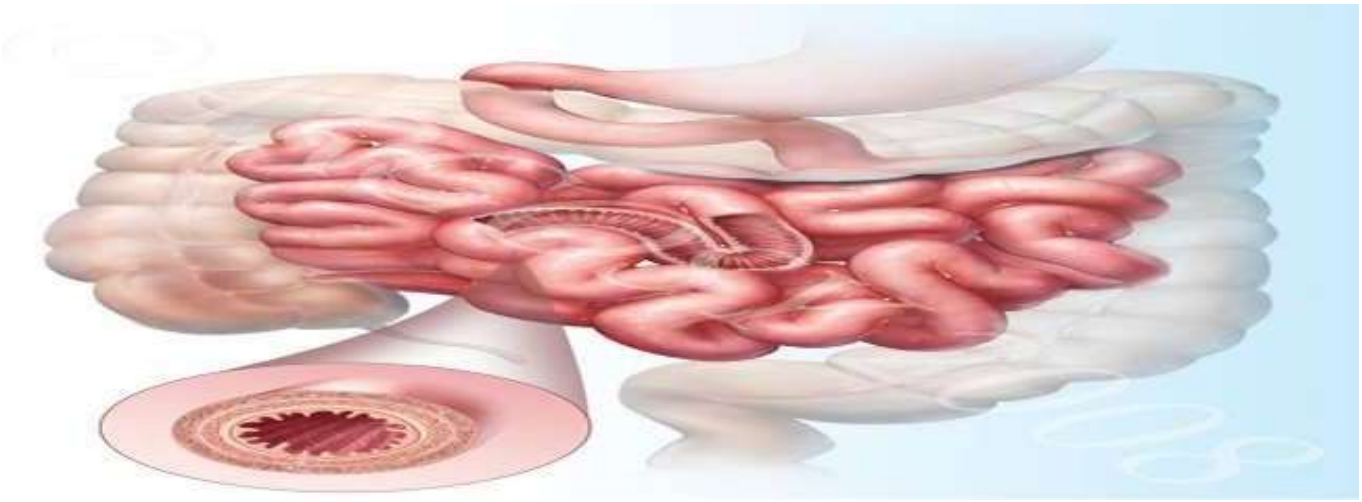
Small intestine

The body's major digestive organ

- The small intestine (or small bowel) is the part of the gastrointestinal tract following the stomach and followed by the large intestine,
- and is where much of the digestion and absorption of food takes place.



Size: 2.5 cm in diameter
5 m long

Length:

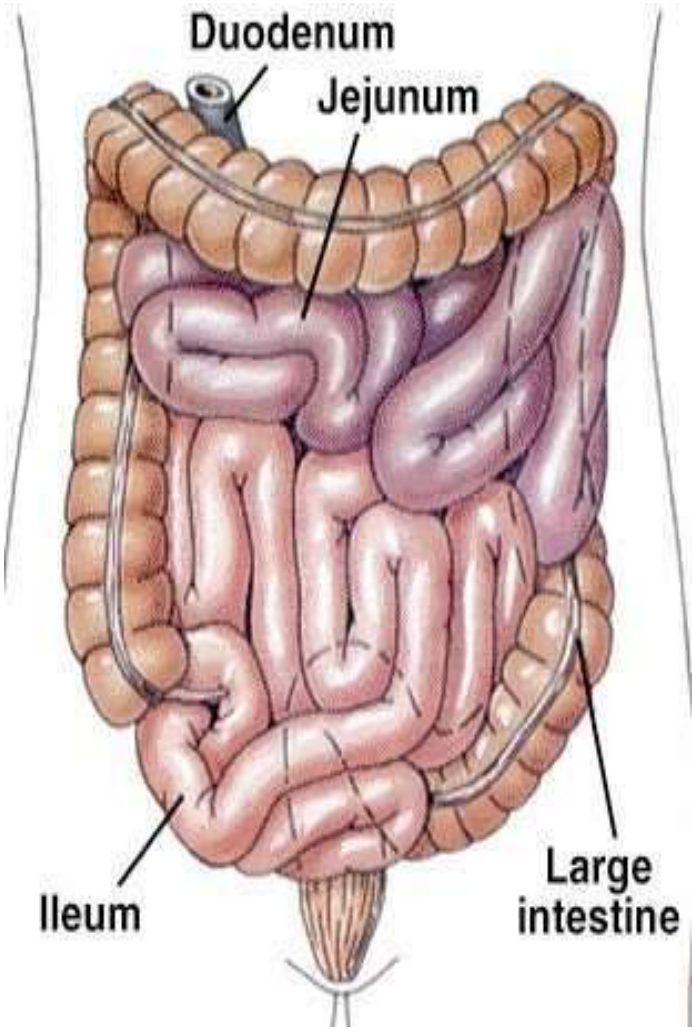
an adult human male is 6.9 m (22 ft 8 in)

adult female 7.1 m (23 ft 4 in).

