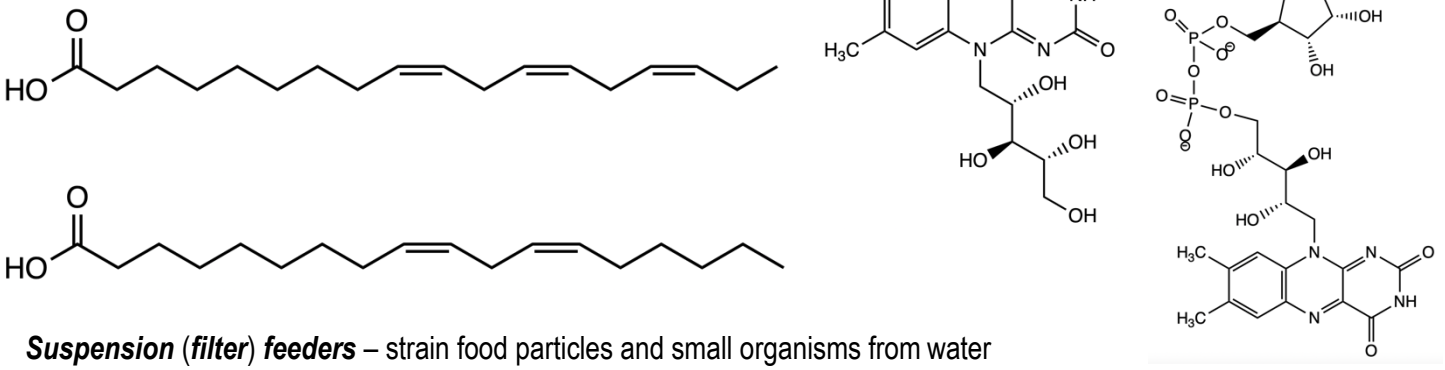
CONCEPT: DIGESTIVE SYSTEM

- Food is a substance that contains nutrients that an organism needs to live
- ***Essential nutrients*** – nutrients that cannot be synthesized, and must be obtained as part of an organism's diet
    - □ ***Essential amino acids*** – 8 amino acids that cannot be synthesized, out of the 20 used to make proteins
    - □ ***Vitamins*** – organic compounds required in small amounts, have diverse array of functions including coenzymes
    - □ ***Minerals*** – inorganic substances required in small amounts, incorporated into proteins, enzymes, and hormones
        - ***Electrolytes*** – mineral ions that influence osmotic balance, and are used in nerve signals
    - □ ***Essential fatty acids*** – include omega-3 and omega-6 fatty acids

EXAMPLE:



- ***Suspension*** (***filter***) ***feeders*** – strain food particles and small organisms from water
    - □ ***Deposit feeders*** – swallow sediment and other types of deposited material
- ***Substrate feeders*** – live on their food source
- ***Fluid feeders*** – suck up nutrient rich fluid like blood and nectar
- ***Mass*** (***bulk***) ***feeders*** – eat large pieces of food, sometimes whole organisms

EXAMPLE:

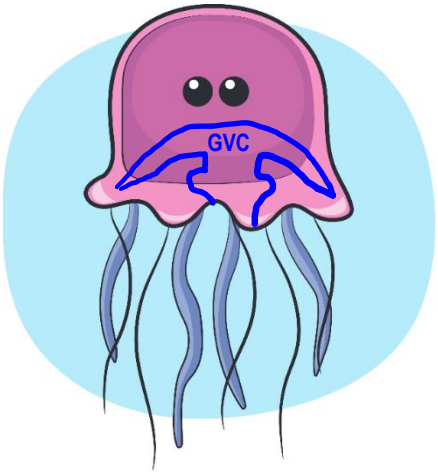
CONCEPT: DIGESTIVE SYSTEM

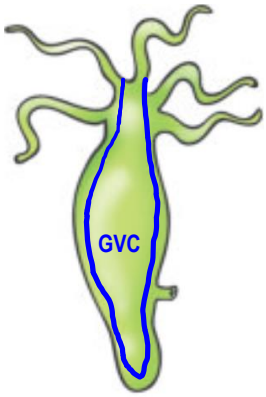
- Mouth parts have wide variety of forms and functions based on the food source of the animal
    - □ Natural selection has a powerful effect on mouth parts because obtaining food is essential to life

