# Small Intestine

The small intestine is the longest part of the alimentary canal and extends from the pylorus of the stomach to the ileocecal junction (Fig. 5.1). The greater part of digestion and food absorption takes place in the small intestine. It is divided into three parts: the duodenum, the jejunum, and the ileum.

## Duodenum

### Location and Description

The duodenum is a C-shaped tube, about 10 in. (25 cm) long, which joins the stomach to the jejunum. It receives the openings of the bile and pancreatic ducts. The duodenum curves around the head of the pancreas (Fig. 5.26). The first inch (2.5 cm) of the duodenum resembles the stomach in that it is covered on its anterior and posterior surfaces with peritoneum and has the lesser omentum attached to

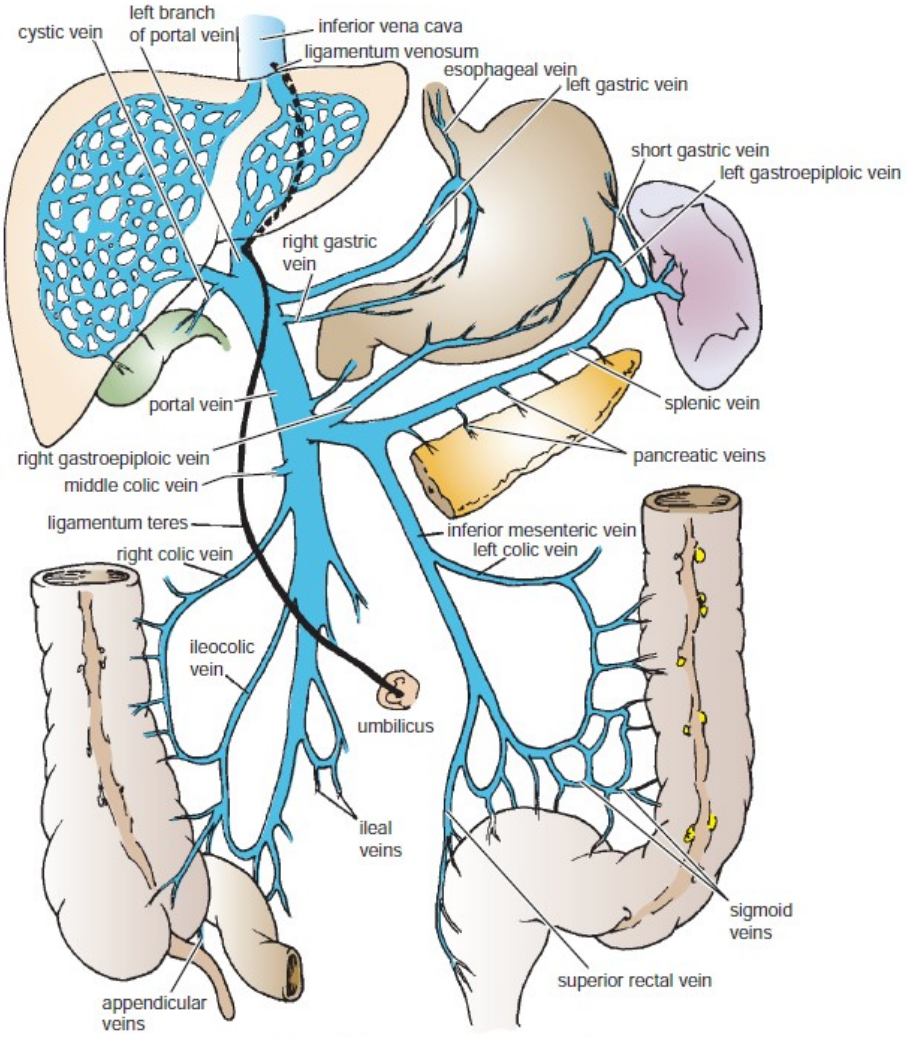


**FIGURE 5.22** Tributaries of the portal vein.

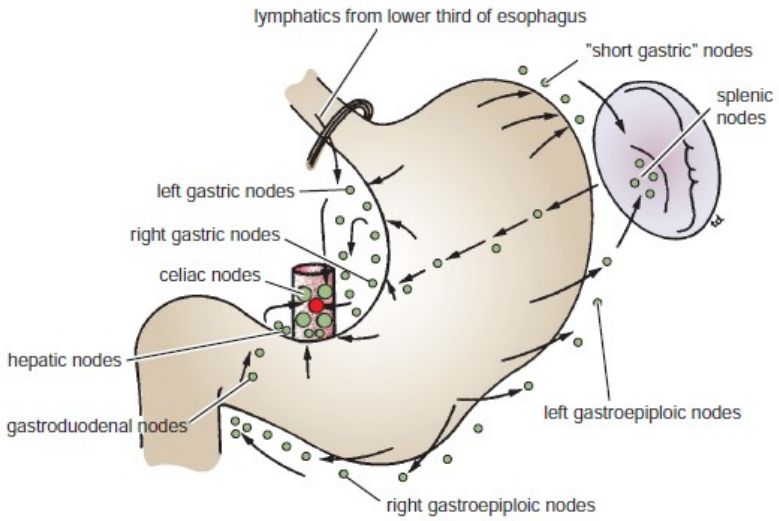


**FIGURE 5.23** Lymph drainage of the stomach. Note that all the lymph eventually passes through the celiac lymph nodes.

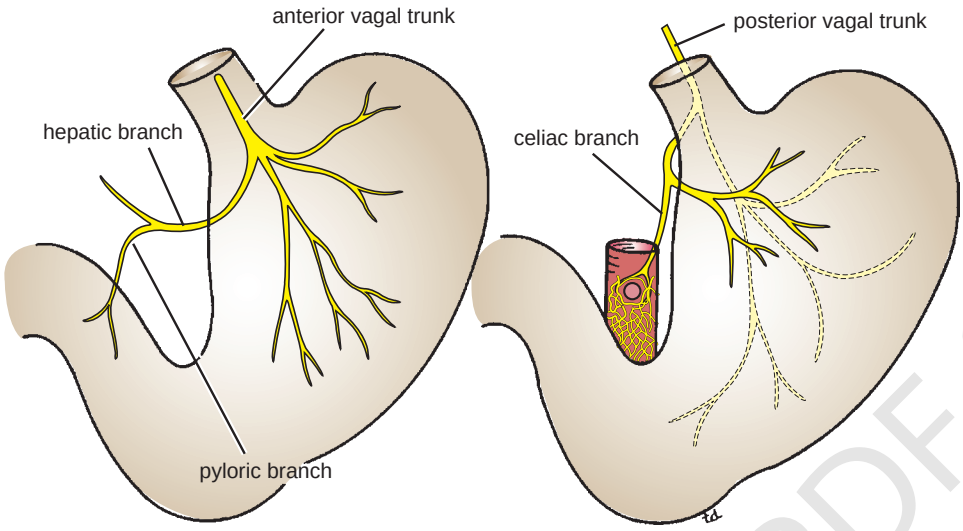


**FIGURE 5.24** Distribution of the anterior and posterior vagal trunks within the abdomen. Note that the celiac branch of the posterior vagal trunk is distributed with the sympathetic nerves as far down the intestinal tract as the left colic flexure.

## CLINICAL NOTES

### Trauma to the Stomach

Apart from its attachment to the esophagus at the cardiac orifice and its continuity with the duodenum at the pylorus, the stomach is relatively mobile. It is protected on the left by the lower part of the rib cage. These factors greatly protect the stomach from blunt trauma to the abdomen. However, its large size makes it vulnerable to gunshot wounds.

