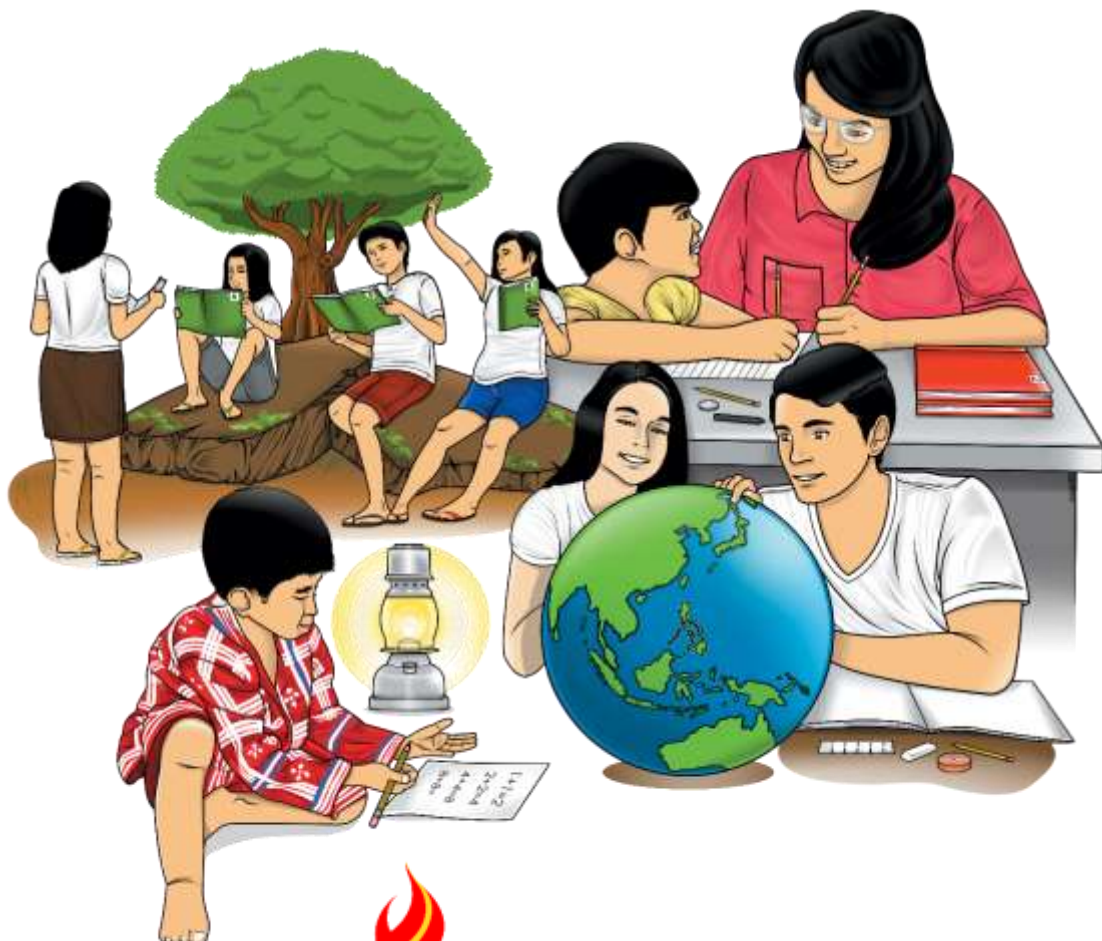


Science

Quarter 4 – Module 1: Structures and Functions of the Digestive System



Science – Grade 8
Alternative Delivery Mode
Quarter 4 – Module 1: Structures and Functions of the Digestive System
First Edition, 2020

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Science

Quarter 4 – Module 1: Structures and Functions of the Digestive System

Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.



What I Need to Know

This module was designed and written with you in mind. It is here to help you master the structures and functions of the digestive system. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students. The lessons are arranged to follow the standard sequence of the course. But the order in which you read them can be changed to correspond with the learner's material you are now using.

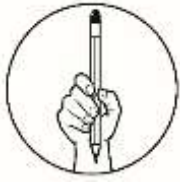
This module contains:

Lesson 1 – The Digestive System

After going through this module, you are expected to:

1. Identify the organs that make up the digestive system;
2. Give the function of each organ;
3. Describe how some accessory organs and glands help the body in the digestive process; and
4. Explain ingestion, digestion, absorption, assimilation, and excretion.

(MELC Week 1 S8LT-IVa-13)



What I Know

Directions: Choose the letter of the correct answer. Write your answers on a separate sheet of paper.

