

Stomach

FUNCTIONAL ANATOMY OF STOMACH

Stomach is a hollow organ situated just below the diaphragm on the left side in the abdominal cavity. Volume of empty stomach is 50 mL. Under normal conditions, it can expand to accommodate 1 L to 1.5 L of solids and liquids. However, it is capable of expanding still further up to 4 L.

PARTS OF STOMACH

In humans, stomach has four parts:

1. Cardiac region
2. Fundus
3. Body or corpus
4. Pyloric region.

1. Cardiac Region

Cardiac region is the upper part of the stomach where esophagus opens. The opening is guarded by a sphincter called cardiac sphincter, which opens only towards stomach. This portion is also known as cardiac end.

2. Fundus

Fundus is a small domeshaped structure. It is elevated above the level of esophageal opening.

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3. Body or Corpus

Body is the largest part of stomach forming about 75% to 80% of the whole stomach. It extends from just below the fundus up to the pyloric region (Fig. 38.1).

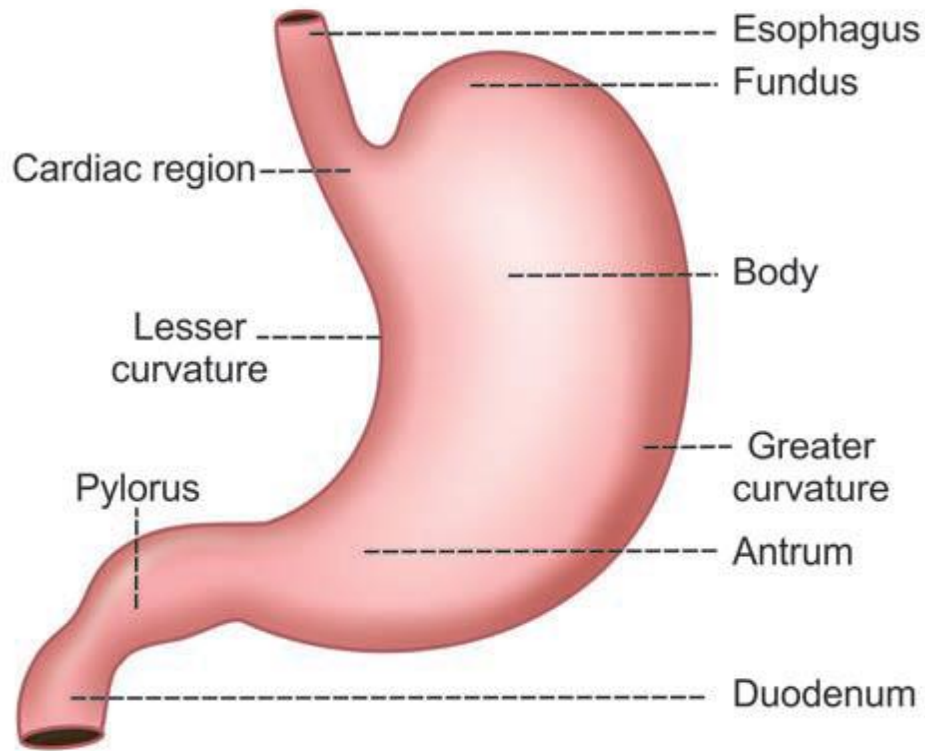


FIGURE 38.1: Parts of stomach

4. Pyloric Region

Pyloric region has two parts, antrum and pyloric canal. The body of stomach ends in antrum. Junction between body and antrum is marked by an angular notch called incisura angularis.

Antrum is continued as the narrow canal, which is called pyloric canal or pyloric end. Pyloric canal opens into first part of small intestine called duodenum. The opening of pyloric canal is guarded by a sphincter called pyloric sphincter.

It opens towards duodenum. Stomach has two curvatures. One on the right side is lesser curvature and the other on left side is greater curvature.

„ **STRUCTURE OF STOMACH WALL**

Stomach wall is formed by four layers of structures:

1. Outer serous layer: Formed by peritoneum.
2. Muscular layer: Made up of three layers of smooth muscle fibers, namely inner oblique, middle circular and outer longitudinal layers.
3. Submucous layer: Formed by areolar tissue, blood vessels, lymph vessels and Meissner nerve plexus.
4. Inner mucus layer: Lined by mucus-secreting columnar epithelial cells. The gastric glands are situated in this layer. Under resting conditions, the mucosa of the stomach is thrown into many folds. These folds are called rugae. The rugae disappear when the stomach is distended after meals. Throughout the inner mucus layer, small depressions called gastric pits are present. Glands of the stomach open into these pits. Inner surface of mucus layer is covered by 2 mm thick mucus.

