

Study Guide Digestive System

1. **Digestion** – is breakdown of complex food molecules like starch into smaller molecules like glucose that can pass through the cell membranes of intestine and get absorbed into blood.
2. **Digestive system** has 2 main components. A) Alimentary canal B) Associated organs – teeth, tongue, salivary glands, liver and pancreas. **Fig 16.1** records the structure and function of each part. Remember them.
3. **Histology of alimentary canal fig 16.2:** is formed of 4 major parts. Starting from outside to inner side:-
4. **Serosa** : or serous membrane is formed of Squamous epithelium and a small amount of connective tissue.

Muscularis Externa: is formed of external longitudinal and inner circular smooth muscles.

Submucosa: is areolar connective tissue having blood and lymphatic vessels in it.

Mucosa: or mucous membrane is formed of 3 parts. A) muscularis is a thin layer of smooth muscles. B) Lamina propria is a small amount of areolar connective tissue. C) Epithelium is mostly simple columnar. It helps in secretion and absorption.

Alimentary Canal: is a long coiled tube starting with mouth and ending at anus.

5. **Mouth = oral cavity = buccal cavity** – is outlined by lips – anterior; cheeks – lateral; tongue inferior; palate - superior. Tongue lies at the floor of oral cavity. Mouth is continuous with posterior oropharynx. Anterior roof of oral cavity is Hard Palate formed of bones – palatine processes of maxilla and palatines. Fig 16.4
6. **Chewing = Mastication:** as we put food into mouth teeth cut it and grind into smaller morsels. Tongue moves food around and mixes saliva to soften and bind food. Mastication has dual voluntary and involuntary control. It means we can chew food by conscious effort = voluntary or by reflex action = involuntary.
7. **Pharynx** – is the throat. Soft Palate forms the roof. It lacks any bone support. Its posterior part hangs freely, the Uvula. It has 3 parts. A) nasopharynx B) oropharynx C) laryngopharynx.
8. **Nasopharynx:** nasopharynx is superior pharynx continuous with nasal cavity. **Pharyngeal tonsils and tubal tonsils** do not allow microorganisms to pharyngotympanic = internal auditory tubes that open into nasopharynx. Food does not enter nasopharynx.
9. **Oropharynx** is the middle pharynx and is posterior continuity of mouth. Air and food cross their paths in it. **Palatine and lingual tonsils** lie in this part.
10. **Laryngopharynx** is inferior pharynx and larynx and esophagus open into it.

11. Swallowing = Deglutition is initiated by tongue. Saliva gets mixed with food during chewing and makes a solid ball = Bolus. Tongue blocks mouth. Uvula blocks nasopharynx. Larynx moves up and epiglottis covers it. Skeletal muscles of esophagus open and Bolus is pushed into esophagus. Now skeletal muscles close opening of esophagus; uvula hangs down opening nasopharynx; larynx moves down allowing air to enter larynx or go out through nasal cavity. Deglutition is controlled by a Reflex action.
12. **Esophagus** is about 10" long and passes through neck, thorax and diaphragm and immediately enters stomach. Fig 161. Esophagus is lined by Adventitia – a coarse, dry connective tissue that fixes it to surrounding organs. All digestive organs in Abdominopelvic cavity are covered with Serous membranes = Serosa. Serosa allows frictionless movement of organs. No secretion or absorption takes place in esophagus. It is lined with Stratified Squamous Epithelium that suddenly changes to Simple Columnar tissue in stomach.
13. **Stomach** is highly distensible curved tube 6-10" in length. When empty hardly wider than colon but when full can hold 1 gallon or 4L of food and can extend up to pelvis. It has 4 main parts. A) Cardiac region lies around cardiac opening = orifice. A sphincter muscle guards the opening and allows food to enter stomach from esophagus. B) Fundus is dome shaped superolateral part tucked below diaphragm. C) Body is the main middle part. D) Pylorus is the funnel shaped part that opens into small intestine. A sphincter guards pyloric orifice and allows only small amount of food to enter duodenum. Fig 16.8.
14. Greater curvature is lateral convex surface. Lesser curvature is medial concave surface. **Lesser omentum** fixes liver to lesser curvature of stomach. **Greater omentum** attaches greater curvature to coils of small intestine and bends superior to wrap spleen and transverse colon and blends with mesocolon that fixes colon to posterior body wall.
15. Stomach wall has innermost oblique muscles in addition to outer longitudinal and inner circular muscles of rest of alimentary canal. It helps in mechanical action of churning and mixing the food by continuous contractions and relaxations of stomach muscles. It helps in mixing gastric juices with food. Food is changed to a creamy paste = Chyme inside stomach by combined mechanical (churning) and chemical action of enzymes. Fig 16.8
16. Gastric glands lie at the base of gastric pits in the stomach mucosa. Fig 16.8d. Chief cells are most common and secrete protein digesting enzymes Rennin and Pepsinogen. Single large cells – Parietal Cells open into gastric glands and secrete concentrated HCl acid. HCl acid change inactive protein digesting enzyme Pepsinogen → Pepsin.
17. A large number of mucous glands open into stomach and secrete mucous. Mucous protects stomach lining from the action of HCl acid and protein digesting enzymes. This explains why stomach and intestine formed of flesh can digest meat without any harm to them.
18. Fat soluble substances like Alcohol and Aspirin easily pass into blood in stomach and can easily cause gastric irritation.