The surface area : 30 square meter

Location : abdominal cavity

- Surrounded by large intestine
- Muscular tube extending form the pyloric sphincter to the ileocecal valve

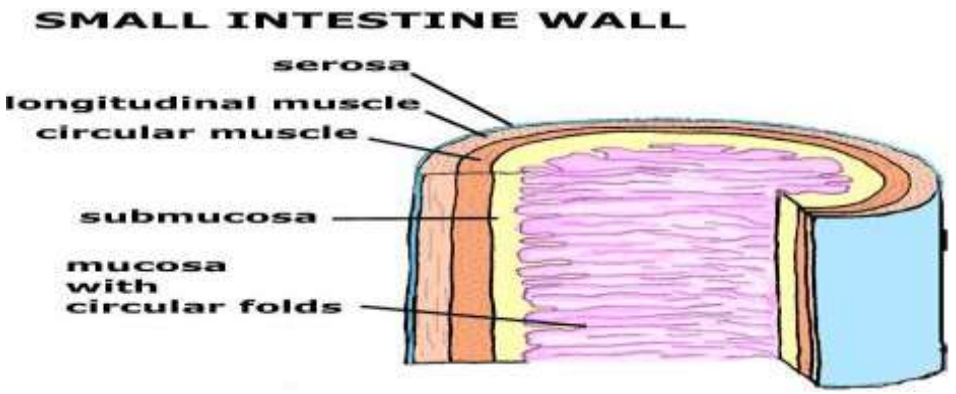


Subdivisions of the Small Intestine

- Duodenum
  - First part
  - Attached to the stomach
  - Length : 25cm / 10-12 inch
  - Shape - C
  - Curves around the head of the pancreas
  - Secretion from the gall bladder and pancrease
- Jejunum
  - Middle part of intestine
  - Attaches anteriorly to the duodenum
  - And posteriorly to ileum
  - Length: 2 m
- Ileum
  - Terminal end.
  - Extends from jejunum to large intestine (caecum)
  - Length: 3 m

Structure of the small intestine

- The walls of the small intestine are composed of the four layers of tissue.

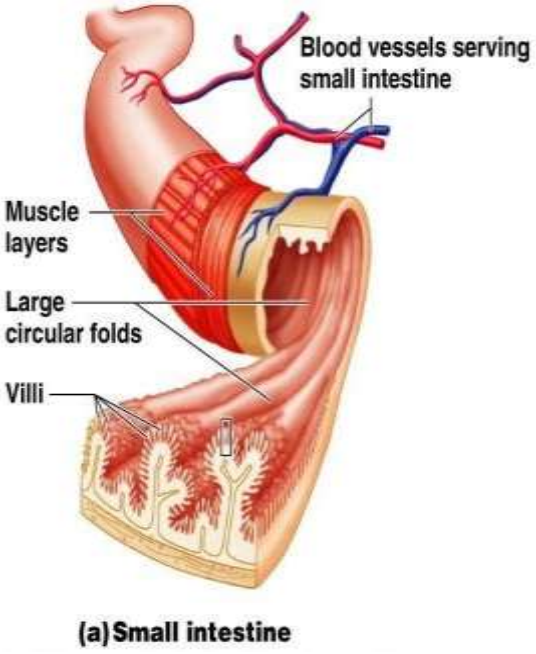


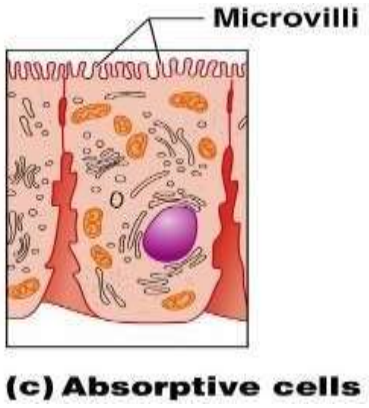
1. Mucus layer :
2. Submucus layer:
3. Muscular layer:
4. Serous layer:

Peritoneum

- A double layer of peritoneum called the mesentery
- attaches the jejunum and ileum to the posterior abdominal wall
- it is fan shaped.
- The large blood vessels and nerves lie on the posterior abdominal wall and the branches to the small intestine pass between the two layers of the mesentery.