GLANDS OF STOMACH –GASTRIC GLANDS

Glands of the stomach or gastric glands are tubular structures made up of different types of cells. These glands open into the stomach cavity via gastric pits.

„ **CLASSIFICATION OF GLANDS OF THE STOMACH**

Gastric glands are classified into three types, on the basis of their location in the stomach:

1. Fundic glands or main gastric glands or oxyntic glands: Situated in body and fundus of stomach
2. Pyloric glands: Present in the pyloric part of the stomach

3. Cardiac glands: Located in the cardiac region of the stomach.

STRUCTURE OF GASTRIC GLANDS

1. Fundic Glands

Fundic glands are considered as the typical gastric glands (Fig. 38.2). These glands are long and tubular. Each gland has three parts, viz. body, neck and isthmus.

Cells of fundic glands

1. Chief cells or pepsinogen cells
2. Parietal cells or oxyntic cells
3. Mucus neck cells
4. Enterochromaffin (EC) cells or Kulchitsky cells
5. Enterochromaffinlike (ECL) cells.

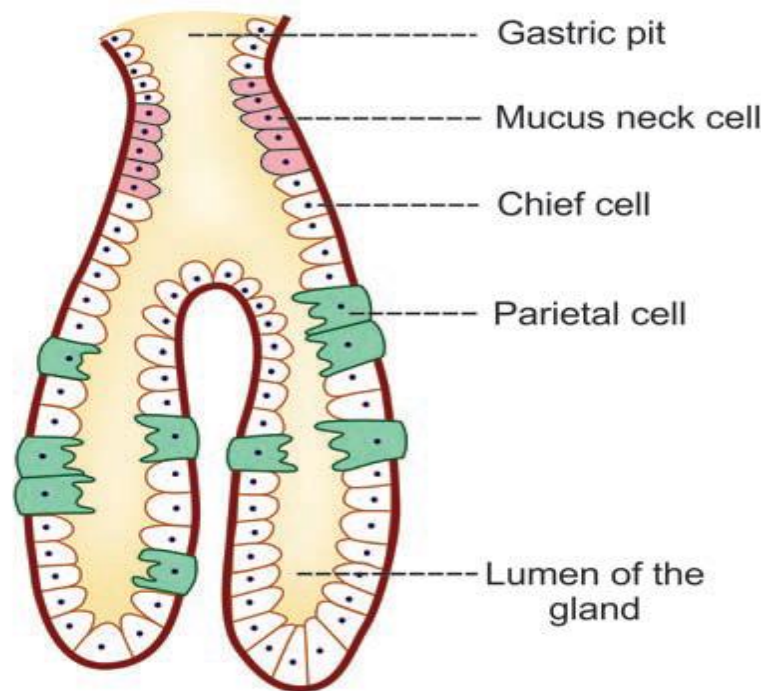


FIGURE 38.2: Gastric glands

Parietal cells are different from other cells of the gland because of the presence of canaliculi (singular= canaliculus). Parietal cells empty their

secretions into the lumen of the gland through the canaliculi. But, other cells empty their secretions directly into lumen of the gland.

2. Pyloric Glands

Pyloric glands are short and tortuous in nature. These glands are formed by G cells, mucus cells, EC cells and ECL cells.

3. Cardiac Glands

Cardiac glands are also short and tortuous in structure, with many mucus cells. EC cells, ECL cells and chief cells are also present in the cardiac glands.

Enteroendocrine Cells

Enteroendocrine cells are the hormone-secreting cells present in the glands or mucosa of gastrointestinal tract, particularly stomach and intestine. The enteroendocrine cells present in gastric glands are G cells, EC cells and ECL cells (Table 38.1).

„ FUNCTIONS OF GASTRIC GLANDS

Function of the gastric gland is to secrete gastric juice. Secretory activities of different cells of gastric glands and enteroendocrine cells are listed in Table 38.1.

