Digestion

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DIGESTION

INTRODUCTION
The process of breakdown of substances into smaller particles and convert them into absorbable material is called digestion.

Ingestion: Taking food into the digestive tract

Propulsion: Move food through alimentary canal

Function of Digestive System
1. Ingestion (consumption of food particles)
2. Breaking them into small particles
3. Transport the small particles to different areas of digestive tract
4. Secretion of necessary enzymes and other substances for digestion
5. Digestion of food particles
6. Absorption of food digestive product (nutrient)
7. Removal of unwanted substances from the body

Parts of Digestive System
Digestive System is made up of gastrointestinal tract (or alimentary canal) and accessory organs (which help in process of digestion).

Parts of Gastrointestinal Tract (GIT)
GIT is a tubular structure which is 30 feet long and runs from mouth to anus.

- Mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Anus

Accessory Organs of Digestive System
- Teeth
- Tongue
- Salivary glands
- Exocrine part of pancreas
- Liver
- Gall bladder
**Blood Supply**

Arteries branch off the abdominal aorta to:

- Digestive Organs
- Hepatic Portal Circulation

Arteries branch off from celiac trunk:

- Hepatic Artery (supply liver)
- Splenic (supply spleen)
- Left gastric (supply stomach)

- Superior/inferior mesenteric arteries (supply small and large intestine)
- Digestive system receives approximately 25% of cardiac output. This increases after a meal.

**Wall of GIT**

Wall of GIT is formed by four layers which are from inside out:

1. Mucus layer
   a) Epithelial lining
   b) Lamina propria
   c) Muscularis mucosa
2. Submucous layer
3. Muscular layer
   a) Circular muscle
   b) Longitudinal muscle
4. Serous or fibrosa layer

**Nerve Supply to GIT**
There are two types of nerve supply

- Intrinsic nerve supply
- Extrinsic nerve supply

**Intrinsic Nerve Supply**
The intrinsic nerve fibers are present within the walls of GIT. These fibers are interconnected and form a network called nerve plexus which includes:

- **Aurebach’s plexus** (present between inner circular muscle and outer longitudinal muscle layer)
  It regulates the movement of GIT by some excitatory neurotransmitter substances like acetylcholine, serotonin; and by some inhibitory neurotransmitter substance such as vasoactive intestinal polypeptide (VIP), neurotensin.

- **Meissner’s plexus** (present between muscular layer and sub-mucosal layer)
  It regulates the secretory function GIT.

The receptors of GIT are stretch receptor (mechanoreceptor), osmoreceptor and chemoreceptor.

The intrinsic nerve supply is control by extrinsic nerve supply.

**Extrinsic Nerve Supply**
Extrinsic nerve supply to GIT is from autonomic nervous system.

**Sympathetic Nerve Fibers**
The sympathetic nerve fibers arise from spinal cord and inhibit the movement and secretion of GIT by secreting noradrenaline.

**Parasympathetic Nerve Fibers**
The parasympathetic nerve fibers arise from brain and accelerate the movement and secretion of GIT by secreting acetylcholine.

**MOUTH**

**Function of Mouth**

- Ingestion of food materials
- Chewing and mixing of food with saliva
• Appreciation of taste of food
• Transfer of food (bolus) to the esophagus by swallowing

**Major Salivary Gland**
- Parotid Gland
- Sub-maxillary Gland
- Sub-lingual Gland

**Properties of Saliva**
- Volume: 1000 to 1500 ml/day
- pH: Slightly acid with a pH of 6.35 to 6.85
- Specific Gravity: 1.002 to 1.012
- Composition: Water (99.5%) and Solid (0.5% which includes enzymes and other organic and inorganic substances)

**Function of Saliva**
1. Prepare the food for swallowing
2. Helps in appreciation of taste
3. Helps in the digestion of cooked starched (by amylase enzyme), maltose (by maltase) and milk fat (by lingual lipase)
4. Keep the mouth clean and protect it from bacterial growth
5. Helps in speech
6. Excretes certain substances like heavy metals
7. Helps in regulation of water balance via thirst mechanism

