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Lecture title: **Digestive system**

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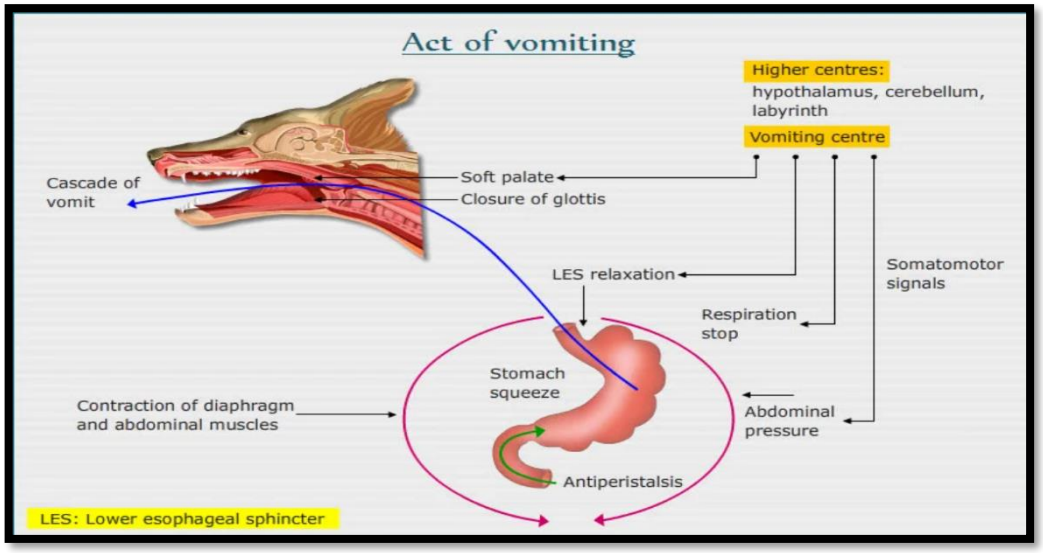
Summary:

Vomiting (emesis)

- is the reflex characterized by forceful oral expulsion the contents of stomach through the oral cavity to removes the irritating materials.
- Some species may use the stomach as a means of conveyance of food to their offspring. They may vomit the contents of the stomach on stimulation by the sight and sound of their offspring. This is generally referred to as **regurgitation** rather than vomiting or emesis.
- Vomiting is very rare in horse due to the presence of well-developed and powerful cardiac sphincter and distant position of the stomach from the abdominal walls.
- The vomiting center located in medulla

- The mechanism of vomiting includes: -
  1. the glottis closes, preventing aspiration of vomitus into the trachea.
  2. the breath is hold in vomiting.
  3. the muscle of the abdomen wall contract due to increases intra-abdominal pressure.
  4. the esophagus and gastric cardiac sphincter relax.
  5. antiperistalsis activity begins, and the gastric contents are ejected.

- Carnivores and most omnivore mammals are emetic species. But rodents are non-emetic species that lack a vomiting reflex



Digestion and absorption

- The digestion of nutrients in monogastric species is predominantly **enzymatic** with a minor **microbial** digestion in the large intestine.
- enzymatic digestion mean, the hydrolysis by the insertion of water molecule
  - glycosidic bonds (carbohydrates)
  - peptide bonds (proteins)
  - ester bonds (lipids)
  - phosphodiester (nucleic acids).
- the enzymes for digestion situated at the apical surface (brush border) of enterocytes.
- But, absorption of end products of nutrients across the intestinal epithelium.

Digestion and Absorption of Carbohydrates

The principal dietary carbohydrates are:

- monosaccharides.
- Disaccharides:

1. Sucrose "glucose and fructose "

2. lactose "glucose and galactose "

- polysaccharides (starch, glycogen) ---- α-1,4-glucosidic linkage
- polysaccharides (hemicellulose, cellulose) ----- β-1,4 glucose unit

1. Digestion of Carbohydrates in the Mouth and Stomach
   - Saliva contains salivary **α-amylase or ptyalin** digest only 5% of starch in the mouth as the feed remain in the oral cavity for a very short period of time.
   - The gastric acidity decreases the activity of salivary amylase.

2. Digestion of Carbohydrates by Pancreatic enzyme
   - **Pancreatic α-amylase** more potent than salivary α-amylase of saliva. It causes the hydrolysis of almost all the starches.

3. Digestion of Carbohydrates by Intestinal Enzymes

   The enterocytes of the small intestine contain brush boarder enzymes such as:
   - Maltase = glucose + glucose
   - Lactase = glucose + galactose
   - Sucrase = glucose + fructose
   - Dextranase breaks α limit dextrin to = glucose + glucose

   They convert polysaccharide to monosaccharide molecules for ready to absorption.

