BIOH122
Human Biological Science 2

Session 15

Digestive System 2 – Stomach and Accessory Structures

Bioscience Department
Session Plan

- Stomach – anatomy and histology
- Stomach – mechanical and chemical digestion
- Pancreas
  - Anatomy
  - Histology
  - Pancreatic juice
  - Functions
- Liver and gall bladder
  - Anatomy
  - Histology
  - Bile juice
  - Functions
Stomach – Anatomy and Histology
The stomach: a J-shaped enlargement of the GI tract that begins at the bottom of the oesophagus and ends at the pyloric sphincter.

Functions:
- Mixes saliva, food, and gastric juice to form chyme.
- Serves as reservoir for food before release into small intestine.
- Secretes gastric juice.
- Secretes gastrin into blood.
Anatomy of the Stomach

- Gross anatomical subdivisions:
  - Cardia
  - Fundus
  - Body
  - Pylorus
Anatomy of the Stomach

- **Rugae**: The mucosal folds, when the stomach is empty

- **Pyloric sphincter**: A smooth muscle sphincter through which the pylorus communicates with the duodenum of the small intestine

- **Lesser curvature**: The concave medial border of the stomach

- **Greater curvature**: The convex lateral border
Histology of the Stomach

- Layers of stomach wall:
  - Mucosa
  - Submucosa
  - Muscularis
  - Serosa
Histology of the Stomach

- **Mucosa**: contains
  - **Surface mucous cells/Epithelial layer**: A layer of simple columnar epithelial cells on the surface of the mucosa
    - Secrete mucus
  - **Lamina propria**: Areolar connective tissue
- **Muscularis mucosae**: smooth muscle
- **Gastric glands**: columns of secretory cells formed by extension of epithelial cells extend down into the lamina propria
  - **Gastric pits**
Histology of the Stomach

Cells of gastric glands:

- Three types of *exocrine glands* cells:
  - Mucous neck cells
  - Chief or zymogenic cells
  - Parietal or oxyntic cells

- Enteroendocrine cells:
  - G cells

- Gastric juice: The secretions of the mucous, parietal, and chief cells
  - 2000–3000 mL per day
Histology of the Stomach

- **The submucosa:** Areolar connective tissue.

- **The muscularis:** has three layers of smooth muscle: longitudinal, circular, and an inner oblique layer.
  - Permits greater churning and mixing of food with gastric juice

- **The serosa:** a part of the visceral peritoneum.
  - At the lesser curvature of the stomach, the visceral peritoneum extends upward to the liver as the lesser omentum.
  - At the greater curvature of the stomach, the visceral peritoneum continues downward as the greater omentum and drapes over the intestines.
Stomach – mechanical and chemical digestion
Stomach: Mechanical Digestion

- **Mixing waves**: peristaltic movements pass over the stomach every 15 to 25 seconds.
  - macerate food, mix it with secretions of the gastric glands, and reduce it to a soupy liquid called **chyme**.

- **Gentle waves** in fundus
- **More vigorous waves** in body of stomach
- **Intense waves** near the pylorus

- **Gastric emptying**: As food reaches the pylorus, each mixing wave periodically forces about 3 mL of chyme into the duodenum through the pyloric sphincter,
Stomach: Chemical Digestion

- **Salivary amylase**: Active for about an hour in fundus while food is not mixed with gastric juice
- **Gastric Juice**: Churning mixes chyme with acidic gastric juice
  - **Salivary amylase**: Inactivated
  - **Lingual lipase**: Activated and digest triglycerides into fatty acids and diglycerides
Stomach: Chemical Digestion

Gastric juice in chemical digestion:

- **Gastrin hormone:**
  - Stimulates parietal cells to secrete HCl and chief cells to secrete pepsinogen.
  - Contracts lower esophageal sphincter.
  - Increases motility of stomach.
  - Relaxes pyloric sphincter.

- **Mucus:** Forms protective barrier that prevents digestion of stomach wall.

- **Intrinsic factor:** Absorption of vitamin B12 for RBC production.
Stomach: Chemical Digestion

- **Hydrochloric acid:**
  - Kills microbes in food
  - Denatures (unfolds) protein molecules
  - Activates pepsinogen into pepsin

- **Pepsin:** Breaks down proteins into peptides
  - Most effective in the very acidic environment of the stomach.

- **Gastric lipase:** Splits short chain triglycerides of milk into fatty acids and monoglycerides
  - Most effective at a pH of 5 to 6 (as in an infant's stomach)
  - Has a limited role in the adult stomach.
Stomach: Absorption

Only a small amount of nutrients are absorbed in the stomach

- **Epithelial cells**: Impermeable to most materials.

