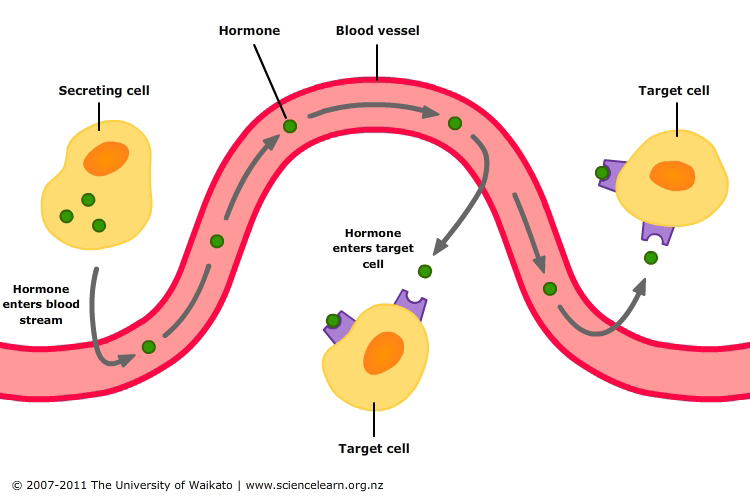
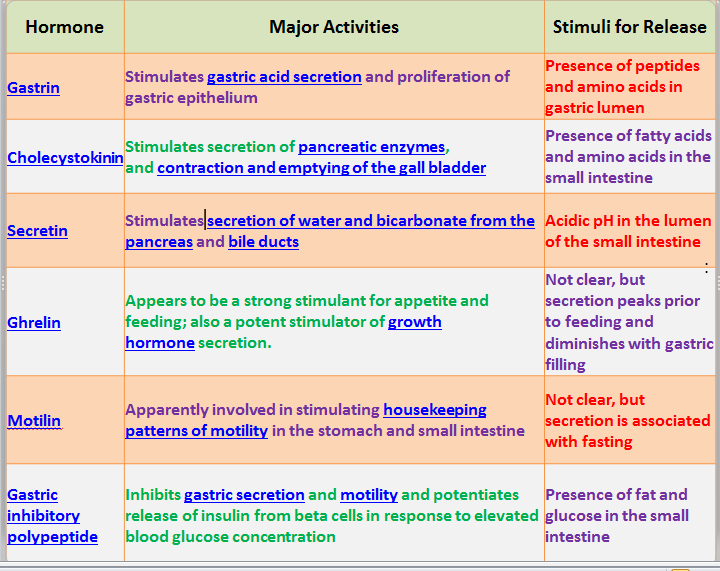
**Digestive Hormonal Functions**

The second of the two systems that control digestive function is the **endocrine system**, which regulates **function** by secreting hormones. Hormones are chemical messengers secreted into blood that modify the physiology of target cells. A target cell for a particular hormone is a cell that has receptors for that hormone and can thus respond to it. Digestive function is affected by hormones produced in many endocrine glands, but the most profound control is exerted by hormones produced within the gastrointestinal tract. The gastrointestinal tract is the largest endocrine organ in the body, releasing more than **20** different peptide hormones, some of which target the brain to regulate appetite and influence the pleasure of eating. Like all endocrine cells, cells in enteric endocrine system do not simply secrete their hormone continuously, which would not be very useful as a control system. Rather, they secrete hormones in response to fairly specific stimuli and stop secreting their hormone when those stimuli are no longer present. **Endocrinocytes** (endocrine cells) in the enteric endocrine system respond to **changes** in the environment within the lumen of the digestive tube, because these cells are part of the epithelium, their apical border is in contact with the contents of the lumen, which allows them to continually "taste" or sample the lumenal environment and respond appropriatelyThere are different hormones related to gastrointestinal system which plays important role in digestion of the food and energy expenditure.

