**Digestive enzyme**

* **Digestive enzymes** are a group of [enzymes](https://en.wikipedia.org/wiki/Enzyme) that break down polymeric [macromolecules](https://en.wikipedia.org/wiki/Macromolecule) into their smaller building blocks, in order to facilitate their absorption by the body.
* Digestive enzymes are found in the [digestive tracts](https://en.wikipedia.org/wiki/Digestive_tract) of animals (including humans) and in the tracts of [carnivorous plants](https://en.wikipedia.org/wiki/Carnivorous_plant).
* Digestive enzymes of diverse specificities are found in the [saliva](https://en.wikipedia.org/wiki/Saliva) secreted by the [salivary glands](https://en.wikipedia.org/wiki/Salivary_glands), in the secretions of cells lining the stomach, in the [pancreatic juice](https://en.wikipedia.org/wiki/Pancreatic_juice) secreted by pancreatic exocrine cells, and in the secretions of cells lining the small and large intestines.
* Digestive enzymes are classified based on their target [substrates](https://en.wikipedia.org/wiki/Enzyme_substrate):
* [Lipases](https://en.wikipedia.org/wiki/Lipase) split [fatty acids](https://en.wikipedia.org/wiki/Fatty_acid) off of [fats](https://en.wikipedia.org/wiki/Fat) and [oils](https://en.wikipedia.org/wiki/Oil).
* [Proteases](https://en.wikipedia.org/wiki/Protease) and [peptidases](https://en.wikipedia.org/wiki/Peptidase) split [proteins](https://en.wikipedia.org/wiki/Protein) into small [peptides](https://en.wikipedia.org/wiki/Peptides) and [amino acids](https://en.wikipedia.org/wiki/Amino_acid).
* [Amylases](https://en.wikipedia.org/wiki/Amylase) split [carbohydrates](https://en.wikipedia.org/wiki/Carbohydrate) such as [starch](https://en.wikipedia.org/wiki/Starch) and [sugars](https://en.wikipedia.org/wiki/Sugar) into [simple sugars](https://en.wikipedia.org/wiki/Monosaccharide) such as [glucose](https://en.wikipedia.org/wiki/Glucose).
* [Nucleases](https://en.wikipedia.org/wiki/Nuclease) split [nucleic acids](https://en.wikipedia.org/wiki/Nucleic_acid) into [nucleotides](https://en.wikipedia.org/wiki/Nucleotides).
* In the human digestive system, the main sites of digestion are the [oral cavity](https://en.wikipedia.org/wiki/Oral_cavity), the [stomach](https://en.wikipedia.org/wiki/Stomach), and the [small intestine](https://en.wikipedia.org/wiki/Small_intestine). Digestive enzymes are secreted by different [exocrine](https://en.wikipedia.org/wiki/Exocrine) glands including:
* Salivary glands
* Gastric glands in the stomach
* Secretory cells(islets) in the [pancreas](https://en.wikipedia.org/wiki/Pancreas)
* Secretory glands in the [small intestine](https://en.wikipedia.org/wiki/Small_intestine)
* **Mouth**
* Complex food substances that are taken by animals and humans must be broken down into simple, soluble, and diffusible substances before they can be absorbed.
* In the oral cavity, salivary glands secrete an array of enzymes and substances that aid in digestion and also disinfection.
* [lingual lipase](https://en.wikipedia.org/wiki/Lingual_lipase): [Lipid](https://en.wikipedia.org/wiki/Lipid) digestion initiates in the mouth. Lingual lipase starts the digestion of the lipids/fats.
* [Salivary amylase](https://en.wikipedia.org/wiki/Alpha-amylase): Carbohydrate digestion also initiates in the mouth. Amylase, produced by the salivary glands, breaks complex carbohydrates, mainly cooked starch, to smaller chains, or even simple sugars. It is sometimes referred to as [ptyalin](https://en.wikipedia.org/wiki/Ptyalin).
* [lysozyme](https://en.wikipedia.org/wiki/Lysozyme): Considering that food contains more than just essential nutrients, e.g. bacteria or viruses, the lysozyme offers a limited and non-specific, yet beneficial antiseptic function in digestion.
* **Stomach**
* The enzymes that are secreted in the [stomach](https://en.wikipedia.org/wiki/Stomach) are *gastric enzymes*. The stomach plays a major role in digestion, both in a mechanical sense by mixing and crushing the food, and also in an enzymatic sense, by digesting it.
* The following are enzymes produced by the stomach and their respective function:
* [1.Pepsin](https://en.wikipedia.org/wiki/Pepsin) is the main gastric enzyme. It is produced by the stomach cells called "chief cells" in its inactive form [pepsinogen](https://en.wikipedia.org/wiki/Pepsinogen), which is a [zymogen](https://en.wikipedia.org/wiki/Zymogen).
