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QUESTION

Describe the microanatomy of the small and large intestine. Note:you are expected to state their function, segment, layers, general features and epithelium of each part of the small and large intestine.

ANSWERS :

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.
The small intestine is divided into 3 sections which are

1.The duodenum
2. The jejunum
3. Ileum.

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). The small intestine is approximately 2.5–3 cm in diameter.
The 3 division of the small intestine :
1.The duodenum is the first section of the small intestine and is the shortest part of the small intestine. It is where most chemical digestion using enzymes takes place. The duodenum is about 25 to 30 cm long (“twelve fingers' length”), C-shaped and is located in the upper abdomen at the level of L1-L3. The head of the pancreas lies in the C loop. It may be subdivided into four sections: superior part, descending part, horizontal part and ascending part.
The duodenum is divided into 4 layers which are: the serosa, the muscularis, the submuscularis and the mucosa.

Function of the duodenum :
The duodenum is largely responsible for the breakdown of food in the small intestine, using enzymes. The duodenum also regulates the rate of emptying of the stomach via hormonal pathways. Secretin and cholecystokinin are released from cells in the duodenal epithelium in response to acidic and fatty stimuli present there when the pylorus opens and emits gastric chyme into the duodenum for further digestion.

Location:25-30 cm long, C-shaped around the head of the pancreas, L1-L3 level

Sections:Superior :superior duodenal flexure), descending: inferior duodenal flexure), horizontal (aorta: inferior vena cava), asceding :duodenojejunal flexure)

Blood supply:Superior (anterior, posterior) and inferior pancreaticoduodenal arteries

Innervation:Celiac plexus, vagus nerve

The epithelium for dueodenum :The mucosa consists of simple columnar epithelium (lamina epithelialis), a connective tissue layer (lamina propria) and a smooth muscle layer (lamina muscularis). The intestinal epithelial cells (enterocytes) are overlaid by a layer of glycoproteins and mucin.

2. The jejunum 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.The transition from the extraperitoneal ascending part of the duodenum to the intraperitoneal jejunum occurs at the duodenojejunal flexure (at the height of L2). The transition to the ileum is not sharply marked and only visible microscopically.The jejunum makes up about 2/5 of the total length of the small intestine (1.5 to 3.5 meters).

Function of the jejunum :
The lining of the jejunum is specialized for the absorption by enterocytes of small nutrient particles which have been previously digested by enzymes in the duodenum. Once absorbed, nutrients (with the exception of fat, which goes to the lymph) pass from the enterocytes into the enterohepatic circulation and enter the liver via the hepatic portal vein, where the blood is processed. The jejunum is involved in magnesium absorption

The basic structure of the jejunum:
mucosa
submucosa
muscularis
serosa

Blood supply:Arterial arcades of the superior mesenteric artery, Superior mesenteric vein

Innervation:Coeliac plexus, superior mesenteric plexus, vagus nerve

The epithelium of jejunum :

Mucosa - simple columnar epithelium; contains crypts of Lieberkuhn and intestinal villi
Submucosa - loose connective tissue containing neurovasculature
Tunica muscularis - an inner circular and outer longitudinal smooth muscle layer
Tunica serosa - simple squamous epithelium

3. 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.In turn, the epithelial cells that line these villi possess even larger numbers of microvilli. Therefore, the ileum has an extremely large surface area both for the adsorption (attachment) of enzyme molecules and for the absorption of products of digestion. The transition from the jejunum to the ileum is not sharply marked, while at the distal end, the ileum opens into the cecum. At the junction between the ileum and the cecum lies the ileocecal valve (ileal ostium), a functional sphincter formed by the circular muscle layers of both the ileum and cecum. It prevents a reflux of the bacteria-rich content from the large intestine into the small intestine.The ileum makes up about 3/5 of the total length of the small intestine (2.5 to 3.5 meters). Compared to the jejunum, the parallel running circular folds in the mucosa (valves of Kerckring) are less prominent.

Function of the ileum:
Enzymatic digestion of nutrients
Absorption of vitamin B12, fats and bile salts, Immunological function

Histologically, the ileum has the same basic structure as the jejunum:
mucosa
submucosa
muscularis
serosa

Blood supply:Straight arteries (branches of the superior mesenteric artery), Superior mesenteric vein

Innervation:Coeliac plexus, Superior mesenteric plexus, Vagus nerve

The epithelium of ileum :
Mucosa: Simple columnar epithelium; also contains Peyer's patches
Submucosa: Contains neurovasculature
Tunica muscularis: Circular and longitudinal muscle layers
Tunica serosa: Simple squamous epithelium.

The Villi
The villi contain large numbers of capillaries that take the amino acids and glucose produced by

digestion to the hepatic portal vein and the liver. Lacteals are the small lymph vessels that are present in villi. They absorb fatty acids and glycerol, the products of fat digestion, into direct circulation.Layers of circular and longitudinal smooth muscle enable the digested food to be pushed along the ileum by waves of muscle contractions called peristalsis. The undigested food (waste and water) are sent to the colon.
Histology of the Small Intestine
The small intestine wall has four layers: the outermost serosa, muscularis, submucosa, and innermost mucosa.

