The Digestive System

Digestive system consists of:
1. Gastrointestinal Tract (GIT).
2. Accessory organs.

GIT is a digestive tract consists of oral cavity, pharynx, esophagus, stomach, small intestinal, large intestine, and anus.

The accessory organs of digestion are the teeth, tongue, salivary glands, liver, gallbladder, and pancreas. Digestion does not take place within these organs, but each contributes something to the digestive process.

The functions of the digestive system are to:
1. ingest the food;
2. break food down into small molecules that can cross plasma membranes.
3. absorb these nutrient molecules.
4. eliminate no digestible wastes.
5. control of all these functions by local, nervous, and hormonal systems.

<table>
<thead>
<tr>
<th>Tunic</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucosa</td>
<td>Simple columnar epithelium</td>
<td>Secretion and absorption</td>
</tr>
<tr>
<td>Submucosa</td>
<td>Highly vascular; autonominically innervated</td>
<td>Absorption</td>
</tr>
<tr>
<td>Muscularis</td>
<td>Smooth muscle</td>
<td>Peristalsis</td>
</tr>
<tr>
<td>Adventitia (visceral serosa)</td>
<td>Visceral peritoneum</td>
<td>Binding and protection</td>
</tr>
</tbody>
</table>
Mouth:
taste,
chewing,
formation of food bolus

Saliva:
lubrication,
rinsing,
digestion

Liver:
bile (excretion,
lipid digestion),
metabolism,
detoxification

Gallbladder:
bile storage

Pancreas (exocrine):
digestive enzymes,
$\text{HCO}_3^-$ as H$^+$ buffer

Passage time
(from time of food intake)

Esophagus:
transport

Proximal stomach:
storage

Distal stomach:
processing,
digestion,
portioning

Small intestine:
digestion,
absorption

Cecum:
storage

Colon:
absorption

Rectum:
storage,
excretion

10 s

1–3 h

7–9 h

25–30 h

30–120 h
The SALIVARY GLANDS :-

The digestive secretion in the oral cavity is saliva, produced by three pairs of salivary glands, which are:

1- The parotid glands :- are just below and in front of the ears.
2- The submandibular (also called submaxillary) glands :-are at the posterior corners of the mandible.
3- the sublingual glands :- are below the floor of the mouth.

Each gland has at least one duct that takes saliva to the oral cavity.

Saliva composition :

1. Water   99.4%.
2. Electrolytes (Na⁺, Cl⁻, HCO₃⁻) to regulate osmotic pressure.
3. Buffers keep pH near (7.0).
4. Glycoprotein.
5. Antibody (IgA) and lysozyme. 0.6%
6. Enzyme –amylose (ptyalin) to digest CHO.
7. Waste product like urea.
8. Mucins

The functions of saliva are reflected by its constituents. Saliva is mostly water, which is important to dissolve food for tasting and to moisten food for swallowing.

Mucins :- serve to lubricate the food, making it easier to swallow, and to keep the mouth moist to facilitate masticatory and speech-related movement.

Saliva has a low NaCl concentration and is hypotonic, making it suitable for rinsing of the taste receptors (NaCl) while eating. Infants need saliva to seal the lips when suckling.

Saliva also contains α-amylase:-- which starts the digestion of starches in the Mouth.

while immunoglobulin A and lysozyme are part of the immune defense system. The high HCO₃ concentration in saliva results in a pH of around 7, which is optimal for α-amylase-catalyzed digestion.
Control of Salivary Secretion:
Each salivary gland receives parasympathetic and sympathetic innervation; the parasympathetic increase the secretion of saliva by all salivary glands. Sympathetic innervation remains uncertain.

The PHARYNX: -
No digestion takes place in the pharynx. Its only related function is swallowing, the mechanical movement of food. The pharynx has three parts: (1) The nasopharynx, posterior to the nasal cavity, serves as a passageway for air. (2) the oropharynx, posterior to the soft palate, is a passageway for both air and food. (3) the laryngopharynx, just inferior to the esophagus, is a passageway for food entering the esophagus.

The ESOPHAGUS: -
The esophagus is a muscular tube that takes food from the pharynx to the stomach; no digestion takes place here.
Peristalsis of the esophagus propels food in one direction and ensures that food gets to the stomach even if the body is horizontal or upside down. At the junction with the stomach, the lumen (cavity) of the esophagus is surrounded by the lower esophageal sphincter (LES or cardiac sphincter), a circular smooth muscle. The LES relaxes to permit food to enter the stomach, then contracts to prevent the backup of stomach contents.

Swallowing mechanism:-
During swallowing, food normally enters the esophagus because other possible avenues are blocked.
Swallowing is a reflex action performed automatically (without our willing it). When we swallow, the soft palate moves back to close off the nasopharynx, and the trachea moves up under the epiglottis so that food is less likely to enter it. (We do not breathe when we swallow.) The tongue presses against the soft palate, sealing off the oral cavity, and the esophagus opens to receive a food bolus.