19. **Small Intestine:** is formed of 3 parts. A) Duodenum B) Jejunum and C) ileum. It is the main site of digestion and absorption of food. It is hanging by fan shaped mesentery from posterior body wall. **Small Intestine is about 20 feet in cadaver = dead body but only about 6-13 feet in living human due to muscle tone.**
20. **Duodenum:** is 1st part of small intestine coils around head of pancreas. Fig 23.20. Bile duct and main pancreatic duct open into duodenum at main papilla. Accessory pancreatic duct opens just before the main pancreatic papilla. Sphincters control openings of bile duct and both pancreatic ducts. It has intestinal glands that secrete complete digestive juice that digests all 4 types of food requiring digestion – carbohydrates, lipids, proteins and nucleic acids. Fig 16.13
21. **Jejunum:** is the middle part of small intestine. Jejunum means ‘empty’ because it gets empty after death of human. Fig 16.10
22. **Ileum:** is the last part of small intestine and opens into large intestine at ileocecal valve. Ileum means ‘coiled’. Both jejunum and ileum are coiled. Note spellings of ileum – small intestine and ilium – is a part of coxal bone of pelvic girdle. Memory aid – ‘e’ is coiled and ‘l’ is straight.
23. **Increase in surface area of small intestine:** is done by 3 modifications. A) Large Circular folds B) Villi are finger like structures formed of thousands of cells C) Microvilli are microscopic extensions of cell membrane on columnar cells. All 3 increase the surface area for secretion of intestinal juice and absorption of food. Fig 16.11.
24. **Large Intestine:** is wider than small intestine but shorter in length – about 5 feet. It is formed of 5 parts. A) Cecum B) Appendix C) Colon D) Rectum and E) Anal Canal.
25. **Cecum:** is reduced in humans due to omnivore diet.
26. **Appendix:** is a small twisted worm like extension of cecum. It is rich in lymphatic tissue. Sometimes it creates trouble due to overgrowth of enteric bacteria in it. In some patients needs surgical removal = Appendicitis.
27. **Colon:** is the largest part of large intestine and frames the jejunum and ileum. Its parts include a) ascending colon b) transverse colon c) descending colon and d) S-shaped sigmoid colon that opens into rectum. No digestion takes place in large intestine. It harbors a large number of enteric bacteria that help in disposal of toxic by-products of digestion and increase the bulk of feces. Water is absorbed here to solidify the feces. It also stores feces. Fig 16.17
28. **Rectum:** is short. We get the feeling to pass feces on entering rectum.
29. **Anal Canal:** is the last part and opens out through anus. Anus is guarded by 1 voluntary and 1 involuntary sphincter muscles. Undigested food and bacteria pass out through anus as feces.

Associated Organs: include teeth, tongue, salivary glands, liver and pancreas.

30. **Teeth:** are fixed in alveoli in Maxilla – upper jaw and mandible – lower jaw. Fig 16.6. Each half jaw has 2 incisors – cutting teeth; 1 canine – tearing teeth; 2 premolars – smaller chewing teeth; and 3 molars – larger chewing teeth. **Permanent teeth** are 32 – (i 2/2, c 1/1, pm 2/2, m 3/3) X 2, in adult humans. **Deciduous teeth** = milk teeth = baby teeth are 20 and include 2 incisors, 1 canine and 2 molars in each half of jaw. Usually incisors and canines have single root, premolars have 2 roots and molars have 3 roots. Infection or impaction in roots give tooth pain and need Root Canal Treatment. Canines and 3rd molar teeth = wisdom teeth are vestigial = nonfunctional in humans.
31. **Tooth:** is formed of bone and is yellow in color. It is covered by white Enamel = ivory, the hardest substance in human body. Crown is the exposed part of tooth. Part of tooth embedded in jaw bone is Root. A narrow part of tooth, Neck joins crown and root. Neck is covered by gum = gingiva. Fig 16.6a. Gingivitis is infection of gums by bacteria and is aggravated by *Entamoeba gingivitis*.
32. **Tongue:** is muscular organ and tastes food. It has 4 types of projections = papillae over it. 1. Filiform – conical; 2. Fungiform – mushroom shaped; 3. Circum-vallate or vallate – larger mushroom shaped 4. Foliate – pleatlike papillae. In adults Fungiform and circumvallate papillae bear taste buds. Tongue is attached with muscles to Hyoid bone. It bears a lingual frenulum on inferior side.
33. **Salivary Glands:** 3 pairs of extrinsic salivary glands open with their ducts into mouth and secrete major amount of Saliva. Small intrinsic salivary glands lie scattered throughout the mucosa of mouth. Saliva performs 4 functions. 1. Moistens food 2. Cleans mouth 3. Dissolves food to be tasted and impacted into bolus 4. Contains enzymes to digest starch. Fig 16.5
34. **Liver:** is the largest gland in human body. It occupies the right upper quadrant in abdomen and lies inferior to diaphragm and mostly covered by rib cage. Fig 16.14.
35. **Lobes of liver:** traditionally liver is divided into 4 lobes. 2 prominent lobes are larger **Right lobe** and smaller **Left lobe**; these are separated by falciparum ligament. 2 much smaller lobes lie on posteroinferior side. **Caudate lobe** lies near superior margin and **Quadrate lobe** lies near inferior margin, next to gall bladder.
36. **Microscopic Anatomy of liver:** liver has distinct hexagonal lobules demarcated by connective tissue. Liver cells = hepatocytes lie in sheets = Plates of hepatocytes. On one side lie microscopic channels = liver sinusoids. On other side lie microscopic channels = Bile canaliculi. Fig 16.15.
37. Hepatic artery (brings O₂) → branches → portal arteriole → blood enters liver sinusoid between hepatocyte sheets → central vein.
38. Bile canaliculi → bile duct branch → bile duct
39. Hepatic Portal vein (brings excess nutrients at absorption) → branches → portal venule → blood enters liver sinusoid between plates of hepatocytes → central vein.

