Anatomy and Physiology II
Lab 7: Digestive System

Images in these slides are from the course textbook unless otherwise noted.

Learning Objectives

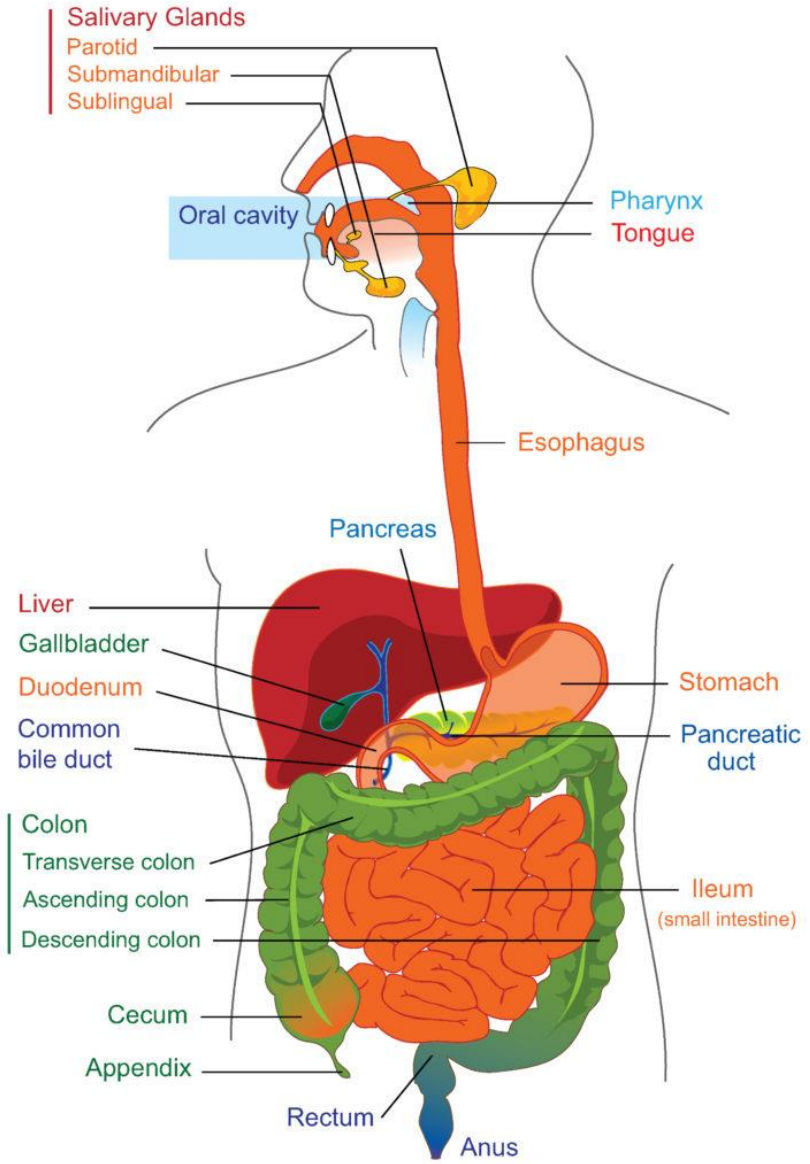
1. Describe overall function of the digestive system
2. Explain the functions of the individual organs and structures of the digestive system
3. Identify the structures of the digestive system and associated parts on a model, in a picture or diagram, or in a specimen.
4. Identify the histologic structures of the of the digestive system in a microscope slide.
5. Identify the digestive enzymes involved in the digestion of proteins, fats and carbohydrates, and their site of origin

Pre-Lab Activities

- Review the Introduction and Background for Lab 7 in the lab manual
- Complete Pre-Lab Exercises 7.1-7.4 in your lab manual and use your answers to complete the **Module 7 Pre-Lab Quiz** on Moodle

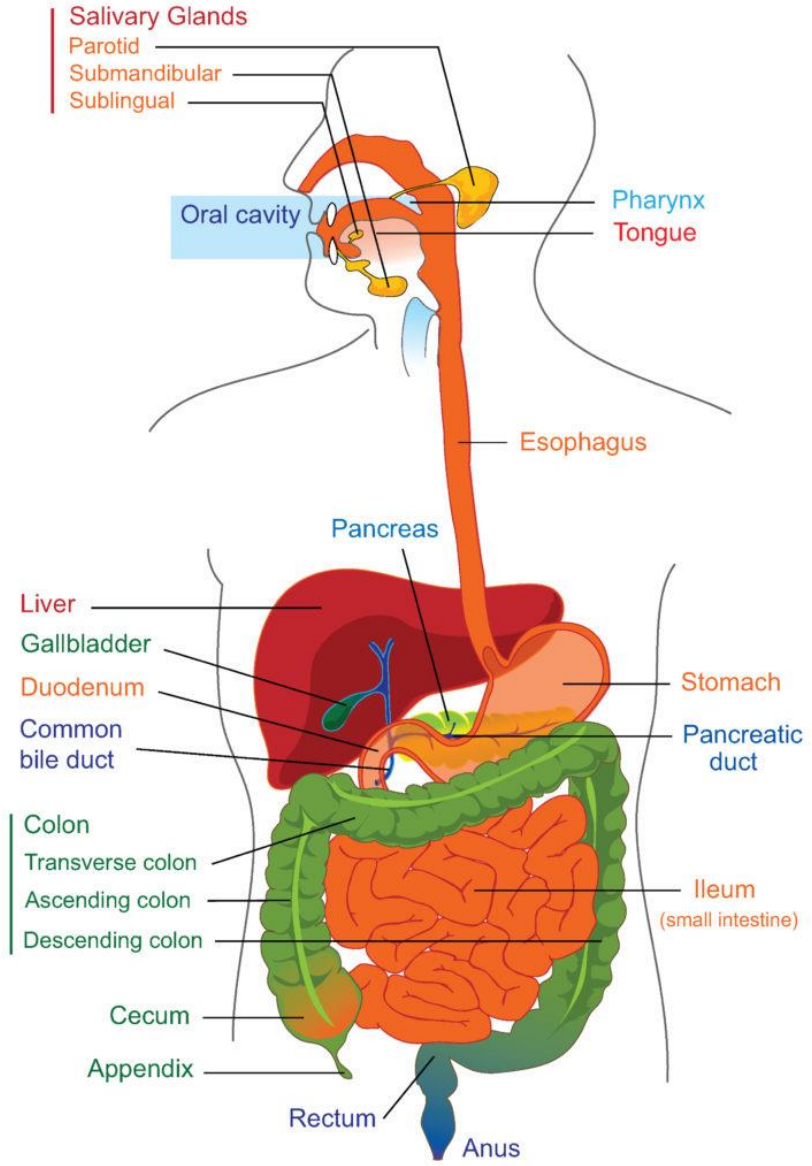
Overview of the Digestive System

- Main functions of the digestive system
  - Break down the foods
  - Release their nutrients
  - Absorb those nutrients
  - Remove the indigestible materials
- It functions cooperatively with the other systems of the body.
- Digestive system can be divided into two groups of organs:
  - Alimentary canal organs
  - Accessory digestive organs



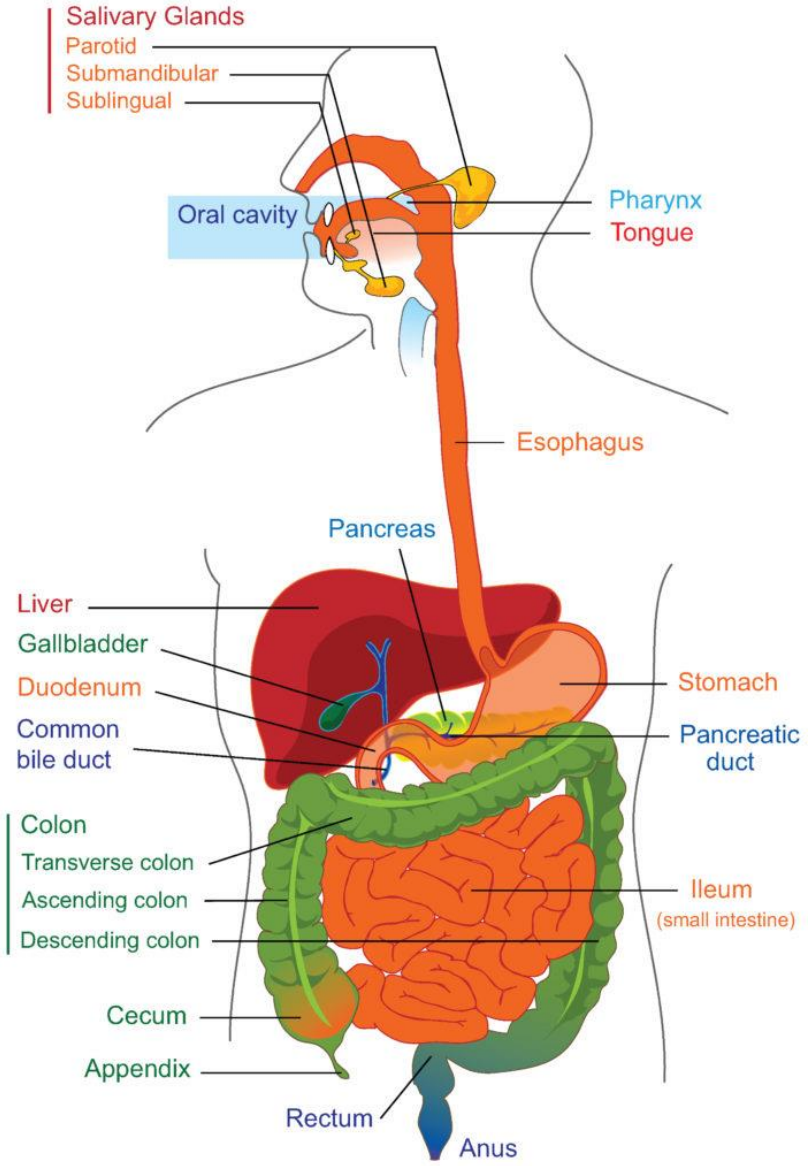
Alimentary Canal Organs

- Also called the gastrointestinal (GI) tract or gut.
  - A one-way tube begins at the mouth and terminates at the anus.
  - The main function of the organs of the alimentary canal is to nourish the body.
  - Organs include: pharynx, esophagus, stomach, and small and large intestines, rectum and anus
  - Lumen of the alimentary canal opens to the external environment at both ends and therefore anything inside the lumen is considered external to the body



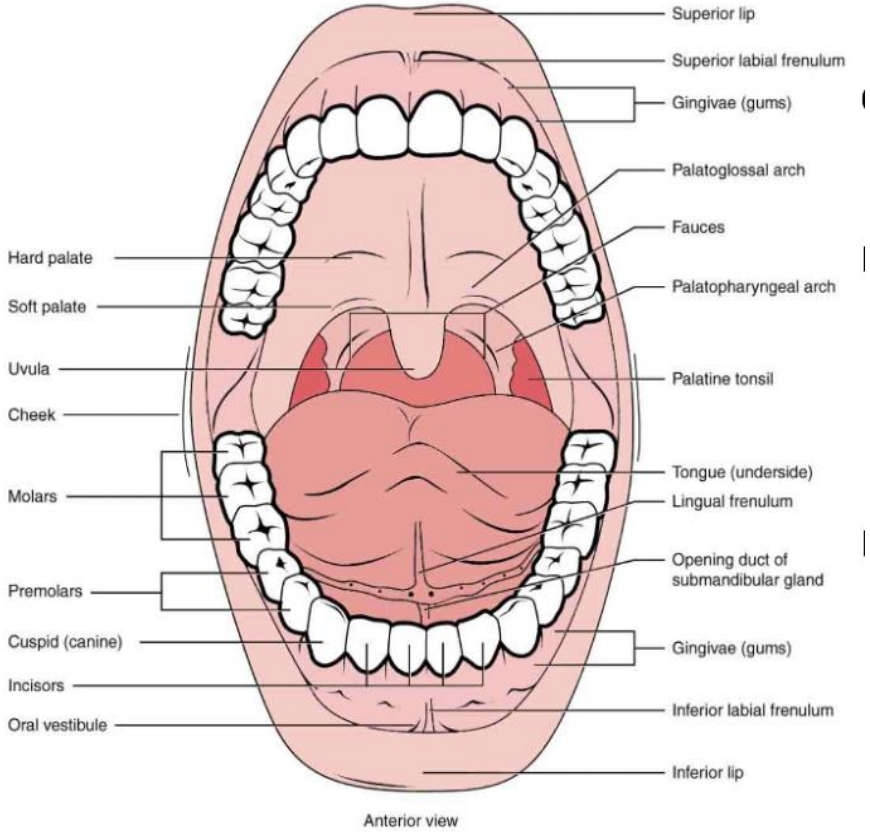
Accessory Organs

- Accessory digestive organs are not part of the tube, i.e. they are not hollow organs that food passes through
  - Secrete substances into the tube
  - Many of these substances are required for digestion or enhance digestion
  - Include: teeth, tongue, salivary glands, liver, gallbladder, and pancreas
    - Liver/gallbladder and pancreas will be considered separately at the end of this lab



