STRUCTURAL ORGANISATION, HISTOLOGY AND FUNCTIONS OF GIT

Gastrointestinal tract

Identifiers (**Latin**- Tractus digestorius (mouth to anus), canalis alimentarius (esophagus to large intestine), canalis gastrointestinales (stomach to large intestine).

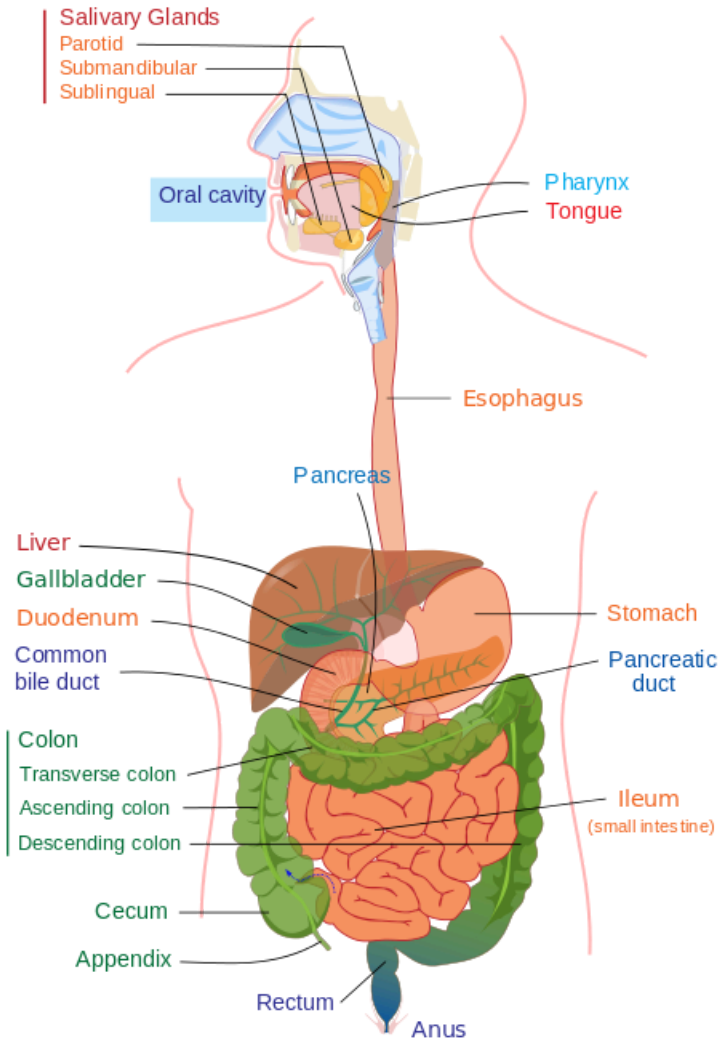


Diagram of Digestive System of human

Major parts of the Gastrointestinal tract

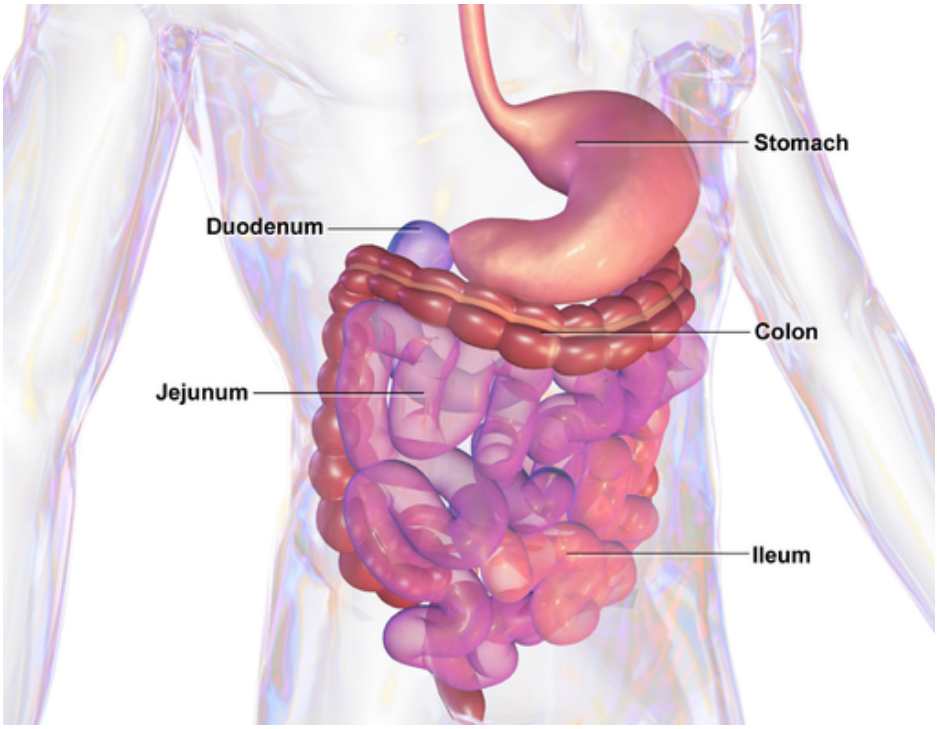
The gastrointestinal tract, (GI tract, GIT, digestive tract, digestion tract, alimentary canal) is the tract from the **mouth** to the **anus** which includes all the organs of the digestive system in **humans** and other **animals**. Food taken in through the mouth is digested to extract nutrients and absorb energy, and expelled in the remaining waste as **faeces**. The mouth, esophagus, stomach and intestines are all part of

the gastrointestinal tract**. Gastrointestinal** is an adjective meaning of or pertaining to the **stomach** and **intestines**. A tract is a collection of related anatomic structures or a series of connected body organs.

All vertebrates and most invertebrates have a digestive tract. The **sponges, cnidarians**, and **ctenophores** are the **early invertebrates** with an **incomplete digestive tract** having just one opening instead of two, where food is taken in and waste expelled.

The **human gastrointestinal tract** consists of the **esophagus, stomach**, and **intestines**, and is divided into the **upper** and **lower gastrointestinal tracts**. The GI tract includes all structures between the mouth and the anus, forming a continuous passageway