1. Digestion (Ch 4)

**Generalized Digestive System**

**Salivary glands (mucin) to lubricate**

**Tongue for chemoreception**

**Structure** | **Function**
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1. Head | 1. Ingestion
2. Foregut | 2. Receiving, Conducting, Storage, Digestion
3. Midgut | 3. Digestion (Acidic secretions)
4. Hindgut | 4. Absorption = Assimilation (Basil secretions)

(Eckert 15-13)

**Foregut**

- Conduction, Storage, Digestion
- Esophagus and Stomach
  - Crop in some for storage/regurgitation
  - e.g., Some birds use to grind with pebbles and sand

**Stomach**

- Food storage
- Begins digestion (e.g., pepsin)
- Mechanical mixing (muscular walls)
- Monogastric (1 chamber, carnivores and omnivores)
- Digastric (> 1 chamber)

**Monogastric Stomach**

- Strong muscular sac/tube
- Sphincters at both ends
- Mucus from goblet cells of gastric pit
- HCl from parietal cells of gastric gland
- Pepsinogen from chief cells of gastric gland

(Eckert 15-17)

**Digastric Stomach**

- Herbivores
- Regurgitation
- Anaerobic fermentation by symbiotic bacteria and protozoans

- Carbohydrates -> sugars and gases
- Sugars, amino acids, short FAs into blood

(Eckert 15-18)
Midgut

- **Chemical digestion and Absorption** (~ small intestine)
  - from stomach through pyloric sphincter into duodenum
  - alkaline

1. **Duodenum** (mucus + secretions from liver, pancreas)
   - bile duct from liver
   - Bile breaks up fats and neutralizes acids
   - proteases, lipases, carbohydrases, antacid

2. **Jejunum** (digestion and absorption)
3. **Ileum** (mostly absorption)

- Internal symbions help digest, provide nutrition, vitamins
- Gas exchange in some air-breathing fishes

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**Epithelial cells sloughed rapidly (2x10^10 cells/day), lining replaced every few days**

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Midgut

- **Intestinal Epithelium, SURFACE AREA**
  - aids absorption of digested nutrients

- epithelium arrangement:
  - **circular folds**
  - **villi** with blood vessels
  - **central lacteal** (lymph system)

- **microvilli** (2x10^3 per mm²)

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Midgut

- **Intestinal Epithelium, SURFACE AREA**

- surface of microvilli:
  - covered with glyocalyx
  - mucus and water mixed in
  - absorption through epithelial cells

- intestinal chyme

- microvilli with actin, interacts with myosin for movement

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Hindgut

- **Water and Ion absorption; Defecation**

- **reabsorb** water and ions at end of small intestine (ileum) and from large intestine/colon

- **feces** into cloaca/rectum for excretion

- cloaca can also be site of urine modification (e.g., birds)

- bacterial digestion in hindgut fermenters (especially in cecum)

- coprophagy/cecotrophy (e.g., rabbits)
**Hindgut**
- Water and Ion absorption; defecation

**Motility**
Contraction of gut and movement of contents:
1. Propulsion, expulsion
2. Mixing and grinding (enzymes, mechanical digestion)
3. Stirring so brush border/epithelial lining gets nutrients

**Peristalsis**
- longitudinal muscle
- circular muscle

**ABSORPTION:**
- Across epithelium of brush border (microvilli)
- Glycocalyx has enzymes for final cleavage
  disaccharidases, aminopeptidases, phosphatases

- Simple Diffusion
  1. fat-soluble substances
  2. small water soluble substances through regulated aquaporins
  3. down concentration or electrochemical gradients

- Facilitated Diffusion and 2nd Active Transport
  1. monosaccharides and amino acids
  2. transporter proteins
  3. down conc. gradient or
  4. coupled to Na+ gradient (Na/K-ATPase)

**ABSORPTION**
- Active Transport
  - amino acids with ~specific transporters coupled to Na+

- Lipids
  - products cross into epithelial cells
    monoglycerides, fatty acids, glycerol
  - reconstructed into triglycerides
  - formed into chylomicrons using cholesterol
    and phospholipids
  - chylomicrons exocytosed
  - taken into central lacteal and into lymph system
Nutrient Transport in Blood
- lipids (chylomicrons) into blood from lymph at thoracic duct
- sugars and amino acids into capillaries of villi
- to liver via hepatic portal vein
  sugars converted to glycogen for storage

Water and Electrolyte Balance in Gut
-Lots of water and electrolytes secreted into lumen
- Need to recover
- Most via lower small intestine (ileum)
- Osmotic gradient b/c absorb salts, carbos, amino acids
- Tips of villi
- Countercurrent exchange with high Na⁺ (Cl⁻ follows) to facilitate water reabsorption

Los Secretions
Alimentary canal is largest endocrine and exocrine gland
Salivary gland
Secretory cells of stomach and intestine
Secretory cells of liver and pancreas

Water, ions, mucus, enzymes

Bile (fat digestion)
- Created in liver, stored in gall bladder
- Also gets rid of some waste products metabolized by liver
- Why is your poop brown?

Los Secretions (order and triggers)
Gastric
Pepsin (pepsinogen) from chief cells
- Response to:
  1. Parasymp. stim.
  2. Gastrin
- Breaks peptide bonds

Mucus from goblet cells
- Protects gut lining
- Works with alkaline electrolytes in glycocalyx
Los Secretions (order and triggers)

**Gastric**
- Gastrin from endocrine cells of distal stomach mucosa
- response to:
  1. gastric chyme with proteins
  2. stomach stretch (gastric distension)
- binds to smooth muscle
- stimulates stomach motility
- stimulates HCl and pepsin release

**Intestine**
- Gastric Inhibitory Peptide (GIP) from duodenum
- response to:
  1. entry of fats and sugars
  2. acts to stop gastric secretion and motility

(also Enterogastric Reflex and sympathetic stimulation)

Control of Los Secretions

Presence of Food stimulates:
- Chemoreceptors lead to activation:
  1. Autonomic Efferent Neurons
  2. GI hormones into blood stream
- stimulates liver, pancreas, gut

Mental influences
- conscious decisions
- learned smells, sounds
- Pavlovian response

Gastrointestinal secretions controlled by hormones:
- endocrine cells of gastric and intestinal submucosa
- complicated, varies in areas of gut

Vitamins and Minerals

**Vit A**
(retinol, retinal; rhodopsin)

Water Soluble:
B Vitamins, Vitamin C

Lipid Soluble:
Vits A, D, E, K

Metalloproteins (e.g., hemoglobin)