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 **MICROANATOMY OF THE SMALL INTESTINE**

The small intestine is the part of the gastrointestinal tract that follows the stomach, which is in turn followed by the large intestine. The small intestine is the site where almost all of the digestion and absorption of nutrients and minerals from food takes place.The average length of the small intestine in an adult human male is 6.9 m (22 feet, 6 inches), and in the adult female 7.1 m (23 feet, 4 inches). It can vary greatly, from as short as 4.6 m (15 feet) to as long as 9.8 m (32 feet). As the small intestine is the main site for the final stages of food digestion and its absorption, its gross and microanatomy are adjusted to that function.

The small intestine is approximately 2.5–3 cm in diameter, and is divided into three sections: All three parts are covered with the greater omentumanteriorly. The duodenum has both intraperitoneal and retroperitoneal parts, while the jejunum and ileum are entirely intraperitoneal organs.

1. **The duodenum**

The duodenumby definition is the first part of the small intestine, the shortest part of the small intestine. It extends from the pyloric sphincter of the **stomach**, wraps around the head of the **pancreas** in a C-shape and ends at duodenojejunalflexure. This flexure is attached to the posterior abdominal wall by a **peritoneal fold** called the suspensory muscle (ligament) of duodenum, also called the **ligament of Treitz**. It is where most chemical digestion using enzymes takes place.

The duodenum has four parts: superior (duodenal bulb/ampulla), descending, horizontal and ascending.

* The superior part (duodenal bulb/ampulla) is the only **intraperitoneal**part, as the hepatoduodenal ligament and greater omentum attach to it.
* The descending part of the duodenum has an opening called the **major duodenal papilla** (tubercle of Vater). The papilla contains the hepatopancreatic sphincter (sphincter of Oddi, Glissons’ sphincter) which regulates the emptying of the bile from the hepatopancreatic ampulla.
1. **The jejunum**

This is the middle section of the small intestine. It has a lining which is designed to absorb carbohydrates and proteins. The inner surface of the jejunum, its mucous membrane, is covered in projections called villi, which increase the surface area of tissue available to absorb nutrients from the gut contents. The epithelial cells which line these villi possess even larger numbers of microvilli. The transport of nutrients across epithelial cells through the jejunum includes the passive transport of some carbohydrates and the active transport of amino acids, small peptides, vitamins, and most glucose. The villi in the jejunum are much longer than in the duodenum or ileum.

 There is no clear line of demarcation between the jejunum and ileum, but there are some anatomical and histological differences that distinguish them:

* The jejunum represents the proximal two-fifths of the jejunum-ileum continuum
* The wall of the jejunum is thicker and its lumen is wider than in ileum
* The jejunum contains more prominent circular folds of Kerckring
1. **The ileum**

The ileum is the final section of the small intestine. The function of the ileum is mainly to absorb vitamin B12, bile salts, and any products of digestion that were not absorbed by the jejunum. The wall itself is made up of folds, each of which has many tiny finger-like projections known as villi on its surface. The ileum has an extremely large surface area both for the adsorption of enzyme molecules and for the absorption of products of digestion.

At the ileocecal junction, the lamina muscularis of the ileum protrudes into the lumen of the cecum forming a structure called the **ileocecal fold**. These muscular fibers form a muscular ring within the fold called the ileocecal sphincter which controls the emptying of ileal content into the large intestine.

