# Digestive System

Lesson by Laurie, Slides by Slidesgo

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# The Diet

Why do things eat

# Three purposes

1. Chemical energy
2. Organic building blocks
3. Essential nutrients (nutrients that can't be made in the body!)
    a. Essential Amino Acids
        i. WTF? VH MILK
            1. Histidine only for infants
        ii. Animal proteins are complete, plant proteins are incomplete
            1. Corn lacks W and K, beans lack M
    b. Essential Fatty Acids
        i. Linoleic acid in mammals
    c. Vitamins
    d. Minerals

# Additional stuff

Herbivores vs. carnivores vs. omnivores

- Animals still tend to be opportunistic feeders

Dietary deficiencies

- Malnutrition – fail to obtain adequate nutrition
- Carbs → fats → proteins
- Deficiencies are often compensated by consuming concentrated sources of salt, snail shells, stones, etc.

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# Processing Food

# Stages

1. Ingestion
2. Digestion
3. Absorption
4. Elimination

IDAEho

# Ingestion

1. Filter-feeding – strain organisms/food from surrounding medium
    a. Humpback whales (baleen)
    b. A type of suspension feeding
2. Substrate feeding – live on/in food source
    a. Leaf miner caterpillars eat through oak leaf
    b. Maggots burrow into carcasses
3. Fluid feeding – suck fluid from living host
    a. Tsetse fly eats human blood
    b. Aphids tap phloem sap
    c. Hummingbirds and bees eat nectar (also benefits host)
4. Bulk feeding – larger pieces of food
    a. Most animals
    b. Adaptations
        i. Tentacles, pincers, claws, venomous fangs, teeth
    c. Rock pythons – don't chew, digest for 2 weeks

# Digestion

1. Mechanical digestion
    a. Chewing and grinding
    b. Breaks food into smaller pieces and increases surface area
2. Chemical digestion
    a. Enzymatic hydrolysis
    b. Makes bigger molecules usable

# Absorption

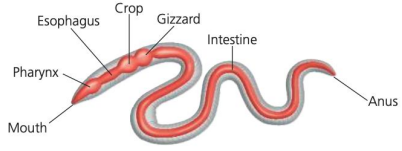
Cells absorb now-small molecules like amino acids and sugars

# Elimination

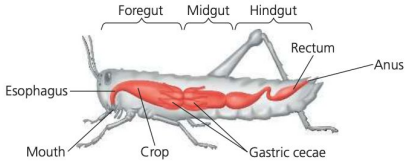
Undigested material exits the digestive system

# Digestive compartments

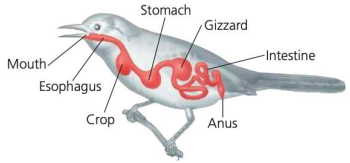
1. Intracellular digestion
    a. Food vacuoles from phagocytosis or pinocytosis
    b. Only method for sponges
2. Extracellular digestion (most animals)
    a. Gastrovascular cavity (1 opening)
        i. Hydra
            1. Gland cells in gastrodermis secrete enzymes and engulf particles, hydrolysis digests particles intracellularly
        ii. Flatworms
    b. Alimentary canal/complete digestive tract has 2 openings




**(a) Earthworm.** The muscular pharynx of an earthworm sucks food in through the mouth. Food passes through the esophagus and is stored and moistened in the crop. Mechanical digestion occurs in the muscular gizzard, which pulverizes food with the aid of small bits of sand and gravel. Further digestion and absorption occur in the intestine before wastes are eliminated through the anus.




**(b) Grasshopper.** A grasshopper has several digestive chambers grouped into three main regions: a foregut, with an esophagus and crop; a midgut; and a hindgut. Food is moistened and stored in the crop, but most digestion occurs in the midgut. Pouches called gastric cecae (singular, *ceca*) extend from the beginning of the midgut and function in digestion and absorption.




**(c) Bird.** Many birds have a crop for storing food and a stomach and gizzard for mechanically digesting it. Chemical digestion and absorption of nutrients occur in the intestine.