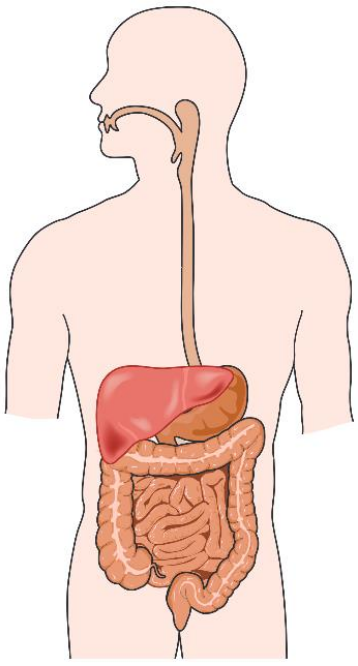
EXAMPLE:

- Nutrients are absorbed from food in a 4-step process:
    - □ ***Ingestion*** – bringing food into the body, specifically the digestive tract
    - □ ***Digestion***- breakdown of food through chemical and mechanical means
        - Humans perform ***extracellular digestion***, but some organisms perform ***intracellular digestion***
    - □ ***Absorption*** – uptake of nutrients from food into the cells of the body
    - □ ***Elimination*** – undigested material is evacuated from the digestive tract
- ***Incomplete digestive tract*** – single opening through which food enters and waste exits
    - □ ***Gastrovascular cavity*** – primary organ for digestion and circulation in cnidaria and platyhelminthes
- ***Complete digestive tract*** (***alimentary canal***) – two openings: food enters through mouth, waste exits through anus

EXAMPLE:



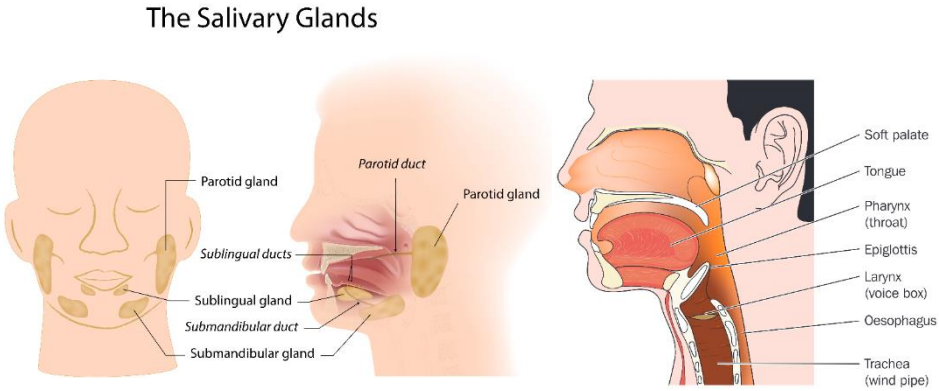


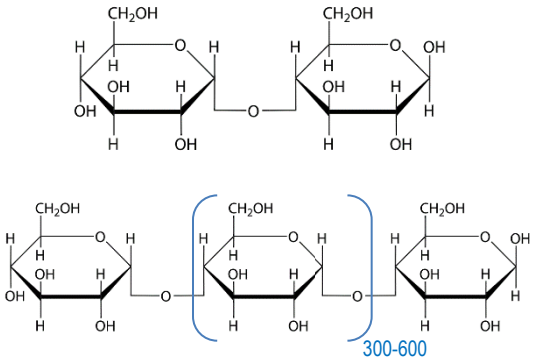


CONCEPT: DIGESTIVE SYSTEM

- Digestion occurs in multiple organs as food moves through the body
- ***Mouth*** – food is mechanically subdivided increasing the total surface area of food particles
    - □ ***Salivary glands*** – secrete saliva, a mixture of water, mucus, and enzymes
        - ***Salivary amylase*** – breaks down carbohydrates to maltose and dextrins
        - ***Mucus*** – glycoproteins that form slimy substance with water, lubricates food bolus
    - □ ***Lingual lipase*** – breaks down fats, released into mouth along with saliva

