Enduring Understanding:

The structure of an organ system affects the function of that system.
Essential Questions:

How do humans digest food?

How does the structure of the digestive system affect its function?

What role do enzymes play in digestion?
Functions of digestive system:

I. **Ingestion** - voluntary process of taking food into the digestive system (eating)

II. **Propulsion** - process that moves food through alimentary canal
   a. swallowing - voluntary
   b. **peristalsis** - involuntary, muscle movement that pushes food along tract
III. **Food breakdown** - food being broken down into building blocks
   a. **mechanical** - physically prepares food for chemical digestion
      1. chewing - teeth
      2. mixing food with saliva - tongue
      3. churning food - stomach
      4. segmentation - sm. intestine
         mixes food with digestive juices
         mixes forwards and backwards
   
   b. **chemical** - use of enzymes to break bonds holding food molecules together
      -begins in mouth, completed in sm. intestine
Types of breakdown:

1. **carbohydrates**
   - disaccharides (sucrose, lactose) and polysaccharides (starch) into monosaccharides
   - monosaccharides:
     - glucose = blood sugar
     - fructose = fruit sugar
     - galactose = milk sugar
   - cellulose not broken down by humans (no enzyme for it)

2. **Proteins**
   - polypeptides, peptides into amino acids (20)
3. **Fats** - oils, fat, lard into fatty acids and glycerol

-our body then uses the monosaccharides, amino acids, fatty acids and glycerol to make new molecules (carbs, proteins, fats)
IV. Absorption - transport of digested end products from the lumen of organs to blood or lymph

- transported by active or passive transport
- happens in the small intestine

V. Defecation - elimination of indigestible substances via anus

feces - dead cells, bacteria, undigestible materials

defecation reflex - signaled when rectum filled
Digestive system is controlled by the parasympathetic nervous system
- sensors located in wall of alimentary canal
  a. **mechanoreceptors** - respond to stretch of organ
  b. **chemoreceptors** - respond to pH contents, presence of certain breakdown products
Organs of the Alimentary Canal
Mouth

(a)

(b)

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Mouth:
- chewing
- releases **salivary amylase** (Ptyalin) - breaks down starch to maltose

Saliva-
- constantly secreted
- increase when food in mouth, emotional stimuli (smell)
- parasympathetic N.S. (trigeminal and plossohayrngeal nerves)

-no food absorption
  exceptions: some drugs ex. nitroglycerine (heart pblms)
Pharynx/esophagus:
- no digestive function
- moves food
- swallowing = **deglutition**
  a. **buccal phase** - voluntary
    - mouth
    - tongue mixes food with saliva into a **bolus**
    - bolus forced into pharynx by tongue
    - once in pharynx - involuntary
  b. **pharyngeal-esophageal phase** - involuntary
    - food from pharynx to esophagus
    - epiglottis covers larynx
    - peristalsis - can go against gravity
    - at end is **cardioesophageal sphincter muscle**
Stomach:
- gastric juice
- **gastrin** - hormone - helps stomach glands produce pepsinogens, mucus, HCl
- **pepsinogens** = precursor to protein digesting enz. (2-3 L./day)
- **HCl** - pH 2- needed to activate pepsinogen to pepsin
- **Rennin** - enz that digests milk protein- produced more so in infants
- alcohol/aspirin digested here
- end result = **chyme**
Stomach - both mechanical and chemical digestion
- 3 muscle layers to help with mechanical digestion

**pyloric sphincter** - muscle that regulates flow of chyme (3 ml at a time) from stomach into small intestine (duodenum)
- if duodenum full - **enterogastic reflex** - inhibits vagus nerve to stop emptying stomach

Increased surface area due to **rugae** - large folds

food is in stomach for 4-6 hrs.
Small Intestine:
- food in here 4-8 hours
- 6-13 feet long
- 3 areas - duodenum, jejunum, ileum
- covered in microvilli - small finger-like projections
- major function - breakdown and absorption
- increased surface area due to:
  1. **plicae circulares** - fold of tissue
  2. villi
  3. microvilli
Major components present in duodenum:

1. **brush border enzymes** - (microvilli released)
   dextrinase, glucoamylase - breakdown disaccharides

2. **Pancreatic enzymes** added here:
   pancreatic amylase - starch breakdown
   trypsin - protein breakdown
   chymotrypsin - protein breakdown
   carboxypeptidase - protein breakdown
   lipases - breakdown fat
   nucleases - digest nucleic acids

3. **Bicarbonate** - basic substance to neutralize stomach acid
   - provides good environment for enzymes
4. Bile

- Hormone **secretin** triggers liver to increase bile output
- Hormone **cholecystokinin** - triggers gall bladder to contract and release stored bile
- Function - emulsifies fat into fat globules
- Needed for absorption of fats, Vit. K, Vit. D, and Vit. A
- Contains: bile salts, bile pigments, cholesterol, phospholipids, electrolytes

- Nutrients are absorbed directly into the circulation system or the lymphatic system

- Most of absorption in jejunum
- In ileum - water, indigestible food, bacteria
- Ends in ileocecal valve
5. Large Intestine
   - 5 feet long
   - contents stay in here 12-24 hours
   - function:
     1. remove water, sodium, vitamins
     2. vitamin production (Vit. B & K - bacteria)
     3. no enzymes found here

