AL-Mustaqbal University College
Department of Pharmacy
Physiology 2nd stage

GIT Physiology Lec 3
Secretory Functions

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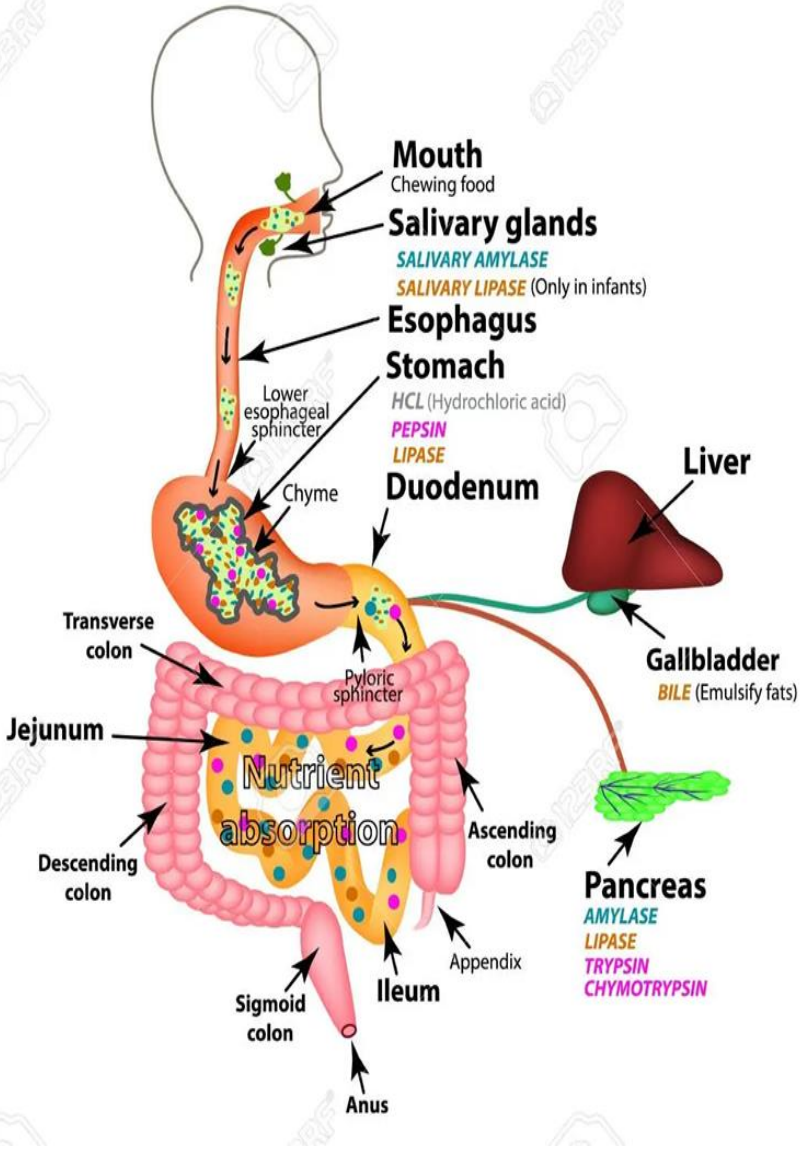
Outline

- General Principles
- Secretion of Saliva
- Gastric Secretion
- Pancreatic Secretion
- Secretion of Bile by the Liver
- Secretions of the Small Intestine



Overview of secretion

Secretory glands sub serve 2 primary functions:

1-Digestive enzymes are secreted in most areas of the alimentary tract, from the mouth to the distal end of the ileum.,

2-Mucous glands located from the mouth to the anus provide mucus for **lubrication** and **protection** of **all** parts of the alimentary tract.

Most digestive secretions are formed in response to the presence of food in the alimentary tract, and the quantity and type of secretions in each segment of the tract is usually the amount needed for proper digestion.

Types of Alimentary Tract Glands

- ✓ **Mucous cell (goblet cells)** *secrets mucus* directly onto the epithelial surface to act as a lubricant that also protects the surfaces from excoriation and digestion.

- ✓ **Pits**,*(in small intestine called crypts of Lieberkühn) are deep and contain specialized secretory cell*
- ✓ **Oxyntic gland** *are large numbers of deep tubular glands in the stomach and upper duodenum*

- ✓ **Complex glands—the salivary glands, pancreas, and liver** (*composed from acinous gland + duct outside the GIT wall)*

BASIC MECHANISMS OF STIMULATION OF THE ALIMENTARY TRACT GLANDS

- **Contact of Food with the Epithelium Stimulates Secretion—Function of Enteric Nervous Stimuli**

The types of stimuli that activate this system are

(1) tactile stimulation,(2) chemical irritation(3) distention of the gut wall.

The resulting nervous reflexes stimulate both the mucous cells on the gut epithelial surface and the deep glands in the gut wall to increase their secretion.

- **Autonomic Stimulation of Secretion Parasympathetic Stimulation the GIT Glandular Secretion Rate**
- **Sympathetic Stimulation Has a Dual Effect on GIT Glandular Secretion Rate**
- **Regulation of Glandular Secretion by Hormones(synthesis –storage – stimuli -calcium–exocytosis)**

Secretion

Table 65-1 Daily Secretion of Intestinal Juices

Type of Secretion	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	

SECRETION OF SALIVA

Saliva Contains a <u>Serous Secretion and a Mucus Secretion</u>.

The principal glands of salivation are the *parotid, submandibular,* and *sublingual glands;* in addition, there are many tiny *buccal* glands.

Daily secretion of saliva normally ranges (0.8 and 1.5L.) as shown by the average value of 1 L

- Saliva contains two major types of protein secretion:
- (1) **a *serous secretion*** that contains *ptyalin* (an *α-amylase*), which is an enzyme for digesting starches, and

(2) ***mucus secretion*** **that contains *mucin* for lubricating and for surface protective purposes**

SECRETION OF SALIVA and NERVOUS REGULATION

The parotid glands secrete almost entirely the **serous secretion,**

submandibular and sublingual glands secrete both **serous secretion and mucus.**

PH of saliva 6.0 and 7.0

1-controlled mainly by parasympathetic nervous signals all the way from the superior and inferior salivatory nuclei in the brain stem.

2-Higher centers of the central nervous system.

