Digestive System:

Ingestion → Digestion → Absorption → Assimilation → Egestion

Assimilation: Transport of absorbed substance to body tissue by blood and utilised by them is called assimilation.

* Foregut (ectodermal)
  * Pharynx
  * Midgut (endodermal)
    * Rectum
    * Anal Canal
  * Hindgut (ectodermal)
    * (etc.)

* Alimentary canal is ecto-endodermal.

* Salivary glands:
  - In human, 3 pair salivary gland + 1. These are exocrine in nature (have ducts). They secrete outside buccal cavity, but open into buccal cavity.
For more PDFs visit: LearningMantras.com

- Palate
  - Hard palate
  - Soft palate
  - uvula

- Frenulum
  - Membrane: 3 mm
  - Movement: 12

- Palatine tonsils
  - 2

- Eustachian tube
  - Movement: 4 mm

- Pharynx
  - Muscles: 3 pairs
  -cartilage

- Artery of palate
  - Nasal artery
  - Maxillary artery

- Salivary glands
  - Submaxillary
  - Sublingual
  - Minor

- Major
  - Parotid
  - Stensen's duct
  - Buccal
  - Palatine glands

- Lacrimal gland
  - Zygomatic

- Zygomatic arch
  - Nasolacrimal duct

- Hard palate
  - Soft palate

- Frenulum
  - Membrane

- uvula
* Ventral surface of tongue is connected to floor buccal cavity by thin membrane called frenum longum.

* On the dorsal surface of tongue papilla tong which contains taste buds.

**Teeth.**

* Origin = ectomesodermal.
* Teeth forming cell = odontoblast cell.
* Mammalian teeth are:
  1. Deciduous teeth embedded in bony sockets
  2. Diphyodont teeth - teeth appear twice time.
  3. Heterodont teeth - teeth differ in structure.

<table>
<thead>
<tr>
<th>Function</th>
<th>Molars (M)</th>
<th>Premolars (PM)</th>
<th>Canine (C)</th>
<th>Incisor (I)</th>
</tr>
</thead>
</table>

* Diphyodont = milky/deciduous/temporary teeth.

* Permanent teeth.

* 12 teeth are monophyodont.

* All premolars & last molar teeth are monophyodont.
* Upper jaw made up of maxilla bone.
* Lower jaw made up of mandible bone.
* Incisor and canines have 1 root.
* Dental formula of adult = 2 1 2 3
* Dental formula of child = 2 1 0 2
* Task of elephant is a upper incisor.
* These are root less teeth.

Enamel
- Hardest substance: (96% inorganic salt)
  - Ectodermal.

Dentine
- Contain 69% inorganic salt.
  - Mesodermal.
  - Secreted by odontoblast cells.

* Cavity of root is called pulp cavity which is lined by odontoblast cells.
* Common passage of food and air is pharynx.

* A cartilaginous flap (epiglottis) prevents entry of food into larynx.

* During swallowing, breathing rate zero.

* Minimising breathing during sleeping.
* In oesophagus only mucous gland + no digestive gland.

* Oesophagus has voluntary and involuntary both muscles.

* Oesophagus open into muscular bag stomach through gastro-oesophageal sphincter/ cardiac sphincter.

* Stomach open into duodenum through pyloric sphincter.

* Stomach is J-shaped, widest part.

* Stomach has 4 parts: cardiac fundus + body + pyloric

* Muscular Contraction in stomach wall called Churning movement.

* Empty stomach has longitudinal folds called gastric rugae.
First, it is important to note the key points about the digestive system:

1. Widest part = Stomach.
2. Longest part = Ileum.
3. Maxm peristalsis occur in = Stomach.
4. Minm " " " = Rectum.
5. Maxm digestion occurs in = Duodenum.
6. Maxm absorption " " " = Jejunum.

