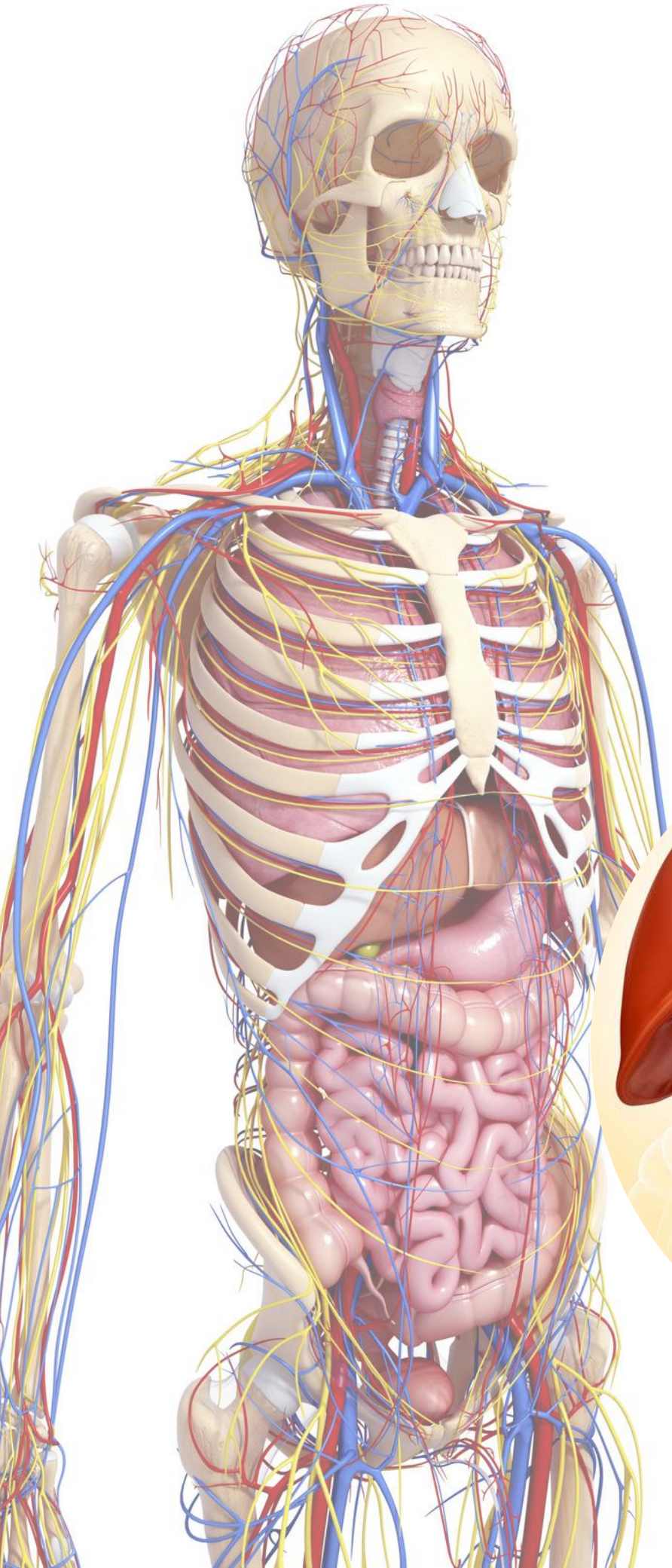
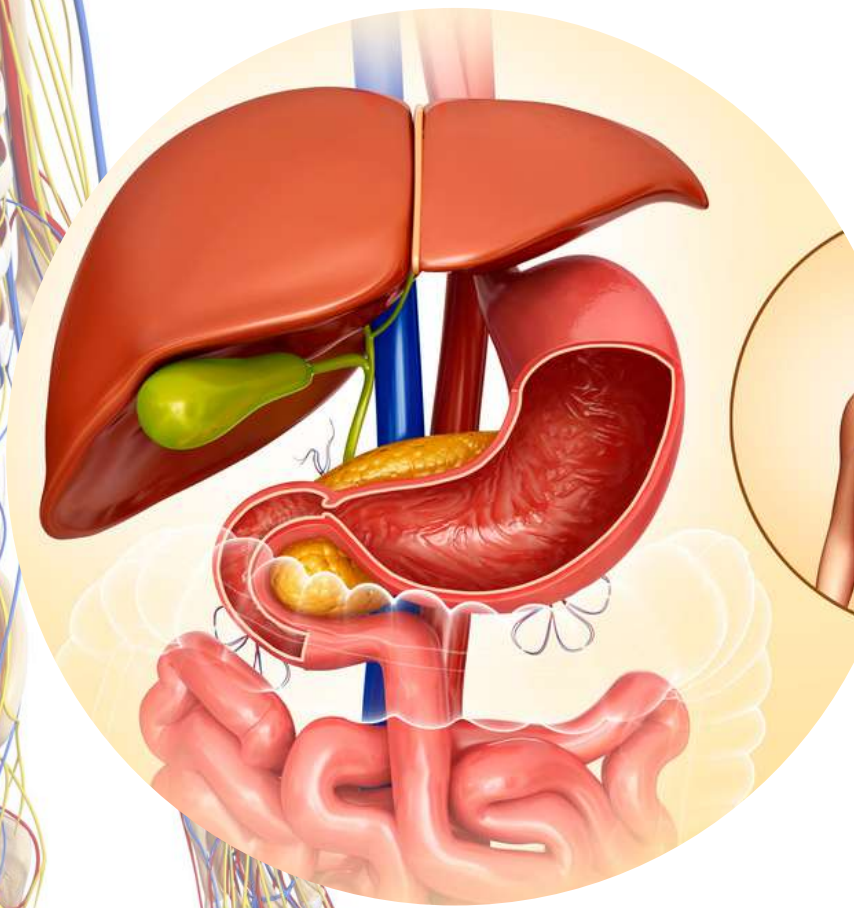
Digestive System
Lesson Plan
Grade 12





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The following unit plan was created in accordance with the Canadian Council on Animal Care's recommendations to replace any present procedures involving the use of animals in teaching, testing and research.

The Three Rs principle of Replacement states, if you can meet your scientific or educational goals without the use of animals, it is your ethical obligation to use non-animal methods. Grade 12 anatomy content is often taught using fetal pigs - here we offer an effective and humane alternative.

This is in alignment with the public's concern for animal welfare and a cultural respect for animals passed down from the Aboriginal perspectives of the First Peoples.

Elisabeth Ormandy created this unit plan and series of lesson plans for your use in teaching life science content to Grades 12 based on the BC Science Curriculum.

These Humane Science Education materials were developed to provide equivalent or greater standards in education for Canadian youth, without the use of animals.

Curriculum Alignment

This lesson plan can be used to create classes for Grades 12 based on the BC Science Curriculum. Specific **Big Ideas** covered in this lesson plan include:

Grade 12 - Organ systems have complex interrelationships to maintain homeostasis.

ORGAN SYSTEMS:

- Structure and function
- Structural and functional interdependence
- Maintenance of homeostasis

We have recommended specific virtual anatomy tools to use to get the most out of the lesson plan. You'll find links to those on pages 5&6.

Lesson Plan Overview

Subject: Science

Unit Overview: Anatomy and Physiology

Unit Duration: ~90 minutes

Grade: 12

Big Idea: Organ systems have complex interrelationships to maintain homeostasis

Curricular Competencies

- *Analyze cause-and-effect relationships*
- *Construct, analyze, and interpret graphs, models, and/or diagrams*
- *Consider the changes in knowledge over time as tools and technologies have developed*

Content

- By the end of this lesson, students are expected to demonstrate understanding of the following:
  - *Digestive system:*
    - *Structure and function*
    - *Structural and functional interdependence*
    - *Maintenance of homeostasis*

Recommended Education Tools

Hardware & Workbooks:

This inventory is for a regular in-person class - use x1 iPad/tablet per student for responsible physical distancing. If teaching online, teachers can screen share their iPad/tablet or desktop.

