

i. **Duodenum** (Duodenum is derived from Latin word digitorum means twelve fingers)

It is the first part of small intestine.

Length: 10-12 inches

Shape: Capital letter C-shaped or horse shoe shaped.

Segments: It is divided into Superior segment, Descending segment, Horizontal Segment and Ascending Segment.

Brunner's gland secretions: The physiological function of Brunner's glands is to secrete mucus and bicarbonates i-e 500 ml per day to protect the proximal duodenum from the corrosive effects of acidified chyme and to neutralize its acidity.

Relation of bile and pancreatic juice with secretin hormone: The small intestine periodically receives food or chyme from stomach which is acidic and it is necessary to put off this fire of acid to avoid acid burn. Secretin work as fireman. Secretin is first hormone to be discovered. The acidic chyme stimulates the release of a hormone called secretin. Secretin affects the pancreas and liver and brings about the release of sodium bicarbonate solution from the pancreas and the production of bile from the liver. When bicarbonate raise pH to neutrality, secretion of secretin turns off by itself.

Digestion in duodenum and jejunum: Most chemical digestion by enzymes takes place in the duodenum and jejunum. Enzymes, found free in the lumen of the duodenum have been produced and released by the pancreas. These enzymes, sodium bicarbonate solution is secreted into the duodenum to provide the optimal pH i-e 7-9 for the enzymes found in this region of the gut. The liver also secretes a substance called bile into the duodenum which is stored in the gall bladder before release. Bile consists of bile salts that emulsify fats. The large globules of fat are mechanically dispersed into many smaller globules. This increases the surface area over which lipases can act. At the same time chyme digestion is in progress by pancreatic enzymes along with intestinal enzyme secreted by jejunum wall. Jejunal walls contain intestinal glands which secrete intestinal juice i-e 1000 ml per day. In human digestion is completed in jejunum and slight absorption also occurs at the end of jejunum. When the acidic chyme touches the mucosa of the duodenum impulses are sent to the brain. The brain then sends impulses to the gastric glands to slow down the release of gastric juice (since the food has moved on). The acid also stimulates the release of a hormone called secretin. Secretin affects the pancreas and liver and brings about the release of sodium bicarbonate solution from the pancreas and the production of bile from the liver. The presence of chyme in the duodenum stimulates the glands to produce their enzymes. It also stimulates the release of a hormone called cholecystinin (CCK). It brings about the release of bile from the liver and secretin stimulates the release of pancreatic juice (containing enzymes and bicarbonates).

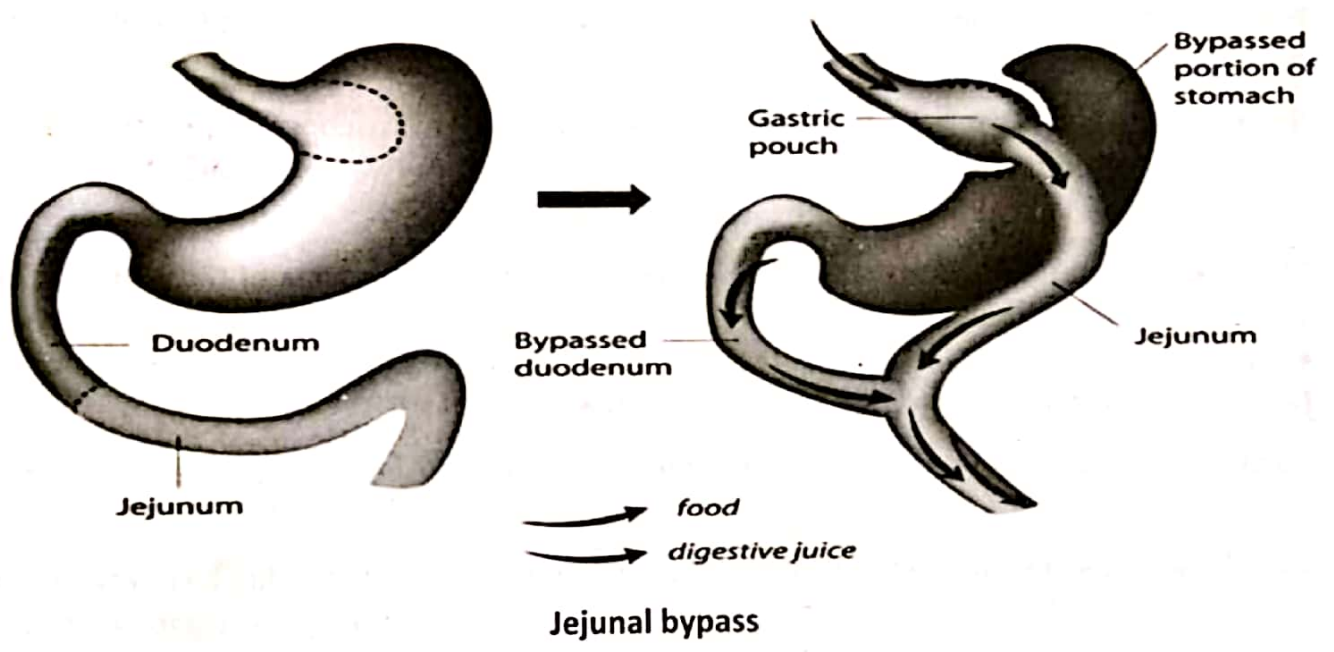
Secretin as fireman: The acidic chyme stimulates the release of a hormone called secretin. Secretin affects the pancreas and liver and brings about the release of sodium bicarbonate solution from the pancreas and the production of bile from the liver. It also stimulates the release of a hormone called cholecystinin (CCK). It brings about the release of bile from the liver and secretin stimulates the release of pancreatic juice (containing enzymes and bicarbonates). All these secretions then in coordination turn acidic pH into alkalinity so "Secretin as fireman" phrase is used for secretin.