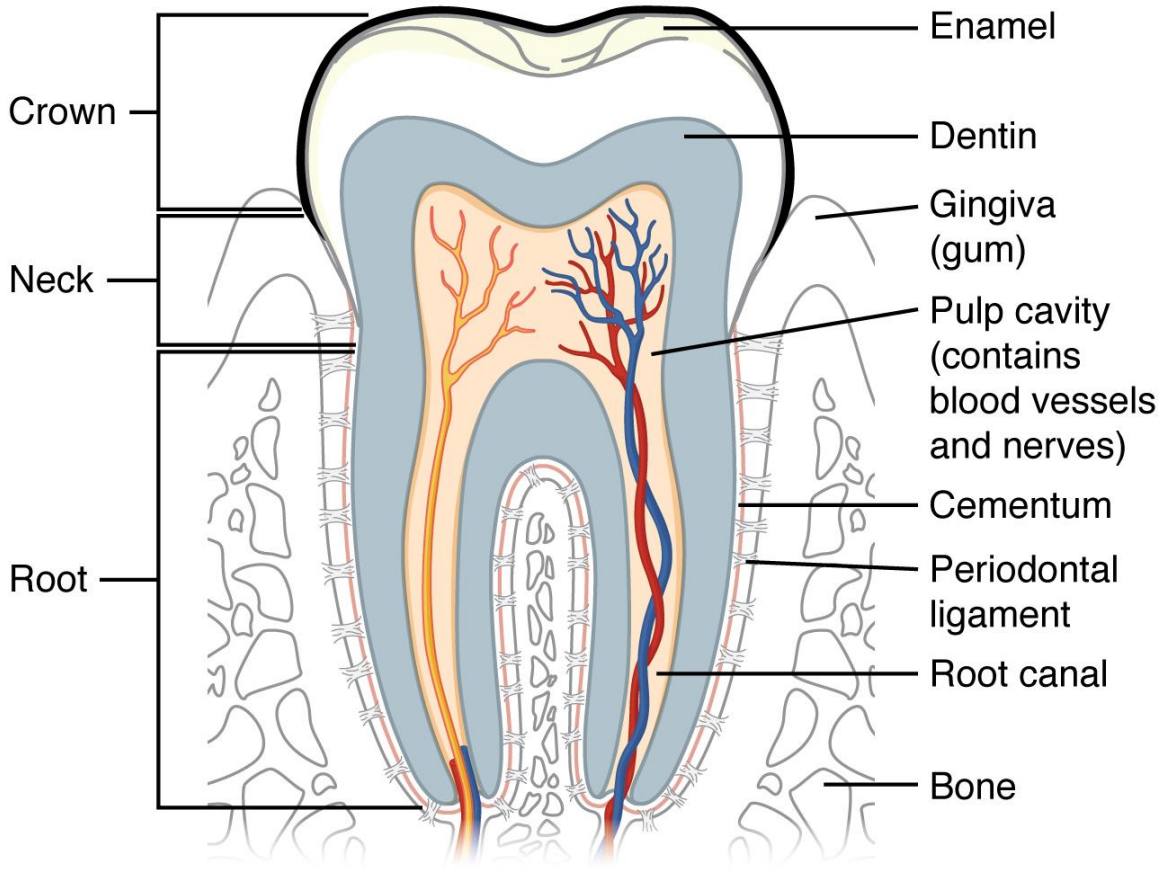
The Mouth

- Mainly mechanical digestion through the **teeth** via chewing (mastication)
- Limited amount of chemical digestion with **salivary amylase** and **lingual lipase** produced by **salivary glands**
- Oral (buccal) cavity
  - Bounded by lips, cheeks, palate, and tongue
  - **Oral orifice** is anterior opening
  - Lined with stratified squamous epithelium
- Hard & soft palate: form the roof of the mouth
- Tongue: forms floor of the mouth; skeletal muscle forms bolus



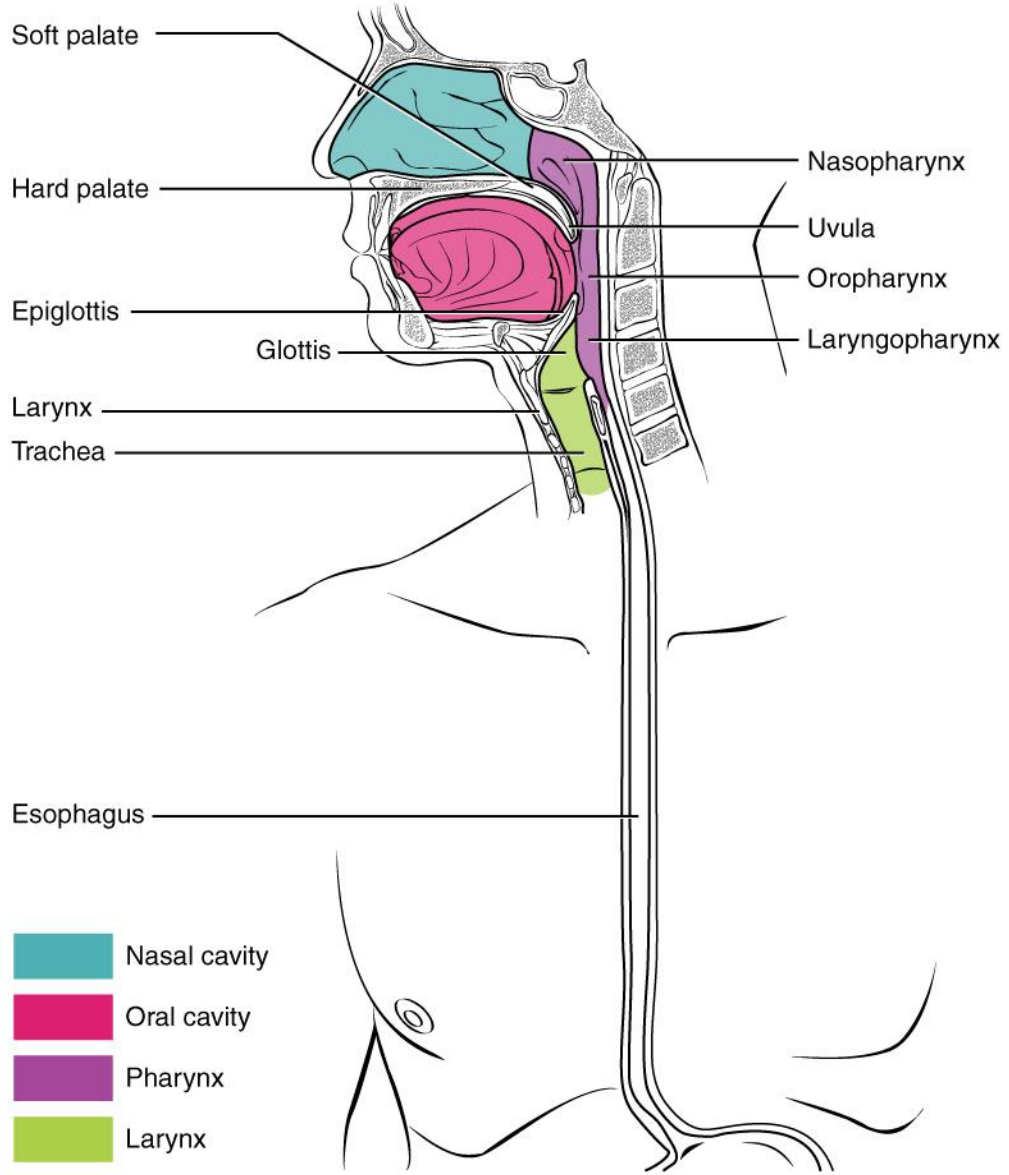
Tooth Anatomy

- Crown
  - Portion above the gum line
  - Enamel
  - Dentin
- Root
  - Embedded within maxilla and mandible
  - Cementum
- Pulp cavity
  - Loose connective tissue
  - Blood vessels and nerves
  - Surrounded by dentin



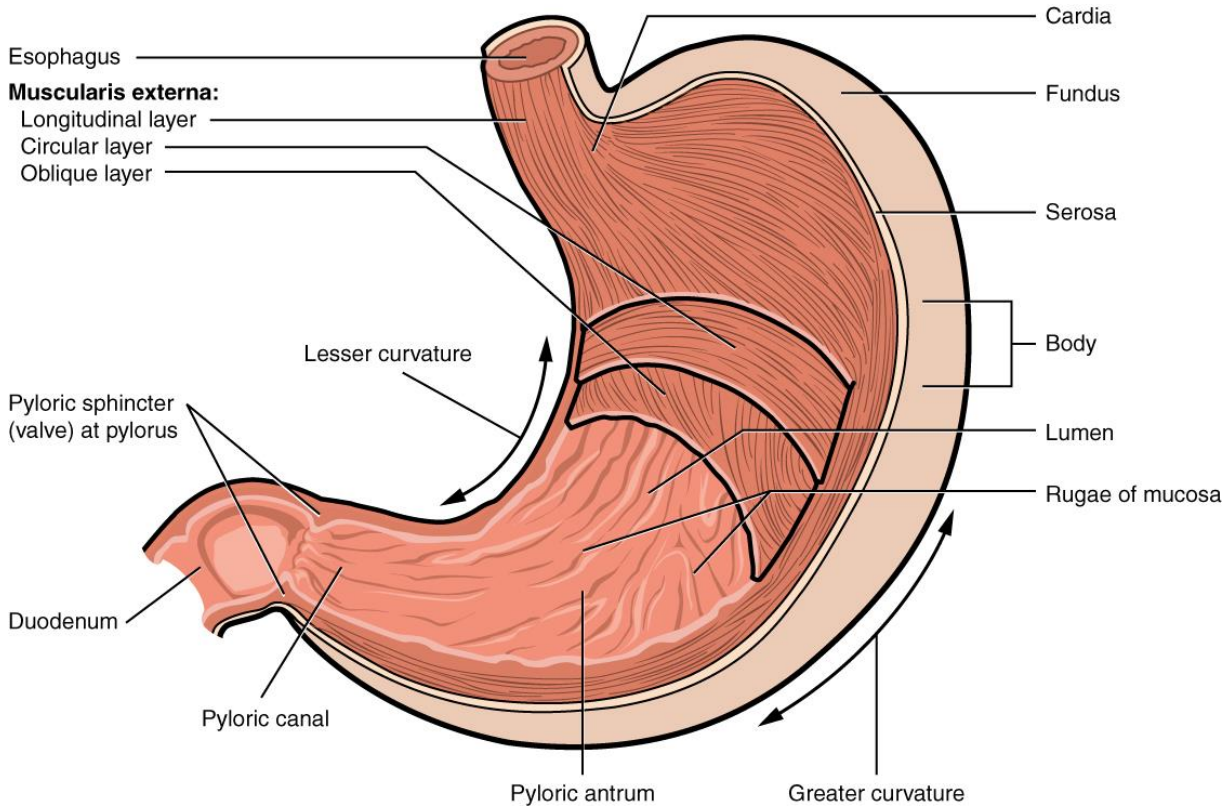
Pharynx and Esophagus

- Pharynx (throat) is involved in both digestion and respiration.
  - When food enters the pharynx, involuntary muscle contractions close off the air passageways.
- Food/air passes from mouth → oropharynx → laryngopharynx→ esophagus
- A food lump, bolus, is moved through the esophagus by skeletal muscles – peristalsis
- Enters the stomach at the lower esophageal sphincter (also called the gastroesophageal or cardiac sphincter).
- The lower esophageal sphincter relaxes to let food pass into the stomach, and then contracts to prevent stomach acids from backing up into the esophagus.



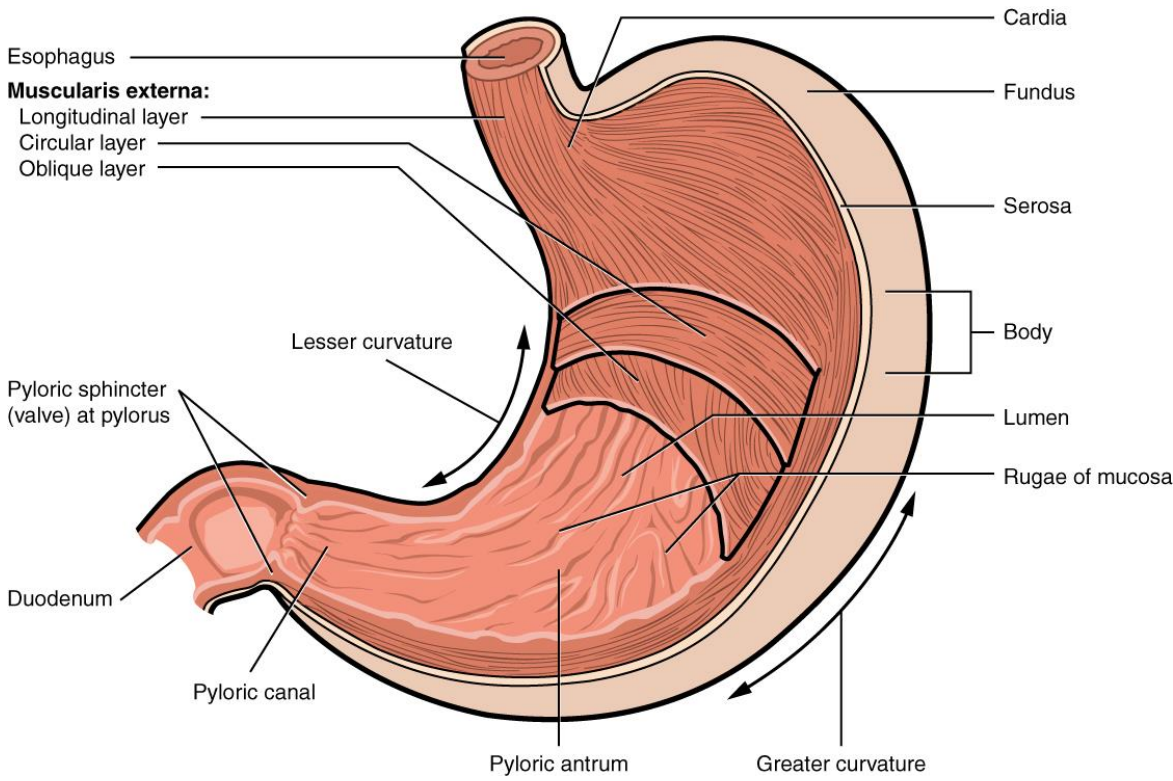
The Stomach

- Four main regions in stomach
  - Cardia: surrounds opening; point where esophagus connects to the stomach.
  - Fundus: dome-shaped region
  - Body: main part of the stomach
  - Pylorus: connects the stomach to the duodenum