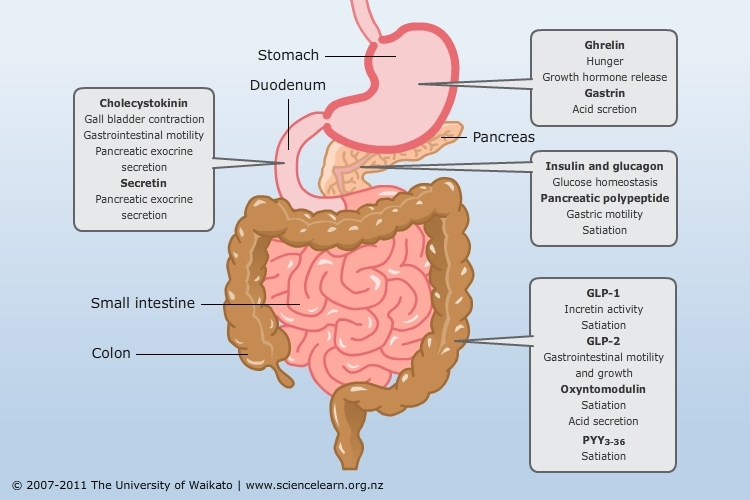
[](https://www.sciencelearn.org.nz/images/2269-hormone-action)

**There are five main hormones that aid in regulation of the digestive system in mammals:**  
**1. Gastrin** is in the stomach when it is stretched and **stimulates** the gastric glands to secrete **gastric juice** rich in  **pepsinogen** (an inactive form of the enzyme pepsin) and **hydrochloric acid**. **Secretion of gastrin is stimulated by food arriving in the stomach**. The secretion is **inhibited** by low pH.  
**2. Secretin** is **peptide hormone (27 amino acids)**  produced and secreted by the S cells in the duodenum and **signals** the secretion of sodium bicarbonate in the pancreas and it **stimulates** the bile secretion in the liver. **This hormone responds to the acidity of the chyme** (in response to meals and to the presence of acid in the duodenum). Secretinsecretion is **enhanced by amino acids, bile acid, fats, increased duodenal acidity and it is inhibited by Somatostatin.  
3. Cholecystokinin (CCK)** is is **peptide hormone** produced by **I cells**   in the duodenum, and **stimulates** the release of digestive enzymes in the pancreas and **stimulates** the emptying of bile in the gall bladder (it reduces appetite). **This hormone is secreted in response to fat in chyme.** CCK secretion in **enhanced by lipid** , **peptones**, **amino acids**, **CCK releasing factors**.

**4. Gastric inhibitory peptide (GIP)** is secreted by the K cells in the duodenum and **decreases** the stomach churning in turn slowing the emptying in the stomach. Another function is to **enhances** insulin secretion in response to a high concentration of blood sugar, and it inhibits the absorption of water and electrolytes in the small intestine. The cell numbers are increased in persons with duodenal ulcer, chronic inflammation of the pancreas, and diabetes resulting from obesity.  
  
**5. Motilin** is **22 amino acids** polypeptide in the duodenum and **increases** the migrating myoelectric complex component of gastrointestinal motility and **stimulates** the production of pepsin. A high level of motilin in the blood stimulates the contraction of the fundus and antrum and accelerates gastric emptying. It contracts the gallbladder and increases the squeeze pressure of the lower esophageal sphincter. Motilin is secreted between meals.



**Glucose Hemostasis**  
**1. Insulin**  
**Insulin** is secreted by the **beta (B) cells** of the pancreas in response to a **rise** in plasma glucose concentration and a fall in glucagon level. It **stimulates** the absorption of carbohydrates (glucose) into stores in muscle and adipose (fatty) tissue.   
  
**2. Glucagon**  
**Glucagon** is produced by pancreatic **alpha (A) cells** in response to a **drop** in plasma glucose concentration; the effects of glucagon are opposite to those of insulin. Glucagon **stimulates** the breakdown of glycogen and the production of new glucose (gluconeogenesis) in the liver. It also decreases the production of gastric and pancreatic secretions.