„ FUNCTIONS OF STOMACH

„ 1. MECHANICAL FUNCTION

i. Storage Function

Food is stored in the stomach for a long period, i.e. for 3 to 4 hours and emptied into the intestine slowly. The maximum capacity of stomach is up to 1.5 L. Slow emptying of stomach provides enough time for proper digestion and absorption of food substances in the small intestine.

ii. Formation of Chyme

Peristaltic movements of stomach mix the bolus with gastric juice and convert it into the semisolid material known as chyme.

„ **2. DIGESTIVE FUNCTION**

Refer functions of gastric juice.

„ **3. PROTECTIVE FUNCTION**

Refer functions of gastric juice.

TABLE 38.1: Secretory function of cells in gastric glands

Cell	secretory products
Chief cells	Pepsinogen Rennin Lipase Gelatinase Urase
Parietal cells	Hydrochloric acid Intrinsic factor of Castle
Mucus neck cells	Mucin
G cells	Gastrin
Enterochromaffin (EC) cells	Serotonin
Enterochromaffin-like (ECL) cells	Histamine

4. HEMOPOIETIC FUNCTION

Refer functions of gastric juice.

5. EXCRETORY FUNCTION

Many substances like toxins, alkaloids and metals are excreted through gastric juice.

„ **PROPERTIES AND COMPOSITION OF GASTRIC JUICE**

Gastric juice is a mixture of secretions from different gastric glands.

▮ PROPERTIES OF GASTRIC JUICE

Volume : 1200 mL/day to 1500 mL/day.

Reaction : Gastric juice is highly acidic with a pH of 0.9 to 1.2. Acidity of gastric juice is due to the presence of hydrochloric acid.

Specific gravity : 1.002 to 1.004

„ COMPOSITION OF GASTRIC JUICE

Gastric juice contains 99.5% of water and 0.5% solids. Solids are organic and inorganic substances. Refer Fig.38.3 for composition of gastric juice.