1. In what process do animals take in food that provides energy and nutrients?
 - A. assimilation
 - B. digestion
 - C. excretion
 - D. ingestion
2. The process in which digested foods are distributed into different parts of the body cells are _____.
 - A. assimilation
 - B. digestion
 - C. excretion
 - D. ingestion
3. What is the process of turning food into smaller molecules with the aid of enzymes?
 - A. churning
 - B. mastication
 - C. chemical digestion
 - D. mechanical digestion
4. Where does the final stage in digestion of food happen?
 - A. liver
 - B. mouth
 - C. small intestine
 - D. large intestine
5. What type of enzyme present in saliva helps break down starch?
 - A. amylase
 - B. lactase
 - C. lipase
 - D. maltase
6. Which of the following breaks down food into tinier pieces to begin mechanical digestion?
 - A. esophagus
 - B. stomach
 - C. teeth
 - D. tongue

7. What organ system is responsible for breaking down of large molecules into smaller molecules and absorption of organic compounds needed by the body?
- A. circulatory system
 - B. digestive system
 - C. Nervous system
 - D. respiratory system
8. What is the main function of the large intestine?
- A. It breaks down hemoglobin.
 - B. It secretes digestive enzymes.
 - C. It regulates the release of bile.
 - D. It reabsorbs water from chyme.
9. What do you call the wavelike contraction of the smooth muscles of digestive tract pushes food in small sections through the gastro-intestinal tube?
- A. mixing movement
 - B. parietal movement
 - C. contractile movement
 - D. peristaltic movement
10. If the liver is severely damaged, metabolism of which nutrients would be most affected?
- A. carbohydrates
 - B. lipids
 - C. proteins
 - D. All of the above
11. What is the most essential function of the intestinal villi?
- A. pushes the fecal matter into the rectum
 - B. increases surface area for nutrient absorption
 - C. secretes serous fluid to decrease friction among the organs
 - D. secretes mucous to facilitate the movement of chyme via the alimentary canal
12. Which of the following shows the correct sequence of the processes involved in the human digestive system?
- A. assimilation, absorption, ingestion, digestion, and egestion
 - B. digestion, ingestion, assimilation, egestion and absorption
 - C. egestion, absorption, digestion, assimilation and ingestion
 - D. ingestion, digestion, absorption, assimilation and egestion
13. What is the term for the food that is chewed and mixed with saliva that turns into a moist ball?
- A. bolus
 - B. chyme
 - C. feces
 - D. gastric juice

14. It is the process by which the nutrients from the digested food move into the blood vessels passing through the lining of the small intestine.
- A. assimilation
 - B. digestion
 - C. egestion
 - D. elimination
15. Which of these substances is an enzyme that digests protein in the stomach?
- A. amylase
 - B. hydrochloric acid
 - C. pepsin
 - D. saliva

Lesson

1

The Digestive System

Why do we eat? Is eating necessary in keeping us alive? Where do we get the energy that enables us to carry out the many activities that we do each day? How do we obtain materials needed for the growth and repair of body parts?

The food that we eat plays a central role in the survival of species. It provides the energy that enables us to carry out the many activities that we do each day such as breathing, walking, studying and cooking. Food also provides the substances needed for growth and repair of body parts.

The cells in the body need food for energy used for growth and repair. Food must be broken down into a form that these microscopic cells can use. The body changes food into a usable form by means of a group of organs referred to as the **digestive system**.



What's In

Activity 1. Tummy Puzzle!

Directions: Hidden in the word puzzle are terms associated to digestive system. Pick fifteen (15) of these terms and write your answers on a separate sheet of paper.

M	W	Q	S	D	F	F	O	O	D	M	E	T	S	Y
O	T	R	S	A	L	I	V	A	Z	G	S	Q	M	K
U	B	P	A	N	C	R	E	A	S	A	O	G	A	H
T	E	E	T	H	X	M	P	X	S	L	P	D	L	H
H	H	J	O	C	K	L	P	F	H	L	H	W	L	Q
S	D	F	N	A	H	A	H	S	Q	B	A	T	I	G
G	H	J	G	M	K	L	A	F	Q	L	G	W	N	T
A	S	W	U	O	R	T	R	Q	D	A	U	T	T	G
F	G	H	E	T	M	J	Y	R	K	D	S	L	E	P
F	S	W	E	S	G	H	N	E	J	D	K	L	S	V
L	I	V	E	R	F	B	X	C	D	E	Q	E	T	Y
G	H	J	K	V	D	F	G	T	A	R	X	A	I	W
G	H	J	K	D	S	A	N	U	S	Q	E	R	N	T
H	J	K	S	A	E	W	A	M	X	C	B	F	E	Q
L	A	R	G	E	I	N	T	E	S	T	I	N	E	F



Note to the Teacher

Please provide the students with a loose copy of this puzzle.



What's New

Activity 2. A Gutsy Game!

This activity is a board game that needs at least two players. The game demonstrates the flow of food into our digestive system. The first one to reach the finish tile wins!

Objectives:

After performing this activity, you are expected to:

1. Identify the parts that compose the digestive system; and
2. Describe the function of each organ.

Materials Needed:

Game board (refer to page 7)

A piece of cube dice or six-sided small box with numbers 1 to 6

Playing token (e.g., pebble, button, etc.)

Procedure:

1. Find someone whom you can play the board game with.
2. Choose a playing token for you and your playmate; place your tokens on the board's starting line.
3. Take turns in rolling the dice.
4. The number on the dice tells the number of boxes you may move your token.
5. Should your token land on a box with instructions beside it, execute the instructions.
6. The player who first makes it all the way throughout the digestive system and down to finish line wins the game.