 **LAYERS OF THE SMALL INTESTINE**

The small intestine has four tissue layers:

1. **The serosa or Adventitia** is the outermost layer of the intestine. The serosa is a smooth membrane consisting of a thin layer of cells that secrete serous fluid, and a thin layer of connective tissue. Serous fluid is a lubricating fluid that reduces friction from the movement of the muscularis. Comprised of loosely arranged fibroblasts and collagen, with the vessels and nerves passing through it. The majority of the small intestine adventitia is covered by mesothelium..
2. **The muscularis externa** is a region of muscle adjacent to the submucosa membrane. It is responsible for gut movement, or peristalsis. It usually has two distinct layers of smooth muscle:the inner circular and outer longitudinal layers with myenteric plexus lying between them.
3. **The submucosa** is the layer of dense, irregular connective tissue or loose connective tissue that supports the mucosa, as well as joins the mucosa to the bulk of underlying smooth muscle. It contains blood vessels, lymphatics and the submucousa plexus
4. **The mucosa** is the innermost tissue layer of the small intestines, and is a mucous membrane that secretes digestive enzymes and hormones. The intestinal villi are part of the mucosa. It has 3 layers; the epithelium, lamina propria, and muscularis mucosae.

The three sections of the small intestine look similar to each other at a microscopic level, but there are some important differences. The jejunum and ileum do not have Brunner’s glands in the submucosa, while the ileum has Peyer’s patches in the mucosa, but the duodenum and jejunum do not.

**Brunner’s Glands**

Brunner’s glands (or duodenal glands) are compound tubular submucosal glands found in the duodenum. The main function of these glands is to produce a mucus-rich, alkaline secretion (containing bicarbonate) in order to neutralize the acidic content of chyme that is introduced into the duodenum from the stomach, and to provide an alkaline condition for optimal intestinal enzyme activity, thus enabling absorption to take place and lubricate the intestinal walls.

**Peyer’s Patches**

Peyer’s patches are organized lymph nodules. They are aggregations of lymphoid tissue that are found in the lowest portion of the small intestine, which differentiate the ileum from the duodenum and jejunum.

Because the lumen of the gastrointestinal tract is exposed to the external environment, much of it is populated with potentially pathogenic microorganisms. Peyer’s patches function as the immune surveillance system of the intestinal lumen and facilitate the generation of the immune response within the mucosa.

**Intestinal Villi**

Intestinal villi (singular: villus) are tiny, finger-like projections that protrude from the epithelial lining of the mucosa. Each villus is approximately 0.5–1.6 mm in length and has many microvilli (singular: microvillus), each of which are much smaller than a single villus.

Villi increase the internal surface area of the intestinal walls. This increased surface area allows for more intestinal wall area to be available for absorption. An increased absorptive area is useful because digested nutrients (including sugars and amino acids) pass into the villi, which is semi-permeable, through diffusion, which is effective only at short distances.

In other words, the increased surface area (in contact with the fluid in the lumen) decreases the average distance traveled by the nutrient molecules, so the effectiveness of diffusion increases.The villi are connected to blood vessels that carry the nutrients away in the circulating blood.

## **CELLS OF THE EPITHELIUM**

## The epithelium of the small intestine lines the luminal surface. There are a number of components to the epithelium:

* **Enterocytes**:- Tall columnar cells, which have an absorptive function. They contain brush border enzymes on the surface which have an important digestive function.
* **Goblet cells**:- Exocrine glands which secrete mucin.
* **Crypts of Lieberkuhn:-** The Crypts of Lieberkuhn are glands found in the epithelial lining. They contain numerous cells such as stem cells to produce new cells to replenish the cells lost due to abrasion, as well as**enteroendocrine cells**to synthesise and secrete hormones.

To protect from pathogens, there are **Paneth cells** which secrete protective agents (such as defensins and lyzozymes) and Peyer’s patches which are only found in the ilium. Peyer’s patches contain mucosal-associated lymphatic tissue (MALT) which house white blood cells and lymphocytes. These cells can produce antibodies to further protect the small intestine from infection.

**Enteroendocrine Cells**

The enteroendocrine cells are located within the Crypts of Lieberkuhn. They secrete hormones in response to various stimuli. There are four main classes of enteroendocrine cell, each with a different secretory product. These are I cells, S cells, K cells and enterochromaffin cells.

