

Small Intestine

Functional Anatomy

Small intestine is the part of gastrointestinal (GI) tract, extending between the pyloric sphincter of stomach and ileocecal valve, which opens into large intestine. It is called small intestine because of its small diameter, compared to that of the large intestine. But it is longer than large intestine. Its length is about 6 meter.

Important function of small intestine is absorption. Maximum absorption of digested food products takes place in small intestine. Small intestine consists of three portions:

1. Proximal part known as duodenum
2. Middle part known as jejunum
3. Distal part known as ileum.

Wall of the small intestine has all the four layers as in stomach (Chapter 36).

Intestinal Villi AND Glands OF Small Intestine

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INTESTINAL VILLI

Mucous membrane of small intestine is covered by minute projections called villi. The height of villi is about 1 mm and the diameter is less than 1 mm. Villi are lined by columnar cells, which are called enterocytes. Each enterocyte gives rise to hair-like projections called microvilli. Villi and microvilli increase the surface area of mucous membrane by many folds. Within each villus, there is a central channel called lacteal, which opens into lymphatic vessels. It contains blood vessels also.

„ CRYPTS OF LIEBERKÜHN OR INTESTINAL GLANDS

Crypts of Lieberkühn or intestinal glands are simple tubular glands of intestine. Intestinal glands do not penetrate the muscularis mucosa of the intestinal wall, but open into the lumen of intestine between the villi. Intestinal glands are lined by columnar cells. Lining of each gland is continuous with epithelial lining of the villi (Fig. 41.1).

Epithelial cells lining the intestinal glands undergo division by mitosis at a faster rate. Newly formed cells push the older cells upward over the lining of villi. These cells which move to villi are called enterocytes. Enterocytes secrete the enzymes. Old enterocytes are continuously shed into lumen along with enzymes.

Types of cells interposed between columnar cells of intestinal glands:

1. Argentaffin cells or enterochromaffin cells, which secrete intrinsic factor of Castle.
2. Goblet cells, which secrete mucus
3. Paneth cells, which secrete the cytokines called defensins.

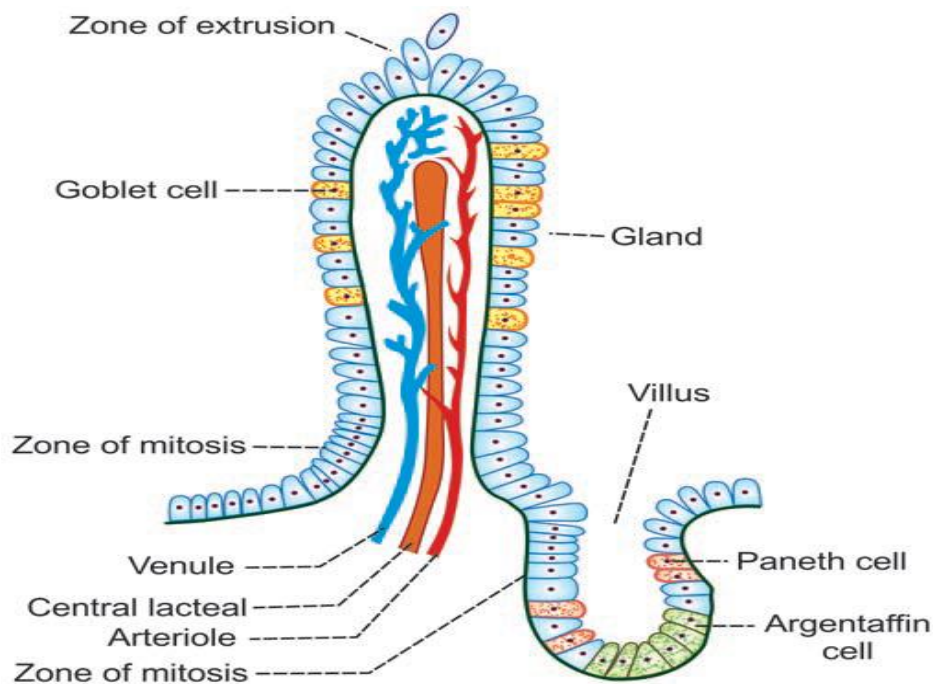


FIGURE 41.1: Intestinal gland and villus

Brunner Glands

In addition to intestinal glands, the first part of duodenum contains some mucus glands, which are called Brunner glands. These glands penetrate muscularis mucosa and extend up to the submucosa coat of the intestinal wall. Brunner glands open into the lumen of intestine directly.

Brunner gland secretes mucus and traces of enzymes.