The small intestine has four tissue layers:

1.The serosa 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.

2. The muscularis 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: circular and longitudinal.

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.

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.

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.

The epithelium of small intestine :The mucosa of the small intestine is characterized by evagination into plicae and villi, which increase the surface area for nutrient absorption, and by short tubular invaginations, the crypts, which provide a protected site for stem cells.The mucosa of the small intestine is lined by a simple columnar epithelium which consists primarily of absorptive cells (enterocytes), with scattered goblet cells and occasional enteroendocrine cells. In crypts, the epithelium also includes Paneth cells and stem cells.

LARGE INTESTINE :
The large intestine absorbs water from the remaining indigestible food matter and compacts feces prior to defecation. The large intestine consists of the cecum and colon.
Function and Form of the Large intestine :
The function of the large intestine (or large bowel) is to absorb water from the remaining

indigestible food matter and then pass the useless waste material from the body. The large intestine consist of the cecum and the colon
Large intestine: A schematic of the large intestine, with the colon marked as follows: cecum
1) ascending colon
2) transverse colon
3) descending colon
4) sigmoid colon,
rectum, and
anus.
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 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.
The large intestine consists of :
1. The cecum
2. The colon
3. The rectum
4. The anal canal.

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. From here it continues up the abdomen, across the width of the abdominal cavity, and then it turns downward, continuing to its endpoint at the anus.The large intestine differs in physical form from the small intestine in being much wider. The longitudinal layer of the muscularis is reduced to three strap-like structures known as the taeniae coli—bands of longitudinal muscle fibers, each about 1/5 in wide. These three bands start at the base of the appendix and extend from the cecum to the rectum.Along the sides of the taeniae are tags of peritoneum filled with fat; these are called epiploic appendages, or appendices epiploicae. The wall of the large intestine is lined with simple columnar epitheliumInstead of having the evaginations of the small intestine (villi), the large intestine has invaginations (the intestinal glands). While both the small intestine and the large intestine have goblet cells that secrete mucin to form mucus in water, they are abundant in the large intestineIn histology, an intestinal crypt—called the crypt of Lieberkühn—is a gland found in the epithelial

lining of the small intestine and colon. The crypts and intestinal villi are covered by epithelium that contains two types of cells: goblet cells that secrete mucus and enterocytes that secrete water and electrolytes.The enterocytes in the mucosa contain digestive enzymes that digest specific food while they are being absorbed through the epithelium. These enzymes include peptidases, sucrase, maltase, lactase and intestinal lipase. This is in contrast to the stomach, where the chief cells secrete pepsinogen. In the intestine, the digestive enzymes are not secreted by the cells of the intestine.Also, new epithelium is formed here, which is important because the cells at this site are continuously worn away by the passing food. The basal portion of the crypt, further from the intestinal lumen, contains multipotent stem cells.During each mitosis, one of the two daughter cells remains in the crypt as a stem cell, while the other differentiates and migrates up the side of the crypt and eventually into the villus. Goblet cells are among the cells produced in this fashion. Many genes have been shown to be important for the differentiation of intestinal stem cells.The loss of proliferation control in the crypts is thought to lead to colorectal cancer.

What the large intestine consists of :

1.Cecum:The first part of the large intestine is the cecum, a sac-like structure that is suspended inferior to the ileocecal valve. It is about 6 cm (2.4 in) long, receives the contents of the ileum, and continues the absorption of water and salts. The appendix (or vermiform appendix) is a winding tube that attaches to the cecum. Although the 7.6-cm (3-in) long appendix contains lymphoid tissue, suggesting an immunologic function, this organ is generally considered vestigial. However, at least one recent report postulates a survival advantage conferred by the appendix: In diarrheal illness, the appendix may serve as a bacterial reservoir to repopulate the enteric bacteria for those surviving the initial phases of the illness. Moreover, its twisted anatomy provides a haven for the accumulation and multiplication of enteric bacteria. The mesoappendix, the mesentery of the appendix, tethers it to the mesentery of the ileum.

Clinical variations: mobile, free, fixed cecum

The epithelium for cecum:mucosa (columnar epithelium), submucosa, muscularis, serosa

Blood supply: cecal arteries and veins

Innervation: superior mesenteric plexus and vagus nerve

Appendix
Common locations: retrocecal or lesser pelvis

The epithelium for appendix :mucosa, submucosa (lymph follicles and parafollicular tissue), muscularis, serosa

Blood supply: appendicular arteries and veins

Innervation: superior mesenteric plexus and vagus nerve.