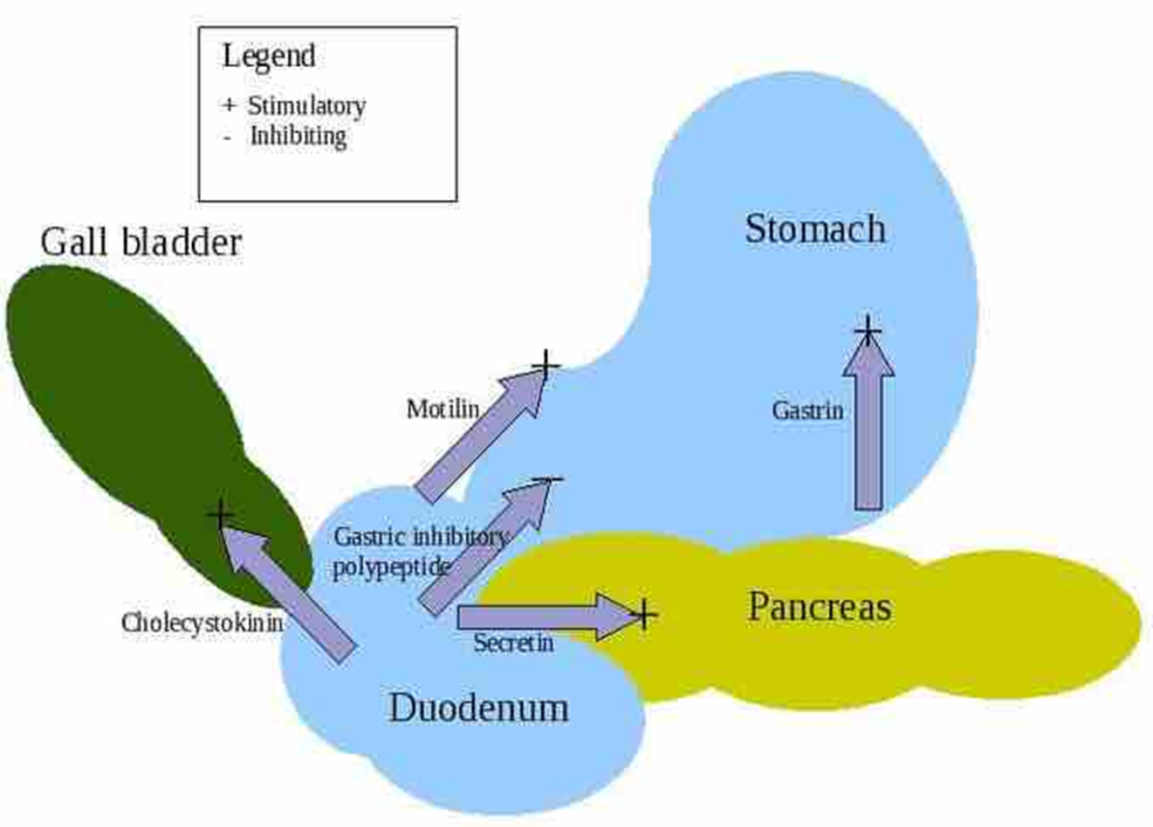


**Appetite Regulating Hormones**There are hormones secreted by **tissues** and **organs** in the body that are **transported** through the bloodstream to the **satiety center**, a region in the brain that triggers impulses that give us feelings of **hunger** or aid in suppressing our **appetite**. **Ghrelin** is a hormone that is released by the stomach and targets the pituitary, signaling to the body that it needs to eat (It increases appetite). **PYY** is produced in the last part of the small intestine known as the ileum as well as parts of the large intestine, It plays a role in slowing down the passage of food along the gut, which increases the efficiency of digestion and nutrient absorption after meal(helps to suppress our appetite). The pancreas releases the hormone **insulin**, which targets the hypothalamus and also aids in suppressing our appetite after we have just eaten and there is a rise in blood glucose levels. The last hormone is **leptin** which also helps to suppress appetite. Leptin is produced by adipose fat tissue and targets the hypothalamus.

