Business

- **Reminder:** No class Monday (Memorial Day)

- **Midterm 2 is Tuesday 5/28/13**
  - Optional review session tomorrow @ 5pm

- **Homework due in Lab**
  1. PreLab 8 (1pt)
  2. Replace a Missing Assignment (4 pts)
    - Homework page 17
Introduction

- Every cell requires a constant energy source
  - Ingested food is complex
    - Modification is needed to utilize
Introduction

- Digestive system is a tube
  - Gastrointestinal tract
    - Specialized regions
      - Mouth
      - Pharynx
      - Esophagus
      - Stomach
      - Small intestine
      - Large intestine
Introduction

- Digestive processes
  1. Ingestion
  2. Propulsion
  3. Mechanical digestion
  4. Chemical digestion
  5. Absorption
  6. Defecation
Figure 23.2

**Ingestion**

- Chewing (mouth)
- Churning (stomach)
- Segmentation (small intestine)

**Mechanical digestion**

- Swallowing (oropharynx)
- Peristalsis (esophagus, stomach, small intestine, large intestine)

**Chemical digestion**

- Mainly $H_2O$

**Propulsion**

- Esophagus
- Pharynx
- Stomach

**Absorption**

- Lymph vessel
- Blood vessel

**Defecation**

- Food
- Anus
- Feces
Introduction

• Histology of the alimentary canal
  • Four basic layers (tunics)
    • Tunica mucosa
      • Protection and absorption
        Epithelium and connective tissue
    • Tunica submucosa
      • Connective tissue
    • Tunica muscularis (externa)
      • Double layer of muscle
    • Tunica serosa
      • Visceral peritoneum
      • Single layer of epithelium
Introduction

- Peritoneum
  - Parietal peritoneum
    - Mesentery
  - Visceral peritoneum
    - Omentum
(a) Schematic cross sections of abdominal cavity illustrate the peritoneums and mesenteries.
Omentia and Mesentery

Liver
Gallbladder
Lesser omentum
Stomach
Duodenum
Transverse colon
Small intestine
Cecum
Urinary bladder

Figure 23.30b
Digestive System

- Mouth
  - Cheek, palate, tongue
  - Opens into oropharynx
  - Salivary glands
(a) Sagittal section of the oral cavity and pharynx
Salivary glands secrete about 1250 ml of saliva per day!
Digestive System

- Teeth
  - Held in place by periodontal ligaments
  - Gingiva covers bone
  - 2 dentitions
    - Deciduous
    - Permanent
Teeth  

20 deciduous

- **Incisors**
  - Central (6–8 mo)
  - Lateral (8–10 mo)

- **Canine (eyetooth)**
  - (16–20 mo)

- **Molars**
  - First molar (10–15 mo)
  - Second molar (about 2 yr)

32 permanent

- **Incisors**
  - Central (7 yr)
  - Lateral (8 yr)

- **Canine (eyetooth)**
  - (11 yr)

- **Premolars (bicuspids)**
  - First premolar (11 yr)
  - Second premolar (12–13 yr)

- **Molars**
  - First molar (6–7 yr)
  - Second molar (12–13 yr)
  - Third molar (wisdom tooth) (17–25 yr)

(a)

Permanent teeth

Figure 23.10a
Digestive System

• Teeth
  • Anatomy
    • Crown covered by enamel
    • Pulp cavity
    • Dentin
    • Roots
  • Function
    • Break down food
    • Mixed with saliva to form bolus
Figure 23.11

Crown

Neck

Root

Enamel
Dentin
Dentinal tubules
Pulp cavity (contains blood vessels and nerves)
Gingiva (gum)
Cementum
Root canal
Periodontal ligament
Apical foramen
Bone
Digestive System

- **Esophagus**
  - Pharynx to stomach
    - Moves bolus to stomach
    - Peristalsis
  - Cardiac (gastroesophageal) sphincter
    - Heartburn

- **Histology**
  - Mucosa
    - Stratified squamous epithelium
    - Abundant mucous glands
  - Serosa
    - Connective tissue
Food is moved through the esophagus to the stomach by peristalsis.
5 The gastroesophageal sphincter opens, and food enters the stomach.
Mucosa (contains a stratified squamous epithelium)

Submucosa (areolar connective tissue)

Lumen

Muscularis externa
  • Longitudinal layer
  • Circular layer

Adventitia (fibrous connective tissue)
Mucosa
(contains a stratified squamous epithelium)