### Gastric Ulcer

The mucous membrane of the body of the stomach and, to a lesser extent, that of the fundus produce acid and pepsin. The secretion of the antrum and pyloric canal is mucous and weakly alkaline (Fig. 5.25). The secretion of acid and pepsin is controlled by two mechanisms: nervous and hormonal. The vagus nerves are responsible for the nervous control, and the hormone **gastrin,** produced by the antral mucosa, is responsible for the hormonal control. In the surgical treatment of chronic gastric and duodenal ulcers, attempts are made to reduce the amount of acid secretion by sectioning the vagus nerves (vagotomy) and by removing the gastrin-bearing area of mucosa, the antrum (partial gastrectomy).

Gastric ulcers occur in the alkaline-producing mucosa of the stomach, usually on or close to the lesser curvature. A chronic ulcer invades the muscular coats and, in time, involves the peritoneum so that the stomach adheres to neighboring structures. An ulcer situated on the posterior wall of the stomach may perforate into the lesser sac or become adherent to the pancreas. Erosion of the pancreas produces pain referred to the back. The splenic artery runs along the upper border of the pancreas, and erosion of this artery may produce fatal hemorrhage. A penetrating ulcer of the anterior stomach wall may result in the escape of stomach contents into the greater sac, producing diffuse peritonitis. The anterior stomach wall may, however, adhere to the liver, and the chronic ulcer may penetrate the liver substance.

### Gastric Pain

The sensation of pain in the stomach is caused by the stretching or spasmodic contraction of the smooth muscle in its walls and is referred to the epigastrium. It is believed that the pain-transmitting fibers leave the stomach in company with the sympathetic nerves. They pass through the celiac ganglia and reach the spinal cord via the greater splanchnic nerves.