**Regulation of salivary secretion**
Salivary secretion is regulated by nervous mechanism and its reflex phenomenon which are of two types
- Unconditioned Reflex (Secretion of saliva due to any substance placed in the mouth)
- Conditioned Reflex (Secretion of saliva due to smell, sight, hearing or thought of food)
STOMACH

Parts of Stomach

- Cardiac Region
- Fundus
- Body or corpus
- Pyloric region

Function of Stomach

Storage Function
The food is stored in the stomach for a long period i.e. for 3 to 4 hours and emptied into the intestine slowly. The maximum capacity of stomach is 1.5 liters. The slow emptying of stomach provides enough time for proper digestion and absorption food substance in the small intestine.

Formation of Chyme
The peristaltic movements of stomach mix the bolus with gastric juice and convert it into semi solid material known as chime.

Digestive function
The gastric juice mainly acts on proteins. The prominent enzymes of gastric juice are pepsin and renin.

Pepsin
Pepsin is secreted by chief cells as pepsinogen which is inactive form of pepsin and is converted by HCl (secreted by parietal cells). Pepsin attacks the peptide bonds of proteins by hydrolysis.

Hemopoietic Function
The intrinsic factor of Castle present in gastric juice plays an important role in erythropoiesis.

Protective Function
The thick mucus present in the gastric juice is responsible for the protection of gastric wall.
Mucus helps in
1. Protection of Stomach wall from irritation or mechanical injury
2. Prevents the digestive action of pepsin on the wall of stomach
3. Protects the gastric mucosa from HCl.

Function of HCl
HCl present in the gastric juice and is secreted by Parietal (Oxyntic) Cells:

- Activates pepsinogen into pepsin
- Kills some bacteria entering the stomach
- Provides aid medium which is necessary for the action of hormones

Excretory Function
Many substances like toxins and metals are excreted through gastric juice.

Gastric Mucosal Barrier (GMB)
- Luminal membrane impermeable to HCl
- Tight junctions between cells

Properties of Gastric Juice
- Volume: 1200 to 1500 ml/day
- Reaction: gastric juice is highly acidic due to HCl, with pH of 0.9 to 1.2
- Specific Gravity: 1.002 to 1.004

Phases of Gastric Secretion
Cephalic Phase
- This phase is purely under nervous control.
- While taking food secretion of gastric juice start.
- The impulses are sent from head so this phase is called cephalic phase.
- The gastric juice secreted in this phase is called as appetite juice this can occur in both conditioned and unconditioned relajes.
- In both reflexes pepsinogen and HCl is secreted.

Unconditioned Reflex
When food is placed in the mouth there is secretion of gastric juice.

Mechanism of Unconditioned reflex
Afferent impulses arise from the taste buds and reach the appetite center in the hypothalamus. From here efferent impulses arise and through vagal stimulation passes in the wall of stomach. The gastric secretion is released by acetylcholine.
**Conditioned Reflex**

In conditioned reflex even sight, smell, thought or hearing of food causes secretion. The impulses arise from cerebellum cortex and reach the stomach through vagal stimulation.

**Gastric Phase**

This phase is under nervous and hormonal control. When the food enter stomach, secretion of gastric juice increases (pepsinogen and HCl are secreted in large quantity).

Three mechanisms are mainly involved in gastric secretion.

**Local Myenteric Reflex**

When food enters the stomach, the food particles stimulate the local nerve impulses in the wall of stomach. This nerve activates the glands of stomach and large quantity of gastric acid is released.

**Vagovagal Reflex**

Presence of food in stomach stimulates the sensory nerve ending, which pass through vagal stimulation. These sensory fibers stimulate both afferent and efferent impulses that are why this phenomenon is called vagovagal reflex.

**Gastrin Mechanism**

Gastrin is one of the important hormones. It is secreted in pyloric region of stomach. Small amount is also secreted in small intestine. In fetus it is also secreted from pancreas. Gastrin is released when food enters the stomach. The mechanism may be the local nerve reflex or vagovagal reflex. Gastrin act through following action:

- It stimulated the secretion of pepsinogen and HCl
- It increases the motility of stomach
- It increases the pancreatic juice which is highly rich in enzyme.