**Phases of Digestion   
A. Cephalic Phase**The cephalic phase of gastric secretion occurs before food enters the stomach due to neurological signals.  
**1.** Thinking of food (i.e., smell, sight) **stimulates** the cerebral cortex.  
**2.** The cerebral cortex **sends messages** to the hypothalamus, the medulla, and the parasympathetic nervous system via the vagus nerve, and to the stomach via the gastric glands in the walls of the fundus and the body of stomach.  
**3.** The gastric glands **secrete** gastric juice.  
**4.** When food enters the stomach, the stomach **stretches** and **activates** stretch receptors.  
**5.** The stretch receptors **send a message** to the medulla and then back to the stomach via the vagus nerve.  
**6.** The gastric glands **secrete** more gastric juice.  
**7.** Chemical stimuli (i.e., partially digested proteins, caffeine) directly **activate** G cells (enteroendocrine cells) that are located in the pyloric region of the stomach to secrete gastrin; this in turn **stimulates** the gastric glands to secrete gastric juice.

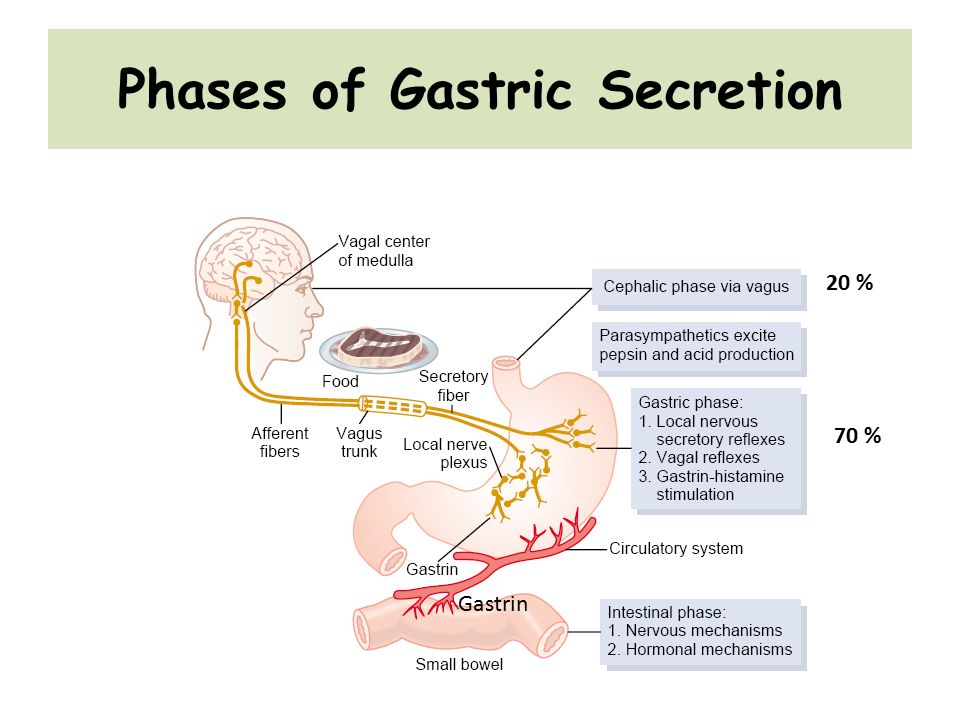
**B. Gastric Phase  
The gastric phase is a period in which swallowed food activates gastric activity in the stomach.** Gastric secretion is stimulated chiefly by three chemicals:  
**1. Acetylcholine (ACh). This is secreted by the parasympathetic nerve fibers of both the short and long reflex pathways**.  
**2. Histamine. This is a paracrine secretion from the enteroendocrine cells in the gastric glands.  
3. Gastrin. This is a hormone produced by enteroendocrine G cells in the pyloric glands.**  
All **three** of these **stimulate** parietal cells to **secrete** hydrochloric acid and intrinsic factor. The chief cells **secrete** pepsinogen in response to gastrin and especially ACh, and ACh also **stimulates** mucus secretion.  
As dietary protein is digested, it breaks down into smaller peptides and amino acids that directly **stimulate** the G cells to **secrete** even more gastrin: this is a **positive feedback loop** that accelerates protein digestion.