### Cancer of the Stomach

Because the lymphatic vessels of the mucous membrane and submucosa of the stomach are in continuity, it is possible for cancer cells to travel to different parts of the stomach, some distance away from the primary site. Cancer cells also often pass through or bypass the local lymph nodes and are held up in the regional nodes. For these reasons, malignant disease of the stomach is treated by total gastrectomy, which includes the removal of the lower end of the esophagus and the first part of the duodenum; the spleen and the gastrosplenic and splenicorenal ligaments and their associated lymph nodes; the splenic vessels; the tail and body of the pancreas and their associated nodes; the nodes along the lesser curvature of the stomach; and the nodes along the greater curvature, along with the greater omentum. This radical operation is a desperate attempt to remove the stomach en bloc and, with it, its lymphatic field. The continuity of the gut is restored by anastomosing the esophagus with the jejunum.

### Gastroscopy

Gastroscopy is the viewing of the mucous membrane of the stomach through an illuminated tube fitted with a lens system. The patient is anesthetized, and the gastroscope is passed into the stomach, which is then inflated with air. With a flexible fiberoptic instrument, direct visualization of different parts of the gastric mucous membrane is possible. It is also possible to perform a mucosal biopsy through a gastroscope.

*(continued)*

### Nasogastric Intubation

Nasogastric intubation is a common procedure and is performed to empty the stomach, to decompress the stomach in cases of intestinal obstruction, or before operations on the gastrointestinal tract; it may also be performed to obtain a sample of gastric juice for biochemical analysis.

1. The patient is placed in the semiupright position or left lateral position to avoid aspiration.
2. The well-lubricated tube is inserted through the wider nostril and is directed backward along the nasal floor.
3. Once the tube has passed the soft palate and entered the oral pharynx, decreased resistance is felt, and the conscious patient will feel like gagging.
4. Some important distances in the adult may be useful. From the nostril (external nares) to the cardiac orifice of the stomach is about 17.2 in. (44 cm), and from the cardiac orifice to the pylorus of the stomach is 4.8 to 5.6 in. (12 to 14 cm). The curved course taken by the tube from the cardiac orifice to the pylorus is usually longer, 6.0 to 10.0 in. (15 to 25 cm) (see Fig. 3.51).

**Anatomic Structures That May Impede the Passage of the Nasogastric Tube**

- **A deviated nasal septum makes the passage of the tube difficult on the narrower side.**
- Three sites of esophageal narrowing may offer resistance to the nasogastric tube—at the beginning of the esophagus behind the cricoid cartilage (7.2 in. [18 cm]), where the left bronchus and the arch of the aorta cross the front of the esophagus (11.2 in. [28 cm]), and where the esophagus enters the stomach (17.2 in. [44 cm]). The upper esophageal narrowing may be overcome by gently grasping the wings of the thyroid cartilage and pulling the larynx forward. This maneuver opens the normally collapsed esophagus and permits the tube to pass down without further delay.

**Anatomy of Complications**

- The nasogastric tube enters the larynx instead of the esophagus.
- Rough insertion of the tube into the nose will cause nasal bleeding from the mucous membrane.
- Penetration of the wall of the esophagus or stomach. Always aspirate tube for gastric contents to confirm successful entrance into the stomach.

its upper border and the greater omentum attached to its lower border; the lesser sac lies behind this short segment. The remainder of the duodenum is retroperitoneal, being only partially covered by peritoneum.

## Parts of the Duodenum

The duodenum is situated in the epigastric and umbilical regions and, for purposes of description, is divided into four parts.

**First Part of the Duodenum** The first part of the duodenum begins at the pylorus and runs upward and backward on the transpyloric plane at the level of the 1st lumbar vertebra (Figs. 5.26 and 5.27).

The relations of this part are as follows:

- **Anteriorly:** The quadrate lobe of the liver and the gallbladder (Fig. 5.10)
- **Posteriorly:** The lesser sac (first inch only), the gastroduodenal artery, the bile duct and the portal vein, and the inferior vena cava (Fig. 5.27)

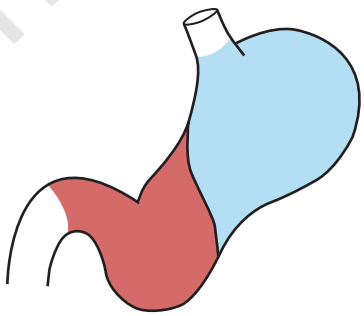

**FIGURE 5.25** Areas of the stomach that produce acid and pepsin (*blue*) and alkali and gastrin (*red*).

- **Superiorly:** The entrance into the lesser sac (the epiploic foramen) (Figs. 5.7 and 5.11)
- **Inferiorly:** The head of the pancreas (Fig. 5.26)

**Second Part of the Duodenum** The second part of the duodenum runs vertically downward in front of the hilum of the right kidney on the right side of the 2nd and 3rd lumbar vertebrae (Figs. 5.26 and 5.27). About halfway down its medial border, the bile duct and the main pancreatic duct pierce the duodenal wall. They unite to form the ampulla that opens on the summit of the major duodenal papilla (Fig. 5.28). The accessory pancreatic duct, if present, opens into the duodenum a little higher up on the minor duodenal papilla (Figs. 5.27 and 5.28).