that includes the main organs of digestion, namely, the stomach, small intestine, and large intestine. However, the complete human digestive system is made up of the gastrointestinal tract plus the accessory organs of digestion (the tongue, salivary glands, pancreas, liver and gallbladder). The tract may also be divided into foregut, midgut, and hindgut, reflecting the embryological origin of each segment. The whole human GI tract is about nine metres (30 feet) long at autopsy. It is considerably shorter in the living body because the intestines, which are tubes of smooth muscle tissue, maintain constant muscle tone in a halfway-tense state but can relax in spots to allow for local distention and peristalsis.

The gastrointestinal tract contains trillions of microbes, with some 4,000 different strains of bacteria having diverse roles in maintenance of immune health and metabolism. Cells of the GI tract release hormones to help regulate the digestive process. These digestive hormones, including gastrin, secretin, cholecystokinin, and ghrelin, are mediated through either intracrine or autocrine mechanisms, indicating that the cells releasing these hormones are conserved structures throughout evolution.



The structure and function can be described both as gross anatomy and as microscopic anatomy or histology. The tract itself is divided into **upper** and **lower** tracts, and the **intestines small** and **large** parts.

Upper gastrointestinal tract

The upper gastrointestinal tract consists of the **buccopharyngeal cavity** (**mouth, pharynx, esophagus,) stomach**, and **duodenum**.