- 6 (or more) iPads or other tablets
- 6 (or more) 3D Anatomica workbooks

Recommended Software:

- 3D Anatomica: https://3danatomica.com
- 3D4Medical Complete Anatomy: https://3d4medical.com

Lesson Plan Overview

Topic: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

Content: The human digestive system: organs, structure and function

Goals	Students will be able to: • Describe the function of the digestive system and its major organs. • Describe the relationships between the different components of the digestive system. • Explain how the digestive system is interdependent with the circulatory system. • Explain how the digestive system maintains homeostasis in the body.
Objectives	After this lesson students will state the structure and function of each organ/tissue in the digestive system and explain how the digestive system is functionally interdependent with other body systems.
Materials	• 3DAnatomica • 3D4Medical • Digestive System Workbook
Introduction	Using the 3DAnatomica and/or 3D4Medical app(s), the teacher will introduce the topic of cardiovascular organ structure and function.
Development	Questions to support inquiry-based learning: • What is the advantage of having specialized tissues in the digestive system? • How does the digestive system help the body maintain internal balance during exercise? • What are the impacts of external stimulants (e.g. alcohol, caffeine) on the digestive system? • What lifestyle decisions would you make to improve your digestive health? • How does the digestive system respond to infection by a pathogen?
Practice	Students will work independently or in pairs to navigate 3DAnatomica and/or 3D4Medical to learn about the structure and function of the digestive organs.

Lesson Plan Approach

If teaching regular in-person classes:

- Split students into **6 groups**.
- Give each group a **Digestive System workbook** to refer to, and one (or more) iPad(s) or tablet(s) with the **3D Anatomica app**, and **3D4Medical Complete Anatomy app** loaded and ready to use.
- Your **introduction** should include discussion of the function of the digestive system, identifying its major components, and the vocabulary you would like students to learn (~ 15 mins). **Define homeostasis**. Have the students follow along using the 3D4Medical Complete Anatomy app.
- Have students **label "Major Structures"** diagram on page 10 using 3D4 Medical.
- **Discuss sequence** of organs and structures that food moves through within the digestive system. Have students use the 3D Anatomica and 3D4Medical Complete Anatomy app to explore the flow of food in their groups, filling their 3D Anatomica workbook and/or handouts provided. This can be student or teacher led (40-45 mins).
- Explore the "**Structures in Detail**" pages using the 3D4 Medical App. The students can cut away at the structures in the app to locate structures that need to be labeled.
- Ask students to brainstorm **ways the digestive system interacts with other systems,** and go over the specific examples provided
- Discuss different ways the digestive system helps maintain homeostasis using examples provided, then ask students to provide their own examples using what they've learned.
- **Close the class with a 20-minute recap** of what the students have learned, discuss how the parts of the digestive system work together, and check for understanding. Begin a **conversation on ethics** of animals in science using the questions provided.

If teaching a physically-distanced class:

- Use x1 iPad for each student and proceed as per the directions above.

If teaching online:

- Lead the students through the digestive system by screen sharing your own iPad/tablet or desktop with the 3D4Medical Complete Anatomy app installed, filling out the tables, and labeling the models as you go.
- Proceed as per the directions above.

Detailed Lesson Content & Teaching Notes

Introduction to the Lesson

Include a First Nations land acknowledgement and ask students to reflect on what respect for animals means to them. Provide an introduction to the apps and models that will be used in class. Provide an overview of how to access 3D Anatomica workbooks if teaching remotely.

What is Homeostasis? Discuss with Students

In biology, **homeostasis** refers to the body's ability to maintain a stable internal environment despite changes in external conditions.

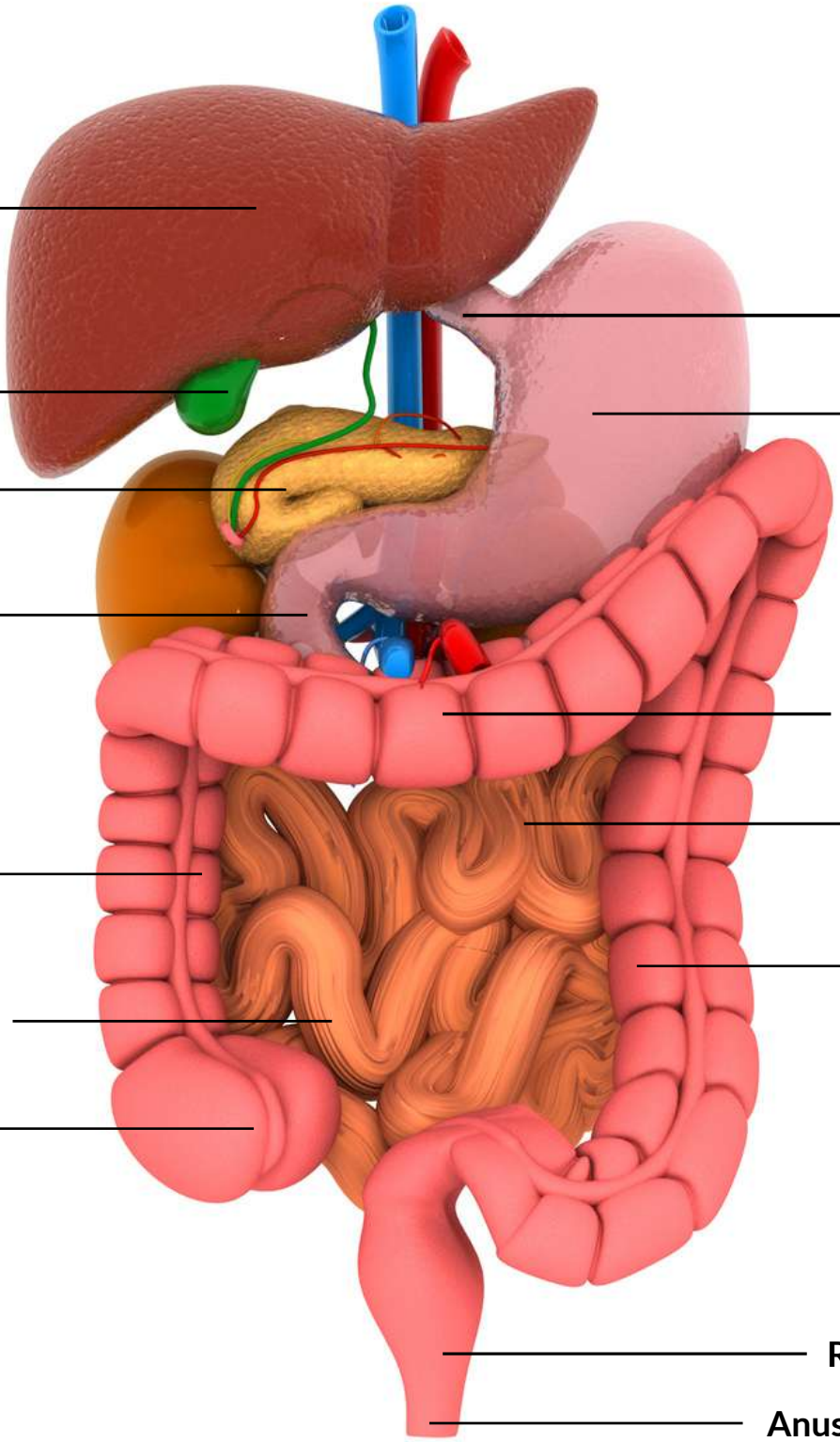
Introduction to the Topic

Students will use the **3D4Medical Complete Anatomy** app to explore the digestive system at large. We recommend covering the function of the digestive system, identifying the major components of the system, and discussing the vocabulary you would like the students to learn early in the lesson.

