Digestive system

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Systematic physiology - 2nd Stage /2nd Semester

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1. What are the functions of digestive system?
2. What are components of digestive system?
3. What are the functions of saliva?
4. How lipid, protein and carbohydrate digest and absorb in GIT?
5. What are the main enzyme for protein digestion?
6. What are the functions of liver?
Motor Functions (Motility) of GIT
Motility of the GIT

1. Motility in the mouth

2 types:

a) **Chewing** is important because
   - The food is lubricated by being mixed with saliva
   - The food is exposed to salivary amylase enzyme, which begins digestion of starch
   - It breaks the food into small pieces to be easily swallowed

b) **Swallowing** is the transport of food from mouth to stomach
   - It consists of 3 phases or steps;
Steps of swallowing

• Buccal Phase:

1. Tongue pushes bolus against soft palate and back of mouth, triggering swallowing reflex.
Steps of swallowing

• **Pharyngeal Phase:**

  2. Upper esophageal sphincter relaxes while epiglottis closes to keep swallowed material out of the airways.
Steps of swallowing

• **Oesophageal Phase:**

3. Food moves downward into the esophagus, propelled by peristaltic waves and aided by gravity.
2. Motility of Esophagus

- The esophagus prevents air from entering the GI tract through the function of the **upper esophageal sphincter**.

- The esophagus prevents **GI contents** from re-entering the esophagus from the stomach through the function of the **lower esophageal sphincter**.

- The contraction that **sweeps down** the esophagus (primary and secondary esophageal peristalsis)
3. Motility of Stomach

- The stomach is divided into proximal and distal areas.
- **Proximal area** is thin walled, holds large volumes of food *(to store food)* because of **receptive relaxation**, and contracts weakly and infrequently.
- **Distal area** is thick walled with strong and frequent contractions that mix and *propel* food into the duodenum.
- Also, **distal area** is responsible for *gastric emptying* into duodenum.
3. Motility of stomach

Gastric peristalsis

Arrow showing partial liquid chyme pushed into duodenum via pylorus and more chyme pushed forth and back in stomach cavity being small pieces
Motility of GIT
Motility of Small intestine

- Motility of the small intestine serves four functions:
  - **Mixing** contents with enzymes and other secretions.
  - Further **reduction** in particle size.
  - Maximizing **exposure of the contents** to membranes of intestinal cells for absorption and digestion.
  - **Propulsion** of contents into the large intestine.
- **Two basic** motility patterns exist: **segmentation** and **peristalsis**.
Motility of GIT

Segmentation movements

Segmental contractions are responsible for mixing and cutting

1 ~ 5 cm

No net forward movement
Motility of GIT

Peristalsis

Peristaltic contractions are responsible for forward movement.

Time zero

Seconds later

Direction of movement: Orad → caudad

Contraction

Bolus

Receiving segment

Bolus moves forward
5. Motility of Large intestine or colon

- 2 basic motility patterns:
  
  a) **Segmentation** in the large intestine causes the contents to be continuously mixed
  
  b) **Mass movement** propels the contents of one segment of the large intestine into the next downstream segment.

- **Defecation** involves involuntary reflexes and voluntary reflexes
Secretory Functions (Secretions) of GIT
Secretions of GIT

• GI secretions function to **lubricate** (water and mucus), **protect** (mucus), **sterilize** (HCl), **neutralize** (HCO$_3^-$), and **digest** (enzymes).

• Secretions arise from **specialized cells** lining the **GI tract**, the **pancreas, liver** and **gallbladder**.