I. **The buccopharyngeal cavity:** It is the space between skull and throat is divided into three parts:

i) **Vestibule (oral cavity)-Mouth** is opening from where food taken in for digestion and also known as **oral cavity-** space bounded by **lips** and **cheeks** externally; the **gums** and **teeths** internally. It temporarily stores food**.**

ii) **Buccal Cavity:** It is the space bounded by palate and ventrally by throat. It has following structures:

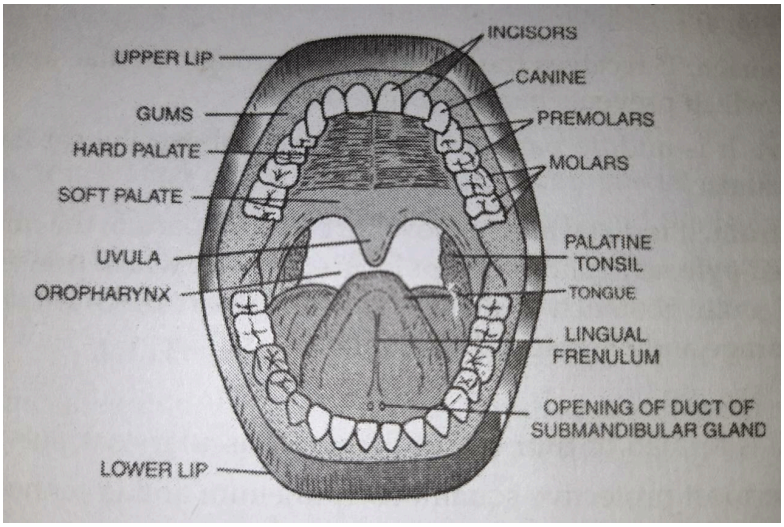
a) **Palate** forms roof of buccal cavity and divided into **anterior hard palate** (supported by bony processes) having foldings, called **palatine rugae**, whichgrip the food during mastication; **posterior soft palate** having free flap called **uvula** or **velum palati** – which closes the internal nares during swallowing of food bolus.

b) **Tongue or Lingua** is thick, musculo-sensory organ present on the floor of buccal cavity. It is greatly protrusible. The dorsum of tongue is lined by a stratified epithelium and has three types of **lingual papillae**-(conical-shaped **filliform papillae**; mushroom-shaped **fungiform papillae**; and 8-12 circular **circumvallate papillae**. These lingual papillae have taste buds formed of chemosensory taste cells and supporting cells. Tongue helps in tasting of foods; formation of food bolus; swallowing of food bolus; etc.

c) **Teeth (Dentes).** In man, teeth are present on both the jaws and are **thecodont** (i.e, embedded in jaw sockets, called alveoli) and **diphyodont** (appear in two sets: **Milk** or **deciduous teeth** and **Permanent teeth**). **Dental formula** represents the number and arrangement of teeth in one half of each jaw. Dental formula of milk teeth is **2102/2102** which indicates absence of premolars, while DF of permanent teeth is **2123/2123**. Permanent teeth in man are of four types: **Incisors** or **cutting teeth**; **Canines** or **tearing teeth**; **Premolars** and **Molars** (collectively called as **grinding** or **cheek teeth**). These teeth help in mastication of food which increases surface area of food for better action of digestive enzymes.

d) **Pharynx.** It is conical-shaped posterior part of bucco-pharyngeal cavity where food and air passages cross each other. It is divided into three parts: upper nasopharynx (with internal nares on its roof and opening of Eustachiancanals on the sides); middle oropharynx (acts as path for food bolus) and lower laryngopharynx (with

glottis and gullut. Glottis is normally open and leads into wind pipe, while gullut is normally closed and leads into oesophagus).



Bucco-pharyngeal cavity of Man

II. Oesophagus: It is long (about 20-25 cms), narrow, muscular and tubular structure. It runs downward through the neck behind the trachea, then passes through the diaphragm and finally opens in the stomach in the abdomen, so it is differentiated into 3 parts: cervical, thoracic and abdominal. It conducts the food to stomach by peristalsis.

