Lecture 24: **Digestive System 1**

- Identify the primary and accessory organs of the digestive system and their major functions and anatomical structures that allow these functions
- Describe the six processes involved in digestion
- Describe the structure and function of the layers that form the wall of the gastrointestinal tract and appreciate how these vary with the functional responsibilities of the regions of the GIT
- Understand the structure and function of the gastrointestinal tract (GIT), in particular the regional variation and which digestive processes occur in the various regions
- Understand the types of propulsion and mechanical digestion
- Understand the cellular composition of the various GIT regions and know what the roles of the various cell types are
- Know the structure and function of the gastric and intestinal pits
- Describe the digestion and absorption of carbohydrates, proteins and lipids
- Understand the general structure and function of the liver, gallbladder and pancreas

Identify the primary and accessory organs of the digestive system and their major functions and anatomical structures that allow these functions

Primary Organs (GIT)
- mouth, pharynx, oesophagus, stomach, small intestine and large intestine.

Accessory organs:
- teeth, tongue, salivary glands, liver, gall bladder and pancreas

Mouth (oral cavity): ingestion and mastication
- lips, cheeks, palate = confinement of ingested food
- mastication = mechanical digestion
-enzymes = chemical digestion
- mucosa – lined
- stratified squamous epithelium

Tongue:
- extrinsic and intrinsic skeletal muscle
- food bolus production and repositioning
- papillae, taste buds and temperature
- initiation of swallowing
- speech

Teeth
- mechanical digestion = mastication of food
- mixing

Salivary glands:
Saliva:

- cleansing, dissolves tastants, wets food for compaction (97-99.5% water), chemical digestion (enzymes) and amylose, lipase, mucin, lysozyme and IgA.

Glands and ducts:
- parotid (serous cells)
- submandibular (serous and mucous cells)
- sublingual (serious and mucous cells)

Pharynx:
- oropharynx and laryngopharynx
- pharyngeal muscles
- stratified squamous epithelium
- mucous- secreting glands
- 2 layers of skeletal muscle:
  Inner: longitudinal
  Outer: 3 stacked pharyngeal constrictors
- primary function = propulsion
- uvula and epiglottis

Oesophagus:
- connects laryngopharynx to stomach
- stratified squamous epithelium
- mucous –secreting oesophageal glands
- gastroesophageal sphincter
- skeletal and smooth muscle
- adventitia
- primary function = propulsion
- longitudinal folds

Stomach
- storage
- 4 main regions = cardia, fundus, body and pyloric
- chyme
- longitudinal folds when empty (rugae)
- primary function and chemical and mechanical digestion: propulsion (entry into duodenum)

Modified tunics of the stomach:
Mucosa:
- columnar mucous – secreting epithelial cells
- 2 layered protective coat of alkaline mucous
- gastric pits
- gastric glands
- gastric juice

Mucosal barrier:
- protection against gastric juice
- alkaline mucous
- tight epithelial junctions
- epithelial regeneration

Muscularis externa:
- 3 layered obliques = food pummelling

Gastric glands:
- regional variation in cellular composition:
  -cardia + pylorus = mainly mucous
  - pyloric antrum= mucous and hormones
- glands of fundus + body produce most of gastric juices
  -mucous neck cells = acidic mucous
  -parietal cells = HCL + IF
  -chief cells = pepsinogen
  - enteroendocrine = local paracrine and endocrine factors

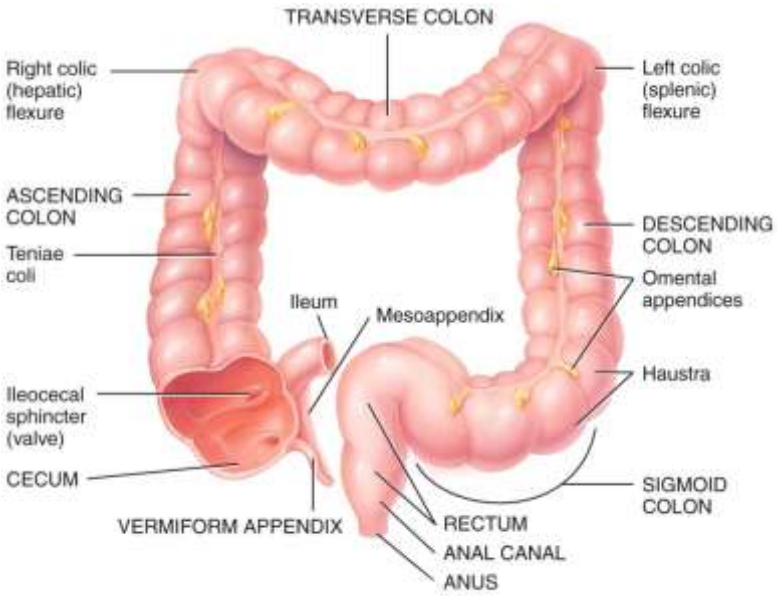
Small intestine:
3 regions:
  - duodenum
  - jejunum
  - ileum
-bile and pancreatic fluid entry
- chyme and mixing/ propulsion
- chemical digestion
- absorption
- ileocecal sphincter
- distinct features for absorption: length, circular folds (plicae, 'rifling'), villi: enterocytes (absorptive epithelia) and microvilli: brush border- BB enzymes
- submucosa:
  - duodenal glands: alkaline mucous
  - lymphoid follicles: pathogens