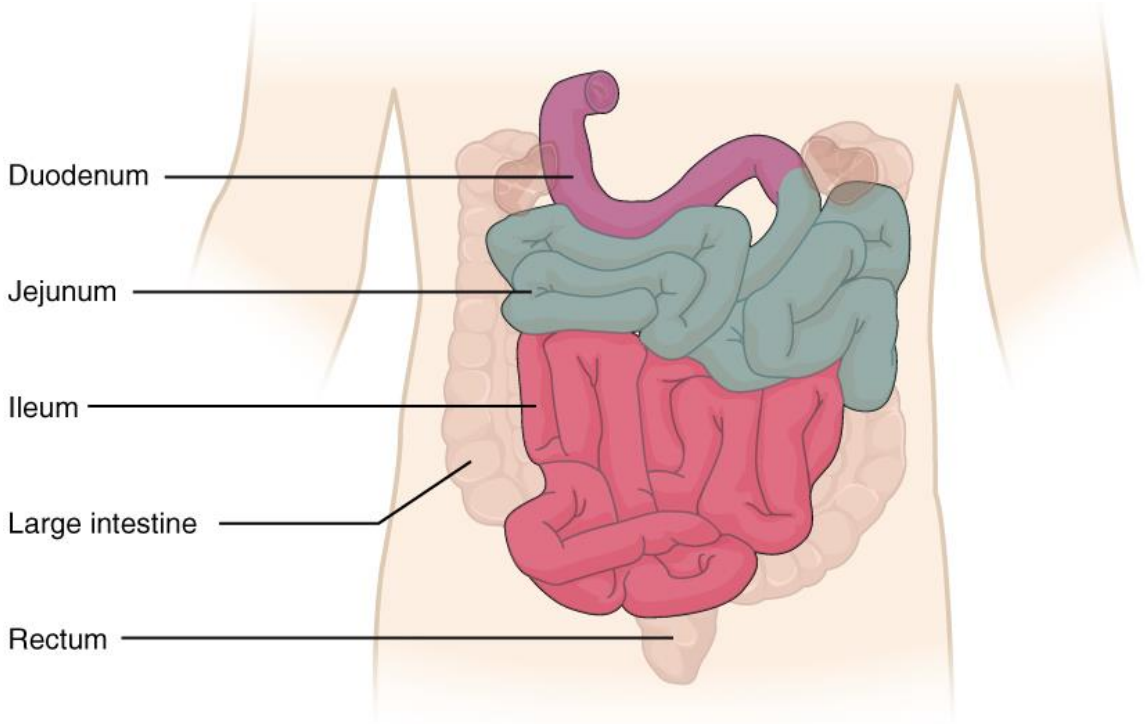
Stomach Digestion

- Further mechanical digestion of food occurs via peristaltic waves- produces soupy liquid known as **chyme**
- Chemical digestion in the stomach occurs by adding gastric juices to the chyme and begins digestion of lipids and proteins
- Pyloric sphincter regulates movement of food from the pylorus into the small intestine.



The Small Intestine

- Small intestine is the place where most digestion and absorption occurs.
- The folds and projections in the lining of the small intestine work to give it an enormous surface area.
- Subdivided into three regions.
  - Duodenum: beneath the pyloric sphincter; area where chyme is mixed with bile and pancreatic enzymes.
  - Jejunum: site of most nutrient absorption
  - Ileum: Empties into cecum of large intestine through ileocecal sphincter
    - Contains dense numbers of Peyer's patches (clusters of immune cells) to aid in immune defense

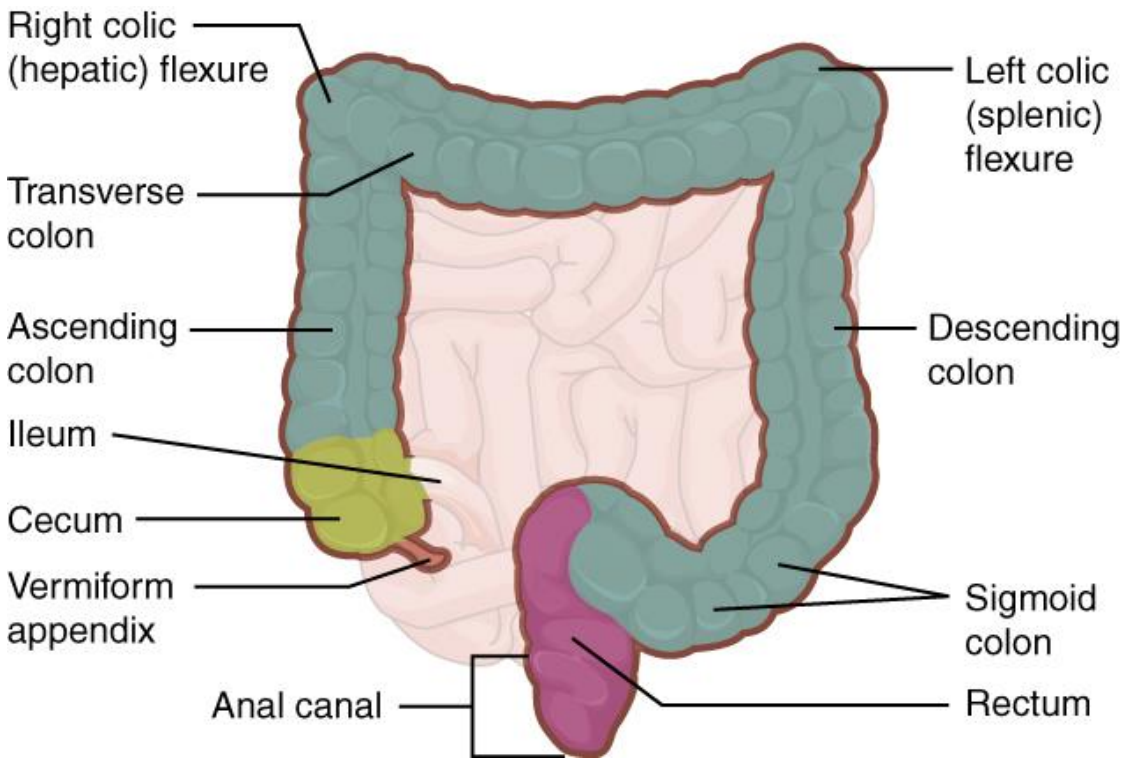


Cells of the Small Intestinal Mucosa

Cell type	Location in the mucosa	Function
Absorptive	Epithelium/intestinal glands	Digestion and absorption of nutrients in chyme
Goblet	Epithelium/intestinal glands	Secretion of mucus
Paneth	Intestinal glands	Secretion of the bactericidal enzyme lysozyme; phagocytosis
G cells	Intestinal glands of duodenum	Secretion of the hormone intestinal gastrin
I cells	Intestinal glands of duodenum	Secretion of the hormone cholecystokinin, which stimulates release of pancreatic juices and bile
K cells	Intestinal glands	Secretion of the hormone glucose-dependent insulinotropic peptide, which stimulates the release of insulin
M cells	Intestinal glands of duodenum and jejunum	Secretion of the hormone motilin, which accelerates gastric emptying, stimulates intestinal peristalsis, and stimulates the production of pepsin
S cells	Intestinal glands	Secretion of the hormone secretin

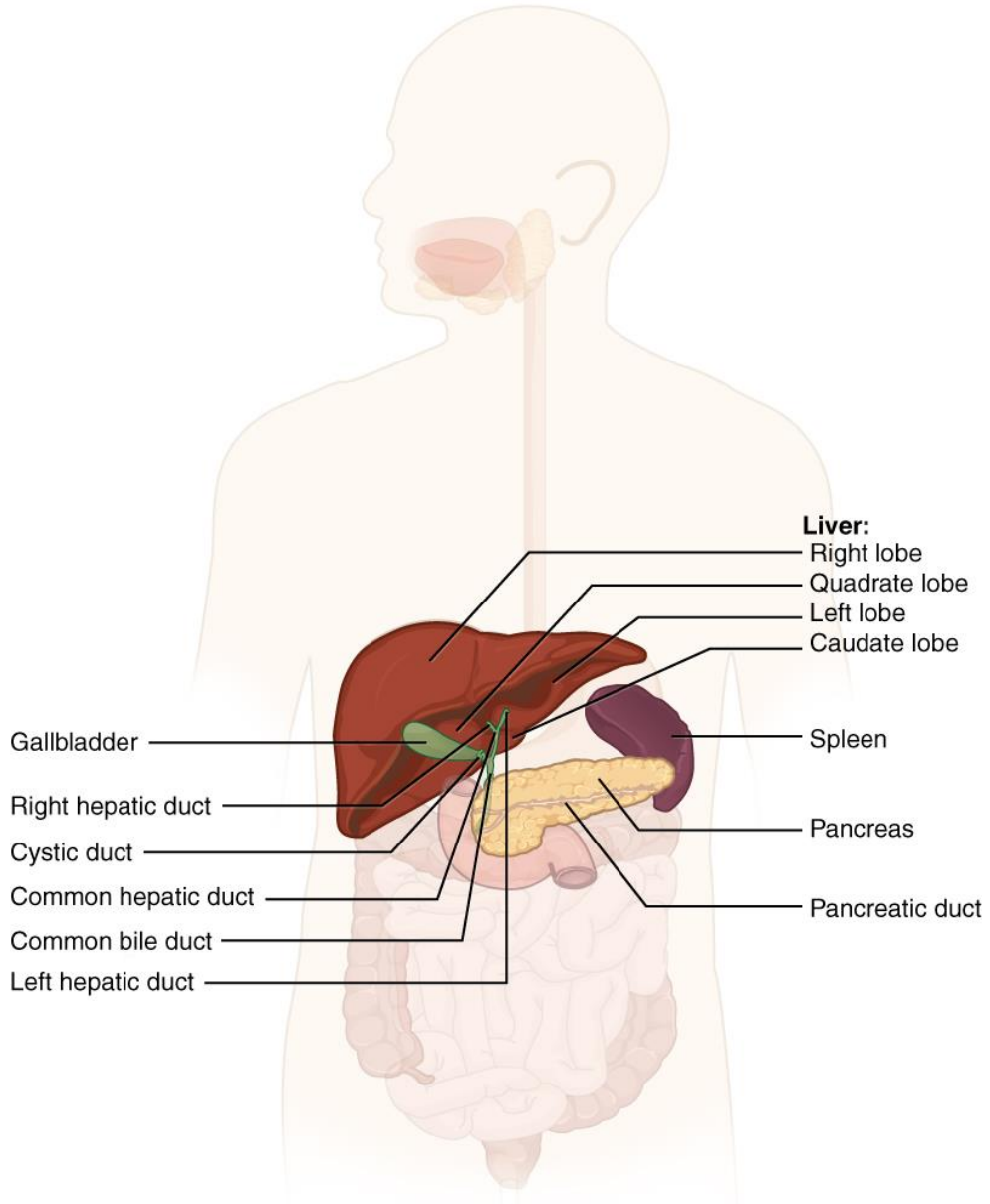
The Large Intestine

- Primary function is to finish absorption of nutrients and water, synthesize certain vitamins, form feces, and eliminate feces from the body.
- Four Main Subdivisions:
  - Cecum: a sac-like structure that is suspended inferior to the ileocecal valve.
    - Receives chyme from small intestine.
    - Appendix is attached to it and serves as a reservoir for intestinal bacteria.
  - Colon: Three parts:
    - Ascending
    - Transverse
    - Descending
  - Rectum
  - Anus: internal and external anal sphincter



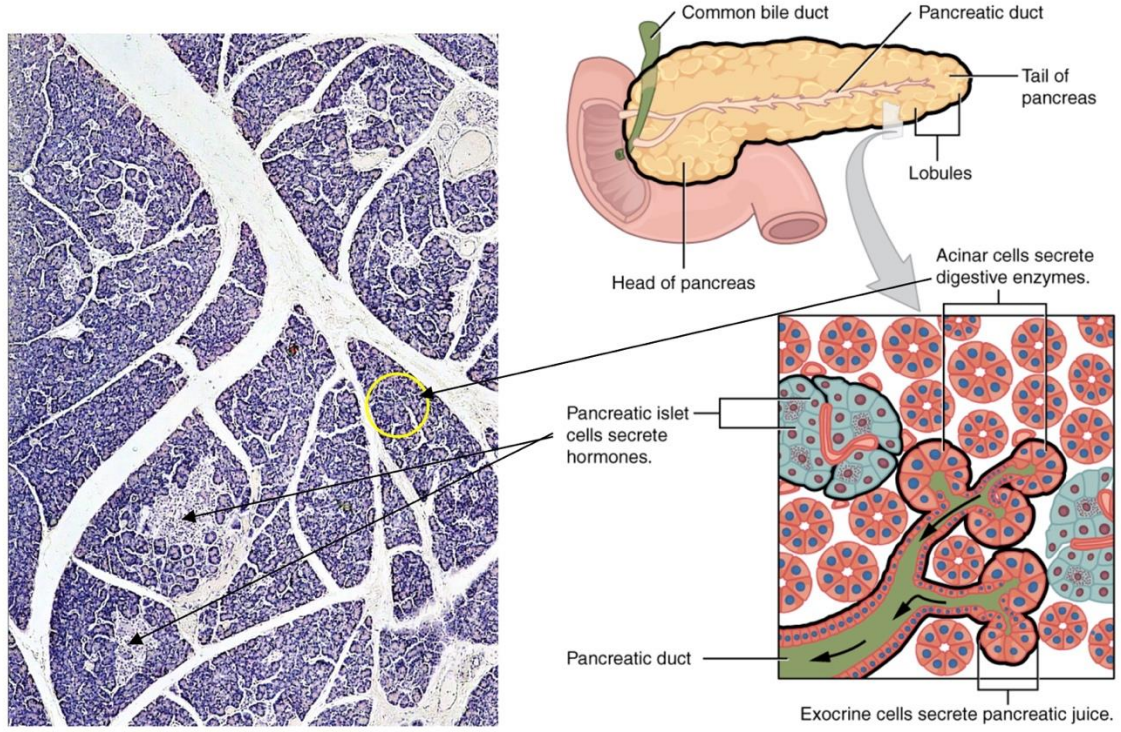
Accessory Organs in Digestion

- Chemical digestion in the small intestine relies on the activities of three accessory digestive organs:
  - Liver
  - Pancreas
  - Gallbladder.