- **Mucosa**
- permanent circular folds, villi and microvilli.
- The permanent circular folds, unlike the rugae of the stomach, are not smoothed out when the small intestine is distended
- They promote mixing of chyme as it passes along.
- The villi : tiny finger-like projections of the mucosal layer into the intestinal lumen, about 0.5 to 1 mm long
- walls : columnar epithelial cells, or enterocytes, with tiny microvilli (1 μm long) on their free border.
- Goblet cells : secrete mucus
- a network of blood and lymph capillaries.
- The lymph capillaries are called lacteals because absorbed fat gives the lymph a milky appearance.
- Absorption and some final stages of digestion of nutrients take place in the enterocytes before entering the blood and lymph capillaries.





- The intestinal glands are simple tubular glands situated below the surface between the villi.

Glands

- The entire epithelium is replaced every 3 to 5 days.
- digestive enzymes that lodge in the microvilli and, together with intestinal juice, complete the chemical digestion of carbohydrates, protein and fats.
- Numerous lymph nodes are found in the mucosa.
- These lymphatic tissues, packed with defensive cells, are strategically placed to neutralise ingested antigens

Blood supply

- **superior** mesenteric artery

venous drainage

- **superior** mesenteric vein that joins other veins to form the portal vein

Nerve supply :

- Vagus nerve

Intestinal juice

About 1500 ml of intestinal juice are secreted daily by the glands of the small intestine.

- Water
- Mucus
- Mineral salts

PH: between 7.8 and 8.0

Functions of the small intestine

- onward movement of its contents by peristalsis, which is increased by parasympathetic stimulation
- secretion of intestinal juice
- completion of chemical digestion of carbohydrates, protein and fats in the enterocytes of the villi
- protection against infection by microbes that have survived the antimicrobial action of the hydrochloric acid in the stomach, by the lymph follicles
- secretion of the hormones : cholecystokinin (CCK) and secretin
- absorption of nutrients.

intestine

- mixed with pancreatic juice, bile and intestinal juice, and is in contact with the enterocytes of the villi.

In the small intestine digestion of all the nutrients is completed:

- carbohydrates are broken down to monosaccharides
- proteins are broken down to amino acids
- fats are broken down to fatty acids and glycerol.

Pancreatic juice

- Pancreatic juice is secreted by the exocrine pancreas and enters the duodenum at the duodenal papilla.
- It consists of:
- water
- mineral salts
- enzymes:
  - amylase
  - lipase
  - nucleases that digest DNA and RNA
- inactive enzyme precursors including:
  - trypsinogen
  - chymotrypsinogen.
- Pancreatic juice is basic - alkaline (pH 8) because it contains significant quantities of bicarbonate ions, which are alkaline in solution.
- When acid stomach contents enter the duodenum they are mixed with pancreatic juice and bile and the pH is raised to between 6 and 8.
- This is the pH at which the pancreatic enzymes, amylase and lipase, act most effectively.

Functions Digestion of proteins:

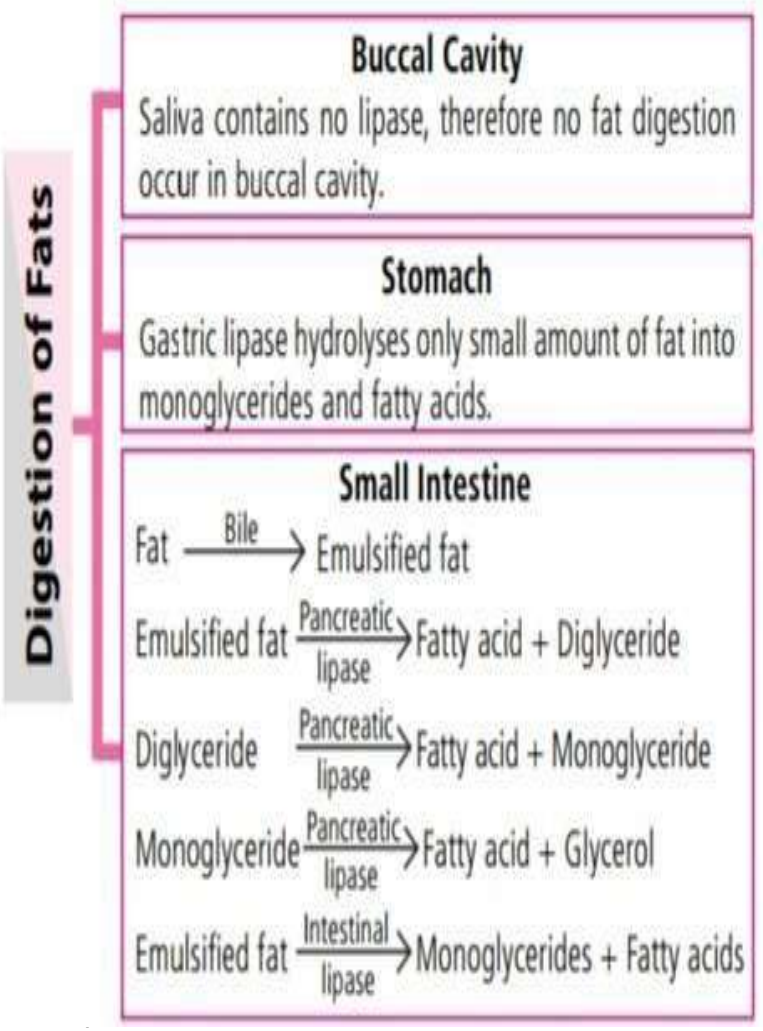
- Trypsinogen and chymotrypsinogen are inactive enzyme activated by enterokinase
- which converts them into the active proteolytic enzymes trypsin and chymotrypsin.
- These enzymes convert polypeptides to tripeptides, dipeptides and amino acids.

Digestion of carbohydrates