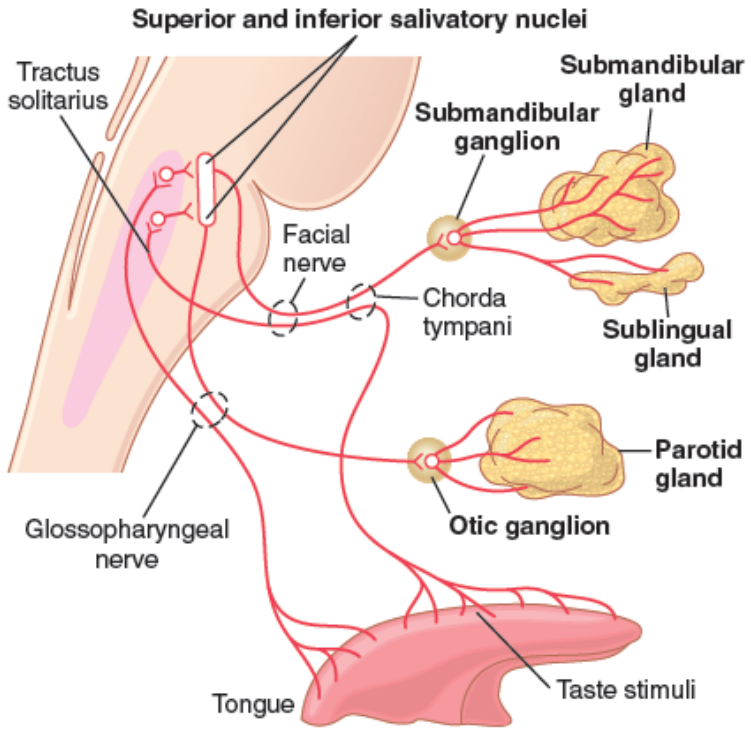


Figure 65-3. Parasympathetic nervous regulation of salivary secretion.

NERVOUS REGULATIONOF SALIVARY SECRETION

3-Reflexes originating in the stomach and upper small intestines—particularly when irritating foods are swallowed or when a person is nauseated

4-Sympathetic stimulation **can also increase salivation a slight amount**

5-secondary factor that also affects salivary secretion is the *blood supply to the glands* because secretion always requires adequate nutrients from the blood

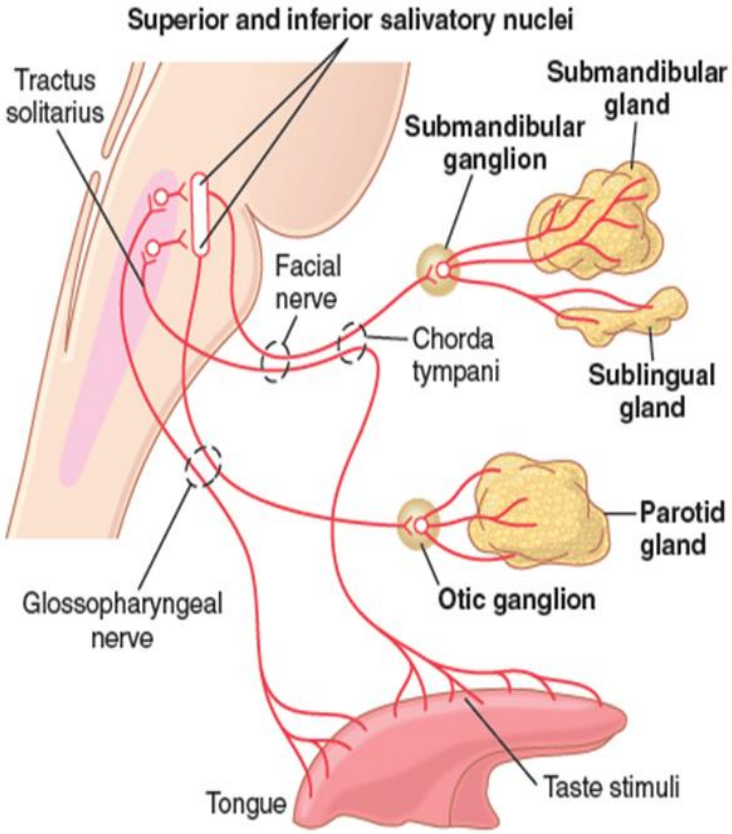


Figure 65-3. Parasympathetic nervous regulation of salivary secretion.

Saliva production is decreased (via inhibition of the parasympathetic nervous system) by sleep, dehydration, fear, and anticholinergic drugs (such as atropine).

SECRETION OF SALIVA

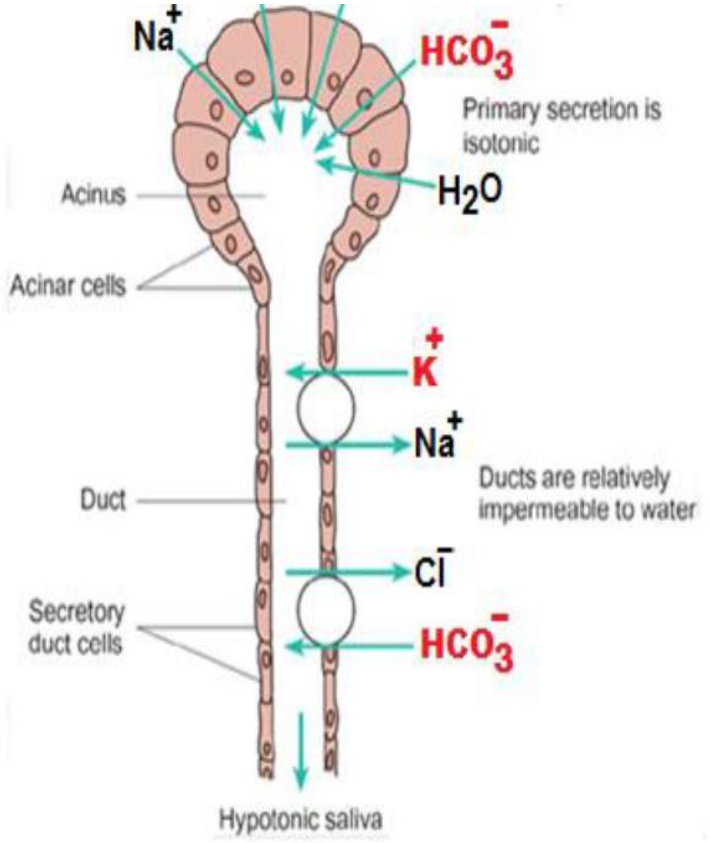


Figure 5.4: Secretion of saliva and electrolytes.