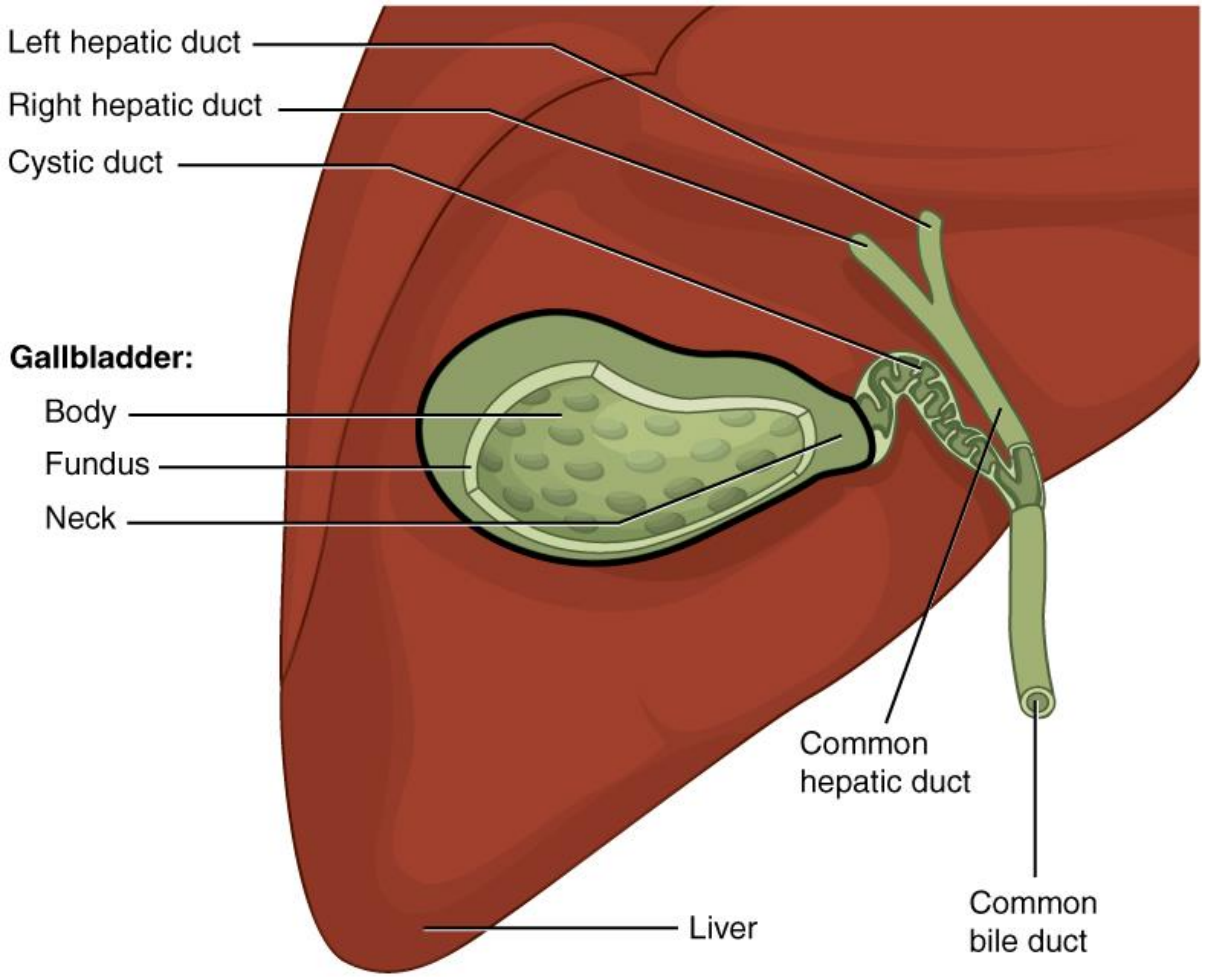
The Pancreas

- Connects the alimentary canal with the duodenum
- Dual functions
- Exocrine gland: produces digestive enzymes
- Endocrine gland: releases hormones
  - Insulin and glucagon



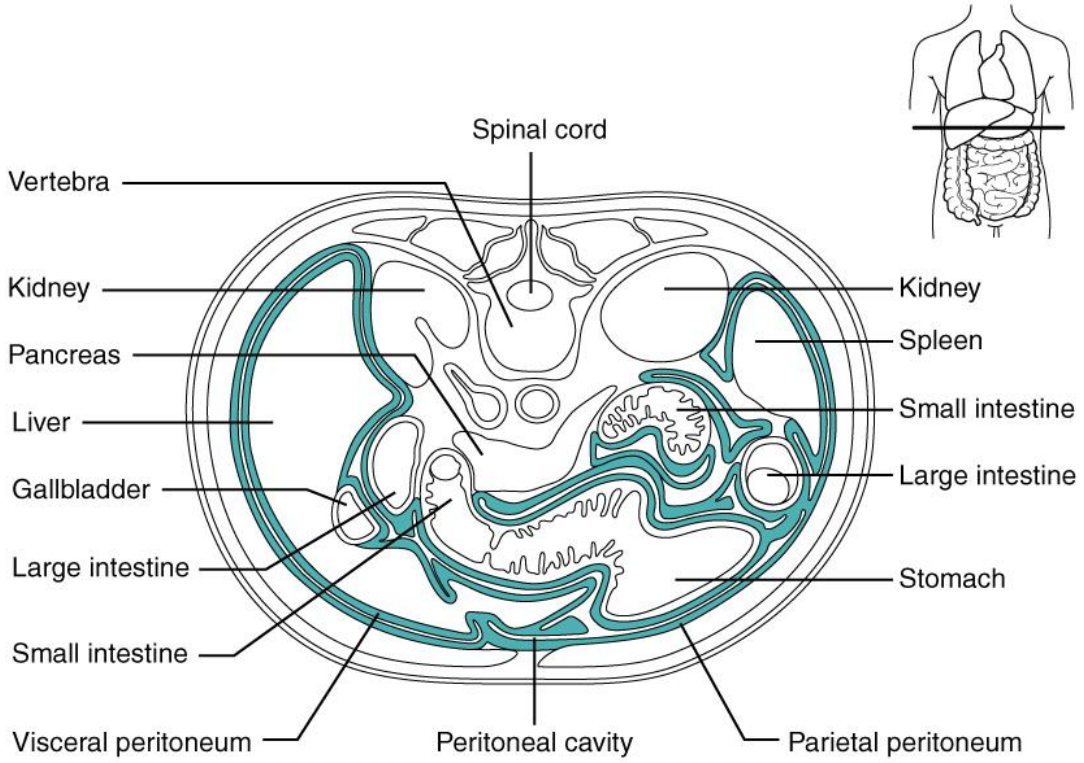
Liver Histology

- The liver is divided into a large right and smaller left lobe
- Digestive role of the liver is to produce bile and export it to the duodenum
- The gallbladder primarily stores, concentrates, and releases bile.
  - Bile plays a critical role in the emulsification of fats



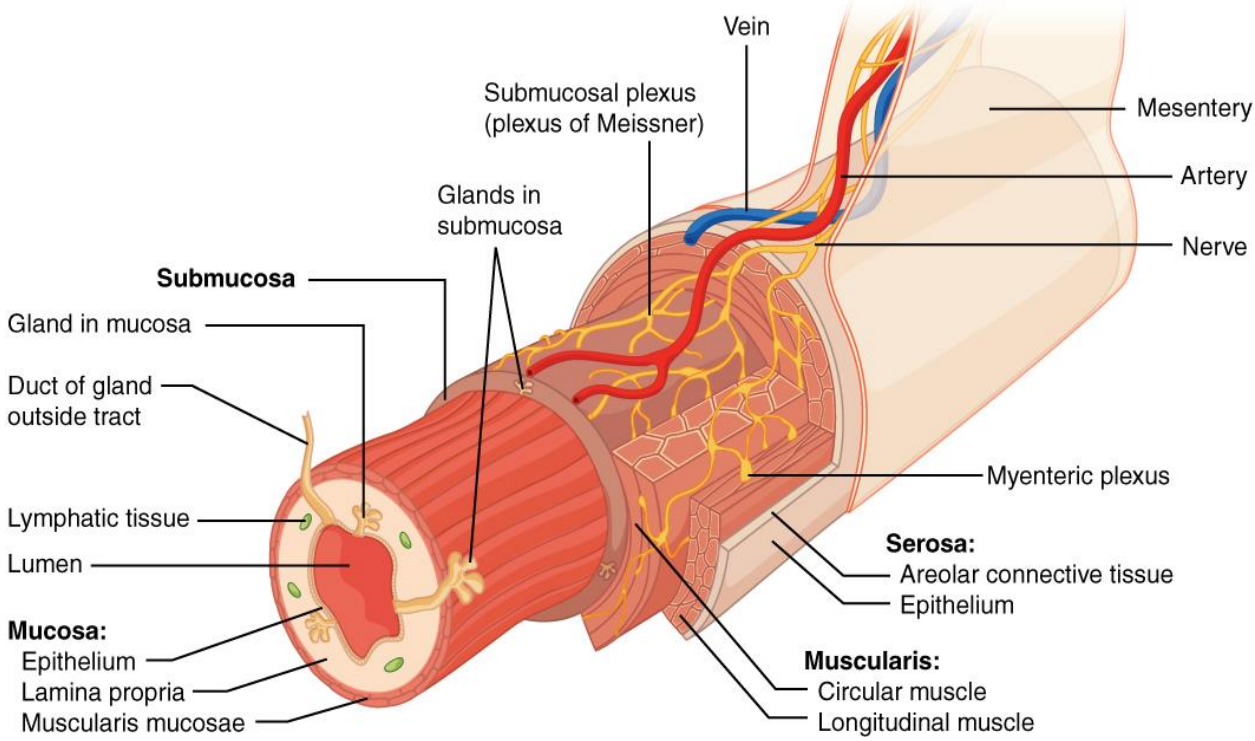
Membranes of the Digestive System

- Peritoneum: double-layered serous membranous sac that holds digestive organs within the abdominal cavity
- Composed of:
  - Parietal peritoneum: lines the abdominal wall
  - Visceral peritoneum: envelopes the abdominal organs
    - Folds over on itself to form the mesentery.