* Pepsinogen is then activated by the stomach acid into its active form, pepsin. Pepsin breaks down the protein in the food into smaller particles, such as [peptide](https://en.wikipedia.org/wiki/Peptide) fragments and [amino acids](https://en.wikipedia.org/wiki/Amino_acids).
* Protein digestion, therefore, primarily starts in the stomach, unlike carbohydrate and lipids, which start their digestion in the mouth.
* [2. Gastric lipase](https://en.wikipedia.org/wiki/Gastric_lipase): Gastric lipase is an acidic [lipase](https://en.wikipedia.org/wiki/Lipase) secreted by the [gastric chief cells](https://en.wikipedia.org/wiki/Gastric_chief_cell) in the [fundic](https://en.wikipedia.org/wiki/Fundic_glands) mucosa in the stomach. It has a pH optimum of 3–6.
* Gastric lipase, together with lingual lipase, comprise the two acidic lipases. These lipases, unlike alkaline lipases (such as [pancreatic lipase](https://en.wikipedia.org/wiki/Pancreatic_lipase)), do not require [bile acid](https://en.wikipedia.org/wiki/Bile_acid) or [colipase](https://en.wikipedia.org/wiki/Colipase) for optimal enzymatic activity.
* Acidic lipases make up 30% of lipid [hydrolysis](https://en.wikipedia.org/wiki/Hydrolysis) occurring during digestion in the human adult.
* Hormones or compounds produced by the stomach and their respective function:
* [Hydrochloric acid](https://en.wikipedia.org/wiki/Hydrochloric_acid) (HCl): This is produced by the cells of the stomach called parietal cells. HCl mainly functions to denature the proteins ingested, to destroy any bacteria or virus that remains in the food, and also to activate pepsinogen into pepsin.
* [Intrinsic factor](https://en.wikipedia.org/wiki/Intrinsic_factor) (IF): Intrinsic factor is produced by the parietal cells of the stomach. Vitamin B12 (Vit. B12) is an important vitamin that requires assistance for absorption in terminal [ileum](https://en.wikipedia.org/wiki/Ileum).
* Initially in the saliva, [haptocorrin](https://en.wikipedia.org/wiki/Haptocorrin) secreted by salivary glands binds Vit. B, creating a Vit. B12-Haptocorrin complex.
* The purpose of this complex is to protect Vitamin B12 from hydrochloric acid produced in the stomach.
* Once the stomach content exits the stomach into the duodenum, haptocorrin is cleaved with pancreatic enzymes, releasing the intact vitamin B12. [Intrinsic factor](https://en.wikipedia.org/wiki/Intrinsic_factor) (IF) produced by the parietal cells then binds Vitamin B12, creating a Vit. B12-IF complex. This complex is then absorbed at the terminal portion of the [ileum](https://en.wikipedia.org/wiki/Ileum).
* [Mucin](https://en.wikipedia.org/wiki/Mucin):
* The stomach has a priority to destroy the bacteria and viruses using its highly acidic environment but also has a duty to protect its own lining from its acid.
* [Gastrin](https://en.wikipedia.org/wiki/Gastrin): This is an important hormone produced by the "[G cells](https://en.wikipedia.org/wiki/G_cells)" of the stomach.
* G cells produce gastrin in response to stomach stretching occurring after food enters it, and also after stomach exposure to protein.
* Gastrin is an [endocrine](https://en.wikipedia.org/wiki/Endocrine) hormone and therefore enters the bloodstream and eventually returns to the stomach where it stimulates parietal cells to produce hydrochloric acid (HCl) and Intrinsic factor (IF).
* There are four types of cells in the stomach:
* [Parietal cells](https://en.wikipedia.org/wiki/Parietal_cell): Produce hydrochloric acid and intrinsic factor.
* [Gastric chief cells](https://en.wikipedia.org/wiki/Chief_cell): Produce pepsinogen. Chief cells are mainly found in the [body of stomach](https://en.wikipedia.org/wiki/Body_of_stomach), which is the middle or superior anatomic portion of the stomach.
* [Mucous neck and pit cells](https://en.wikipedia.org/wiki/Foveolar_cell): Produce mucin and bicarbonate to create a "neutral zone" to protect the stomach lining from the acid or irritants in the stomach [chyme](https://en.wikipedia.org/wiki/Chyme).
* [G cells](https://en.wikipedia.org/wiki/G_cell): Produce the hormone gastrin in response to distention of the stomach mucosa or protein, and stimulate parietal cells production of their secretion. G cells are located in the [antrum](https://en.wikipedia.org/wiki/Pyloric_antrum) of the stomach, which is the most inferior region of the stomach.