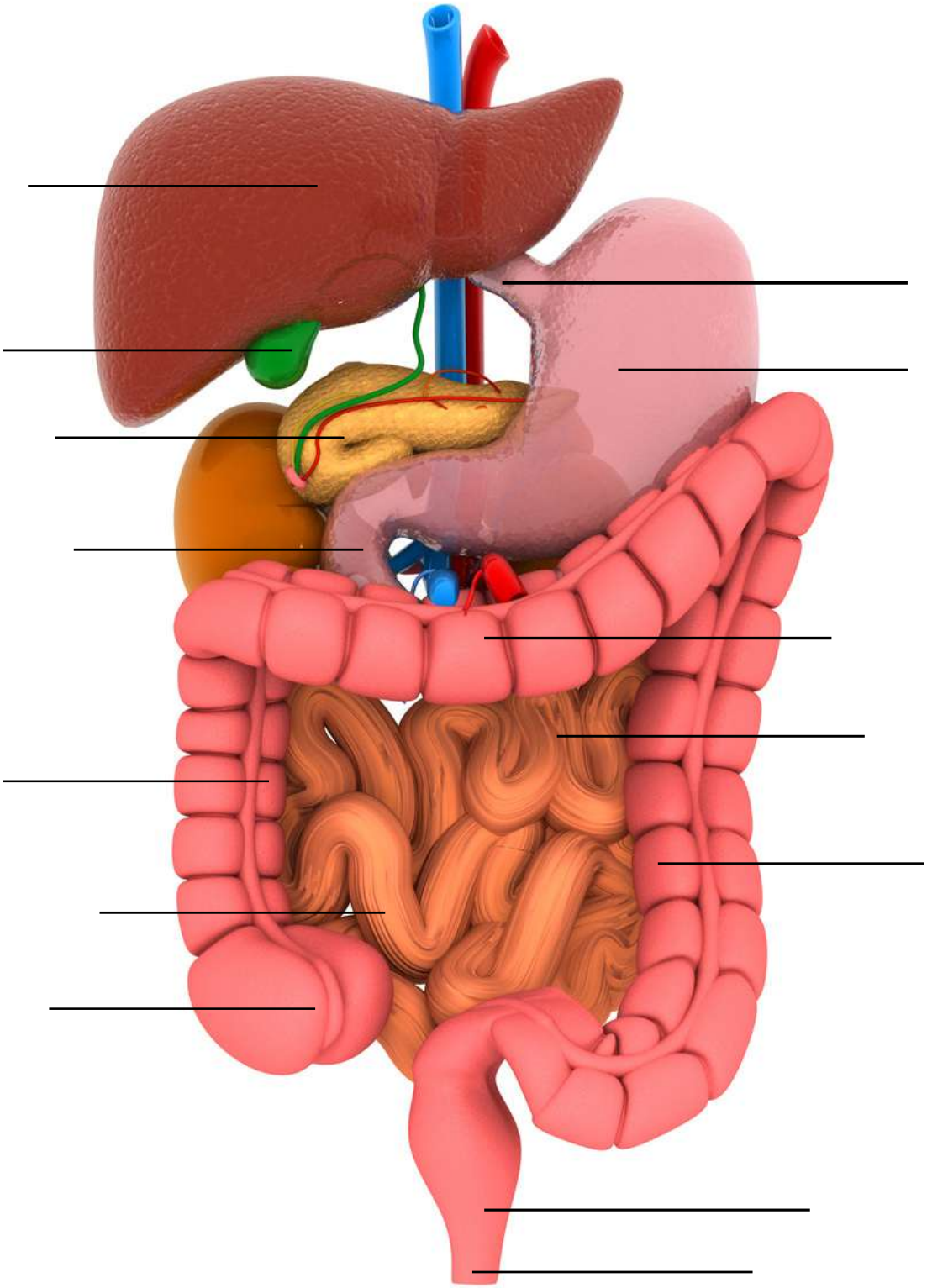
THE DIGESTIVE SYSTEM AT-A-GLANCE

Function	The digestive system is responsible for taking whole foods and turning them into nutrients and energy, which allows the body to function, grow and repair itself.
Components	Mouth, esophagus, stomach, small intestine, large intestine, rectum, liver, pancreas, gallbladder.
Important vocabulary	Homeostasis, mouth, salivary glands, salivary amylase, palate, esophagus, pharynx, epiglottis, esophageal sphincter, bolus, peristalsis, stomach, chyme, mucus cells, parietal cells, peptic cells, pepsin, HCl, peptides, pyloric sphincter, pancreas, mesenteric vessels, exocrine, endocrine, pancreatic duct, alkaline, neutralize, basic, amylase, peptidases, lipases, nucleases, glycogen, glucose, secretin, gallbladder, bile, bile duct, small intestine, enzymatic hydrolysis, duodenum, jejunum, ileum, villi, microvilli, cytoplasmic, amino acids, lipoproteins, large intestine, cecum, iliac crest, appendix, ascending colon, transverse colon, descending colon, rectum, feces, anus, liver.

Digestive System Major Structures (Teacher Copy)



Digestive System Major Structures (Student Copy)



Digestive System Food Flow (Teacher Copy)

Explore the path food moves through within the digestive system, noting the function and structure of each major organ, using the apps provided, and fill out your workbook.

Order	Organ	Structure, function & information
1	Mouth	2 Types of Digestion: • **Mechanical Digestion:** chewing • **Chemical Digestion:** saliva breaks down carbohydrates/starches 3 sets of **salivary glands** produce saliva to lubricate and break down the food. **Teeth:** mix of canines and molars to masticate (tear/bite/grind/crush) the food into smaller pieces. **Tongue:** muscular organ that mixes the food with saliva and aids with swallowing. **Salivary Amylase:** enzymes that digest the carbohydrates in the mouth. **Palate:** forms the roof of the mouth.
2	Esophagus	• From the **mouth**, food passes through the **pharynx** (5-6 inches long). • During swallowing, the sphincter muscles relax and raise the **epiglottis**, which prevents the bolus from entering the trachea. • After bolus leaves pharynx, it enters the **esophagus**. • **Peristalsis:** contractions of the esophagus that move food bolus along in a wave like motion. • **Esophageal sphincter:** separates esophagus from the stomach to prevent food reflux.
3	Stomach	Thick-walled, J-shaped organ, lies on left side of body, under diaphragm. Stores food and mixes it with **gastric juice**. Bolus enters the stomach, then is converted to semi-fluid, partially digested food called **chyme**. Stomach contents are extremely acidic (pH b/w 1.5-2.5). Acidity breaks down food tissues, kills microorganisms & activates digestive enzymes. 3 layers of muscles churn and mix contents by contracting. Pacemaker cells stimulate stomach contractions, which increase in number the fuller the stomach. Hunger pains= churning of an empty stomach. Mucus lining of stomach contains inner gastric juice producing gastric glands. Stomach empties into the first part of the **small intestine (duodenum)**. **Pyloric sphincter** at the bottom of the stomach controls this emptying.

3.1	Pancreas	Location: just below the stomach Two types of tissues: • **Acinar Cells -** secrete digestive juices which travel through pancreatic duct to small intestine • **Islets of Langerhans:** secrete insulin and glucagon into blood Connections: Plentiful blood supply through mesenteric vessels. Mesentery connective tissue holds it in place. Pancreatic and common duct connect it to the small intestine. Pancreas supplies **digestive enzymes** to break down: lipids (fats) into glycerol and fatty acids, carbohydrates into glucose, proteins into amino acids. These are released into the duodenum via the pancreatic duct.
3.2	Gallbladder	Stores bile produced in the liver, which is released into the duodenum via the bile duct. Breaks down fatty contents of food.
4	Small Intestine (SI)	Site of most enzymatic hydrolysis of food and absorption of nutrients (~ 6m in length). Made up of 3 major sections: • **Duodenum** - 25-30 cm long, receives food from stomach, receives bile & pancreatic juice through common duct. Site of most active enzyme production and digestion. • **Jejunum** - 1-1.5 m long, fewer intestinal glands, more specialized for absorption. • **Ileum** - 4-5 m long, produces no enzymes, but does most of the absorption of nutrients not taken up by jejunum or duodenum. Large surface area of SI results from several levels of folding: **Circular folds** in submucosa slow passage of food and increase the area. Covered with **villi** - finger-like microscopic projections, which themselves are covered with **microvilli** - tiny cytoplasmic projections from the surface of individual columnar epithelial cells. Capillaries wrap around villi to absorb nutrients. SI Function: neutralize acidity of the acid stomach contents with bicarbonate from pancreas. Mechanically mixes chyme w/**pancreatic juice**, **bile** and intestinal secretions to continue breakdown of food. Absorbs simple sugars and amino acids into blood by active transport (requires ATP). Absorbs fatty acids and glycerol, reassembles into new fat molecules, coats them with lipoproteins and cholesterol and sends them into the lymph system. Blood vessels from villi in SI merge to form **hepatic portal vein** (which leads to liver).