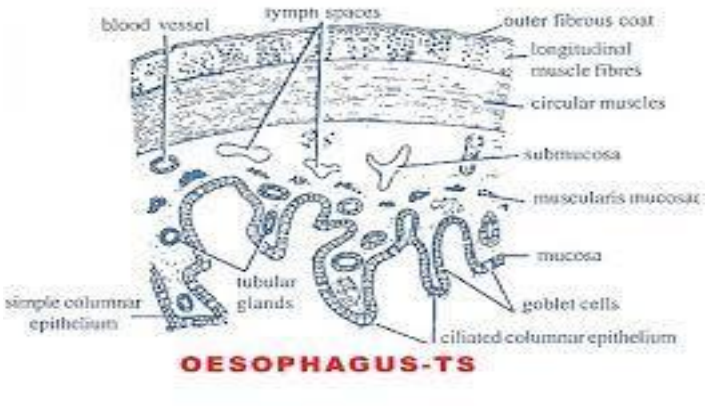
Histology: Histologically, the wall of oesophagus is formed of four coats:

i) Tunica adventitia is outermost, thin layer of fibrous connective tissue.

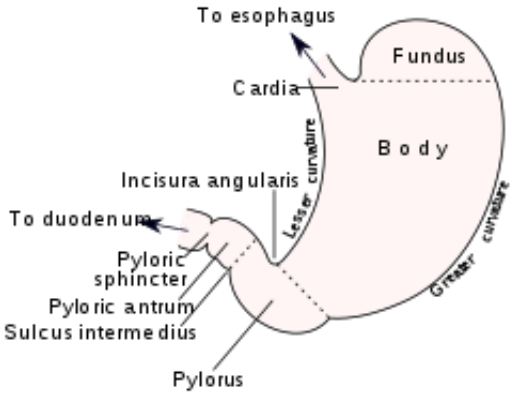
ii) Muscularis is formed of two types of smooth muscles: outer longitudinal and inner circular muscle fibres.

iii) Submucosa is formed of areolar connective tissue and is with blood vessels, lymph vessels and nerve fibres.

iv) Mucosa is the innermost coat and is formed of three layers: innermost simple columnar epithelium, middle lamina propria of areolar connective tissue and outermost muscularis mucosae of smooth muscle fibres. Its mucosa is raised into longitudinal folds, called oesophageal rugae, which normally close it to prevent entry of air and expand it to receive the food bolus during swallowing.



III. Stomach (Gaster): It is thick, muscular and J-shaped organ present on left upper parts of abdominal cavity. It is suspended by a mesentry called mesogaster. It is differentiated into three parts:



Human Stomach- External Structure

i) Cardiac stomach. It receives the oesophagus through cardiac aperture guarded by a cardiac sphincter which prevents backflow of food.

ii) Pyloric antrum. It is distal and narrow part which opens in the duodenum by pyloric aperture (also called pylorus) guarded by pyloric sphincter which prevents predigested food to enter the duodenum. Stomach is most distensible part of GIT. It helps in mechanical churning, food storage and chemical digestion of food.

Histology: Stomach wall is formed of four coats- Serosa, muscular coat, sub-mucosa and mucosa.

i) Serosa is outermost protective squamous epithelium and is connected to muscular coat by a subserosa of connective tissue.

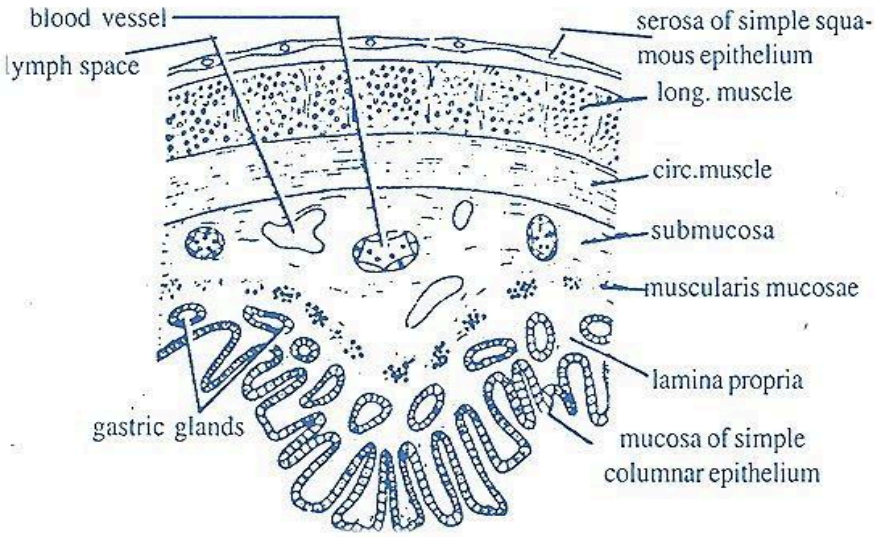
ii) Muscular coat is formed of 3 types of smooth muscles: outer longitudinal, middle circular and inner oblique muscle fibres. It helps in churning of food.