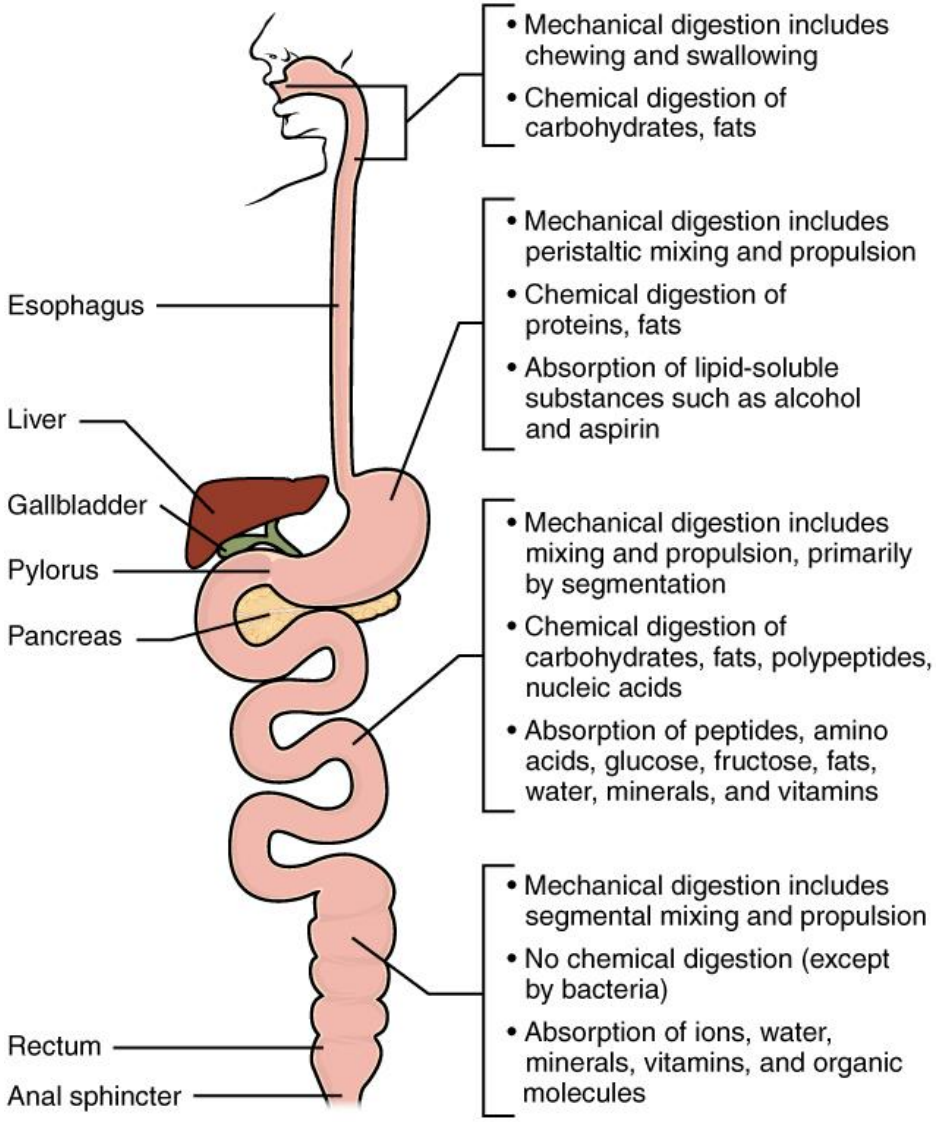
Histology of the Alimentary Canal

- The organs of the digestive tract have four basic tissue layers:
  - Mucosa: deepest layer; composed of epithelial tissue and faces the lumen of the GI tract
  - Submucosa: surrounds the mucosa and is composed of connective tissue and glands
  - Muscularis: composed of smooth muscle and may be oriented in circular or longitudinal direction
  - Serosa (or adventitia in the esophagus): superficial layer composed of connective and epithelial tissue



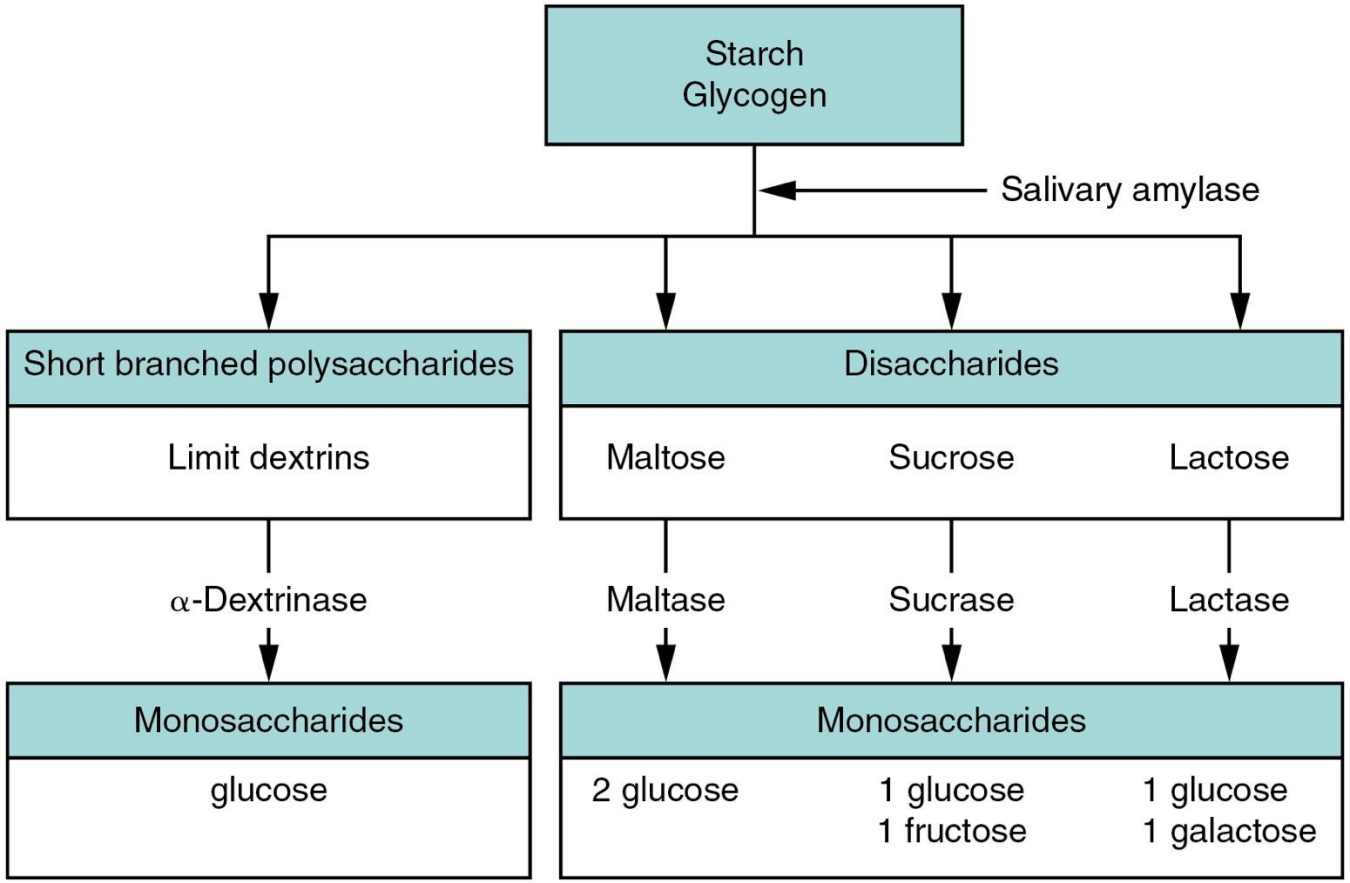
Chemical Digestion

- Large food molecules (for example, proteins, lipids, nucleic acids, and starches) must be broken down into subunits that are small enough to be absorbed by the lining of the alimentary canal.
- This is accomplished by enzymes through hydrolysis.



Carbohydrate Digestion

- Starts in the mouth.
- In the small intestine, pancreatic amylase does most of starch and carbohydrate digestion.
- Brush border enzymes hydrolyze disaccharides into monosaccharides.



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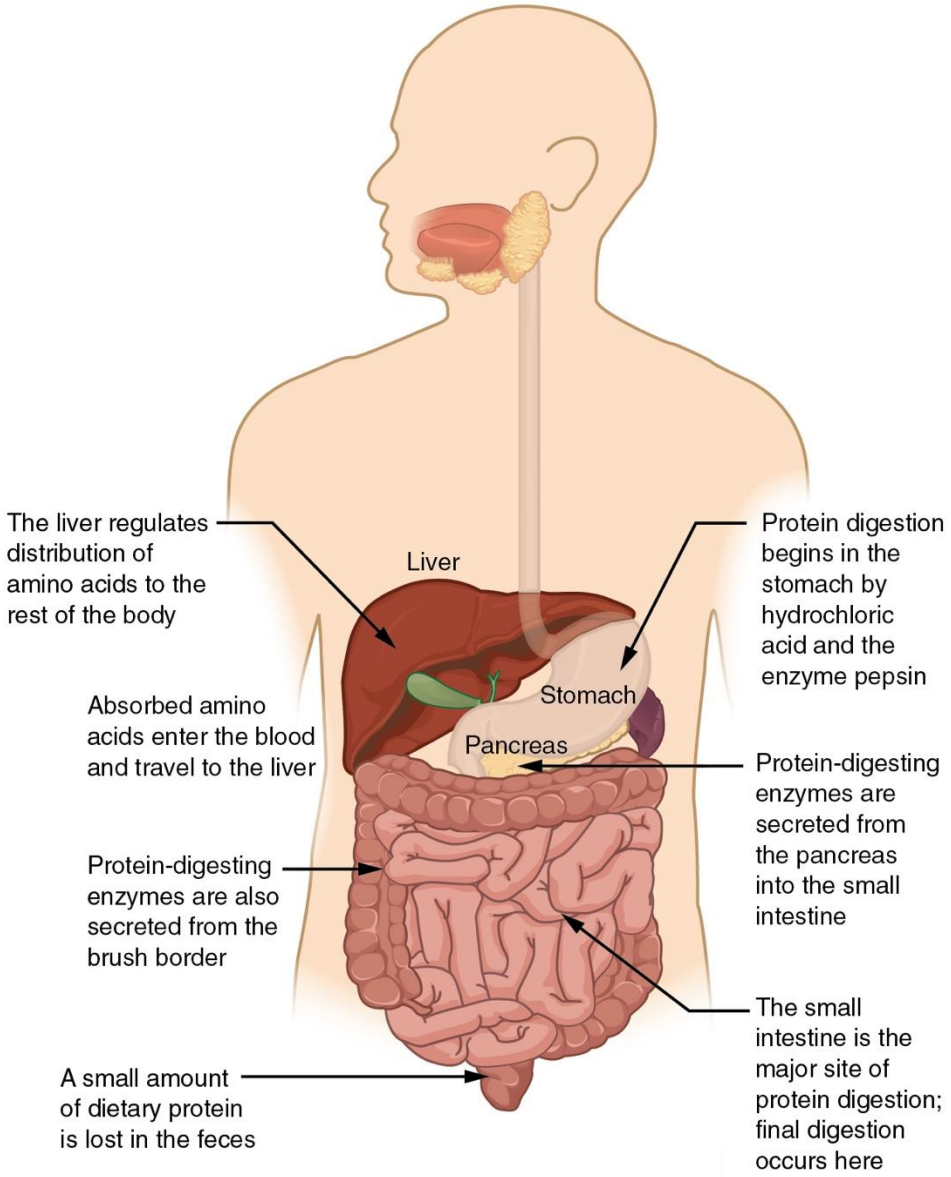
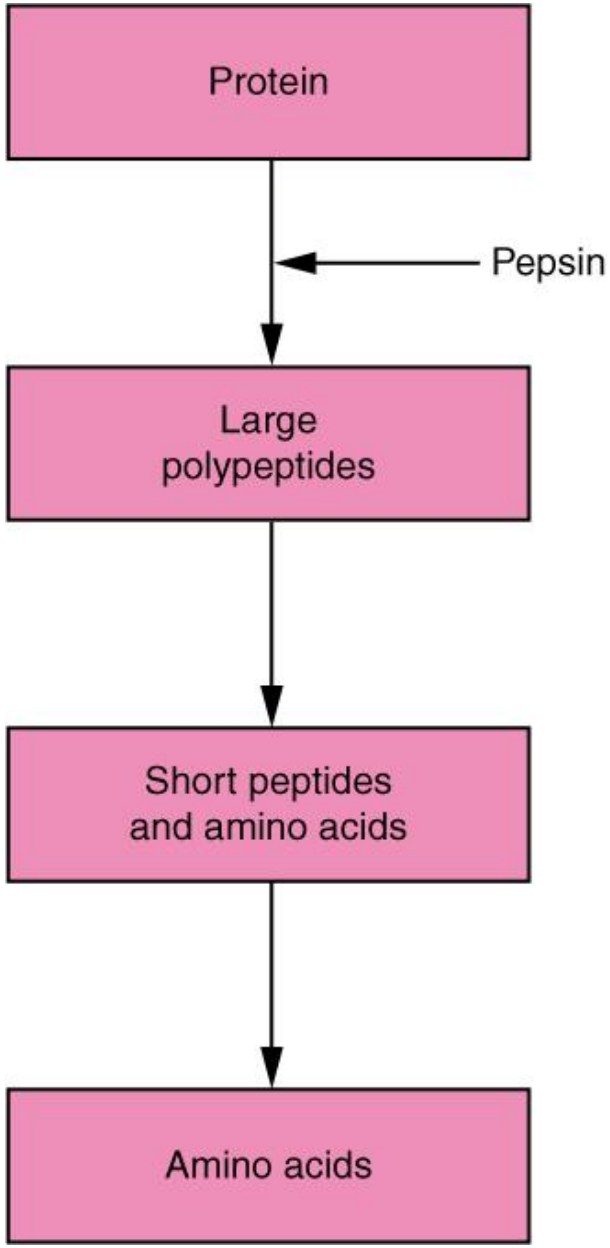
Protein Digestion

- Starts in the stomach, where HCl and pepsin break proteins into smaller polypeptides.
- In small intestine, pancreatic enzymes including chymotrypsin and trypsin, act on specific bonds in amino acid sequences.
- The brush border secrete enzymes which further break down peptide chains.