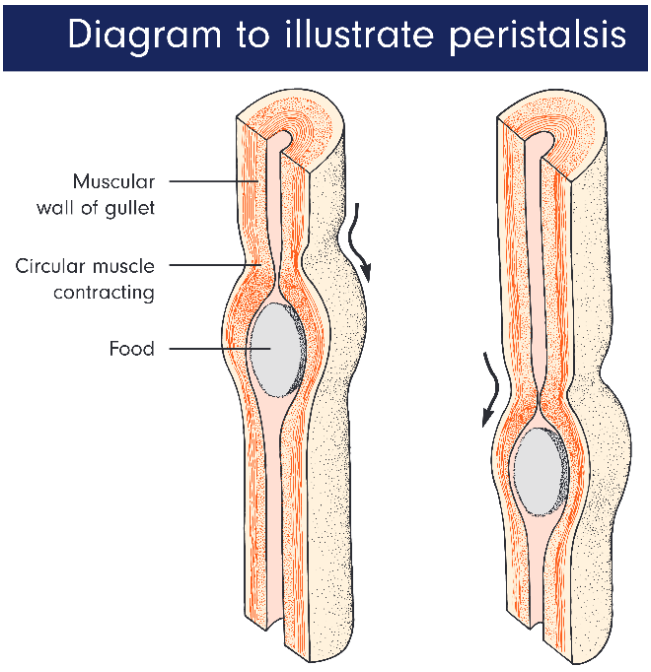
EXAMPLE:

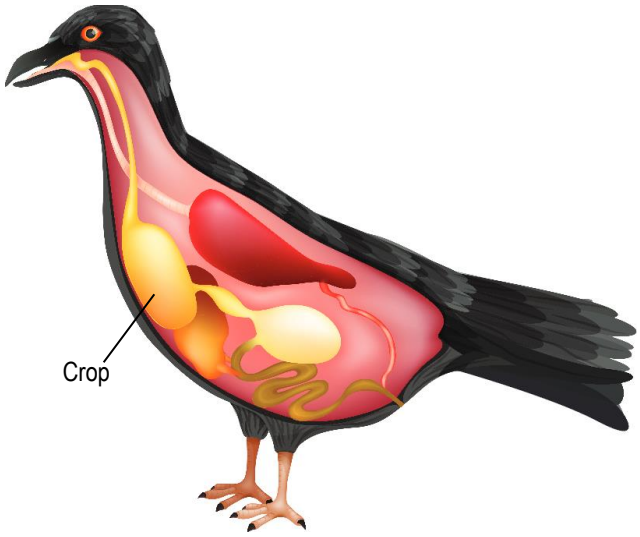




- The chewed food, or ***bolus***, moves through the pharynx to the esophagus
- ***Esophagus*** – organ that connects the mouth to the stomach, transports food by peristalsis
    - □ ***Peristalsis*** – rhythmic, wave-like contraction of smooth muscle
    - □ ***Crop*** – some birds have a modified portion of the esophagus used for food storage

EXAMPLE:

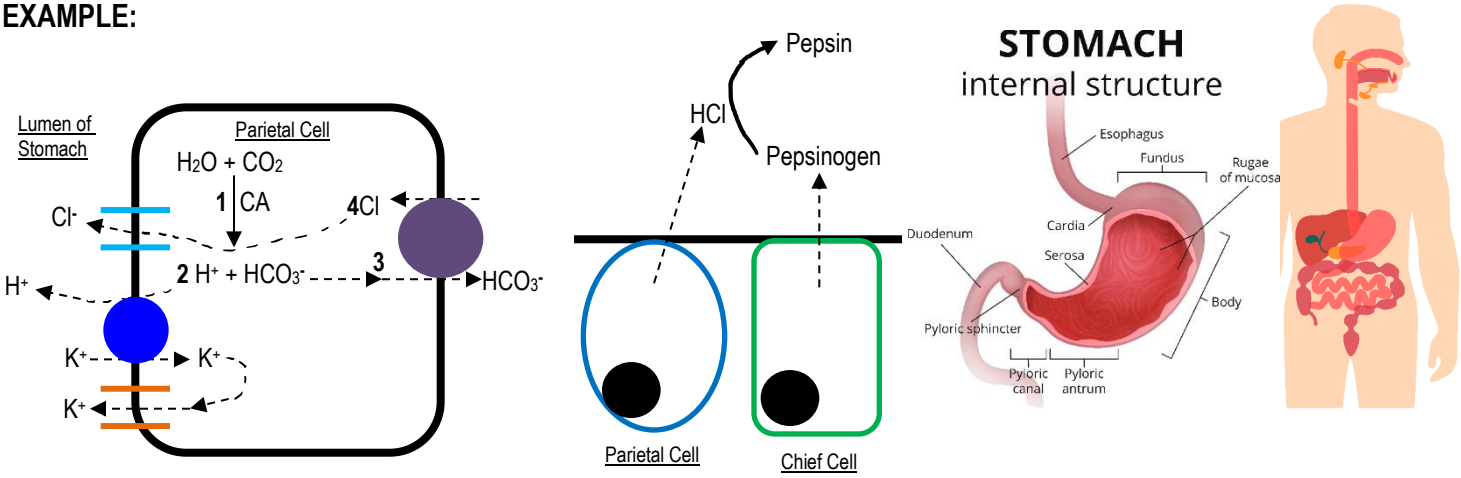




CONCEPT: DIGESTIVE SYSTEM

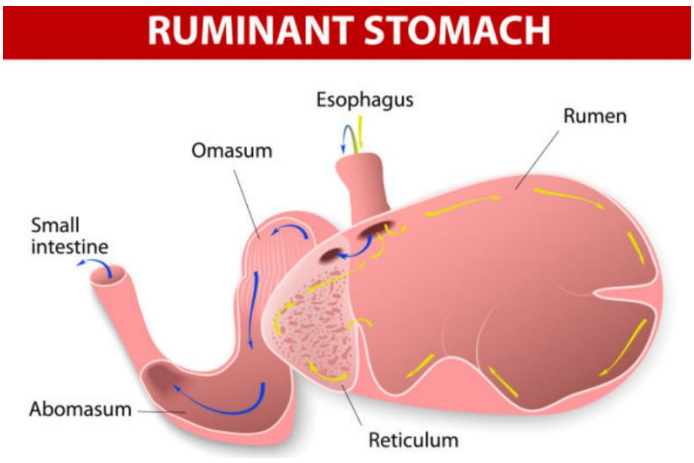
- ***Stomach*** – muscular digestive organ that creates acidic environment for protein digestion
  - □ ***Sphincter*** – circular muscle that maintains constriction of an orifice
    - Cardiac sphincter seals esophagus end, pyloric sphincter seals intestine end
  - □ ***Gastric juice*** – digestive fluid secreted by stomach
    - ***Chyme*** – food mixed with gastric juice
  - □ ***Parietal cell*** – secretes HCl to help breakdown food, activate pepsinogen, and kill pathogens
    - ***Gastrin*** – hormone secreted in response to food entry, increases HCl production
  - □ ***Chief cell*** – secretes pepsinogen, an inactive form of the enzyme (zymogen) that is safer to store
    - ***Pepsinogen*** is converted to the protease ***pepsin*** at low pH
  - □ ***Mucous cell*** – secretes mucus to lubricate and protect stomach from acid

EXAMPLE:



- Gizzard – modified stomach found in birds, and some other organisms that replaces chewing
  - □ Contains swallowed stones, sand, and grit that help grind up food
- Ruminants – mammals that have a specialized, 4-chamber stomach for fermenting and digesting plant matter
  - □ Rumen – largest chamber that contains bacteria and protists that can produce cellulase
  - □ Ruminants often regurgitate the cud, and rechew it to ensure they extract as much nutrition as possible