Small peptides also **buffer** the stomach acid so the pH does not fall excessively low. As digestion continues and these peptides **empty** from the stomach, the pH **drops** lower and lower. Below pH of **2**, stomach acid **inhibits** the parietal cells and G cells: this is a **negative feedback loop** that **winds down** the gastric phase as the need for pepsin and HCl **declines**.



**The gastric phase of digestion**: During the gastric phase, gastrin is secreted. The stomach stretches and churns while enzymes break down proteins.

**C. IntestinalPhase**The intestinal phase occurs in the duodenum as a response to the arriving **chyme**, and it moderates gastric activity via **hormones** and **nervous reflexes**. The duodenum initially **enhances** gastric secretion, but soon **inhibits it**. The stretching of the duodenum **accentuates** vagal reflexes that **stimulate** the stomach, and peptides and amino acids in the chyme **stimulate** the G cells of the duodenum to secrete more gastrin, which further **stimulates** the stomach.  
Soon, however, the acid and semi-digested fats in the duodenum **trigger** the enterogastric reflex. That is, the duodenum **sends** inhibitory signals to the stomach by way of the enteric nervous system, while also **sending** signals to the medulla that **inhibit** the vagal nuclei. This **reduces** vagal stimulation of the stomach and **stimulates** sympathetic neurons that **send** inhibitory signals to the stomach.



**Chyme**

Chyme also stimulates duodenal enteroendocrine cells to release secretin and cholecystokinin. These hormones primarily stimulate the pancreas and gallbladder, but they also suppress gastric secretion and motility. The effect of this is that gastrin secretion declines and the pyloric sphincter contracts tightly to limit the admission of more chyme into the duodenum. This gives the duodenum time to work on the chyme it has received before being loaded with more.

The enteroendocrine cells also secrete glucose -dependent insulinotropic peptide. Originally called gastric-inhibitory peptide, it is no longer thought to have a significant effect on the stomach. Rather, it probably stimulates insulin secretion in preparation for processing the nutrients that are about to be absorbed by the small intestine.

**Individual hormones**

**Somatostatin**

Somatostatin is a peptide secreted by the delta (D) cells in response to eating, especially when [fat](https://www.britannica.com/topic/fat) enters the [duodenum](https://www.britannica.com/science/duodenum). It is an inhibitory modulator of the secretion of acid and pepsin and of the release of [gastrin](https://www.britannica.com/science/gastrin), insulin, and other intestinal hormones. It [inhibits](https://www.merriam-webster.com/dictionary/inhibits) motility of the gallbladder and intestines and suppresses the secretion of [lipase](https://www.britannica.com/science/lipase) by the pancreas.

[**Serotonin**](https://www.britannica.com/science/serotonin)

[Serotonin](https://www.britannica.com/science/serotonin), or 5-hydroxytryptamine, is an amine that is formed from [amino acid](https://www.britannica.com/science/amino-acid) 5-hydroxytrytophan in the enterochromaffin cells (EC) and in other similar cells called enterochromaffin-like cells (ECL). These cells also secrete [histamine](https://www.britannica.com/science/histamine) and kinins, which likewise have important messenger functions in glandular secretions and on blood vessels. Serotonin acts in paracrine fashion. Both EC and ECL cells are widely distributed in the [gastrointestinal tract](https://www.britannica.com/science/alimentary-canal).

