Pancreatic and Biliary Secretions

When gastric contents empty into the duodenum, they are mixed not only with juice secreted by the small-intestine mucosa, but also with the secretions of the exocrine pancreas and liver that are released into the duodenum.

The pancreas

The **pancreas** is an elongated gland that lies behind and below the stomach, above the first loop of the duodenum . This mixed gland contains both exocrine and endocrine tissue. The exocrine part consists of secretory cells known as **acini**, which connect to ducts that empty into the duodenum.

The smaller endocrine part consists of the **islets of Langerhans**, which are dispersed throughout the pancreas. The most important hormones secreted by the islet cells are insulin and glucagon.

The exocrine pancreas secretes a pancreatic juice consisting of two components:

(1) *pancreatic enzymes* actively secreted by the *acinar cells* that form the acini

(2) an *aqueous alkaline solution* actively secreted by the *duct cells* that line the pancreatic ducts. The aqueous (watery) alkaline component is rich in sodium bicarbonate (NaHCO3).

The acinar cells secrete three types of **pancreatic enzymes** :-

(1) *proteolytic enzymes* (**trypsin,chymotrypsin and carboxypeptidase**) for protein digestion,

(2) *pancreatic amylase* for carbohydrate digestion

(3) *pancreatic lipase* for fat digestion.

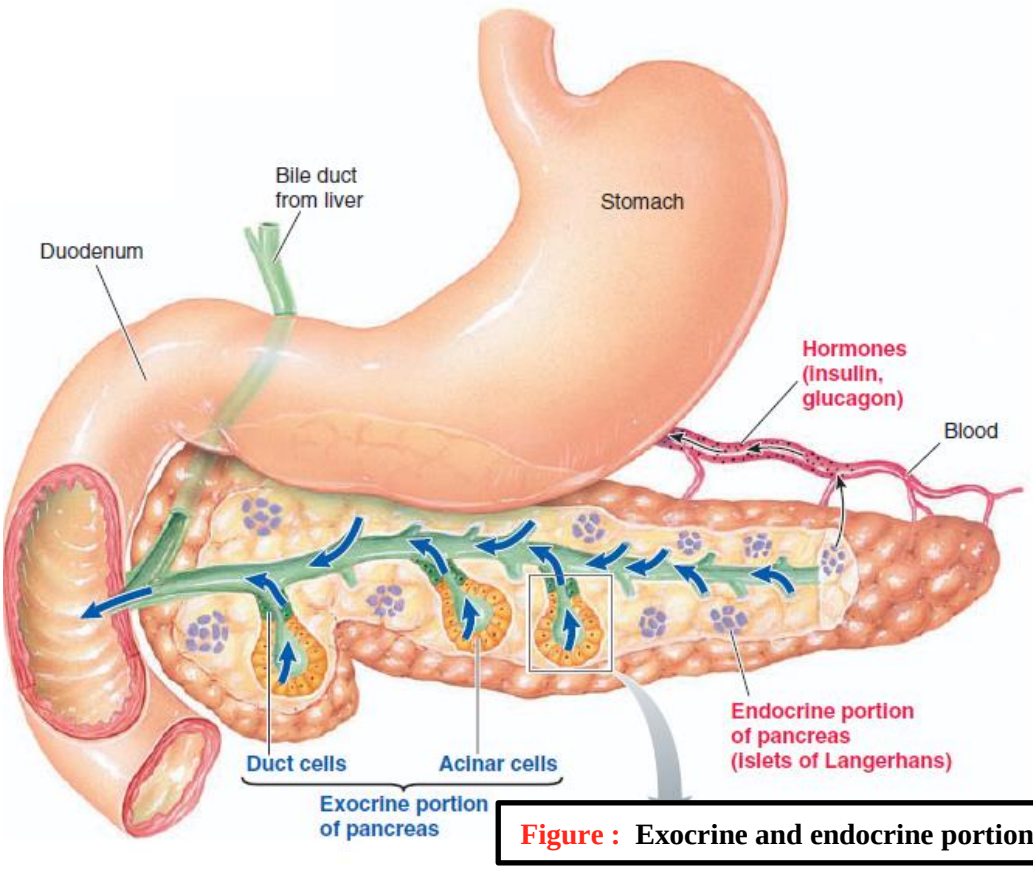


Figure : **Exocrine and endocrine portions of the pancreas.**

Pancreatic Aqueous Alkaline Secretion

Pancreatic enzymes function best in a neutral or slightly alkaline environment, yet the highly acidic gastric contents empty into the duodenum in the vicinity of pancreatic enzyme entry into the duodenum.

This acidic chyme must be neutralized enters the duodenum, so the amount of $NaHCO_3$ secreted parallels duodenal acidity.