„ PROPERTIES AND COMPOSITION OF SUCCUS ENTERICUS

Secretion from small intestine is called succus entericus.

„ PROPERTIES OF SUCCUS ENTERICUS

Volume : 1800 mL/day

Reaction : Alkaline

pH : 8.3

„ COMPOSITION OF SUCCUS ENTERICUS

Succus entericus contains water (99.5%) and solids (0.5%). Solids include organic and inorganic substances (Fig. 41.2). Bicarbonate concentration is slightly high in succus entericus.

FUNCTIONS OF SUCCUS ENTERICUS

„ 1. DIGESTIVE FUNCTION

Enzymes of succus entericus act on the partially digested food and convert them into final digestive products. Enzymes are produced and released into succus entericus by enterocytes of the villi.

Proteolytic Enzymes

Proteolytic enzymes present in succus entericus are the peptidases, which are given in Fig. 41.2. These peptidases convert peptides into amino acids.

Amylolytic Enzymes

Amylolytic enzymes of succus entericus are listed in Fig. 41.2. Lactase, sucrase and maltase convert the disaccharides (lactose, sucrose and maltose) into two molecules of monosaccharides (Table 41.1).

Dextrinase converts dextrin, maltose and maltriose into glucose. Trehalase or trehalose glucohydrolase causes hydrolysis of trehalose (carbohydrate present in mushrooms and yeast) and converts it into glucose.

Lipolytic Enzyme

Intestinal lipase acts on triglycerides and converts them into fatty acids.

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2. PROTECTIVE FUNCTION

i. Mucus present in the succus entericus protects the intestinal wall from the acid chyme, which enters the intestine from stomach; thereby it prevents the intestinal ulcer.

ii. Defensins secreted by paneth cells of intestinal glands are the antimicrobial peptides.

These peptides are called natural peptide antibiotics because of their role in killing the phagocytosed bacteria.

„ 3. ACTIVATOR FUNCTION

Enterokinase present in intestinal juice activates trypsinogen into trypsin. Trypsin, in turn activates other enzymes (Chapter 39).

„ 4. HEMOPOIETIC FUNCTION

Intrinsic factor of Castle present in the intestine plays an important role in erythropoiesis (Chapter 10). It is necessary for the absorption of vitamin B12.

5. HYDROLYTIC PROCESS

Intestinal juice helps in all the enzymatic reactions of digestion.

„ FUNCTIONS OF SMALL INTESTINE

„ 1. MECHANICAL FUNCTION

Mixing movements of small intestine help in the thorough mixing of chyme with the digestive juices like succus entericus, pancreatic juice and bile.

