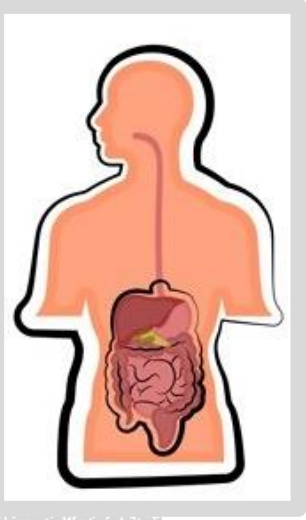


THE STOMACH
PHYSIOLOGY & REGULATION

Maha Saja, M.B.B.S, MSc Physiology, PhD

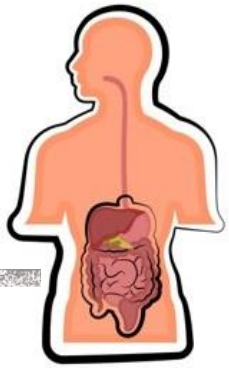
Office no. 8, Level 3, College of Medicine.

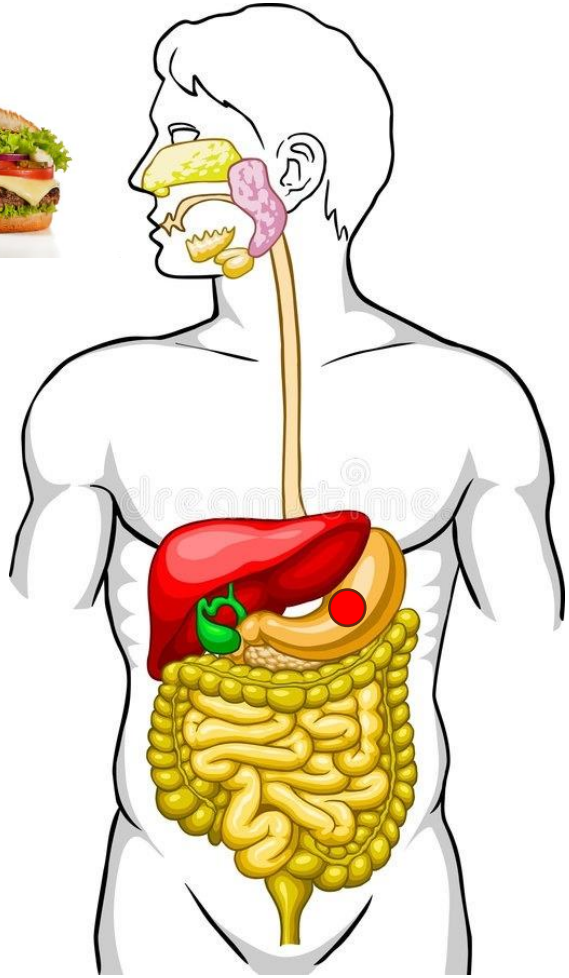
msaja@ksu.edu.sa

OBJECTIVES

- Discuss the role of the stomach in digestion.
- Enumerate the functions of the stomach.
- Discuss the secretory functions of the stomach.
  - What are the glands lining the stomach wall.
  - Discuss the cells lining the different glands and their specific secretions.
  - Discuss the mechanism of HCl secretion by parietal cells.
  - Discuss control mechanisms of gastric secretions.
  - Enumerate and discuss the phases of gastric secretion.
- Describe the different motility patterns in the stomach and their role in digestion.
- Describe the mechanism of stomach emptying and discuss the factors controlling it.
- Discuss the role of the stomach in digesting the main food constituents.
- Discuss the pathophysiologic basis of peptic ulcer and gastritis.

INTRODUCTION





Our second stop in our journey with the burger is the ***stomach***

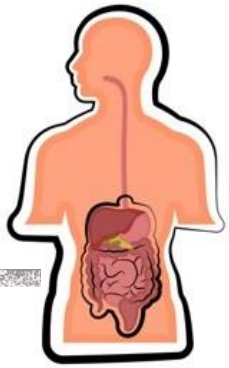
The burger that reached the stomach is no longer a burger

It is called "food bolus"

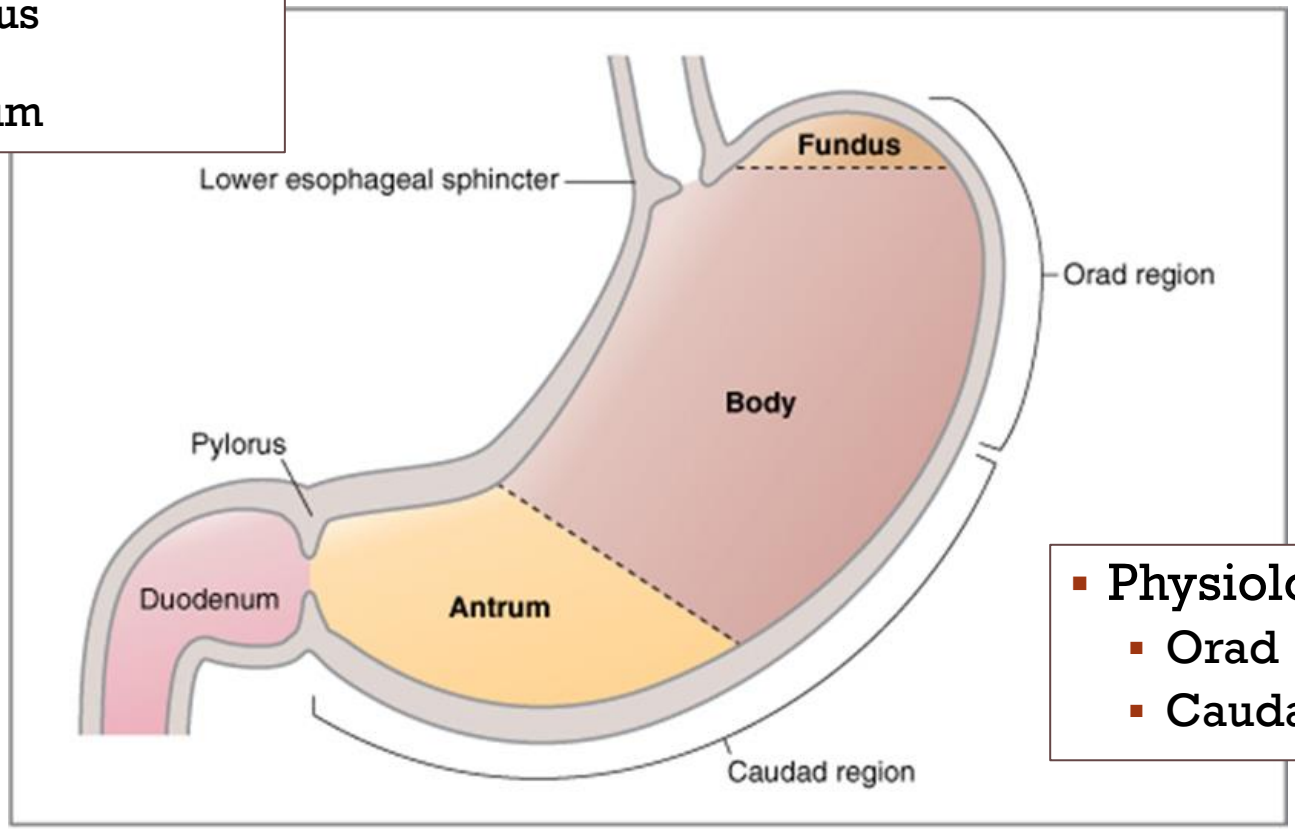
(Sherwood. Human Physiology: From cells to Systems, 7th ed.)

SECRETORY FUNCTION OF THE STOMACH

FUNCTIONAL ANATOMY OF THE STOMACH



- Anatomically:
  - Fundus
  - Body
  - Antrum



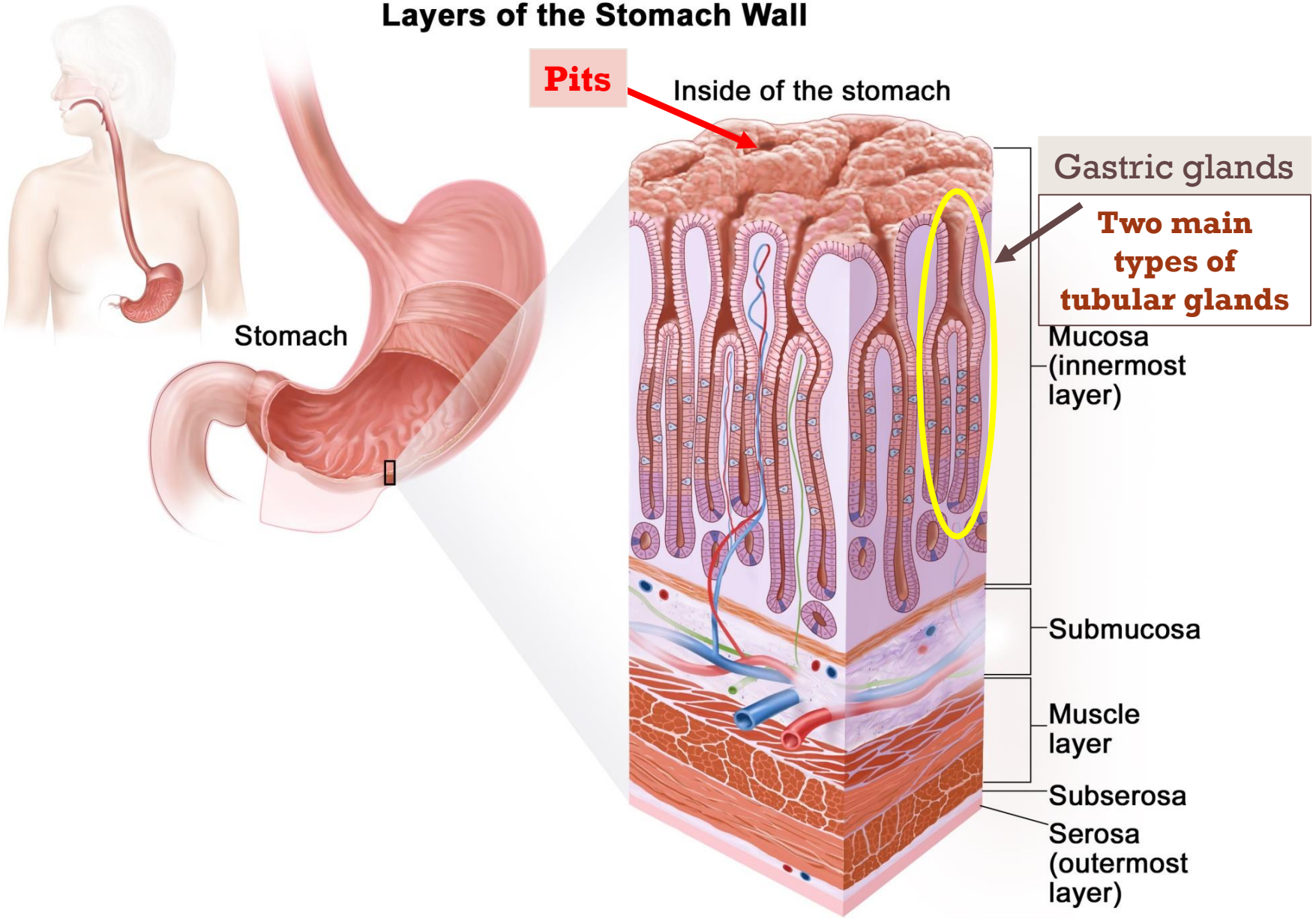
- Physiologically:
  - Orad
  - Caudad

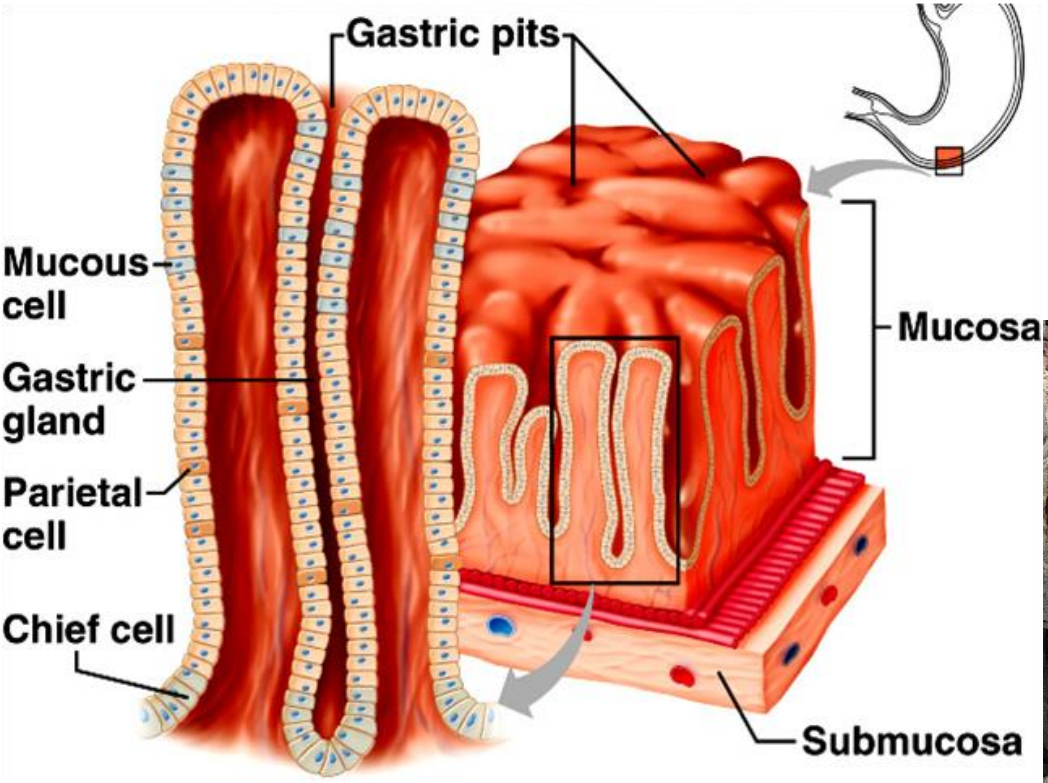
What are the major functions of the stomach?