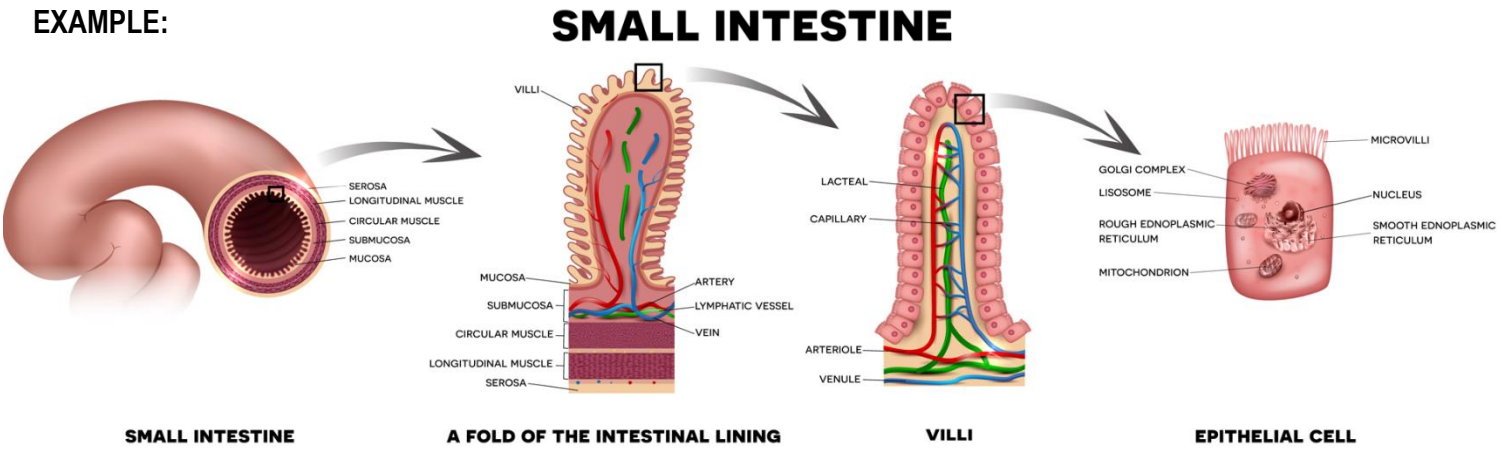
EXAMPLE:



CONCEPT: DIGESTIVE SYSTEM

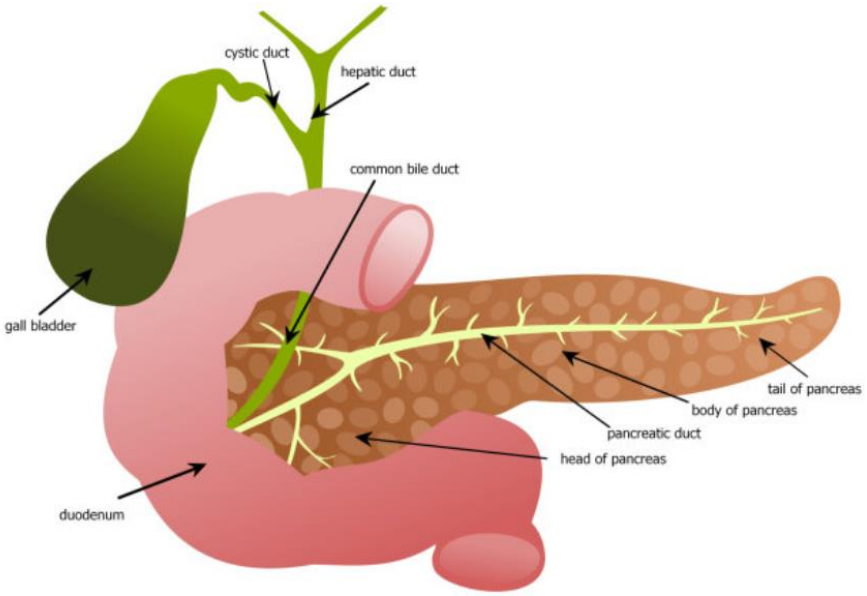
- ***Small intestine*** – long tube in which digestion and absorption occurs, assisted by secretions from the pancreas and liver
    - □ The small intestine is long (~6m), and has a lot of surface area due to its folded structure covered in villi
    - □ ***Villi*** – projections of epithelial tissue that surround blood vessels and lymphatic vessels, called ***lacteals***
    - □ ***Microvilli*** – tiny projections on the apical surface of the epithelial tissue