**Intestinal Phase**

- When the food enters the intestine initially there is secretion of gastric juice and finally it is inhibited.
- When the food leaves the stomach and enter intestine, immediately there is release of gastrin from the cells of intestine.
- This gastrin is also transported to stomach by blood
- Gastrin acts on the glands of stomach and causes the secretion of gastric juice.
- Secretin and cholecystokinin hormones secrete more amount of pancreatic juice when chyme enter small intestine.
- The gastric secretion is inhibited by Enterogastric reflex and GI hormones.

**Enterogastrone**

It is secreted in the mucosa of duodenum. It inhibits the gastric secretion and also the gastric motility.

**GIP**

Gastrin inhibitory peptide is secreted from duodenum and jejunum also. This is secreted when the food containing glucose enters. It is also stimulates pancreatic cells to increase release of insulin.
Vasoactive intestinal peptide (VIP) is a polypeptide secreted in intestine, which causes inhibition of gastric and HCl. It also causes peripheral vasodilation.

**PANCREAS**
Pancreas is supplied with splanchnic (sympathetic) nerve and vagus (parasympathetic) nerve. It secretes pancreatic juice in the duodenum through Wisung’s duct.

**Properties of Pancreatic juice**
- Volume: 500 to 800 ml/day
- Reaction: highly alkaline with pH of 8 to 8.3
- Specific Gravity: 1.010 to 1.018

**Composition of Pancreatic Juice**
Pancreatic juice contains 99.5% water and 0.5% solid.

**Function of Pancreatic Juice**

**Digestion of Protein**
The major proteolytic enzymes of pancreatic juice are trypsin and chymotrypsin.

**Trypsin**
Trypsinogen is activated only when it reaches small intestine. Activation of trypsin can damage pancreas so it is prevented by an inhibitor protein called trypsin inhibitor. The inactive trypsinogen is converted into active trypsin by Enterokinase.

**Action of Trypsin**
- Digestion of protein
- Curdling of milk
- Acceleration of blood clotting
- Activation of other enzymes

**Chymotrypsin**
Chymotrypsin also performs the same function as trypsin except it has no action on blood clotting.

**Digestion of Lipids**
The lipolytic enzymes present in pancreatic juice are pancreatic lipase, cholesterol ester hydrolase etc.

**Digestion of Carbohydrates**
Like salivary amylase the pancreatic amylase also converts starch into dextrin and maltose.
**LIVER AND GALLBLADDER**
Liver is the largest gland in the body weighing about 1.5kg in man which helps in digestion through its bile secretion. The common bile duct unites with pancreatic duct to form the common hepatopancreatic duct or ampulla of Vater which opens into duodenum.

**Properties of Bile**
- Volume: 800 to 1200 ml/day
- Reaction: alkaline with pH of 8 to 8.6
- Specific gravity: 1010 to 1011

**Composition of Bile**
Bile contains 97.6% of water and 2.4% of solids.

**Storage of Bile**
Most of the bile from liver enters the gallbladder where it is stored. It is released from gallbladder into intestine whenever it is required by the contraction of gallbladder and relaxation of Oddi sphincter present in the duct. When bile is stored in gallbladder it undergoes following changes:
- A large amount of water and electrolytes (except calcium and potassium) are absorbed resulting in high concentration of bile salts, bile pigments, cholesterol, fatty acids and lecithin.
- The pH and specific gravity of bile are altered in gall bladder
- Some amount of mucin is added to bile

**Function of Bile and Bile Salts**
1. Emulsification of Fats (reduced the surface tension of fats)
2. Absorption of fats
3. Choleretic action (stimulates the secretion of bile from liver)
4. Cholagogue Action (Release of bile from gallbladder)
5. Laxative Action (induces defecation)
6. Prevention of gallstone formation
7. Excretion of some toxins, bacteria, heavy metals and cholesterol