The relations of this part are as follows:

- **Anteriorly:** The fundus of the gallbladder and the right lobe of the liver, the transverse colon, and the coils of the small intestine (Fig. 5.29)
- **Posteriorly:** The hilum of the right kidney and the right ureter (Fig. 5.27)
- **Laterally:** The ascending colon, the right colic flexure, and the right lobe of the liver (Fig. 5.27)
- **Medially:** The head of the pancreas, the bile duct, and the main pancreatic duct (Figs. 5.27 and 5.28)

**Third Part of the Duodenum** The third part of the duodenum runs horizontally to the left on the subcostal plane, passing in front of the vertebral column and following the lower margin of the head of the pancreas (Figs. 5.26 and 5.27).

The relations of this part are as follows:

- **Anteriorly:** The root of the mesentery of the small intestine, the superior mesenteric vessels contained within it, and coils of jejunum (Figs. 5.26 and 5.27)

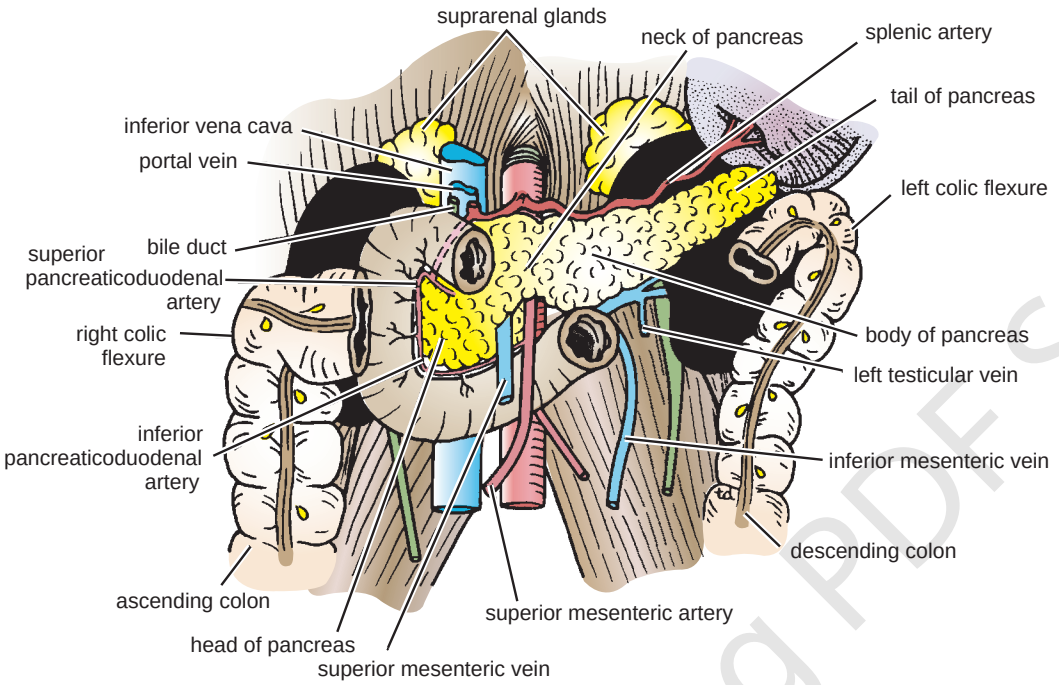


**FIGURE 5.26** Pancreas and anterior relations of the kidneys.

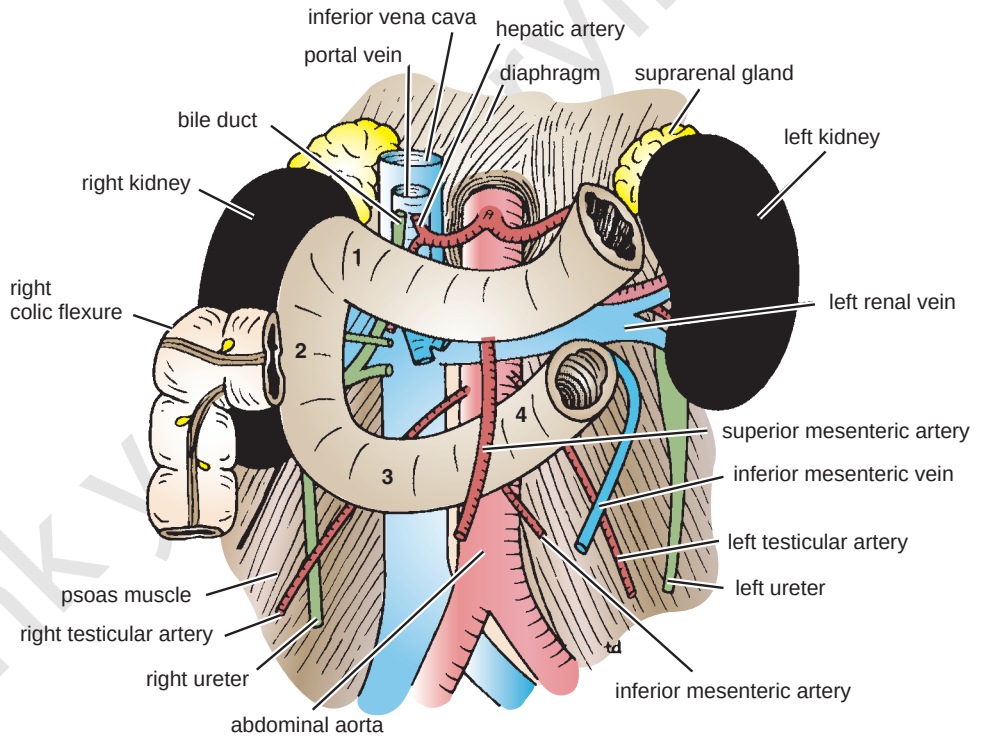


**FIGURE 5.27** Posterior relations of the duodenum and the pancreas. The numbers represent the four parts of the duodenum.

- **Posteriorly:** The right ureter, the right psoas muscle, the inferior vena cava, and the aorta (Fig. 5.27)
- **Superiorly:** The head of the pancreas (Fig. 5.26)
- **Inferiorly:** Coils of jejunum