Small intestine: Tunic modifications
- goblet cells: mucous, ↑ distally
- intestinal crypts (cf. gastric glands)
  -intestinal juice: watery mucous
  - enteroendocrine cells = secretin, CCK (enteogastrones)
  - intraepithelial lymphocytes - release cytokines to kill infected cell
  - Paneth cells - antimicrobials (defensins & lysozymes
  - stem cells - migration - apoptosis - villi tips - 2-4 d

Large intestine:

5 regions: cecum, appendix, colon, rectum, anal canal

- food absorption already complete
- water, mineral, vitamin, absorption
- bacterial flora
- propulsion/compaction and storage of feces
- defecation



(a) Anterior view of large intestine showing major regions

-Mucosa - columnar epithelia
-lack of folds, villi, microvilli, digestive enzymes
-water, electrolytes, bacterial vitamins
-abundance of crypt goblet cells:
-lubrication and protection from bacterial flora products
-stratified squamous epithelia of anal canal mucosa
- Anal sinuses - mucous

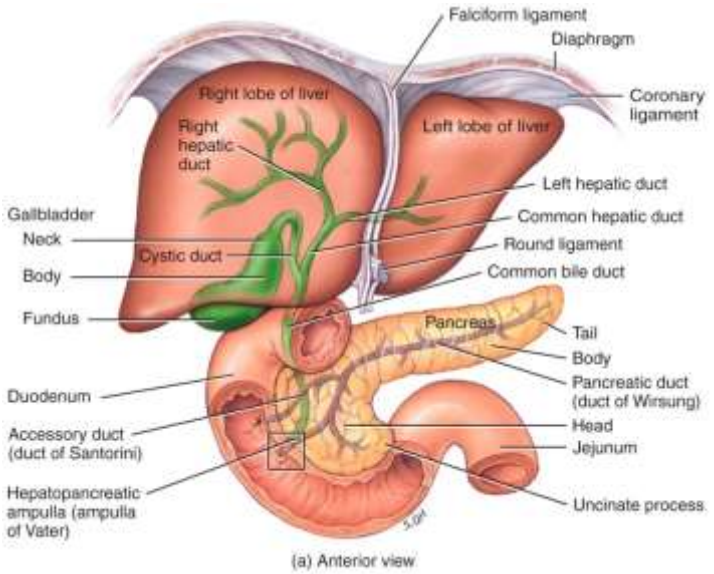
Accessory digestive organs:

Liver & Gallbladder

- production, storage, concentration and secretion of bile
- fat emulsification -'dish detergent'
- liver has > 200 functions

Pancreas

- exocrine/endocrine organ
- pancreatic juice (1200-1500 ml/d)
    - enzymes for all foodstuffs: proteases, amylase, lipases, nucleases (acinar cells)
    - bicarbonate ion rich (duct epithelial cells)



(a) Anterior view

Describe the 6 processes involved in digestion:

Ingest → mechanical Breakdown → propulsion → digest → absorption → excrete
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Ingestion: This process involves taking foods and liquids into the mouth (eating)

Secretin: Each day, cells within the walls of the GI tract and accessory organs secrete a total of about 7 litres of water, acid, buffers and enzymes into the lumen of the tract.

Mixing and propulsion: Churning and movement of food through GI tract

Digestion: mechanical and chemical breakdown of food

Absorption: passage of digested food products from GI tract into blood and lymph.

Defecation: elimination of faeces from GI tract.

Describe the structure and function of the layers that form the wall of the gastrointestinal tract and appreciate how these vary with the functional responsibilities of the regions of the GIT

The wall of the GI tract from the lower oesophagus to the anal canal has the same basic, four – layered arrangement of tissues.
The four layers of the tracts, from deep to superficial, are the mucosa, submucosa, muscularis and serosa/ adventitia

Mucosa: is the inner lining of the GI tract, and is a mucous membrane. It is composed of:
1. A layer of epithelium (in direct contact with GI tract content)
2. A layer of connective tissue called the lamina propia
3. A thin layer of smooth muscle.