**Function of Liver**
1. Metabolic function (metabolism of carbohydrates, proteins, fats, vitamins and hormones)
2. Storage function (store glycogen, amino acids, iron, folic acid and vitamins)
3. Synthetic function (glucose by glycogenesis)
4. Secretion of Bile
5. Excretion of some toxins, bacteria, heavy metals and cholesterol
6. Heat production (by metabolism)
7. Hemopoietic function (stores products like iron for hemoglobin, vitamin B12 for erythropoiesis)
8. Hemolytic function (destroys senile RBCs after the lifespan of 120 days)
9. Inactivation of Hormones and Drugs

**SMALL INTESTINE**
Small intestine consist of three portions

1. Proximal Part known as duodenum
2. Middle Part known as jejunum
3. Distal Part known as ileum

**Functions of Small intestine**

1. **Absorptive Function**
   - Absorption of Carbohydrates
   - Absorption of Proteins
   - Absorption of Fats
   - Absorption of Waters and Minerals
   - Absorption of Vitamins

2. **Mechanical Function** (mixing movement of small intestine help in the mixing of chyme with juices)

3. **Secretory Function** (secretes succus entericus, enterokinases and GI hormones).

4. **Hormonal Function** (secretes GI hormones)

5. **Digestive Function** (digests food and converts them into final digestive product)

6. **Activator Function** (enterokinases activates trypsin)

7. **Hemopoietic Function** (play important role in erythropoiesis)

8. **Hydrolytic Function** (helps in the enzymatic reaction of all the juices)

**LARGE INTESTINE (COLON)**

**Parts of Large Intestine**

- Cecum with appendix
- Ascending colon
- Transverse colon
- Descending colon
- Sigmoid colon or pelvic colon
• Rectum
• Anal canal

Function of Large intestine

Absorptive Function
Large intestine play important role in absorption of:
• Water
• Electrolyte
• Organic substances like glucose
• Alcohol
• Drugs like anesthetic agents, sedatives and steroids

Formation of Feces (all the unwanted substance left after the absorption forms the feces)

Excretory Function (exertion of heavy metals like mercury, lead and arsenic etc. through feces)

Secretion (secretes mucin and inorganic substances like chlorides and bicarbonate)

Synthetic Function (the bacterial flora of large intestine synthesis folic acid, vitamin B12 and K)

MOVEMENT OF GIT

Mastication
Mastication or chewing is the first mechanical process of GIT by which the food substances are cut into small pieces and crushed down into a soft bolus.

The significant of Mastication
• Breakdown of foodstuffs into smaller particles
• Mixing of saliva with food substances thoroughly
• Lubrication and moistening of dry food by saliva so that the bolus can be easily swallowed
• Appreciation of taste of food

Control of Mastication
Action of mastication is mostly a reflex process. It is control voluntarily also. The center of mastication is situated in medulla and cerebral cortex.

Deglutition
Swallowing of food is known as deglutition. It occurs in three stages:
1. **Oral Stage**: When food enter into pharynx from mouth; voluntary stage
2. **Pharyngeal Stage**: When food enter into esophagus from pharynx; involuntary stage (glossopharyngeal nerve)
3. **Esophageal Stage**: When food enter into stomach from esophagus; involuntary stage (vagus nerve)

The wavelike muscular contractions of the intestine or other tubular structure that propel the contents onward by alternate contraction and relaxation is called peristalsis movement.

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**Movement of Stomach**

**Hunger Contraction**

The movement of empty stomach is related to the sensations of hunger so this movement is called the hunger contraction.

The activities of smooth muscles of stomach increases during gastric digestion (when stomach is filled with food) and when the stomach is empty.

**Receptive Relaxation**

Relaxation of upper portion of stomach when bolus enters the stomach from esophagus is called receptive relaxation which accommodates the food easily without much increase in pressure inside the stomach.

**Peristalsis of Stomach**

When the food enters the stomach the peristaltic contraction appears with a frequency of 3/minutes. It starts from the lower part of the body of stomach and passes through the pylorus till the pyloric sphincter. This type of peristalsis movement is called digestive peristalsis because it is responsible for the grinding of food particles and mixing hem with gastric juice for digestive activities.
**Filling of Stomach**
While taking food, the food arranges itself in the stomach in different layers. The first eaten food is placed against the greater curvature in the fundus and body of the stomach. The successive layers of food particles lie nearer the lesser curvature until the last portion of eaten food lies near the upper end of lesser curvature adjacent to cardiac sphincter.