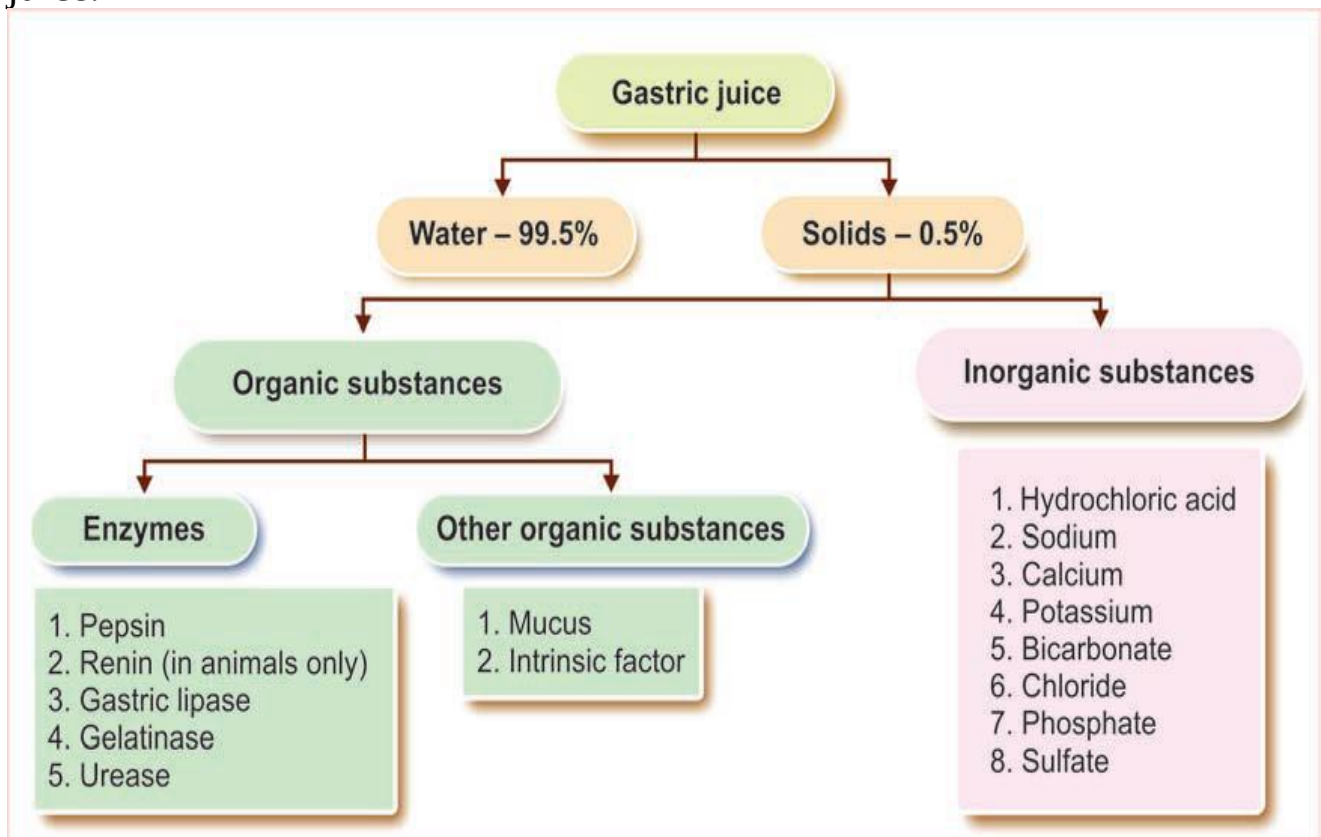


FIGURE 38.3: Composition of gastric juice

„ FUNCTIONS OF GASTRIC JUICE

„ 1. DIGESTIVE FUNCTION

Gastric juice acts mainly on proteins. Proteolytic enzymes of the gastric juice are pepsin and rennin (Table 38.2). Gastric juice also contains some other enzymes like gastric lipase, gelatinase, urase and gastric amylase.

Enzyme	Activator	Substrate	End products
Pepsin	Hydrochloric acid	Proteins	Proteoses, peptones and polypeptides
Gastric lipase	Acid medium	Triglycerides of butter	Fatty acids and glycerols
Gastric amylase	Acid medium	Starch	Dextrin and maltose (negligible action)
Gelatinase	Acid medium	Gelatin and collagen of meat	Peptides
Urase	Acid medium	Urea	Ammonia

TABLE 38.2: Digestive enzymes of gastric juice

Pepsin

Pepsin is secreted as inactive pepsinogen. Pepsinogen is converted into pepsin by hydrochloric acid. Optimum pH for activation of pepsinogen is below 6.

Action of pepsin

Pepsin converts proteins into proteoses, peptones and polypeptides. Pepsin also causes curdling and digestion of milk (casein).

Gastric Lipase

Gastric lipase is a weak lipolytic enzyme when compared to pancreatic lipase. It is active only when the pH is between 4 and 5 and becomes inactive at a pH below 2.5. Gastric lipase is a tributyrase and it hydrolyzes

tributyrin (butter fat) into fatty acids and glycerols.

Actions of Other Enzymes of Gastric Juice

- i. Gelatinase: Degrades type I and type V gelatin and type IV and V collagen (which are proteoglycans in meat) into peptides.
- ii. Urase: Acts on urea and produces ammonia
- iii. Gastric amylase: Degrades starch (but its action is insignificant)
- iv. Rennin: Curdles milk (present in animals only).

2. HEMOPOIETIC FUNCTION

Intrinsic factor of Castle, secreted by parietal cells of gastric glands plays an important role in erythropoiesis. It is necessary for the absorption of vitamin B12 (which is called extrinsic factor) from GI tract into the blood. Vitamin B12 is an important maturation factor during erythropoiesis. Absence of intrinsic factor in gastric juice causes deficiency of vitamin B12, leading to pernicious anemia (Chapter 14).

„ PROTECTIVE FUNCTION –FUNCTION OF MUCUS

Mucus is a mucoprotein, secreted by mucus neck cells of the gastric glands and surface mucus cells in fundus, body and other parts of stomach. It protects the gastric wall by the following ways:

Mucus:

- i. Protects the stomach wall from irritation or mechanical injury, by virtue of its high viscosity.
- ii. Prevents the digestive action of pepsin on the wall of the stomach, particularly gastric mucosa.
- iii. Protects the gastric mucosa from hydrochloric acid of gastric juice because of its alkaline nature and its acid-combining power.

3. FUNCTIONS OF HYDROCHLORIC ACID

Hydrochloric acid is present in the gastric juice:

- i. Activates pepsinogen into pepsin.

- ii. Kills some of the bacteria entering the stomach along with food substances. This action is called bacteriolytic action.
- iii. Provides acid medium, which is necessary for the action of hormones.