- **Mucous cells**: Absorb some water, ions, and short-chain fatty acids, as well as certain drugs (especially aspirin) and alcohol.
Pancreas
Anatomy of the Pancreas

The pancreas: retroperitoneal gland

- **Size:** 12–15 cm long and 2.5 cm thick,
- **Location:** Posterior to the greater curvature of the stomach.
- **Three parts:** a head, body, and tail
  - Head close to curve in C-shaped duodenum
- **Two major ducts:** Convey the secretions into the small intestine
  - Pancreatic duct (duct of Wirsung)
  - Accessory duct (duct of Santorini)
Anatomy of the Pancreas

(a) Anterior view

- Falciform ligament
- Diaphragm
- Coronary ligament
- Right lobe of liver
- Left lobe of liver
- Right hepatic duct
- Left hepatic duct
- Common hepatic duct
- Round ligament
- Common bile duct
- Gallbladder
- Neck
- Body
- Fundus
- Cystic duct
- Duodenum
- Accessory duct (duct of Santorini)
- Hepatopancreatic ampulla (ampulla of Vater)
- Pancreas
- Tail
- Body
- Head
- Jejunum
- Uncinate process
- Common bile duct
- Hepatopancreatic ampulla (ampulla of Vater)
- Pancreatic duct (duct of Wirsung)
- Mucosa of duodenum
- Major duodenal papilla
- Sphincter of the hepatopancreatic ampulla (sphincter of Oddi)

(b) Details of hepatopancreatic ampulla

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Pancreatic Duct

- Pancreatic duct joins common bile duct from liver and gallbladder
- Sphincter of Oddi: on major duodenal papilla
  - regulates the passage of pancreatic juice and bile into duodenum
- Opens 10cm below pyloric sphincter
Histology of the Pancreas

- **Acini** - dark clusters
  - 99% of gland
  - Exocrine portion
  - Secrete pancreatic juice

- **Islets of Langerhans** - pale staining cells
  - 1% of gland
  - Endocrine portion
  - Secrete hormones glucagon, insulin, somatostatin, and pancreatic polypeptide
Histology of the Pancreas

(b) Pancreatic islet and surrounding acini

- Blood capillary
- Exocrine acini
- Alpha cell (secretes glucagon)
- Beta cell (secretes insulin)
- Delta cell (secretes somatostatin)
- F cell (secretes pancreatic polypeptide)
Composition and Functions of Pancreatic Juice

- a clear, colorless liquid
- Produced 1.2-1.5 liters/day
- pH of 7.1 to 8.2
- Contains water, some salts, sodium bicarbonate, and several enzymes

- Sodium bicarbonate: converts the acid stomach contents to a slightly alkaline pH (7.1-8.2), halting stomach pepsin activity and promoting activity of pancreatic enzymes
Composition and Functions of Pancreatic Juice

- **Digestive enzymes:**
  - **Pancreatic amylase:** digest Starch
  - **Pancreatic lipase:** digest triglycerides
  - **Proteases:** digest proteins
    - **Trypsinogen** - activated by enterokinase (a brush border enzyme)
    - **Chymotrypsinogen** - activated by trypsin
    - **Procarboxypeptidase** - activated by trypsin
    - **Proelastase** - activated by trypsin
    - **Trypsin inhibitor** - combines with any trypsin produced inside pancreas
  - **Ribonuclease and deoxyribonuclease:** digest RNA and DNA
Regulation of Pancreatic Secretions

Hormones secreted by Small intestine:

- **Secretin**
  - Stimulates secretion of pancreatic juice that are rich in bicarbonate ions, promotes normal growth and maintenance of pancreas, enhances effects of CCK.

- **Glucose-dependent insulino tropic peptide (GIP)**
  - Stimulates pancreatic beta cells to release insulin.

- **Cholecystokinin (CCK)**
  - Stimulates secretion of pancreatic juice rich in digestive enzymes, promotes normal growth and maintenance of pancreas, enhances effects of secretin.
Regulation of Pancreatic Secretions

1. Parasympathetic impulses along vagus (X) nerves
2. Stimulate secretion of pancreatic enzymes
3. Acidic chyme containing partially digested fats (fatty acids) and proteins (amino acids)
4. Stimulates secretion of pancreatic juice rich in bicarbonate ions
5. Stimulates secretion of pancreatic juice rich in digestive enzymes
6. Blood
Liver and Gallbladder
Liver and Gallbladder

- **The liver:**
  - **Weight:** the heaviest gland in the body about 1.4 kg in an average adult
  - **Size:** the second largest organ in the body after the skin.
  - **Location:** inferior to the diaphragm and occupies most of the right hypochondriac and part of the epigastric regions of the abdominopelvic cavity

- **The gallbladder:**
  - **Size:** Pear-shaped sac 7–10 cm long
  - **Location:** in a depression of the posterior surface of the liver
Anatomy of the Liver and Gallbladder

- **Liver:**
  - Right and Left lobes
  - Falciform ligament
  - Quadrate lobe
  - Caudate lobe
  - Ligamentum teres (round ligament)
  - Right and left coronary ligaments
Anatomy of the Gallbladder

- **Gallbladder:**
  - Fundus
  - Body
  - Neck
Histology of the Liver

(a) Overview of histological components of liver

(b) Details of histological components of liver
Histology of the Liver

- **Hepatocytes**: Major functional cells of the liver
  - Metabolic, secretory, and endocrine functions
  - **Secrete bile**: a yellow, brownish, or olive-green liquid serves as both an excretory product and a digestive secretion.