2. Colon:The cecum blends seamlessly with the colon. Upon entering the colon, the food residue first travels up the ascending colon on the right side of the abdomen. At the inferior surface of the liver, the colon bends to form the right colic flexure (hepatic flexure) and becomes the transverse colon. The region defined as hindgut begins with the last third of the transverse colon and continues on. Food residue passing through the transverse colon travels across to the left side of the abdomen, where the colon angles sharply immediately inferior to the spleen, at the left colic flexure (splenic flexure). From there, food residue passes through the descending colon, which runs down the left side of the posterior abdominal wall. After entering the pelvis inferiorly, it becomes the s-shaped sigmoid colon, which extends medially to the midline The ascending and descending colon, and the rectum (discussed next) are located in the retroperitoneum. The transverse and sigmoid colon are tethered to the posterior abdominal wall by the mesocolon.It is about 1.5 meters in length and consists of four parts:
i. Ascending
ii. Transverse
iii. Descending
iv. Sigmoid colon

Morphological features:Appendices epiploicae, haustra, taenia coli, semilunar folds.

Blood supply:Colic (right, middle, left) and sigmoid arteries

Innervation:Superior mesenteric plexus, vagus nerve, inferior mesenteric plexus, pelvic splanchnic nerves

The epithelium for colon:Simple columnar epithelium with crypts of Lieberkuhn and goblet cells.

3.Rectum:Food residue leaving the sigmoid colon enters the rectum in the pelvis, near the third sacral vertebra. The final 20.3 cm (8 in) of the alimentary canal, the rectum extends anterior to the sacrum and coccyx. Even though rectum is Latin for “straight,” this structure follows the curved contour of the sacrum and has three lateral bends that create a trio of internal transverse folds called the rectal valves. These valves help separate the feces from gas to prevent the simultaneous passage of feces and gas.The rectum begins at the height of S2-S3 and ends at the perineum. It is about 12 to 16 cm long und may be subdivided into three parts:
i. The upper third lies intraperitoneally
ii. The middle third retroperitoneally
iii. The lower third under the pelvic diaphragm and therefore extraperitoneally.

Two flexures: sacral, perineal

- Three rectal folds: superior, middle, inferior
- Rectal ampulla :reservoir during defecation

Supply

- Arteries: superior, middle, inferior rectal arteries
- Veins: superior, middle, inferior rectal veins

The epithelium of rectum:Intestinal epithelium (simple columnar epithelium), At the anal transitional zone - stratified squamous non-keratinized

Function:
Electrolytes absorption, continence.

4. Anal Canal: Then the food residue finally reaches the last part of the large intestine, the anal canal, which is located in the perineum, completely outside of the abdominopelvic cavity. This 3.8–5 cm (1.5–2 in) long structure opens to the exterior of the body at the anus. The anal canal includes two sphincters. The internal anal sphincter is made of smooth muscle, and its contractions are involuntary. The external anal sphincter is made of skeletal muscle, which is under voluntary control. Except when defecating, both usually remain closed.
The anal canal may be subdivided into the columnar, intermediate and cutaneous zone.

i. Columnar zone - The lumen has folds of mucous membrane (anal columns) produced by arterial cavernous bodies (anal cushions) in the submucosa. These columns are connected to each other at their distal ends by transverse folds (anal valves). Behind the anal valves lie crypts (crypts of Morgagni) into which the excretory ducts of the anal glands open. All anal valves together form the dentate (or pectinate) line, a serrated line where the intestinal mucosa merges with the squamous epithelium of the anal canal.

ii. Intermediate zone - Distally from the dentate line lies a 1 cm long zone with anal mucosa (anoderm).

iii. Cutaneous zone - This zone below the anal verge (anocutaneous line) is a hollow between the internal and external anal sphincter and has regular perianal skin.

Epithelium of the anal canal:
The tension of the corrugator cutis ani muscle gives it its fan-like look.In the anal canal the intestinal mucosa (colorectal zone) changes to anal mucosa (anoderm) through a transitional zone and finally merges with the perianal skin (cutaneous zone).

I. Colorectal zone - It equates the histological structure of the rectum with simple columnar epithelium. Folds of mucous membrane filled with small arteries form cushions in the wall.

ii. Transitional zone - It resembles the histological structure of the rectum but it presents both simple columnar epithelium and stratified squamous epithelium. Characteristic are transverse mucous folds with crypts and anal glands (tubular epithelial ducts).

iii. Anoderm (“white zone”) - It has stratified squamous non-keratinized epithelium, which is associated with the internal anal sphincter. This zone features densely packed sensory neurons registering the status of the intestinal content (e.g. solid, liquid or gaseous).

iv. Cutaneous zone - It is equal to the histological structure of the skin with stratified squamous keratinized epithelium. It is strongly pigmented and has all typical skin-associated structures such sweat and sebaceous glands, Pacinian corpuscles and hair follicles.

The epithelium of the large intestine :The wall of the large intestine is lined with simple columnar epithelium.