**Fourth Part of the Duodenum** The fourth part of the duodenum runs upward and to the left to the **duodenojejunal flexure** (Figs. 5.26 and 5.27). The flexure is held in position by a peritoneal fold, the **ligament of Treitz,** which is attached to the right crus of the diaphragm (Fig. 5.12). The relations of this part are as follows:

- **Anteriorly:** The beginning of the root of the mesentery and coils of jejunum (Fig. 5.30)

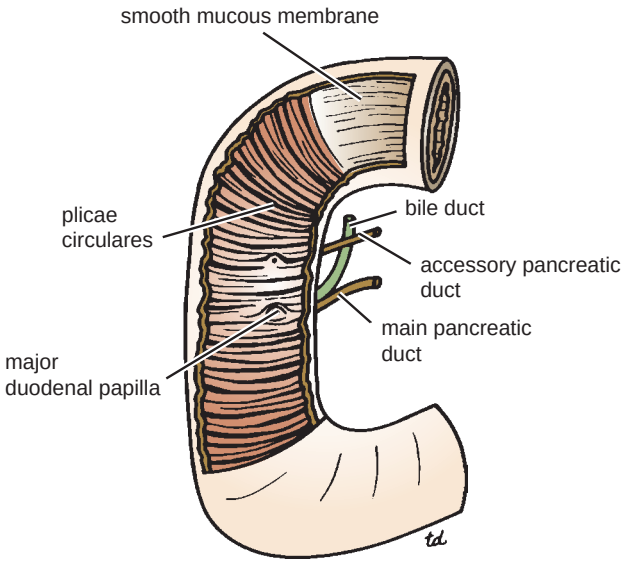


**FIGURE 5.28** Entrance of the bile duct and the main and accessory pancreatic ducts into the second part of the duodenum. Note the smooth lining of the first part of the duodenum, the plicae circulares of the second part, and the major duodenal papilla.

- **Posteriorly:** The left margin of the aorta and the medial border of the left psoas muscle (Fig. 5.27)

### Mucous Membrane and Duodenal Papillae

The **mucous membrane** of the duodenum is thick. In the first part of the duodenum, it is smooth (Fig. 5.28). In the remainder of the duodenum, it is thrown into numerous circular folds called the **plicae circulares.** At the site where the bile duct and the main pancreatic duct pierce the medial wall of the second part is a small, rounded elevation called the **major duodenal papilla** (Fig. 5.28). The accessory pancreatic duct, if present, opens into the duodenum on a smaller papilla about 0.75 in. (1.9 cm) above the major duodenal papilla.