5	Large Intestine (LI)	Size: 1.5m long. Joins w/ SI near iliac crest, in the lower right corner of abdomen. The **caecum** is the name given to the blind end of the LI. Appendix projects from the caecum. LI has 4 major parts: • **Ascending colon:** rises up right side of the abdomen • **Transverse colon:** crosses top of abdomen • **Descending colon:** goes down left side where it joins the • **Rectum** Feces are formed from indigestible food, excreted materials and bacterial cells. Feces leave through the anus. Anus normally held closed by internal (smooth) and external (skeletal) anal sphincters. Functions: **Peristalsis** - mechanical movement moves feces along. **Absorption** - some salts and water absorbed from feces. Bacteria (E.coli) work on undigested food from the SI and produce gases (flatulence, about 1.5L/day), amino acids and some vitamins. The intestinal lining absorbs the amino acids and vitamins produced. Unlike the SI, the LI does NOT have villi.
6	Liver	Location: on the right side of the body, under the ribs, below the diaphragm. Size: 2 lobes, roughly triangular, ~1.5 kg. Connections: all blood from the intestines travels through the **hepatic portal vein** and arrives at the liver. Functions: 1. Produces **bile** that breaks down (emulsifies) fats into small droplets, but large enough surface area for pancreatic lipase to work on. Bile is stored in **gallbladder**. Bile is green b/c it contains broken down hemoglobin pigments from liver. 2. Converts **glucose** to **glycogen** post meal, then in the hours between meals, back to glucose. 3. Maintains blood sugar levels under control of pancreatic hormones. 4. Interconverts carbs to fats, and amino acids to carbs and fats. 5. Converts hemoglobin (from old blood cells) into **bilirubin**, pigments which give bile its colour. 6. Produces blood proteins, like **albumin**. These proteins regulate the osmotic balance of blood and fibrinogen (aids in blood clotting). 7. Breaks down and detoxifies: blood circulating hormones, alcohol, some antibiotics, many drugs, and toxins found in some foods. 8. Stores iron and vitamins. 9. Makes **cholesterol.**

Digestive System Food Flow (Student Copy)

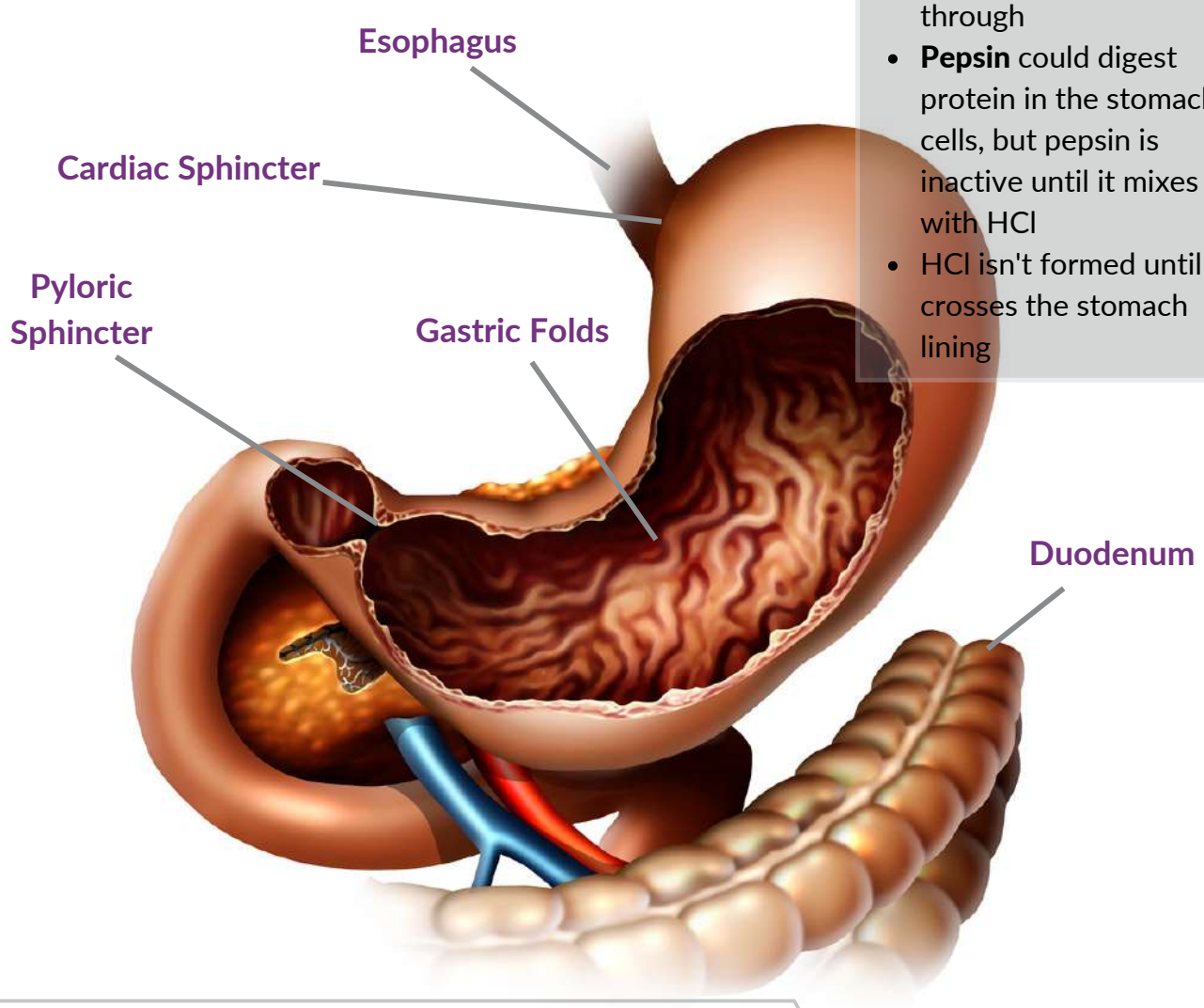
Explore the path food moves through within the digestive system, noting the function and structure of each major organ, using the apps provided.

Order	Organ	Structure, function & information
1	Mouth	
2	Esophagus	
3	Stomach	

3.1	Pancreas	
3.2	Gallbladder	
4	Small Intestine (SI)	

5	Large Intestine (LI)	
6	Liver	

Components in Detail:
Stomach Anatomy (Teacher Copy)



Why doesn't the stomach digest itself?

- A mucus layer prevents the **HCl** from eating through
- **Pepsin** could digest protein in the stomach cells, but pepsin is inactive until it mixes with HCl
- HCl isn't formed until it crosses the stomach lining

There are 3 types of stomach cells:

- **Mucus cells**: secrete protective coat
- **Parietal cells**: secrete **HCl** (pH 3) which kill bacteria and help breakdown food
- **Peptic cells**: secrete **pepsinogen**, which forms the enzyme **pepsin** when combined with **HCl**. Pepsin is a **hydrolytic enzyme** that breaks down proteins into smaller amino acid chains called **peptides**
- Peptides are broken down into individual amino acids further on in digestive system by other enzymes

Protein + H2O --- Pepsin ---> Peptides

Components in Detail:
Stomach Anatomy (Student Copy)