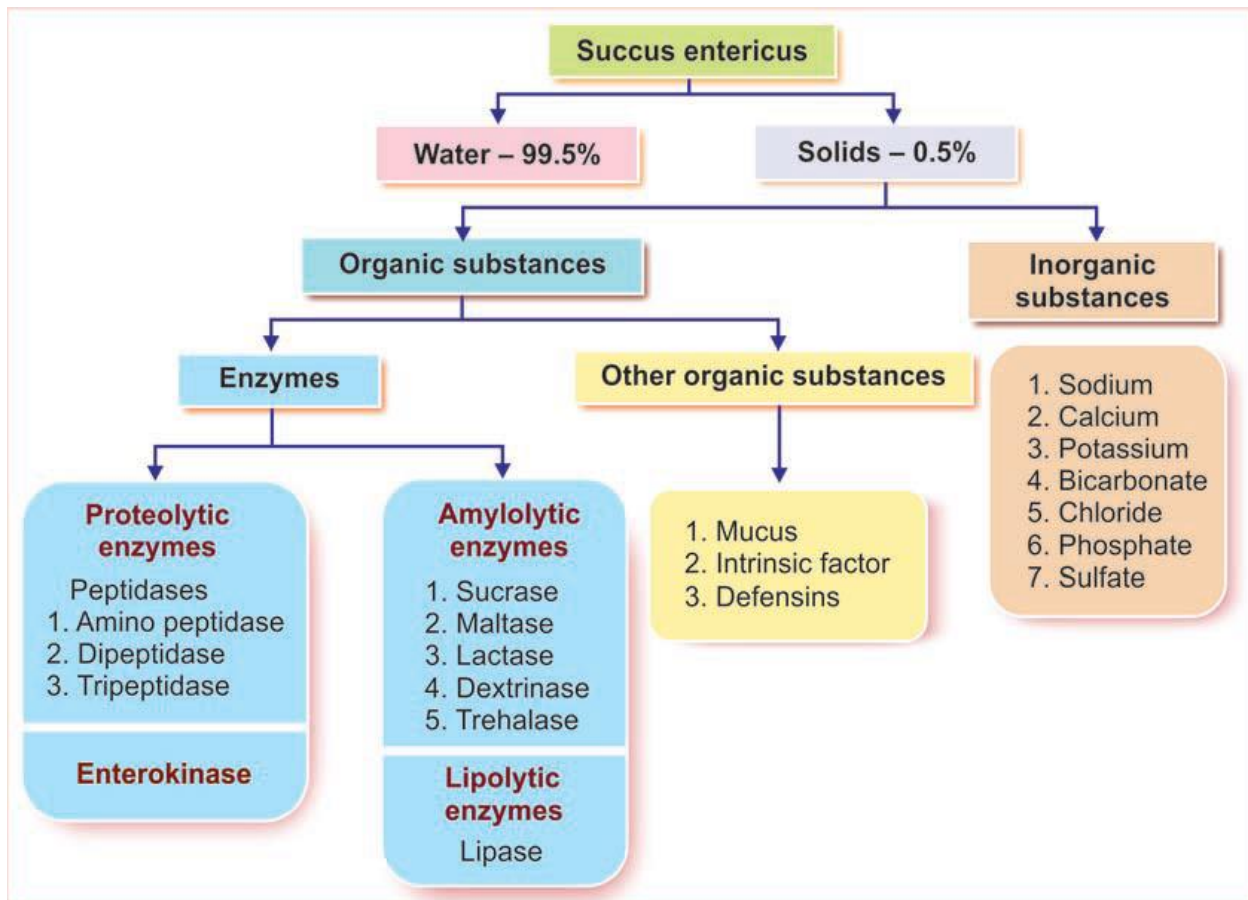


FIGURE 41.2: Composition of succus entericus

„ **2. SECRETORY FUNCTION**

Small intestine secretes succus entericus, enterokinase and the GI hormones.

„ **3. HORMONAL FUNCTION**

Small intestine secretes many GI hormones such as secretin, cholecystokinin, etc. These hormones regulate the movement of GI tract and secretory activities of small intestine and pancreas (Chapter 44).

„ **4. DIGESTIVE FUNCTION**

Refer functions of succus entericus.

5. ACTIVATOR FUNCTION

Refer functions of succus entericus.

„ **6. HEMOPOIETIC FUNCTION**

Refer functions of succus entericus.

„ 7. HYDROLYTIC FUNCTION

Refer functions of succus entericus.

8. ABSORPTIVE FUNCTIONS

Presence of villi and microvilli in small intestinal mucosa increases the surface area of mucosa. This facilitates the absorptive function of intestine. Digested products of foodstuffs, proteins, carbohydrates, fats and other nutritive substances such as vitamins, minerals and water are absorbed mostly in small intestine. From the lumen of intestine, these substances pass through lacteal of villi, cross the mucosa and enter the blood directly or through lymphatics.

TABLE 41.1: Digestive enzymes of succus entericus

Enzyme	Substrate	End products
Peptidases	Peptides	Amino acids
Sucrase	Sucrose	Fructose and glucose
Maltase	Maltose and maltotriose	Glucose
Lactase	Lactose	Galactose and glucose
Dextrinase	Dextrin, maltose and maltotriose	Glucose
Trehalase	Trehalose	Glucose
Intestinal lipase	Triglycerides	Fatty acids

Absorption of Carbohydrates

Refer Chapter 45.

Absorption of Proteins

Refer Chapter 46.

Absorption of Fats

Refer Chapter 47.

Absorption of Water and Minerals

i. In small intestine, sodium is absorbed actively. It is responsible for absorption of glucose, amino acids and other substances by means of sodium cotransport.

ii. Water moves in or out of the intestinal lumen until the osmotic pressure of intestinal contents becomes equal to that of plasma.

iii. In ileum, chloride ion is actively absorbed in exchange for bicarbonate. The significance of this exchange is not known.

iv. Calcium is actively absorbed mostly in upper part of small intestine.

Absorption of Vitamins

Most of the vitamins are absorbed in upper part of small intestine and vitamin B12 is absorbed in ileum. Absorption of water-soluble vitamins is faster than fatsoluble vitamins.

„ REGULATION OF SECRETION OF SUCCUS ENTERICUS

Secretion of succus entericus is regulated by both nervous and hormonal mechanisms.

„ NERVOUS REGULATION

Stimulation of parasympathetic nerves causes vasodilatation and increases the secretion of succus entericus. Stimulation of sympathetic nerves causes vasoconstriction and decreases the secretion of succus entericus. But, the role of these nerves in the regulation of intestinal secretion in physiological conditions is uncertain. However, the local nervous reflexes play an important role in increasing the secretion of intestinal juice. When chyme enters the small intestine, the mucosa is stimulated by tactile stimuli or irritation. It causes the development of local nervous reflexes, which stimulate the glands of intestine.