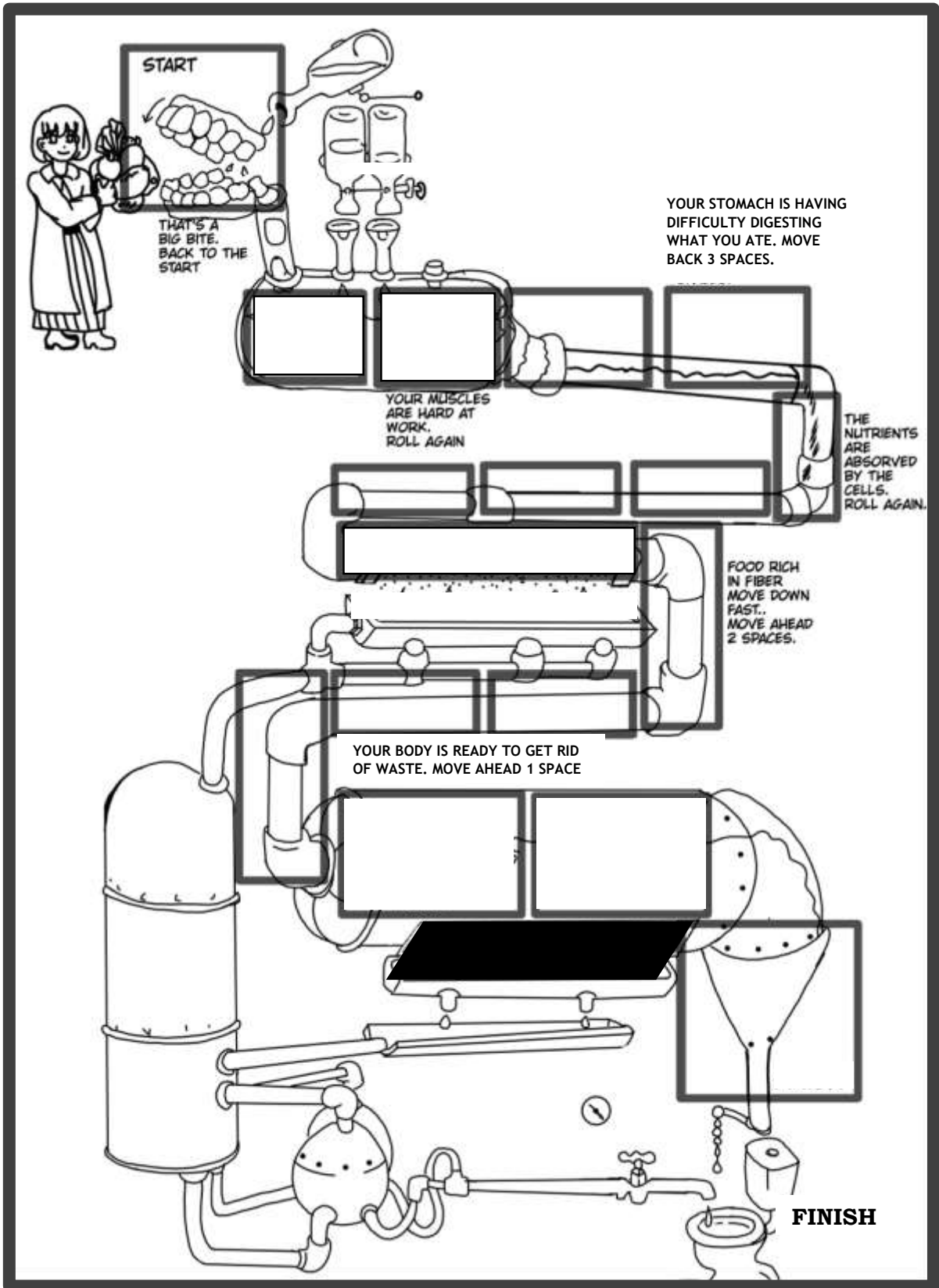
Questions:

1. What does the playing token represent?
_____ .

2. What do the boxes on the game represent?
_____ .

3. What do the instructions beside the boxes tell you about the digestive system?
_____ .

BOARD GAME



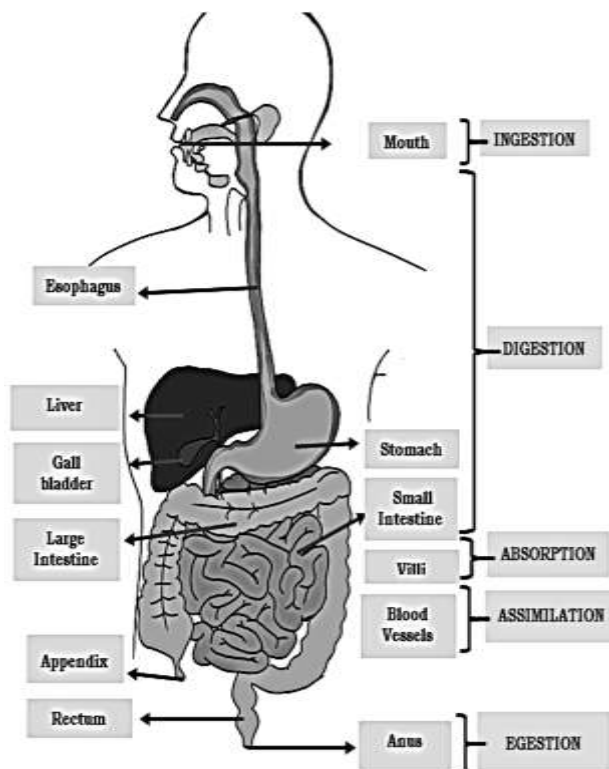
Illustrated by: Rosa Mia L. Pontillo



What is It

In Activity 1, you must have inferred that the digestive system is composed of different organs that work together to break down food and nourish the body. It also involves important processes in order to carry out the function of the digestive system.