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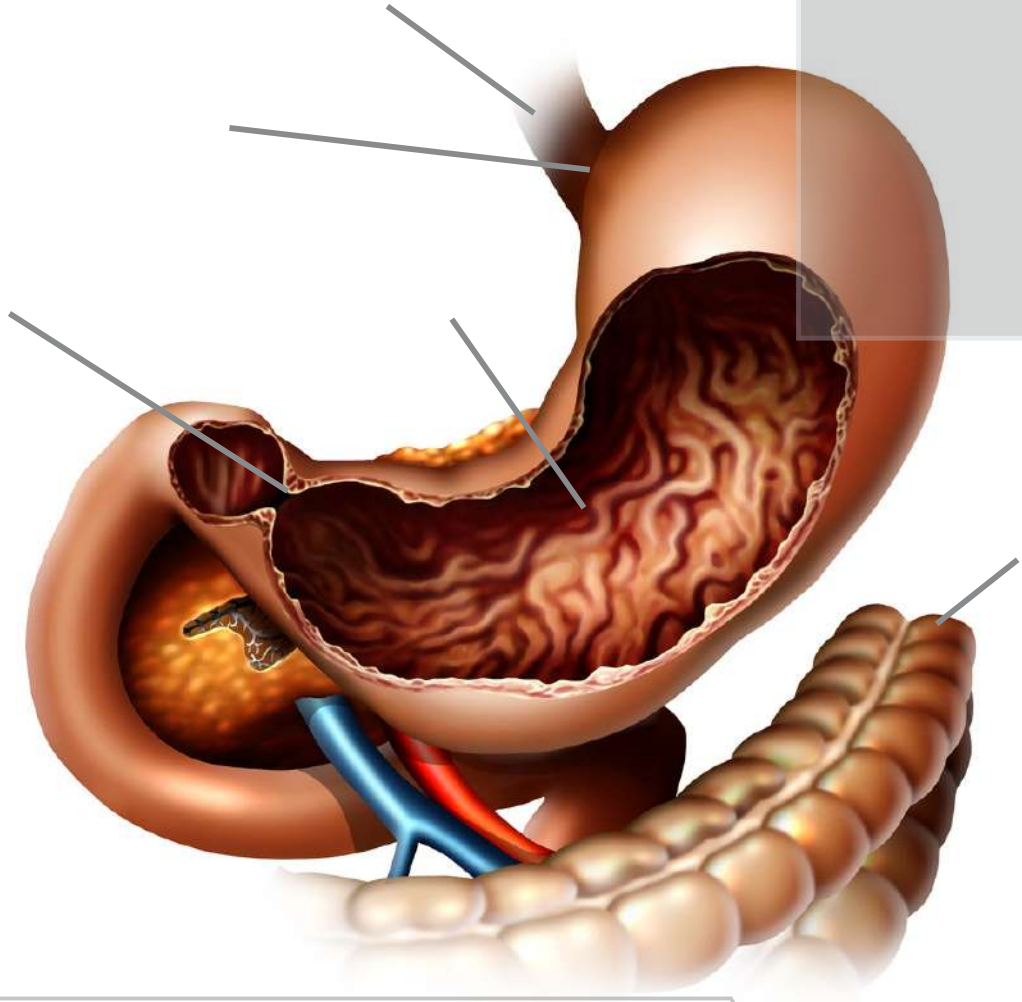

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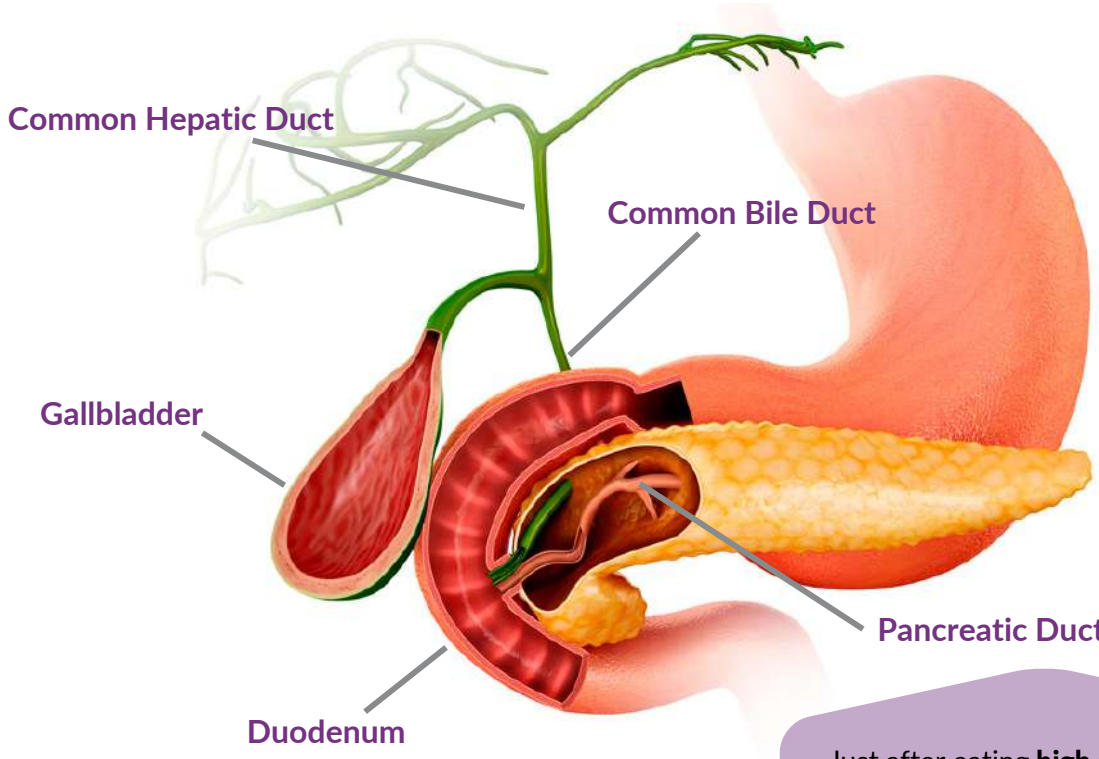
Components in Detail:
Pancreas (Teacher Copy)

Exocrine Functions: cell secretions are released into a duct

- **Produces bicarbonate ions (HCO_3)**.
  - These neutralize stomach acids and make pH of intestine 7-8 (alkaline).
  - released through pancreatic duct. Small intestine enzymes are optimum at basic pH
- **Produces digestive enzymes**: amylases, peptidases, lipases, and nucleases
  - released through pancreatic duct into the small intestine

Endocrine Functions: cell secretions released into blood

- **Produces insulin**: controls cellular uptake of glucose and its conversion into glycogen (insulin secreted when low glucose levels in blood).
- **Produces glucagon**: stimulates conversion of glycogen into glucose (glucagon secreted when high glucose levels detected in blood)
- This regulates blood sugar.



Just after eating **high glucose** level food, **insulin** is secreted which causes cells to take up glucose in the liver and muscle. Glucose is then converted into **glycogen** for storage. When fasting, glucagon converts glycogen in the liver and muscle into glucose

Components in Detail:
Pancreas (Student Copy)

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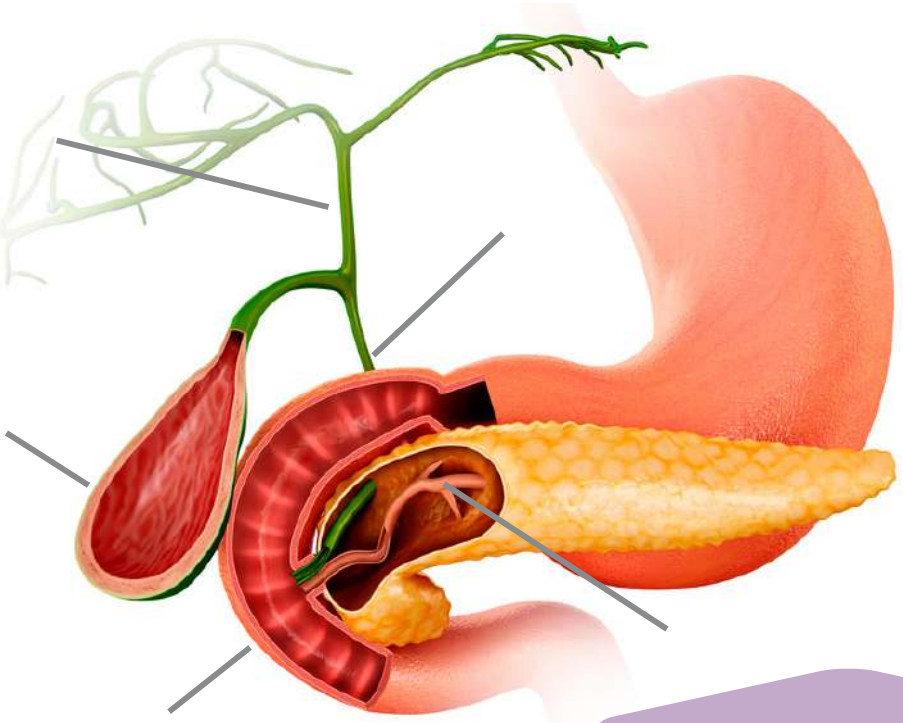