I Cells secrete Cholecystokinin **(CCK)** in response to the presence of fat in the small intestine. CCK stimulates the contraction of the gallbladder (which pushes bile out into the cystic duct) and the release of pancreatic enzymes. Both bile and pancreatic enzymes have a key role in lipid digestion.

S Cells secrete Secretin in response to the low pH of chyme in the small intestine. Secretin induces HCO3–secretion from the pancreas and inhibits gastric emptying.

K Cells secrete Gastric-Inhibitory Peptide **(GIP),** in response to chyme entering the small intestine. GIP has a misleading name as it actually stimulates insulin release, ready to put the newly digested carbohydrates into cells for storage.

Finally, **Enterochromaffin Cells**are mechanically stimulated by the presence of chyme in the small intestine. They release serotonin, which acts on the enteric nervous system to activate the cystic fibrosis transmembrane regulators (CFTR). This ion channel secretes Cl– ions into the intestinal lumen, with Na+ions and H2O following.  Na+ is required in the lumen for the absorption of a number of nutrients.

 **MICROANATOMY OF THE LATGE INTESTINE**

The large intestine, also known as the colon or large bowel, represents the last part of the gastrointestinal tract. Spanning the abdominal and pelvic cavities, it has a length of approximately 1.5 meters. The large intestine is composed of 4 parts. It includes the cecum and ascending colon, transverse colon, descending colon and sigmoid colon. It starts in the right iliac region of the pelvis, just at or below the right waist, where it is joined to the bottom end of the small intestine (cecum). From here it continues up the abdomen (ascending colon), then across the width of the abdominal cavity (transverse colon), and then it turns down (descending colon), continuing to its endpoint at the anus (sigmoid colon to rectum to anus). The large intestine is about 4.9 feet (1.5 m) long—about one-fifth of the whole length of the intestinal canal.

**THE CECUM**

The cecum is the first part of the large intestine, lying in the **right iliac fossa** of the [abdomen](https://www.kenhub.com/en/library/anatomy/abdomen-and-pelvis). The cecum is intraperitoneal with various folds and pockets (**retrocecal peritoneal recesses**) surrounding it.The terminal ileum joins the cecum at the **ileocolic junction**. The ileocecal orifice is marked by the **ileal papilla**, which consists of two folds called **ileocecal lips**(superior, inferior). The folds fuse together around the orifice which prevents reflux of cecal contents into the ileum. An **ileocecal valve**regulates the passage of intestinal contents from the small into the large intestine. The functions of the cecum involve temporary storage of chyme, and fluid and electrolyte reabsorption.

**THE ASCENDING COLON**

The portion of the large intestine located between the cecum and rectum is termed the **colon**. It consists of four parts; ascending, transverse, descending, and sigmoid. The main functions of the colon include fluid and electrolyte reabsorption. In addition, the microflora generates energy through a process called fermentation.

The **ascending colon**travels through the right iliac fossa, right flank, and right hypochondriac region. It ends at the **right colic (hepatic) flexure**. The ascending colon is retroperitoneal and it is connected to the posterior abdominal wall by the **Toldt’s fascia**. A deep vertical groove or recess (**right paracolic gutter**) lies between the ascending colon and the lateral abdominal wall. The ascending colon is heavily involved in fluid and electrolyte reabsorption, gradually forming fecal matter.

**TRANSVERSE COLON**

The transverse colon is the second major part of the colon. It extends between the **right**and **left colic (splenic) flexures**, spanning the right hypochondriac, epigastric and left hypochondriac regions of the abdomen. The greater curvature of the stomach and gastrocolic ligament are superior to the transverse colon, while the greater omentum hangs over and extends inferiorly to it. The transverse colon is intraperitoneal. A peritoneal mesentery (**transverse mesocolon**) attaches it to the posterior wall of the omental bursa. This forms two abdominal compartments called **supracolic**and **infracolic compartments**.