The function of the digestive system is **digestion**, the breakdown of organic compounds into their simple forms for use by the cells. Digestion is the chief function of the digestive system. It breaks down food mechanically and chemically.



Let us take a journey throughout the human digestive system to see how it works and how the organs coordinate in order to carry out the processes of digestion (see figure 1). To make it a little more interesting, try to imagine what happens to a hamburger when eaten. Remember that ground meat is mostly protein, mayonnaise is mostly fat, and the bun is mostly carbohydrate. The journey of the food starts from the mouth down to the anus takes about 18-20 hours.

A. INGESTION is the first process that happens in digestive system. It is the journey of taking in food or any substance into the body through the **mouth**. The journey of food starts when a bit of hamburger enters your mouth.

Figure 1. Parts and Processes of the Digestive System

Illustrated by: Rosa Mia L. Pontillo

B. DIGESTION is the second process involved in digestive system. It is the process that involves break down of large food molecules into smaller molecules for easy absorption of the cells. Both chemical and mechanical digestions begin immediately in the mouth. While the food is in the mouth, the **teeth** cut, crush, and break it apart into tiny pieces while the **tongue** helps mix food with saliva secreted by the **salivary glands** forming into a moist ball called **bolus** so it can be easily swallowed. This process is known as mastication or chewing considered as a mechanical digestion, which is the initial stage of digestion. The saliva contains **salivary amylase**, the enzyme that breaks down starch into smaller carbohydrate. Then, the bolus passes from the mouth to the **esophagus** - a tube that attaches the mouth to the stomach. A series of wave-like muscle contractions known as **peristalsis** push and transport foods and liquids in small sections to the **stomach**.

The stomach is a J-shaped, bag-like muscular organ that can hold approximately one liter of fluid and food. The primary function of the stomach is to store food, which turns to chyme after being acted on by the stomach acid. **Chyme** is a semifluid material formed from bolus that is acted upon by the gastric juices secreted by the stomach. The walls of the stomach have special cells that secrete **gastric juices** like **hydrochloric acid** and **pepsin** that begin the chemical breakdown of proteins.

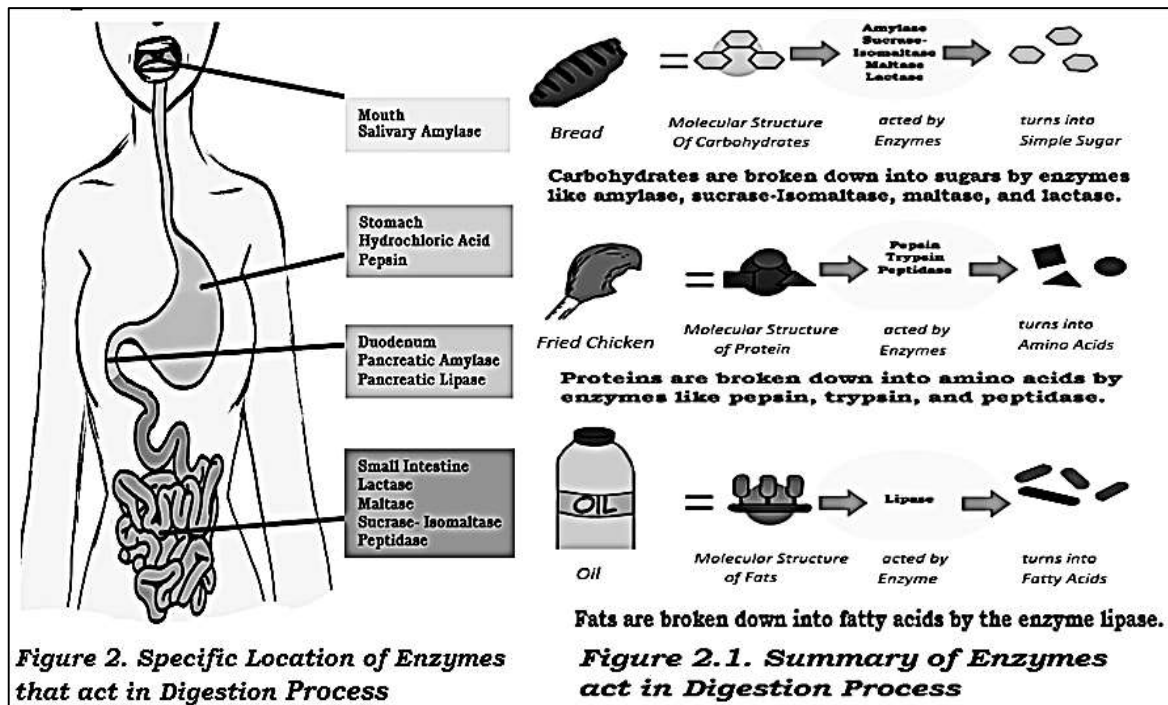


Figure 2. Specific Location of Enzymes that act in Digestion Process

Figure 2.1. Summary of Enzymes act in Digestion Process

Illustrated by: Rosa Mia L. Pontillo

Let us take a short detour into the three organs that are part of the digestive system and helps in secretion of essential substances. These organs are the liver, the pancreas and the gall bladder.