„ SECRETION OF GASTRIC JUICE

SECRETION OF PEPSINOGEN

Pepsinogen is synthesized from amino acids in the ribosomes attached to endoplasmic reticulum in chief cells. Pepsinogen molecules are packed into zymogen granules by Golgi apparatus. When zymogen granule is secreted into stomach from chief cells, the granule is dissolved and pepsinogen is released into gastric juice. Pepsinogen is activated into pepsin by hydrochloric acid.

„ SECRETION OF HYDROCHLORIC ACID

According to Davenport theory, hydrochloric acid secretion is an active process that takes place in the canaliculi of parietal cells in gastric glands. The energy for this process is derived from oxidation of glucose. Carbon dioxide is derived from metabolic activities of parietal cell.

Some amount of carbon dioxide is obtained from blood also.

It combines with water to form carbonic acid in the presence of carbonic anhydrase. This enzyme is present in high concentration in parietal cells. Carbonic acid is the most unstable compound and immediately splits into hydrogen ion and bicarbonate ion. The hydrogen ion is actively pumped into the canaliculus of parietal cell.

Simultaneously, the chloride ion is also pumped into canaliculus actively. The chloride is derived from sodium chloride in the blood. Now, the hydrogen ion combines with chloride ion to form hydrochloric acid. To compensate the loss of chloride ion, the bicarbonate ion

from parietal cell enters the blood and combines with sodium to form sodium bicarbonate. Thus, the entire process is summarized as (Fig. 38.4):

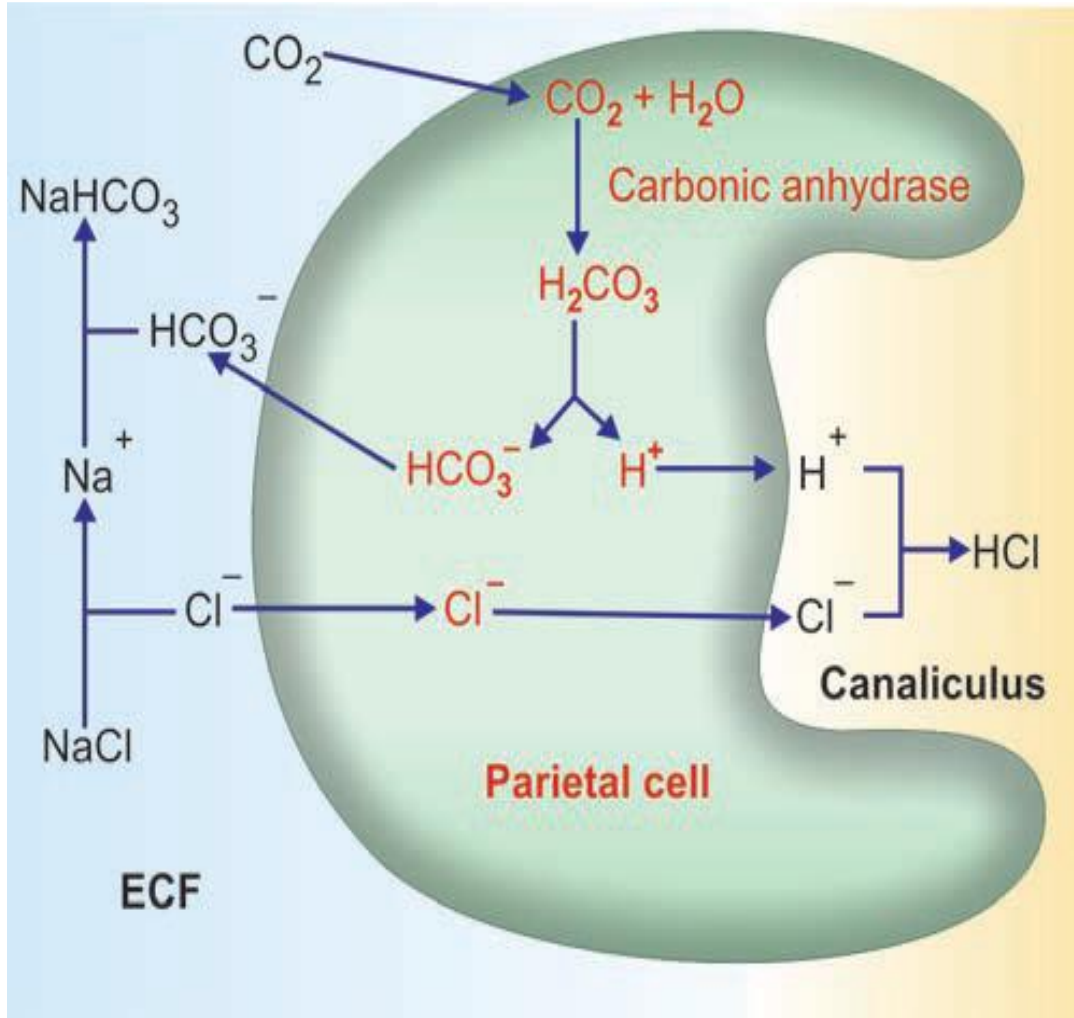
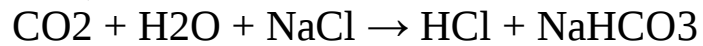


