

- *digestion* – the process of enzymatic digestion, which began in the stomach, is completed in the small intestine
- *absorption* – the small intestine is the region where most nutrients and other materials are absorbed.

The small intestine is divided into the duodenum, which is 200–300 mm in length, the jejunum, which is approximately 2 m in length, and the ileum, which is approximately 3 m in length.

The wall of the small intestine has a rich network of both blood and lymphatic vessels. The gastrointestinal circulation is the largest systemic regional vasculature and nearly a third of the cardiac output flows through the gastrointestinal viscera. The blood vessels of the small intestine receive blood from the superior mesenteric artery via branched arterioles. The blood leaving the small intestine flows into the hepatic portal vein that carries it via the liver to the systemic circulation. Drugs that are metabolized by the liver are degraded before they reach the systemic circulation; this is termed *hepatic presystemic clearance* or *first-pass metabolism*.

The wall of the small intestine also contains lacteals, which contain lymph and are part of the lymphatic system. The lymphatic system is important in the absorption of fats from the gastrointestinal tract. In the ileum there are areas of aggregated lymphoid tissue close to the epithelial surface which are known as Peyer's patches (named after the 17th century Swiss anatomist Johann Peyer). These cells play a key role in the immune response as they transport macromolecules and are involved in antigen uptake.

The surface area of the small intestine is increased enormously, by about 600 times that of a simple cylinder, to approximately 200 m² in an adult, by several adaptations which make the small intestine such a good absorption site:

- *Folds of Kerckring* – these are submucosal folds which extend circularly most of the way around the intestine and are particularly well developed in the duodenum and jejunum. They are several millimetres in depth.
- *Villi* – these have been described as finger-like projections into the lumen (approximately 0.5–1.5 mm in length and 0.1 mm in diameter). They are well supplied with blood vessels. Each villus contains an arteriole, a venule and a blind-ending lymphatic vessel (lacteal). The structure of a villus is shown in Figure 19.5.

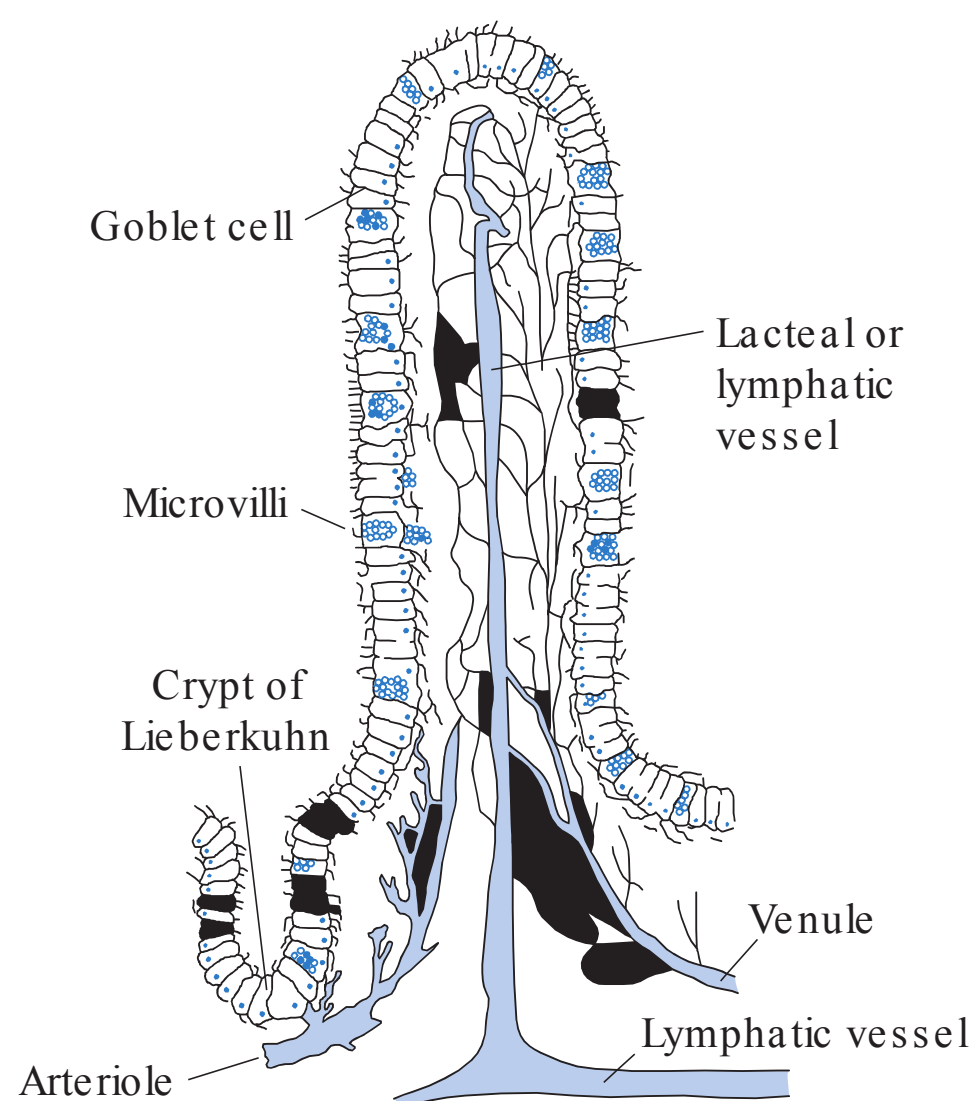


Fig. 19.5 • Structure of a villus.

- *Microvilli* – 600–1000 of these brush-like structures (~ 1 μm in length and 0.1 μm in width) cover each villus, providing the largest increase in surface area. These are covered by a fibrous substance known as glycocalyx.

The luminal pH of the small intestine increases to between 6 and 7.5. Sources of secretions that produce these pH values in the small intestine are:

- *Brunner's glands* – these are located in the duodenum and are responsible for the secretion of bicarbonate, which neutralizes the acid emptied from the stomach.
- *Intestinal cells* – these are present throughout the small intestine and secrete mucus and enzymes. The enzymes, hydrolases and proteases, continue the digestive process.
- *Pancreatic secretions* – the pancreas is a large gland that secretes about 1–2 L of pancreatic juice per day into the small intestine via a duct. The components of pancreatic juice are sodium bicarbonate and enzymes. The enzymes consist of proteases, principally trypsin, chymotrypsin and carboxypeptidases, which are secreted as inactive precursors or zymogens and are converted to their active forms in the lumen by the enzyme enterokinase. Lipase and amylase are both secreted in their active forms. The bicarbonate component is largely regulated by the pH of chyme delivered into the small intestine from the stomach.