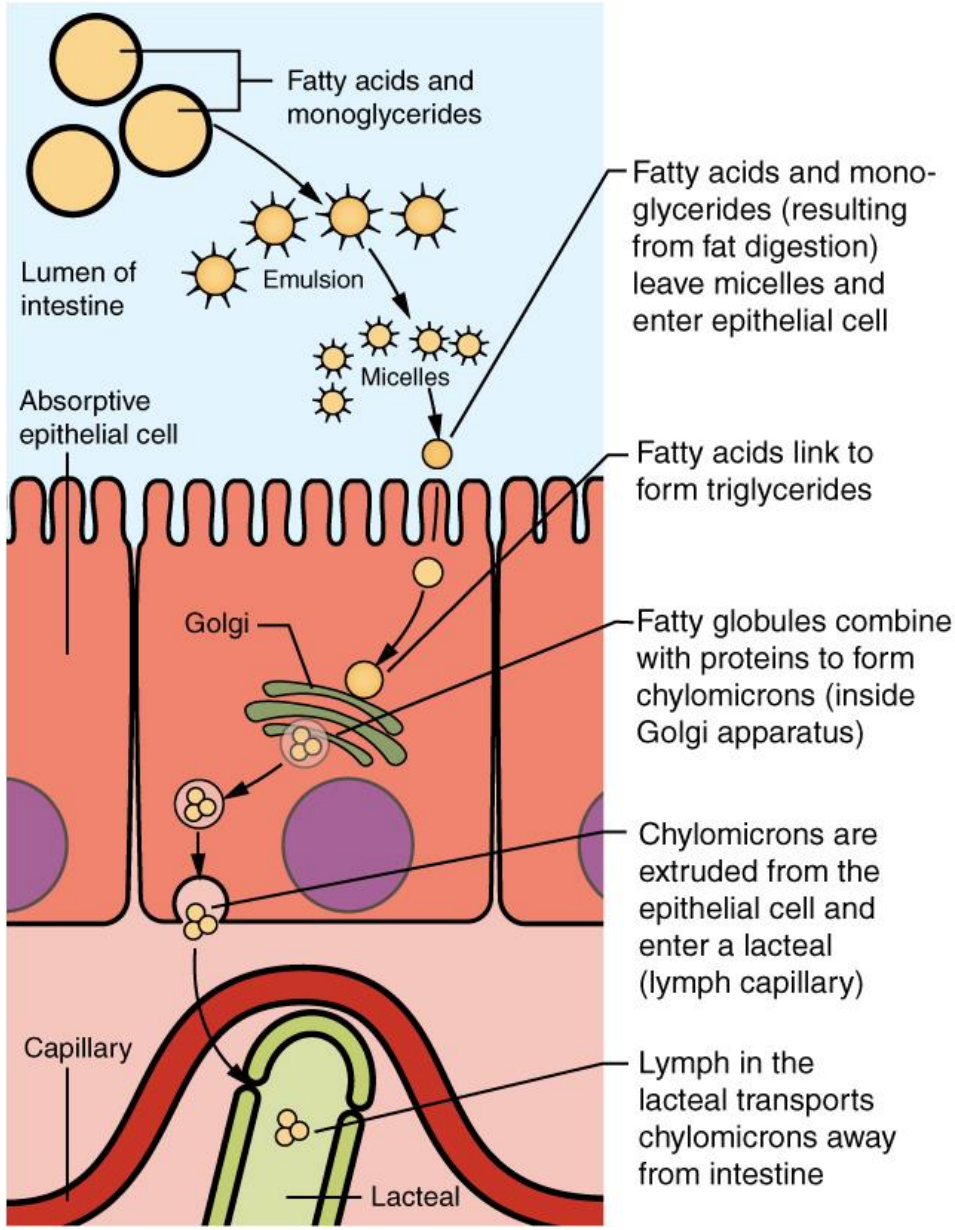
Proteins to Amino Acids

- Amino acids are absorbed by small intestine and transported into blood



Lipid Digestion

- Starts in the mouth by lingual lipase, but remain limited in its effect. Some digestion occurs also in stomach by gastric lipase.
- Because the pancreas is the only consequential source of lipase, virtually all lipid digestion occurs in the small intestine.
- Pancreatic lipase breaks down each triglyceride into two free fatty acids and a monoglyceride
- Lipids are emulsified within the bile and absorbed by intestine but transported through lymphatic system.



Lab Exercise 7.1: Exploring Digestive System Anatomy in Models

Materials:

- Sagittal head model, a torso model, and a wooden plaque model of the digestive system (if available). If not, use the models in Figures 7.10-7.16 of the lab manual.
- Watch models of the digestive system to review.

Procedure for Exercise 7.1:

- Obtain a sagittal head model, wooden plaque model, and a torso model the digestive system (if available). If not, use the models in Figures 7.10-7.16.
- Use these models to locate and identify the mandible and tooth anatomy, parotid gland, submandibular gland, hard palate, soft palate, uvula, esophagus, liver, gallbladder, spleen, pancreas, stomach (including its cardiac sphincter/ upper esophageal sphincter, pyloric sphincter, and rugae), small intestine (including duodenum, ileum, circular folds/ plicae circularis, and ileocecal valve), appendix, large intestine (including cecum, ascending colon, transverse colon, descending colon, sigmoid colon, and tenia coli), rectum, and anus.
- Complete Tables 7.1-7.6 in the lab manual.

Lab Exercise 7.2: Histological Examination of Digestive Organs

Materials:

- Slides of the gastroesophageal junction (longitudinal section), duodenum, ileum (cross-sections), salivary glands, liver, and pancreas.

Procedure for Exercise 7.2:

- View the the various slides using the 10x and 40x objectives.
- Make notes about the function(s) of the structures you've just located.
- Remember that total magnification is calculated as follows: (magnification of the objective lens) x (magnification of the ocular lens).
- After you complete the drawing and labeling activities in the Lab Exercise 7.2 section of your lab manual, have your instructor or TA verify the accuracy of your work.

Lab Exercise 7.3: Apply Your Knowledge of Digestive Organs

- Use the information you've learned in this lab to answer the questions in in the Lab Exercise 7.3 section of your lab manual

Lab Exercise 7.4: Digestive Enzymes Part A

Materials:

- Test tubes, graduated pipets, 2% protein solution, pepsin solution, and biuret solution.

Procedure:

1. Use a marker to label two test tubes A and B.
2. Use a clean, graduated pipet to add 3 mL of the 2% protein solution to test tube 1.
3. Add 1 mL of the 2% protein solution to test tube 2.
4. Use a clean graduated pipet to add 2 mL of the 1% pepsin solution to test tube 2. Gently swirl the test tube to mix the contents.
5. Place both test tubes in a 40°C water bath for 15 minutes.
6. Remove the test tubes from the water bath and use a clean, graduated pipette to add 1 mL of biuret test solution to each test tube.
7. Observe the color and appearance of the resulting solution in each test tube and record the observations in the data table. Note: The biuret test solution is a bluish purple in the presence of polypeptides and lavender pink in the presence of amino acids.

Lab Exercise 7.4: Digestive Enzymes Part B

Materials:

- Test tubes, graduated pipets, 1% litmus-milk solution, and lipase solution.

Procedure:

1. Use a marker to label test tubes C and D.
2. Use a clean, graduated pipette to add 2 mL of the 1% litmus – milk solution to test tube 3. The solution contains buttermilk, a fat.
3. Add 1 mL of the litmus – milk solution to test tube 4.
4. Use a clean graduated pipette to add 1 mL of the 1% lipase solution to test tube 4. Gently swirl the test tube to mix the contents.
5. After three minutes, record the color of the solution in the data table. Note: litmus is a pH indicator. Litmus appears blue in basic solutions and pink in acidic solutions.

Lab Exercise 7.4: Digestive Enzymes Part C

- **Materials:**
  - Test tubes, graduated pipets, 1% starch solution, amylase solution, 1% glucose (dextrose) solution, iodine solution, and Benedict's reagent.
- **Procedure:**
  1. Use a marker to label four test tubes E–H.
  2. Use a clean, graduated pipette to add 1 mL of the 1% starch solution to each test tube 5, 6 and 7.
  3. Use a clean graduated pipette add 1 mL of the 1% amylase solution to test tube 6 and 7.
  4. Use a clean graduated pipette at 1 mL of the 1% glucose (dextrose) solution to test tube 8.
  5. Gently swirl the test tubes to mix the contents.
  6. Allow the test tubes to sit undisturbed for about two minutes.
  7. Evaluate the starch – amylase solution for starch.
     - Use a clean, graduated pipette add 4 to 6 drops of iodine solution to the test tube 5 and 6.
     - Record the color of the resulting solutions in the table. Note: test tube 5 is a positive control sample for the iodine starch test. Iodine forms a blue/black color in the presence of starch.
  8. Evaluate the starch – amylase solution for glucose.
     - Use a clean, graduated pipette to add 1 mL of Benedict's reagent to test tubes 7 and 8.
     - Place the test tubes in a boiling water bath using a test tube clamp.
     - After 10 minutes, remove the test tubes from the hot water bath using a test tube clamp.
  9. Record the color of the resulting solutions in the data table. Note: test tube eight is a positive control sample for Benedict's test. Benedict's reagent contains Cu^{2+} which, when heated, reacts with glucose to form a red, orange, or mustard colored precipitate.

- **Record experimental observations for Parts A, B, and C in Table 7.7 in the lab manual**

Lab Exercise 7.5: Fetal Pig Dissection –Digestive Identification

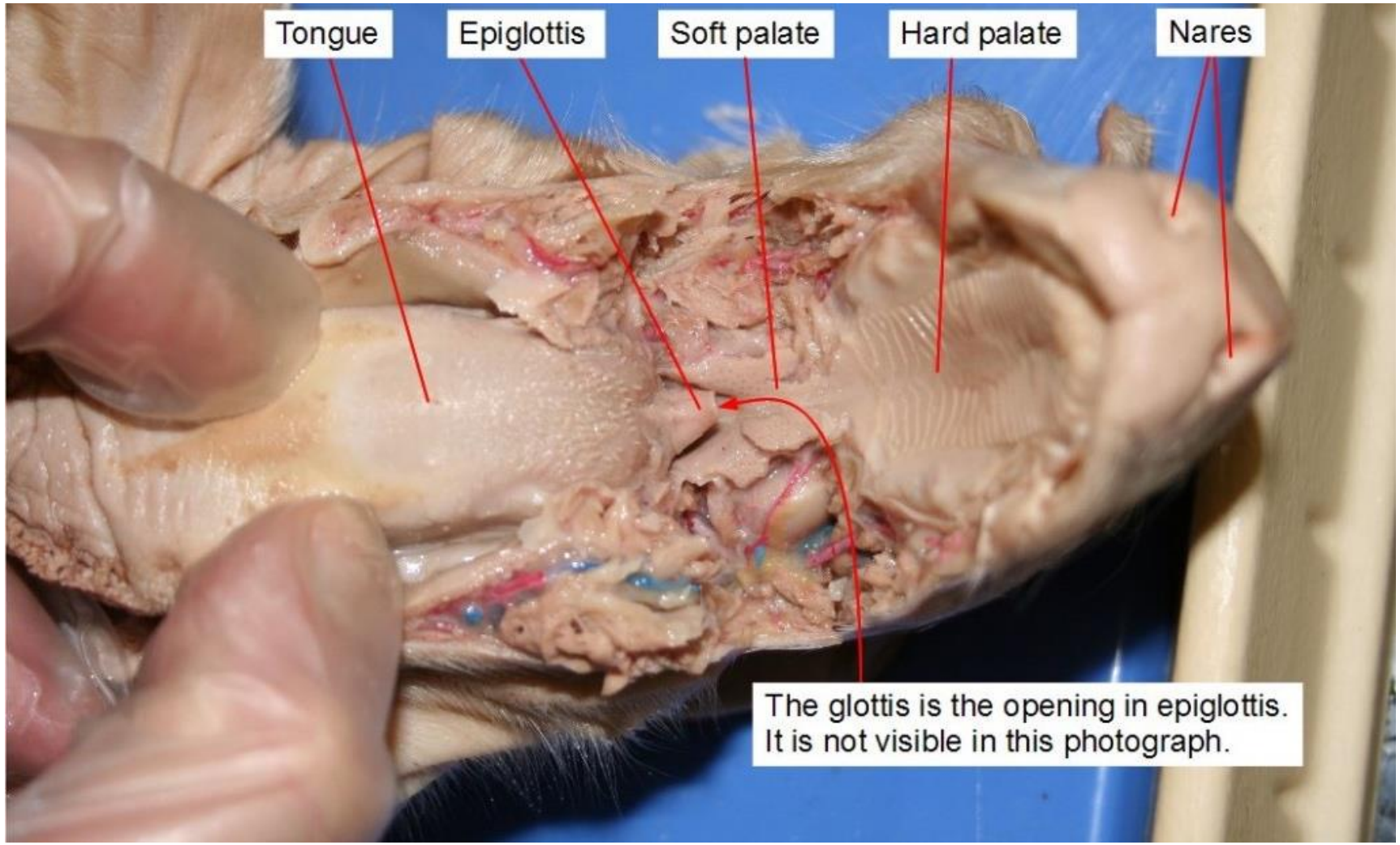
Materials:

- Preserved pig, tools, PPE, diagrams
- Gloves, scalpel/scissors, blunt probe, tweezers.
- Use human terminology wherever terms for the pig may differ.
- Follow BSL-1 safety protocols

Procedure:

- Follow instructions in Lab Exercise 7.5 in the lab manual
- Identify digestive structures listed in Table 7.8 in the lab manual
- For online students (or if **no specimen** are available), use the **figures** in the next slides to identify each structure
- Watch the fetal pig dissection video for full dissection
- Watch the fetal pig dissection of the digestive system for this exercise.