4. Absorption of Carbohydrate
   - The end products of the carbohydrate digestion (monosaccharides) are absorbed through the enterocytes and transported to the portal circulation.
   - The absorption of **glucose and galactose** is occurred through specific transporters called sodium-linked glucose transporter (SGLT-1) at the brush border of the enterocytes of the duodenum and jejunum.
   - The glucose then leaves the enterocytes (basolateral membrane)
   - The fructose is absorbed by facilitated diffusion
   - Glucose transport by blood to the liver to begin glycogenesis

Digestion and Absorption of Proteins

The protein substrates available for digestion are of two types:

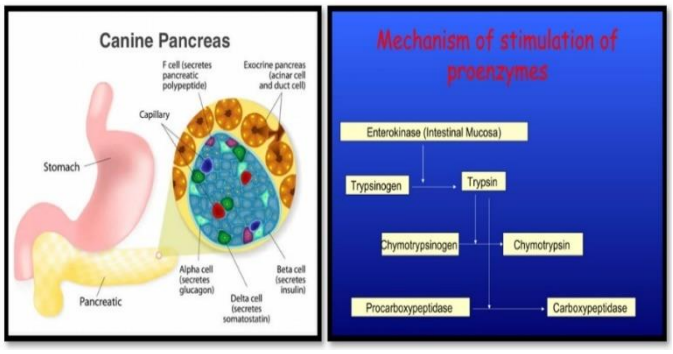
- **Exogenous or dietary proteins** are long chains of amino acids bound together by peptide linkages.
- **Endogenous proteins** such as plasma proteins.

1. Digestion of Proteins in the Stomach

- The digestion of dietary proteins begins at the **stomach.** The saliva lacks proteolytic enzymes.
- The predominant proteolytic enzyme of the stomach is **pepsin**. It is secreted as **inactive pepsinogen** and activates under the influence of gastric **HCl** (pH range of 2.0–3.0) convert to active form. The enzyme is inactive at a pH above 5.0. It hydrolyses peptide bonds that between amino acids.

2. Digestion of Proteins in Intestine

- Most protein digestion occurs at the duodenum and jejunum, under the influence of
  1) proteolytic enzymes from pancreatic secretion are stimulated by **CCK** and **Secretin** to release the pancreatic enzymes as in active form but, presence enterokinase which covert inactive form to active form.
  (trypsin, chymotrypsin, carboxypolypeptidase, and elastase).



  2) peptidases from brush border.

3. Absorption of Amino Acids

- Amino acids are absorbed by active transport processes against concentration and electrochemical gradients and transported to the portal circulation.

1. Absorption of Immunoglobulins in Neonates
   - The maternal immunoglobulins are absorbed from the small intestine in animals like cattle, horse, sheep, goat, dog, and cat through colostrum.
   - Protein enters in the enterocytes by pinocytosis and transports to the lymphatics.

Digestion and Absorption of Lipids

- The dietary lipids include:
  - triglycerides (TG)
  - phospholipids (PL)
  - sterols
  - cholesterol ester
  - fat-soluble vitamins

1. Digestion of Lipids in Oral Cavity
   - The lipid digestion starts at oral cavity by the enzyme **lingual lipases.** Lingual lipase cleaves triglycerides (TG) into fatty acids and glycerol.

2. Digestion of Lipids in Stomach
   - Hydrophobic lipids are clustered together in large droplets hence required special machinery called **emulsification** to facilitate digestion in aqueous medium
   - **Gastric lipase** causes hydrolysis of **TG** into monoacylglycerol and fatty acids.

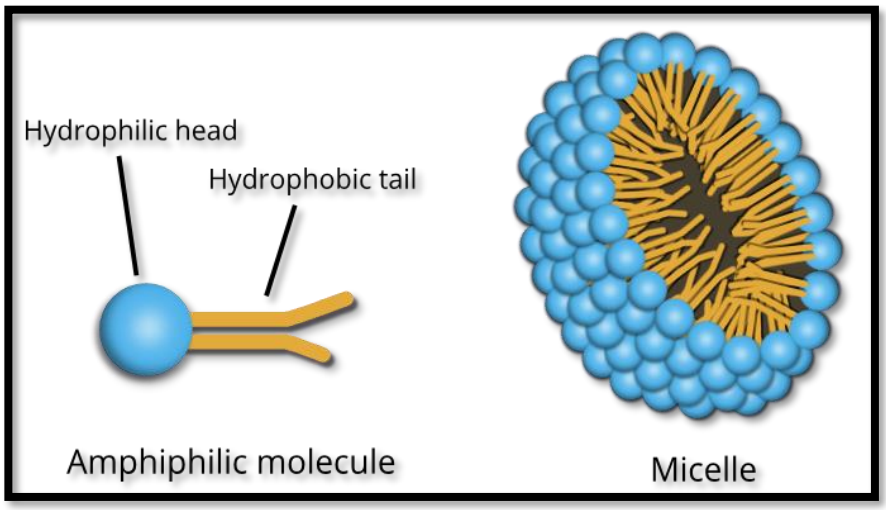
3. Digestion of Lipids in small intestine