Pancreatic amylase converts all digestible polysaccharides (starches) not acted upon by salivary amylase to disaccharides.

Digestion of fats

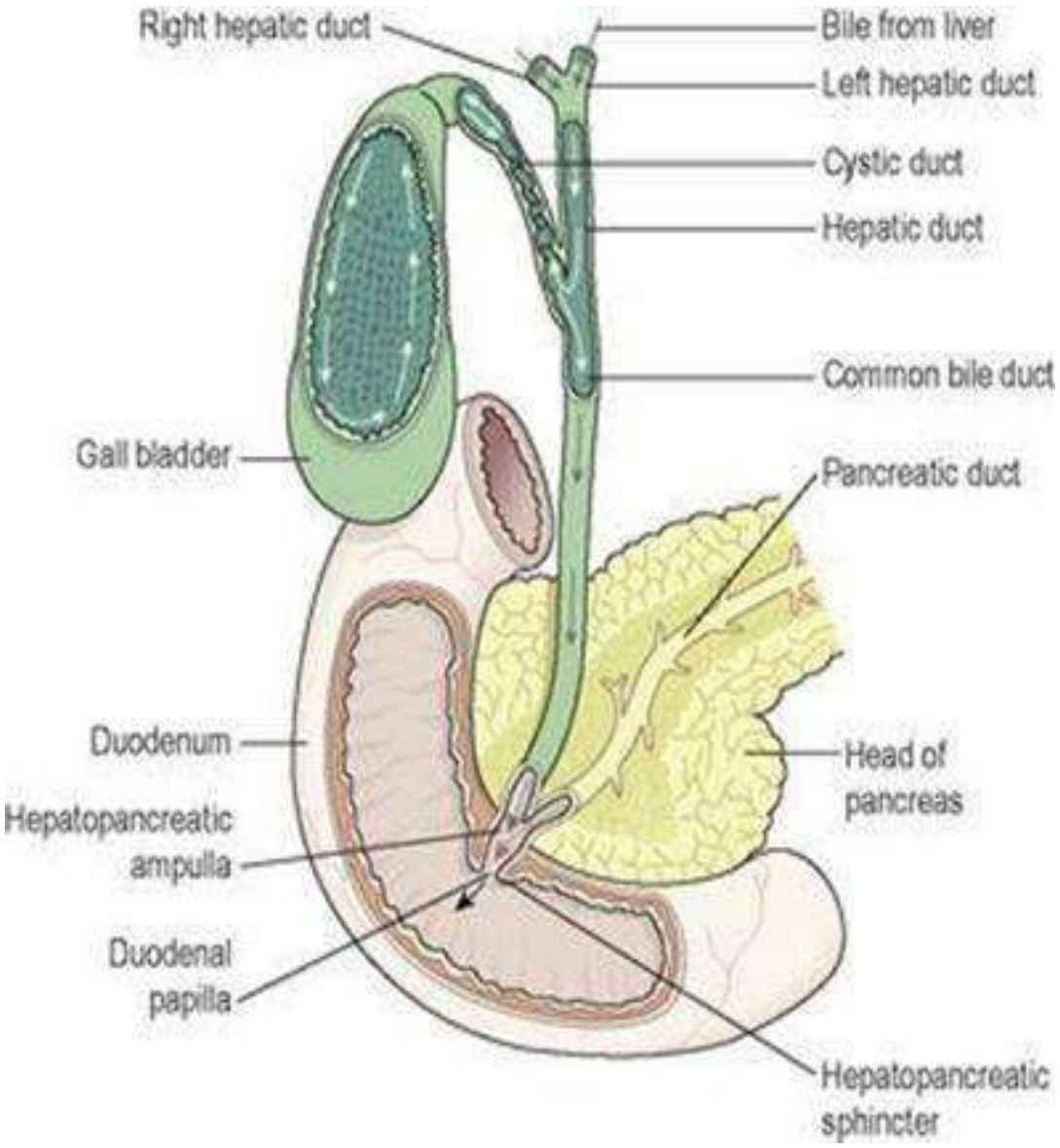
- Lipase converts fats to fatty acids and glycerol.
- To aid the action of lipase, bile salts emu fats, i.e. reduce the size of the globules, increasing their surface area.