FIGURE 38.4: Secretion of hydrochloric acid in the parietal cell of gastric gland

Factors Stimulating the Secretion of Hydrochloric Acid

1. Gastrin
2. Histamine
3. Vagal stimulation.

Factors Inhibiting the Secretion of Hydrochloric Acid

1. Secretin
2. Gastric inhibitory polypeptide
3. Peptide YY.

„ REGULATION OF GASTRIC SECRETION

Regulation of gastric secretion and intestinal secretion is studied by some experimental procedures.

PHASES OF GASTRIC SECRETION

Secretion of gastric juice is a continuous process. But the quantity varies, depending upon time and stimulus.

Accordingly, gastric secretion occurs in three different phases:

- I. Cephalic phase
- II. Gastric phase
- III. Intestinal phase.

In human beings, a fourth phase called interdigestive phase exists. Each phase is regulated by neural mechanism or hormonal mechanism or both.

CEPHALIC PHASE

Secretion of gastric juice by the stimuli arising from head region (cephalus) is called cephalic phase (Fig.38.6). This phase of gastric secretion is regulated by nervous mechanism. The gastric juice secreted during this phase is called appetite juice.

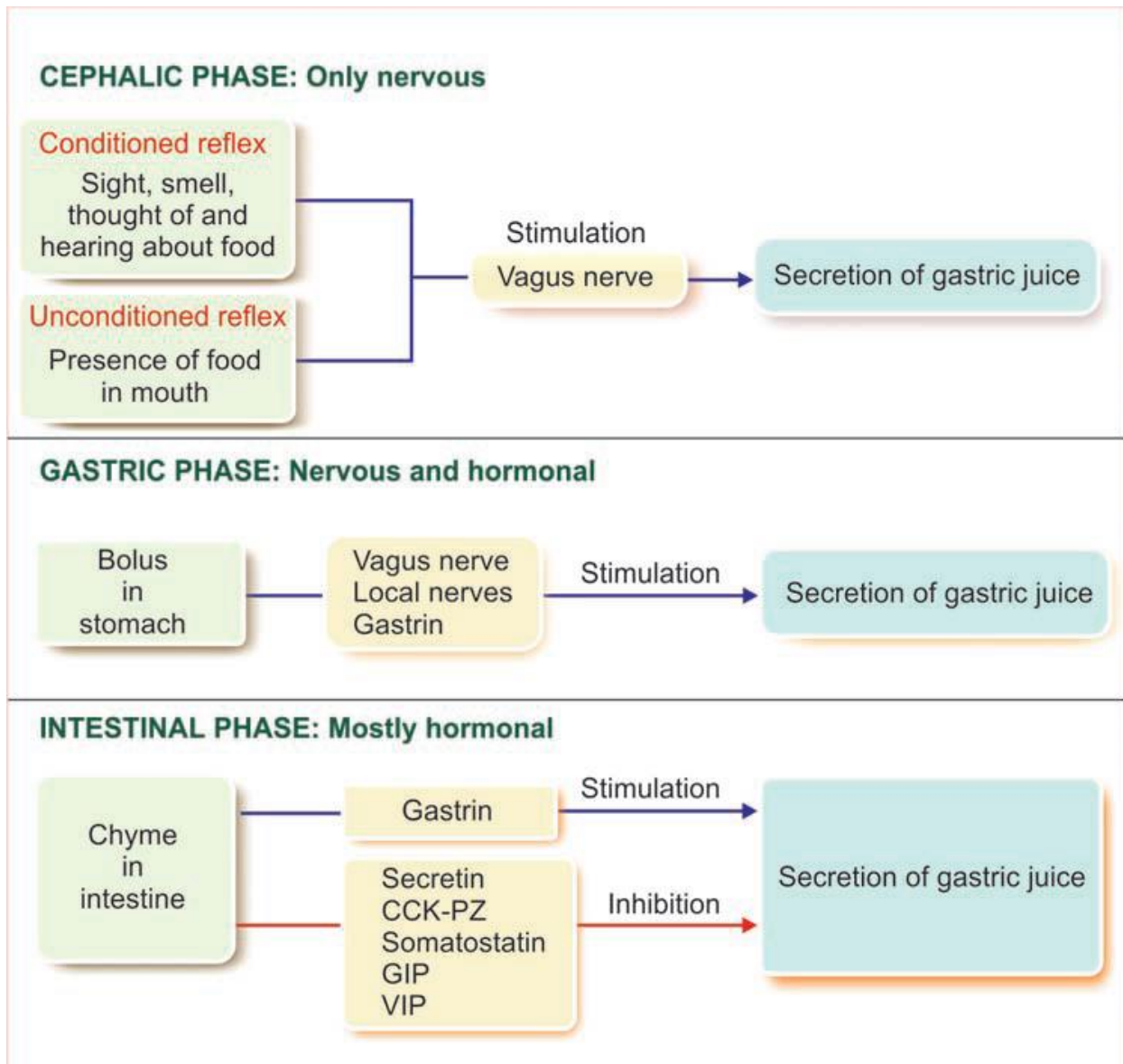


FIGURE 38.6: Schematic diagram showing the regulation of gastric secretion

CCKPZ= Cholecystokininpancreozymin, GIP = Gastric inhibitory peptide, VIP = Vasoactive intestinal peptide.

During this phase, gastric secretion occurs even without the presence of food in stomach. The quantity of the juice is less but it is rich in enzymes and hydrochloric acid. Nervous mechanism regulates cephalic phase through reflex action. Two types of reflexes occur:

1. Unconditioned reflex

2. Conditioned reflex.

1. Unconditioned Reflex

Stages of reflex action:

- i. Presence of food in the mouth stimulates the taste buds and other receptors in the mouth.
- ii. Sensory (afferent) impulses from mouth pass via afferent nerve fibers of glossopharyngeal and facial nerves to amygdala and appetite center present in hypothalamus.
- ii. From here, the efferent impulses pass through dorsal nucleus of vagus and vagal efferent nerve fibers to the wall of the stomach.