iii) Sub-mucosa is formed of areolar connective tissue having blood and lymph capillaries and nerve fibres. It allows distension of stomach to store the food.

iv) Mucosa is innermost coat and is differentiated into three parts: outer muscularis mucosae of smooth muscle fibres; middle lamina propria of reticular connective tissue

and innermost columnar surface epithelium which is folded to form longitudinal folds, called gastric rugae, and forms numerous gastric glands between them.

v) Each gastric glands has mucus-secreting goblets cells, HCl-secreting oxyntic cells and pepsin and rennin-secreting peptic cells.



STOMACH-TS(rabbit)

Function:

a) Digestion

In the human digestive system, a bolus (a small rounded mass of chewed up food) enters the stomach through the esophagus via the lower esophageal sphincter. The stomach releases proteases (protein-digesting enzymes such as pepsin) and hydrochloric acid, which kills or inhibits bacteria and provides the acidic pH of 2 for the proteases to work. Food is churned by the stomach through muscular contractions of the wall called peristalsis – reducing the volume of the bolus, before looping around the fundus and the body of stomach as the boluses are converted into chyme (partially digested food). Chyme slowly passes through the pyloric sphincter and into the duodenum of the small intestine, where the extraction of nutrients begins.

Gastric juice in the stomach also contains pepsinogen. Hydrochloric acid activates this inactive form of enzyme into the active form, pepsin. Pepsin breaks down proteins into polypeptides.

b) Absorption

Although the absorption in the human digestive system is mainly a function of the small intestine, some absorption of certain small molecules nevertheless does occur in the stomach through its lining. This includes:

Water, if the body is dehydrated

Medication, such as aspirin

Amino acids

10–20% of ingested ethanol (e.g. from alcoholic beverages)

Caffeine

To a small extent water-soluble vitamins (most are absorbed in the small intestine)

The parietal cells of the human stomach are responsible for producing intrinsic factor, which is necessary for the absorption of vitamin B12. B12 is used in cellular metabolism and is necessary for the production of red blood cells, and the functioning of the nervous system.

c) Control of secretion and motility

The movement and the flow of chemicals into the stomach are controlled by both the autonomic nervous system and by the various digestive hormones of the digestive system:

Gastrin: The hormone **gastrin** causes an increase in the secretion of HCl from the parietal cells, and pepsinogen from chief cells in the stomach. It also causes increased motility in the stomach. Gastrin is released by G cells in the stomach in response to distension of the antrum, and digestive products (especially large quantities of incompletely digested proteins). It is inhibited by a pH normally less than 4 (high acid), as well as the hormone somatostatin.

Cholecystokinin: **Cholecystokinin (CCK)** has most effect on the gall bladder, causing gall bladder contractions, but it also decreases gastric emptying and increases release of pancreatic juice, which is alkaline and neutralizes the chyme. CCK is synthesized by I-cells in the mucosal epithelium of the small intestine.

Secretin: In a different and rare manner**, secretin** which has most effects on the pancreas, also diminish acid secretion in the stomach. Secretin is synthesized by S-cells which are located in the duodenal mucosa as well as in the jejunal mucosa in smaller numbers.