**DESCENDING COLON**

The descending colon extends between the left colic flexure and sigmoid colon. It travels through the left hypochondriac region, left flank and left iliac fossa. The **left paracolic gutter**is located between the descending colon and the lateral abdominal wall. This part of the colon is retroperitoneal. **Toldt’s fascia** fixes the descending colon to the posterior abdominal wall.

**SIGMOID COLON**

The S-shaped sigmoid colon travels from the left iliac fossa until the third sacral vertebra (**rectosigmoid junction**). This part of the colon is intraperitoneal. It is connected to the pelvic wall by the **sigmoid mesocolon**.

**RECTUM**

The [rectum](https://www.kenhub.com/en/library/anatomy/the-rectum) stretches between the **rectosigmoid junction**and the anal canal. The typical characteristics of the large intestine (taenia coli, haustra, epiploic appendages) change or even terminate at the rectum. The roles of the rectum include temporary storage of fecal matter and defecation.The rectum has a characteristic S-shape marked by several bends or turns; **sacral**, **anorectal**and **lateral flexures**. The latter correspond with three infoldings called **transverse rectal folds**. The rectum ends at a dilated ampulla.

The rectum is partially intraperitoneal since the inferior third is **subperitoneal**. The peritoneum reflects from the rectum towards the bladder in males (**rectovesical pouch**) and the vaginal fornix in females (**recto-uterine pouch**or pouch of Douglas). The spaces around the rectum are potential spaces for infections, abscess formation, and many other pathologies.

OTHER SRUCTURES

The appendix is attached to its inferior surface of the cecum. It contains the least lymphoid tissue, and it is a part of mucosa-associated lymphoid tissue, which gives it an important role in immunity.Appendicitis is the result of a blockage that traps infectious material in the lumen. The appendix can be removed with no apparent damage or consequence to the patient.

On the surface of the large intestine, bands of longitudinal muscle fibers called taeniae coli, each about 0.2 inches wide, can be identified. There are three bands, starting at the base of the appendix and extending from the cecum to the rectum.Along the sides of the taeniae, tags of peritoneum filled with fat, called epiploic appendages (or appendices epiploicae) are found. The sacculations, called haustra, are characteristic features of the large intestine, and distinguish it from the small intestine.

 **FUNCTION**

The large intestine has 3 primary functions: absorbing water and electrolytes, producing and absorbing vitamins, and forming and propelling feces toward the rectum for elimination. By the time indigestible materials have reached the colon, most nutrients and up to 90% of the water has been absorbed by the small intestine. The role of the ascending colon is to absorb the remaining water and other key nutrients from the indigestible material, solidifying it to form stool. The descending colon stores feces that will eventually be emptied into the rectum. The sigmoid colon contracts to increase the pressure inside the colon, causing the stool to move into the rectum. The rectum holds the feces awaiting elimination by defecation. The large intestine also houses an extensive microflora that is essential for our survival.

**LAYERS OF THE LARGE INTESTINE.**

Like the rest of the gastrointestinal canal, the large intestine is made of four tissue layers:

1.The innermost layer, known as the **mucosa**, is made of simple columnar epithelial tissue. The mucosa of the large intestine is smooth, lacking the villi found in the small intestine. Many mucous glands secrete mucus into the hollow lumen of the large intestine to lubricate its surface and protect it from rough food particles.

2.Surrounding the mucosa is a layer of blood vessels, nerves and connective tissue known as the **submucosa**, which supports the other layers of the large intestine.

3.The **muscularis layer** surrounds the submucosa and contains many layers of visceral muscle cells that contract and move the large intestine. Continuous contraction of smooth muscle bands in the muscularis produces lumpy, pouch-like structures known as haustra in the large intestine.

4.The **serosa** forms the outermost layer. The serosa is a thin layer of simple squamous epithelial tissue that secretes watery serous fluid to lubricate the surface of the large intestine, protecting it from friction between abdominal organs and the surrounding muscles and bones of the lower torso.