**Neurotensin**

Secreted by the N cells of the [ileum](https://www.britannica.com/science/ileum) in response to fat in the small intestine, neurotensin modulates motility, relaxes the lower esophageal sphincter, and blocks the stimulation of acid and pepsin secretion by the [vagus nerve](https://www.britannica.com/science/vagus-nerve).

[**Pancreatic polypeptide**](https://www.britannica.com/science/pancreatic-polypeptide)

Special endocrine cells, “PP” cells, secrete pancreatic polypeptide in response to [protein](https://www.britannica.com/science/protein) meals. Their function is intimately related to vagal and cholinergic activity. The level of pancreatic polypeptide is frequently raised in [diabetes](https://www.britannica.com/science/diabetes-mellitus).

[**Secretin**](https://www.britannica.com/science/secretin)

Secreted by the S cells of the duodenum in response to meals and to the presence of acid in the duodenum, [secretin](https://www.britannica.com/science/secretin) stimulates the production of bicarbonate by the pancreas.

[**Vasoactive intestinal peptide**](https://www.britannica.com/science/vasoactive-intestinal-peptide)

Secreted locally by endocrine cells or [nerve](https://www.britannica.com/science/nerve-anatomy) endings, vasoactive intestinal peptide is located almost exclusively in nerves distributed throughout the gastrointestinal tract. It inhibits the release of gastrin and the secretion of acid, is a mild stimulant of [bicarbonate](https://www.britannica.com/science/bicarbonate) secretion from the pancreas, and is a powerful stimulant of the secretion of water and electrolytes by the small and large intestines. It relaxes the sphincters and slows intestinal transit time. There is another group of peptide messengers that is found in quantity within the brain and in the nerves of the gastrointestinal tract. These include [substance P](https://www.britannica.com/science/substance-P), endorphins, enkephalins, and bombesin.

[**Substance P**](https://www.britannica.com/science/substance-P)

Present in significant amounts in the vagus nerves and the myenteric plexus, substance P stimulates saliva production, contraction of [smooth muscle](https://www.britannica.com/science/smooth-muscle) cells, and inflammatory responses in tissues, but it is uncertain whether it is anything other than an evolutionary vestige.

[**Endorphins**](https://www.britannica.com/science/endorphin)**and [enkephalins](https://www.britannica.com/science/enkephalin)**

Endorphins and enkephalins, each [comprising](https://www.merriam-webster.com/dictionary/comprising) five amino acids in the molecule, are present in the vagus nerves and the myenteric plexus. They have the properties of opiate (opium-derived) substances such as morphine; they bind to the same receptors and are neutralized by the opiate [antagonist](https://www.merriam-webster.com/dictionary/antagonist) naloxone. There is no evidence that endorphins and enkephalins are circulating hormones, but the enkephalins may have a physiological paracrine role in modulating smooth muscle activity in the gastrointestinal tract, and endorphins may serve in modulating the release of other peptides from endocrine cells in the digestive system.

**Bombesin**

A peptide that is found in the [intrinsic](https://www.merriam-webster.com/dictionary/intrinsic) nerves of the gastrointestinal tract, bombesin stimulates the release of gastrin and pancreatic enzymes and causes contraction of the gallbladder. These functions may be secondary, however, to the release of cholecystokinin, a hormone secreted by the [mucosa](https://www.britannica.com/science/mucous-membrane) of the [intestine](https://www.britannica.com/science/intestine) that has similar effects. It is uncertain if bombesin has a physiological role or if it is an evolutionary vestige.

**Prostaglandins**

Prostaglandins are hormonelike substances involved in the contraction and relaxation of the smooth muscle of the gastrointestinal tract. Prostaglandins are also able to protect the mucosa of the alimentary tract from injury by various insults (boiling water, alcohol, aspirin, bile acids, stress) by increasing the secretion of [mucus](https://www.britannica.com/science/mucus) and bicarbonate from the mucosa, which in turn stimulates the migration of cells to the surface for repair and replacement of the mucosal lining.

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