ii. **Jejunum** (The word Jejunum is derived from Latin word jejunos means to empty). It is the middle part of small intestine

Length: It is about 4-7 feet (2.5 m) long, it makes about 2/5th of small intestine.

Jejunal bypass: The procedure in which functional volume of jejunum is reduced due to overweight and obesity. Its main objective is to reduce weight and lose obesity.

Jejunal bypass surgery: Weight loss jejunal bypass surgery became popular in the late 1960s. Surgically 35 cm of proximal jejunum was anastomosed, end to end or end to side to the terminal 10 cm of ileum. It was presumed that the patient undergoing this procedure would experience continued hyperphagia but would accomplish weight loss due to malabsorption. Resultantly patient whose weight was 157 kg before operation lost 58 kg at the end of one year. However this surgery has long been abandoned as a method of weight reduction because of serious short and long term complications.



➤ Duodenal and jejunal enzymatic activities sketch

Enzyme:	Released by intestinal glands:	Released by pancreas:	Action:
Aminopeptidase	Yes		Peptides to amino acids
Enterokinase	Yes		Inactive trypsinogen into trypsin
Maltase	Yes		Maltose to glucose
Sucrase	Yes		Sucrose to glucose and fructose
Exopeptidase	Yes		Peptides into amino acids
Lactase	Yes		Lactose into glucose and galactose
Amylase	Yes	Yes	Starch / glycogen into maltose
Chymotrypsin		Yes	Proteins into amino acids
Trypsin		Yes	Chymotrypsinogen into chymotrypsin
Lipase		Yes	Lipid into fatty acids and glycerol
Carboxypeptidase		Yes	Peptides to amino acids

Endopeptidase		Yes	Proteins into peptides
Eripsin	Yes		Dipeptides to Amino acids
Phospholipase		Yes	Phospholipids is hydrolyzed into fatty acid and lipophilic substances
Elastase		Yes	Elastin fibers to peptides
Nuclease	Yes		DNA/RNA to nucleotides

iii. **Ileum** (The word ileum is derived from Latin word ilia means "groin or flank")

It is the last part of small intestine

Length: 9-11 feet (3-4m), it makes about $\frac{3}{5}$ th of small intestine.

Function: In ileum less digestion occurring as compare to duodenum and jejunum. The food which escapes from duodenum is completely digested in ileum. Intestinal glands (1st part of ileum) and its intestinal fluid are also found.

Main function of ileum: The main function of ileum is the absorption of completely digested nutrients and pass it into the blood because of much absorptive epithelium.