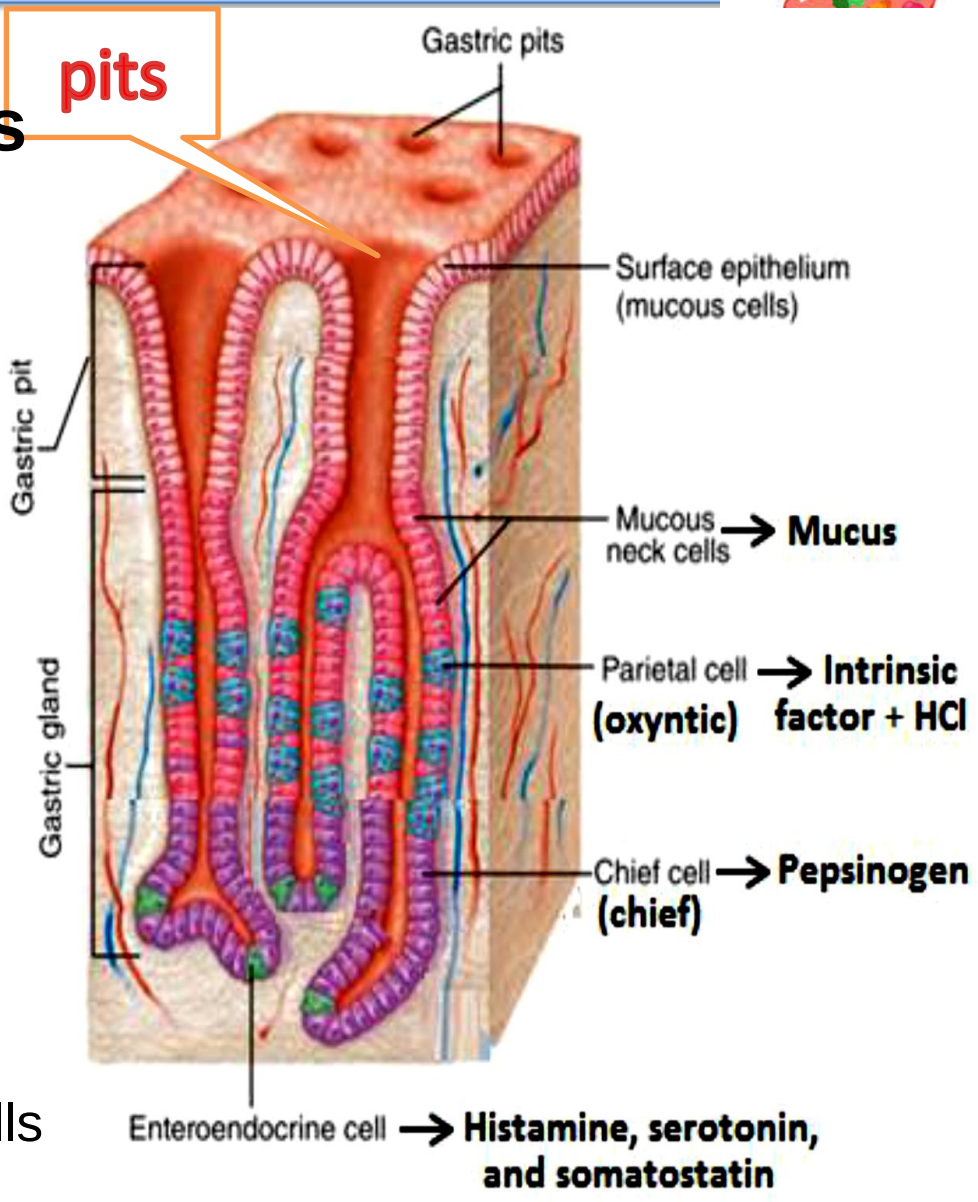
Functions of saliva:

- **[A] Protection of the mouth** by:
- Cooling hot foods, By maintaining healthy oral tissues. The mouth is loaded with pathogenic bacteria that can easily destroy tissues and can also cause dental caries. However, saliva helps prevent the harmful effects of bacteria by:
- □ Continuous washing away the pathogenic bacteria as well as the food particles that provide the bacteria with metabolic support.
- □ Saliva contains many factors that can kill bacteria such as thiocyanate ions, proteolytic enzymes, and
- antibodies (IgA).
- **[B] Digestion** of starch by α-amylase (which is ultimately inactivated by the low pH of the stomach), and fat by lingual lipase.
- **[C] Lubrication of food** and making swallowing easier, and **moisten** the mouth, facilitating speech. It also **neutralizes** any gastric acid that refluxes from stomach into the lower esophagus (heartburn).

GASTRIC SECRETION (Stomach)

Secretions from the Oxyntic(Gastric) Glands

A typical stomach oxyntic gland is composed of three types of cells: (1) ***mucous neck cells,*** **which secrete mainly *mucus;*** (2) ***peptic*** **(or *chief*) cells, which secrete large quantities of *pepsinogen;*** **and (3) *parietal*** **(or *oxyntic*) *cells*, which secrete *hydrochloric acid*** **and *intrinsic factor*.** Secretion of hydrochloric acid by the parietal cells involves special mechanisms



Basic Mechanism of HCL Secretion

When stimulated, the parietal cells secrete an acid solution that contains about 160 mmol/L of hydrochloric acid, which is nearly isotonic with the body fluids. The pH Of this acid is about **0.8,** demonstrating its **extreme acidity**.

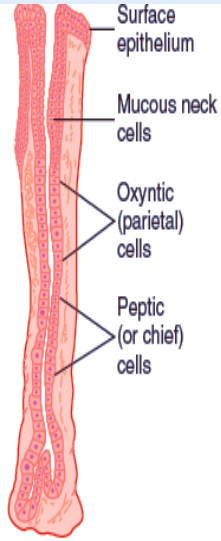


Figure 65-4. Oxyntic gland from the body of the stomach.

❖ **The Basic Factors That Stimulate Gastric Secretion Are Acetylcholine, Gastrin, and Histamine.**

Acetylcholine released by parasympathetic stimulation excites secretion of pepsinogen by peptic cells, hydrochloric acid by parietal cells, and mucus by mucous cells. In comparison, both gastrin and histamine strongly stimulate secretion of acid by parietal cells but have little effect on the other cells

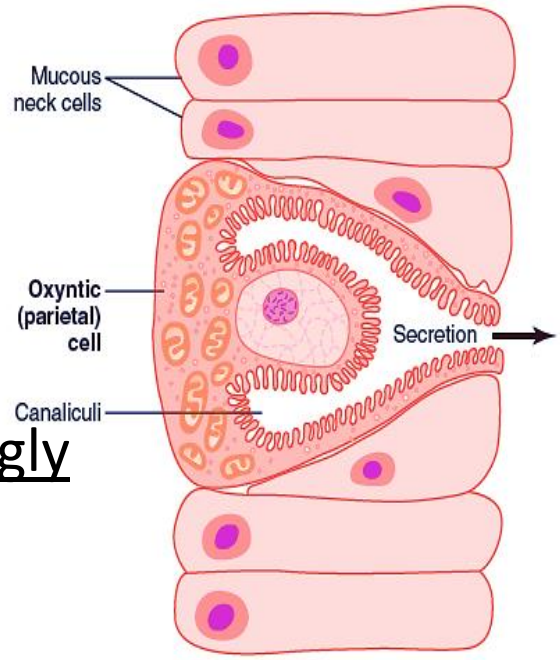


Figure 65-5. Schematic anatomy of the canaliculi in a parietal (oxyntic) cell.