The Stomach:

The term gastric always refers to the stomach which it a thick-walled, J-shaped organ that lies on the left side of the abdominal cavity deep to the liver and diaphragm.
The stomach is continuous with the esophagus above and the duodenum of the small intestine below.
The length of the stomach remains at about 25 cm (10 in.) regardless of the amount of food it holds, but the diameter varies, depending on how full it is. As the stomach expands, deep folds in its wall, called rugae, gradually disappear.
When full, it can hold about 4 liters (1 gallon).
The stomach receives food from the esophagus, stores food, mixes food with its juices (thereby starting the digestion of proteins), and moves food into the small intestine.

Regions of the Stomach :-
The stomach has four regions:-
1- The cardiac region:- which is near the heart, surrounds the lower esophageal sphincter where food enters the stomach.
2- The fundic region:- which holds food temporarily, is an expanded portion superior to the cardiac region.
3- The body region:- which comes next, is the main part.
4- The pyloric region :- narrows to become the pyloric canal leading to the pyloric sphincter through which food enters the duodenum, the first part of the small intestine.

Digestive Functions of the Stomach :-
The stomach both physically and chemically acts on food.
The motor functions of the stomach are three fold:
(1) storage of large quantities of food until the food can be processed in the stomach, duodenum, and lower intestinal tract .
(2) mixing of this food with gastric secretions until it forms a semifluid mixture called chime .
(3) slow emptying of the chyme from the stomach into the small intestine at a rate suitable for proper digestion and absorption by the small intestine .

Its wall contains three muscle layers: One layer is longitudinal, another is circular, and the third is obliquely arranged.
This muscular wall not only moves the food along, but it also churns, mixing the food with gastric juice and breaking it down to small pieces.

The columnar epithelial lining of the stomach has millions of gastric pits, which lead into gastric glands.
The gastric glands produce gastric juice, which contains pepsinogen, HCl, and mucus.
Chief cells secrete pepsinogen, which becomes the enzyme pepsin when exposed to hydrochloric acid (HCl) released by parietal cells.
The HCl causes the stomach to have a high acidity with a pH of about 2, and this is beneficial because it kills most of the bacteria present in food. Although HCl does not digest food, it does break down the connective tissue of meat and activate pepsin.

The wall of the stomach is protected by the thick layer of mucus secreted by the mucous cells.
Normally, the stomach empties in about 2–6 hours. When food leaves the stomach, it is a thick, soupy liquid called chyme.
Chyme enters the small intestine in squirts by way of the pyloric sphincter, which acts like a valve, repeatedly opening and closing.

Gastric Secretion:
1. Mucus cells secrete mucous, trefoil peptide and bicarbonate.
2. Parietal cells secrete acid and intrinsic factors.
3. Enterochromaffin like cells secretes histamine.
4. Chief cells secrete Pepsinogen.
5. G-cells secrete gastrin.
6. D-cells secrete somatostatin.
Contents of Gastric Juice:

TABLE 26-1 Contents of normal gastric juice (fasting state).

<table>
<thead>
<tr>
<th>Cations: Na⁺, K⁺, Mg²⁺, H⁺ (pH approximately 1.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anions: Cl⁻, HPO₄²⁻, SO₄²⁻</td>
</tr>
<tr>
<td>Pepsins</td>
</tr>
<tr>
<td>Lipase</td>
</tr>
<tr>
<td>Mucus</td>
</tr>
<tr>
<td>Intrinsic factor</td>
</tr>
</tbody>
</table>

Regulation of Gastric Secretion (Control of Gastric Secretion):
(a) The Cephalic Phase

Function:
Sight, smell, taste, or thoughts of food

Duration:
Short (minutes)

Mechanism:
Neural: via preganglionic fibers in vagus nerve and synapses in submucosal plexus

Actions:
Primary: increased volume of gastric juice by stimulating mucus, enzyme, and acid production
Secondary: stimulation of gastrin release by G cells

(b) The Gastric Phase

Function:
Entire secretion started in cephalic stage; homogenize and acidify chyme; initiate digestion of proteins by pepsin

Duration:
Long (6-4 hours)

Mechanisms:
Neural: short reflexes triggered by
1. stimulation of stretch receptors as stomach fills
2. stimulation of chemoreceptors as pH increases
Hormonal: stimulation of gastrin release from G cells by parasympathetic activity and presence of peptides and amino acids in chyme
Local: release of histamine by mast cells as stomach fills (not shown)

Actions:
Increased acid and pepsinogen production; increased motility and initiation of mixing waves

(c) The Intestinal Phase

Function:
Control rate of chyme entry into duodenum

Duration:
Long (hours)

Mechanisms:
Neural: short reflexes (enterogastric reflex) triggered by distension of duodenum
Hormonal:
Primary: stimulation of cholecystokinin (CCK), gastric inhibitory peptide (GIP), and secretin release by presence of acid, carbohydrates, and lipids
Secondary: release of gastrin stimulated by presence of undigested proteins and peptides (not shown)

Actions:
Feedback inhibition of gastric acid and pepsinogen production; reduction of gastric motility