EXAMPLE:



- ***Duodenum*** – start of small intestine where chyme enters from stomach, secretes hormones in response to chyme
    - □ ***Secretin*** – hormone stimulates bicarbonate release from pancreas
    - □ ***Cholecystokinin*** (***CCK***) – hormone that stimulates pancreas to secrete digestive enzymes
- ***Pancreas*** – secretes bicarbonate-rich solution containing digestive enzymes
    - □ ***Trypsin*** and chymotrypsin are proteases that break down proteins into smaller polypeptides
        - ***Enterokinase*** – enzyme produced by the small intestine that activates trypsinogen
    - □ ***Nucleases*** – break down nucleic acids
    - □ ***Pancreatic amylase*** – breaks down carbohydrates into maltose and dextrins
    - □ ***Pancreatic lipases*** – break down triacylglycerides into 2 fatty acids and a monoacylglyceride

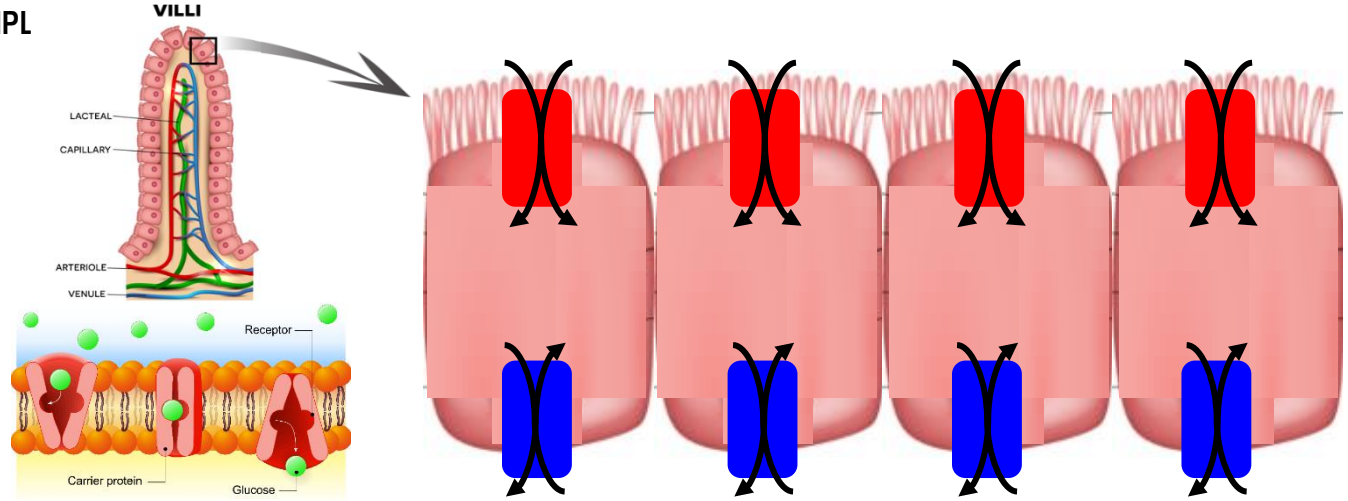
EXAMPLE:



CONCEPT: DIGESTIVE SYSTEM

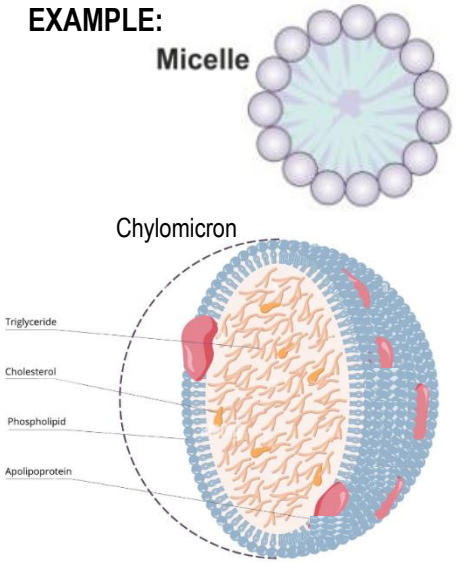
- Absorption through the epithelium of the small intestine is highly selective, and requires specific transporters
  - □ Transport is active requiring ATP to move nutrients against their concentration gradients
  - □ Blood vessels from villi converge into the hepatic portal vein that transports nutrients directly to the liver
- Glucose uses secondary active transport to cross the epithelium from the intestinal lumen to extracellular fluid
  - □ Na^+/K^+-ATPase located on basolateral membrane transports Na^+ out of the cell, establishing Na^+ gradient
  - □ Na^+/glucose cotransporter located on apical membrane brings glucose and Na^+
  - □ Glucose carrier on basolateral membrane moves glucose out of cell by facilitated diffusion

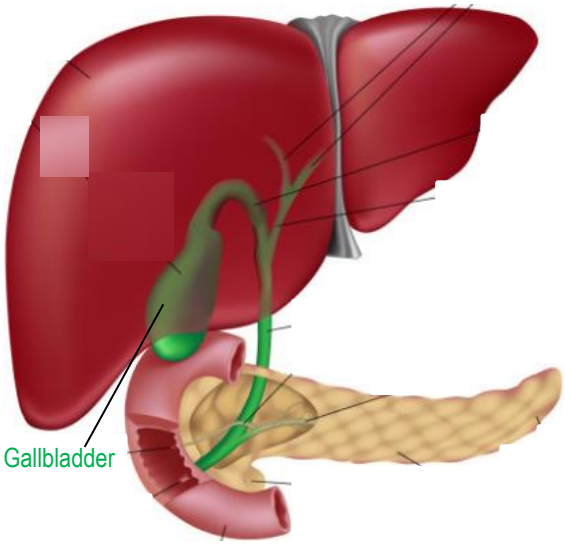
EXAMPL

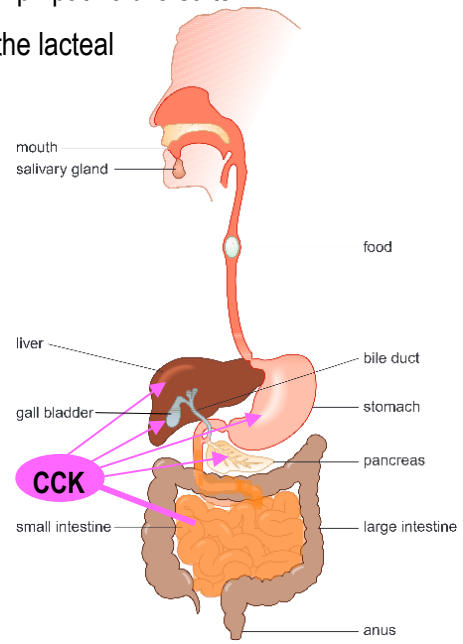


- Fats are broken down by bile and lipases, and are absorbed from intestinal lumen into enterocytes as micelles
  - □ Bile increases the surface area of fats (***emulsification***) making them easier for lipases to breakdown
  - □ ***Cholecystokinin*** (***CCK***) – hormone that stimulates bile production in liver, and bile release from gallbladder
    - Bile is produced in the liver, and stored in the gallbladder, contains amphipathic bile salts
  - □ Fats are packaged into ***chylomicrons*** in enterocytes to be transported into the lacteal

EXAMPLE:



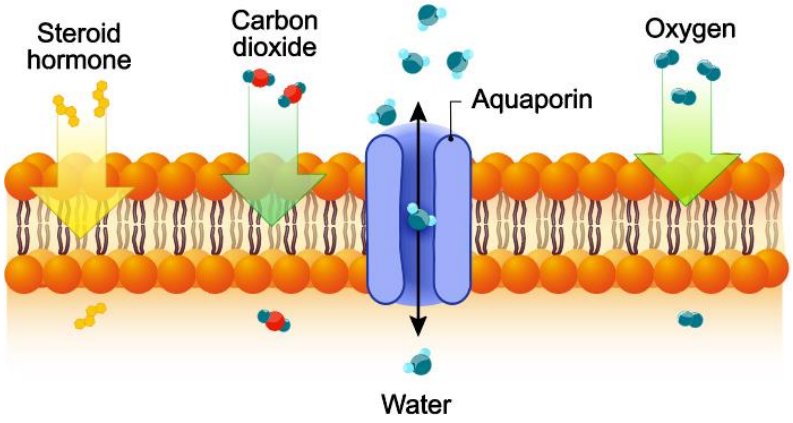


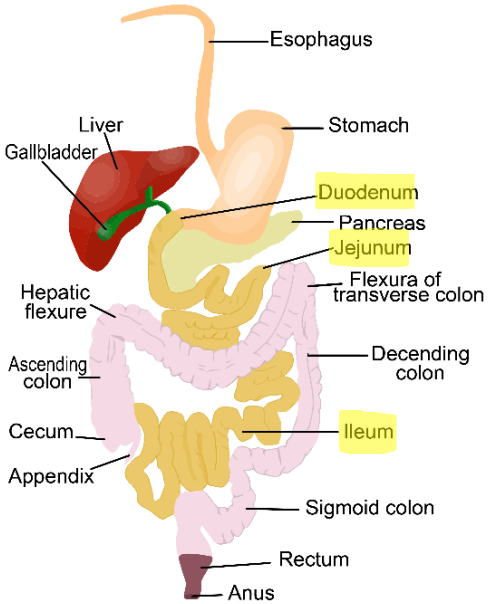


CONCEPT: DIGESTIVE SYSTEM

- Water is absorbed passively through osmosis, absorbed solutes in the small intestine pull water
  - □ Water is reclaimed from saliva, mucus, and digestive juices, and water is absorbed from digested materials
  - □ ***Aquaporins*** – protein channels that allow for the passage of water

EXAMPLE: **AQUAPORIN**

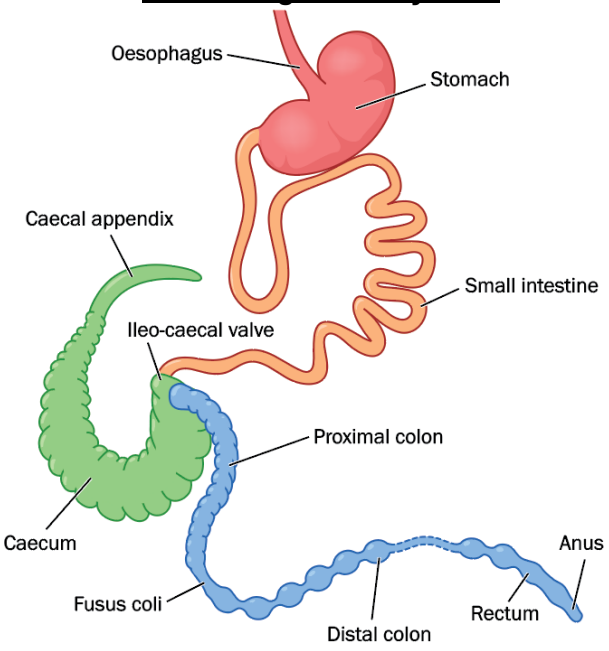




- ***Large intestine*** – wider, but shorter than small intestine, main function is to absorb water and compact feces
  - □ ***Cecum*** – sack at beginning of large intestine, in herbivores this structure is specialized for cellulose digestion
  - □ ***Colon*** – main section of the large intestine, and home to incredible microbiome of bacteria essential to life
  - □ ***Rectum*** – stores feces for elimination
  - □ Cloaca – orifice that excretes both urine and feces, urine flows from kidney to large intestine
- ***Appendix*** – small extension on cecum that houses useful gut bacteria, and contains tissue related to immune function

EXAMPLE:

Rabbit Digestive System



Human Large Intestine