The functions of HCl

[1] **It participates in the breakdown of protein**: The high acidity of the chyme alters the protein molecules, thereby changing protein structure so as to break up connective tissue and cells in the ingested food.

[2] It hinders the growth of pathogenic bacteria:

[3] **It activates pepsinogens and provides an optimal pH for the action of pepsin**

- Breaks of mucosal barrier and exposure of the mucosal surface to damage occurs due to highly concentrated HCl, 10% ethanol, salicylic acid, or acetylsalicylic acid (aspirin). The damaged mucosa liberates histamine
- Erosive gastritis can occur as a result of chronic use of non-steroidal anti-inflammatory drugs (NSAIDs).

Secretion and Activation of Pepsinogen and Intrinsic Factor

pepsinogen
is first secreted, it has no digestive activity.

activated to form active *pepsin*

HCl

Secretion of Intrinsic Factor for B12 by Parietal Cells

PYLORIC GLANDS—SECRETION OF MUCUS AND GASTRIN

- **Pepsin functions** as an active proteolytic enzyme in a highly acidic medium (optimum pH 1.8 to 3.5)
- **Intrinsic Factor** essential for absorption of vitamin B_{12} in the ileum, is secreted by the *parietal cells* along with the secretion of hydrochloric acid
- *achlorhydria (lack of stomach acid secretion)*
- *pernicious anemia*

SURFACE MUCOUS CELLS

The entire surface of the stomach mucosa between glands has a continuous layer of a special type of mucous cells called simply "**surface mucous cells**."

They secrete large quantities of viscid mucus that coats the stomach mucosa

Even the slightest contact with food or any irritation of the mucosa directly stimulates the surface mucous cells to secrete additional quantities of this thick,

alkaline, viscid mucus.

gel layer of mucus
1 mm
alkaline.

- ✓ **providing a major shell of protection for the**

stomach wall, as well as contributing to lubrication of

food transport

- ✓ **stomach wall is not directly exposed to the highly acidic, proteolytic stomach**

secretion.

Gastrin

*****

- **Gastrin, main gastrointestinal hormone, is secreted by antral G cells and has the following effects:**

- **It stimulates the parietal cells to secret HCl.**
- **It stimulates the chief cells to secret pepsinogen.**
- **It stimulates the enterochromaffin-like cells (ECL cell, or enteroendorine cells) to release histamine.**
- **It enhances muscle contractions of pyloric pump (minor effect) and has a slight constrictor effect on the gastroesophageal sphincter.**
- **It stimulates contraction of intestinal muscle, relaxes ileocecal valve, and sti movements.**

Stimulation of Acid Secretion by **Gastrin**

When meats or other **protein-containing foods reach the antral end** of the stomach, some of the proteins from these foods have a **stimulatory effect on the gastrin cells to cause release of gastrin into the digestive juices of the stomach**

Regulation of Pepsinogen Secretion

Regulation of pepsinogen secretion by the peptic cells in the oxyntic glands is much less complex than regulation of acid secretion; it occurs in response to two types of signals:

(1) **by acetylcholine released from the vagus nerves or from the gastric enteric nervous plexus, and**

(2) **stimulation of peptic cell secretion in response to acid in the stomach.**

Phases of gastric secretion:

- Cephalic phase
- Gastric phase
- Intestinal phase

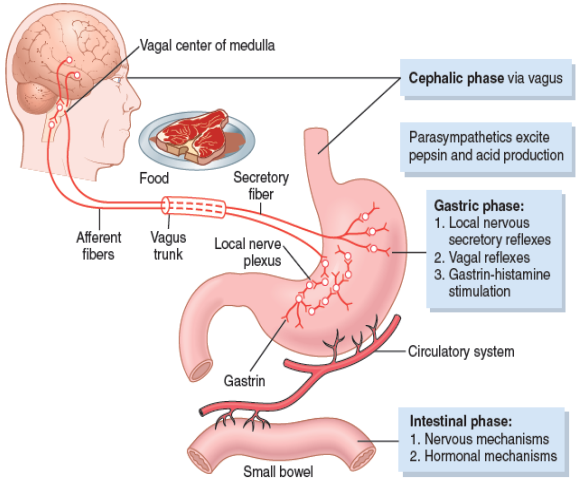


Figure 65-7. Phases of gastric secretion and their regulation.