Gastric inhibitory peptide: **Gastric inhibitory peptide (GIP)** decreases both gastric acid release and motility. GIP is synthesized by K-cells which are located in the duodenal and jejunal mucosa.

Enteroglucagon: **Enteroglucagon** decreases both gastric acid and motility.

Other than gastrin, these hormones all act to turn off the stomach action. This is in response to food products in the liver and gall bladder, which have not yet been absorbed. The stomach needs to push food into the small intestine only when the intestine is not busy. While the intestine is full and still digesting food, the stomach acts as storage for food.

The exact demarcation between the upper and lower tracts is the suspensory muscle of the duodenum. This differentiates the embryonic borders between the foregut and midgut, and is also the division commonly used by clinicians to describe gastrointestinal bleeding as being of either "upper" or

"lower" origin. Upon dissection, the duodenum may appear to be a unified organ, but it is divided into four segments based upon function, location, and internal anatomy. The four segments of the duodenum are as follows (starting at the stomach, and moving toward the jejunum): bulb, descending, horizontal, and ascending. The suspensory muscle attaches the superior border of the ascending duodenum to the diaphragm.

The suspensory muscle is an important anatomical landmark which shows the formal division between the duodenum and the jejunum, the first and second parts of the small intestine, respectively. This is a thin muscle which is derived from the embryonic mesoderm.

Lower gastrointestinal tract

The lower gastrointestinal tract includes most of the **small intestine** and all of the **large intestine**. In human anatomy, the intestine (bowel, or gut. Greek: éntera) is the segment of the gastrointestinal tract extending from the pyloric sphincter of the stomach to the anus and, as in other mammals, consists of two segments, the small intestine and the large intestine. In humans, the small intestine is further subdivided into the duodenum, jejunum and ileum while the large intestine is subdivided into the caecum, ascending, transverse, descending and sigmoid colon, rectum, and anal canal.

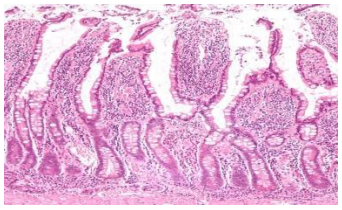
Small intestine

The small intestine begins at the duodenum and is a tubular structure, usually between 6 and 7 m long. Its mucosal area in an adult human is about 30 m2.[19] The combination of the circular folds, the villi, and the microvilli increases the absorptive area of the mucosa about 600-fold, making a total area of about 250 square meters for the entire small intestine.[20] Its main function is to absorb the products of digestion (including carbohydrates, proteins, lipids, and vitamins) into the bloodstream. There are three major divisions:

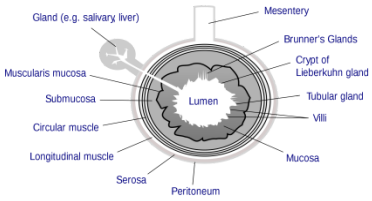
Doudenum: It is widest and smallest (about 25 cm) part of small intestine. It forms a C-shaped curve and receive the chime from the stomach and the hepato-pancreatic duct whose opening is guarded by a sphincter of Oddi, receive pancreatic juice containing digestive enzymes and bile from the gall bladder. The digestive enzymes break down proteins, and bile emulsifies fats into micelles. The duodenum contains Brunner's glands which produce a mucus-rich alkaline secretion containing bicarbonate. These secretions, in combination with bicarbonate from the pancreas, neutralize the stomach acids contained in the chyme. Histologically, its submucosae is peculiar in having low circular folds, called plicate circulares, and mucus-secreting Brunner’s glands.

Jejunum: This is the midsection of the small intestine, connecting the duodenum to the ileum. It is about 2.5 m long, beginning is marked by a sharp bend called duodenojejunal flexure and contains the circular folds also known as plicae circulares which having numerous villi that increase its surface area. As the products of digestion of sugars, amino acids, and fatty acids are absorbed into the bloodstream here so it is the main site of digestion and absorption of diffusible nutrients.