1. The epithelium: in the mouth, the pharynx, oesophagus, and anal canal is mainly *non keratinised stratified squamous epithelium* that serves a protective function. *Simple columnar epithelium* serves the functions of secretion and absorption, and line the stomach and intestines.
   The rate of renewal of GI tract epithelial cells is rapid, with old cells being replaced every 5-7 days. Tight junctions firmly seal neighbouring simple columnar cells to prevent leakage between cells. Exocrine cells are located among epithelial cells and secrete mucous and fluid into the lumen of the tract.
   Several types of endocrine cells, collectively called enteroendocrine cells secrete hormones.

2. The lamina propria: is alveolar connective tissue containing many blood and lymphatic vessels, which are the routes by which nutrients absorbed into GI tract reach other tissues in the body. This layer supports the epithelium and binds it to muscalaris mucosae.
   The lamina propria also contains the majority of the cells of the mucosa- associated lymphatic tissues (MALT). These lymphatic nodules containing immune system cells are present all along the GI tract, especially: tonsils, small intestine, appendix and large intestine.

3. Muscularis mucosae: is a thin layer of smooth muscle fibres that throws the mucous membrane of stomach and small intestines into many folds, increasing surface area for digestion and absorption. Movement of the muscularis mucosae ensures all absorptive cells are fully exposed to contents of GI tract.

Submucosa:

Consists of alveolar connective tissue that binds mucosa to muscularis. H contains many blood and lymphatic vessels that receive absorbed food molecules. Also located in the submucosa is an extensive network of neurons known as the submucosal plexus. The submucosa may also contain glands and lymphatic tissue.

Muscularis:

The muscularis of the mouth, pharynx and superior and middle parts of the oesophagus contains skeletal muscle that produces voluntary swallowing. Skeletal muscle also forms the external anal sphincter, which permits voluntary control of defecation. Throughout the rest of the tract, the muscularis consists of smooth muscle that is generally found in two sheets:

1. Inner sheets of circular fibres
2. Outer sheet of longitudinal fibres.

Involuntary contractions of the smooth muscle help break down food, mix it with digestive secretions and propel it along the tract. Between the layers of the muscularis is a second plexus of neurons – the pysnteric plexus.

Serosa:

Portions of the GI tract that are suspended in the abdominal cavity have a superficial layer called the serosa. As its name implies, the serosa is a serous membrane composed of alveolar connective tissue and simple squamous epithelium. The serosa is also called the visceral peritoneum because it forms a portion of the peritoneum.

The oesophagus lacks a serosa: instead, only a single layer of alveolar connective tissue called adventitia forms the superficial layer of this organ.

Understand the structure and function of the gastrointestinal tract (GIT), in particular the regional variation and which digestive processes occur in the various regions

-The GIT is a continuous muscular tube that winds through the body from the mouth to the anus
- Organs of the GIT are primary digestive organs and include:
  -mouth, pharynx, oesophagus, stomach, small and large intestine
-**Mechanical digestion:** occurs in mouth (mastification) and stomach (churning).
-**Propulsion:** occurs via peristalsis in oesophagus/ pharynx (swallowing) and stomach/ intestines.
-Digestions: occurs in the stomach and small intestine, where enzymes are secreted (or supplied to by accessory digestive organs) to further breakdown food.
-**Absorption:** of water and nutrients occurs predominantly in the small intestine, which is lined with villi and many lymph and blood vessels. Absorption of water also occurs in the large intestine.
-Excretion: occurs at the large intestine

- Understand the types of propulsion and mechanical digestion

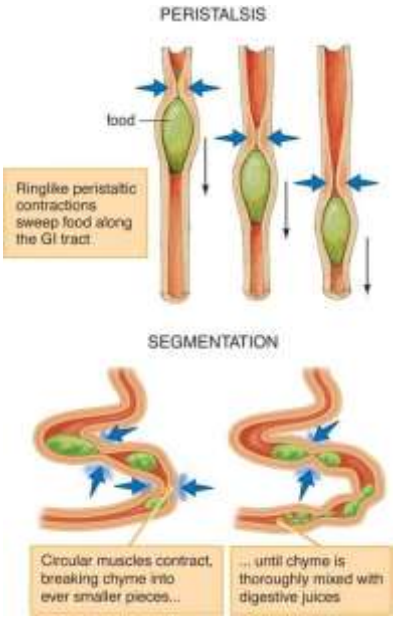
Peristalsis: adjacent segments of the GIT alternately contract and relax, moving food along tract distally. Occurs in the oesophagus, stomach, small and large intestine.