### Blood Supply

**Arteries** The upper half is supplied by the superior pancreaticoduodenal artery, a branch of the gastroduodenal artery (Figs. 5.20 and 5.26). The lower half is supplied by the inferior pancreaticoduodenal artery, a branch of the superior mesenteric artery.

**Veins** The superior pancreaticoduodenal vein drains into the portal vein; the inferior vein joins the superior mesenteric vein (Fig. 5.22).

### Lymph Drainage

The lymph vessels follow the arteries and drain upward via pancreaticoduodenal nodes to the gastroduodenal nodes and then to the celiac nodes and downward via pancreaticoduodenal nodes to the superior mesenteric nodes around the origin of the superior mesenteric artery.

### Nerve Supply

The nerves are derived from sympathetic and parasympathetic (vagus) nerves from the celiac and superior mesenteric plexuses.

## Jejunum and Ileum

### Location and Description

The jejunum and ileum measure about 20 ft (6 m) long; the upper two fifths of this length make up the jejunum. Each has distinctive features, but there is a gradual change from one to the other. The jejunum begins at the duodenojejunal flexure, and the ileum ends at the ileocecal junction.

The coils of jejunum and ileum are freely mobile and are attached to the posterior abdominal wall by a fan-shaped fold of peritoneum known as the **mesentery of the small**

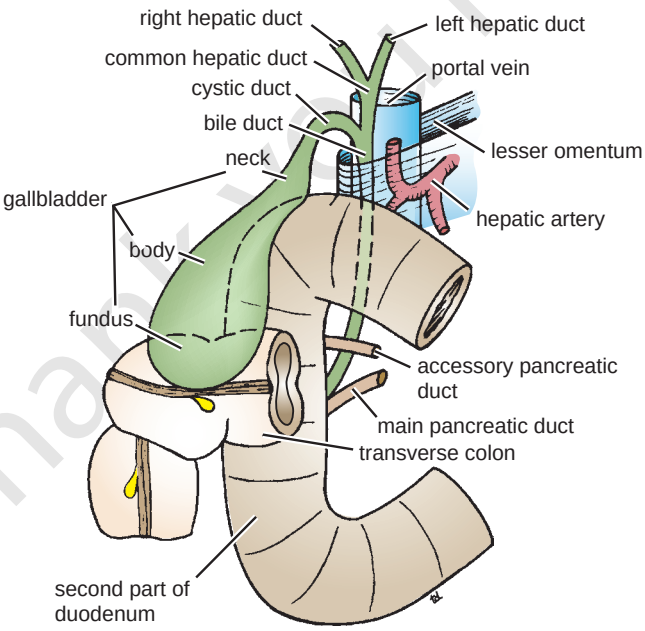


**FIGURE 5.29** The bile ducts and the gallbladder. Note the relation of the gallbladder to the transverse colon and the duodenum.

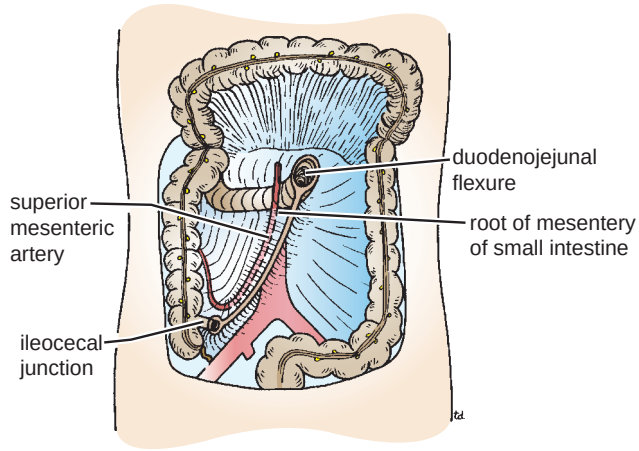


**FIGURE 5.30** Attachment of the root of the mesentery of the small intestine to the posterior abdominal wall. Note that it extends from the duodenojejunal flexure on left of the aorta, downward, and to the right to the ileocecal junction. The superior mesenteric artery lies in the root of the mesentery.

## CLINICAL NOTES

### Trauma to the Duodenum

Apart from the first inch, the duodenum is rigidly fixed to the posterior abdominal wall by peritoneum and therefore cannot move away from crush injuries. In severe crush injuries to the anterior abdominal wall, the third part of the duodenum may be severely crushed or torn against the third lumbar vertebra.