The **liver** produces bile, a green fluid that turns large fat droplets into smaller ones and stores them in the **gall bladder**. When necessary, bile gets into the small intestine and helps in the digestion of fat. The **pancreas** makes three different kinds of enzymes namely amylase, peptidase, and lipase released through a pancreatic duct that aid in the digestion of all three organic compounds such as carbohydrates, proteins, and fats respectively. The process takes about half of a liter of digestive juices each day. The liver is the biggest organ inside the body with a mass of about two kilograms. Gall bladder - a small pear-shaped sac that can hold about 50ml of bile. The pancreas is a small organ found below the stomach.

The **small intestine** is an organ that breaks down food further into substances, such as glucose, that can be absorbed by the villi. It has three parts namely the duodenum, the jejunum, and ileum. The **duodenum** is the first and shortest part of the small intestine that starts at the lower end of the stomach and extends for about 20 cm to 25 cm in length. Basically, it is in charge for the continuous breaking-down process as it partially receives the chyme from the stomach, it resumes chemical digestion of food, and prepares for absorption through the villi.

Organic compounds such as carbohydrates, proteins, and fats are specifically broken down with the aid of different enzymes. **Carbohydrates** are broken down into sugars by enzymes like amylase, maltase and lactase. **Proteins** are broken down into amino acids by enzymes like trypsin and peptidase. **Fats** are broken down into fatty acids by the enzyme lipase. After about four hours, the stomach pushes food into the small intestines. See Figure 2 and Figure 2.1. The production and release of enzymes and acids in the digestive system is called **secretion**. It aids in the breaking down of complex food molecules into their chemical building blocks.

The **jejunum** is the second part of the small intestine that is 2.5 cm in length. Its wall works for absorption through enterocytes or columnar cells of small nutrient particles which have been previously digested by the enzymes in the duodenum.

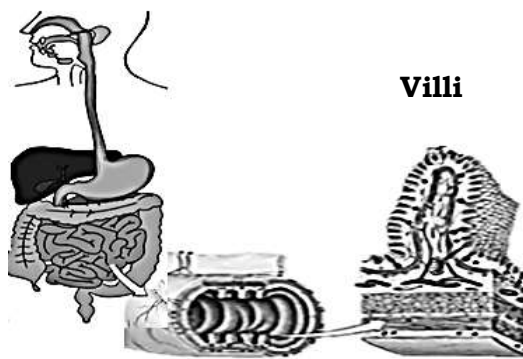


Figure 3. Absorption of nutrients through the villi.

Illustrated by: Rosa Mia L. Pontillo

C. Absorption is the third process that happens in the digestive system. It occurs mostly in the small intestine where several digestive juices, pancreatic juice, and bile aid in the chemical digestion of food. Absorption is the process of passing the soluble food molecules in the wall of the small intestine through the **villi** – the tiny, finger-like projections from the epithelial lining of the intestinal wall. Each villus contains blood capillaries that enable it to absorb water, glucose, amino acids, vitamins, minerals, and fatty acids. It also increases the amount of surface area available for the absorption of nutrients. See figure 3.

D. Assimilation is the fourth process that occurs in the digestive system. It is the movement of digested food nutrients into the blood vessels of the small intestine through diffusion and use of nutrients into the body cells through the **microvilli** – microscopic cellular membrane projections that serves to expand the surface area for diffusion and also to lessen any increase in volume. See figure 4.

The third part of the small intestine is the **ileum** which is about 3.5 meters in length. Its main function is the assimilation (absorption) of B₁₂ and the re-assimilation (reabsorption) of conjugated bile salts.

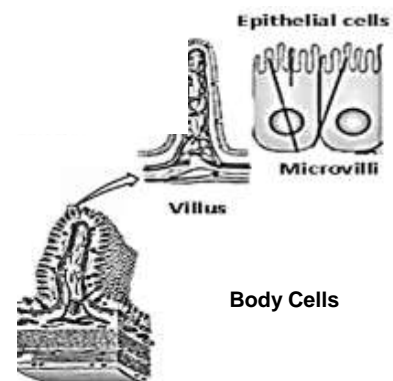
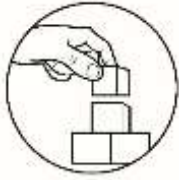


Figure 4. Diffusion of Nutrients through the Microvilli.

Illustrated by: Rosa Mia L. Pontillo

The **Large intestine** is divided into caecum, ascending colon, transverse colon, descending colon, and sigmoid colon. This is where reabsorption of liquid, electrolytes and some vitamins from the undigested food takes place. It secretes mucus to aid in the formation of feces and maintains alkaline conditions. This is the last segment of the gastrointestinal tract that completes absorption and compacts waste.