Segmentation: nonadjacent segments of the GIT alternately contract and relax. Moving food forward and backwards. Food mixing and slow propulsion occur. Occurs in small intestine.

Swallowing (deglutition): contracts at pharyngeal muscles allows swallowing action to propel food down oesophagus.

Chewing: mechanically digests food in the mouth.

Churning: of the stomach mixes and mechanically digests food in stomach.

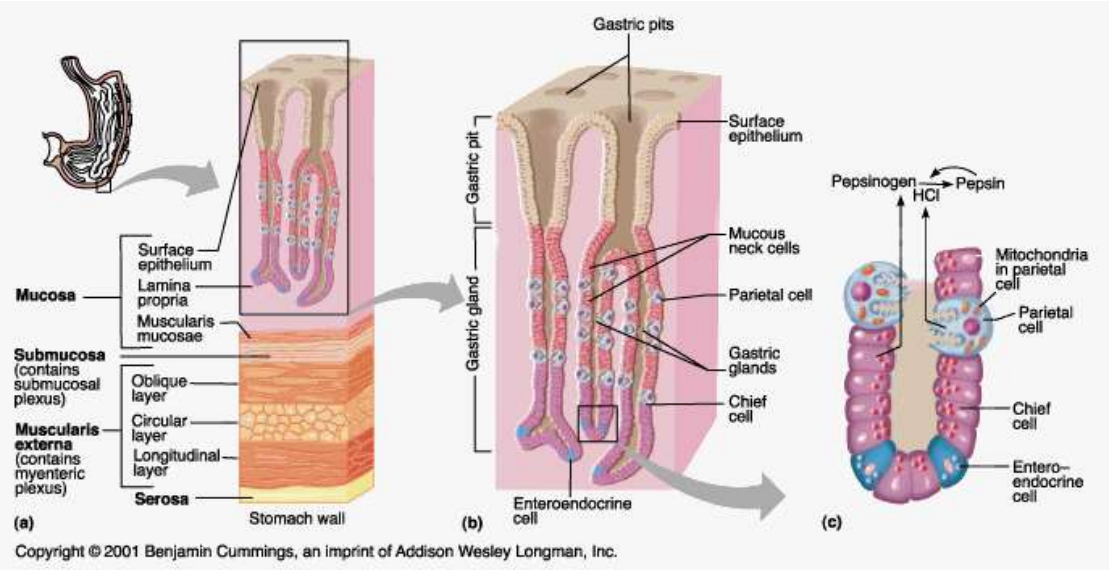


- Understand the cellular composition of the various GIT regions and know what the roles of the various cell types are

The stomach contains 4 principal secretory cell types:
Chief cells: secrete pepsinogen (inactive form of enzyme pepsin) and lipases that assist in the breakdown of proteins and lips respectively.
Parietal cells: secrete HCL and intrinsic factor. This allows the stomach to remain acidic, and assists in the activation of enzymes (e.g. pepsin).
Mucous neck cells: secrete thin, soluble, acidic mucous.
Endocrine cells: secrete chemical messages/ hormones into lamina propria that can regulate other secretions.
- throughout the tract, goblet and mucosa cells produce mucous, and serous cells secrete a watery substance containing enzymes and ions. These secretions provide lubrication and enzymes aid digestion.

- Know the structure and function of the gastric and intestinal pits

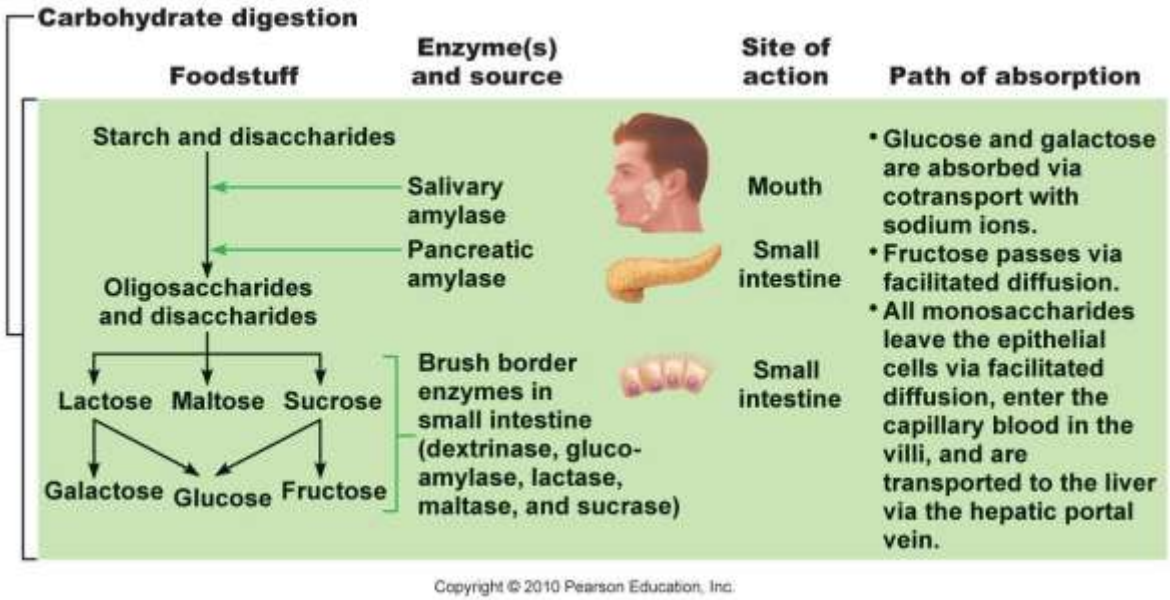
-gastric pits are depressions in the mucous lining the stomach into which gastric glands empty their secretions
- the top of the gastric pits are lined with mucous cells to provide a protective layer for the acidic stomach
- down further it is lined with chief, parietal and endocrine cells.