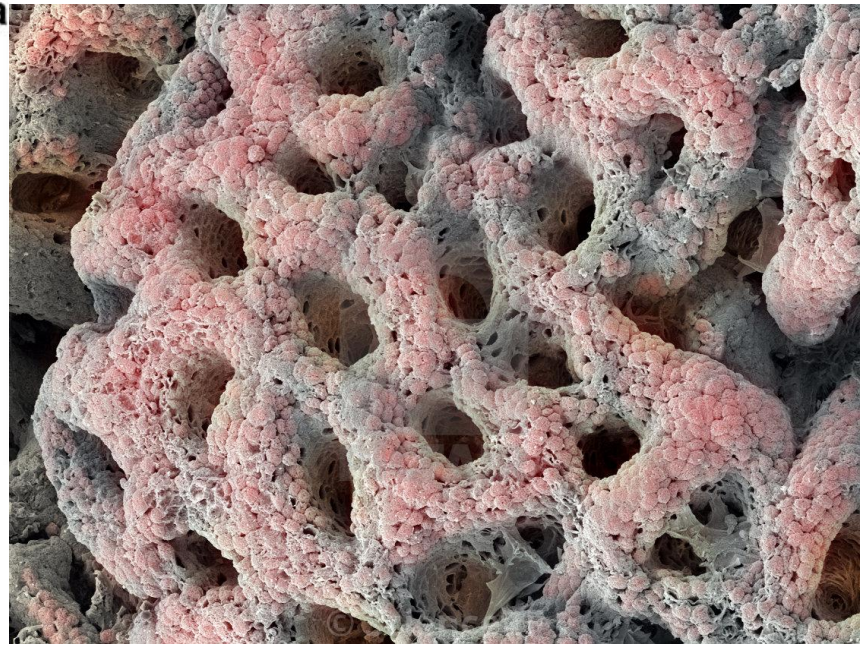
GASTRIC MUCOSA

- Gastric mucosa is formed of columnar epithelium that is folded into “pits”.
- The pits are the opening of gastric glands.
- There are several types of gastric glands in the stomach and are distributed differentially in the stomach.

Layers of the Stomach Wall

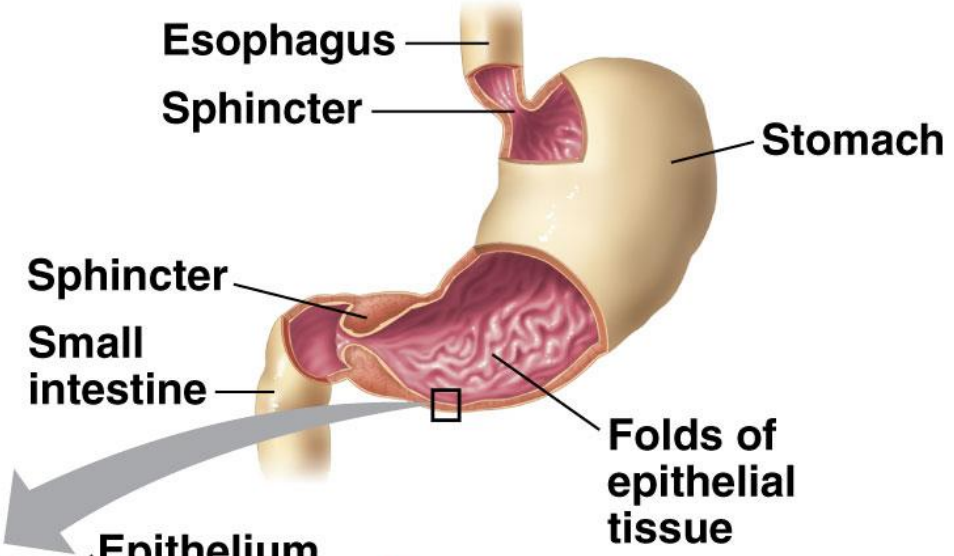


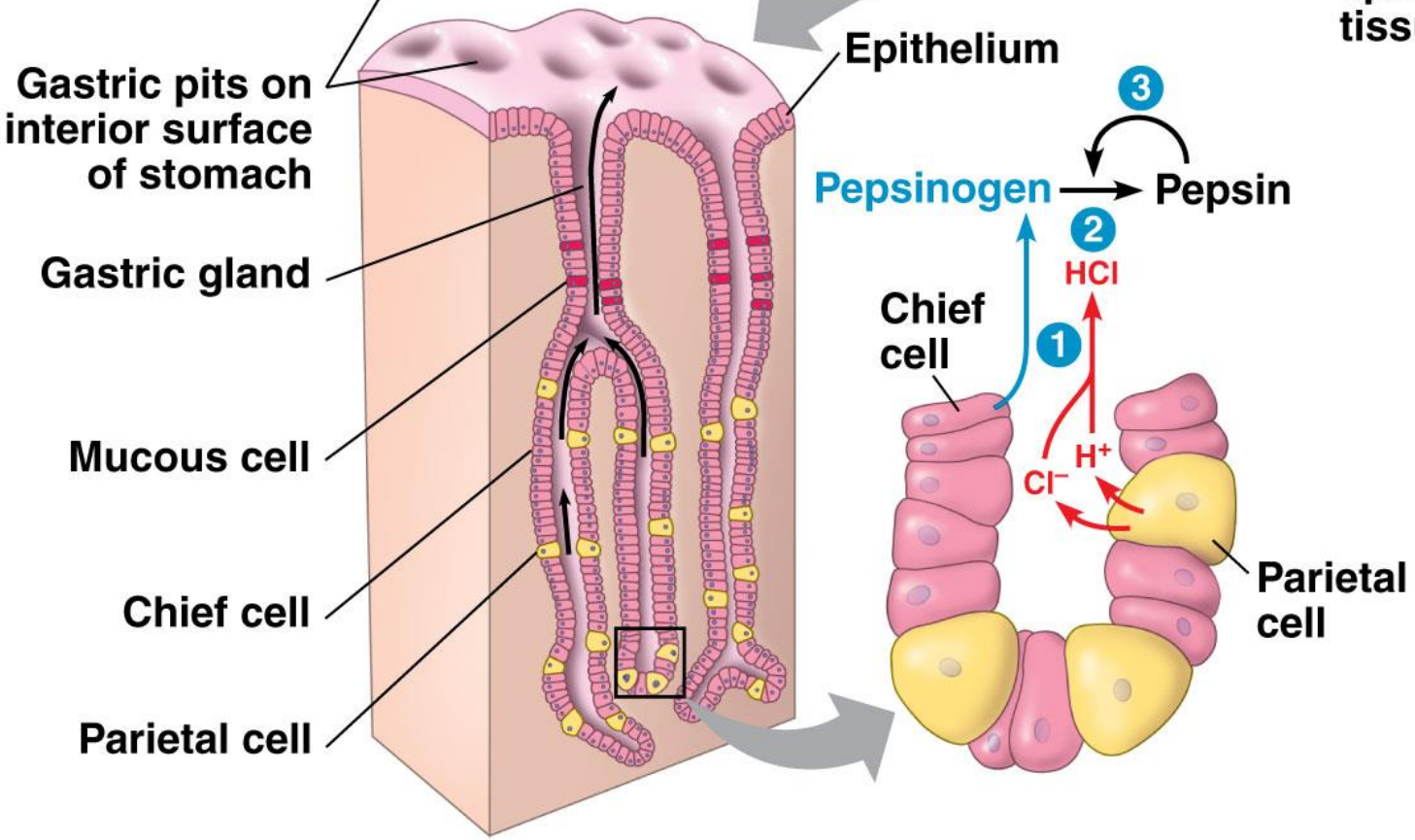




Stomach lining with gastric pits, SEM BStomach lining^b. Coloured scanning electron micrograph (SEM) of the inner lining of the stomach (gastric mucosa). The indents are gastric pits. These contain cells that secrete enzymes, mucous and hydrochloric acid into the stomach. Magnification: x40 when printed 10 centimetres wide.

https://www.picfair.com/pics/05549938-stomach-lining-with-gastric-pits-sem





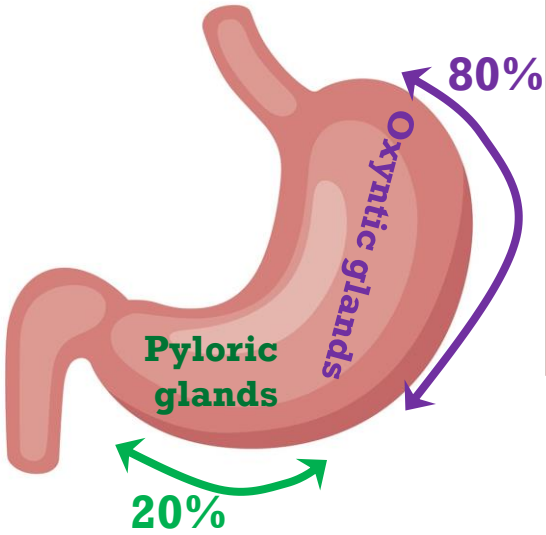
GASTRIC GLANDS

Gastric glands

Oxyntic (gastric) glands

Secrete;
HCl
Pepsinogen
IF
Mucus

Found in;
Body & fundus
(above the notch)

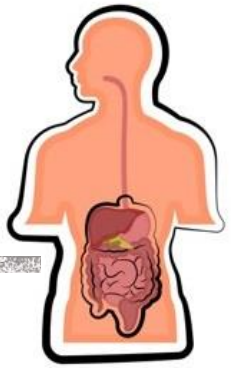


Pyloric glands

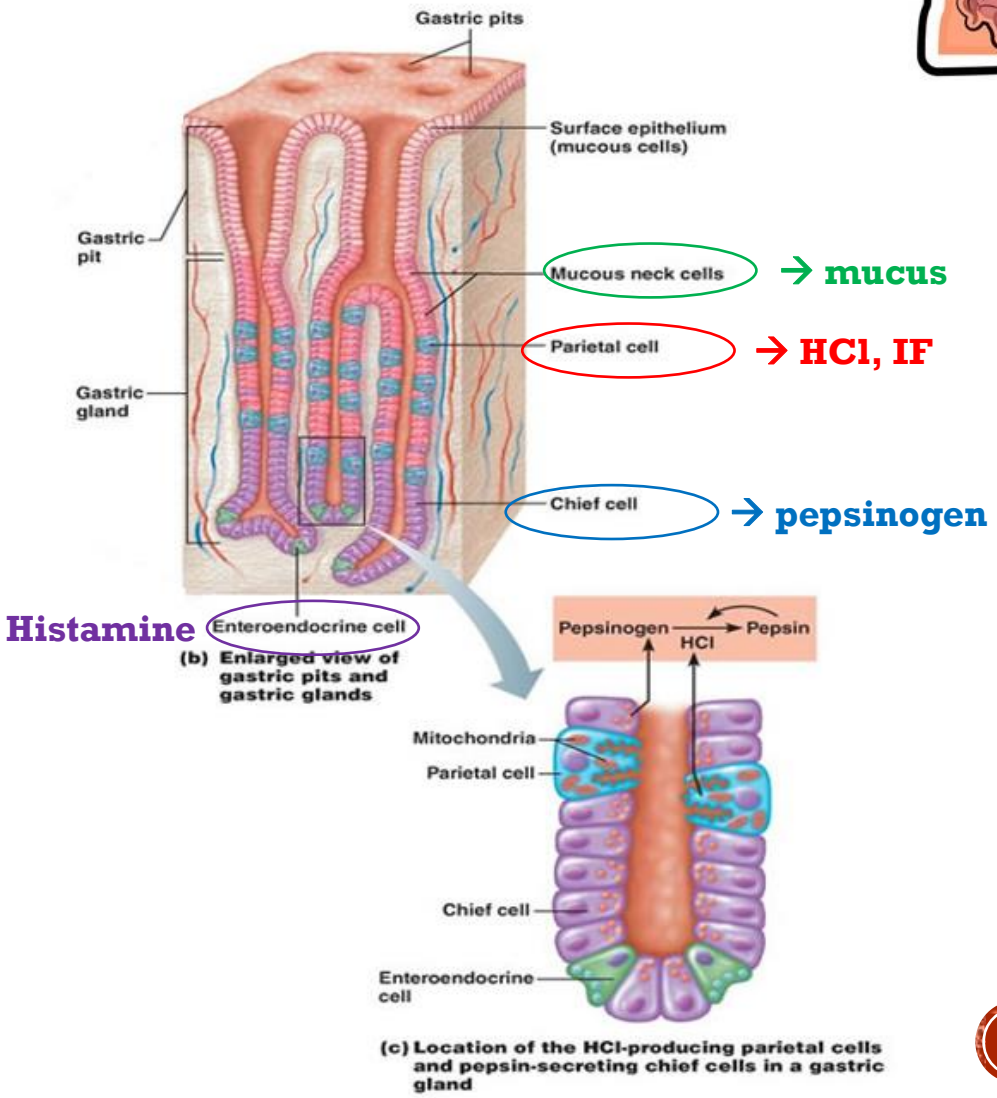
Secrete;
Gastrin
Mucus

Found in;
Antrum
(below the notch)