- The emulsification is further reinforced in the duodenum by the bile salts reduces the surface tension and prevents the aggregation of lipids particles to form droplets

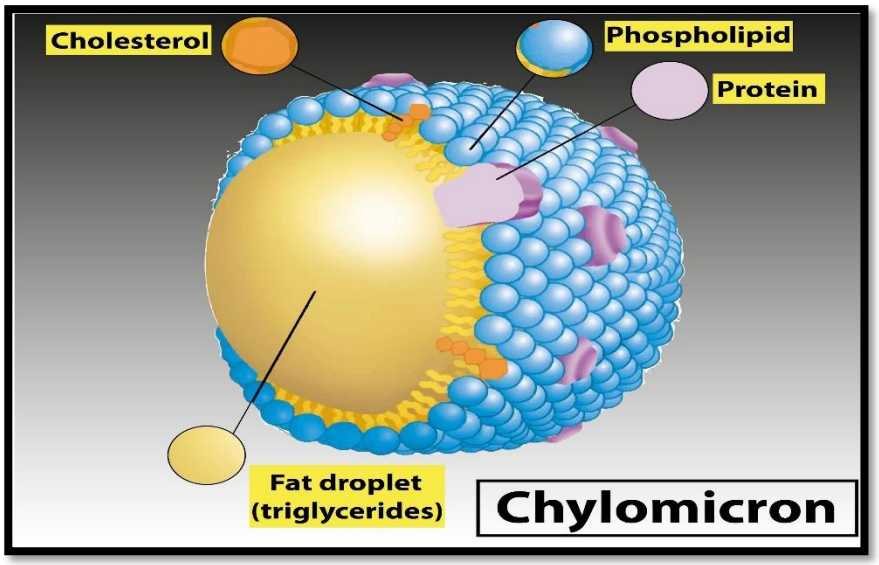
- In **neonates**, both gastric and lingual lipase play important role in digesting milk
- In the **jejunum**, TGs are digested by pancreatic lipase.
- Phospholipids are hydrolyzed by pancreatic phospholipase A2 to yield free fatty acids and Lys-phosphatidylcholine.
- Cholesterol in the diet can be absorbed through micelles.
- Only the esterified cholesterol requires enzyme hydrolysis by cholesterol esterase to release free cholesterol.

4. Absorption of Lipids

- The fatty acids and monoacylglycerol generated by the enzymatic hydrolysis of lipids are unable to reach in the intestinal brush border membrane due to their poor solubility in the aqueous membrane. **Micelle** formation is required to bring the lipid molecules close to the microvilli.
- **Micelle Formation:** Micelles are the aggregation of phospholipids and cholesterol together with bile salts in such a manner that the hydrophobic ends of the lipid molecules are inside and hydrophilic ends are outside the aggregate to keep the lipids in aqueous solution then move to intestinal mucosal cells and release contents near the brush border.

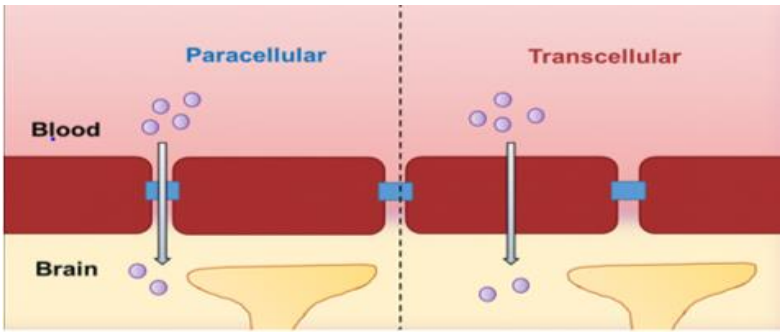


- **Chylomicrons** are the droplets of the lipid in the core that consists primarily of **triglycerides** and **cholesterol ester** and in the surface consists of **lipoprotein** and **phospholipid**
- Formed in the smooth endoplasmic reticulum (sEPR) of the mucosal cell of duodenum
- Secret from basolateral membrane of mucosal cell by exocytosis to lymphatic system then to blood stream
- The triglycerides and proteins of chylomicrons that help in transporting the lipids through the bloodstream to various parts of the body