- **Bile canaliculi**: Small ducts between hepatocytes that collect bile produced by the hepatocytes.
  - **Bile flow**: Bile canaliculi → Bile ductules → Bile ducts → Right and left hepatic ducts → Common hepatic duct joins the Cystic duct → Common bile duct → Small intestine

- **Hepatic sinusoids**
- **Central Vein**
- **Stellate reticuloendothelial (Kupffer) cells**
Bile flow

Key:
- Liver
- Gallbladder
- Pancreas

(c) Ducts carrying bile from liver and gallbladder and pancreatic juice from pancreas to duodenum

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Histology of the Gallbladder

Histology:
- **Mucosa**: Simple columnar epithelium arranged in rugae
- **Submucosa**: not present
- **Muscular coat**: smooth muscle fibers
  - Contraction of the smooth muscle fibers ejects the contents of the gallbladder into the cystic duct.
- **Serosa or visceral peritoneum**

Functions of the gallbladder:
- To *concentrate the bile* produced by the liver (up to tenfold) by absorbing water and ions.
- To *store bile* until it is needed in the small intestine.
Blood Supply to the Liver

- **Double blood supply**: from
  - **Hepatic artery**: oxygenated blood from branch of the aorta
  - **Hepatic portal vein**: Nutrient rich blood from stomach, spleen and intestines

- **Hepatic vein**: All blood eventually leave the liver via hepatic vein
Composition and Function of Bile

- **Secreted by** hepatocytes
  - 800-1000 ml of bile/day
  - a yellow, brownish, or olive-green liquid
  - pH 7.6 to 8.6
- **Transported by** a duct system to the gallbladder for concentration and temporary storage.
- **Excretory product:** containing components of worn-out red blood cells
- **Digestive secretion**
Composition and Function of Bile

Components:

- Water, cholesterol and several ions
- A phospholipid called lecithin
- Bile salts = Na and K salts of bile acids: digestive product
  - Play a role in emulsification, the breakdown of large lipid globules into a suspension of small lipid globules.
  - Aid in the absorption of lipids following their digestion.
- Bile pigments = bilirubin from haemoglobin: excretory product
Regulation of Bile Secretion

- Parasympathetic impulses and vagus nerves
  - Cholecystokinin (CCK)
  - Secretin
Functions of Liver

- **Carbohydrate metabolism**: maintains normal blood glucose level by:
  - **Glycogenolysis**: Break down glycogen to glucose and release the glucose into the bloodstream.
  - **Gluconeogenesis**: Convert certain amino acids, triglycerides and lactic acid to glucose.
  - **Glycogenesis**: Converts glucose to glycogen and triglycerides for storage.
Functions of Liver

- **Lipid metabolism:**
  - **Storage:** Hepatocytes store some triglycerides;
  - **Lipolysis:** Break down fatty acids to generate ATP;
  - **Lipogenesis:** Synthesize lipoproteins, which transport fatty acids, triglycerides, and cholesterol to and from body cells;
  - **Cholesterol synthesize**
  - **Synthesize bile salts** from cholesterol
Functions of Liver

- **Protein Metabolism:**
  - **Deamination:** Removes NH2 (amine group) from amino acids so can use what is left as energy source
  - **Urea cycle:** Converts resulting toxic ammonia (NH3) into urea for excretion by the kidney
  - **Protein synthesis:** Synthesizes plasma proteins alpha and beta globulins, albumin, prothrombin, and fibrinogen.
  - **Converts one amino acid into another amino acids**
Functions of Liver

- **Processing of drugs and hormones:**
  - Detoxify substances such as alcohol and excrete drugs such as penicillin, erythromycin, and sulfonamides into bile.
  - Chemically alter or excrete thyroid hormones and steroid hormones such as estrogens and aldosterone.

- **Synthesis of bile and bile salts**

- **Excretion of waste products:**
  - Bilirubin from RBC recycling
Functions of Liver

- **Storage:**
  - Fat soluble vitamins - A, B12, D, E, K and minerals iron and copper

- **Phagocytosis:** aged RBCs, WBCS and some bacteria

- **Activation of vitamin D**
Readings and Resources

- Harris, P, Nagy, S & Vardaxis, N 2010, Mosby’s Dictionary of Medicine, Nursing and Health Professions, 2nd edn, Mosby Elsevier.
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