- iv. Vagal efferent nerve endings secrete acetylcholine, which stimulates gastric secretion.

2. Conditioned Reflex

Stages of reflex action:

- i. Impulses from the special sensory organs (eye, ear and nose) pass through afferent fibers of neural circuits to the cerebral cortex. Thinking of food stimulates the cerebral cortex directly.
- ii. From cerebral cortex, the impulses pass through dorsal nucleus of vagus and vagal efferents and reach the stomach wall.
- iii. Vagal nerve endings secrete acetylcholine, which stimulates the gastric secretion.

▮ GASTRIC PHASE

Secretion of gastric juice when food enters the stomach is called gastric phase. This phase is regulated by both nervous and hormonal control. Gastric juice secreted during this phase is rich in pepsinogen and hydrochloric acid.

Mechanisms involved in gastric phase are:

1. Nervous mechanism through local myenteric reflex and vagovagal reflex.
2. Hormonal mechanism through gastrin Stimuli, which initiate these two mechanisms are:
 1. Distention of stomach
 2. Mechanical stimulation of gastric mucosa by bulk of food
 3. Chemical stimulation of gastric mucosa by the food contents.

INTESTINAL PHASE

Intestinal phase is the secretion of gastric juice when chyme enters the intestine. When chyme enters the intestine, initially, the gastric secretion increases but later it stops. Intestinal phase of gastric secretion is regulated by nervous and hormonal control.

Initial Stage of Intestinal Phase

Chyme that enters the intestine stimulates the duodenal mucosa to release gastrin, which is transported to stomach by blood. There it increases gastric secretion.

Later Stage of Intestinal Phase

After the initial increase, there is a decrease or complete stoppage of gastric secretion. Gastric secretion is inhibited by two factors:

1. Enterogastric reflex
2. Gastrointestinal (GI) hormones.

FACTORS INFLUENCING GASTRIC SECRETION

Gastric secretion is also influenced by some factors which increase the gastric secretion by stimulating gastric mucosa such as:

1. Alcohol
2. Caffeine.