„ **HORMONAL REGULATION**

When chyme enters the small intestine, intestinal mucosa secretes enterocrinin, secretin and cholecystokinin, which promote the secretion of succus entericus by stimulating the intestinal glands.

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Large Intestine

FUNCTIONAL ANATOMY OF LARGE INTESTINE

Large intestine or colon extends from ileocecal valve up to anus (Fig. 36.1).

„ **PARTS OF LARGE INTESTINE**

Large intestine is made up of the following parts:

1. Cecum with appendix
2. Ascending colon
3. Transverse colon
4. Descending colon
5. Sigmoid colon or pelvic colon
6. Rectum
7. Anal canal.

STRUCTURE OF WALL OF LARGE INTESTINE

Wall of large intestine is formed by four layers of structures like any other part of the gut.

1. Serous layer: It is formed by peritoneum.
2. Muscular layer: Smooth muscles of large intestine are distributed in two layers, namely the outer longitudinal layer and inner circular layer. The longitudinal muscle fibers of large intestine are arranged in the form of three long bands called tenia coli. The length of the tenia coli is less when compared to the length of large intestine. Because of this, the large intestine is made into series of pouches called haustra.
3. Submucus layer: It is not well developed in large intestine.

4. Mucus layer: The crypts of Leiberkühn are present in mucosa of large intestine. But the villi, which are present in mucus membrane of small intestine, are absent in the large intestine. Only mucus-secreting glands are present in the mucosa of large intestine.

SECRETIONS OF LARGE INTESTINE

Large intestinal juice is a watery fluid with pH of 8.0.

„ COMPOSITION OF LARGE INTESTINAL JUICE

Large intestinal juice contains 99.5% of water and 0.5% of solids (Fig. 42.1). Digestive enzymes are absent and concentration of bicarbonate is high in large intestinal juice.

„ FUNCTIONS OF LARGE INTESTINAL JUICE

Neutralization of Acids

Strong acids formed by bacterial action in large intestine are neutralized by the alkaline nature of large intestinal juice. The alkalinity of this juice is mainly due to the presence of large quantity of bicarbonate.

Lubrication Activity

Mucin present in the secretion of large intestine lubricates the mucosa of large intestine and the bowel contents, so that, the movement of bowel is facilitated. Mucin also protects the mucus membrane of large intestine by preventing the damage caused by mechanical injury or chemical substances.

FUNCTIONS OF LARGE INTESTINE

„ 1. ABSORPTIVE FUNCTION

Large intestine plays an important role in the absorption of various substances such as:

- i. Water
- ii. Electrolytes
- iii. Organic substances like glucose
- iv. Alcohol
- v. Drugs like anesthetic agents, sedatives and steroids.

