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

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).

FUNCTIONS

Digestion

The small intestine is where most chemical digestion takes place. Many of the digestive enzymes that act in the small intestine are secreted by the pancreas and liver and enter the small intestine via the pancreatic duct. Pancreatic enzymes and bile from the gallbladder enter the small intestine in response to the Hormone cholecystokinin, which is produced in the small intestine in response to the presence of nutrients. Secretin, another hormone produced in the small intestine, causes additional effects on the pancreas, where it promotes the release of bicarbonate into the duodenum in order to neutralize the potentially harmful acid coming from the stomach.

The three major classes of nutrients that undergo digestion are proteins, lipids (fats) and carbohydrates:

1. Proteins are degraded into small peptides and amino acids before absorption.[19] Chemical breakdown begins in the stomach and continues in the small intestine. Proteolytic enzymes, including trypsin and chymotrypsin, are secreted by the pancreas and cleave proteins into smaller peptides. Carboxypeptidase, which is a pancreatic

brush border enzyme, splits one amino acid at a time. Aminopeptidase and dipeptidase free the end amino acid products.

2. Lipids (fats) are degraded into fatty acids and glycerol. Pancreatic lipase breaks down triglycerides into free fatty acids and monoglycerides. Pancreatic lipase works with the help of the salts from the bile secreted by the liver and stored in the gall bladder. Bile salts attach to triglycerides to help emulsify them, which aids access by pancreatic lipase. This occurs because the lipase is water-soluble but the fatty triglycerides are hydrophobic and tend to orient towards each other and away from the watery intestinal surroundings. The bile salts emulsify the triglycerides in the watery surroundings until the lipase can break them into the smaller components that are able to enter the villi for absorption.

3. Some carbohydrates are degraded into simple sugars, or monosaccharides (e.g., glucose). Pancreatic amylase breaks down some carbohydrates (notably starch) into oligosaccharides. Other carbohydrates pass undigested into the large intestine and further handling by intestinal bacteria. Brush border enzymes take over from there. The most important brush border enzymes are dextrinase and glucoamylase, which further break down oligosaccharides. Other brush border enzymes are maltase, sucrase and lactase. Lactase is absent in some adult humans and, for them, lactose (a disaccharide), as well as most polysaccharides, is not digested in the small intestine. Some carbohydrates, such as cellulose, are not digested at all, despite being made of multiple glucose units. This is because the cellulose is made out of beta-glucose, making the inter-monosaccharidal bindings different from the ones present in starch, which consists of alpha-glucose. Humans lack the enzyme for splitting the beta-glucose-bonds, something reserved for herbivores and bacteria from the large intestine.

Absorption

Digested food is now able to pass into the blood vessels in the wall of the intestine through either diffusion or active transport. The small intestine is the site where most of the nutrients from ingested food are absorbed. The inner wall, or mucosa, of the small intestine, is lined with simple columnar epithelial tissue. Structurally, the mucosa is covered in wrinkles or folds called plicae circulares, which are considered permanent features in the wall of the organ. They are distinct from rugae which are considered non-permanent or temporary allowing for distention and contraction. From the plicae circulares project microscopic finger-like pieces of tissue called villi (Latin for "shaggy hair"). The individual epithelial cells also have finger-like projections known as microvilli. The functions of the plicae circulares, the villi, and the microvilli are to increase the amount of surface area available for the absorption of nutrients, and to limit the loss of said nutrients to intestinal fauna.

Each villus has a network of capillaries and fine lymphatic vessels called lacteals close to its

surface. The epithelial cells of the villi transport nutrients from the lumen of the intestine into these capillaries (amino acids and carbohydrates) and lacteals (lipids). The absorbed substances are transported via the blood vessels to different organs of the body where they are used to build complex substances such as the proteins required by our body. The material that remains undigested and unabsorbed passes into the large intestine.

Absorption of the majority of nutrients takes place in the jejunum, with the following notable exceptions:

I. Iron is absorbed in the duodenum.

II. Folate (Vitamin B9) is absorbed in the duodenum and jejunum.

III. Vitamin B12 and bile salts are absorbed in the terminal ileum.

IV. Water is absorbed by osmosis and lipids by passive diffusion throughout the small intestine.

V. Sodium bicarbonate is absorbed by active transport and glucose and amino acid co-transport

VI. Fructose is absorbed by facilitated diffusion.

SEGMENTS

- **Duodenum**: a short section that receives secretions from the pancreas and liver via the pancreatic and common bile ducts.This 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.

EPITHELIAL LINING

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.

The submucosa comprises loose connective tissue, numerous blood vessels and the Meissner's plexus.

The muscularis consists of an inner circular and an outer longitudinal musculature between which the Auerbach’s plexus lies.

- **Jejunum**: considered to be roughly 40% of the small gut in man, but closer to 90% in animals. 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.

EPITHELIAL LINING

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

- **Ileum** empties into the large intestine; considered to be about 60% of the intestine in man, but veterinary anatomists usually refer to it as being only the short terminal 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.

EPITHELIAL LINING

Mucosa: Simple columnar epithelium; also contains Peyer's patches

Submucosa: Contains neurovasculature

Tunica muscularis: Circular and longitudinal muscle layers

Tunica serosa: Simple squamous epithelium

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.

GENERAL FEATURES

- The small intestine finishes the process of digestion, absorbs the nutrients, and passes the residue on to the large intestine.
- The length of the small intestine can vary greatly, from as short as 2.75 m (9.0 ft) to as long as 10.49 m (34.4 ft)
- It is approximately 1.5 cm in diameter in newborns after 35 weeks of gestational age.
- It lies between the stomach and large intestine, and receives bile and pancreatic juice through the pancreatic duct to aid in digestion.