**Emptying of Stomach**
The food remains in the stomach for about 3 hours. During this period, digestion takes place. The digested food in the form of chyme is emptied into the intestine slowly with the help of peristaltic contractions.

**Movement of Small Intestine**
Four type of movement occur in small intestine

**Mixing Movements**: proper mixing of chyme with different juices
   a) **Segmentation Contraction**: The contractions occur at regularly spaced intervals along a section of intestine.
   b) **Pendular Movement**: small portion of intestine sweep forward and backward or upward or downward

**Propulsive Movement**: pushing the chyme in opposite direction of intestine
   a) **Peristaltic Movement**: the wave of contraction followed by wave of relaxation
   b) **Peristaltic Rush**: Powerful peristaltic contraction

**Peristalsis in Fasting**: Contraction of large portion of intestine

**Movements of Villi**: are small, finger-like projections that protrude from the epithelial lining of the intestinal wall

**Movement of Large Intestine**
Large intestine show sluggish movements in two types
   1. **Mixing movement**: Segmentation contraction
   2. **Propulsive Movements**: Mass peristalsis

**Defecation**
Voiding of feces is known as defecation. Feces is formed in the large intestine and stored in sigmoid colon.

**Defecation of Reflex**
The mass movement drives the feces into sigmoid colon where the feces are stored. The desire for defecation occurs when some feces enters rectum due to mass movement.
**Importance of Defecation Reflex**

The pudendal nerve (somatic nerve) always keeps the external anal sphincter constricted. During defecation reflex the pudendal nerve is inhibited by impulses which arise from cerebral cortex. This causes relaxation of external anal sphincter and defecation occurs.

**Pathway of Defecation Reflex**

- When rectum is distended (contracted) due to entry of feces by mass movement, sensory nerves ending are stimulated and impulses are transmitted via afferent fibers to spinal cord.
- Spinal cord in turn sends motor impulses via efferent fibers to the descending colon, sigmoid colon and in the rectum.
- These efferent impulses cause strong contraction of descending colon, sigmoid colon and rectum and also relaxation of internal sphincter muscle. Simultaneously voluntary relaxation of external sphincter occurs through pudendal nerve and ultimately defecation occurs.

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**Evacuation**

The gases accumulated in GIT are classified into two groups

1. **Exogenous gases** (enter GIT either by swallowing through mouth or drinking carbonated drinks)
2. **Endogenous gases** (produce during digestion of food and interaction between bacteria and food stuff in intestine)

**Evacuation of Accumulated Gases**

Evacuation of accumulated gasses occurs by two processes

1. **Belching**: process by which gas accumulated in stomach is expelled through mouth
2. **Flatulence**: process by which gas accumulated in intestine is released through anus under pressure with disagreeable odor and sound (due to vibration of anal sphincter).
DISEASES

Xerostomia
- Diminished saliva secretion
- Result in difficulty in chewing, swallowing, inarticulate speech and dental caries.

Acini
- Cluster of secretory cells that form sacs

Jaundice
1. Prehepatic
   - Excessive breakdown of RBC.
2. Hepatic
   - Liver is diseased and not able to deal with normal levels of bilirubin.

Diarrhoea
- Excessive defecation of highly fluid faecal material. Eliminates harmful material from the body
- Also eliminates water (dehydration), nutrient material and HCO₃ (metabolic acidosis)
- Caused by:
  - Viral/bacterial infection leading to excessive intestinal motility
  - Lactase deficiency
  - Toxins of *Vibrio Cholera* (bacterium) ⇒ secretion of vast amounts of fluid by small intestinal mucosa

Ulcer
- Peptic ulcer in oesophagus, stomach or duodenum
- Weakness in GMB
- Increased acidity leads to increased histamine leading to increased acidity and a vicious cycle
- *Helicobacter Pylori* ⇒ 90% of peptic ulcers