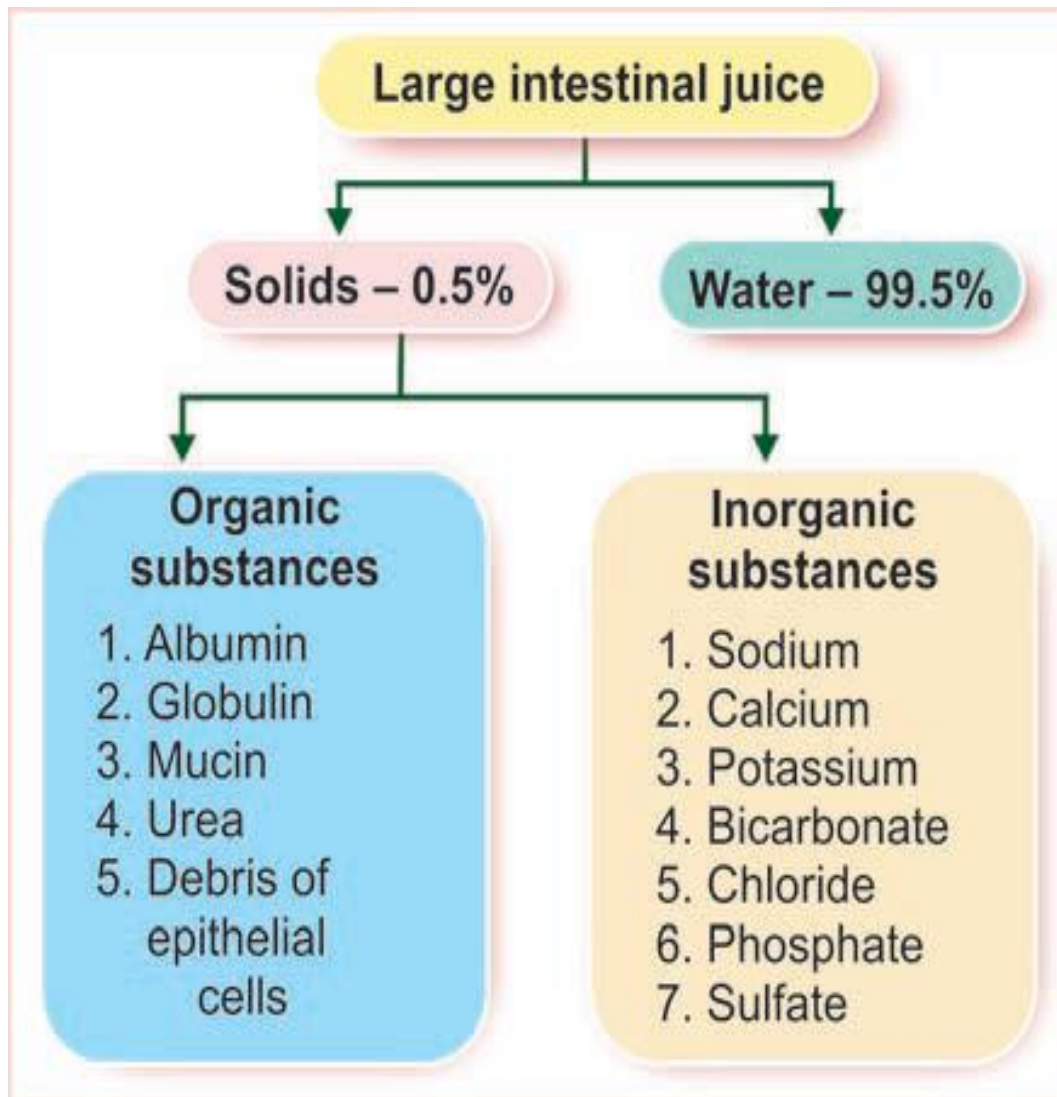


FIGURE 42.1: Composition of large intestinal juice

„ **2. FORMATION OF FECES**

After the absorption of nutrients, water and other substances, the unwanted substances in the large intestine form feces. This is excreted out.

„ **3. EXCRETORY FUNCTION**

Large intestine excretes heavy metals like mercury, lead, bismuth and arsenic through feces.

„ **4. SECRETORY FUNCTION**

Large intestine secretes mucin and inorganic substances like chlorides and bicarbonates.

„ **5. SYNTHETIC FUNCTION**

Bacterial flora of large intestine synthesizes folic acid, vitamin B12 and vitamin K. By this function, large intestine contributes in erythropoietic activity and blood clotting mechanism.

„ **DIETARY FIBER**

Dietary fiber or roughage is a group of food particles which pass through stomach and small intestine without being digested and reach the large intestine unchanged. Other nutritive substances of food are digested and absorbed before reaching large intestine. Characteristic feature of dietary fiber is that it is not hydrolyzed by digestive enzymes. So, it escapes digestion in small intestine and passes to large intestine.

It provides substrate for microflora of large intestine and increases the bacterial mass. The anaerobic bacteria, in turn, degrade the fermentable components of the fiber. Thus, in large intestine, some of the components of fiber are broken down and absorbed and remaining components are excreted through feces.

Components of Dietary Fiber

Major components of dietary fiber are cellulose, hemicelluloses, D-glucans, pectin, lignin and gums. Cellulose, hemicelluloses and pectin are partially degradable, while other components are indigestible.

Dietary fiber also contains minerals, antioxidants and other chemicals that are useful for health. Sources of Dietary Fiber Sources of dietary fiber are fruits, vegetables, cereals, bread and wheat grain (particularly its outer layer).

Significance of Dietary Fiber

Diet with high dietary fiber has health benefits since dietary fiber:

1. Delays emptying of stomach.
2. Increases formation of bulk and soft feces and eases defecation.
3. Contains substances such as antioxidants and other useful substances.

When high dietary fiber food is taken, other foods, which may cause some diseases may be decreased in quantity or completely excluded from diet. Diet with high fiber content tends to be low in energy and it may be useful in reducing the body weight.

Some components of dietary fiber also reduce blood cholesterol level and thereby decrease the risk for coronary heart disease and gallstones. Dietary fiber is suggested for treating or to prevent constipation and bowel syndrome. It is also useful in treatment of some disorders such as diabetics, cancer, ulcer, etc.