Physiology 12

The Gastrointestinal Tract

Overview

Gastrointestinal system

- Parotid salivary gland
- Sublingual salivary gland
- Submandibular salivary gland
- Pharynx
- Trachea
- Esophagus
- Liver
- Gallbladder
- Stomach
- Pancreas
- Small intestine
- Colon
- Cacum
- Rectum
- Anus

Large intestine

©1995 Pearson Education Inc., publishing as Benjamin Cummings
Basic functions of the GI tract

- Digestion
- Secretion
- Absorption
- Motility

Digestion: Dissolving and breaking down ingested particles
Basic functions of the GI tract

- **Digestion**: Dissolving and breaking down ingested particles
- **Secretion**: Releasing enzymes, bile and Hydrochloric acid into the lumen of the GI tract
- **Absorption**: Moving molecules from the lumen into the blood or lymph
- **Motility**: Moving food through the GI Tract
Structure of the Gastrointestinal Tract Wall
Digestion and Absorption of nutrients

- Carbohydrate
- Protein
- Fat
Digestion and Absorption of Nutrients

- **Carbohydrate:**
  - Body only absorbs monosaccharides (glucose, fructose, galactose)
  - Enzymes on luminal membrane break down complex sugars into monosaccharides
  - Monosaccharides enter body by facilitated diffusion
  - Cellulose (fiber) cannot be broken down
Digestion and Absorption of nutrients

- **Protein**: Free amino acids and short chains can be absorbed.

- **Enzymes**
  - Stomach (pepsin)
  - Small intestine (chymotrypsin, Trypsin)
  - Pancreas (Carboxypepsidase)
  - Small intestine epithelium (Aminopepsidase)

Digestion and Absorption of nutrients

- **Carbohydrate**
- **Protein**
- **Fat**: must be Emulsified in lumen before absorbed
Structure of Bile Salts

Emulsification of Fat

Fat Digestion/ Lipase
Following the pathway of ingested food
Secretions from the Stomach

- Parietal cells – secrete acid
- Chief cells – secrete pepsinogen
- Enterochromaffin-like cells – release histamine into the body
Conversion of Pepsinogen to Pepsin

Regulation of stomach acid secretion
### Table 17.4: Control of HCl Secretion During a Meal

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephalic</td>
<td>Digestive enzymes activate, activation of gastric mucin</td>
<td>secretion</td>
</tr>
<tr>
<td>Stomach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastric</td>
<td>Long and short胃蠕动, 空肠, 散射</td>
<td>secretion</td>
</tr>
<tr>
<td>Intestinal</td>
<td>Intestinal contents (selected phase)</td>
<td>Long and short 胃蠕动, 空肠, 消化道, mucosal</td>
</tr>
</tbody>
</table>

### Cephalic/Gastric Phases

- Cephalic phase
  - Activation of digestive enzymes
  - Stimulation of gastric mucin

- Gastric phase
  -Long and short gastric contractions, HCl secretion

### 3 Regions of Stomach
- **Fundus**
- Upper **Esophageal sphincter**
- **Body** (secretes mucus, pepsinogen, and HCl)
- **Pyloric sphincter**
- **Antrum** (secretes mucus, pepsinogen, and gastrin)
Small intestine

- Duodenum
- Jejunum
- Ileum

Liver

- Produces Bile
  - Bile pigments (bilirubin)
- Has enterohepatic circulation
Secretion of Bile is regulated by the hormone Cholecystokinin (CCK)

Pancreas
- Secretes Bicarbonate to neutralize stomach acid
- Secretes digestive enzymes
  - Trypsin
- Regulates whole body metabolism via
  - Insulin
  - Glucagon
  - Somatostatin
Structure of the pancreas

Pancreatic enzyme precursors

Pancreas

Inactive enzymes

Trypsinogen

Active enzymes

Trypsin

Membrane bound enterokinase

Epithelial cell

Lumen of small intestine

Pancreatic duct

Enterokinase

Chymotrypsinogen

Trypsin

Trypsin

Chymotrypsin

Carboxypeptidase

Enterocytes
Regulation of the Pancreas

- Acid levels in Small Intestine stimulate pancreatic bicarbonate release (via Secretin)
- Amino and Fatty acids stimulate enzyme release (via Cholecystokinin, CCK)

Small intestine

Villi in small intestine

Lymph duct

Villi

Microvilli

Epithelial cells

Venules

Nerve fiber

Capillaries

Vessels

Lacteal

Arteriole

Muscularis mucosae

Muscularis propria

Lumen
Movement of the Small Intestine

**Figure 44-7.** Absorption of sodium through the intestinal epithelium has also the concomitant absorption of water—that is, the water "follows" the sodium through the epithelial membrane.
Physiology 12

Regulation of systemic Metabolism
Feast or Famine

Everyday the body must shift its metabolism

In the fed (absorptive) state

- Food is being digested or absorbed
- Energy comes primarily from carbohydrates
- Extra carbohydrates are converted to fat (via liver glycogen production)
In the fed (absorptive) state

- Food is being digested or absorbed
- Energy comes primarily from carbohydrates
- Extra carbohydrates are converted to fat (via liver glycogen production)
- Ingested fatty acids are stored in adipose
- Excess amino acids are converted to Fat
In the Fasted (postabsorptive) state
- Glycogen and fat production stops
- Liver releases glucose to maintain blood glucose levels
  - (brain must have glucose)
- Most energy comes from Fatty acids and Keytones
In the Fasted (postabsorptive) state

- Glycogen and fat production stops
- Liver releases glucose to maintain blood glucose levels
  - (brain must have glucose)
- Most energy comes from fatty acids and ketones
- Muscle breaks down muscle glycogen for fuel.
Feast or famine states are regulated by Pancreatic hormones

- Insulin
- Glucagon
The endocrine Pancreas

Islet of Langerhans

Target-cell responses

- Insulin release
  - Glucose uptake and phosphorylation
  - Glucose and amino acids uptake
  - ATP synthesis
  - Glycolysis
  - ATP production

- Adipocytes
  - Glucose uptake and utilization
  - Triacylglycerol accumulation
  - Lipolysis

- Liver
  - Glucose uptake and glycogen synthesis
  - Gluconeogenesis
  - Fat synthesis
  - Amino acid incorporation
Insulin is produced by the Pancreatic islet beta cells, its release is regulated
- Circulating glucose
- Circulating amino acids
- Sympathetic/parasympathetic nerves
- Other gut hormones
**Glucagon**

- Secreted from the pancreatic islet alpha cells
- Stimulated by drops in blood sugar

**Plasma concentrations**

- Glucose (mmol/L)
- Glucagon (pg/ml)
- Insulin (U/L)

**Glucagon secretion**

- Pancreatic islet alpha cells
- Secretion
- Plasma glucagon
- Liver
- Glycogenolysis
- Gluconeogenesis
- Ketogenesis
- Plasma glucose
- Plasma ketones
Total regulation of metabolism is a balanced equation

Food ingested = total energy expended

Total energy expenditure = Work + Heat produced + energy stored