- Describe the digestion and absorption of carbohydrates, proteins and lipids

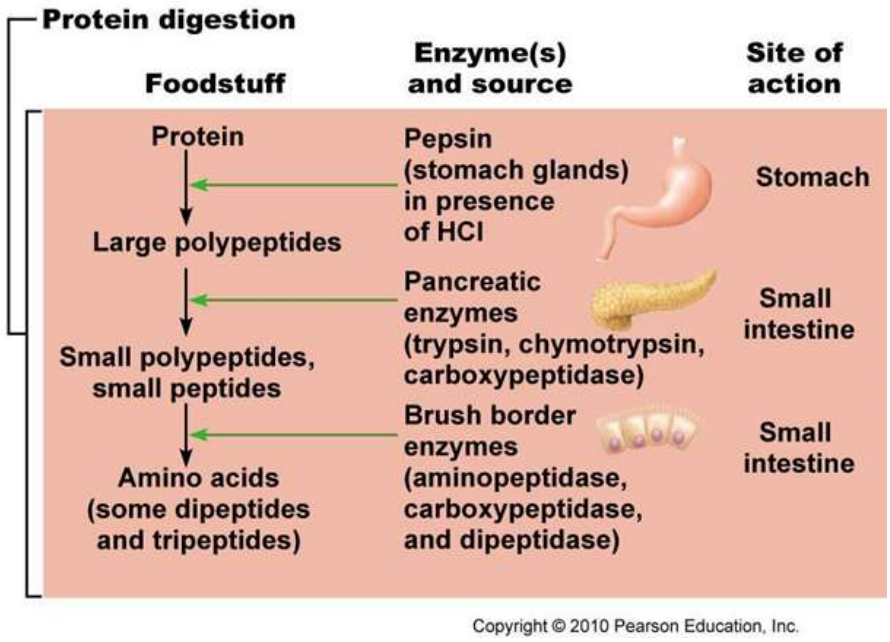
Carbohydrates

- **monosaccharides** - absorbed sugar species, glucose, galactose, fructose
- **disaccharides** – sucrose, lactose
- **polysaccharides** – glycogen, starch, ✖cellulose✖