Hard Palate, Soft Palate, Glottis, Epiglottis, and Tongue



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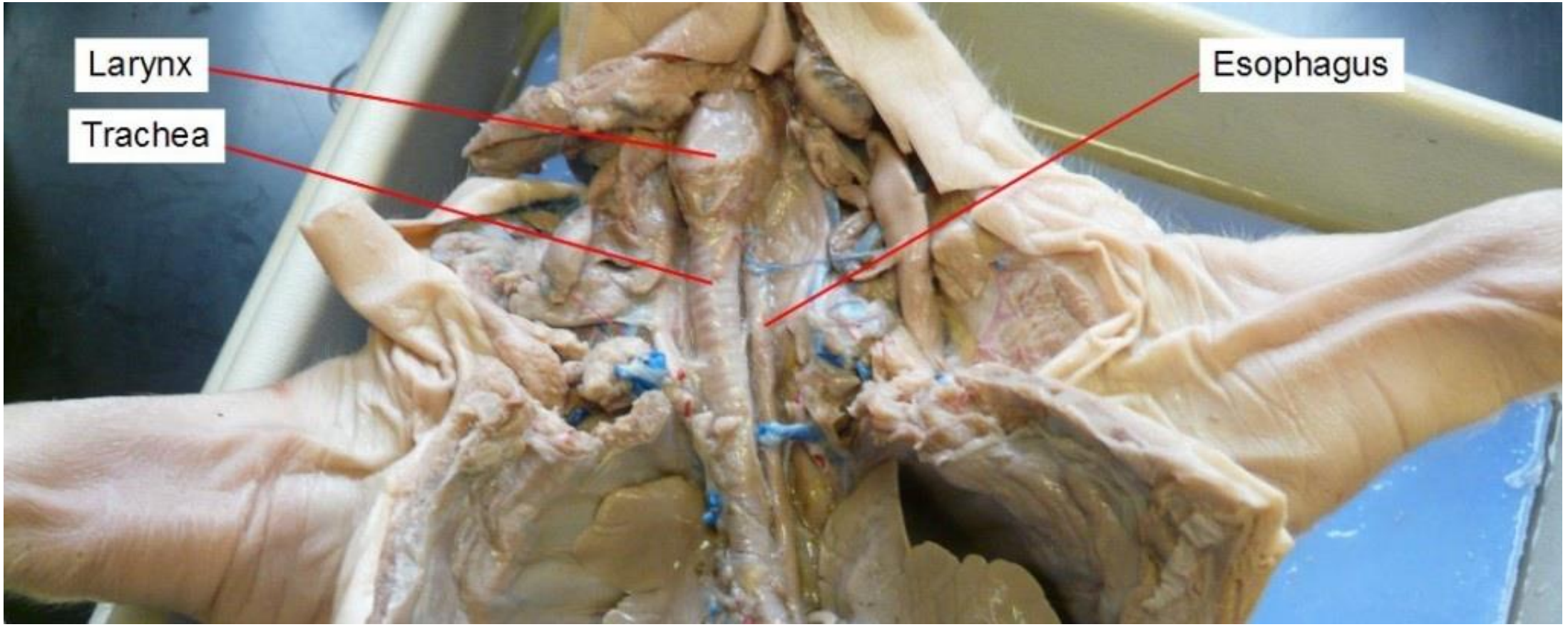
Larynx, Trachea, and Esophagus



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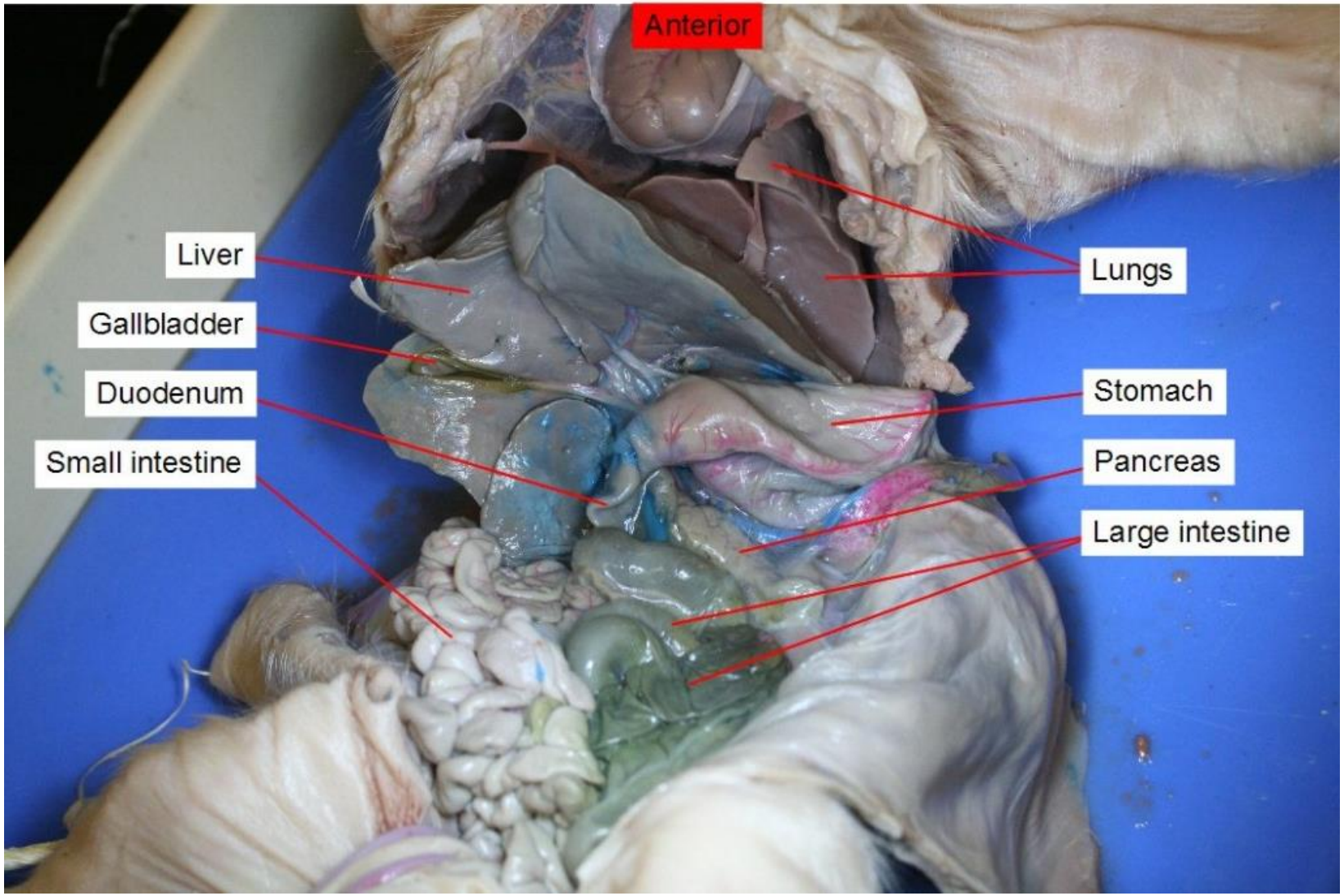
Duodenum, Gallbladder, Liver, Lungs, Large Intestine, Pancreas, Small Intestine, and Stomach



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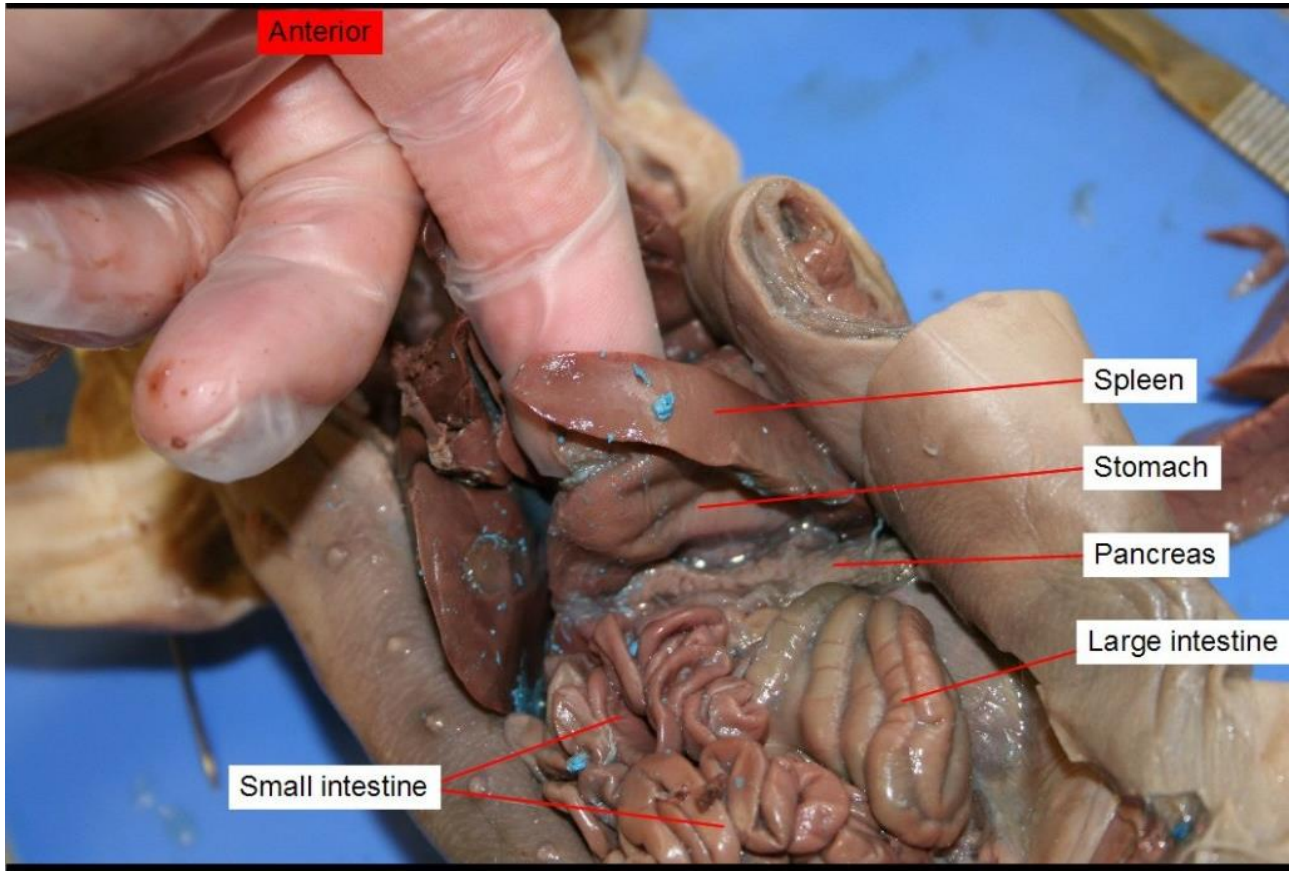
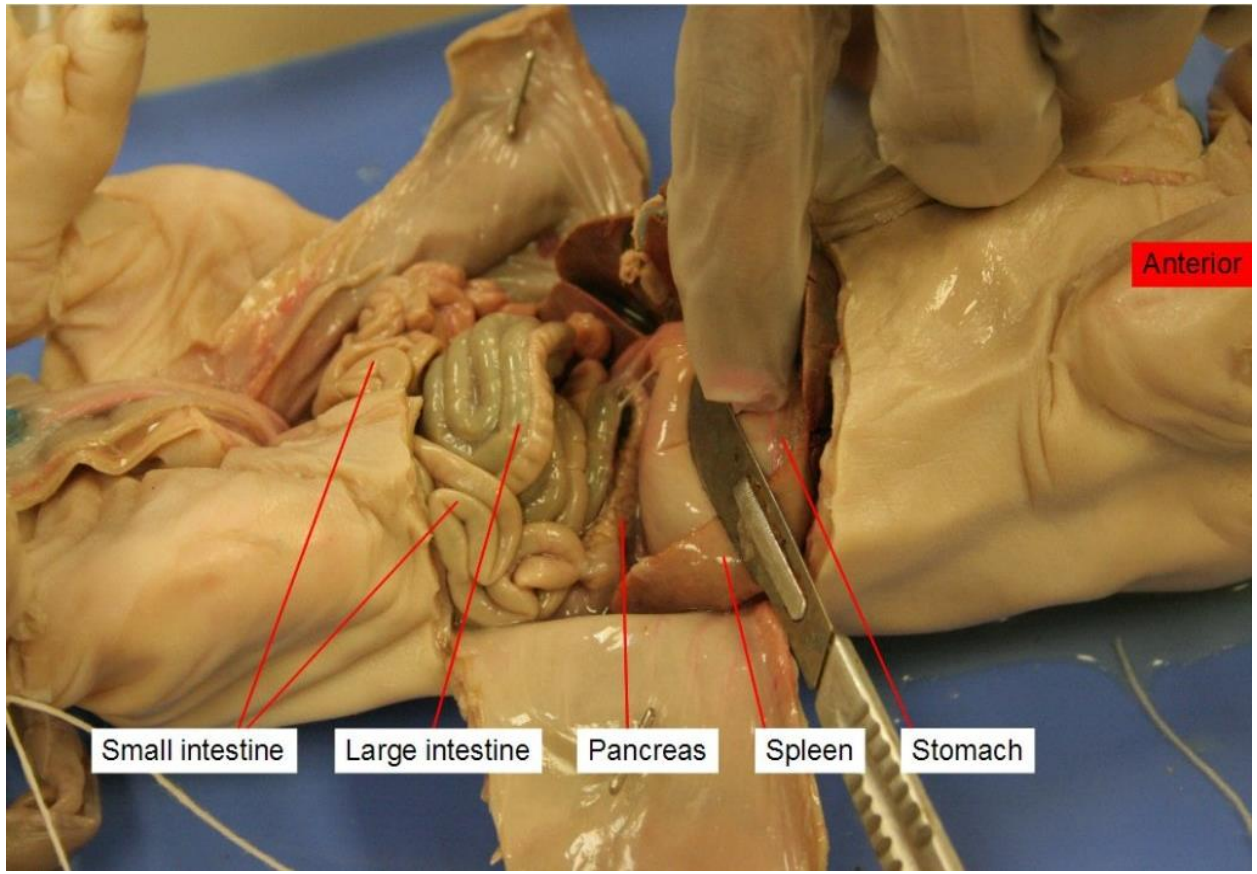
Large Intestine, Pancreas, Small Intestine, Spleen and Stomach