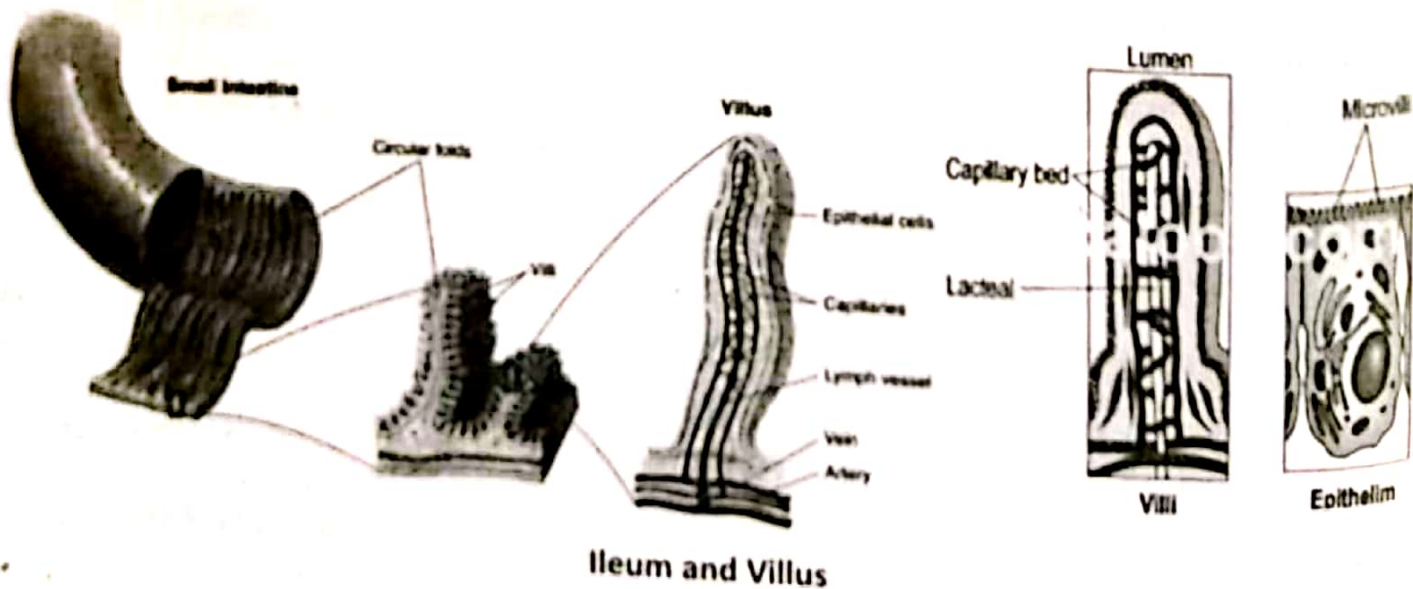
Ileum structure: The mucosa is folded and the millions of microscopic projections created by the folding of the inner surface of the wall are called villi. In between the villi are intestinal glands (Crypts of Leiberkuhn) which secrete intestinal juice.

The possession of the villi and the folds in the cell surface membranes of the epithelial cells lining the villi (microvilli) massively increases the surface area. The epithelial cells produce various enzymes that are not released into the lumen but are bound to the cell surface of the microvilli (also called brush border because of its appearance).

Rugae: The folding like structure at the end of jejunum and in ileum of small intestine is called Rugae.

Villi: Small finger like projections on the rugae are called villi. Each villus has network of blood capillaries, lymph capillaries (lacteals) and lymph nodes known as Payer's patches storing lymph bearing B and T lymphocytes and a single layer of epithelial cells.

Microvilli: Each villus is further covered with micro villi.



Absorption of food in small intestine: Large molecules have now been chemically digested into their constituent subunits by enzymes. They now need to be absorbed through the intestine wall, along with mucus and the digestive juices. Absorption takes place by simple diffusion, facilitated diffusion and active transport.

Active transport into blood capillaries: Monosaccharides (glucose and galactose), amino acids, dipeptides and tripeptides are actively transported into the epithelial cells lining of the intestinal wall. It is thought that their absorption is coupled with the absorption of sodium. When receptors are filled then nutrients be actively transported from the lumen side of the epithelium, and into the cells. From here they diffuse into the blood capillaries.

Passive transport into blood capillaries: fructose molecules are absorbed into blood passively through epithelial cells.

Facilitated diffusion into lacteals: The fatty acids, glycerol and monoglycerides form complexes with bile salts called micelles. The micelles come into contact with epithelium cells and the fat-soluble fat components diffuse into the epithelium cell, leaving behind the fat insoluble bile salts. In the epithelium, the fatty acids and glycerol are reformed by the endoplasmic reticulum to make triglycerides. They are packaged (chylomicrons) into globules with cholesterol and phospholipids and then coated with protein to be passed out from the epithelial cell into the lacteal.