• The **total volume** of GIT secretions is about **6-8 L/day**
Secretions of GIT in Mouth

Salivary Glands

- **Three pairs** of glands
  - *Parotid*
  - *Sublingual*
  - *Submandibular*

- **Functions of saliva**
  - Lubricates, cleanses oral cavity
  - Dissolves chemicals
  - Suppresses bacterial growth
  - Digest starch by amylase
### GIT secretions in Stomach

<table>
<thead>
<tr>
<th>Source</th>
<th>Substance Secreted</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucous neck cell</td>
<td>Mucus</td>
<td>Physical barrier between lumen and epithelium</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td></td>
<td>Buffers gastric acid to prevent damage to epithelium</td>
</tr>
<tr>
<td>Parietal cells</td>
<td>Gastric acid (HCl)</td>
<td>Activates pepsin; kills bacteria</td>
</tr>
<tr>
<td>Intrinsic factor</td>
<td></td>
<td>Complexes with vitamin B₁₂ to permit absorption</td>
</tr>
<tr>
<td>Enterochromaffin-like cell</td>
<td>Histamine</td>
<td>Stimulates gastric acid secretion</td>
</tr>
<tr>
<td>Chief cells</td>
<td>Pepsin(ogen)</td>
<td>Digests proteins</td>
</tr>
<tr>
<td>Gastric lipase</td>
<td></td>
<td>Digests fats</td>
</tr>
<tr>
<td>D cells</td>
<td>Somatostatin</td>
<td>Inhibits gastric acid secretion</td>
</tr>
<tr>
<td>G cells</td>
<td>Gastrin</td>
<td>Stimulates gastric acid secretion</td>
</tr>
</tbody>
</table>
Function of hydrochloric acid

1. Activating pepsinogen
2. Provide optimum for pH for action of pepsins
3. Food protein denaturation and easy decomposition;
4. Kill bacteria in food into the stomach
5. Promoting pancreatic, small intestinal and bile secretion
6. Helping Fe$^{2+}$、Ca$^{2+}$ absorption.
Function of pepsins

Function of pepsinogen

Pepsinogen $\xrightarrow{\text{HCl}}$ Pepsin

$\text{pH 2-3.5}$

Pepsin $\rightarrow$ Protein $\rightarrow$ Peptone
Mucus secretion

- Soluble and insoluble mucus are secreted by cells of the stomach.
- **Soluble mucus** mixes with the contents of the stomach and helps to lubricate chyme.
- **Insoluble mucus** forms a protective barrier against the high acidity of the stomach content.

**Intrinsic Factor**

- Help absorption of vitamin B12
Pancreatic Secretion

- Pancreas has **2 functions**:  
  a) **Endocrine functions**: secretes insulin and glucagon from islets of Langerhans  
  b) **Exocrine function**: secretion of pancreatic juice

- It has **2 components**: aqueous and enzymatic components.

- **Aqueous component** (contains HCO3) is important for neutralizing stomach acid in the duodenum so pancreatic enzymes can function properly

- **Enzymatic component** is essential for the proper digestion and absorption of carbohydrates, fats, and proteins

- **Pancreatic enzymes** include trypsin, chemotrypsin, lipase, and amylase
Functions of pancreatic juice enzymes

- Starch: Pancreatic amylase → Maltose + glucose, pH 6.7-7.0
- Fat (Triglyceride): Pancrelipase + Colipase → Oil + Monoglyceride + Fatty Acids, pH 7.8-8.5
- Trypsinogen: Kinase, HCl, Tissue Fluid → Trypsin → Protein
- Chymotrypsinogen → Chymotrypsin → Polypeptide
- Carboxypeptidase → Amino Acid
The Liver and Gall Bladder

Functions of the Liver

- **Metabolic regulation**
  - Store absorbed nutrients, vitamins
  - Release nutrients as needed
- **Hematological regulation**
  - Plasma protein production
  - Remove old RBCs
- **Production of bile**
  - Required for fat digestion and absorption
Secretion of small intestine

• Secretion from duodenal gland and intestinal gland
• Secretory volume is 1〜3L/day
• It contains inorganic ion, mucoprotein, IgA, various enzyme, e.g. enterokinase, etc

• Function:
  • Protective effect by mucous
  • Digestion by enzymes such as peptidase, sucrase, lipase
  • Dilution
Secretion of large intestine

1. colonic alkaline secretion to neutralize acids produced by intestinal bacteria
2. secretion of mucous for protection, lubrication of fecal matter
3. Vitamin B and K absorption made from bacterial flora in colon
Digestion and Absorption
Digestion and Absorption

- Digestion is a process essential for the conversion of food into a small and simple form.
  - mechanical digestion by mastication and swallowing
  - chemical digestion by enzymes

- Absorption is the process of transporting small molecules from the lumen of the gut into blood stream or lymphatic vessel.
**Digestion and Absorption**

- **Small intestine** is primary site for digestion and absorption of food.