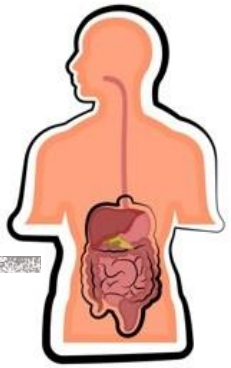
OXYNTIC "GASTRIC" GLANDS



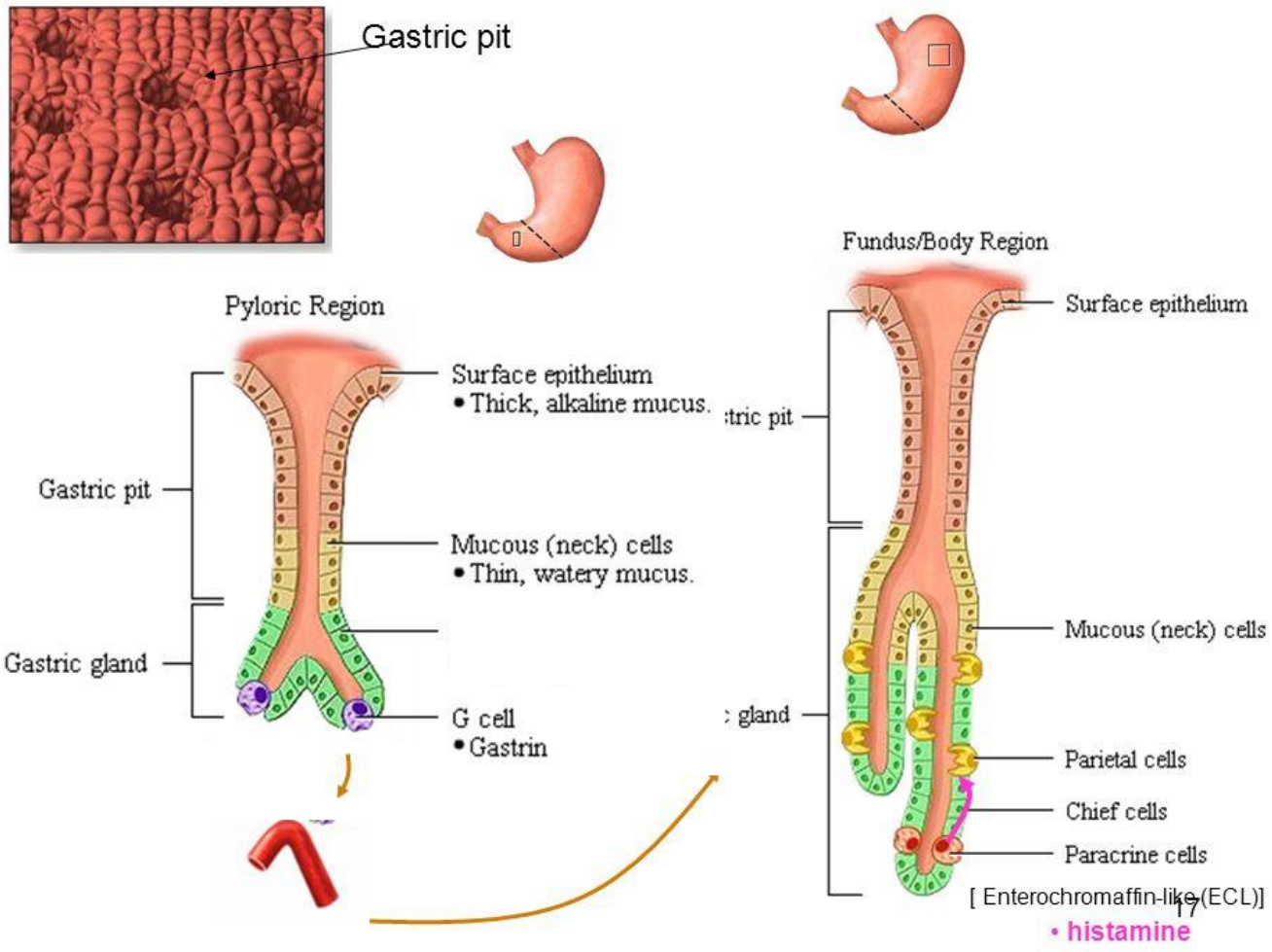
What are the cells lining the oxyntic glands and what does each cell produce?



PYLORIC GLANDS

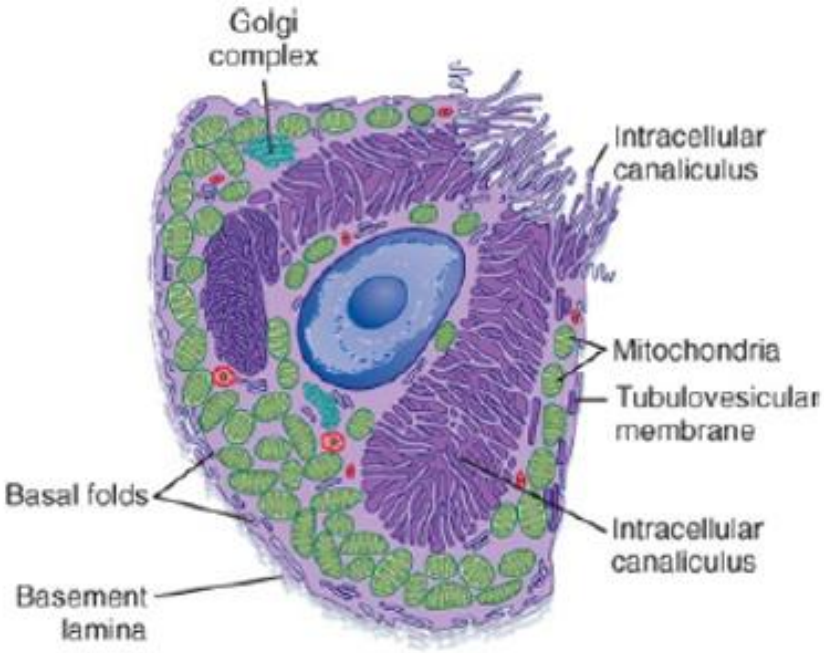


What are the cells lining the pyloric glands and what does each cell produce?