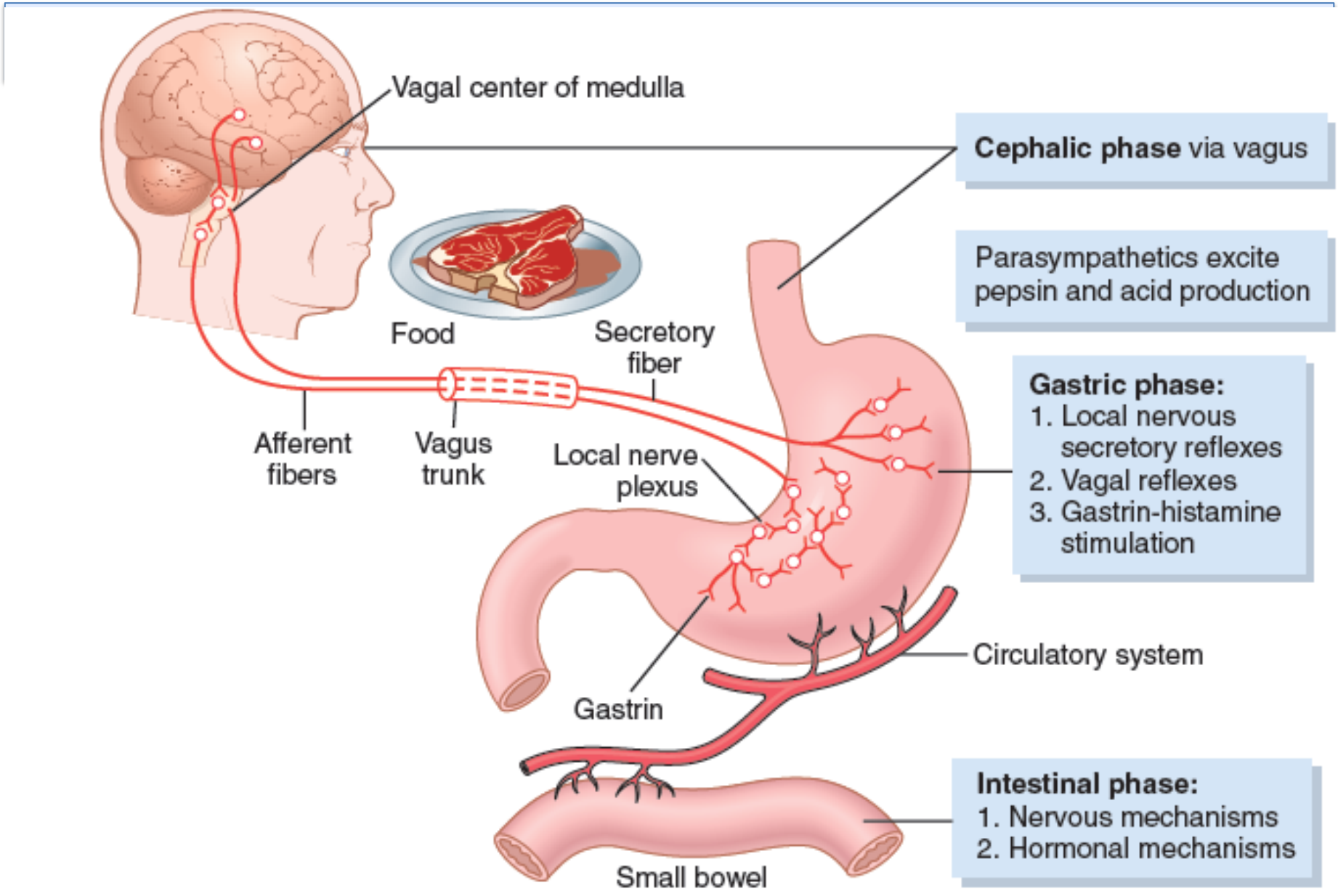


Figure 65-7. Phases of gastric secretion and their regulation.

Cephalic phase 20%

The phase of gastric secretion occurs even before food enters the stomach, especially while it is being eaten. It results from the **sight, smell, thought, or taste of food, and the greater the appetite**, the more intense is the stimulation. This phase of secretion normally accounts for about **20 per cent** of the gastric secretion associated with eating a meal.

Gastric phase 70%

Once food enters the stomach, it excites

(1) long vago-vagal reflexes from the stomach to the brain and back to the stomach,

(2) **local enteric reflexes**, and

(3) the **gastrin mechanism**,

all of which in turn cause secretion of gastric juice during several hours while food remains in the stomach. The gastric phase of secretion accounts for about **70 %**of the total gastric secretion associated with eating a meal and therefore accounts for most of the total daily gastric secretion of about 1500 milliliters

3-Intestinal Phase

- The presence of food in the upper portion of the small intestine, particularly in the **duodenum**, will continue to cause stomach secretion **of small amounts of gastric** juice, probably partly because of small amounts of gastrin released by the duodenal mucosa
- **Intestinal Factors**
- Although intestinal chyme slightly stimulates gastric secretion during the early intestinal phase of stomach secretion, it paradoxically **inhibits gastric secretion a**t other times.

Inhibition of Gastric Secretion by Post-Stomach

- This inhibition results from at least two influences.
- 1. The presence of food in the small intestine initiates a ***reverse enterogastric reflex***. This reflex can be initiated by distending the small bowel, by the presence of acid in the upper intestine, by the presence of protein breakdown products, or by irritation of the mucosa.
- 2. The presence of acid, fat, protein breakdown products, hyperosmotic or hypo-osmotic fluids, or any irritating factor in the upper small intestine causes release of **several intestinal hormones**. One of these is *secretin,* However, secretin opposes stomach secretion.

Pancreatic Secretion

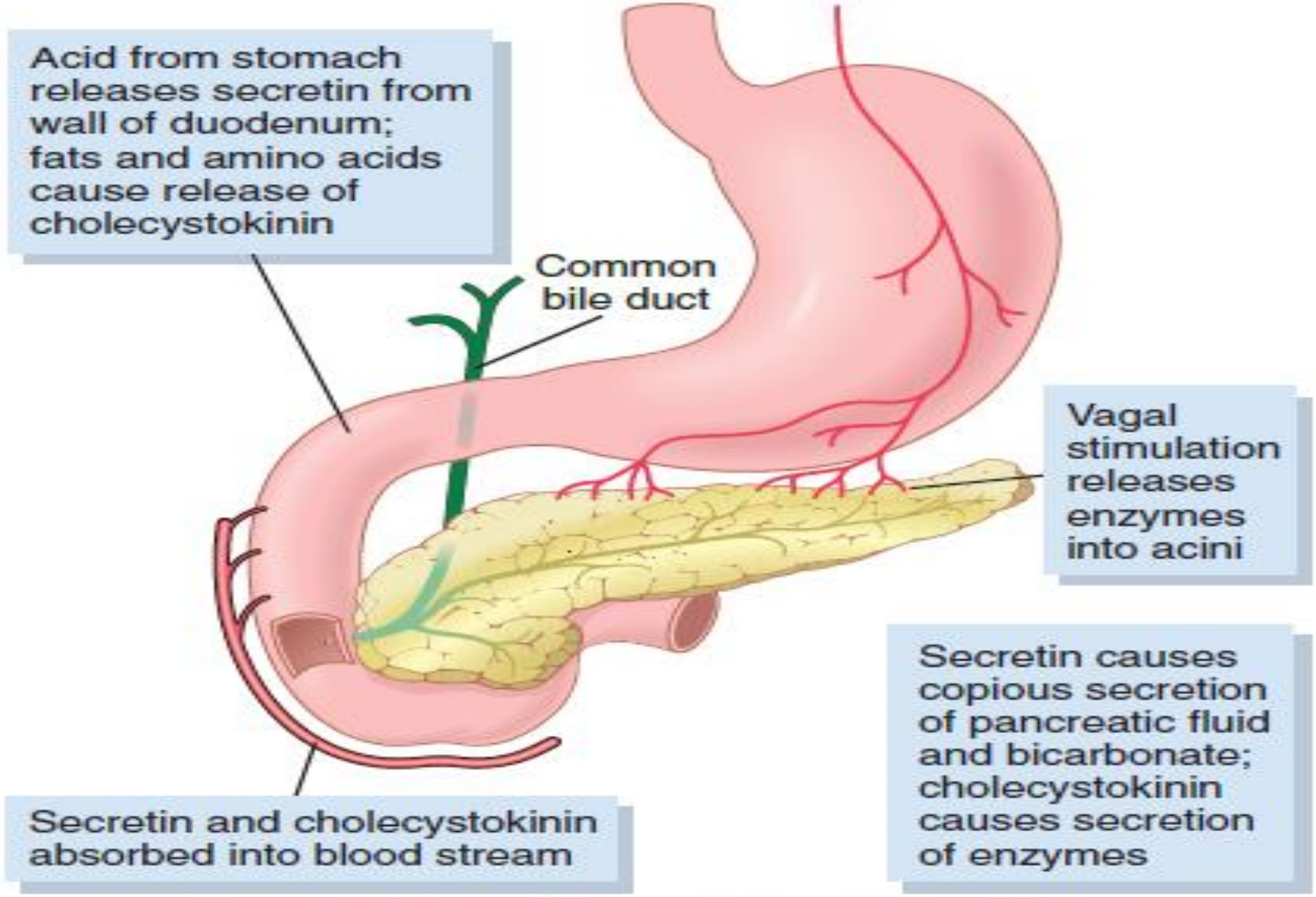


Figure 65-10. Regulation of pancreatic secretion.

