Homework – Due in Lab

- Homework page 17
- Lab Manual Page 593
  - Number counter clockwise, starting in left hand corner
    - There are 31 possible answers
  - Skip 1, 2, 7, 8, 10, 12, 16, 26, 27, 30
Digestive System

Part 1
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
Figure 23.1

- Mouth (oral cavity)
- Tongue
- Esophagus
- Liver
- Gallbladder
- Salivary glands
  - Parotid gland
  - Sublingual gland
  - Submandibular gland
- Pharynx
- Stomach
- Pancreas
  - (Spleen)
- Small intestine
  - Duodenum
  - Jejunum
  - Ileum
- Large intestine
  - Transverse colon
  - Descending colon
  - Ascending colon
  - Cecum
  - Sigmoid colon
  - Rectum
  - Vermiform appendix
  - Anal canal
- Anus
Introduction

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

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

Chemical digestion

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

Absorption
- Lymph vessel
- Blood vessel
- Mainly H₂O
- Feces

Defecation
- Anus
Relationships Among Digestive System Organs

- **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
Relationships Among Digestive System Organs

- Peritoneum
  - Parietal peritoneum
  - Mesentery
    - Covers stomach, omentum, small intestine
(a) Schematic cross sections of abdominal cavity illustrate the peritoneums and mesenteries.
Omenta and Mesentery

Liver

Gallbladder

Lesser omentum

Stomach

Duodenum

Transverse colon

Small intestine

Cecum

Urinary bladder
Anatomy and Physiology of the 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!
Anatomy and Physiology of the Digestive System

- Teeth
  - Held in place by periodontal ligaments
  - Gingiva covers bone
  - 2 dentitions
    - Deciduous
    - Permanent
Teeth  20 deciduous  32 permanent

**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)

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**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)
Anatomy and Physiology of the Digestive System

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

Neck

Root

Enamel

Dentin

Dentinal tubules

Pulp cavity (contains blood vessels and nerves)

Gingiva (gum)

Cementum

Root canal

Periodontal ligament

Apical foramen

Bone
Anatomy and Physiology of the 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
Relaxed muscles

Circular muscles contract

Bolus of food

Longitudinal muscles contract

Gastroesophageal sphincter closed

Food is moved through the esophagus to the stomach by peristalsis.
5 The gastroesophageal sphincter opens, and food enters the stomach.
Figure 23.12a

- **Mucosa** (contains a stratified squamous epithelium)
- **Submucosa** (areolar connective tissue)
- **Lumen**
- **Muscularis externa**
  - Longitudinal layer
  - Circular layer
- **Adventitia** (fibrous connective tissue)
Figure 23.12b

Mucosa (contains a stratified squamous epithelium)

Esophagus stomach junction

simple columnar epithelium
Figure 23.14a
Cardia

Esophagus
Muscularis externa
- Longitudinal layer
- Circular layer
- Oblique layer

Duodenum
Pyloric canal
Pyloric sphincter (valve) at pylorus

Fundus
Serosa
Body
Lumen
Rugae of mucosa

Lesser curvature
Greater curvature
Anatomy and Physiology of the 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
Anatomy and Physiology of the Digestive System

- **Stomach**
  - Four tunics
    - Muscularis
      - Additional layer of muscle in an oblique orientation
      - Three layers of smooth muscle
Anatomy and Physiology of the 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

- **Mucosa**
- **Surface epithelium**
- **Lamina propria**
- **Muscularis mucosae**
- **Oblique layer**
- **Circular layer**
- **Longitudinal layer**
- **Serosa**

(a) Layers of the stomach wall (l.s.)
(b) Enlarged view of gastric pits and gastric glands

- Gastric pits
- Surface epithelium (mucous cells)
- Mucous neck cells
- Parietal cell
- Chief cell
- Enteroendocrine cell

Figure 23.15b
(c) Location of the HCl-producing parietal cells and pepsin-secreting chief cells in a gastric gland
Anatomy and Physiology of the 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 $\text{B}_{12}$ in small intestine
(c) Location of the HCl-producing parietal cells and pepsin-secreting chief cells in a gastric gland
Chemical digestion in the stomach