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# Digestive Organs

In mammals

# Oral cavity, Pharynx, Esophagus

1. Oral cavity
    a. Teeth mechanically break down food
    b. Salivary glands secrete mucus (water, salts, cells, glycoproteins) to lubricate food, buffer pH, and protect against microbes (lysozyme) and amylase
    c. Tongue evaluates material and creates/pushes bolus
2. Pharynx (esophagus and trachea)
    a. Esophagus usually sealed with a contracted sphincter
    b. Bolus triggers swallowing reflex
    c. Movement of larynx tips epiglottis down
    d. Esophageal sphincter relaxes
3. Esophagus
    a. Peristalsis
4. Another sphincter

# Digestion in Stomach

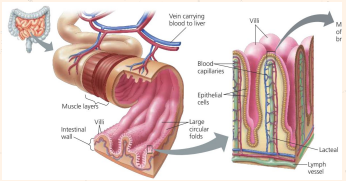
1. Storage
    a. Elastic wall with rugae (accordion-like folds)
    b. Stretches to 2L
2. Makes chyme
3. Chemical digestion
    a. HCl, pH = 2 – disrupts ECM, denatures proteins, exposes peptide bonds
    b. Pepsin/pepsinogen
    c. Cells
        i. Parietal (HCl)
            1. Use ATP pump to expel H+ into lumen
            2. Cl- diffuses into lumen to make HCl
        ii. Chief (pepsin)
            1. Secretes pepsinogen, HCl clips part of it off to expose active site, pepsin activates more pepsinogen
        iii. Mucous cells – protect and lubricate cells
        iv. New epithelial layer formed every 3 days
4. Churns every 20s to make chyme and move material

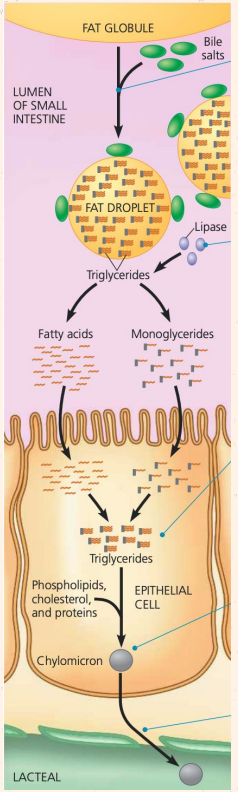
# Digestion in the Small Intestine (Duodenum)

1. Chyme arrives → secretin released → pancreas release
    a. Bicarbonate (neutralizes acidity and acts as a buffer)
    b. Trypsin and chymotrypsin
2. Epithelial lining secretes more enzymes
3. Bile (gallbladder) secreted to break down fats
    a. Bile salts = emulsifiers
    b. Bile made in liver
    c. Bilirubin and biliverdin

# Absorption in the Small Intestine (Jejunum & Ileum)

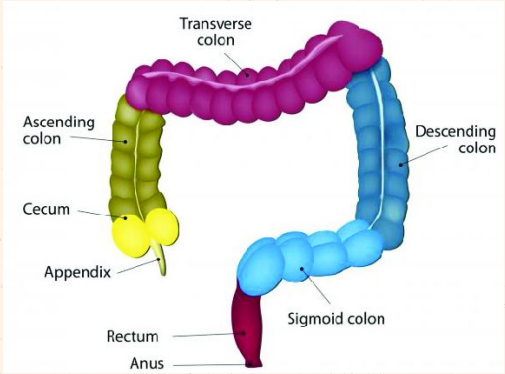
1. Large surface area (tennis court)
    a. Large folds
    b. Brush border – villi with microvilli
2. Transport
    a. Active
        i. Amino acids, small peptides, vitamins, glucose
    b. Passive
        i. Fructose diffuses into cells from lumen
    c. Capillaries in villus core → hepatic portal vein → liver → heart → organs
        i. Liver converts nutrients to other forms, removes toxic substances
3. Fats
    a. Globules broken down by bile salt → droplets hydrolyzed by lipase into fatty acids and monoglycerides → coated with phospholipids, cholesterol, and proteins to make chylomicrons
    b. Chylomicrons exocytosed into lacteal (core of villus) → lymphatic system
4. Lots of water reabsorbed via osmosis