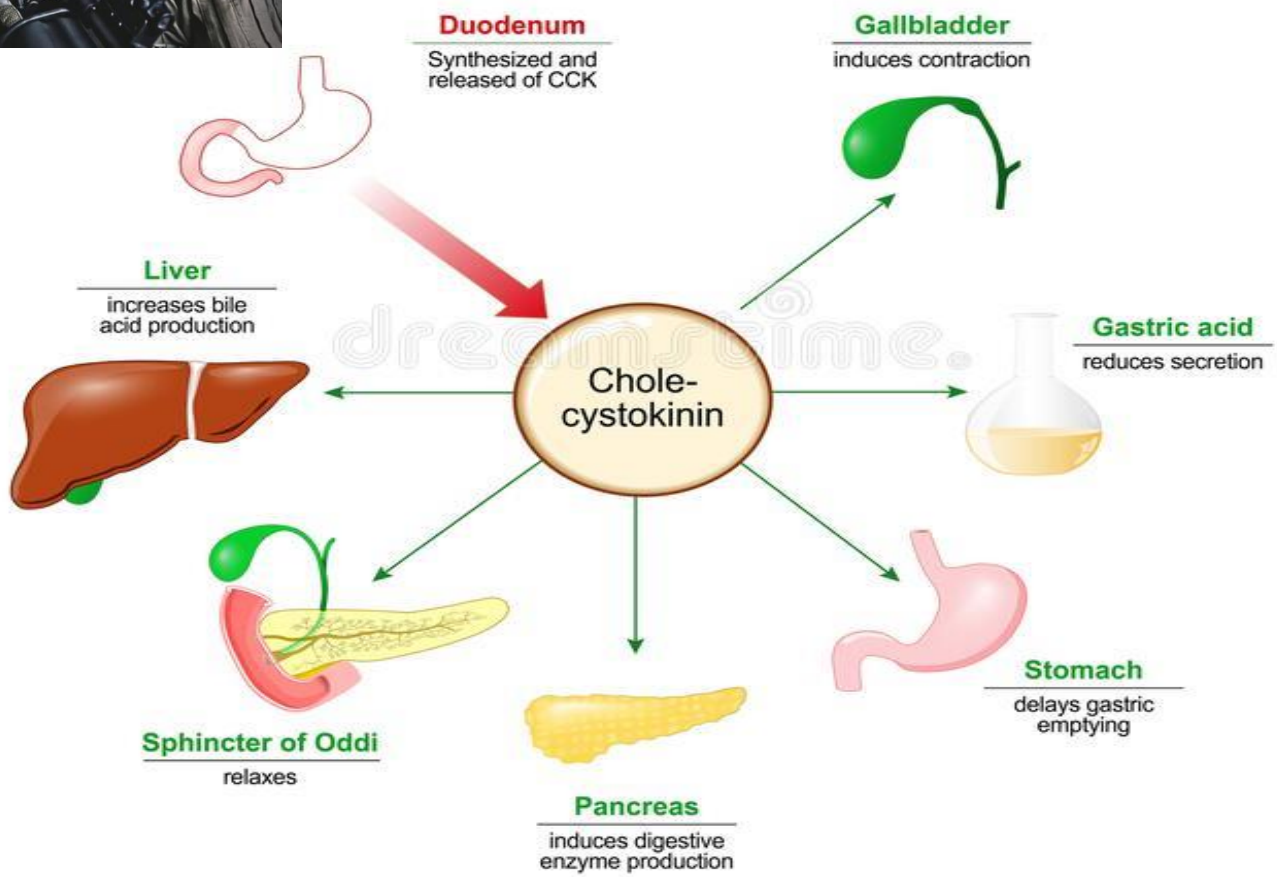
Regulation of Pancreatic Secretion

- **Basic Stimuli That Cause Pancreatic Secretion**
- Three basic stimuli are important in causing pancreatic secretion:
- 1. ***Acetylcholine.***
- ***2.Cholecystokinin,*** ~~golden~~
- **3. *Secretin*,**

production of large quantities of pancreatic digestive enzymes but relatively small quantities of water and electrolytes to go with the enzymes

stimulates secretion of large quantities of water solution of sodium bicarbonate by the pancreatic ductal epithelium.

Cholecystokinin



Pancreatic Digestive Enzymes

- Pancreatic secretion contains multiple enzymes for digesting all of the three major types of food: proteins, carbohydrates, and fats.

❖ It also contains large quantities of bicarbonate ions, which play an important role in neutralizing the acidity of the chyme emptied from the stomach into the duodenum.

❖ The most important of the pancreatic enzymes for digesting proteins are *trypsin*, *chymotrypsin*, and *carboxypolypeptidase* (***active enzyme***)

Pancreatic Digestive Enzymes

- **inactive** forms trypsinogen, chymotrypsinogen, and procarboxypolypeptidase, converted to active form ***by enzyme called enterokinase, from wall of small intestine***
- The pancreatic enzyme for digesting carbohydrates is ***pancreatic amylase***, which hydrolyzes starches, glycogen, and most other carbohydrates (except cellulose) to form mostly disaccharides and a few tri-saccharides.
- The main enzymes for fat digestion are (1) pancreatic lipase (2) cholesterol esterase (3) phospholipase.