The liver

Besides pancreatic juice, the other secretory product emptied into the duodenal lumen is **bile**. The **biliary system** includes the *liver*, the *gallbladder*, and associated ducts.

Liver Functions

The **liver** is the largest and most important metabolic organ in the body; it can be viewed as the body's major biochemical factory. Its functions include the following:

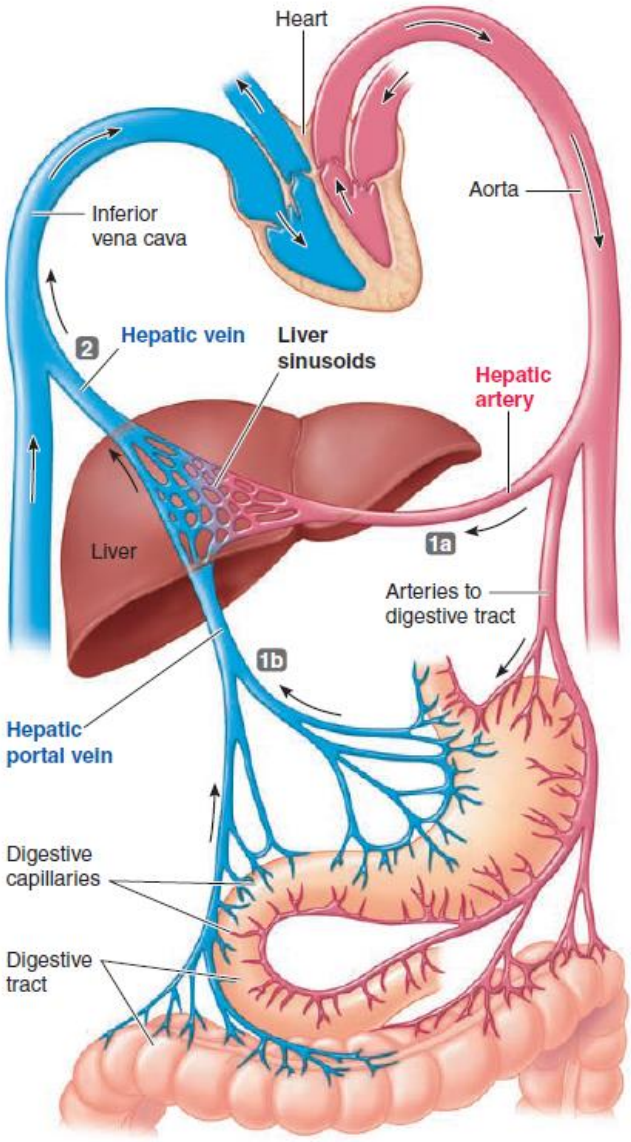
1. **Secretion of *bile salts***, which aid fat digestion and absorption. This is the only liver function directly related to digestion.
2. **Metabolic processing** of the major categories of nutrients after their absorption from the digestive tract
3. **Detoxifying** or degrading body wastes and hormones, as well as drugs and other foreign compounds
4. **Synthesizing** plasma proteins, including those needed for blood clotting , those that transport steroid and thyroid hormones and cholesterol in the blood
5. **Storing** glycogen, fats, iron, copper, and many vitamins
6. **Activating vitamin D**, which the liver does in conjunction with the kidneys
7. **Secreting the hormones** , such as thrombopoietin (stimulates platelet Production)
8. Producing acute phase proteins important in **inflammation**
9. **Excreting** cholesterol and bilirubin
10. Removing bacteria and worn-out red blood cells, thanks to its resident macrophages.

Given this range of complex functions, there is amazingly little specialization among cells within the liver. Each liver cell, or **hepatocyte**, performs the same wide variety of metabolic and secretory tasks (*hepato* means "liver"; *cyte* means "cell").

Liver Blood Flow

To carry out these wide-ranging tasks, the anatomic organization of the liver permits each hepatocyte to be in direct contact with blood from two sources: arterial blood coming from the heart and venous blood coming directly from the digestive tract. Like other cells, the hepatocytes receive fresh arterial blood via the hepatic artery, which supplies their oxygen and delivers blood-borne metabolites for hepatic processing processing.

Venous blood also enters the liver by the **hepatic portal system**, a unique and complex vascular connection between the digestive tract and the liver from the stomach and intestine enter the *hepatic portal vein*.



Bile is continuously secreted by the liver and is diverted to the gallbladder between meals.

The liver continuously secretes bile, even between meals. The opening of the bile duct into the duodenum is guarded by the **sphincter of Oddi**, which prevents bile from entering the duodenum except during digestion of meals. When this sphincter is closed, bile secreted by the liver hits the closed sphincter and is diverted back up into the **gallbladder**, a small, saclike structure tucked beneath but not directly connected to the liver.