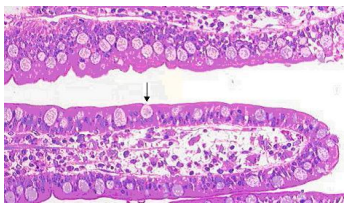
Ileum: The final section of the small intestine is longest part having about 3 m long, more coiled and occupies a largest part of central and lower parts of abdominal cavity and contains villi similar to the jejunum. It absorbs mainly vitamin B12 and bile acids, as well as any other remaining nutrients. Finally, it opens in the caecum of large intestine guarded by an **ileo-caecal valve.**



T.S. of Small Intestine;



Section of Gut of Duodenum;



section of villi showing Goblet cells

Diagram showing histologically four layers of GIT (oral view)

Histology

The four layers that make up the wall of the ileum are consistent with those of the gastrointestinal tract. From the inner to the outer surface, these are:

a) A **mucous membrane**, itself formed by three different layers:

i) A **single layer** of tall cells that line the lumen of the organ. The epithelium that forms the innermost part of the **mucosa** has five distinct types of cells that serve different purposes, these are: **enterocytes** with microvilli, which digest and absorb nutrients; **goblet cells**, which secrete mucin, a substance that lubricates the wall of the organ; **Paneth cells**, most common in the terminal part of the ileum, are only found at the bottom of the intestinal glands and release antimicrobial substances such as alpha defensins and lysozyme; **microfold cells**, which take up and transport antigens from the lumen to lymphatic cells of the lamina propria; and **enteroendocrine cells**, which secrete hormones.

ii) An underlying **lamina propria** composed of loose connective tissue and containing germinal centers and large aggregates of lymphoid tissue called Peyer's patches, which are a distinctive feature of the ileum.

iii) A thin layer of smooth muscle called **muscularis mucosae**.

b) A **submucosa** formed by dense irregular connective tissue that carries the larger blood vessels and a nervous component called submucosal plexus, which is part of the enteric nervous system.
c) An external **muscular layer** formed by two layers of smooth muscle arranged in circular bundles in the inner layer and in longitudinal bundles in the outer layer. Between the two layers is the **myenteric plexus**, formed by nervous tissue and also a part of the enteric nervous system.
d) A **serosa** composed of mesothelium, a single layer of flat cells with varying quantities of underlying connective and adipose tissue. This layer represents the visceral peritoneum and is continuous with the mesentery.

Function

The main function of the ileum is to absorb vitamin B12, bile salts, and whatever products of digestion 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. 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 DNES (diffuse neuroendocrine system) cells of the ileum secrete various hormones (gastrin, secretin, cholecystokinin) into the blood. Cells in the lining of the ileum secrete the protease and carbohydrase enzymes responsible for the final stages of protein and carbohydrate digestion into the lumen of the intestine. These enzymes are present in the cytoplasm of the epithelial cells.

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 small lymph vessels, and are present in villi. They absorb fatty acid and glycerol, the products of fat digestion. Layers of circular and longitudinal smooth muscle enable the chyme (partly digested food and water) to be pushed along the ileum by waves of muscle contractions called peristalsis. The remaining chyme is passed to the colon.

Large intestine

Structure: Illustration of the large intestine.

The large intestine also called the colon, consists of the cecum, rectum, and anal canal. It also includes the appendix, which is attached to the cecum. The colon is the last part of the digestive system. It extracts water and salt from solid wastes before they are eliminated from the body and is the site in which flora-aided (largely bacterial) fermentation of unabsorbed material occurs. Unlike the small intestine, the colon does not play a major role in absorption of foods and nutrients. About 1.5 litres or 45 ounces of water arrives in the colon each day. The length of the average adult human colon is 65 inches or 166 cm (range of 80 to 313 cm) for males, and 61 inches or 155 cm (range of 80 to 214 cm) for females.