Secretion of Bile by the Liver; Functions of the Biliary Tree

One of the many functions of the liver is to secrete *bile*, **600 and 1000 ml/day**. **Bile functions:**

- **1-bile plays an important role in fat digestion and absorption**, not because of any enzymes in the bile that cause fat digestion, but because *bile acids* in the bile do two things:
- (1) **They help to emulsify the large fat particles of** the food into many minute particles, the surface of which can then be attacked by **lipase enzymes** secreted in pancreatic juice.
- (2) **absorption of the digested fat end products**

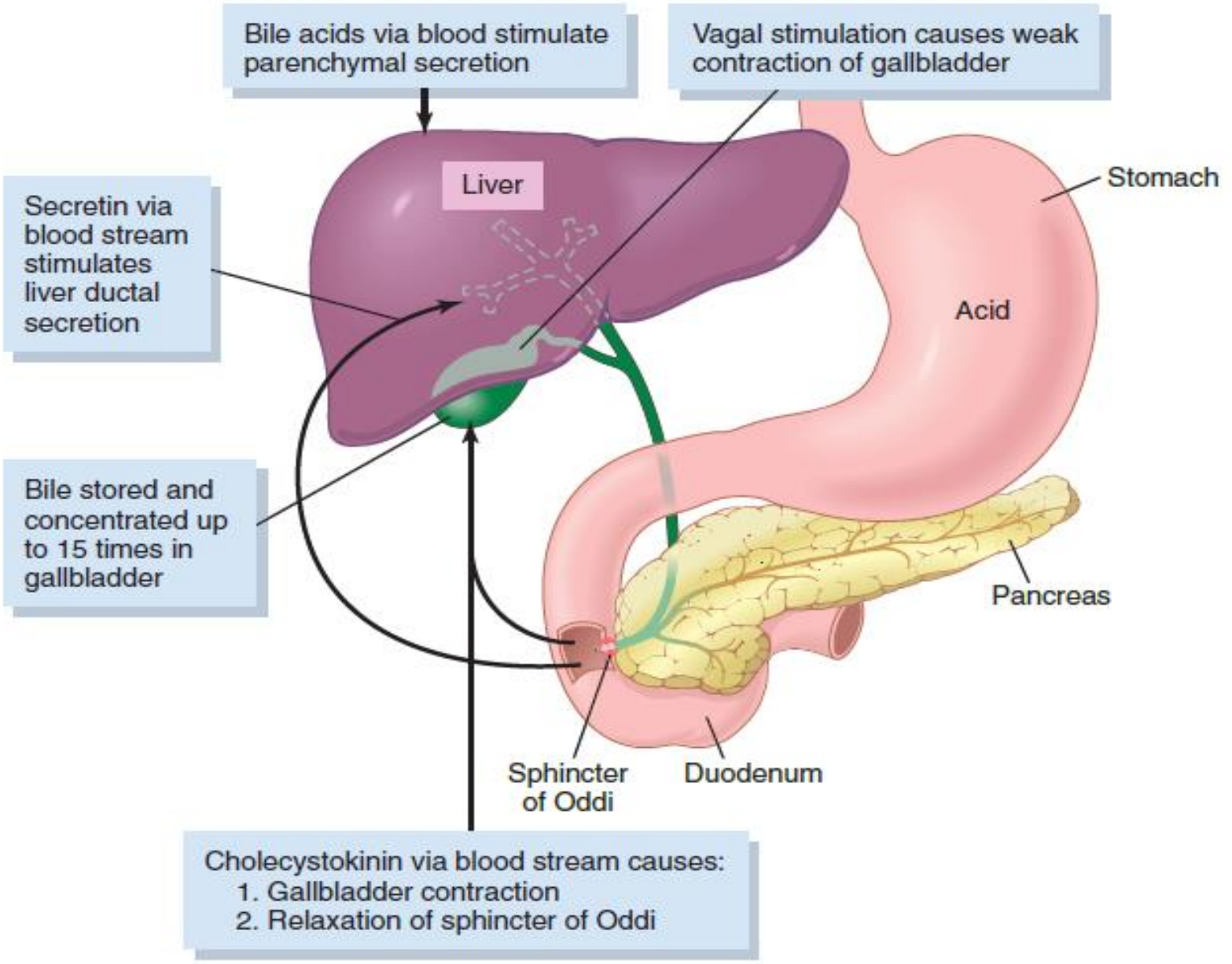
Functions of the Bile

- **Second, bile serves as a means for excretion of several important waste products from the blood. (*bilirubin*,, and excesses of *cholesterol*.,…..)**
- **Physiologic Anatomy of Biliary Secretion**

1. **Hepatocyte secreted into minute bile canaliculi**
2. **bile flows in the canaliculi toward the interlobular septa, where the canaliculi empty into terminal bile ducts**

hepatic duct and *common bile duct*

bile either empties directly into the duodenum or is diverted for minutes up to several hours through the *cystic duct* into the *gallbladder*

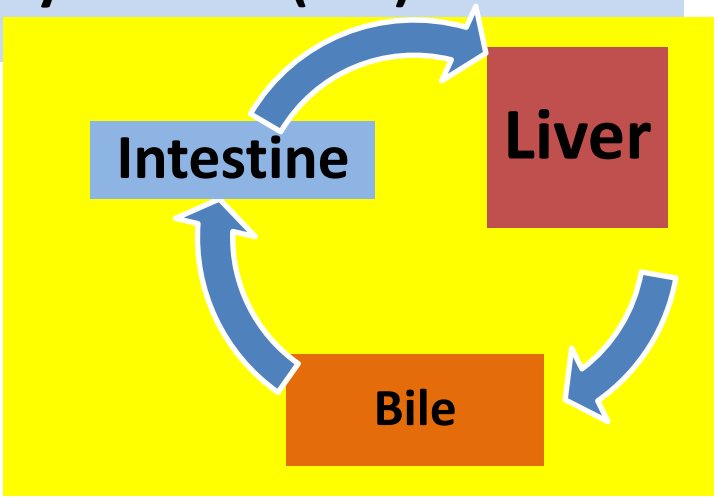

Bile acids via blood stimulate parenchymal secretion
Vagal stimulation causes weak contraction of gallbladder
Liver
Stomach
Secretin via blood stream stimulates liver ductal secretion
Acid
Bile stored and concentrated up to 15 times in gallbladder
Pancreas
Sphincter of Oddi
Duodenum
Cholecystokinin via blood stream causes:
1. Gallbladder contraction
2. Relaxation of sphincter of Oddi

Composition of Bile.

- **most abundant substances secreted in the bile are *bile salts*, which account for**
- **. Also secreted or excreted in large concentrations are *bilirubin*, *cholesterol*, *lecithin*, and the usual *electrolytes* of plasma.**
- **<u>Emptying of the Gallbladder—Stimulatory Role of Cholecystokinin.</u>**
- When food begins to be digested in the upper gastrointestinal tract, the gallbladder begins to empty,
- especially when **fatty foods** reach the duodenum about 30 minutes after a meal.
- The mechanism of **gallbladder emptying is rhythmical** contractions of the wall of the gallbladder, but effective emptying also requires simultaneous **relaxation of the *sphincter of Oddi***, which guards the exit of the common bile duct into the duodenum.

Enterohepatic Circulation of Bile Salts.