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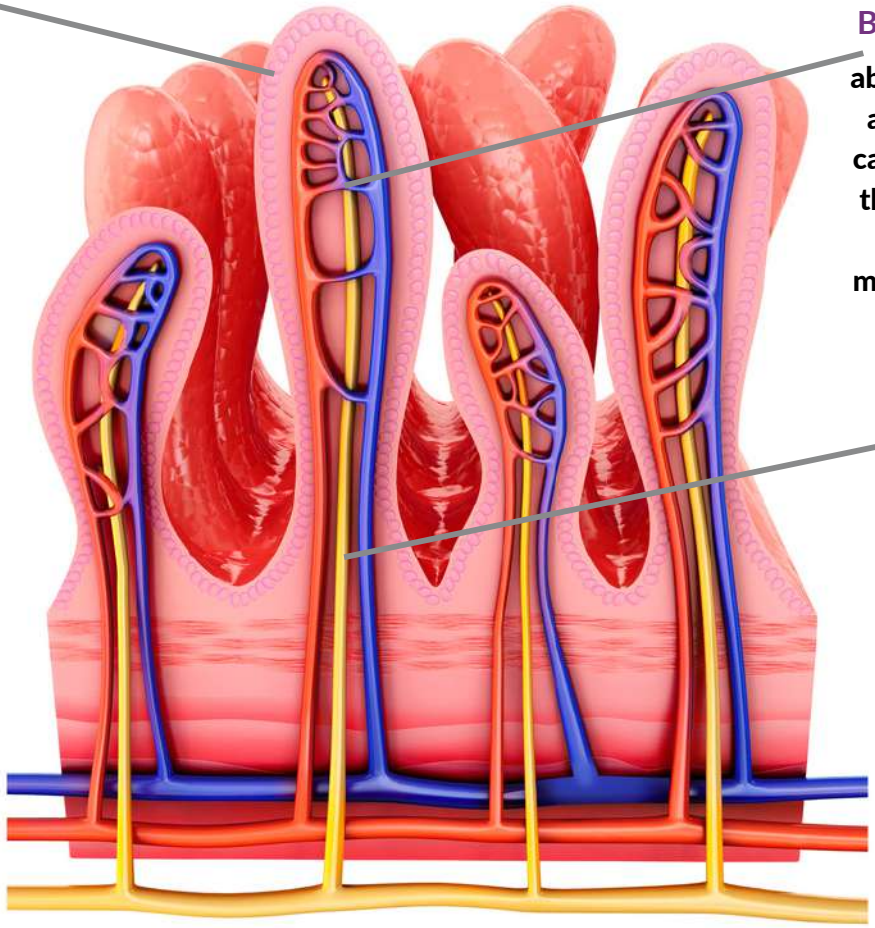
Components in Detail: Villi and Nutrient Breakdown

Epithelial cells

Outer layer of villi one cell thick to increase rate of diffusion.
Can be covered in various types of cells with different functions:

- microvilli for absorption
- glandular cells produce and release enzymes/mucus into intestinal lumen
- some have digestive enzymes bound to their outer membrane



Blood Capillaries

absorb amino acids and glucose, and carry them back to the hepatic portal vein, liver and mesenteric vessels

Lacteal

Lymph vessel that returns lipoprotein droplets and fluid to bloodstream

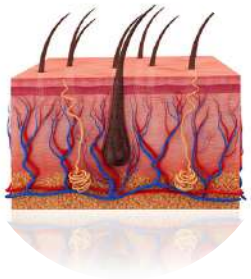
Nutrient Breakdown

Complex Carbohydrates (starch)	Amylases →	Disaccharides (maltose, lactose)	Maltase Lactase →	Glucose
Proteins	Pepsin Trypsin →	Short polypeptides	Peptidases →	Amino Acids
Fats	Cholesterol + Bile Salts →	Emulsified Fat droplets	Lipases →	Fatty acids + Glycerol
Nucleic Acids	Nucleases →	Phosphates, sugars, and bases		

How Does the Digestive System Work Together With Other Organ Systems? (Teacher Copy)

Ask students how they think the different organ systems work together based on what they've learned so far – specific questions can include:

1. How does the integumentary and digestive system interact?
2. How does the muscular system aid in digestion?
3. Does the digestive system produce any hormones ? How do they interact with the body?
4. What does the Hepatic Portal System have to do with the digestive and cardiovascular system?



Integumentary System

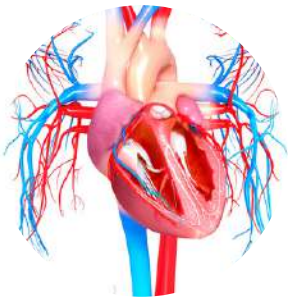
The skin provides **vitamin D**, which plays an integral role in the absorption of **vitamin C** in the digestive tract, and helps protect the digestive tract. The digestive system provides nutrients required by skin, hair, and nails.

Muscular System

Peristalsis is created by **smooth muscles**, while **skeletal muscles** aid in voluntary sphincter control, swallowing, and protect and support abdominal organs. The digestive system provides cellular energy (**ATP**), which is required by muscular cells, from micro-nutrients produced in the digestive tract. Lactic acid build up after muscle activity is metabolised by the liver.

Endocrine System

Endocrine hormones aid in secretion regulation in accessory organs and digestive glands; glucose storage in the liver is controlled by insulin and glucagon. Hormones are also produced by the small intestine and stomach.



Cardiovascular System

Blood vessels transport nutrients from the digestive system to various other parts of the body. Nutrients from the digestive system are provided for the formation of blood cells and plasma protein. Plasma proteins are produced by the liver. It also destroys old red blood cells and detoxifies blood.

How Does the Digestive System Work Together With Other Organ Systems? (Student Copy)

Ask students how they think the different organ systems work together based on what they've learned so far – specific questions can include:

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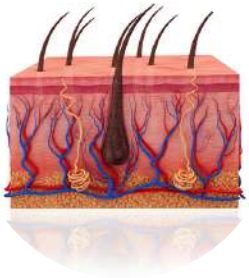
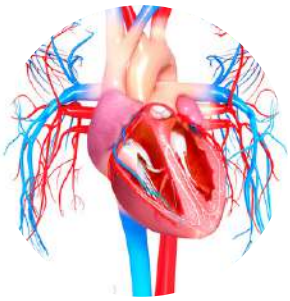


Integumentary System

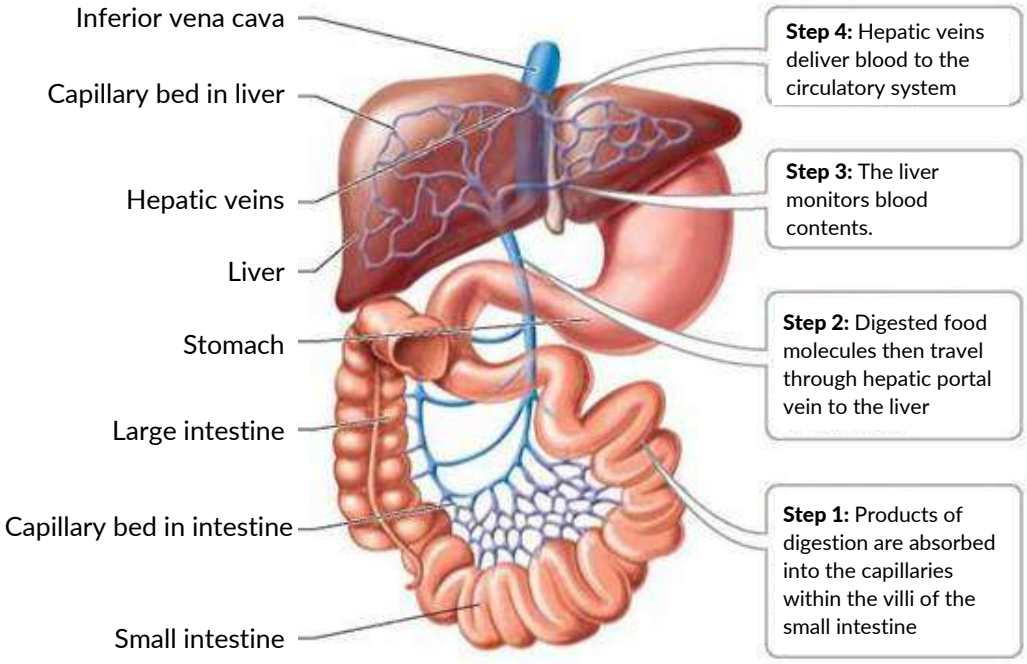
Muscular System

Endocrine System



Cardiovascular System

Hepatic Portal System:
Cardiovascular and Digestive System Interdependence



The hepatic portal system is a series of veins that carry blood from the capillaries of the stomach, intestine, spleen, and pancreas to capillaries in the liver. It is part of the body's filtration system. Its main function is to deliver de-oxygenated blood to the liver to be detoxified further before it returns to the heart.