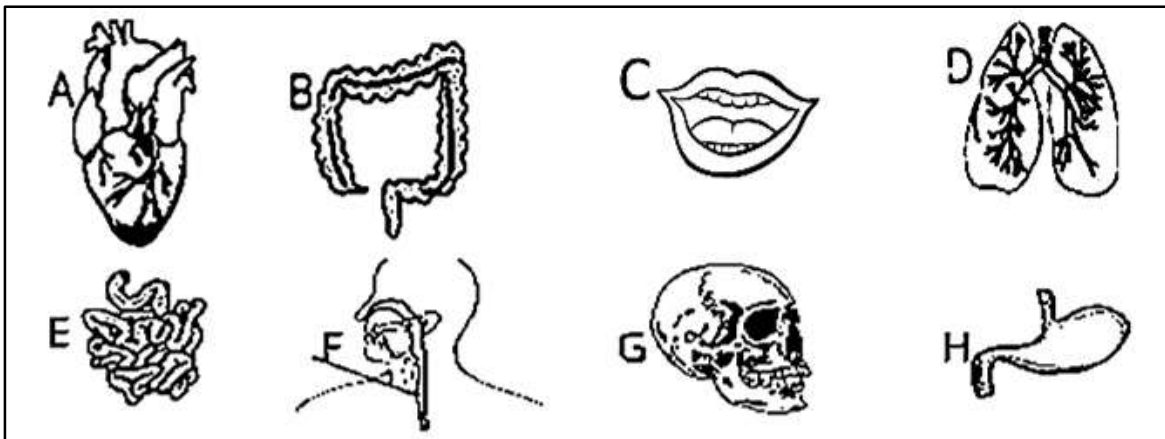
E. Egestion is the last process that occurs in the digestive system. It is the release of undigested food collected in the **rectum** called **feces** and pushed out of the body through the **anus** by defecation.



What's More

Activity 3. Pick Me UP!

Directions: Identify the five organs that are part of the digestive system from among the picture in the box below. Write only the letters corresponding to your answer on a separate sheet of paper.



Illustrated by: Rosa Mia L. Pontillo

Activity 4. Match ME!

Directions: Describe the function of each organ in the digestive system by matching column A with column B. Write only the letter of the correct answer on a separate sheet of paper.

Column A

1. This is where the food is mechanically broken down by chewing. The tongue helps in pushing the bits and broken into small pieces for easier digestion. In here, the saliva softens the food to of food into the pharynx.
2. It reabsorbs water from undigested food materials coming from the small intestine.
3. It is where the waste or remaining food materials that become more solid known as feces will be temporarily stored and eliminated
4. It is a tube that connects the mouth and stomach. It carries the food down to your stomach for temporary storage and further digestion.
5. Here, the food is mixed with intestinal juices which contain enzymes that help in digestion. It is where the final digestion and absorption of nutrients happen
6. J-shaped organ found at the end of the esophagus on the upper left side of the abdomen or abdominal cavity that produces gastric juices and acids.

Column B

A.



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B.



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C.



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D.



Illustrated by: Rosa Mia L. Pontillo

E.



Illustrated by: Rosa Mia L. Pontillo

F.

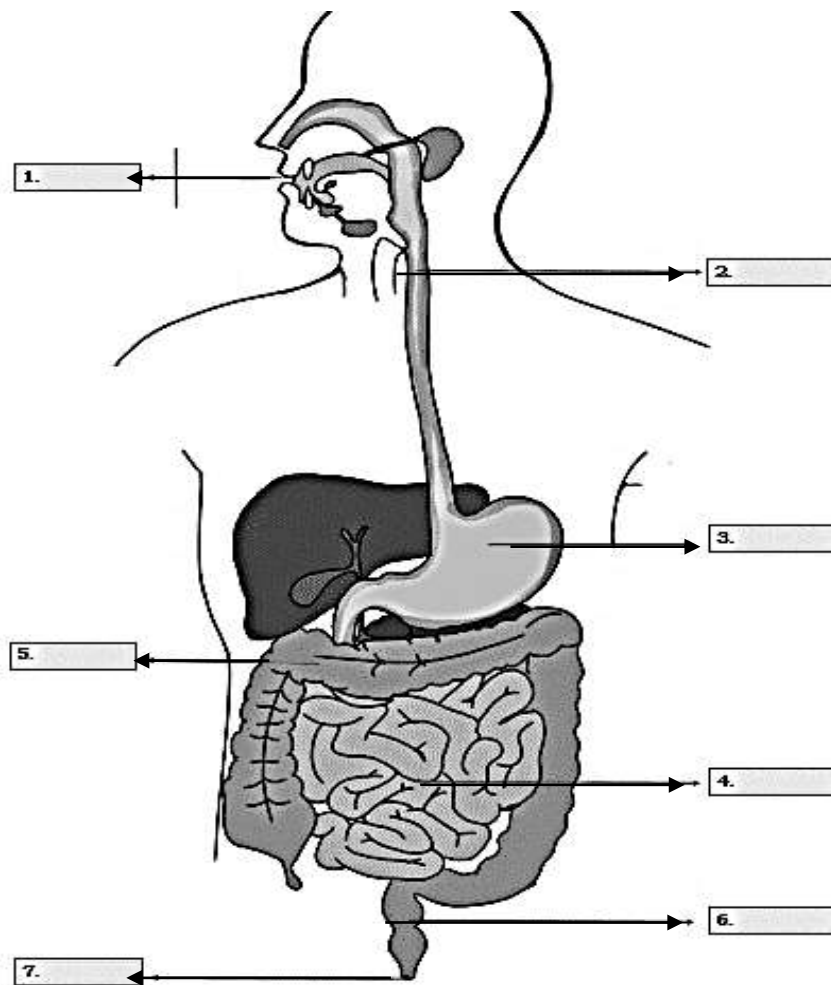


Illustrated by: Rosa Mia L. Pontillo

Activity 5. I Fill You!