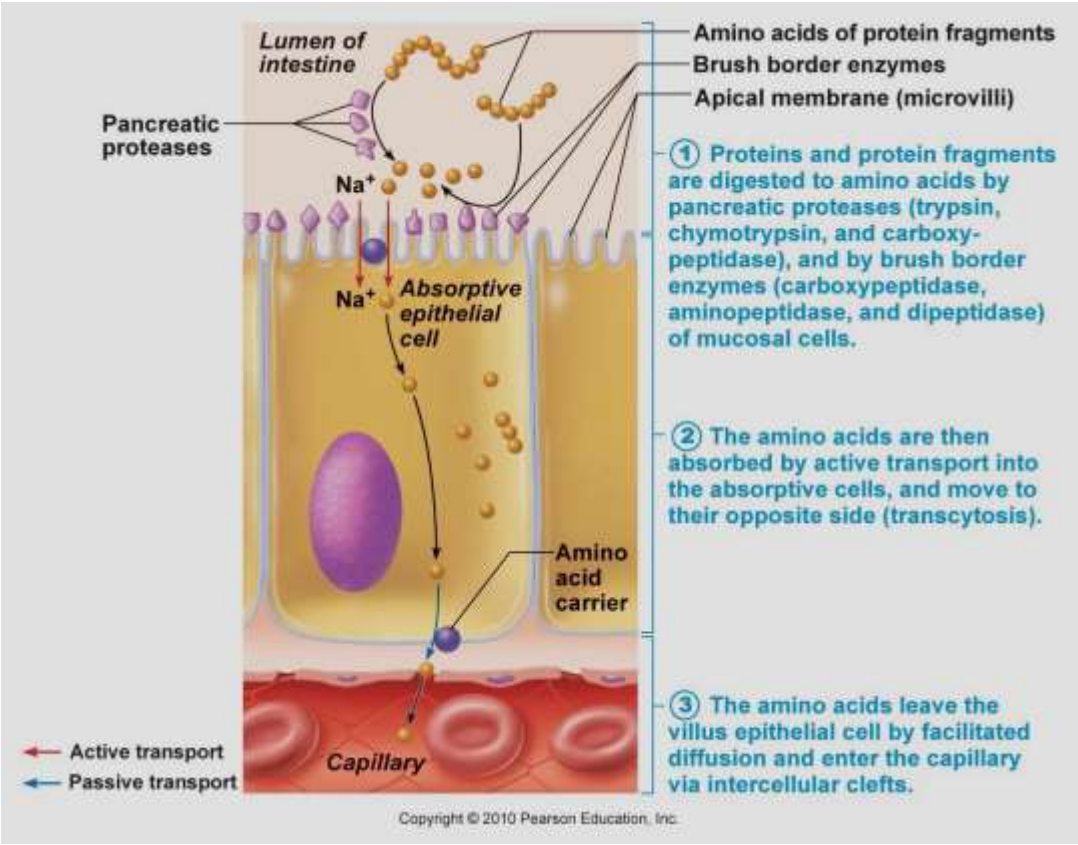


Proteins

Proteins broken down into smaller components (polypeptides)



Proteins



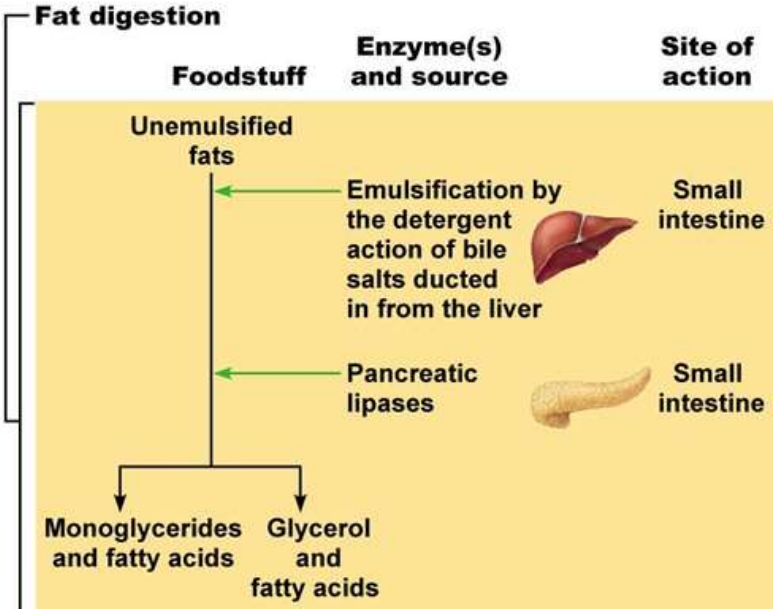
Lipids digestion

Lingual lipase

- From tongue glands
- Begins hydrolysis of triglycerides → fatty acids and monoglycerides
    - Begins in mouth and continues in stomach
- Water soluble – action limited by hydrophobicity of lipids

Pancreatic lipase

- Action facilitated by bile salts
- Hydrolysis
- triglycerides → FA + monoglycerides