The hepatic portal system consists of:

- **Hepatic portal vein:** This is the main vein connected to the liver. It forms at the connection of the inferior and superior mesenteric veins.
- **Inferior mesenteric vein:** This vein takes blood from the colon and rectum and connects with the portal vein.Superior mesenteric vein: This drains blood from the small intestine and connects with the hepatic portal vein.
- **Gastrosplenic vein:** This tributary is formed by the union of the splenic vein from the spleen and the gastric vein from the stomach. It joins with the mesenteric vein inside the pancreas.

The hepatic portal system is designed to rid the body of toxins, and it cannot detect those that are designed to help it. Some drugs must be taken under the tongue, through the skin, or via suppository to avoid entering the hepatic portal system and being prematurely metabolized in the liver before reaching general circulation.

How Does the Digestive System Help Maintain Homeostasis?

To keep the internal environment in the body functioning properly, maintaining homeostasis is required. The digestive system, along with other body systems, help maintain energy homeostasis.

Provide Nutrients

For all systems to work properly, the body needs **macro** and **micro-nutrients**. Chemical and mechanical digestion break down ingested food to gain access to these nutrients. This begins in the **mouth**, where food is mixed with **enzymes and saliva**, and continues as it enters the stomach, where it is mixed and **gastric juices** and churned into **chyme**. The **stomach** also produces several hormones that regulate digestion of food. Once the chyme enters the **small intestine**, it is further digested by bacteria. Nutrients are **absorbed** by the small intestine, with some further absorption of water occurring in the **large intestine**.

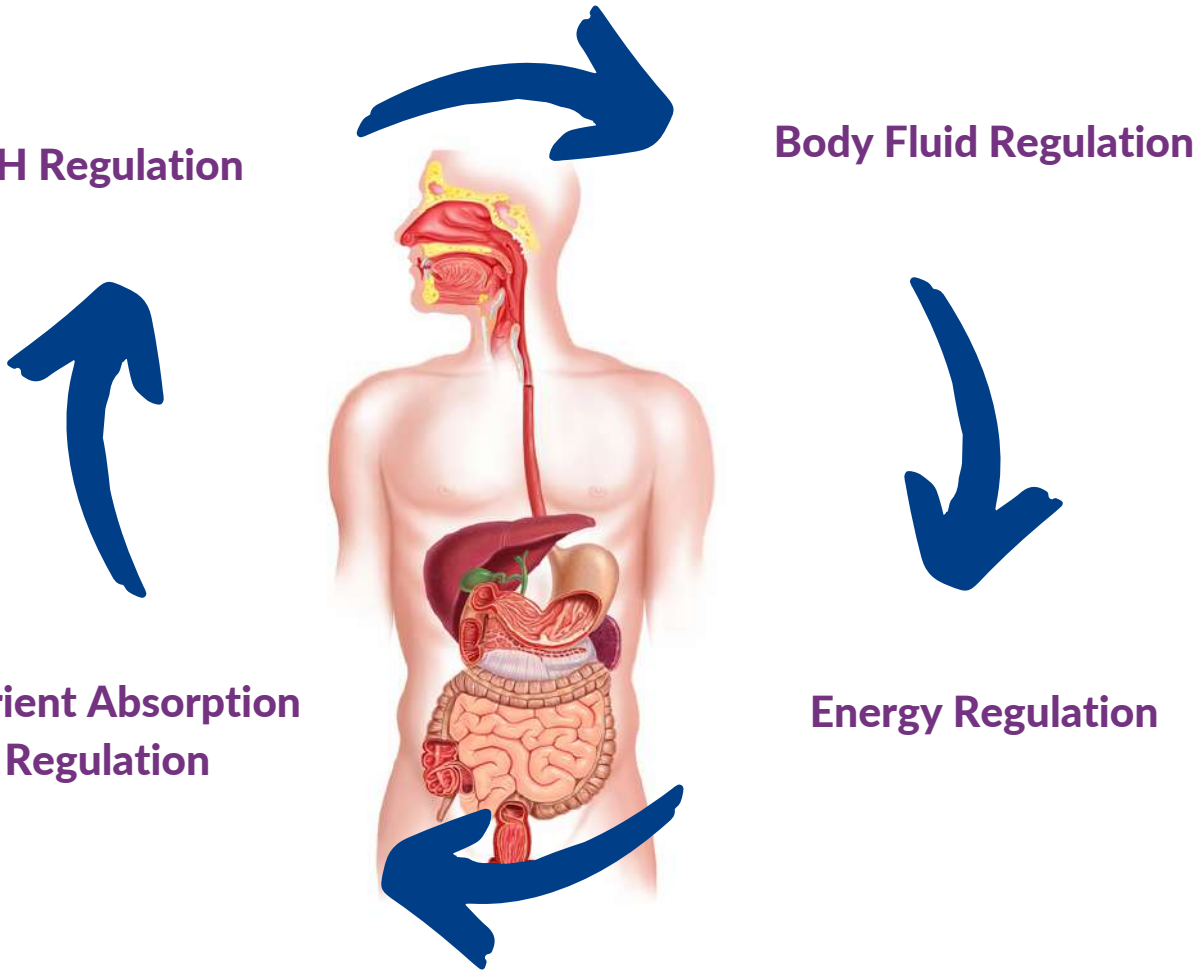
Bacterial flora located in the intestine are essential in the role of **homeostasis**. They both allow for nutrient absorption by breaking down the food, and produce vitamins such as **biotin** and **vitamin K**, which help protect harmful bacteria from entering the system.

Digestive Organs

The **bile salts** manufactured by the **liver** that enter the intestines help **emulsify fats**, simplifying their absorption and digestion process. The liver is a vital player in the role of homeostasis. It breaks down alcohol, drugs, and other toxic substances. It stores **glucose** as **glycogen** after meals, and produces **plasma proteins**. In between meals, it releases glucose to keep the concentration of blood glucose constant, regulating the body's blood sugar.

What are some other examples of the digestive systems ability to maintain homeostasis within the body?

How Does the Digestive System Help Maintain Homeostasis?