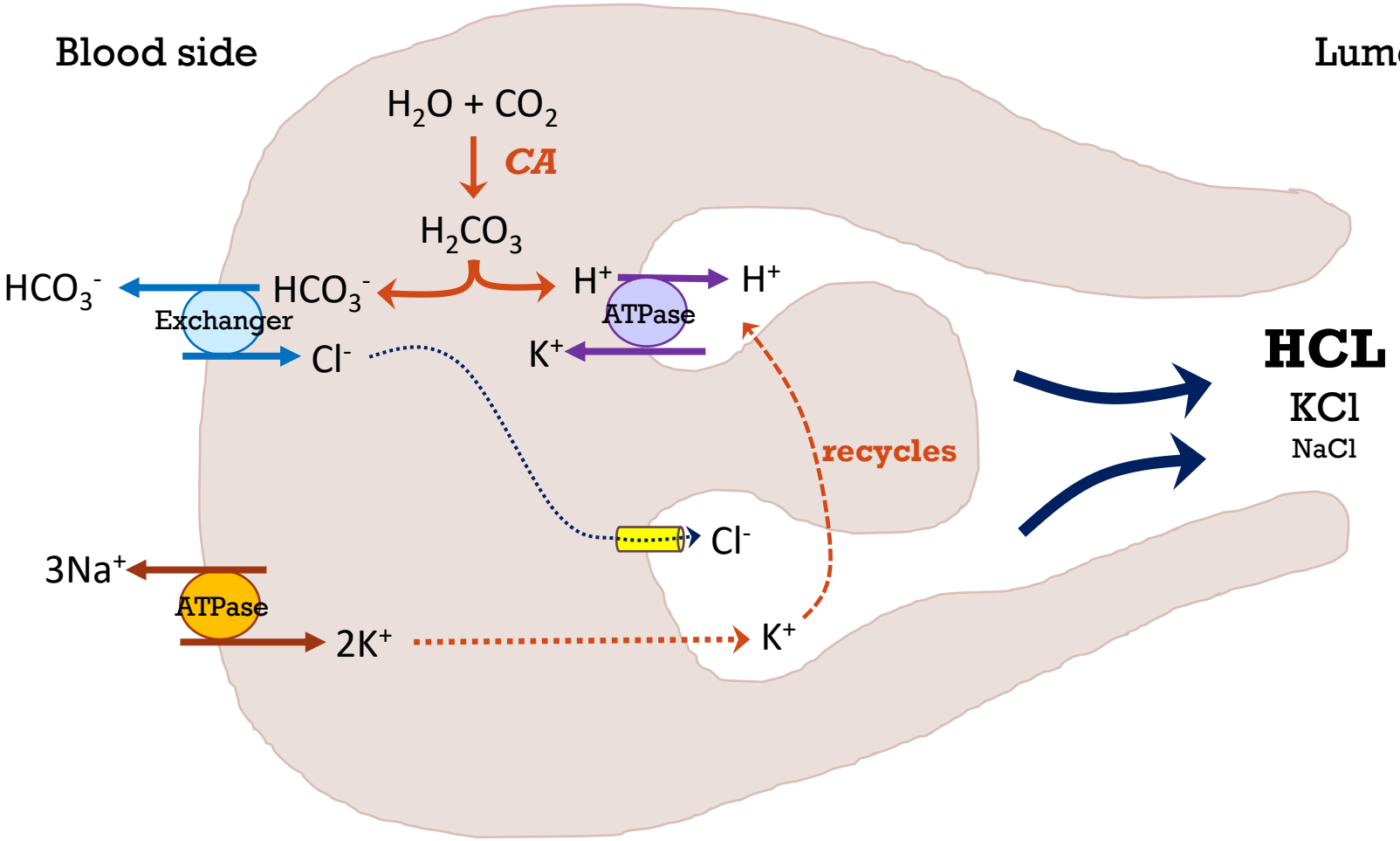
MECHANISM OF HCL SECRETION

THE PARIETAL CELL

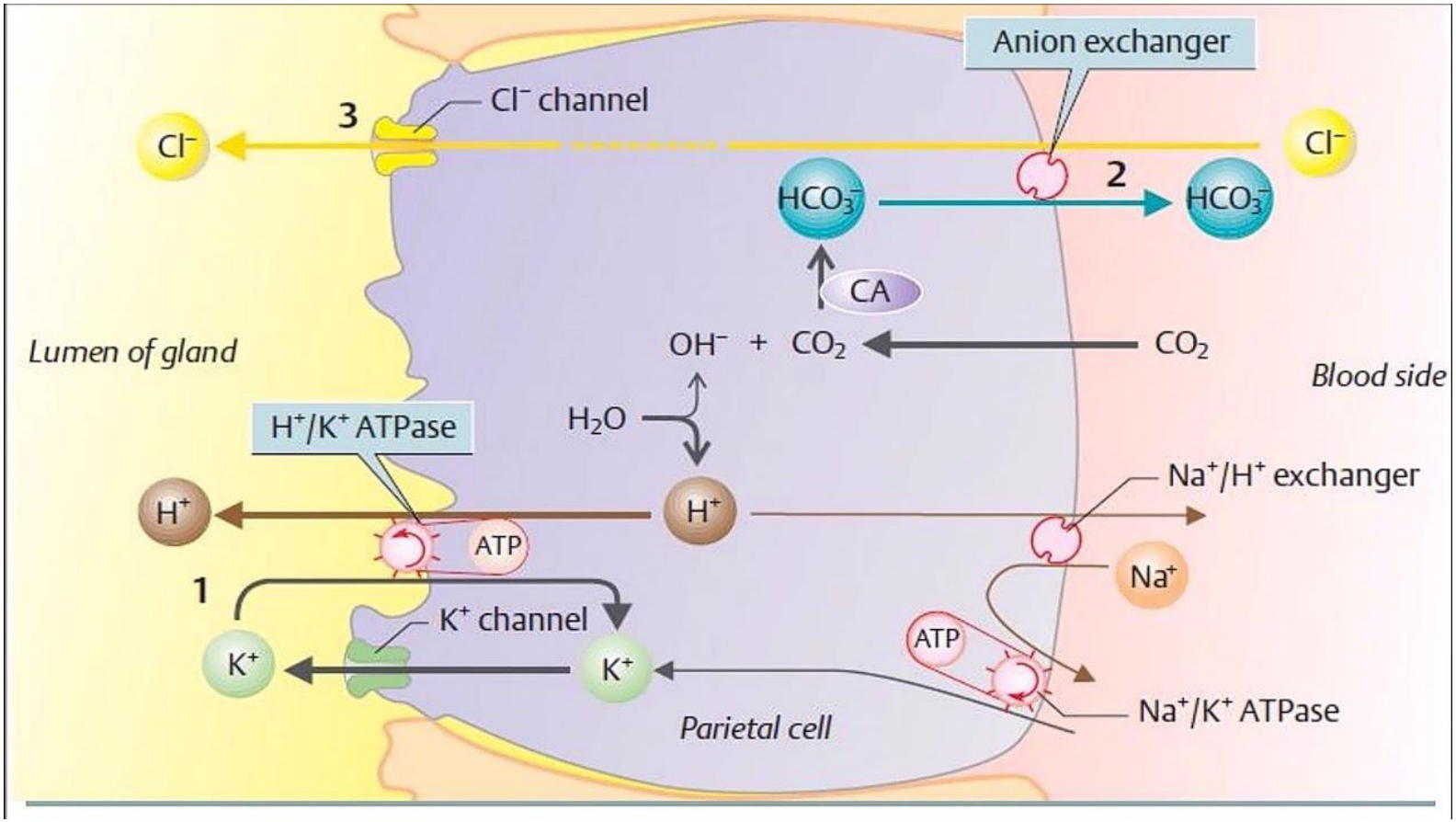


B

MECHANISM OF HCL SECRETION BY PARIETAL CELLS



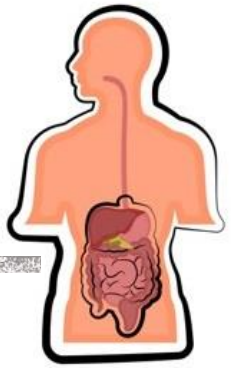
MECHANISM OF HCL SECRETION BY PARIETAL CELLS

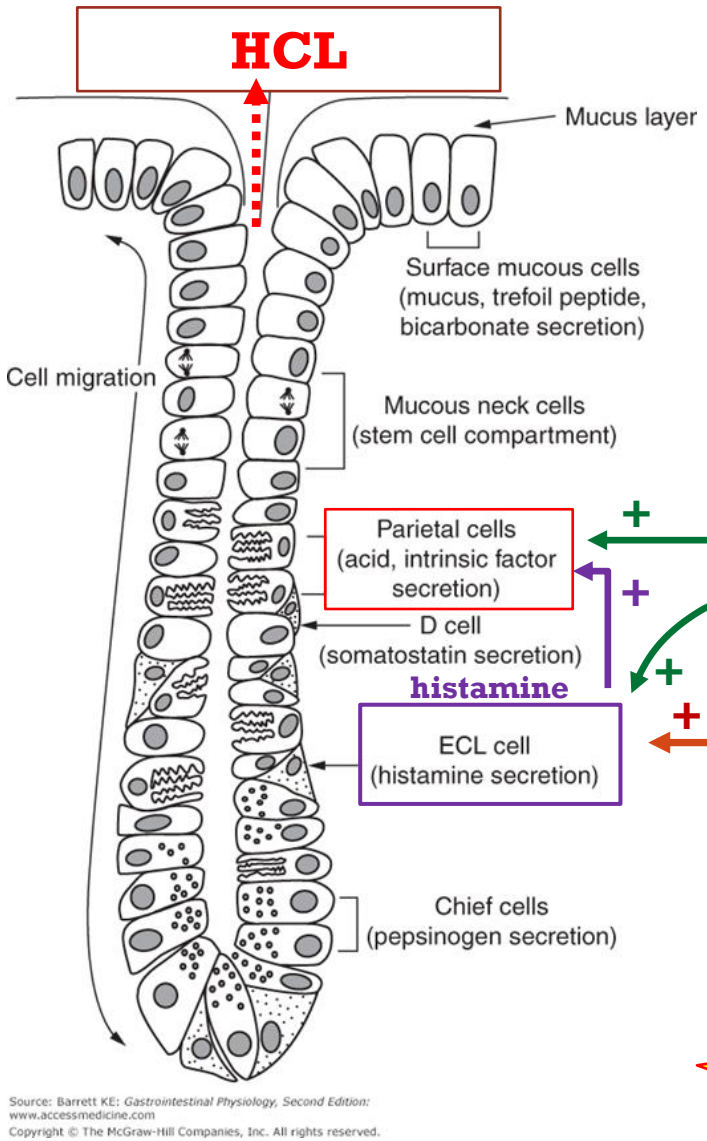


A VIDEO ON MECHANISM OF HCL SECRETION

https://youtu.be/XhB7WNJVg3U

CONTROL OF HCL SECRETION





Acetylcholine

\+

\+

\+

Gastrin

\+

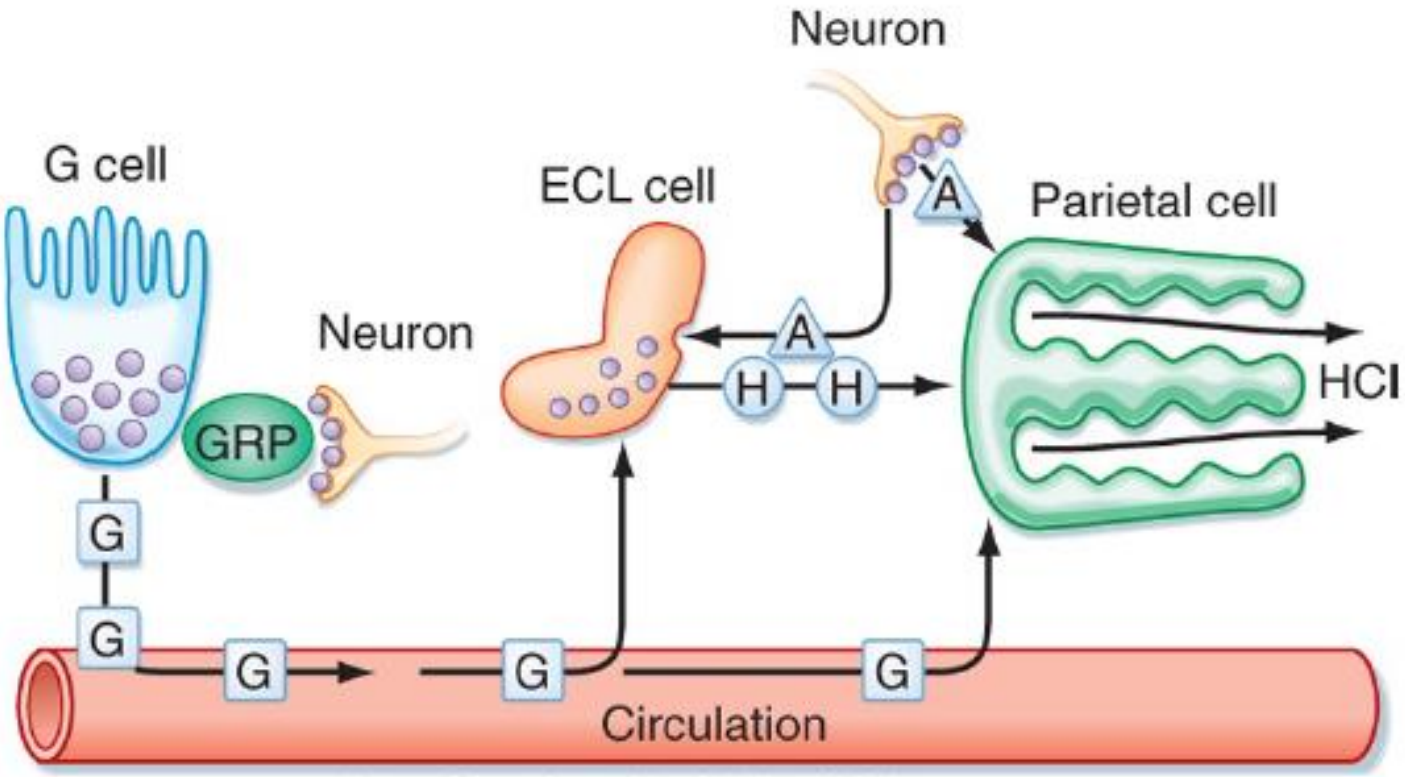
G cells
Pyloric glands

\+

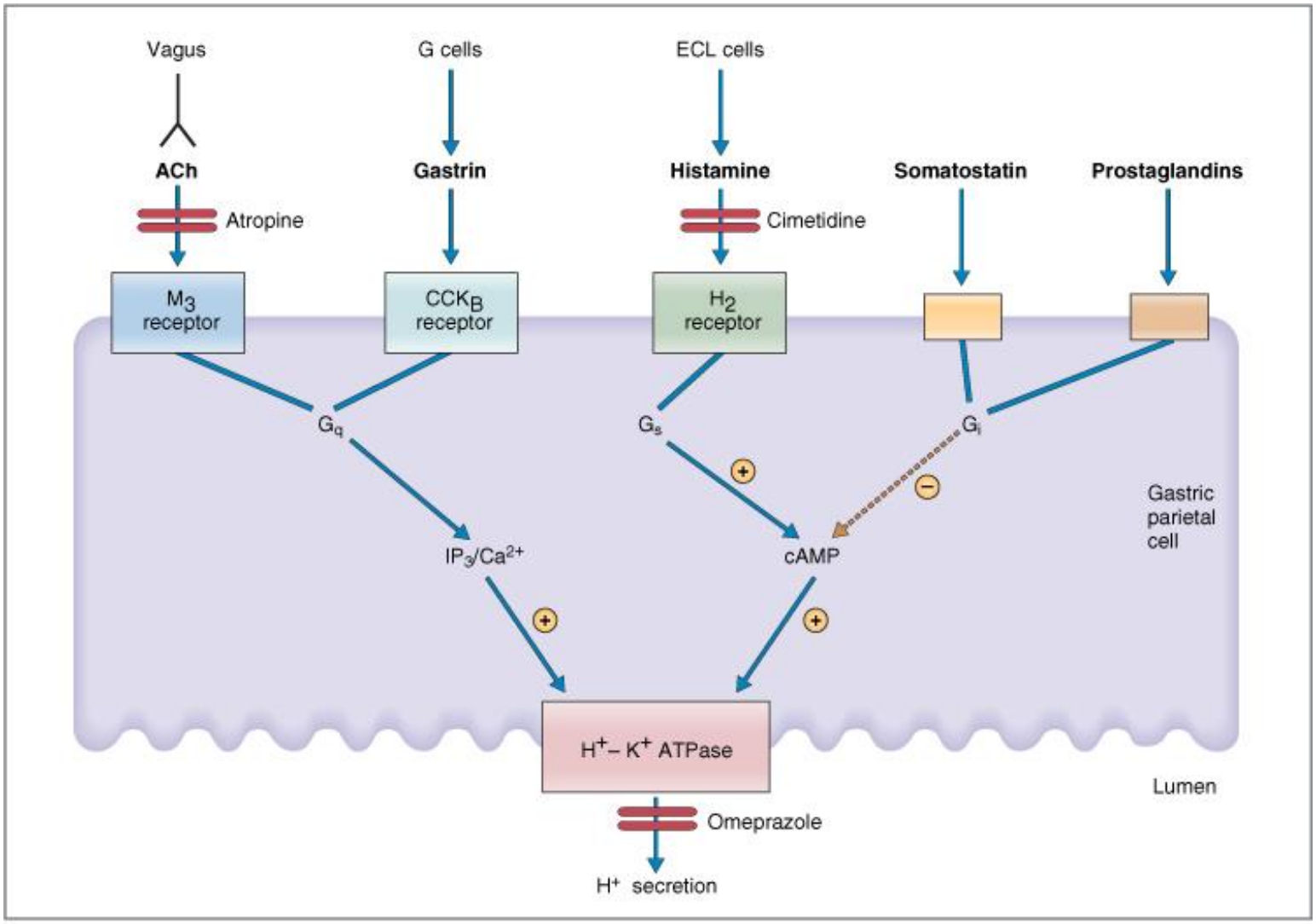
Meat
Protein in
antrum

CONTROL OF HCL SECRETION

ACETYLCHOLINE, GASTRIN, AND HISTAMINE STIMULATE THE PARIETAL CELL



AGENTS THAT STIMULATE AND INHIBIT H^+ SECRETION BY GASTRIC PARIETAL CELLS



OTHER GASTRIC SECRETIONS

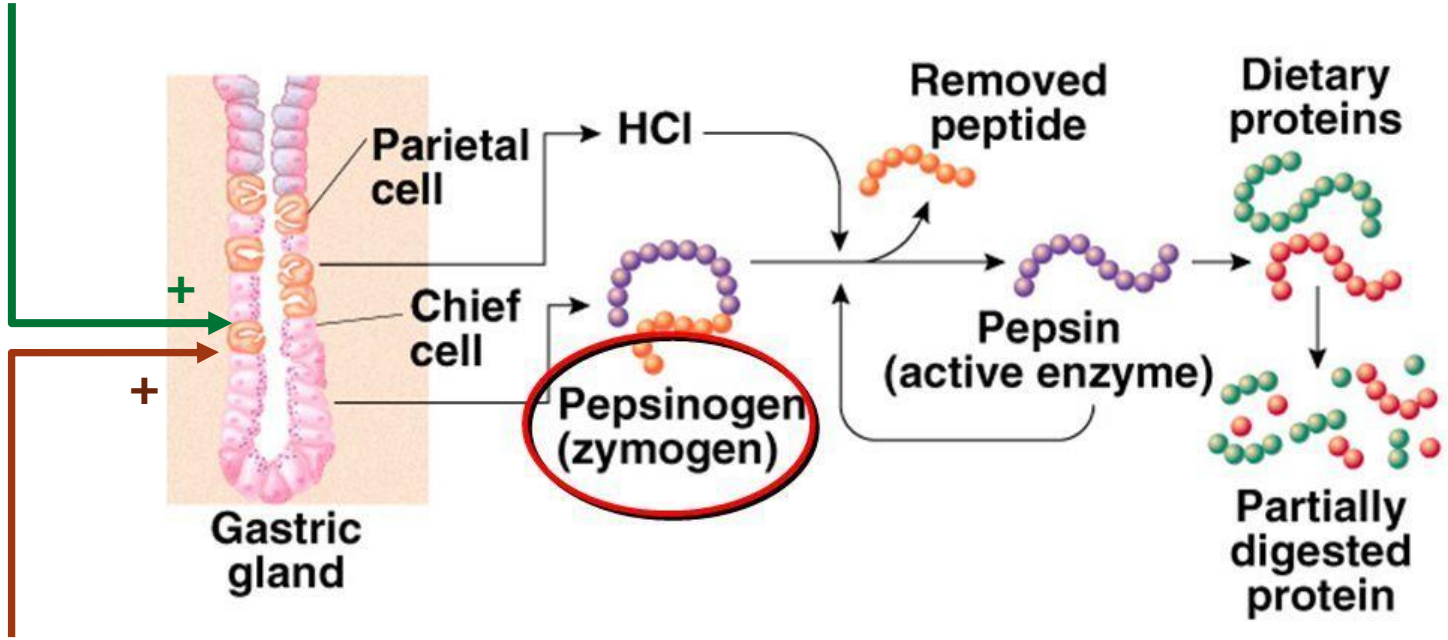
OTHER GASTRIC SECRETIONS

- In addition to HCl, parietal cells secrete IF.. ***What is its importance?***