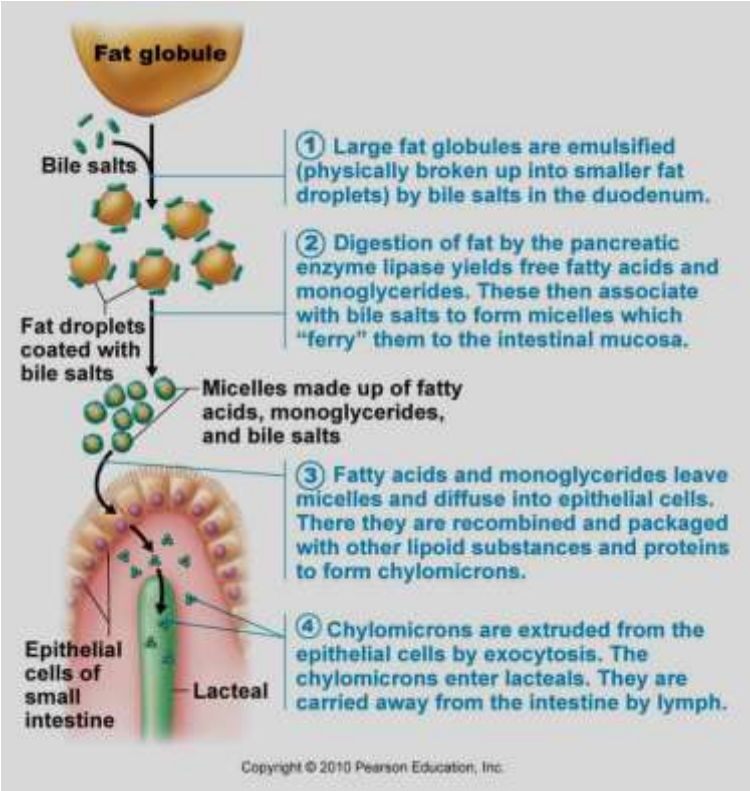


Lipid digestion involves lingual lipase from glands of the tongue, and pancreatic lipase from the pancreas. The most important and abundant dietary lipids are triglycerides, which consist of three fatty acids attached to a single molecule of glycerol.

The lingual and pancreatic lipases break off two of the fatty acids, leaving monoglycerides. Lipases are water-soluble enzymes, and lipids tend to form large drops that exclude water molecules. As a result, lipases can attack only the exposed surfaces of the lipid drops. Lingual lipase begins breaking down triglycerides in the mouth and continues for a variable time within the stomach, but the lipid drops are so large, and the available time so short, that only about 20 percent of the lipids have been digested by the time the chyme enters the duodenum.

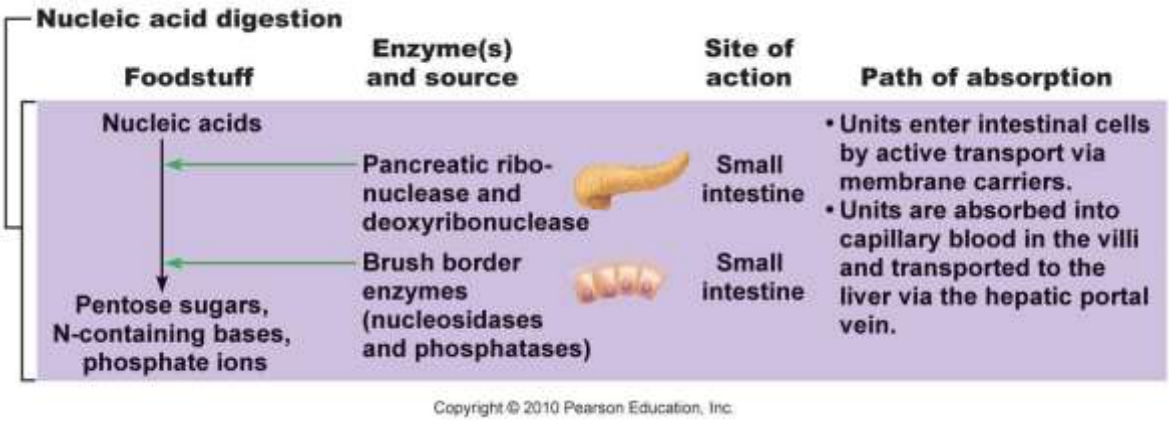
Bile salts improve chemical digestion by emulsifying the lipid drops into tiny emulsion droplets, thereby providing better access for pancreatic lipase. The emulsification occurs only after the chyme has been mixed with bile in the duodenum. Pancreatic lipase then breaks apart the triglycerides to form a mixture of fatty acids and monoglycerides.