Bile is subsequently stored and concentrated in the gallbladder between meals.

Bile contains several organic constituents, namely, *bile salts*, *cholesterol*, *lecithin*, and *bilirubin* it is important for the digestion and absorption of fats, primarily through the activity of bile salts.

Small Intestine

The **small intestine** is the site where most digestion and absorption takes place. The small intestine lies coiled within the abdominal cavity, extending between the stomach and the large intestine. It is arbitrarily divided into three segments—the **duodenum**, the **jejunum**, and the **ileum**.

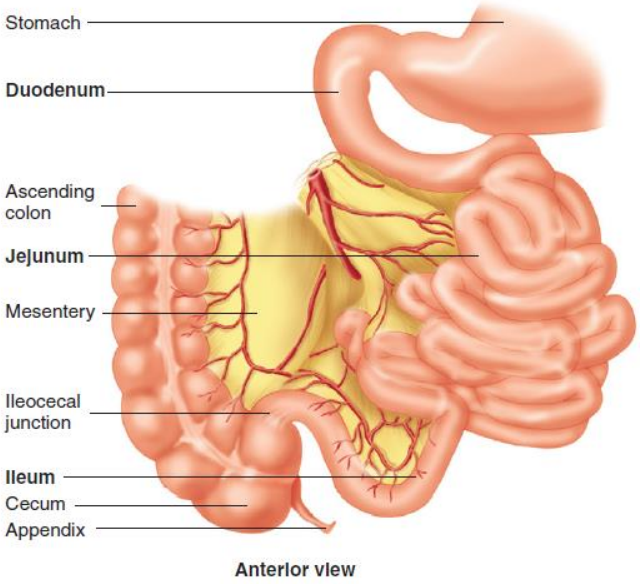


FIGURE 24.15 APR Small Intestine

The small intestine is remarkably well adapted for its primary role in absorption.

All products of carbohydrate, protein, and fat digestion, and most of the ingested electrolytes, vitamins, and water, are normally absorbed by the small intestine. Usually, only the absorption of calcium and iron is adjusted to the body's needs. Thus, the more food consumed, the more that is digested and absorbed.

Most absorption occurs in the duodenum and jejunum; very little occurs in the ileum, not because the ileum does not have absorptive capacity but because most absorption has already been accomplished before the intestinal contents reach the ileum.

Adaptations that Increase the Small Intestine's Surface Area

The following special modifications of the small-intestine mucosa greatly increase the surface area available for absorption:

■ The inner surface of the small intestine is thrown into permanent **circular folds** that are visible to the naked eye and increase the surface area threefold.

■ Extending from this folded surface are microscopic, fingerlike projections known as **villi**, which give the lining a velvety appearance and increase the surface area another 10 times. The surface of each villus is covered by epithelial cells interspersed occasionally with mucous cells.

■ Even smaller hairlike projections, the *microvilli* or *brush border*, arise from the luminal surface of these epithelial cells, increasing the surface area another 20-fold. Each epithelial cell has as many as 3000 to 6000 of these microvilli, which are visible only with an electron microscope. The small-intestine enzymes perform their functions within the membrane of this brush border.