# Processing in Large Intestine

1. Colon
    a. Completes water recovery
    b. Feces
        i. Cellulose
        ii. Too little water absorbed = diarrhea
        iii. Feces move too slowly = constipation
        iv. Bacteria produce methane and hydrogen sulfide
2. Cecum
    a. Very long in animals that eat plants
    b. Contains appendix
3. Rectum
    a. Feces stored here before elimination
    b. Contractions create urge to defecate
    c. 2 sphincters (inner = involuntary, outer = voluntary)

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7770@1667276984221/Anatomy-of-the-large-intestine.png

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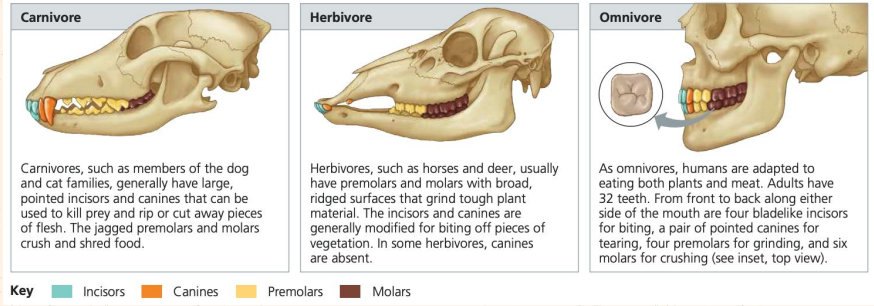
# Evolutionary Adaptations

# Dental Adaptations

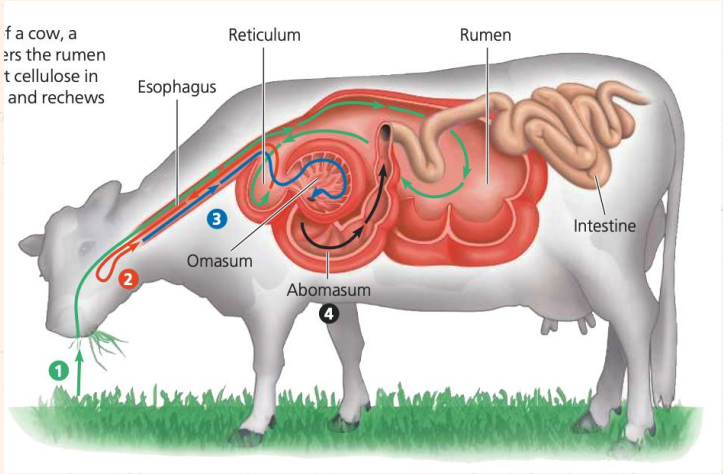
1. Carnivores
   a. Large, pointed incisors
   b. Canines for killing/ripping/cutting
   c. Jagged premolars and molars to crush and shred
2. Herbivores
   a. Incisors and canines for biting off vegetation
   b. Canines may be absent
   c. Broad, ridged molars for grinding
3. Omnivores
   a. Bladelike incisors for biting
   b. Pointed canines for tearing
   c. Premolars for grinding
   d. Molars for crushing



# Stomach & Intestinal Adaptations

1. Large, expandable stomachs in carnivorous vertebrates
    a. Long time between meals
2. Length
    a. Longer for herbivores and omnivores
    b. Plants harder to digest
    c. Longer cecum
    d. Longer colon

# Mutualistic Adaptations




Microorganisms

- Bacteria make vitamins
  - K, biotin, folic acid
- Regulate development of epithelium
- Regulate function of immune system

Herbivores

- Large cecum – horses, kolas, elephants
- Large crop – hoatzin
- Large intestine and cecum – rabbits and rodents (practice coprophagy)
- Ruminants
  - Rumen and reticulum (cellulose digested by microorganisms)
  - Cud regurgitated and chewed
  - Omasum (water removed)
  - Abomasum (digestion by own enzymes)