Directions: Label the main organs involved in the digestive system in the figure and answer the questions that follow. Write your answers on a separate sheet of paper.

1. Label the organ pointed by the arrow.



Illustrated by: Rosa Mia L. Pontillo

2. Name the enzymes secreted by the organs identified from box #1, #3 and #4.

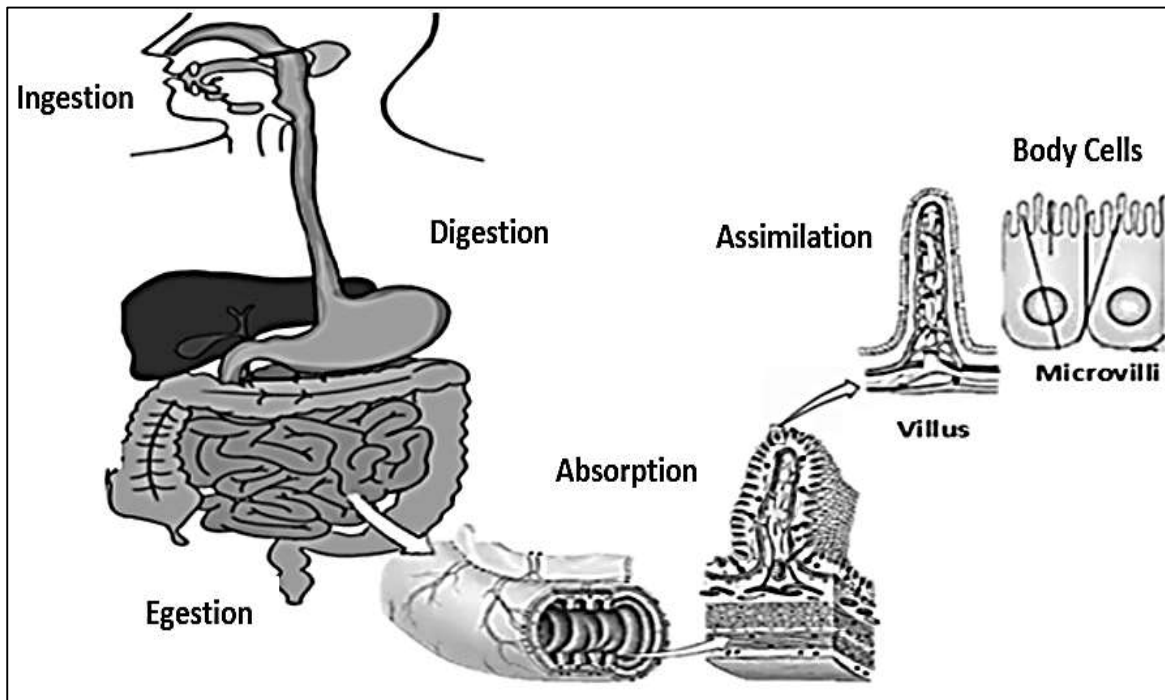
_____.

3. The liver produces bile. How does bile help in digestion of food?

_____.

Activity 6. Share It!

Directions: Study the figure below and answer the questions that follow. Write your answers on a separate sheet of paper.



Illustrated by: Rosa Mia L. Pontillo

Questions:

1. When does ingestion begin?
2. What happens to food when it is in your:
 - a. mouth _____;
 - b. stomach _____;
 - c. small intestine _____?
3. How are nutrients from the food you eat absorbed after digestion?
4. Why are villus and microvilli important in the human digestive system?
5. What happens to the undigested food in the large intestine?

Scoring Rubrics	
2 points	Discussions are complete with no misconception.
1 point	Discussions are incomplete with minor misconception.
0 point	There is no discussion shown.