- Peptic (chief) cells secrete pepsinogen.. ***What is its role in digestion?***
- Mucus cells secrete mucus.. ***Why?***

SECRETION OF PEPSINOGEN

Production & Action of Pepsin

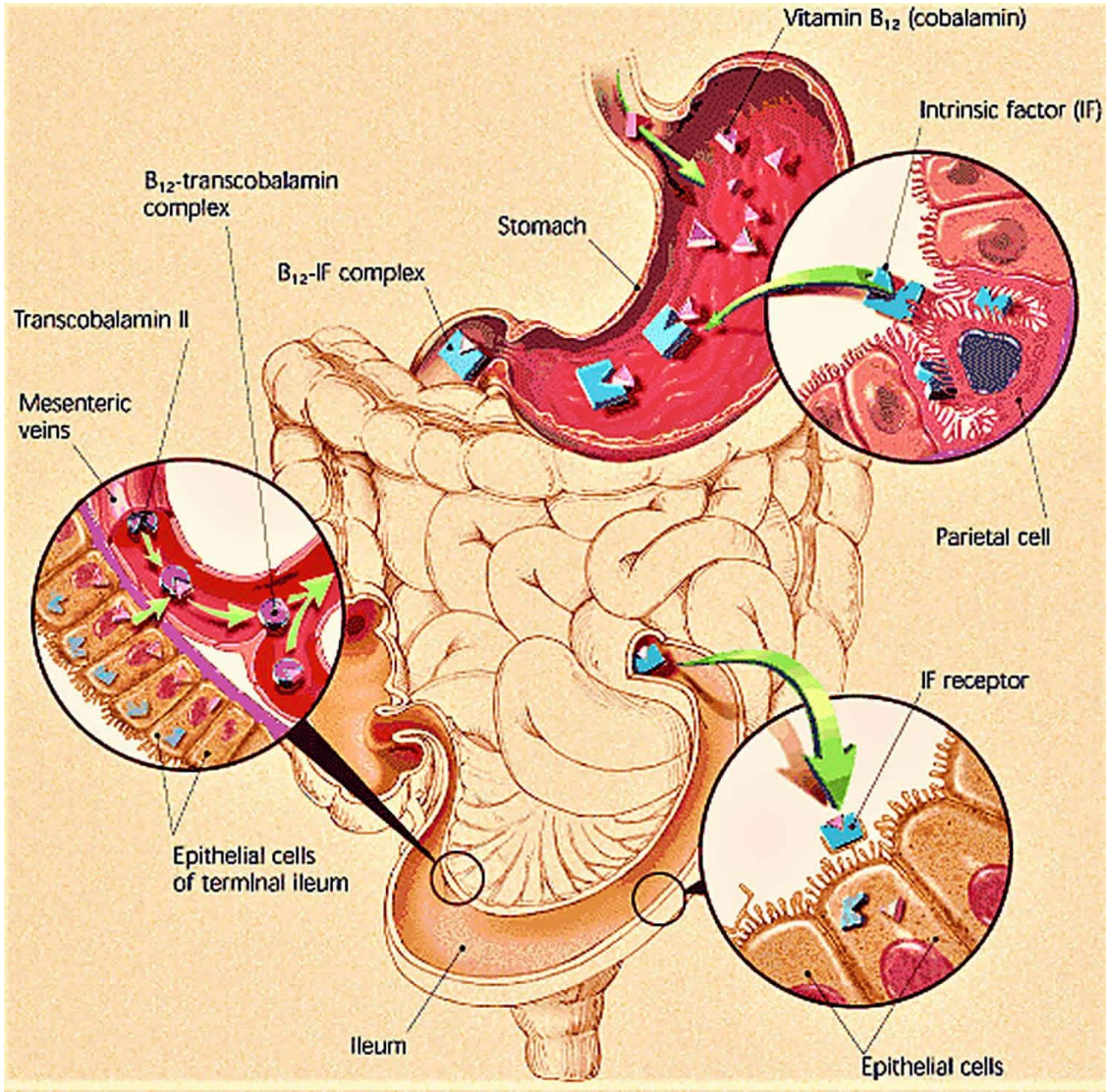
Acetylcholine



Acid in stomach

Optimum pH for pepsin = 1.8 – 3.5
pH > 5 → inactivates pepsin

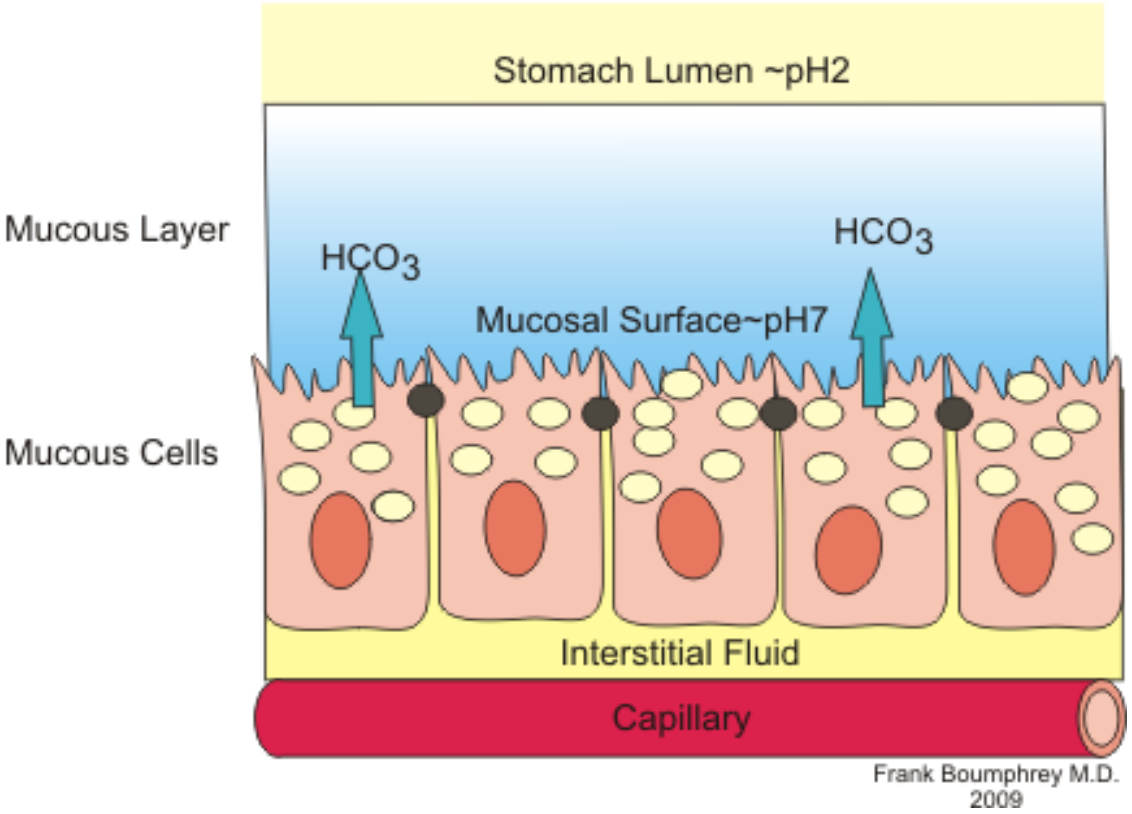
SECRETION OF INTRINSIC FACTOR



SECRETION OF MUCUS

- Mucus cells secrete large quantities of ***viscid mucus*** that coats the muscle mucosa.
- The mucus is ***alkaline***.

What is the importance of the mucus layer?



EFFECTS OF VAGAL ACTIVATION ON GASTRIC SECRETION

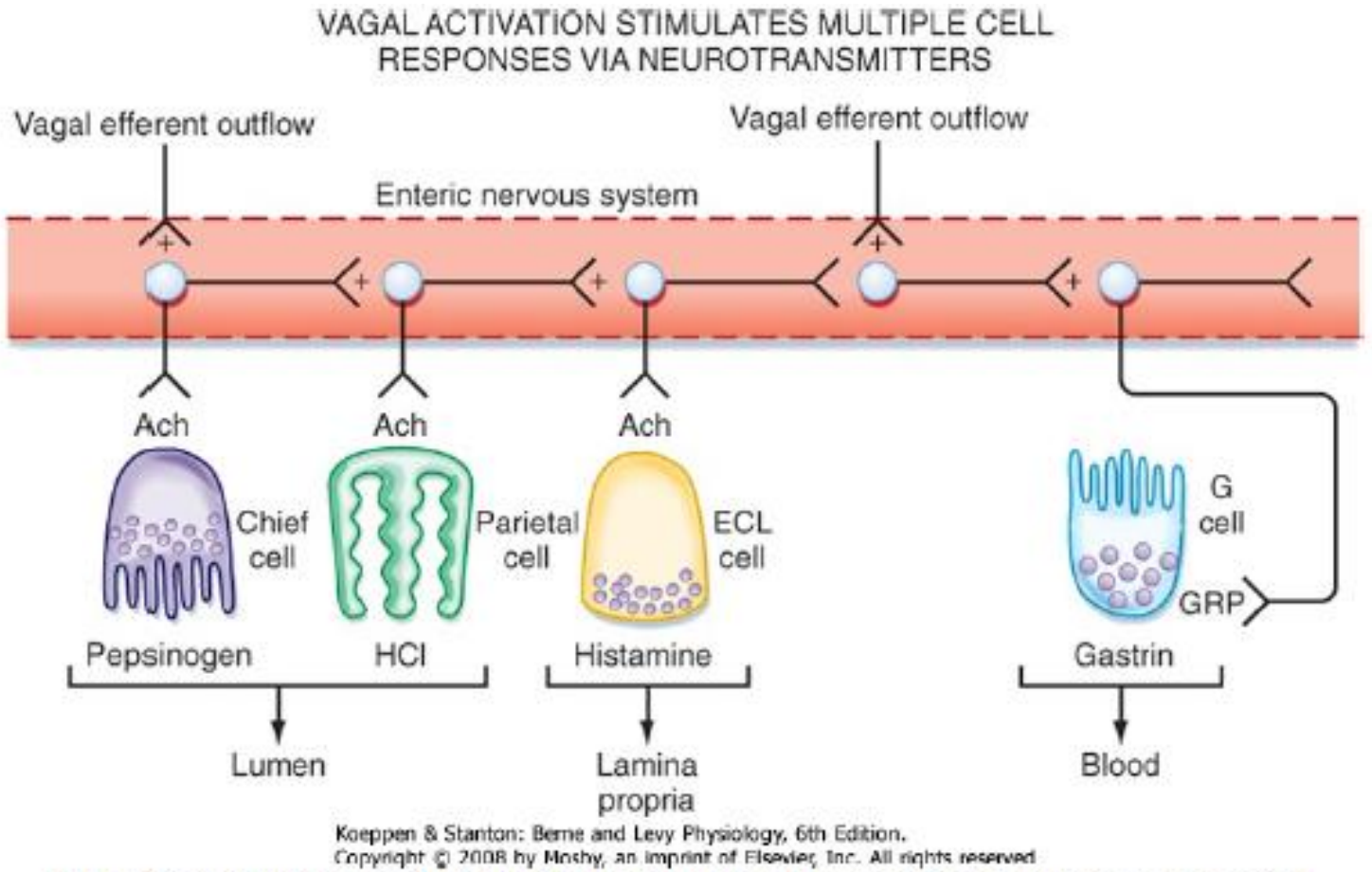


Figure 28-9 Vagal parasympathetic stimulation of gastric secretions via enteric neurons. Vagal preganglionic neurons innervate the myenteric and submucosal plexus; the terminals of the vagal preganglionic neurons innervate many enteric neurons and thus bring about changes in function as described in Figure 28-7.