Bile

- Bile, secreted by the liver,
- is unable to enter the duodenum when the hepatopancreatic sphincter is closed;
- therefore it passes from the hepatic duct along the cystic duct to the gall bladder where it is stored.
- Bile has a pH of around 8
- between 500 and 1000 ml are secreted daily.
- It consists of:

❑ water
❑ mineral salts
❑ mucus
❑ bile salts
❑ bile pigments, mainly bilirubin
❑ cholesterol.

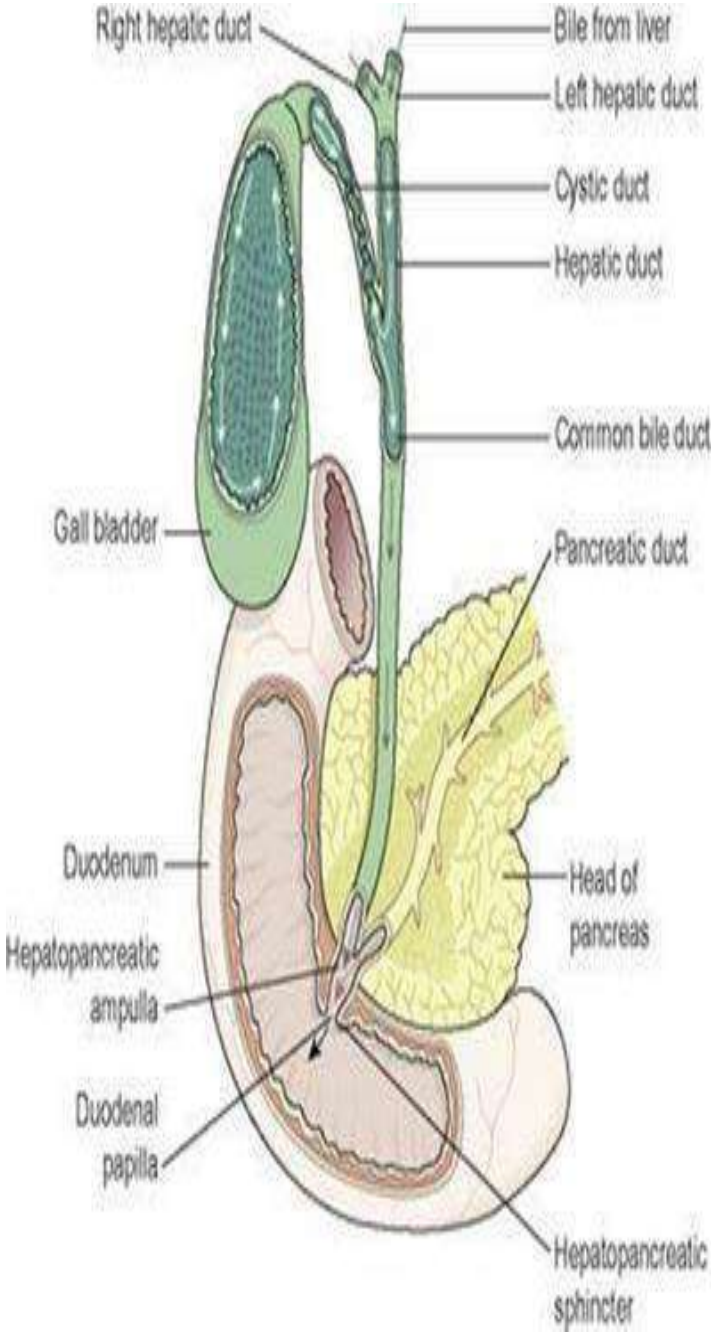


Functions

- The bile salts emulsify fats in the small intestine.
- make cholesterol and fatty acids soluble, enabling both these and fat-soluble vitamins (i.e. vitamins A, D, E and K) to be readily absorbed.
- The bile pigment, bilirubin, is a waste product of the breakdown of erythrocytes (RBC) and is excreted in the bile rather than in the urine because of its low solubility in water.

Release from the gall bladder

- After a meal, the duodenum secretes the hormones secretin and CCK during the intestinal phase of gastric secretion
- They stimulate contraction of the gall bladder and relaxation of the hepatopancreatic sphincter, enabling the bile and pancreatic juice to pass through the duodenal papilla into the duodenum together.
- Secretion is markedly increased when chyme entering the duodenum contains a high proportion of fat.



Chemical digestion associated with enterocytes

Alkaline intestinal juice (pH 7.8 to 8.0) assists in raising the pH of the intestinal contents to between 6.5 and 7.5.

- Enterokinase activates pancreatic peptidases such as trypsin which convert some polypeptides to amino acids and some to smaller peptides.
- The final stage of breakdown of all peptides to amino acids takes place at the surface of the enterocytes.
- Lipase completes the digestion of emulsified fats to fatty acids and glycerol in the intestine.
- Sucrase, maltase and lactase complete the digestion of carbohydrates by converting disaccharides such as sucrose, maltose and lactose to monosaccharides at the surface of the enterocytes.

Control of secretion

- Mechanical stimulation of the intestinal glands by chyme
- main stimulus for the secretion of intestinal juice, although the hormone secretin may also be involved.

Absorption of nutrients

- Absorption of nutrients from the small intestine through the enterocytes occurs by several processes, including diffusion, osmosis, facilitated diffusion and active transport.
- Water moves by osmosis, small fat-soluble substances, e.g. fatty acids and glycerol, are able to diffuse through cell membranes while others are generally transported inside the villi by other mechanisms.
- Monosaccharides and amino acids pass into the capillaries in the villi.
- Fatty acids and glycerol enter into the lacteals where they are transported along lymphatic vessels and enter the circulation at the thoracic duct
- Some proteins are absorbed unchanged, e.g. antibodies present in breast milk and oral vaccines, such as poliomyelitis vaccine.
- The extent of protein absorption is believed to be limited.

- Other nutrients such as vitamins, mineral salts and water are also absorbed from the small intestine into the blood capillaries.
- Fat-soluble vitamins are absorbed into the lacteals along with fatty acids and glycerol.
- Vitamin B12 combines with intrinsic factor in the stomach and is actively absorbed in the terminal ileum.
- The surface area through which absorption takes place in the small intestine is greatly increased by the circular folds of mucous membrane and by the very large number of villi and microvilli present.
- It has been calculated that the surface area of the small intestine is about five times that of the whole body.
- Large amounts of fluid enter the alimentary tract each day. Of this, only about 1500 ml is not absorbed by the small intestine, and passes into the large intestine.