40. **Portal area:** has 1. Portal venule 2. Portal arteriole and 3. Bile duct branch, lie at periphery of lobule. Central vein lies at the center of each lobule. Central veins combine to form hepatic veins that open into inferior vena cava.
41. **Bile:** Liver produces metabolic waste, Bile. Bile is stored in Gall Bladder. Bile has **bile pigments** – mainly bilirubin formed by breakdown of hemoglobin and **bile salts** – derivatives of cholesterol. Bile does not have any digestive enzymes but is important for lipid digestion. Bile salts breakdown bigger lipid globules into smaller droplets – Emulsification. It increases surface area for action of Lipase enzyme. Bile juice is also basic and augments pancreatic juice to neutralize acidity of food released into duodenum by stomach.
42. **Digestion in mouth:** Mastication breaks food into smaller parts to increase surface area. Carbohydrate digestion begins. Salivary amylase enzyme present in saliva, starch/glycogen → maltose sugar. Flow Chart 16.18 is quite helpful to understand digestion and absorption.
43. **Digestion in stomach:** Protein digestion begins. Rennin acts on liquid milk and changes it into curd like solid. It helps to retain milk for longer period in stomach. HCl acid changes Pepsinogen → pepsin. Pepsin breaks proteins → peptides. HCl acid also kills microorganisms. Oversecretion of HCl can cause Gastric Ulcers – lesions in gastric epithelium. Mostly gastric ulcers are caused by bacterium *Helicobacter pylori*. Sometimes release of acidic food causes ulcers in duodenum = Peptic ulcers.
44. **Digestion in small intestine:** Small intestine receives gastric juices of Pancreas, liver and its own intestinal juice of duodenal glands. Both pancreatic and intestinal juices are complete digestive juices having digestive enzymes for all 4 foods requiring digestion.
45. **Carbohydrates:** Starch / glycogen → maltose → glucose.
46. **Proteins:** proteins → peptides → amino acids.
47. **Lipids:** lipids → monoglycerides + fatty acids.
48. **Nucleic acids:** DNA and RNA → nucleotides → ribose or deoxyribose + nitrogen bases and phosphates.
49. **Absorption:** glucose, amino acids, pentose sugars, phosphates and nitrogen bases get absorbed directly into blood by facilitated diffusion and active transport. Most absorption takes place in small intestine. Bile salts combine with fat molecules to form **Micelles** – tiny water soluble structures. Micelles also have cholesterol and fat soluble vitamins A, D, E and K. Now fat digestion takes place. Monoglycerides and fatty acids leave micelles and enter intestinal cells. Here natural fats (triglycerides) are regenerated and secreted into Lacteal lymphatic vessels as **Chylomicrons** – tiny lipoprotein droplets. Thoracic lymphatic duct releases fats into subclavian veins.

50. **Some absorption in colon:** colon reabsorbs vitamins K, Biotin, and B₅ = pantothenic acid released by bacteria, Na⁺ and K⁺ ions, and most of water. Undigested food remains in colon for 10-12 hours and changes into feces.
51. **Vitamins:** must be absorbed as such because body cannot synthesize them.
52. **Importance of fiber in diet:** fibers from cereals, vegetables, fruits and salads increase bulk of food and later feces. This helps in easy bowel movement. Fibers also help to absorb water and keep feces softer. Bacteria living in colon can digest fibers and are helpful in: a) disposal of toxic by-products of digestion b) secrete vitamins like K and some B-complex vitamins c) increase bulk of feces – about 50%.
53. **Defecation of egestion:** Mass movements (3-4 times a day) of colon, push feces into rectum and anal canal, and out of anus.
54. **Movements of alimentary canal:** include Peristalsis – a weak contraction of muscularis externa from mouth toward anus that pushes the food forward. Segmenting movements help move food to and fro in same organ. Fig 16.3
55. **Important Hormones released by GI tract** are depicted in Table 16.1. These include Gastrin, Secretin, Cholecystokinin (CCK) and Gastric Inhibitory Peptide (GIP).