Esophagus stomach junction

simple columnar epithelium
Digestive System

- Stomach
  - From cardiac orifice to pyloric sphincter
    - Rugae
  - Greater curvature
    - Convex lateral surface
    - Greater omentum
  - Lesser curvature
    - Concave medial surface
    - Lesser omentum
Figure 23.30a

- Falciform ligament
- Liver
- Gallbladder
- Spleen
- Stomach
- Ligamentum teres
- Greater omentum
- Small intestine
- Cecum
Liver
Gallbladder
Lesser omentum
Stomach
Duodenum
Transverse colon
Small intestine
Cecum
Urinary bladder
Digestive System

- **Stomach**
  - Four tunics
    - Muscularis
      - Additional layer of muscle in an oblique orientation
      - Three layers of smooth muscle
Figure 23.14a

- Cardia
- Fundus
- Esophagus
- Muscularis externa
  - Longitudinal layer
  - Circular layer
  - Oblique layer
- Pyloric sphincter (valve) at pylorus
- Pyloric canal
- Pyloric antrum
- Rugae of mucosa
- Body
- Lumen
- Serosa
- Duodenum
- Lesser curvature
- Greater curvature
- (a)
Digestive System

• Stomach
  • Four tunics
    • Mucosa
      • Gastric glands
        o Mucous cells = Mucous
        o Parietal cells = Intrinsic factor and HCL
        o Zymogenic (chief) cells = Pepsinogen
        o Enteroendocrine cells = Gastrin and cholecystokinin
Mucosa contains gastric glands

- **Submucosa**
  - (contains submucosal plexus)

- **Muscularis externa**
  - (contains myenteric plexus)

- **Serosa**

(a) Layers of the stomach wall (l.s.)

- **Surface epithelium**
- **Lamina propria**
- **Oblique layer**
- **Circular layer**
- **Longitudinal layer**
- **Stomach wall**

Figure 23.15a
(b) Enlarged view of gastric pits and gastric glands

- Gastric pits
- Surface epithelium (mucous cells)
- Mucous neck cells
- Parietal cell
- Chief cell
- Enteroendocrine cell
(c) Location of the HCl-producing parietal cells and pepsin-secreting chief cells in a gastric gland
Digestive System

- Chemical digestion in the stomach
  - Protein catabolism $\rightarrow$ polypeptides
- Secretions $\text{HCl}$
  - Pepsinogen $\rightarrow$ pepsin
  - HCl
    - pH 1.5–3.5
    - Denatures protein in food
    - Kills many bacteria
- Intrinsic factor
  - Required for absorption of vitamin $B_{12}$ in small intestine
(c) Location of the HCl-producing parietal cells and pepsin-secreting chief cells in a gastric gland
Digestive System

- Chemical digestion in the stomach
  - Enteroendocrine cells
    - Secrete hormone like substances
      - Gastrin
      - Cholecystokinin
        - Actually produced by enteroendocrine cells in the duodenum
Chemical digestion in the stomach

- Chyme
  - Product of stomach digestion

Prevention of autodigestion

- Mucous
- Gastritis
- Peptic ulcers
  - Gastric ulcers
  - Duodenal ulcers
(a) A gastric ulcer lesion
(b) *H. pylori* bacteria
Digestive System

• Control of gastric secretions
  • Neural control
    • Vagus nerve
    • Enteric nervous system
  • Hormonal control
    • Gastrin
Digestive System

- Control of gastric secretions
  - Stimulatory and inhibitory events occur in three phases
    1. Cephalic
    2. Gastric
    3. Intestinal
Figure 23.17

Stimulatory events

1. Sight and thought of food → Cerebral cortex
2. Stimulation of taste and smell receptors

1. Stomach distension activates stretch receptors → Vagovagal reflexes→ Medulla → Vagus nerve
2. Food chemicals (especially peptides and caffeine) and rising pH activate chemoreceptors → G cells → Gastrin release to blood

Intestinal phase

- Presence of low pH, partially digested foods, fats, or hypertonic solution in duodenum when stomach begins to empty → Intestinal (enteric) gastrin release to blood → Brief effect
- Distension of duodenum; presence of fatty, acidic, hypertonic chyme, and/or irritants in the duodenum
- Release of intestinal hormones (secretin, cholecystokinin, vasoactive intestinal peptide)