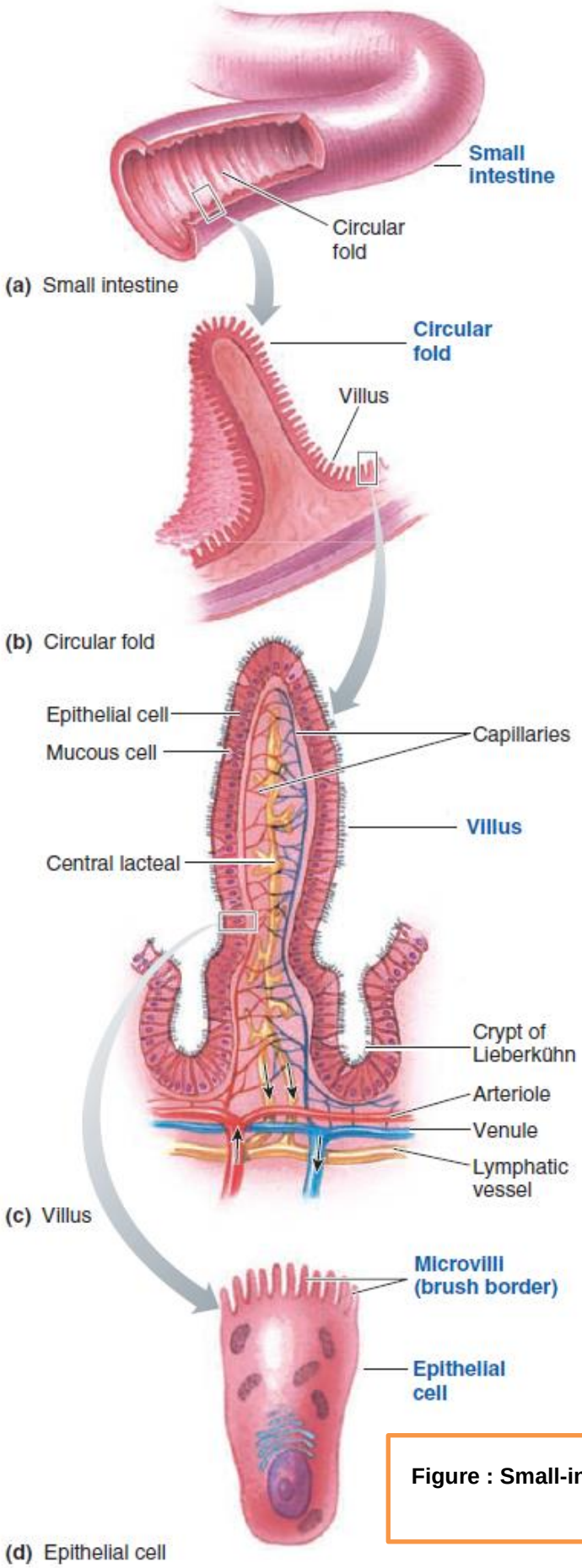


Figure : Small-intestine absorptive surface

Large Intestine

The **large intestine** consists of the colon, cecum, appendix, and rectum. The **cecum** forms a blind-ended pouch below the junction of the small and large intestines at the ileocecal valve. The small, fingerlike projection at the bottom of the cecum is the **appendix**, a lymphoid tissue that houses lymphocytes. The **colon**, which makes up most of the large intestine, is not coiled like the small intestine but consists of three relatively straight parts—the *ascending colon*, the *transverse colon*, and the *descending colon*. The end part of the descending colon becomes S shaped, forming the *sigmoid colon*, and then straightens out to form the rectum.

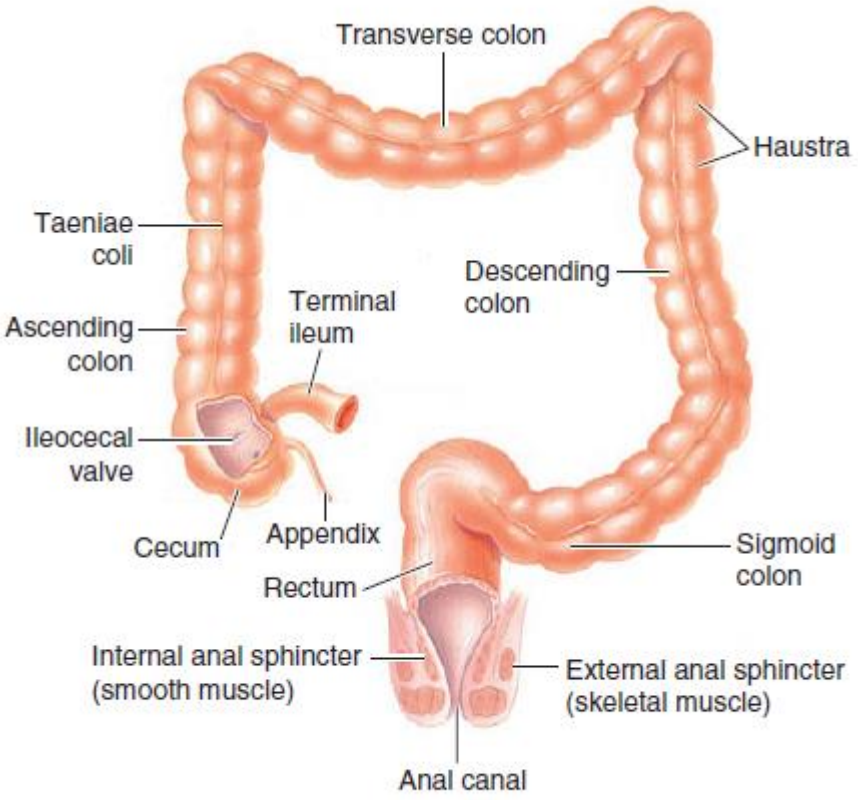


Figure 16-26 Anatomy of the large intestine.

The large intestine is primarily a drying and storage organ.

The colon normally receives about 500 mL of chyme from the small intestine each day. Because most digestion and absorption have been accomplished in the small intestine, the contents delivered to the colon consist of indigestible food residues (such as cellulose), unabsorbed biliary components, and the remaining fluid. The colon removes more H2O and salt, drying and compacting the contents to form a firm mass known as **feces** for elimination from the body. The primary function of the large intestine is to store feces before defecation.