Sections of the colon: In mammals, the colon consists of six sections; the cecum plus the ascending colon, the transverse colon, the descending colon, the sigmoid colon, and the rectum.

Cecum (first portion of the colon) and appendix

Ascending colon (ascending in the back wall of the abdomen)

Right colic flexure (flexed portion of the ascending and transverse colon apparent to the liver)

Transverse colon (passing below the diaphragm)

Left colic flexure (flexed portion of the transverse and descending colon apparent to the spleen)

Descending colon (descending down the left side of the abdomen)

Sigmoid colon (a loop of the colon closest to the rectum)

Rectum

Anus

The parts of the colon are either intra-peritoneal or behind it in the retro-peritoneum. Retro-peritoneal organs, in general, do not have a complete covering of peritoneum, so they are fixed in location. Intra-peritoneal organs are completely surrounded by peritoneum and are therefore mobile. Of the colon, the ascending colon, descending colon and rectum are retroperitoneal, while the cecum, appendix, transverse colon and sigmoid colon are intra-peritoneal. This is important as it affects which organs can be easily accessed during surgery, such as a laparotomy.

In terms of diameter, the cecum is the widest, averaging slightly less than 9 cm in healthy individuals, and the transverse colon averages less than 6 cm in diameter. The descending and sigmoid colon are slightly smaller, with the sigmoid colon averaging 4–5 cm in diameter. Diameters larger than certain thresholds for each colonic section can be diagnostic for mega-colon.

Caecum 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 micro-flora, and is able to help to repopulate the colon with bacteria if the micro-flora has been damaged during the course of an immune reaction. The appendix has also been shown to have a high concentration of lymphatic cells.

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.[16][17][18] Taking into account all ages and sexes, colon cancer occurs here most often (41%).[19]

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.

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.[20] 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. Gut flora are very dense in this region.

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 (see sigmoid; cf. sigmoid sinus). 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.

Sigmoidoscopy is a common diagnostic technique used to examine the sigmoid colon.

Rectum: The rectum is the last section of the large intestine. It holds the formed feces awaiting elimination via defecation. It is about 13 cm long.

Function

The large intestine absorbs water and any remaining absorbable nutrients from the food before sending the indigestible matter to the rectum. The colon absorbs vitamins that are created by the colonic bacteria, such as vitamin K (especially important as the daily ingestion of vitamin K is not normally enough to maintain adequate blood coagulation), thiamine and riboflavin.[citation needed] It also compacts feces, and stores fecal matter in the rectum until it can be discharged via the anus in defecation. The large intestine also secretes K+ and Cl-. Chloride secretion increases in cystic fibrosis. Recycling of various nutrients takes place in colon. Examples include fermentation of carbohydrates, short chain fatty acids, and urea cycling.

By the time the chyme has reached this tube, most nutrients and 90% of the water have been absorbed by the body. At this point some electrolytes like sodium, magnesium, and chloride are left as well as indigestible parts of ingested food (e.g., a large part of ingested amylose, starch which has been shielded from digestion heretofore, and dietary fiber, which is largely indigestible carbohydrate in either soluble or insoluble form). As the chyme moves through the large intestine, most of the remaining water is removed, while the chyme is mixed with mucus and bacteria (known as gut flora), and becomes feces. The ascending colon receives fecal material as a liquid. The muscles of the colon then move the watery waste material forward and slowly absorb all the excess water, causing the stools to gradually solidify as they move along into the descending colon.

The bacteria break down some of the fiber for their own nourishment and create acetate, propionate, and butyrate as waste products, which in turn are used by the cell lining of the colon for nourishment. No protein is made available. In humans, perhaps 10% of the undigested carbohydrate thus becomes available, though this may vary with diet; in other animals, including other apes and primates, who have proportionally larger colons, more is made available, thus permitting a higher portion of plant material in the diet. The large intestine produces no digestive enzymes — chemical digestion is completed in the small intestine before the chyme reaches the large intestine. The pH in the colon varies between 5.5 and 7 (slightly acidic to neutral).

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