Inhibitory events

1. Loss of appetite, depression
2. Emotional upset
1. Excessive acidity (pH < 2) in stomach
2. Emotional upset

1. Lack of stimulatory impulses to parasympathetic center
2. Sympathetic nervous system activation

1. Gastrin secretion declines
2. Overrides parasympathetic controls

1. Cephalic phase
2. Gastric phase
3. Intestinal phase

- Stimulate
- Inhibit
Enteric Nervous System

- “In house nerve supply” to alimentary canal
  - Local reflex arcs
  - Regulate digestive system activity
  - Digestive activity also subject to extrinsic controls through ANS
Digestive System

- **Control of gastric secretions**
  - Stimulatory and inhibitory events occur in three phases
  1. Cephalic
     - Hearing, seeing, smelling, tasting, thinking about food
     - Vagus nerve stimulated
       - Gastric secretion starts
Digestive System

- Control of gastric secretions
  - Stimulatory and inhibitory events occur in three phases
    1. Cephalic
    2. Gastric
      - Arrival of food in stomach
        - Stomach distension, peptides, low acidity $\rightarrow$ gastrin released
          - Relaxes pyloric sphincter
          - Increases stomach motility
Digestive System

- Control of gastric secretions
  - Stimulatory and inhibitory events occur in three phases
    1. Cephalic
    2. Gastric
    3. Intestinal
      - Chyme reaches duodenum
        - Intestinal distention $\rightarrow$ enterogastric reflex
        - Release of secretin, CCK, VIP
          - Inhibit stomach motility and delay emptying
Figure 23.17

Stimulatory events

1. Sight and thought of food → Cerebral cortex
2. Stimulation of taste and smell receptors → Hypothalamus and medulla oblongata
1. Stomach distension activates stretch receptors → Vagovagal reflexes
2. Food chemicals (especially peptides and caffeine) and rising pH activate chemoreceptors → G cells
1. Presence of low pH, partially digested foods, fats, or hypertonic solution in duodenum when stomach begins to empty

Inhibitory events

1. Lack of stimulatory impulses to parasympathetic center → Cerebral cortex
2. Emotional upset

1. Excessive acidity (pH <2) in stomach
2. Distension of duodenum; presence of fatty, acidic, hypertonic chyme, and/or irritants in the duodenum

Stomach secretory activity

Enterogastric reflex

Local reflexes

Gastrin secretion declines → G cells

Overrides parasympathetic controls → Sympathetic nervous system activation

Loss of appetite, depression

1. G cells
2. Stimulation of taste and smell receptors

Food chemicals

Conditioned reflex

Vagus nerve

Medulla

G cells

Gastrin release to blood

Stimulatory events

Inhibitory events

Stomach secretory activity

Vagal nuclei in medulla

Pyloric sphincter

Release of intestinal hormones (secretin, cholecystokinin, vasoactive intestinal peptide)

1. Distension; presence of fatty, acidic, partially digested food in the duodenum

Sight and thought of food

Stomach distension

Food chemicals

Presence of low pH, partially digested foods, fats, or hypertonic solution in duodenum when stomach begins to empty

Vagovagal reflexes

Local reflexes

Stomach secretory activity

Gastrin release to blood

Vagal nuclei

Pyloric sphincter

Release of intestinal hormones (secretin, cholecystokinin, vasoactive intestinal peptide)

Stimulatory events

Inhibitory events

1. Loss of appetite, depression
2. Emotional upset

Excessive acidity (pH <2) in stomach

Distension of duodenum; presence of fatty, acidic, hypertonic chyme, and/or irritants in the duodenum

Stimulate

Inhibit
**Propulsion**: Peristaltic waves move from the fundus toward the pylorus.

**Grinding**: The most vigorous peristalsis and mixing action occur close to the pylorus.

**Retropulsion**: The pyloric end of the stomach acts as a pump that delivers small amounts of chyme into the duodenum, simultaneously forcing most of its contained material backward into the stomach.
Presence of fatty, hypertonic, acidic chyme in duodenum

Duodenal entero-endocrine cells

Chemoreceptors and stretch receptors

Enterogastrones (secretin, cholecystokinin, vasoactive intestinal peptide)

Enteroendocrine cells

Enterogastrones

Enteric neurons

CNS centers

Sympathetic activity;
Parasympathetic activity

Contractile force and rate of stomach emptying decline

Initial stimulus

Physiological response

Result

Stimulate

Inhibit

Duodenal stimuli decline

Secrete

Target

Via short reflexes

Via long reflexes

Enterogastric Reflex

Figure 23.20