The stomach has gastric glands which secrete gastric juice.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Cells of Gastric Mucosa</th>
<th>Secretion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mucous cell</td>
<td>Mucous</td>
</tr>
<tr>
<td></td>
<td>(Enterolet cell)</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>oxyntic cell</td>
<td>HCl + C</td>
</tr>
<tr>
<td></td>
<td>(Parietal cell)</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Chief cell/pepticell</td>
<td>Pepsinogen</td>
</tr>
<tr>
<td></td>
<td>Zymogen cell</td>
<td>Pro-rezinin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gastric Lipase</td>
</tr>
<tr>
<td>4.</td>
<td>Argentaffin cell.</td>
<td>Gastrin hormone</td>
</tr>
<tr>
<td></td>
<td>(a) G cell</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) D cell</td>
<td>Somatostatin</td>
</tr>
<tr>
<td></td>
<td>(c) E C cell</td>
<td>Histamine &amp; Serotonin</td>
</tr>
</tbody>
</table>
falciform ligament

Liver A

Cystic duct

Common bile duct

* C.I.F (Castle's Intrinsic Factor) is essential for absorption of vit-B12.

* Vit-B12 is required for RBC maturation.

* Gastric juice contain 3 enzymes:
  - Pepsinogen + pro-panin + gastric lipase.

Intestine

Small intestine
  - Length more
  - Diameter less

  - Jejunum
  - Ileum

Large intestine
  - Length less
  - Diameter more

  - Caecum
  - Colon
  - Rectum
* Duodenum is C-shape. In this bile juice and pancreatic juice are carried by hepatopancreatic duct.

* Opening of hepatopancreatic duct is guarded by sphincter of Oddi.

* Small bladder is for storage and concn of bile juice. Its duct is called cystic duct.

* Contractn in gall-bladder is stimulated by CCK hormone.

* Gall-Stone is due to accumulation of cholesterol.
Caecum is for cellulose digestion.
Caecum is host for Symbiotic micro-organism.
In human caecum is small-blind sac from 1st finger like projection vermiform appendix arise. It is vestigial.
Ileum open into large intestine through ileo-caecal wall.

Colon has 4 parts: -
Ascending, Transverse, Descending & Sigmoid Colon.

In the wall of colon they muscular bands
Himcol and small pouches haustra

Haustra increase water absorption surface area.

Rectum is for storage of excreta, muscular movement in rectum is called bowel movement

Due to enlargement of rectal vein causes piles / Haemorrhoids. (Bleeding with excreta).

Bowel movement irregular than constipation.

Bowel "diarrhoea" abnormal frequently

For More PDFs Visit: LearningMantras.com
Histology of Alimentary Canal:

A. Mucosa
   - Visceral peritoneum
   - Areolar connective tissue

B. Muscularis Layer
   - Outer: LSM (Longitudinal muscle layer)
   - Inner: CML (Circular muscle layer)

C. Submucosa
   - Consist of loose connective tissue
     - This layer contains blood vessels, nerve, lymph vessels

D. Mucosa
   - Inner layer: Consist of 3 sublayer
     - Muscularis mucosa: Thin layer of smooth muscle
     - Lamina propria: Made up of RFCT (Reticular fibrous connective tissue)
     - Epithelium: Gt lines the lumen

* In a pharynx, buccal cavity, esophagus: Stratified squamous epithelium
* In a stomach, intestine: Simple columnar epithelium
* G nerve plexis: Nerve to wall of aliment canal
* Petlewal's plexus
  - Myenteric
  - Nerve to LM and CML
  -ört C3, C4
* Gt Coordinate peristalsis
(ii) Submucosal plexus (Meissner's plexus) -
+ Int b/w CML and Sub-mucosal layer
+ Control secretion of GIT.

* Activity of GIT regulated by ANS.
* Parasympathetic system stimulate peristalsis
  and secretion of GIT.
* Sympathetic system inhibited peristalsis
  and secretion.

* Modifications:
  (i) In oesophagus outer layer, it is not visceral
      peritonium, it is Tunica adventitia.
  
  (ii) In stomach, extra/oblique muscle layer
      + Int.
  
  (iii) In the Submucosa of Duodenum, multi-
        cellular, Brunner's gland + Int.

  
  GI's secretion is alkaline.

  GI's secretion no enzyme + Int.

  (iv) In small intestine epithelium form
     Transverse and longitudinal folds.

     Small transverse fold = Plica circularis, valvulae
     conniventes.

     Folds of kerking.
* Long longitudinal fold = villi.

* Cells of villi have brush border of microvilli.

* Villi + microvilli + plica circularis = increase absorption surface area.

* Each villi has simple lymph capillary in center and a network of blood capillary.

* B/w 2 villi epithelium invaginate and formed crypts of Lieberkuhn which secrete intestinal juice “succus entericus.”