Tubeworms in hydrothermal vents get all energy from mutualistic chemoautotroph bacteria

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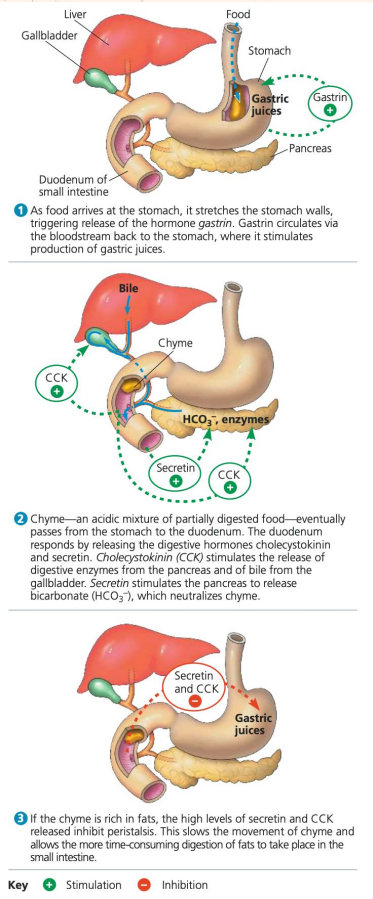
# Regulation

# Regulation of digestion

Collaboration between enteric nervous system and endocrine system

1. Food stretches stomach walls → gastrin released by stomach and circulates back → gastric juices produced
2. Chyme passes to duodenum → duodenum releases CCK and secretin
    a. CCK stimulates pancreas to release digestive enzymes and gallbladder to release bile
    b. Secretin stimulates pancreas to release bicarbonate
3. If chyme is rich in fats, secretin and CCK inhibit peristalsis to allow for digestion

Humans store energy as glycogen in liver and muscle cells and as fat in adipose cells



# Glucose Homeostasis

Pancreatic hormones (produced by cells in islets of Langerhans)

- Glucagon – alpha cells
  - Release glucose from energy stores into the blood
- Insulin – beta cells
  - Stimulate uptake of glucose from the blood
  - Acts on nearly all cells but brain cells

Diabetes Mellitus (deficiency of insulin or decreased response)

- Severe diabetic ketoacidosis – overreliance on fats causes acid metabolites formed during fat breakdown to accumulate and lower pH
- Excess of glucose that kidneys can't absorb = sugar in urine
- Type 1 (insulin-dependent)
  - Autoimmune (beta cells destroyed)
  - Usually appears in childhood
  - Treated with insulin injections
- Type 2 (non-insulin dependent)
  - Target cells fail to respond normally
  - Usually controlled with regular exercise and healthy diet

# Regulation of Appetite and Consumption

Appetite

- Stomach wall secretes ghrelin → you become hungry
  - More ghrelin present in dieters
- Insulin suppresses appetite
- Adipose tissue secretes leptin to suppress appetite
- Small intestine secretes PYY after meals, which suppresses appetite and counters ghrelin

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# Practice

# Digestive System Practice

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At which of the following pH levels will human pepsin be most active:

W) 2

X) 4

Y) 6

Z) 8

Approximately how often is the entire stomach lining in a human replaced?

W) Every three days

X) Every five days

Y) Every week

Z) Every month

In the human digestive system, nutrient absorption predominantly occurs in which of the following?

W) Duodenum and jejunum

X) Stomach and duodenum

Y) Jejunum and ileum

Z) Ileum and cecum

# 2014 Opens

**21. Diabetes is a condition in which the body either does not produce normal amounts of insulin or does not respond to insulin. Symptoms include elevated blood concentrations of glucose and ketone bodies, including acetone. Ketone bodies are formed during the breakdown of which of the following macromolecules?**

A. Polypeptides.
B. Polysaccharides.
C. Glycerol.
D. Lactose.
E. Fatty acids.

# 2013 Opens

**20. The lymphatic system is most involved in the absorption of nutrients from which of the following foods?**

A. Bacon
B. Banana
C. Lettuce
D. Skim milk
E. White bread

# Thanks!