PHASES OF GASTRIC SECRETION

PHASES OF GASTRIC SECRETION

- Gastric secretion starts even before food reaches the stomach and when food is in the stomach and continues even after food leaves stomach into duodenum.

- It can generally be divided into ***three phases***:

1. ***Cephalic phase*** → Before food arrives at stomach (30% of gastric secretion).

2. ***Gastric phase*** → when food enters the stomach (60% of gastric secretion).

3. ***Intestinal phase*** → when chyme enters duodenum (10% of gastric secretion.)

PHASES OF GASTRIC SECRETION

- https://youtu.be/ifDp57pvKOg

PHASES OF GASTRIC SECRETION

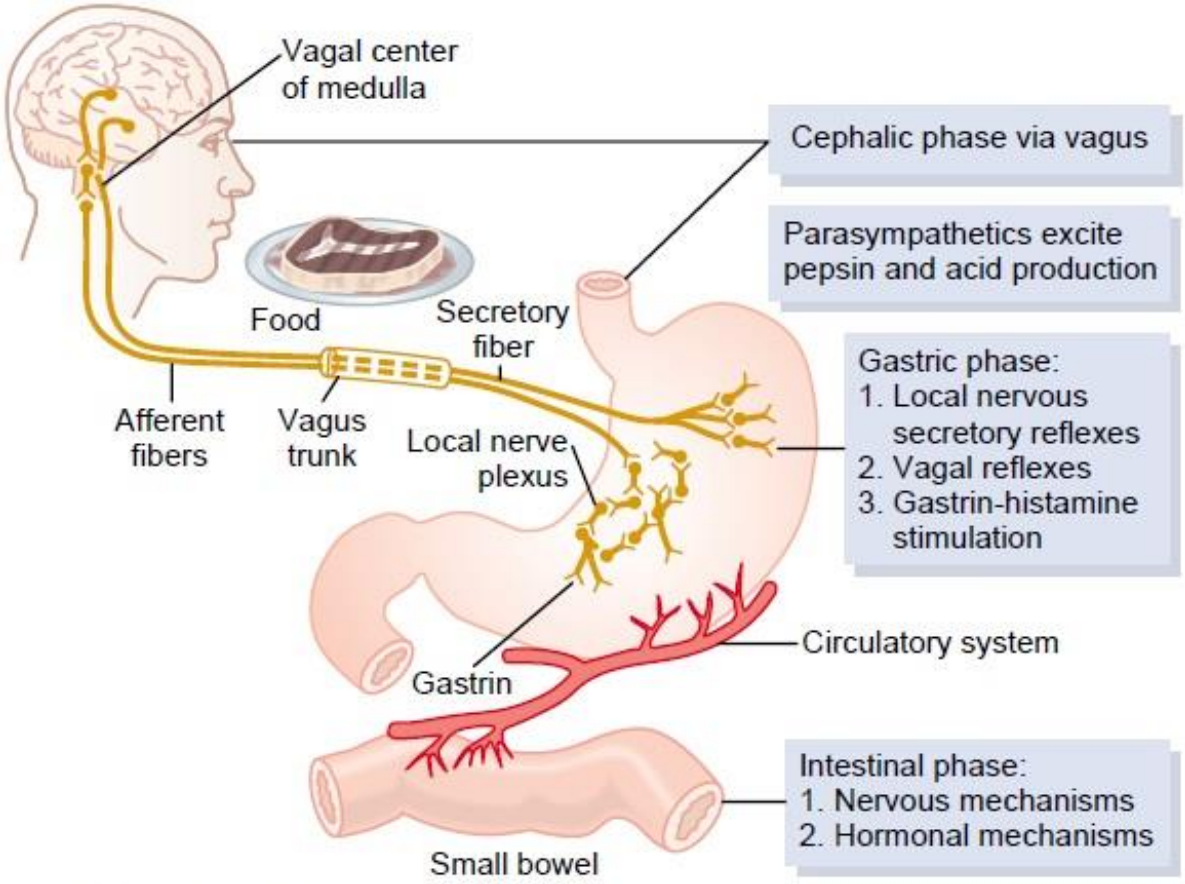


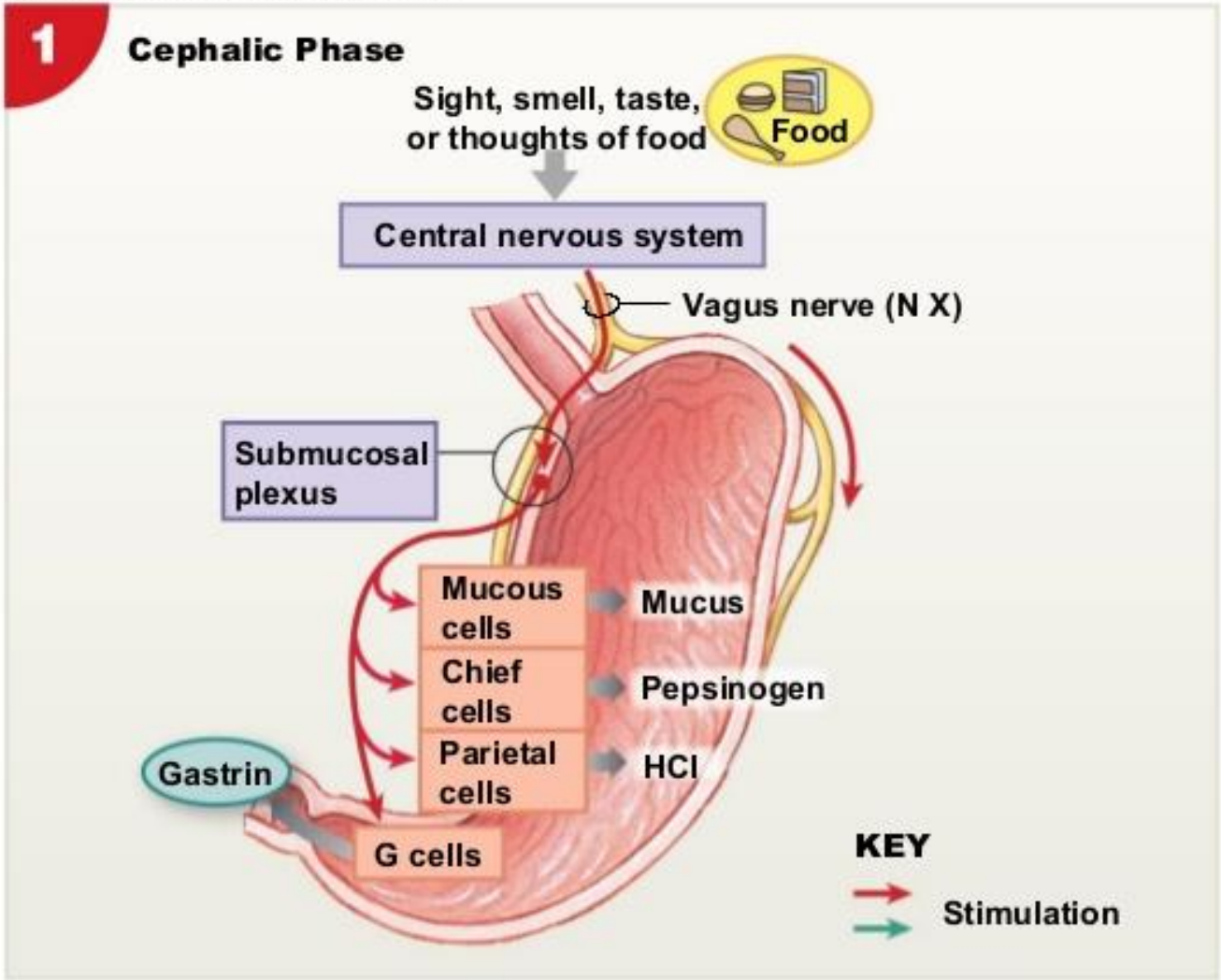
Figure 64–7

Phases of gastric secretion and their regulation.

CEPHALIC PHASE

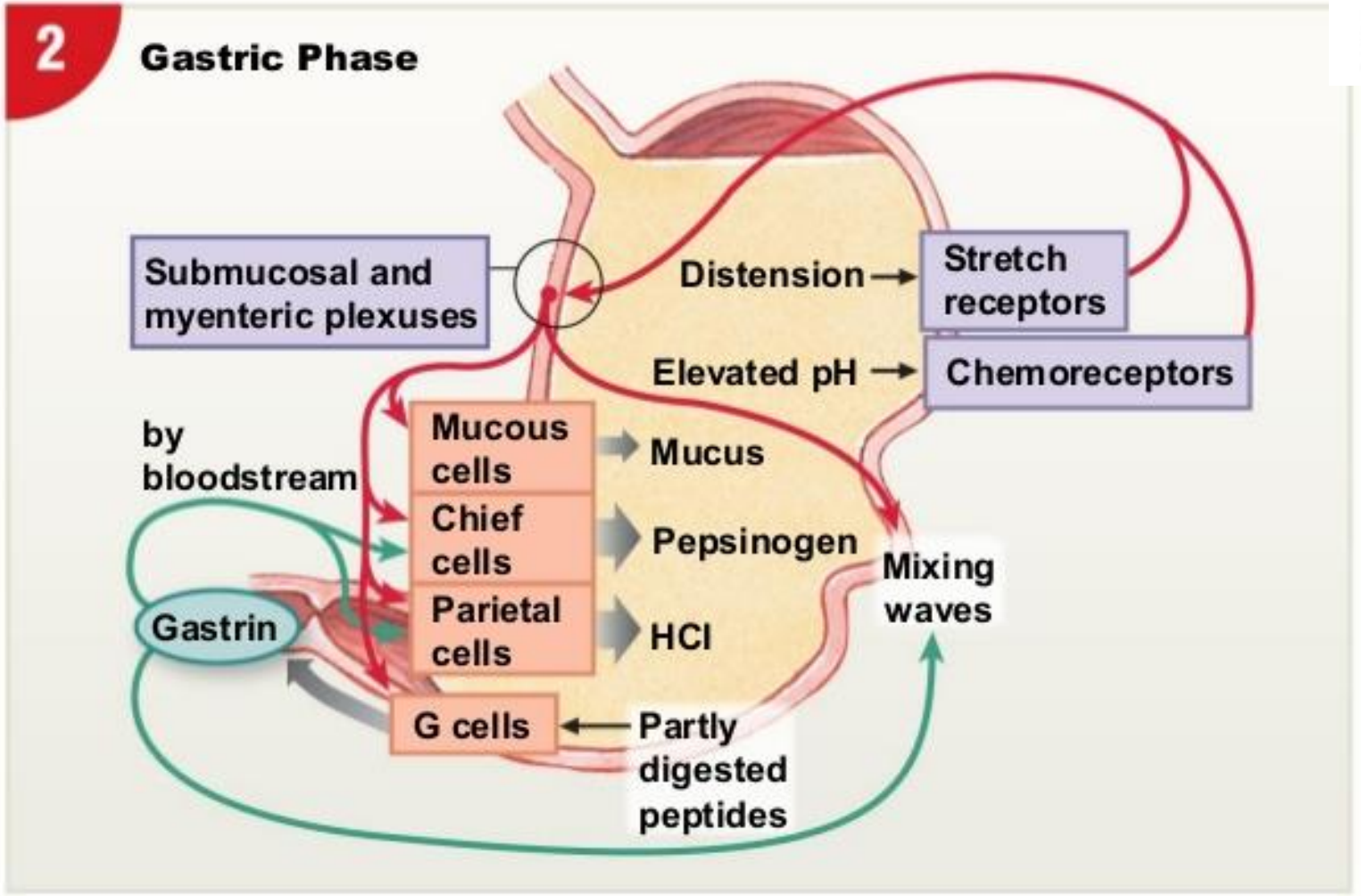
Figure 16-9 The Phases of Gastric Secretion.