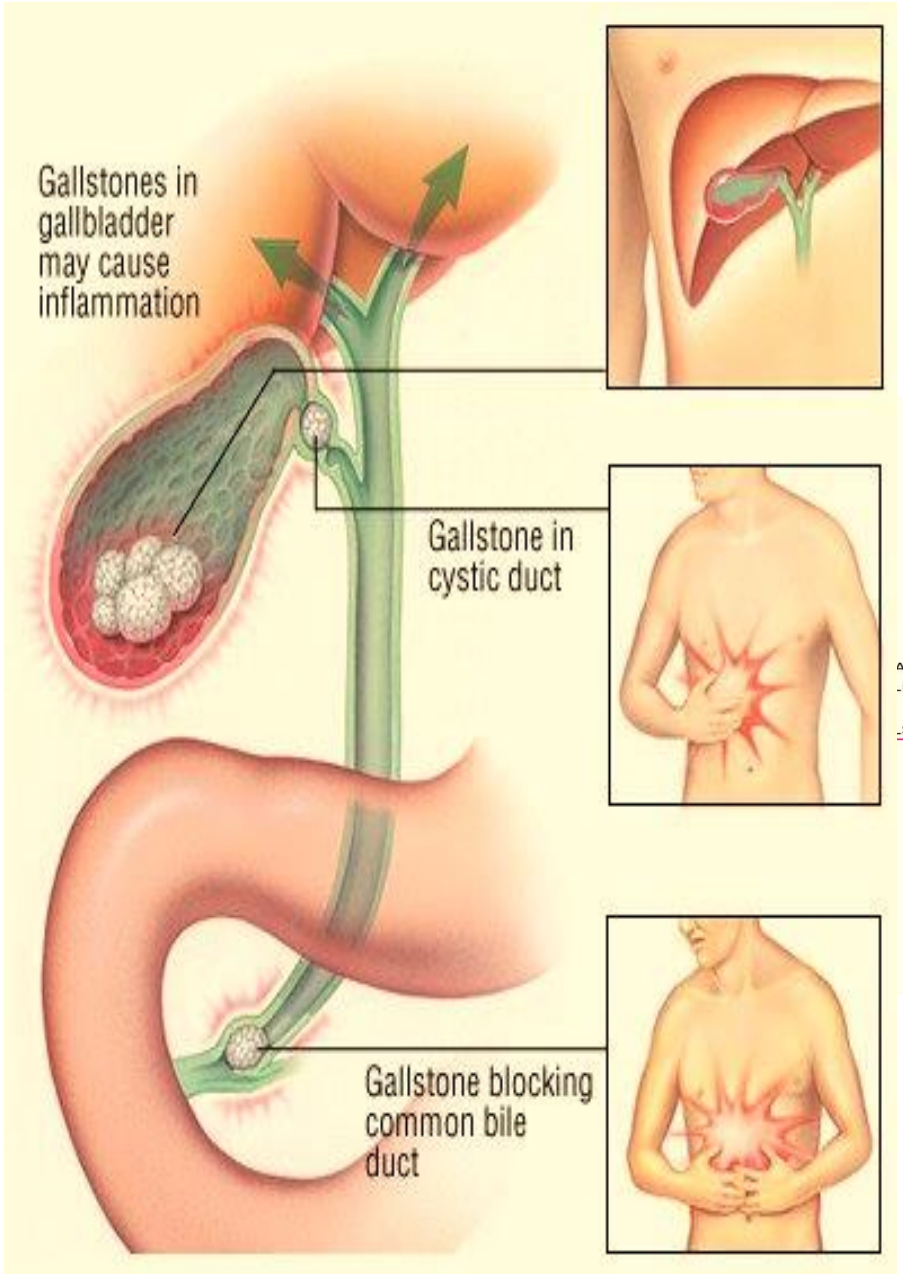
- **the most potent stimulus for causing the gallbladder contractions is the hormone** cholecystokinin (cck)

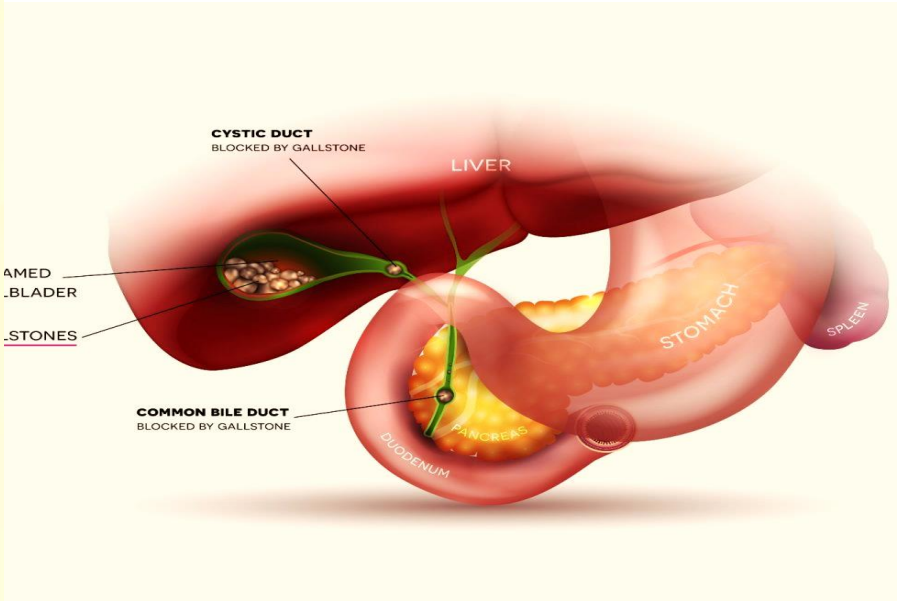


- About 94 per cent of the bile salts are reabsorbed into the blood from the small intestine, about one half of this by ***diffusion*** through the mucosa in the early portions of the small intestine and the remainder by an ***active transport*** process through the intestinal mucosa in the distal ileum

Secretions of the Small Intestine

- **Secretion of Mucus by Brunner's Glands in the Duodenum**
- **Brunner's Glands** secrete large amounts of **alkaline mucus** in response to
- (1) tactile or irritating stimuli on the duodenal mucosa
- (2) vagal stimulation, which causes increased Brunner's glands secretion concurrently with increase in stomach secretion; and (3)
- gastrointestinal hormones, especially *secretin*.
- **Protection function**


Gallstones in gallbladder may cause inflammation
Gallstone in cystic duct
Gallstone blocking common bile duct


CYSTIC DUCT
BLOCKED BY GALLSTONE
LIVER
AMED
BLADER
STONES
STOMACH
SPLEEN
COMMON BILE DUCT
BLOCKED BY GALLSTONE
PANCREAS
DUODENUM