- Enteroidocrine cells
  - Secret hormone like substances
    - Gastrin
    - Cholecystokinin
      - Actually produced by enteroidocrine cells in the duodenum
Anatomy and Physiology of the Digestive System

- Chemical digestion in the stomach
  - Chyme
    - Product of stomach digestion
  - Prevention of autodigestion
    - Mucous
    - Gastritis
    - Peptic ulcers
      - Gastric ulcers
      - Duodenal ulcers
Figure 23.16

(a) A gastric ulcer lesion
(b) *H. pylori* bacteria
Anatomy and Physiology of the Digestive System

- Control of gastric secretions
  - Neural control
    - Vagus nerve
    - Enteric nervous system
  - Hormonal control
    - Gastrin
Anatomy and Physiology of the Digestive System

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

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

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

Brief effect

Intestinal (enteric) gastrin release to blood

<table>
<thead>
<tr>
<th>Stimulatory events</th>
<th>Inhibitory events</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Sight and thought of food</td>
<td>Lack of stimulatory impulses to parasympathetic center</td>
</tr>
<tr>
<td>2 Stimulation of taste and smell receptors</td>
<td>Cerebral cortex</td>
</tr>
<tr>
<td>Stomach distension activates stretch receptors</td>
<td>Vagus nerve</td>
</tr>
<tr>
<td>Food chemicals (especially peptides and caffeine) and rising pH activate chemoreceptors</td>
<td>Local reflexes</td>
</tr>
<tr>
<td>Presence of low pH, partially digested foods, fats, or hypertonic solution in duodenum when stomach begins to empty</td>
<td>Gastrin secretion declines</td>
</tr>
<tr>
<td>Intestinal (enteric) gastrin release to blood</td>
<td>G cells</td>
</tr>
<tr>
<td>Enterogastric reflex</td>
<td>Stimulatory events</td>
</tr>
<tr>
<td>Local reflexes</td>
<td>1 Loss of appetite, depression</td>
</tr>
<tr>
<td>Vagal nuclei in medulla</td>
<td>Excessive acidity (pH &lt;2) in stomach</td>
</tr>
<tr>
<td>Vagal nerve</td>
<td>Emotional upset</td>
</tr>
<tr>
<td>Pyloric sphincter</td>
<td></td>
</tr>
<tr>
<td>Release of intestinal hormones (secretin, cholecystokinin, vasoactive intestinal peptide)</td>
<td>Distension of duodenum; presence of fatty, acidic, hypertonic chyme, and/or irritants in the duodenum</td>
</tr>
</tbody>
</table>

Stomach secretory activity

Cerebral cortex

Hypothalamus and medulla oblongata

Vagus nerve

G cells

Stomach secretory activity

Cephalic phase

Gastric phase

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
Anatomy and Physiology of the 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
        o Gastric secretion starts
Anatomy and Physiology of the 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
Anatomy and Physiology of the 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
**Cephalic phase**

- Sight and thought of food
- Stimulation of taste and smell receptors

**Gastric phase**

- Stomach distension activates stretch receptors
- Food chemicals (especially peptides and caffeine) and rising pH activate chemoreceptors

**Intestinal phase**

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

**Stimulatory events**

1. Sight and thought of food → Cerebral cortex
2. Stimulation of taste and smell receptors → Hypothalamus and medulla oblongata
3. Stomach distension activates stretch receptors → Vagovagal reflexes
4. Food chemicals (especially peptides and caffeine) and rising pH activate chemoreceptors → G cells

**Inhibitory events**

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

**Stomach secretory activity**

- Gastrin release to blood → Gastrin secretion declines
- G cells → Overrides parasym-pathetic controls
- Vagal nerve

**Enterogastric reflex**

- Local reflexes → Enterogastric reflex
- Vagal nuclei in medulla
- Pyloric sphincter

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

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

-- Stimulate
-- Inhibit

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

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

3 **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

Secrete

Enterogastroles (secretin, cholecystokinin, vasoactive intestinal peptide)

Enterogastrones

Enteric neurons

CNS centers

↑ sympathetic activity;
↓ parasympathetic activity

Via short reflexes

Via long reflexes

Duodenal stimuli decline

Contractile force and rate of stomach emptying decline

Initial stimulus

Physiological response

Result

Stimulate

Inhibit