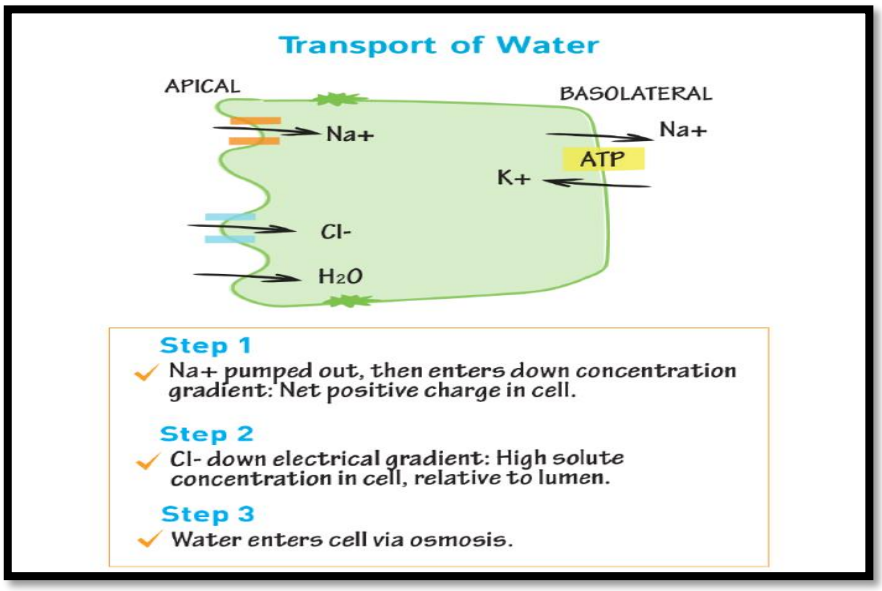
Absorption of Minerals

- The dietary minerals exist as complex structures with major nutrients like proteins, carbohydrates, and fats.
- The absorption of minerals occurs via the enterocytes



Absorption of Water

- Bi-directional movement of water across the mucosa of the small and large intestines occurs in response to osmotic gradients.
- About 98% water is reabsorbed in the intestine to reduce the fecal water loss (only 2%).
- The osmotic gradient is created by absorption of solutes and that promote the water uptake in the intestine



Gastro intestinal hormones

1-Gastrin

- Gastrin is produced by cells called G cells in the antral portion of the gastric mucosa and duodenum
- physiologic actions
  - Stimulation of gastric acid and pepsin secretion
  - Stimulation of the growth of the mucosa of the stomach and small and large intestines
  - Stimulation of gastric motility.

2-Gastrin inhibitory peptide (GIP)

- produced by cells in the mucosa of the duodenum
- **Physiological actions**
  - It inhibits gastric secretion and motility.
  - **Induces satiety**

3- Leptin

- Produced by Stomach and adipose tissue

- Physiological actions
  - Decrease feed intake
  - Increase energy expenditure
  - Induce satiety (**satiety hormone**)

4- Ghrelin

- produced by cells in the Stomach.
- **Physiological actions**
  - Increase gastric acid
  - Increase gastric emptying
  - induce hunger (**hunger hormone**)

5-Cholycytokinin-pancreozymin (CCK)

- Is secreted by cells in the mucosa of the duodenum.
- physiologic actions
  - Stimulation of pancreatic enzyme secretion.
  - It causes contraction of the gallbladder and relaxation of the sphincter of Oddi
  - CCK augments the action of secretin in producing secretion of an alkaline pancreatic juice.

6-Secretin

- Secretin is secreted by S-cells located in the duodenum
- **physiologic actions**
  - Increases the secretion of bicarbonate by the duct cells of the pancreas and biliary tract.
  - Augments the action of CCK in producing pancreatic secretion of digestive enzymes.

- It decreases gastric acid secretion and may cause contraction of the pyloric sphincter.

7- Motilin

- produced by M cell in duodenum
- **Physiological actions**

  Increases intestinal motility

8- Somatostatin

- Produced by D cell in the Stomach and small intestine
- **Physiological actions**

  Inhibits the release of GH, CCK, gastrin, motilin, secretin, GIP, VIP

9-Vasoactive intestinal peptide (VIP)

- It is found in nerves in the gastrointestinal tract.
- **Physiological actions**
  - Stimulates intestinal secretion of electrolytes (Cl-, HCO3 -) and hence of water.
  - Relaxation of intestinal smooth muscle