Digestion and absorption of lipids

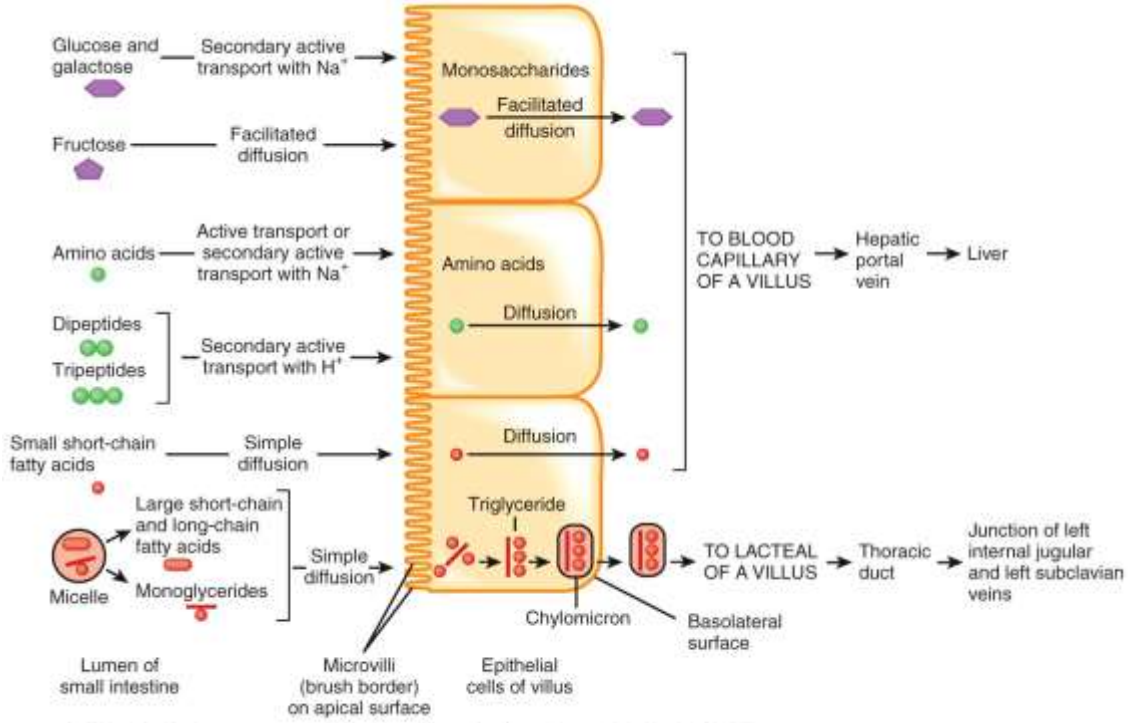


Digestion and absorption of nucleic acids

Broken down by enzymes released by the pancreas

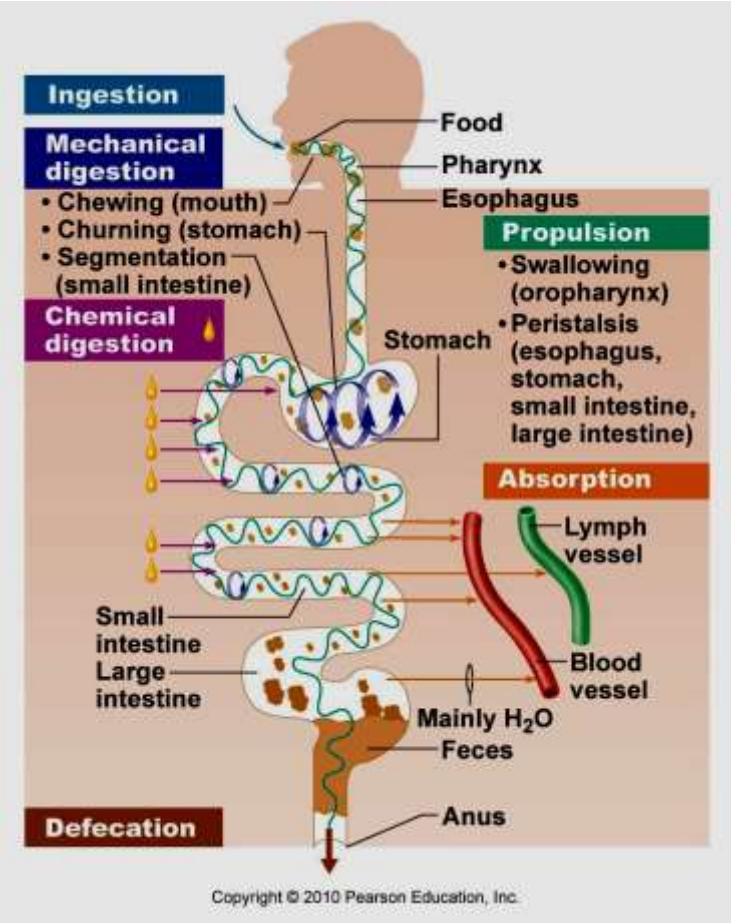


Summary of small intestine absorption



(a) Mechanisms for movement of nutrients through absorptive epithelial cells of villi

Summary of GIT activities



Understand the general structure and function of the liver, gallbladder and pancreas

Liver/ gall bladder: has 200+ functions, produces and secretes bile. Made up of a left and right hepatic ducts. Gall bladder stores and concentrates bile, serving as a reservoir for unused bile produced by the liver. It is pear-shaped and located under the liver.

Pancreas: located behind the stomach, its endocrine function is to regulate blood sugar. Its exocrine function is to produce enzymes important for digestion from its exocrine glands, in combination known as pancreatic juices.