In Summary:

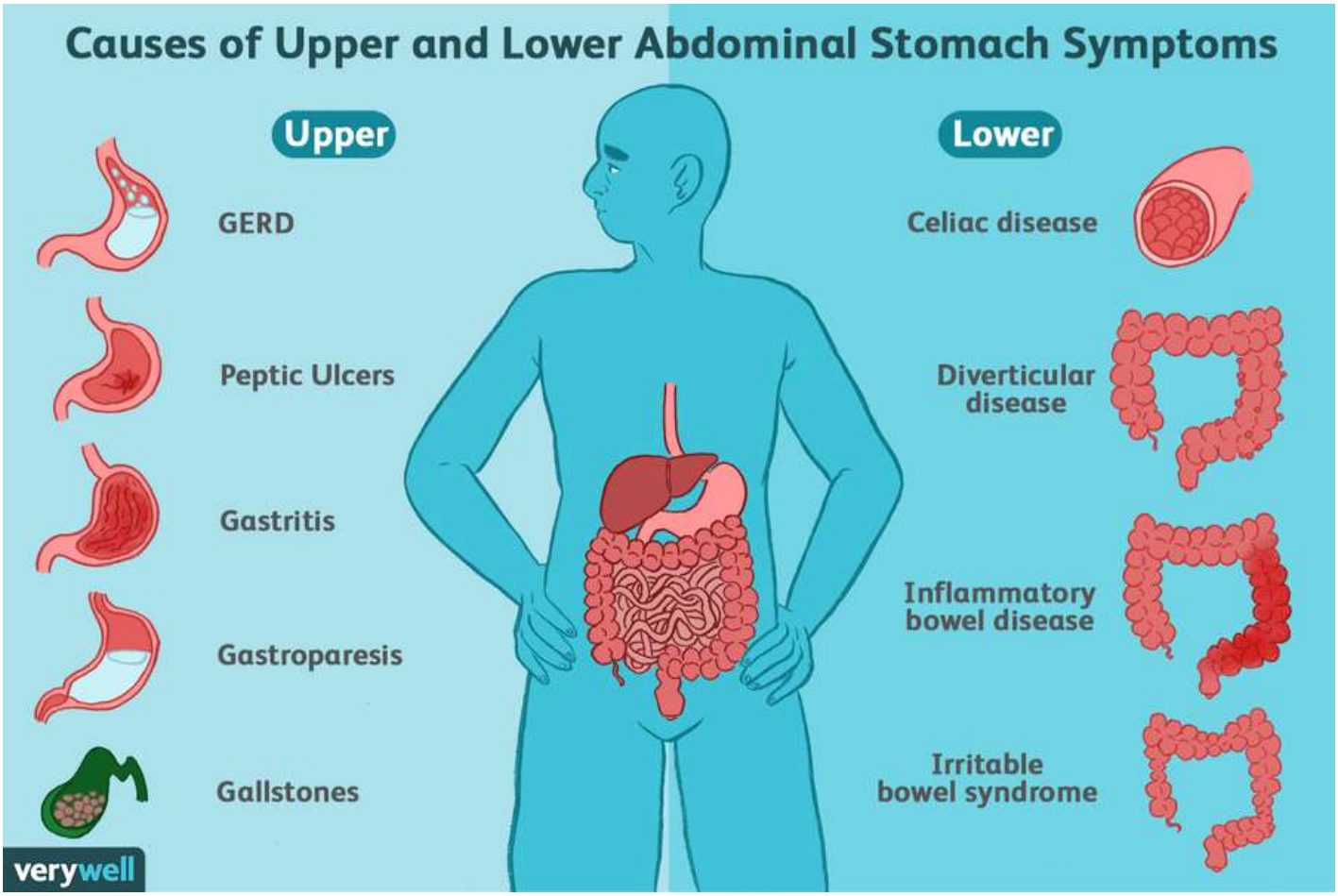
What is the digestive systems role in homeostasis?

- To transfer nutrients to the internal environment from the external environment

Examples:

- **Provides energy** required by cell processes according to individual needs, these molecules must constantly be replaced
- **Avoids losses to body proteins** by maintaining a positive nitrogen balance
- **Provides vitamins and nutrients** that cannot be synthesized by cells, e.g. essential amino acids/fatty acids
- **Maintains body fluid composition**, like urine, bile, or sweat, despite incorporation into body structures (bones/other tissues) or losses from the body

Common Digestive Diseases



Gastroesophageal reflux disease (GERD): GERD is the main cause of the symptom commonly known as heartburn. When the lower esophageal sphincter isn't functioning properly, stomach contents back up (or reflux) into the esophagus. It's a very common condition, marked by a burning sensation in the upper abdomen, usually after eating.

Peptic ulcers: A peptic ulcer is an erosion of the lining of the stomach or duodenum caused by stomach acid and pepsin (a digestive enzyme). Symptoms can include bleeding, gastric obstruction and in some cases, life-threatening perforation. Most peptic ulcers are caused by a Helicobacter pylori (H. pylori) infection.

Gastritis: Gastritis is an inflammation of the stomach lining with symptoms similar to heartburn. It's usually treated with medication to reduce stomach acid.

Gastroparesis: Also referred to as delayed gastric emptying, gastroparesis is a disorder in which the stomach takes too long to empty its contents, usually caused by damage to the stomach nerves.

Gallstones: Gallstones can form in the gallbladder when bile hardens. When gallstones block the cystic duct of the gallbladder, you may feel severe pain.

Celiac disease: People who have celiac disease can't eat gluten since it damages the small intestine. This is a condition you would need to have diagnosed by a healthcare provider, and it's often mistaken for other gastrointestinal disorders before being recognized.

Diverticular disease: Diverticulitis is the inflammation of diverticula, which are protrusions in the walls of the intestines. The presence of these sacs is known as diverticulosis. Most people with diverticulosis may never experience symptoms. Diverticulitis, on the other hand, produces sharp pains in the lower left abdomen, usually accompanied by a fever. If you suspect diverticulitis, see a healthcare provider as soon as you can. If left untreated, diverticulitis can cause life-threatening complications.

Inflammatory bowel disease: This is an umbrella term for two separate conditions: ulcerative colitis and Crohn's disease. Both are chronic conditions that require lifelong monitoring and treatment.

Irritable bowel syndrome (IBS): People dealing with this very common digestive disorder have recurring abdominal pain, and either diarrhea, constipation or both.

Closing Check-In and Discussion

During the check closing in:

Recap with the students the path food moves through within the digestive system. Go over ways the digestive system interacts with other body systems, as well as how it helps maintain homeostasis. Ask the following questions:

- **Were you able to successfully learn the structure and function of individual parts of the digestive system?**
- **How might virtual dissections and models compare with using real specimens?**

Closing - Discussion on Ethics

The knowledge to create these accurate virtual models of the digestive system had to initially come from real humans and or animals. However, now that we have such a plentiful resources for accurate models of these structures, as well as the ability to perform dissections virtually, do you think we need to continue using animals? Why or Why not?

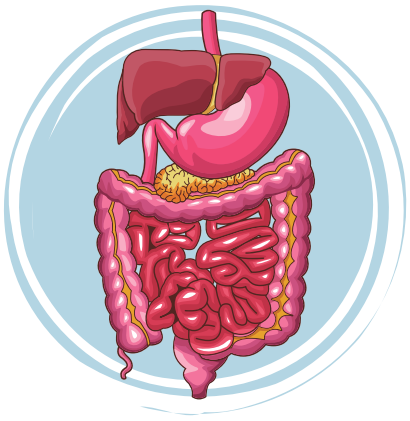
Think

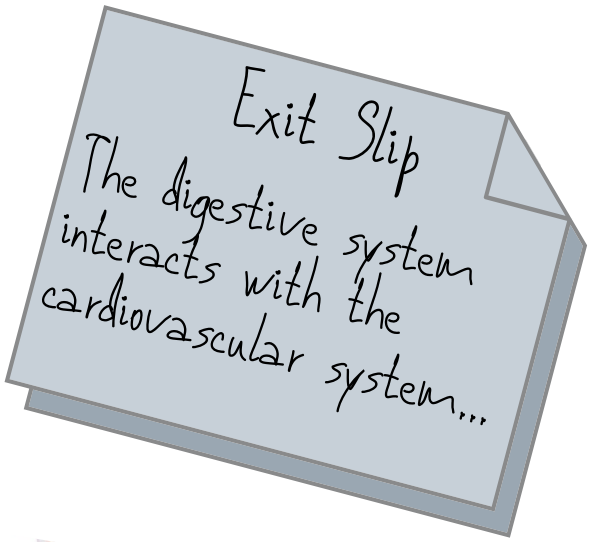
Ask the students to think about where they stand on the subject of animal dissections and the use of animals in science. They don't need to answer right away, rather, this is to get them to start forming their own ethical opinions and will be discussed later on in the unit.

Formative Assessment

The formative assessment can be in the form of an exit slip. This involves asking each student at the end of the class to answer 2-3 questions on a sheet of paper and hand it in, with their names on it, to ensure understanding of the main concepts covered. Examples of questions to include:

- **What is one way the digestive system maintains homeostasis within the body?**
- **What is one way the digestive system interacts with other body systems?**
- **What are the main structures food moves through within the digestive system?**





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