Slide 1



GASTRIC PHASE

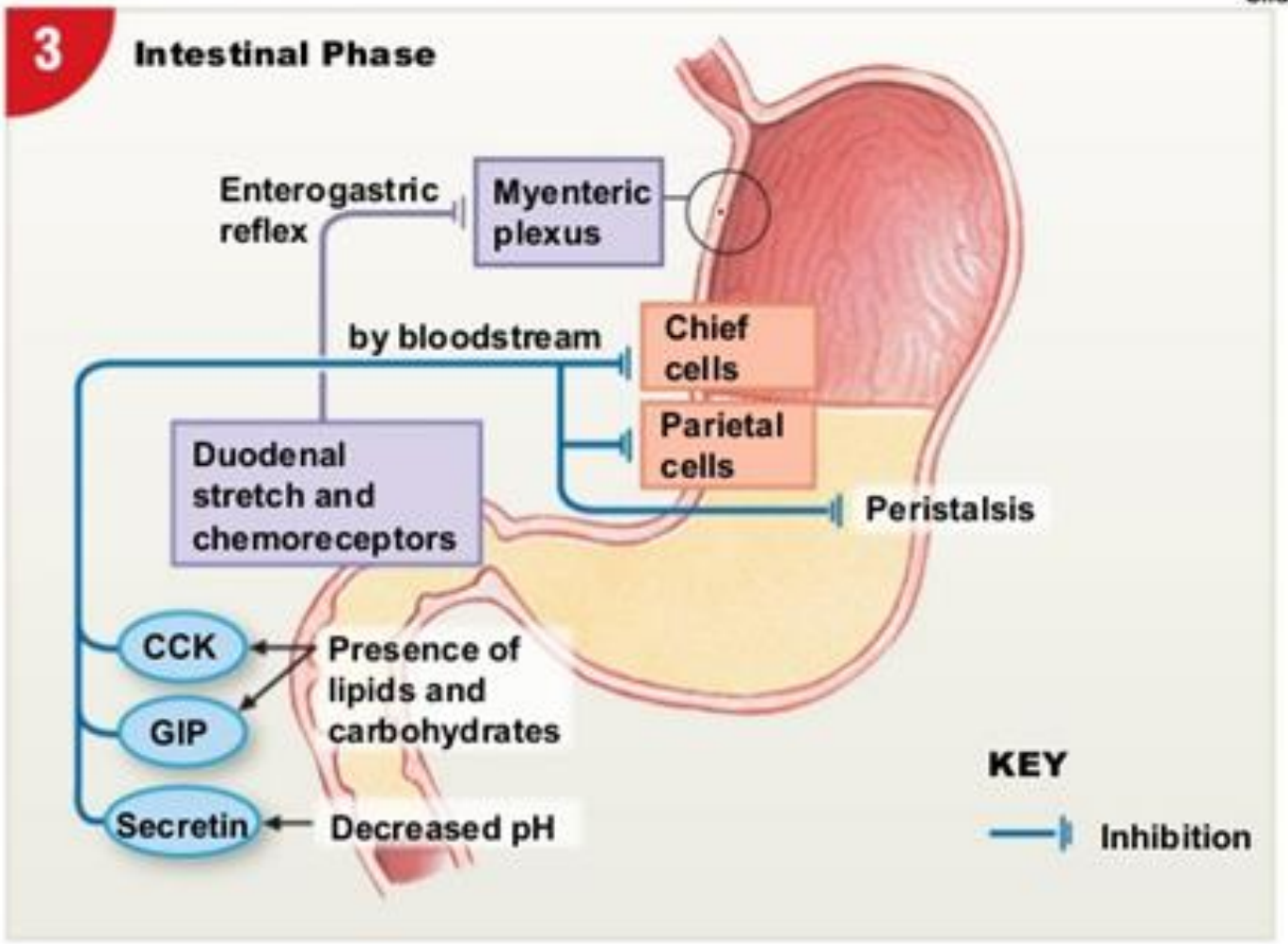
Figure 16-9 The Phases of Gastric Secretion.



INTESTINAL PHASE

Figure 16-9 The Phases of Gastric Secretion.

Slide



GASTRIC MOTILITY

GASTRIC MOTILITY

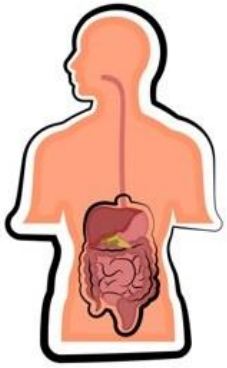
- ***What is the purpose of gastric motor activity "motility"?***

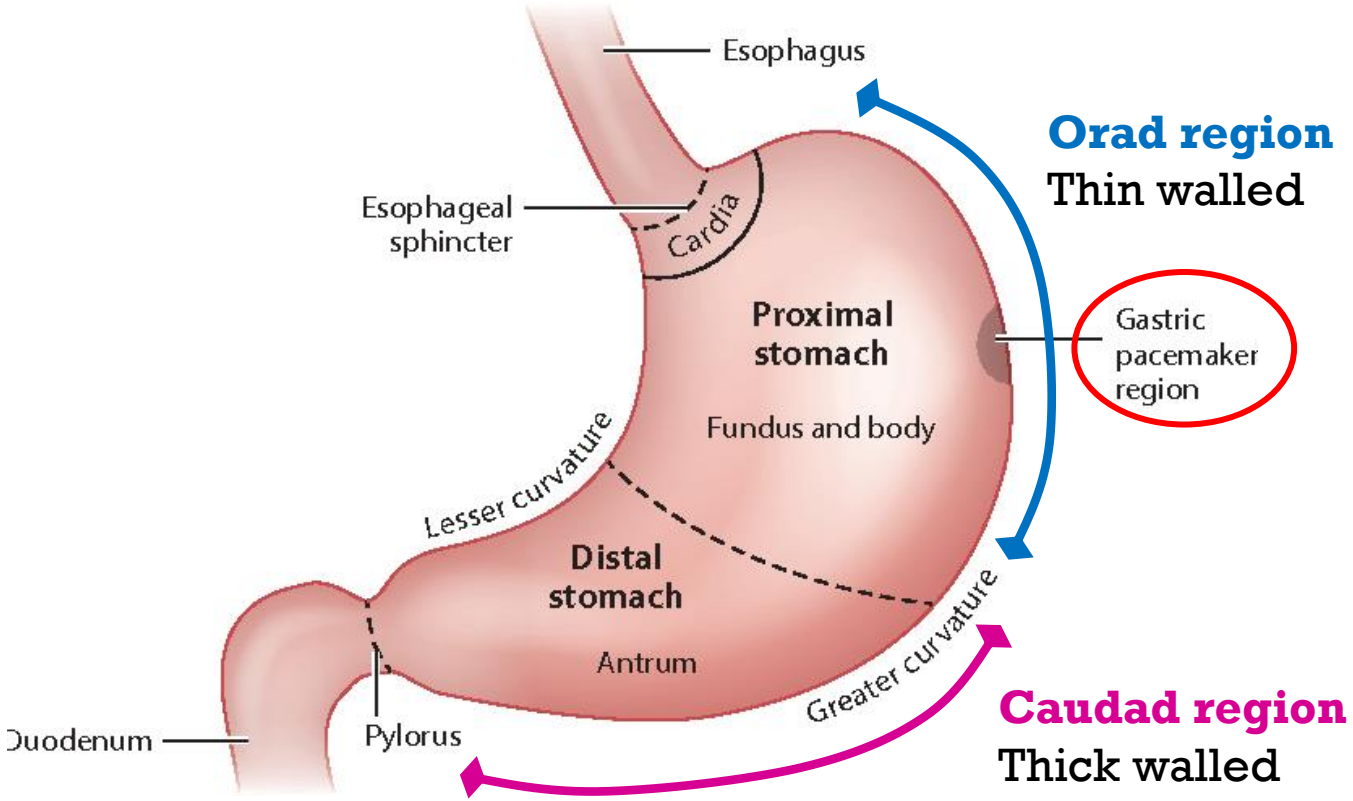
- **<u>Three main functions</u>;**

Motor function of the stomach

- **Storage "reservoir"** → Mainly in the proximal portion; Involves muscle relaxation
- **Mixing and grinding** → Churns food to transform it into a form that can pass through the pylorus and easy for intestine to deal with
- **Emptying into duodenum** → Emptying of modified gastric contents "**chyme**" into duodenum

GASTRIC MUSCLE WALL





Orad region
Thin walled

Caudad region
Thick walled

Gastric muscle wall is made of ***3 layers***:

- Outer longitudinal
- Middle circular
- Inner oblique

Thickness of muscle layer increases as we move from proximal to distal regions

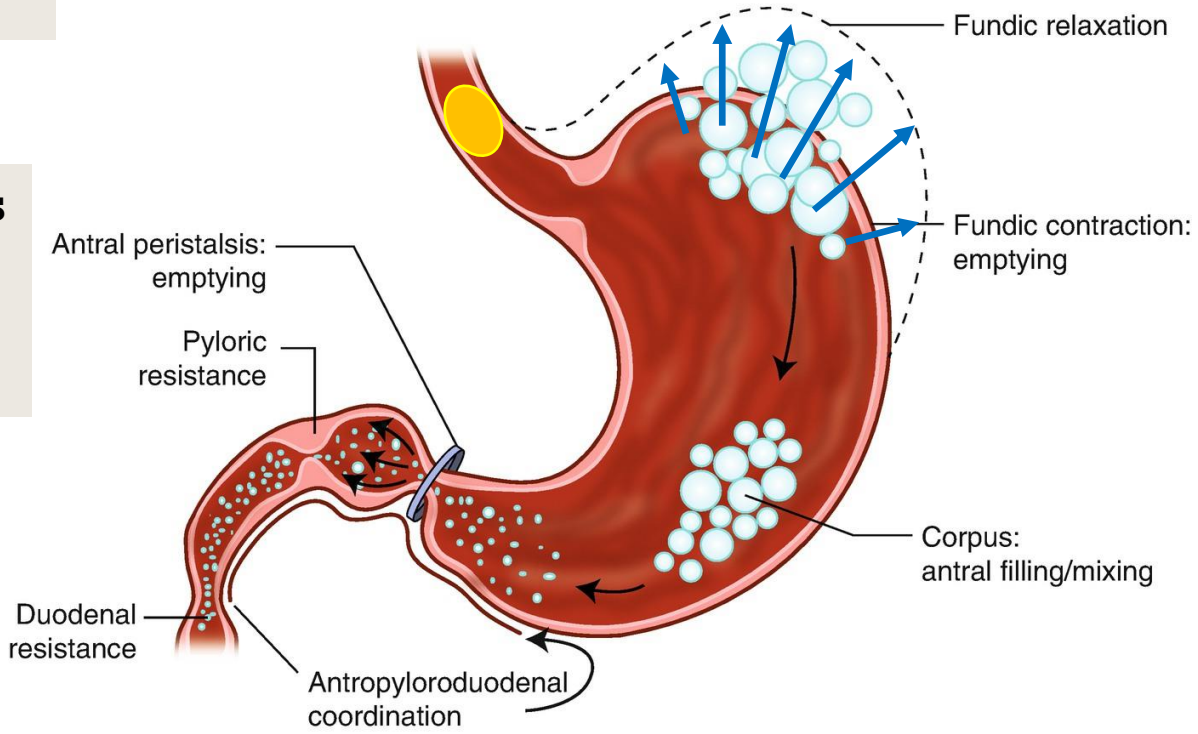
GASTRIC FILLING

When bolus of food in the esophagus approaches the stomach

A wave of relaxation recedes it that relaxes the LES & the orad region of the stomach "***Receptive relaxation***"

Allow food to enter and the volume of stomach increases without an increase in intragastric pressure

Vagovagal reflex



Empty stomach 50 ml → Full stomach 1000 ml

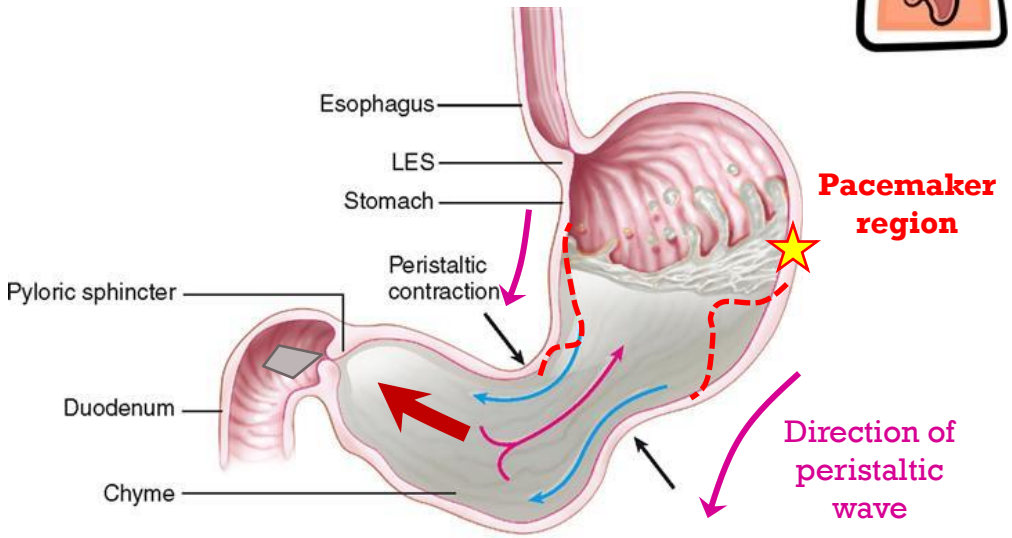
GASTRIC MIXING & EMPTYING

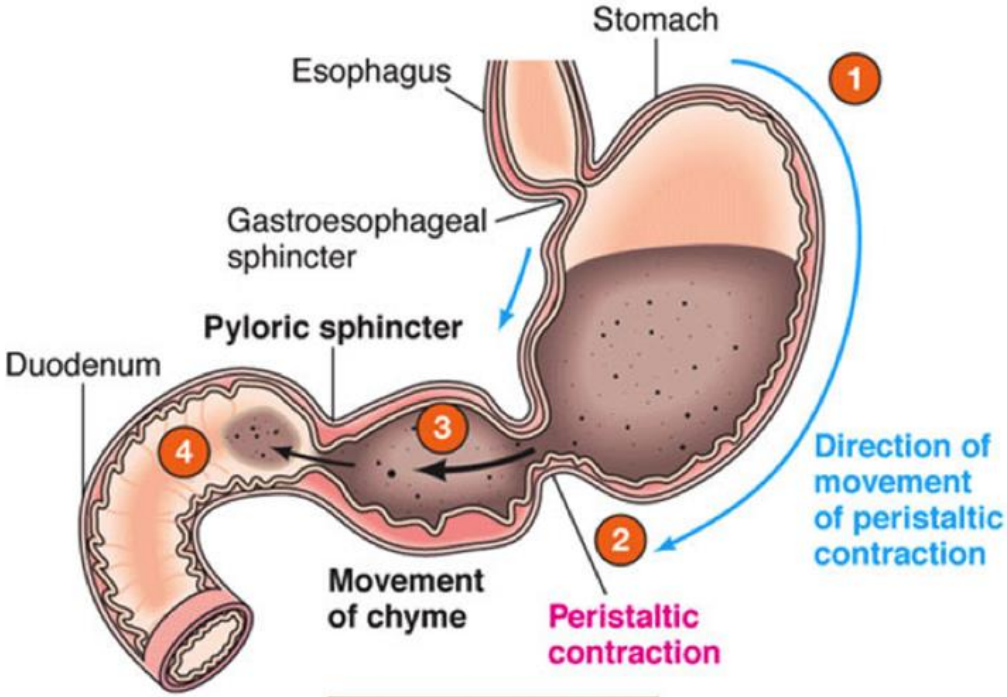
Stomach movement - Stock Video Clip - K001/4911 - Science Photo Library