- **Digestion** occurs in the GI lumen by secreted enzymes and on surface of enterocytes by membrane-bound enzymes.

- Absorption occurs by **simple diffusion**, facilitated diffusion, active transport, endocytosis, and paracellular transport.

- **Surface area** of small intestine is greatly increased by extensive folding and the projection of **fingerlike villi** covered with microvilli.
Intestinal Villi

Intestinal surface area is enhanced by finger-like villi.
Intestinal Villus
Digestion of CHO

Glucose polymers
- Starch, glycogen

Amylase (salivary and pancreatic)

Disaccharides
- Maltose
  - Maltase
  - 2 glucose
- Sucrose
  - Sucrase
  - 1 glucose + 1 fructose
- Lactose
  - Lactase
  - 1 glucose + 1 galactose
Enterocytes absorb glucose and galactose through an Na-dependent secondary active transport process, while fructose is absorbed by facilitated transport.
# Digestion of Proteins

<table>
<thead>
<tr>
<th>REGION</th>
<th>PROTEINS</th>
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</thead>
<tbody>
<tr>
<td><strong>ORAL CAVITY</strong></td>
<td></td>
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<tr>
<td><strong>ESOPHAGUS</strong></td>
<td></td>
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<tr>
<td><strong>STOMACH</strong></td>
<td>Polypeptides</td>
</tr>
<tr>
<td></td>
<td>Pepsin</td>
</tr>
<tr>
<td><strong>SMALL INTESTINE</strong></td>
<td>Polypeptides → Short peptides → Amino acids</td>
</tr>
<tr>
<td></td>
<td>Trypsin</td>
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<tr>
<td></td>
<td>Chymotrypsin</td>
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<td></td>
<td>Carboxypeptidase</td>
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<tr>
<td><strong>INTESTINAL MUCOSA</strong></td>
<td>Facilitated diffusion and cotransport</td>
</tr>
<tr>
<td></td>
<td>Amino acids</td>
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<tr>
<td></td>
<td>Peptidases</td>
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<tbody>
<tr>
<td><strong>BLOODSTREAM</strong></td>
<td>Capillary</td>
</tr>
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</table>

Amino acids
Absorption of proteins

• The whole proteins by **endocytosis**

• Amino acids and di and tripeptides by **Na-dependent** 2ry active transport
Digestion of fats

- Cholesterol esters
  - Cholesterol ester hydrolase
  - Cholesterol

- Triglyceride
  - Lipase
  - Cholesterol ester hydrolase
  - Phospholipids
    - Phospholipase A2
    - Phosphate + Fatty acids

- Monoglyceride
  - Free fatty acids

Absorption
Absorption of Fats in the Small Intestine

- **Lumen**
  - Emulsification
  - Large fatty molecule
  - By effects of lipase, cholesterol ester hydrolase and phospholipase A<sub>2</sub>
  - Fatty Acids, Cholesterol, Monoglycerides
  - Bile salts
  - Micelles

- **Intestinal Epithelia**
  - The smooth endoplasmic reticulum
  - Triglycerides
  - Cholesterol esters
  - Phospholipids
  - In Golgi, they are packaged into chylomicra or very low density lipoprotein (VLDL) particles.

- **Exocytosis**
  - Venous system
  - Lymph vessel
  - Chylomicra (CM) or VLDL particles
  - On Apoprotein B

- **Vessels**
Thank you