* Secretion by the previous cells is controlled by the [enteric nervous system](https://en.wikipedia.org/wiki/Enteric_nervous_system). Distention in the stomach or innervation by the [vagus nerve](https://en.wikipedia.org/wiki/Vagus_nerve) (via the [parasympathetic](https://en.wikipedia.org/wiki/Parasympathetic) division of the [autonomic nervous system](https://en.wikipedia.org/wiki/Autonomic_nervous_system)) activates the ENS, in turn leading to the release of [acetylcholine](https://en.wikipedia.org/wiki/Acetylcholine). Once present, acetylcholine activates G cells and parietal cells.
* Pancreas
* Pancreas is both an endocrine and an exocrine gland, in that it functions to produce endocrinic hormones released into the circulatory system (such as [insulin](https://en.wikipedia.org/wiki/Insulin), and [glucagon](https://en.wikipedia.org/wiki/Glucagon)), to control glucose metabolism, and also to secrete digestive/exocrinic pancreatic juice, which is secreted eventually via the pancreatic duct into the duodenum.
* Digestive or exocrine function of pancreas is as significant to the maintenance of health as its endocrine function.
* Two cells in the pancreatic parenchyma make up its digestive enzymes:
* [Ductal cells](https://en.wikipedia.org/wiki/Ductal_cells): Mainly responsible for production of [bicarbonate](https://en.wikipedia.org/wiki/Bicarbonate) (HCO3), which acts to neutralize the acidity of the stomach chyme entering duodenum through the pylorus.
* [Acinar cells](https://en.wikipedia.org/wiki/Centroacinar_cells): Mainly responsible for production of the inactive pancreatic enzymes ([zymogens](https://en.wikipedia.org/wiki/Zymogens)) that, once present in the small bowel, become activated and perform their major digestive functions by breaking down proteins, fat, and DNA/RNA. Acinar cells are stimulated by [cholecystokinin](https://en.wikipedia.org/wiki/Cholecystokinin) (CCK), which is a hormone/neurotransmitter produced by the intestinal cells (I cells) in the duodenum. CCK stimulates production of the pancreatic zymogens.
* [Pancreatic juice](https://en.wikipedia.org/wiki/Pancreatic_juice), composed of the secretions of both ductal and acinar cells, contains the following digestive enzymes:[[2]](https://en.wikipedia.org/wiki/Digestive_enzyme)
* [Trypsinogen](https://en.wikipedia.org/wiki/Trypsinogen), which is an inactive(zymogenic) protease that, once activated in the duodenum into [trypsin](https://en.wikipedia.org/wiki/Trypsin), breaks down proteins at the basic amino acids. Trypsinogen is activated via the duodenal enzyme [enterokinase](https://en.wikipedia.org/wiki/Enterokinase) into its active form trypsin.
* [Chymotrypsinogen](https://en.wikipedia.org/wiki/Chymotrypsinogen), which is an inactive (zymogenic) protease that, once activated by duodenal enterokinase, turns into [chymotrypsin](https://en.wikipedia.org/wiki/Chymotrypsin) and breaks down proteins at their [aromatic amino acids](https://en.wikipedia.org/wiki/Aromatic_amino_acids). Chymotrypsinogen can also be activated by trypsin.
* [Carboxypeptidase](https://en.wikipedia.org/wiki/Carboxypeptidase), which is a protease that takes off the terminal amino acid group from a protein
* Several [elastases](https://en.wikipedia.org/wiki/Elastase) that degrade the protein [elastin](https://en.wikipedia.org/wiki/Elastin) and some other proteins.
* [Pancreatic lipase](https://en.wikipedia.org/wiki/Pancreatic_lipase) that degrades triglycerides into two fatty acids and a [monoglyceride](https://en.wikipedia.org/wiki/Monoglyceride).[[3]](https://en.wikipedia.org/wiki/Digestive_enzyme)
* [Sterol esterase](https://en.wikipedia.org/wiki/Sterol_esterase)
* [Phospholipase](https://en.wikipedia.org/wiki/Phospholipase)
* Several [nucleases](https://en.wikipedia.org/wiki/Nuclease) that degrade nucleic acids, like [DNAase](https://en.wikipedia.org/wiki/DNAase) and [RNAase](https://en.wikipedia.org/wiki/RNAase)
* [Pancreatic amylase](https://en.wikipedia.org/wiki/Pancreatic_amylase) that breaks down starch and [glycogen](https://en.wikipedia.org/wiki/Glycogen) which are alpha-linked glucose polymers. Humans lack the cellulases to digest the carbohydrate [cellulose](https://en.wikipedia.org/wiki/Cellulose) which is a beta-linked glucose polymer.