These crypts are lined by paneth cell which secrete enzymes.

* In ileum region payers patches/guttural tonsils + tnt which secrete lymphocyte.

---

<table>
<thead>
<tr>
<th>Word</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunica adventia</td>
<td>Oesophagus</td>
</tr>
<tr>
<td>Oblique muscles</td>
<td>Stomach</td>
</tr>
<tr>
<td>Brunner’s gland</td>
<td>Duodenum</td>
</tr>
<tr>
<td>Payers patches</td>
<td>Ileum</td>
</tr>
<tr>
<td>Taenia &amp; Hausa</td>
<td>Colon</td>
</tr>
<tr>
<td>Max vell</td>
<td>Jejunum</td>
</tr>
</tbody>
</table>
Physiology of Digestion.

Digestion in Bucal cavity:

1. Buccal cavity performs 2 major functions:
   a) Mastication of food.
   b) Facilitation of swallowing.

2. Saliva:
   a) In saliva, starch, digestive enzymes, salivary amylase, ptyalin, etc.

3. About 30% starch is hydrolysed in buccal cavity into maltose by salivary amylase enzyme at optimum pH 6.8.
* Salivary amylase is activated by pH. If pH of buccal cavity fall then ptyalin activity reduce.

* In buccal cavity only carbohydrate digestion occur.

* Saliva mix masticated food is called bolus which enter into oesophagus through pharynx. For this buccal cavity is called deglutition.

* In oesophagus no digestion.

**Digestion in stomach.**

1. Due to relaxation of gastro-oesophageal sphincter bolus enter into stomach.

2. Contraction in muscular wall of stomach is called chewing movement due to this gastric juice mixed onto food.

3. Relaxation of gastro-oesophageal sphincter at regular interval during chewing movement is called gastro-oesophageal relaxation disorder – heart burn – disease.

4. If this sphincter do not open properly then food accumulate in oesophagus and this is cardiac achalasia disease.
* Gastric Juice contain HCl + Cl⁻ + mucous + Enzyme
  \( \text{pepsinogen} \) + protease + gastric lipase.

* Mucous + Bicarbonate protect epithelium of stomach from HCl.

* HCl convert Fe⁺³ of food into Fe⁺² form. \( \text{FeCl}_2 \) convert to \( \text{FeCl}_3 \) then \( \text{FeCl}_2 \) absorb Fe⁺² in Duodenum.

\[ \text{FeCl}_3 \rightarrow \text{FeCl}_2 \]

\[ \text{FeCl}_2 \text{ absorb } \text{FeCl}_3 \text{ in Duodenum.} \]

So, no secretions of HCl causes iron deficiency anemia.

** Group of protein digestive enzymes are called proteolytic enzymes. These are of 2 types.

- Endopeptidase, \( \text{α}-\)endopeptidase

  protein \( \rightarrow \) peptones. \( \text{α}-\)endopeptidase.

  + proteases

  \( \rightarrow \) dipeptide + AA.
* Main function of HCl is activation of enzyme.

* Pepsinage activated by HCl. It is endopeptidase enzyme in acidic medium.

* Pepsinogen → HCl. pepsin → protease.

  protein → pepsin → peptones + proteases
  \[ \text{pH} 2-3 \]

* Gastric lipase is secreted in small amount. It acts on only 1% emulsified fat.

* Rennin is activated by HCl. It is for milk protein coagulation, so help in milk protein digestion. The initial step of milk protein digestion is rennin. It is found only in infant (mammalian child). It is absent in adult.

  prorennin → HCl. rennin.
  casein → Ca⁺⁺ Ca - paracasein. (milk protein) → rennin. \[ \text{peptones + proteases} \]
* Stomach is main site for protein digestion.

* After activity of gastric juice acidic food is called chyme.

**Digestion in Small Intestine.**

- Bile Juice, pancreatic juice and intestinal juice mixes gritty food in small intestine.

- **Bile Juice and pancreatic juice released into duodenum but intestinal juice into jejunum.**

**Bile - Juice.**

- **Synthesised by liver.**
- **Store:** concentrated by gall bladder.
- Have no enzymes.
- **Alkaline:** pH: 7.5 – 8.5
- Contain bile salts, bile pigments and cholesterol.