LARGE INTESTINE

The large intestine, also known as the large bowel, is the last part of the gastrointestinal tract and of the digestive system in vertebrates. Water is absorbed here and the remaining waste material is stored as feces before being removed by defecation.

FUNCTIONS

The function of the large intestine (or large bowel) is to absorb water from the remaining indigestible food matter, and then to pass the useless waste material from the body.

- reabsorption of water and mineral ions such as sodium and chloride
- formation and temporary storage of faeces
- maintaining a resident population of over 500 species of bacteria
- bacterial fermentation of indigestible materials.

SEGMENTS

Cecum and appendix

The cecum is the first section of the colon and involved in the digestion, while the appendix which develops embryologically from it, is a structure of the colon, not involved in digestion and considered to be part of the gut-associated lymphoid tissue. The function of the appendix is uncertain, but some sources believe that the appendix has a role in housing a sample of the colon's microflora, and is able to help to repopulate the colon with bacteria if the microflora has been damaged during the course of an immune reaction. The appendix has also been shown to have a high concentration of lymphatic cells.

EPITHELIAL LINING

The mucosa of the appendix, colon, and rectum has a simple columnar epithelium shaped into straight tubular crypts.

Ascending colon

The ascending colon is the first of four main sections of the large intestine. It is connected to the small intestine by a section of bowel called the cecum. The ascending colon runs upwards through the abdominal cavity toward the transverse colon for approximately eight inches (20 cm).

One of the main functions of the colon is to remove the water and other key nutrients from waste material and recycle it. As the waste material exits the small intestine through the ileocecal valve, it will move into the cecum and then to the ascending colon where this process of extraction starts. The unwanted waste material is moved upwards toward the transverse colon by the action of peristalsis. The ascending colon is sometimes attached to the appendix via Gerlach's valve. In ruminants, the ascending colon is known as the spiral colon.Taking into account all ages and sexes, colon cancer occurs here most often (41%).

EPITHELIAL LINING

The mucosa of the appendix, colon, and rectum has a simple columnar epithelium shaped into straight tubular crypts.

Transverse colon

The transverse colon is the part of the colon from the hepatic flexure, also known as the right colic, (the turn of the colon by the liver) to the splenic flexure also known as the left colic, (the

turn of the colon by the spleen). The transverse colon hangs off the stomach, attached to it by a large fold of peritoneum called the greater omentum. On the posterior side, the transverse colon is connected to the posterior abdominal wall by a mesentery known as the transverse mesocolon.

The transverse colon is encased in peritoneum, and is therefore mobile (unlike the parts of the colon immediately before and after it).

The proximal two-thirds of the transverse colon is perfused by the middle colic artery, a branch of the superior mesenteric artery (SMA), while the latter third is supplied by branches of the inferior mesenteric artery (IMA). The "watershed" area between these two blood supplies, which represents the embryologic division between the midgut and hindgut, is an area sensitive to ischemia.

EPITHELIAL LINING

The mucosa of the appendix, colon, and rectum has a simple columnar epithelium shaped into straight tubular crypts.

Descending colon

The descending colon is the part of the colon from the splenic flexure to the beginning of the sigmoid colon. One function of the descending colon in the digestive system is to store feces that will be emptied into the rectum. It is retroperitoneal in two-thirds of humans. In the other third, it has a (usually short) mesentery.The arterial supply comes via the left colic artery. The descending colon is also called the distal gut, as it is further along the gastrointestinal tract than the proximal gut.

EPITHELIAL LINING

The mucosa of the appendix, colon, and rectum has a simple columnar epithelium shaped into straight tubular crypts.

Sigmoid colon

The sigmoid colon is the part of the large intestine after the descending colon and before the rectum. The name sigmoid means S-shaped.The walls of the sigmoid colon are muscular, and contract to increase the pressure inside the colon, causing the stool to move into the rectum.

The sigmoid colon is supplied with blood from several branches (usually between 2 and 6) of

the sigmoid arteries, a branch of the IMA. The IMA terminates as the superior rectal artery.

EPITHELIAL LINING

The mucosa of the appendix, colon, and rectum has a simple columnar epithelium shaped into straight tubular crypts.

Rectum

The rectum is the last section of the large intestine. It holds the formed feces awaiting elimination via defecation.

EPITHELIAL LINING

Intestinal epithelium (simple columnar epithelium)

At the anal transitional zone - stratified squamous non-keratinized

The epithelial layer is followed by the connective tissue layer (lamina propria) with blood and lymph vessels and a muscle layer (lamina muscularis mucosae).

The submucosa contains loose connective tissue with blood vessels, lymph follicles and the Meissner's plexus. It has a dense network of veins (rectal venous plexus) and is thickened at the transverse folds.

The muscularis has the typical inner circular and outer longitudinal musculature between which the Auerbach's plexus lies. The ring musculature continues as the sphincter ani externus muscle within the sphincter system whereas the outer longitudinal musculature continues as the corrugator cutis ani muscle inserting at the skin around the anus.

LAYERS

- 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.
- 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.
- 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.

- Finally, 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.

GENERAL FEATURES

1. In an average adult, the large intestine is about 1.5m long and 5cm wide. It consists of the caecumappendixcolon and rectum.

2. The large intestine 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. It is about 4.9 feet (1.5 m) long, which is about one-fifth of the whole length of the intestinal canal.

3. 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 that gives it an important role in immunity.

4. On the surface of the large intestine, three bands of longitudinal muscle fibers called taeniae coli, each about 0.2 inches wide, can be identified. They start at the base of the appendix and extend from the cecum to the rectum.