   - no villi - has **goblet cells** - produce mucus (lubricant)
   - has haustra (sacs)
   - rectum stores feces until excreted
   - excretion out anus
     - has sphincter muscles
       a. inner - involuntary
       b. external - voluntary
Accessory Organs
Teeth

baby - 20 teeth
adult- 32 teeth

incisors
canine
bicuspids
molars

mechanical digestion
Salivary Glands

- 3 pairs
  a. parotid - anterior to ears
  b. submandibular
  c. sublingual

saliva - chemical breakdown
  - mucus to moisten and bind to food
  - salivary amylase - starch digestion
  - lysozyme - inhibit bacteria
  - antibodies - inhibit bacteria
Liver
- 4 lobes
- 1 cell carries on 500 metabolic activities
  - many mitochondria
- largest gland of body
functions:
  a. secretes bile
     **bilirubin** (pigment from RBC broken down - excreted in bile - makes skin yellow if not broken down
  b. removes nutrients from blood (hepatic portal vein)
  c. converts glucose to glycogen (storage)
  d. stores iron/vitamins
  e. converts amino acids to fatty acids and urea
  f. metabolizes fats, proteins, carbs
  g. makes plasma proteins for blood
  h. detoxifies body (alcohol/poison)
  i. phagocytizes old RBC
Gall Bladder

- pear-shaped green sac
- stores bile
  - concentrates it

-gallstones - crystallized cholesterol

Pancreas

- inferior to stomach
- exocrine function - secretes pancreatic juices into duodenum
- endocrine function - hormone production (insulin, glucagon)

Problems with digestive system

1. **constipation** - abnormally slow movement of feces
   - insufficient bulk in diet, emotions

2. **diarrhea** - chyme passing through intestine too fast
   - due to pathogens, prunes, emotions
   - can cause dehydration

3. **colon cancer** - can be diet related, genetic
   sigmoidoscopy
   colonoscopy

4. **pancreatitis** - inflammation of pancreas
   associated with alcoholism
   pancreas can "digest" itself
5. **jaundice** - bilirubin pigment in bloodstream
   - could indicate liver problem
   - common in infants
     - use special lights to break bilirubin down

6. **hepatitis** - inflammation of liver
   - causes blood borne pathogens, alcoholism

7. **cirrhosis** - chronic liver inflammation
   - liver hardens, common of alcoholism
   - need transplant

8. **heartburn** - cardioesophageal spincter does not close properly
   - gastric juices go up into esophagus - burn
9. **hiatal hernia** - superior stomach protrudes through diaphragm
   - can surgically fix

10. **ulcers** - cause *Helicobacter pylori*

11. **Appendicitis** - inflammation of appendix
    - symptoms - pain in lower right quadrant, fever, nausea, vomiting
    - surgery - if bursts - can be life threatening

12. **Hemorrhoids** - inflammation of hemorrhoidal veins
    - symptoms - itching, pain, bleeding
    - treatment - increase bulk in diet, surgery
13. Crohn's disease - localized inflammatory degeneration
- can happen anywhere in digestive tract, but mainly in distal ileum and proximal colon
- wall becomes thickened, constricts lumen, can get ulcerations/fissures

14. Diabetes -
Type I - (diabetes mellitus) pancreas produces too little insulin
- can't move glucose into cells where needed, so get high concentration of glucose in blood = hyperglycemia
- symptoms - excessive hunger, thirst, excessive urination, wgt. loss
- rare in Asians, Africans, Native Am.
- more common in children, adults < 30
- no prevention
diagnosis - blood sample after 8 hr. fast  

-normal = 110 mg/dL, >126 mg/dL = diabetes

long term effects:

- artherosclerosis
- digestion pblms
- males - erectile dysfunction
- damage to retina, kidney


treatment: insulin injections/pump for life

**hypoglycemia** = low blood sugar, can pass out if inject too much insulin
**Type II** - body cells are resistant to insulin
- most common type
- can be regulated with diet
- more common in elderly, family history, gestational diabetes
ham + cheese sandwich w/ mayo, lettuce, french fries, milk.

ham - protein, lipid
cheese - lipid, protein
lettuce - carbs
mayo - lipid
bread - carbs

french fries - lipids, carbs
milk - protein, lipids, carbs
mouth - breakdown food into smaller pieces
- start digestion of starch (carbs)

bread + french fries → starch →
chemical / mechanical maltose

esophagus - transport food from mouth to stomach
nothing broken down
no type of digestion
Stomach - digest proteins
- churning food

ham, cheese, milk $\rightarrow$ amino acids

mechanical (muscles) + chemical

pepsin = enzyme for proteins

HCl $\rightarrow$ helps break down protein

rennin $\rightarrow$ breaks down milk

Chyme enters sm. intestine
Small intestine = duodenum, jejunum, ileum

- Enzymatic activity
- Absorption

- bread, lipids (mayo, cheese, ham), lettuce
- milk

Pancreatic enzymes:
- Amylase
- Trypsin (pancreas)
- Chymotrypsin

Proteins → amino acids
Carbs → monosaccharides (glucose, fructose, galactose)
Lipids → fatty acids + glycerol

- Bile
large intestine - water removal

no digestion

E.coli make Vit K, Vit. B

no digestion

feces -> bacteria dead cells, undigested material (cellulose ex.)

stored in rectum

eliminated through the anus