* **Bile salts**
  - Inorganic: NaCl, NaHCO3
  - Organic: Na-taurate, Na-bileate

1. Emulsification of fat
2. Make food mean alkaline.
3. Help in absorption of fat and fat soluble vitamin.

6. Activation of lipase enzyme.

* Conversion of large fat globules into small one is called emulsification.

* If bile duct is blocked, fat digestion is affected.

Pancreatic juice:

- It is synthesised and secreted by pancreas.
- It is carried into duodenum by hepatopancreatic duct. It is alkaline.

Pancreatic juice contain enzymes:

1. Trypsinogen
2. Chymotrypsinogen
   + Procarboxypeptidase
   + Amylase
   + Lipase
   + Nuclease
   + Nucleotidase
* Trypsinogen is activated by Enterokinase enzyme. It is secreted by intestinal Brush border epithelium.

* Trypsin and Chymotrypsin is Endopeptidase in an alkaline medium but Carboxypeptidase is Exopeptidase.

* Chymotrypsin and Carboxypeptidase are activated by Trypsin enzyme.

Trypsinogen $\xrightarrow{\text{Enterokinase}}$ Trypsin.

Chymotrypsinogen $\xrightarrow{\text{Trypsin}}$ Chymotrypsin.

Pro-carboxypeptidase $\xrightarrow{\text{Trypsin}}$ Carboxypeptidase.

Trypsin, Chymotrypsin, $\xrightarrow{\text{pH = 7 to 8 }}$ Peptides and Proteins

Protein $\xrightarrow{\text{Trypsin, Chymotrypsin}}$ Peptides + Proteins

Carboxypeptidase $\xrightarrow{\text{pH = 8 to 9}}$ Dipeptide

* In adult humans, Chymotrypsin also helps in milk protein digestion.
* 70% starch → maltose.
  pH 7.8

* Emulsified fat → lipase → Monoglyceride + Diglyceride
  pH 7.8

* Nucleic acid → nuclease.
  (DNA + RNA) → (DNAse + RNAse) → nucleotide.
  Nucleotide → nucletidase.
  Nucleoside.

Intestinal Juice.

1. It is also called sucus entericus.
2. It is secreted by crypts of Lieberkühn.
3. It is alkaline fluid.
4. It contains enzymes: dipeptidase, maltase, lactase, sucrase, lipase, nucleotidase, nucleosidase.
Dipeptide → Dipeptidase → Amino acid

Maltose → Maltase → Glucose + Glucose

Lactose → Lactase → Glucose + Galactose (Milk sugar)

Sucrose → Sucrase → Glucose + Fructose

Invertase

Monoglyceride → Lipase → Fatty acid + Glycerol

Nucleotides → Nucleotidase → Nucleosides

Nucleosides → Nucleosidase → Base + pentose sugar

After activity of pancreatic juice alkaline food is called Chyle.

End product of digestion = AA + glucose + fructose + inlactase + fatty acid + glycerol.
Absorption

process by which end product of digestion, move into blood or lymph through epithelium of gut.

- Absorption occur by simple diffusion, facilitated transport and active transport.
- Some glucose, some AA, Cl- by passive transport
  (Simple diffusion)
- Some glucose, some AA, Fructose by facilitated transport with the help of carrier protein
- Major part of glucose and AA, Na+, K+ by active transport.

<table>
<thead>
<tr>
<th>Part of gut</th>
<th>Absorbed Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mouth (Buccal cavity)</td>
<td>Some chemicals/drugs absorbed by lower side of tongue</td>
</tr>
<tr>
<td>2. Stomach</td>
<td>Water, Electrolyte, Drugs, Simple sugar, Alcohol</td>
</tr>
<tr>
<td>3. Duodenum</td>
<td>Fe++, Ca++, Principle organ for absorption of nutrients (glucose, AA, vitamin)</td>
</tr>
<tr>
<td>4. Jejunum</td>
<td>Most of water and electrolyte</td>
</tr>
</tbody>
</table>
5. **ileum** = fatty acid + vit.B12 + glycerol.

6. **colon** = water, electrolyte, vitamins.
   (Large intestine)

---

- All substances are absorbed into blood. Except:
  - Long chain fatty acid + glycerol.
  - Fat soluble vitamins.