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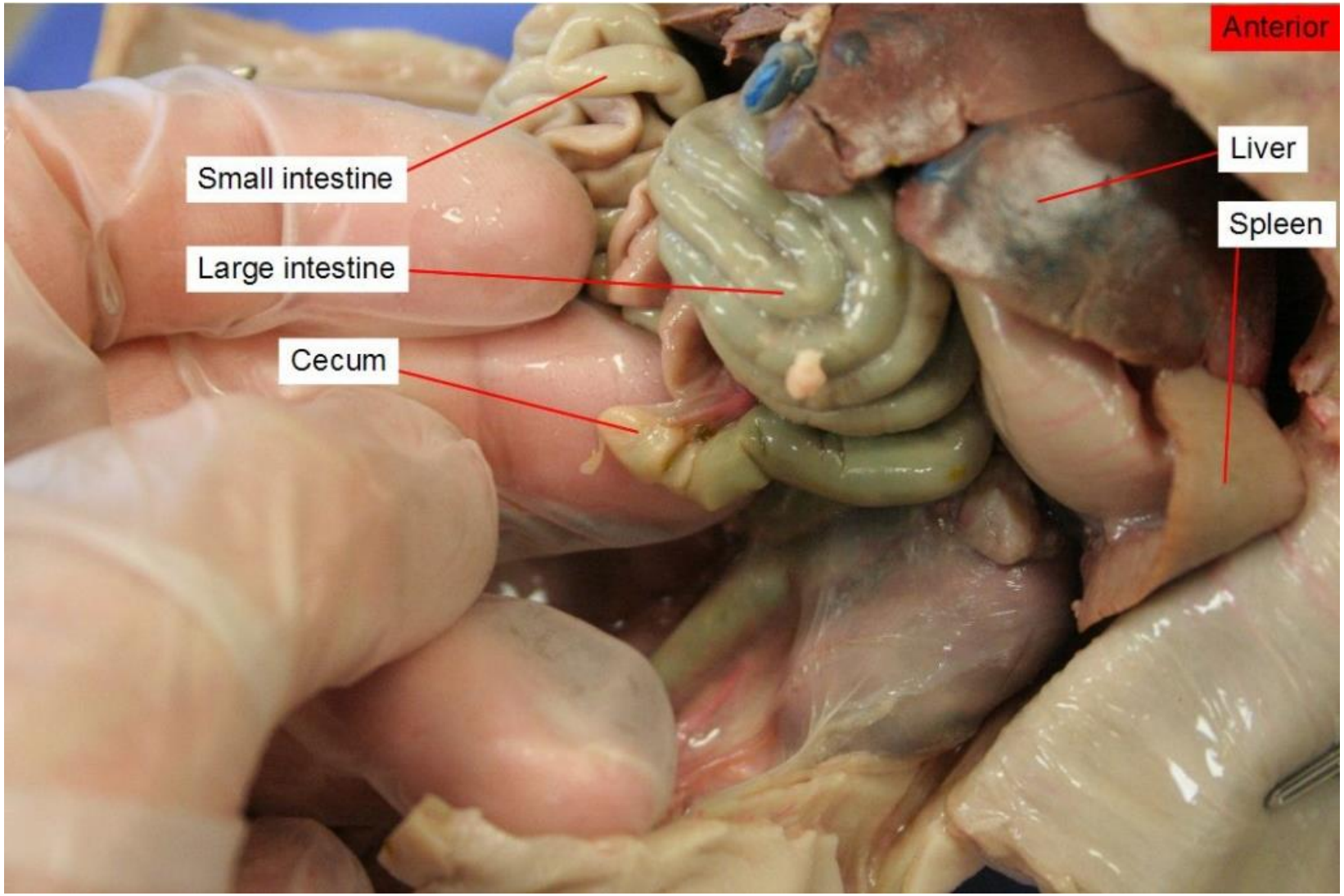
Cecum, Large Intestine, Liver, Small Intestine, and Spleen



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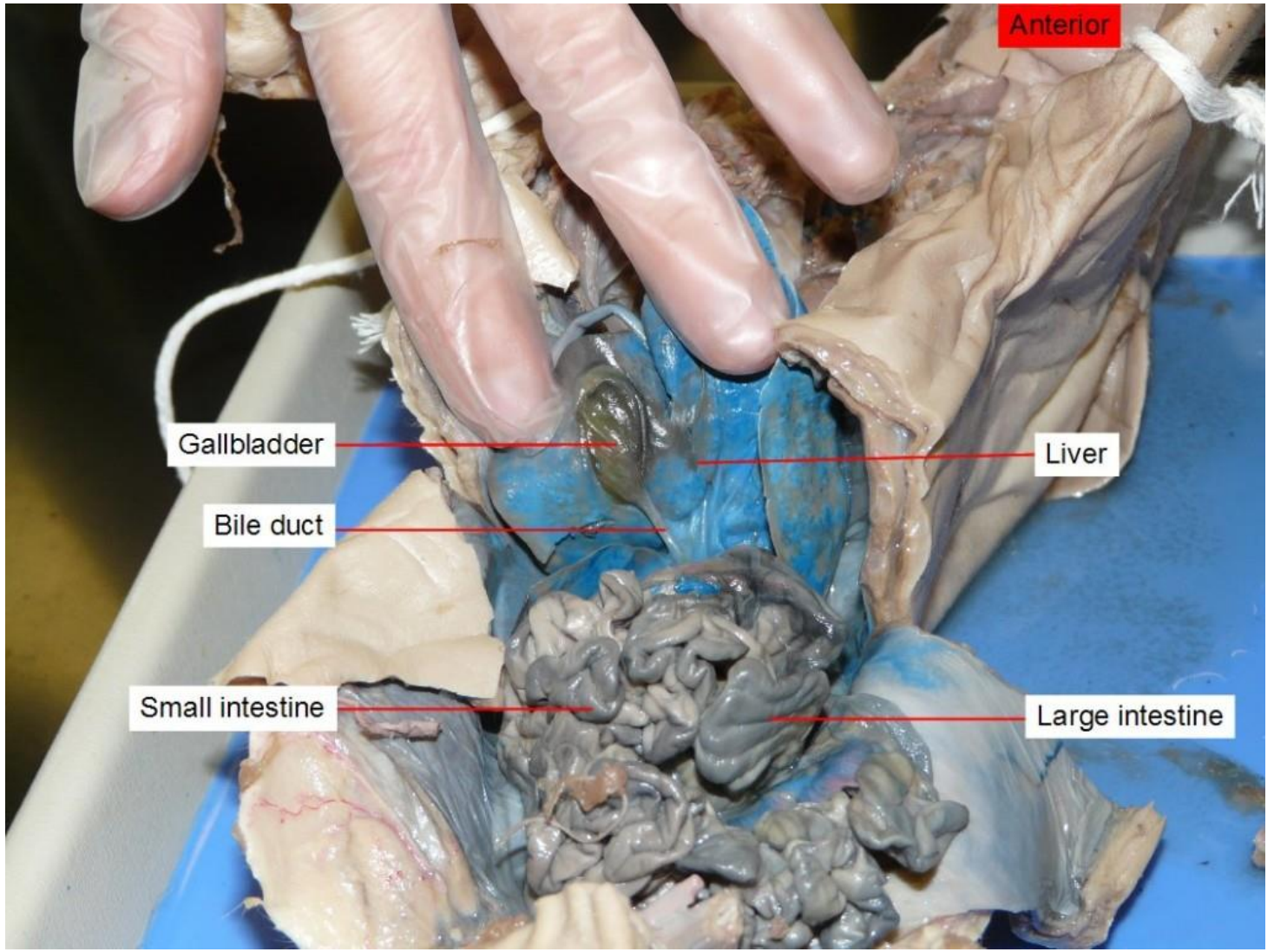
Bile Duct, Gallbladder, Large Intestine, Liver, and Small Intestine



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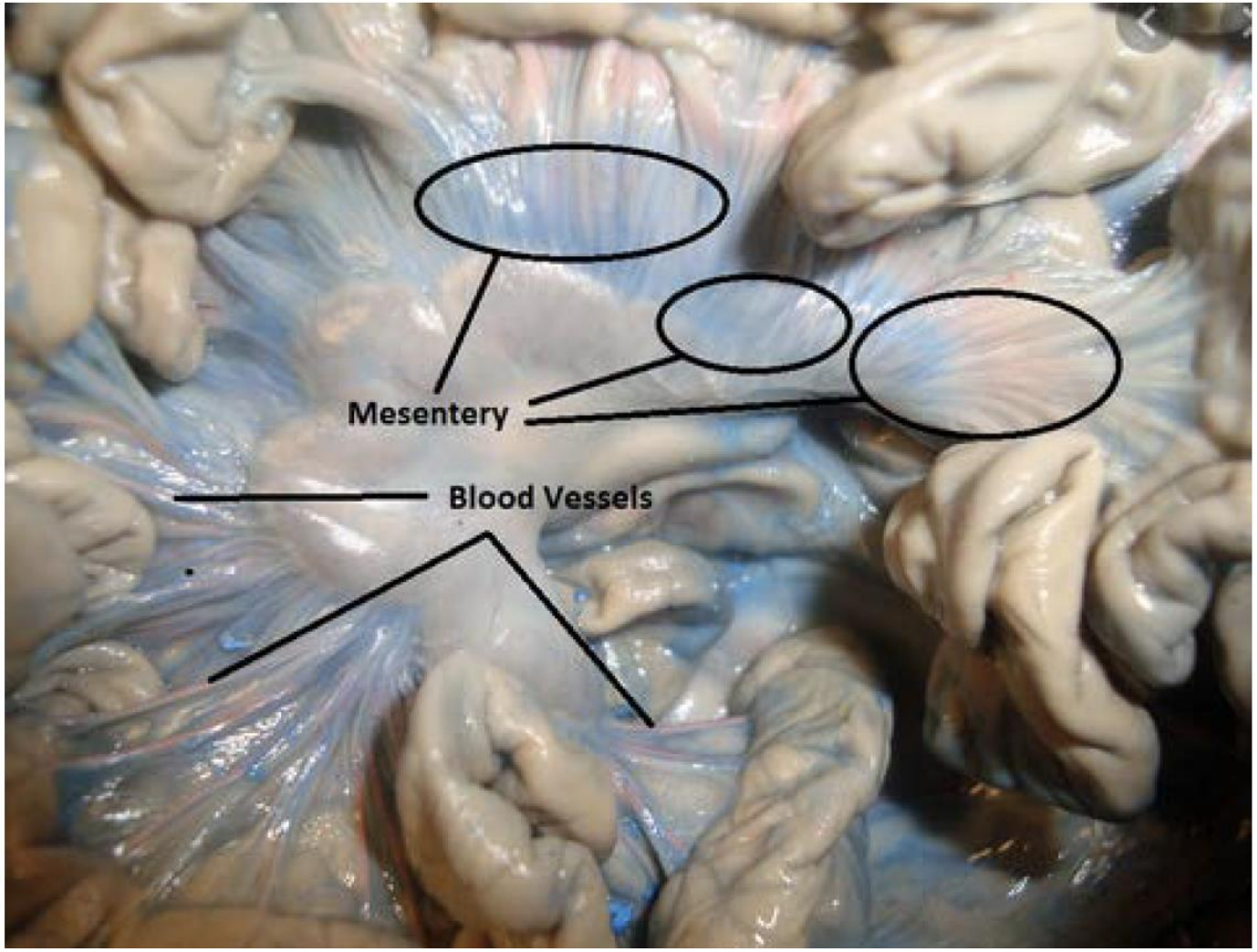
Abdominal Cavity Showing Mesentery



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Lab 7 Assignments

Reading Assignment:

- Lab Manual: Chapter 7

See Module 7 for more information & assignments

- Pre-Lab 7 Quiz
- Lab Exercises 7.1-7.5 Assignments
- Post-Lab 7 Quiz

Lab 7 References

Additional Resources:

- Gage7SLR. (2011). Anatomy and Physiology 2 Anatomy Model Walk Through for Digestive System [Video]. YouTube. https://youtu.be/_l8aLmomDPU?si=mazY4Fua_aKUOlzu
- XoletteScience. (2012). Fetal Pig Dissection Part 3- Digestive System [Video]. YouTube. https://youtu.be/dkaUnbTF2FU?si=T7JF4L_p0TKjA5Dm

Fetal Pig Images:

- *Fetal Pig.* (2023). Google Photos: https://photos.app.goo.gl/gBk5EEluM8u5kEVn2
- *Digestive System*. (2025). Whitmen College: https://www.whitman.edu/academics/majors-and-programs/biology/virtual-pig/digestive-system
- *Fetal Pig Dissection.* (n.d.). Lumen Biology II Lab Manual. https://courses.lumenlearning.com/bio2labs/chapter/reading-fetal-pig-dissection/