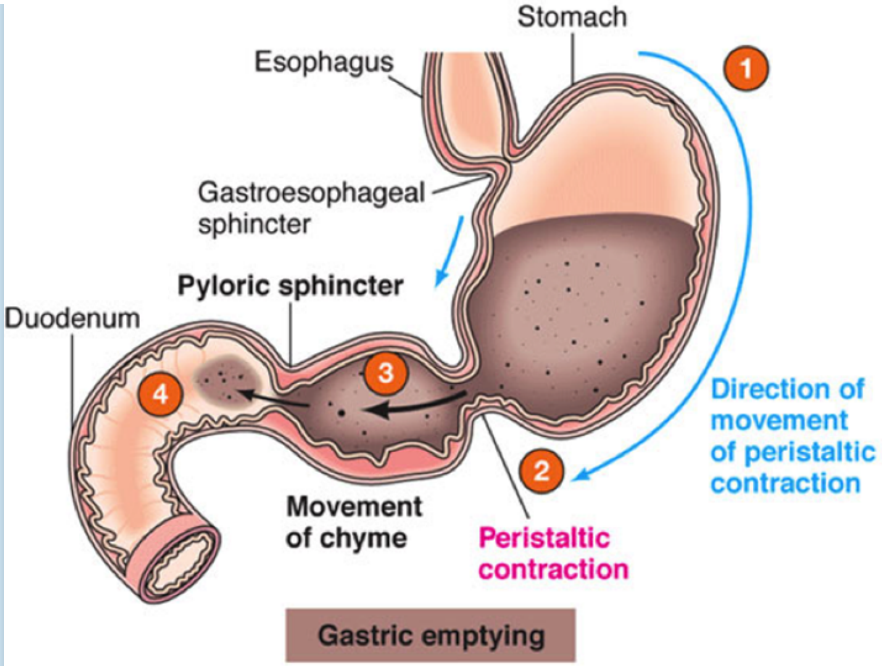
- Regulation of stomach emptying:
  - Duodenal factors:
    - Inhibitory enterogastric nervous reflexes mediated by:
      - Direct from duodenum to stomach via enteric nervous system
      - Extrinsic nerves to sympathetic ganglia
      - Vagus nerves to the brain stem

      All these reflexes strongly inhibit pyloric pump & increase tone of the pyloric sphincter
      - Factors that initiate these reflexes are:

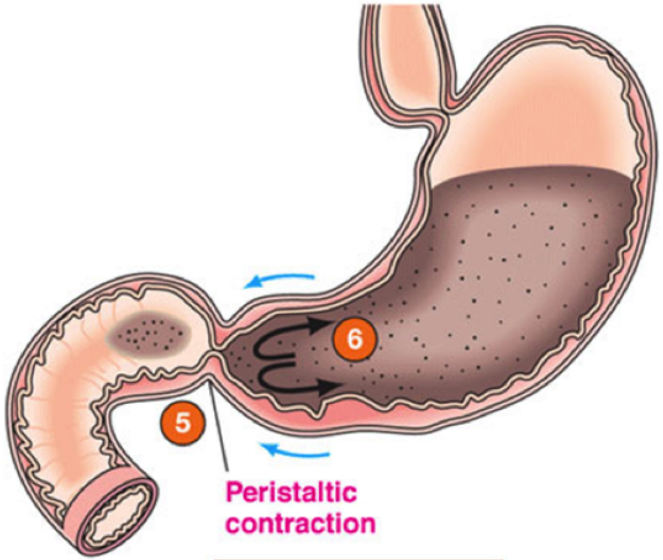
      Duodenal distention, irritation of mucosa, acidity of duodenal chyme, breakdown products such as proteins & fats
    - Hormonal feedback

Motor functions of the stomach

- Regulation of stomach emptying:
  - Duodenal factors:
    - Hormonal feedback
      - The main stimulus for releasing these inhibitory hormones is fat in the duodenum
      - Through receptors on epithelial cells
      - Released hormones carried by blood to the stomach
      - They inhibit pyloric pump & increase contraction of pyloric sphincter
      - The most potent hormone, **CCK** released from jejunum by fat
      - **Secretin** released from duodenal mucosa in response to acid
      - **Gastric inhibitory peptide** (GIP) from upper small intestine mainly by fat in chyme and carbohydrates



Gastric emptying



Gastric mixing

1. A peristalic contraction originates in the upper fundus and sweeps down toward the pyloric sphincter.
2. The contraction becomes more vigorous as it reaches the thick-muscled antrum.
3. The strong antral peristalic contraction propels the chyme forward.
4. A small portion of chyme is pushed through the partially open sphincter into the duodenum. The stronger the antral contraction, the more chyme is emptied with each contractile wave.
5. When the peristaltic contraction reaches the pyloric sphincter, the sphincter is tightly closed and no further emptying takes place.
6. When chyme that was being propelled forward hits the closed sphincter, it is tossed back into the antrum. Mixing of chyme is accomplished as chyme is propelled forward and tossed back into the antrum with each peristaltic contraction.

Digestion

- Digestion of carbohydrate in mouth & stomach
  - Food mixed with saliva that contain ptyalin (an α amylase) secreted by parotid gland
  - It hydrolysis starch to maltose
  - It continues in stomach for 1 hr
  - Gastric acid deactivate it

Digestion

- Digestion of proteins in the stomach
  - Pepsin
    - secreted by chief (peptic) cells
    - It is active at pH 2-3 and inactive at pH 5
    - Initiate protein digestion (10-20% of protein digestion)
    - Can digest collagen
  - Hydrochloric acid
    - secreted by parital (oxyntic) cells

Absorption

- Stomach is a poor absorptive area of GIT
  - It lacks the villous type of absorptive membrane
  - It has tight junctions between epithelial cells
  - Only a few highly-lipid soluble substances can be absorbed such as:
    - Alcohol
    - Aspirin


THANK
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