### Duodenal Ulcer

As the stomach empties its contents into the duodenum, the acid chyme is squirted against the anterolateral wall of the first part of the duodenum. This is thought to be an important factor in the production of a duodenal ulcer at this site. An ulcer of the anterior wall of the first inch of the duodenum may perforate into the upper part of the greater sac, above the transverse colon. The transverse colon directs the escaping fluid into the right lateral paracolic gutter and thus down to the right iliac fossa. The differential diagnosis between a perforated duodenal ulcer and a perforated appendix may be difficult.

An ulcer of the posterior wall of the first part of the duodenum may penetrate the wall and erode the relatively large gastroduodenal artery, causing a severe hemorrhage.

The gastroduodenal artery is a branch of the hepatic artery, a branch of the celiac trunk (Fig. 5.4).

### Duodenal Recesses

The importance of the duodenal recesses and the occurrence of herniae of the intestine were already alluded to on page 163.

### Important Duodenal Relations

The relation to the duodenum of the gallbladder, the transverse colon, and the right kidney should be remembered. Cases have been reported in which a large gallstone ulcerated through the gallbladder wall into the duodenum. Operations on the colon and right kidney have resulted in damage to the duodenum.

**intestine** (Fig. 5.30). The long free edge of the fold encloses the mobile intestine. The short root of the fold is continuous with the parietal peritoneum on the posterior abdominal wall along a line that extends downward and to the right from the left side of the 2nd lumbar vertebra to the region of the right sacroiliac joint. The root of the mesentery permits the entrance and exit of the branches of the superior mesenteric artery and vein, lymph vessels, and nerves into the space between the two layers of peritoneum forming the mesentery.

In the living, the jejunum can be distinguished from the ileum by the following features:

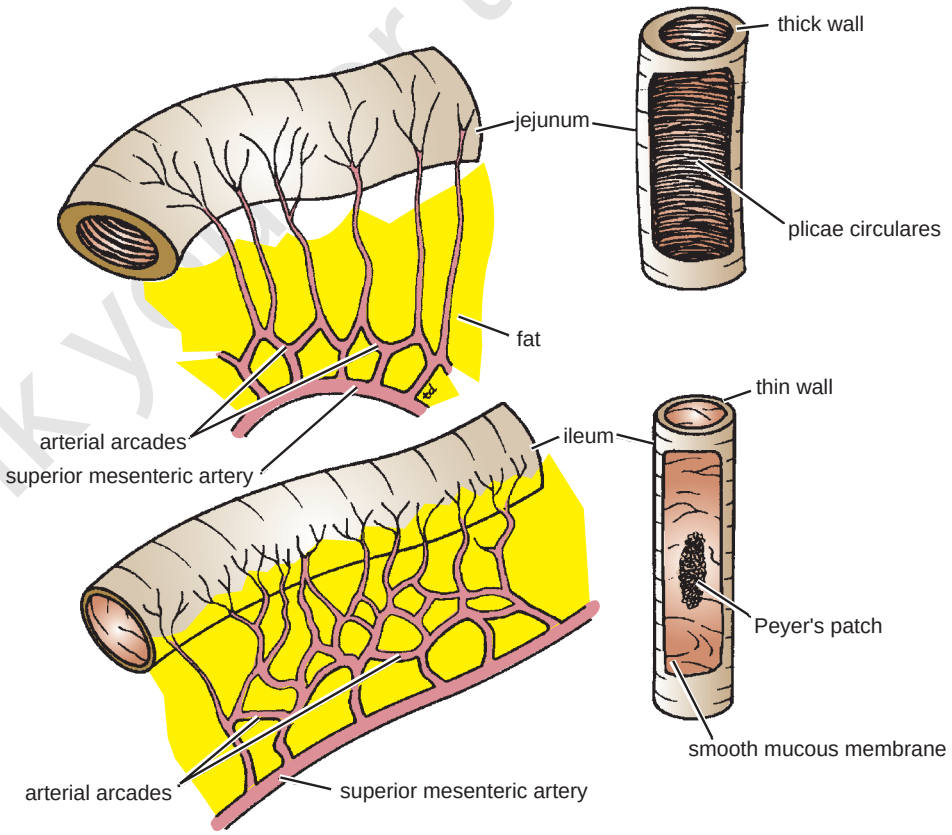


**FIGURE 5.31** Some external and internal differences between the jejunum and the ileum.

- The jejunum lies coiled in the upper part of the peritoneal cavity below the left side of the transverse mesocolon; the ileum is in the lower part of the cavity and in the pelvis (Fig. 5.3).
- The jejunum is wider bored, thicker walled, and redder than the ileum. The jejunal wall feels thicker because the permanent infoldings of the mucous membrane, the plicae circulares, are larger, more numerous, and closely set in the jejunum, whereas in the upper part of the ileum they are smaller and more widely separated and in the lower part they are absent (Fig. 5.31).
- The jejunal mesentery is attached to the posterior abdominal wall above and to the left of the aorta, whereas the ileal mesentery is attached below and to the right of the aorta.
- The jejunal mesenteric vessels form only one or two arcades, with long and infrequent branches passing to the intestinal wall. The ileum receives numerous short terminal vessels that arise from a series of three or four or even more arcades (Fig. 5.31).
- At the jejunal end of the mesentery, the fat is deposited near the root and is scanty near the intestinal wall. At the ileal end of the mesentery, the fat is deposited throughout so that it extends from the root to the intestinal wall (Fig. 5.31).
- Aggregations of lymphoid tissue (Peyer's patches) are present in the mucous membrane of the lower ileum along the antimesenteric border (Fig. 5.31). In the living, these may be visible through the wall of the ileum from the outside.

## Blood Supply

**Arteries** The arterial supply is from branches of the superior mesenteric artery (Fig. 5.32). The intestinal branches arise from the left side of the artery and run in the mesentery to reach the gut. They anastomose with one another to form a series of arcades. The lowest part of the ileum is also supplied by the ileocolic artery.

**Veins** The veins correspond to the branches of the superior mesenteric artery and drain into the superior mesenteric vein (Fig. 5.22).

## Lymph Drainage

The lymph vessels pass through many intermediate mesenteric nodes and finally reach the superior mesenteric nodes, which are situated around the origin of the superior mesenteric artery.

## Nerve Supply

The nerves are derived from the sympathetic and parasympathetic (vagus) nerves from the superior mesenteric plexus.

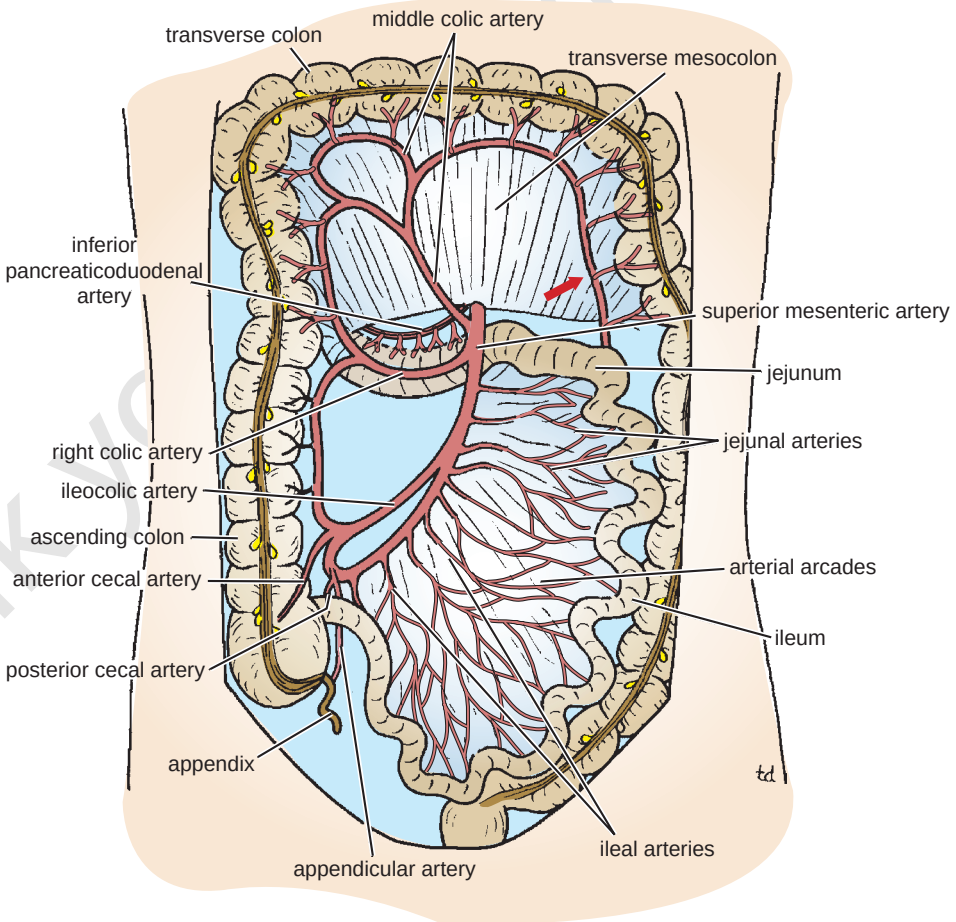


**FIGURE 5.32** Superior mesenteric artery and its branches. Note that this artery supplies blood to the gut from halfway down the second part of the duodenum to the distal third of the transverse colon (*arrow*).