---

* Fatty acids and glycerol being insoluble so cannot absorb into blood. They incorporate with bile salt and formed fat droplets called micelles. These micelles enter into epithelial cell at villi. They are re-formed into very small protein coated fat droplets called chylomicrons. These chylomicron dispersed into lymph of lymph capillary / lacteals.

* Fat is absorb by lacteals, in the form of chylomicrons.
1) Jaundice.

Disorders:
(i) Liver is affected.
(ii) In this skin, eyes turn yellow due to accumulation of bile pigments.

2) Constipation.
3) Diarrhoea.
4) Indigestion:

* In this food is not properly digested so filling of fullness.
Reason for indigestion: overeating, spicy food, anxiety, food poisoning, improper secretion of enzymes.

5) Vomiting: content of stomach expelled out through mouth is called vomiting.

Vomiting centre located on medulla oblongata.

6) PEM (protein energy malnutrition):

In this kwashiorkor and marasmus disease including.

(i) Marasmus is produced by deficiency of protein and calorie. It occurs in children less than 1 year age. It's skin become dry, thin, wrinkled. No swelling on body. No fat below the skin, infant's rate and body weight declines. Ribs are prominent.
Kwashiorkor: It's a disease caused by deficiency of protein in the diet. It usually occurs in children under 4 years of age. In this condition, edema (swelling of body tissues) occurs, and some fat is still left on the skin. Their skin appears normal, but failure of body growth and brain development is a result.

**Digestive glands:**

- **Liver:**
  - Hepatic vein
  - Hepatic artery
  - Portal vein
  - Bile duct
  - Gallbladder

- **Hepatic Triad:**
  - Portal triad
  - Central vein
  - Branch of hepatic vein

**Largest gland:**
- Endodermal
- Weight: 1-2-1.5 kg
- Triangular shape, bilobed; right lobe is larger than left
- Each lobe is made up of many hepatic lobules
* Structural & Functional unit of liver = Hepatic lobules.

* Each lobule is covered by connective tissue sheets called Glisson's capsule.

* Each lobule contains many hepatic cells which synthesise and secrete bile juice.

* Hepatic cells arrange in radial rows, called hepatic cords.

* Btw 2 hepatic cords, Blood sinus present called hepatic sinusoids which is lined by Kupffer cells. These are phagocytic cells.

* Hepatic portal vein carry deoxygenated blood from intestine to liver.

* Heart - Lungs, Liver receive both oxygenated and de-oxygenating blood.

* Liver synthesises:
  - Urea
  - York
  - Bile-Juice
  - Plasma-protein
  - Clotting factor
  - Heparin
  - Vit-A from β-carotin.
Detoxification of alcohol done by the liver.

In an alcohol addict, person liver damage due to accumulation of fatty acid.

### Vitamins

- **G** - organic substance which are not synthesized by body.
  - Vit-D (in skin) and Vit-K. B12. In colon, are formed by body.
- **Vitamins are of 2 types:**
  - Water soluble:
  - Fat-soluble: A, D, E, K.

<table>
<thead>
<tr>
<th>Vit.</th>
<th>Chemical name</th>
<th>Deficiency Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Retinol</td>
<td>Night blindness, Xerophthalmia</td>
</tr>
<tr>
<td>D</td>
<td>Calciferol</td>
<td>Sunshine vitamin, Osteomalacia in adults, Rickets in child</td>
</tr>
<tr>
<td>E</td>
<td>Tocopherol</td>
<td>Sterility</td>
</tr>
<tr>
<td>K</td>
<td>Phylloquinone, (Naphthoquinone)</td>
<td>Haemorrhagia, Continuous bleeding</td>
</tr>
<tr>
<td>Vitamin</td>
<td>Function</td>
<td>Condition</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>C</td>
<td>Ascorbic Acid (works as co-factor)</td>
<td>Scurvy - (Bleeding gums)</td>
</tr>
<tr>
<td>B1</td>
<td>Thiamine</td>
<td>Beri-Beri</td>
</tr>
<tr>
<td>B12</td>
<td>Cyanocobalamin (co-enzyme, RBC maturation)</td>
<td>Pernicious anaemia</td>
</tr>
</tbody>
</table>

- *Vit-K is essential for formation of prothrombin in liver, so it helps in blood coagulation.*
- *In milk, bread, egg vit-C absent.*
- *Watermelon:* $B_{12}$