Mixing of food in the stomach transforms it into a semifluid mix called "chyme"

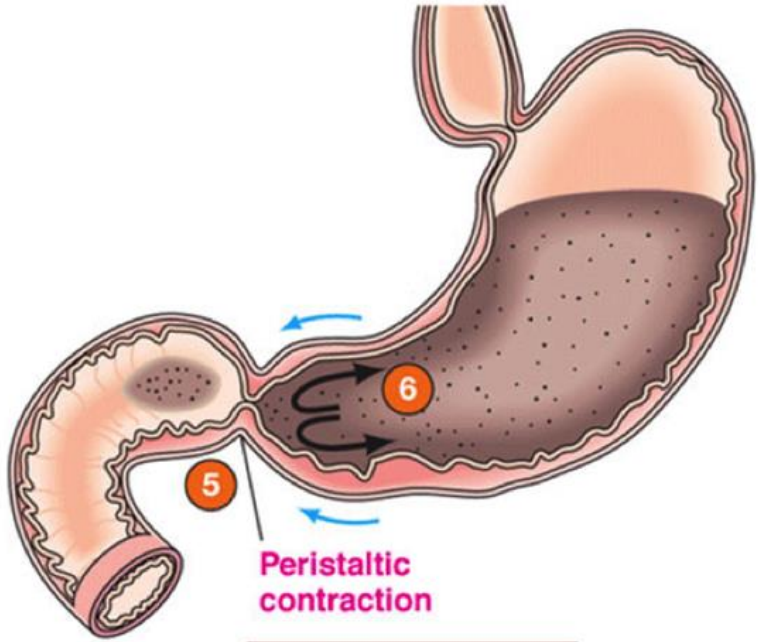
If particles are < 2mm they will squeezed through the tight pyloric sphincter and get emptied into duodenum "***Pyloric pump***"

If particles are > 2mm they will pump into the tight pyloric sphincter and tumble back into antrum "***retropulsion***"





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.

ROLE OF PYLORUS

- It is slightly tonically contracted almost all the time “pyloric sphincter”.
- It is usually open enough to allow water & fluids to pass.
- It is controlled by nervous and humoral reflexes from the stomach and duodenum

REGULATION OF GASTRIC EMPTYING

- ***What is the purpose of gastric emptying?***
  - To deliver chyme to the intestine to continue its digestion and absorption.
  - The rate at which chyme is delivered matters!

Factors that influence gastric emptying

Promote emptying

Usually are ***gastric factors***

Two main factors;
Distension of stomach
Gastrin

Inhibit emptying

Usually are ***duodenal factors***

Four main factors;
Fat
Acid
Hypertonicity
Distension
Trigger neural or hormonal response

GASTRIC FACTORS IN GASTRIC EMPTYING

Food in the stomach

Distension

Proteins stimulate release of ***gastrin***

neural

Increase motility of the stomach

DUODENAL FACTORS IN GASTRIC EMPTYING

Chyme in the duodenum

Distension

\+

Enterogastric reflex

Fat

\+

CCK
I cells

Acid

\+

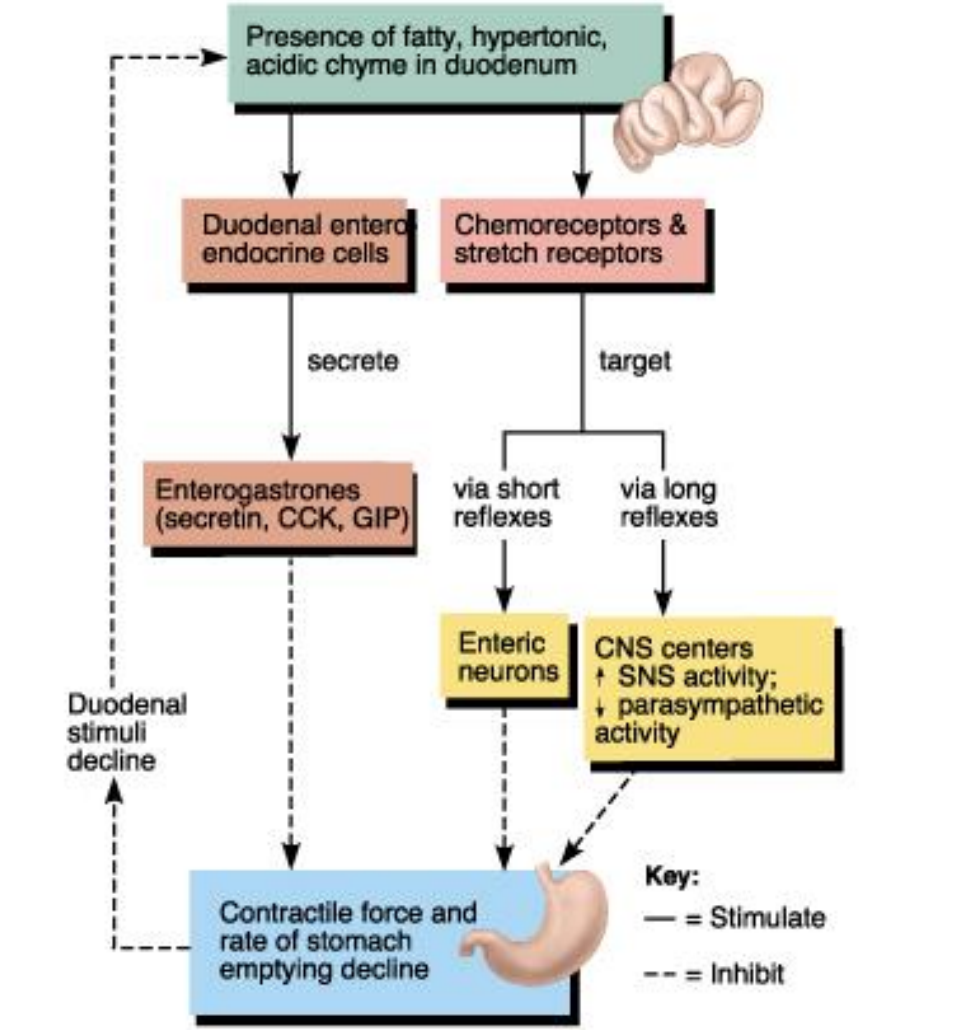
Secretin
S cells

hypertonicity

GIP

Decrease motility of the stomach

DUODENAL FACTORS IN GASTRIC EMPTYING



DUODENAL FACTORS IN GASTRIC EMPTYING

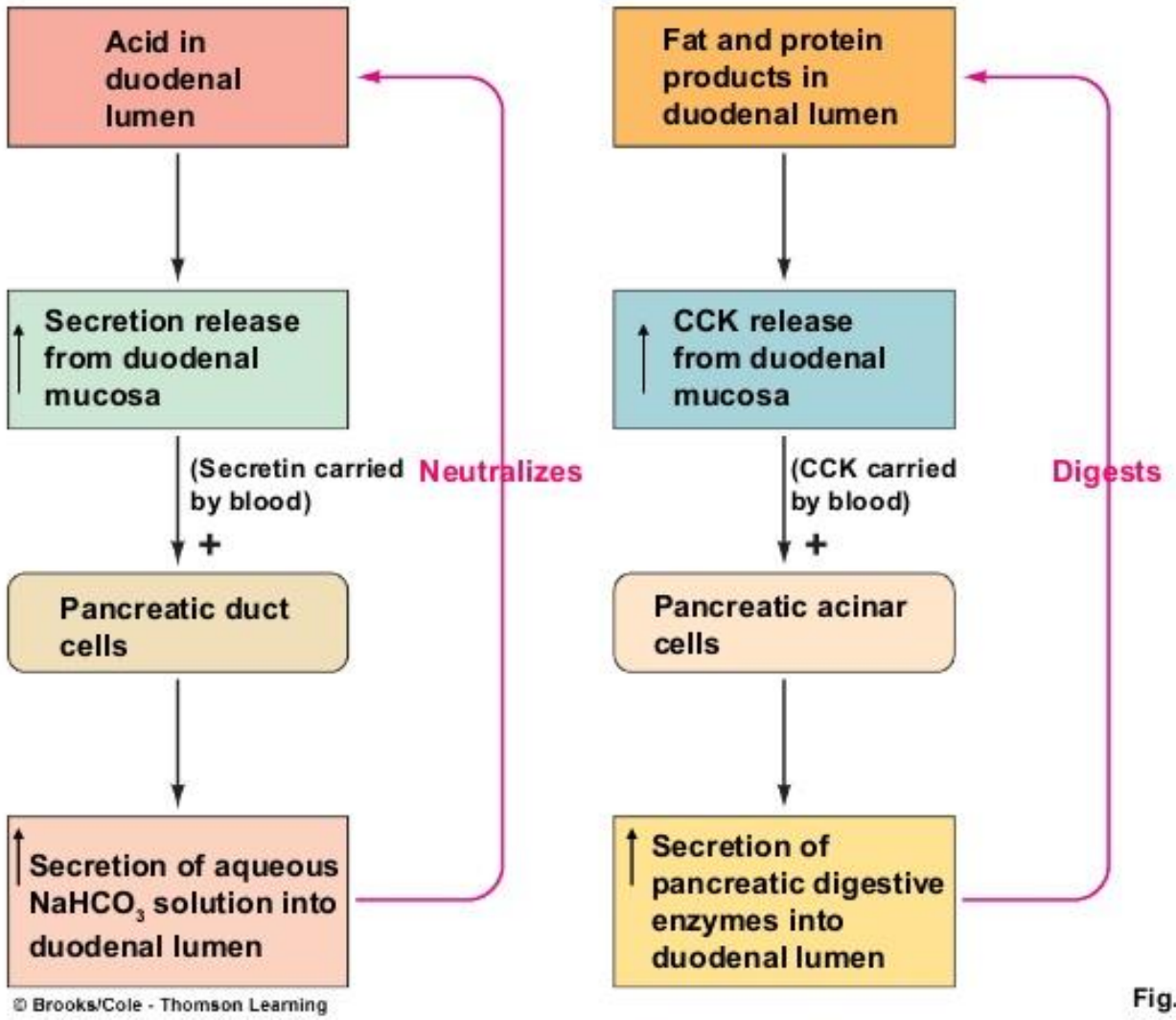


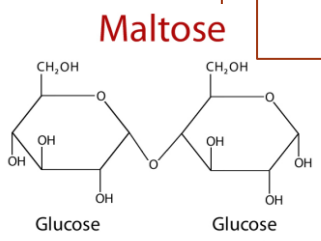
Fig. 15-12, p. 488

DIGESTION IN THE STOMACH

DIGESTION IN THE STOMACH

Carbohydrates

- Carbs in diet include;
  - Cellulose.
  - Starch.
  - Disaccharides.
- Stomach digests 30-40% of consumed starch to maltose by action of salivary amylase.



Fat

- Fat in diet include;
  - TGs.
  - Cholesterol.
- Stomach digests <10% of consumed TGs by action of lingual lipase.

Protein

- Initiates protein digestion.
- By action of pepsin.
- Stomach digests 10-20% of consumed proteins transforming them into polypeptides, peptones.

ABSORPTION IN THE STOMACH

- 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

REFERENCES

- Sherwood. Human Physiology: From cells to Systems, 7th ed.
- Guyton & Hall Textbook of Medical Physiology. 13th ed.
- Linda Costanzo. Physiology 4th ed.

Thank you