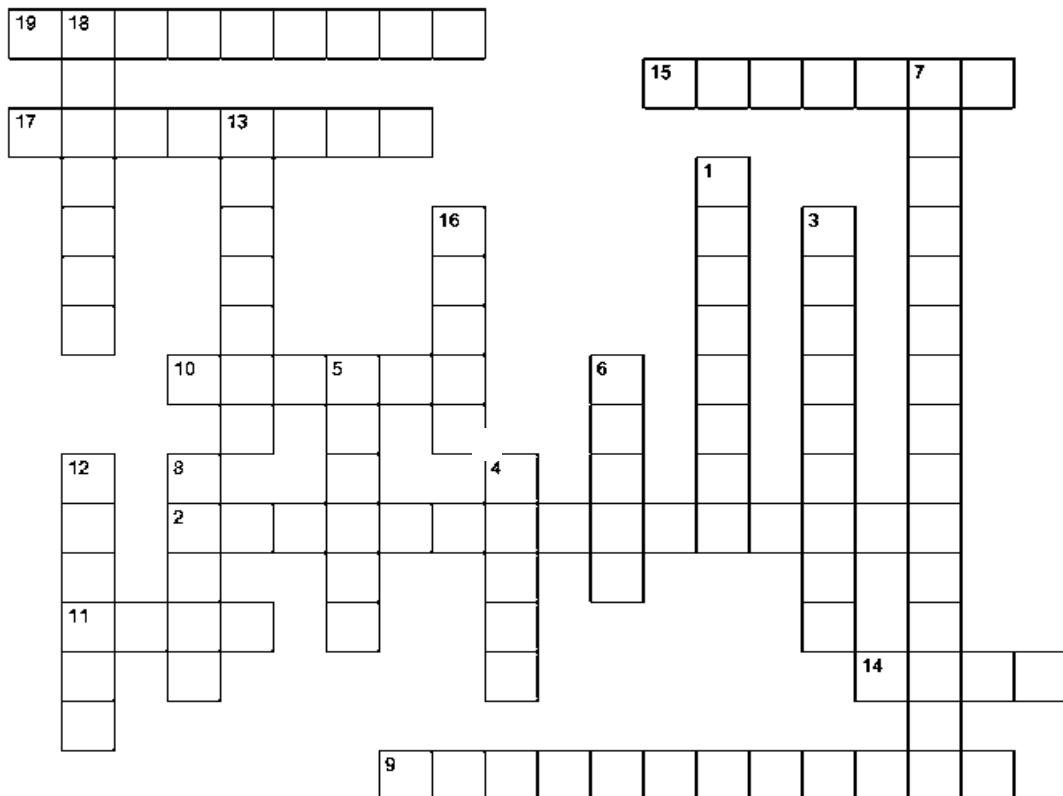


What I Have Learned

Activity 7. Wordy GUT!

Directions: Complete the crossword puzzle. Write your answers on a separate sheet of paper.

DIGESTIVE SYSTEM CROSSWORD PUZZLE



Down:

- 1 produces pancreatic juice
- 3 intakes of food
- 4 produces bile
- 5 helps mix the food with saliva in the mouth
- 6 entry point of food
- 7 where final digestion takes place
- 8 absorbs vitamin B₁₂ and bile salts
- 12 breaks down fats into fatty acids
- 13 speeds up chemical digestion
- 16 products of digestion in the stomach
- 18 secretes acids and enzymes

Across:

- 2 reabsorbs water from undigested food
- 9 where bile is being stored
- 10 acts as temporary storage of feces
- 11 exit point of feces
- 14 digests fats
- 15 breaks down carbohydrates
- 17 shortest region of the small intestine
- 19 connects the mouth to the stomach



What I Can Do

Activity 8. I Create You Gullet!

Directions: Create a comic strip of digestive process on a sheet of bond paper based on the situation below. Put a title of your comic strip on one square. Make ten more squares for your story. Each square shall show both drawings and words to tell your story. The following terms and concepts should include in your comic strip:

- Mechanical digestion
- Chemical digestion
- Mouth
- Saliva
- Esophagus
- Peristalsis
- Stomach
- Small intestine
- Villi
- Large intestine
- Rectum
- Anus

Situation: Imagine that you are a piece of food (bread, pizza, mango, etc.) that is about to be eaten by a human being! As you journey through the digestive system, starting from the first bite and ending with your exit from the human body, you are able to meet the different organs and enzymes that interact with you.

Scoring Rubric (per square)	
2 points	Discussions and illustrations are complete with no misconception.
1 point	Discussions and illustrations are incomplete with minor misconception.
0 point	There is no discussion and illustration shown



Assessment

Directions: Choose the letter of the correct answer. Write your answers on a separate sheet of paper.

1. The following organs are part of the human digestive system EXCEPT:
 - A. mouth
 - B. esophagus
 - C. small Intestine
 - D. gastro vascular cavity
2. In which part of the digestive system does the breaking down of food into tinier pieces occur?
 - A. mouth
 - B. stomach
 - C. small intestine
 - D. large Intestine
3. Which of the following helps in the digestion of food in the mouth?
 - A. amylase
 - B. bile
 - C. protease
 - D. saliva
4. What enzyme aids the digestion of lipids in the small intestine?
 - A. amylase
 - B. gastric enzyme
 - C. lipase
 - D. pepsin
5. Which tiny structures line the internal surface of the small intestine to increase its surface area for the absorption of nutrients?
 - A. bile ducts
 - B. cilia
 - C. salivary glands
 - D. villi
6. What is the largest internal organ of the human body?
 - A. heart
 - B. gall bladder
 - C. liver
 - D. stomach

7. Which of the following is produced by the liver?
- A. amylase
 - B. bile
 - C. pepsin
 - D. renin
8. Which organ stores bile and pumps it into duodenum?
- A. appendix
 - B. colon
 - C. gall bladder
 - D. pancreas
9. What is the result of chemical digestion of carbohydrates?
- A. amino acid
 - B. bile
 - C. fatty acids
 - D. simple sugars
10. Where does absorption of nutrients mostly occur?
- A. stomach
 - B. small intestine
 - C. large intestine
 - D. all the above
11. What aids the passage of food through the digestive tract?
- A. pull from the anus
 - B. chemical absorption
 - C. movement of the cilia
 - D. wavelike muscle contractions
12. What is the main work of the digestive system?
- A. fights disease
 - B. regenerates cells
 - C. breaks down food
 - D. distributes energy throughout the body
13. Which of the following is the correct order of the digestive tract?
- A. mouth → rectum → esophagus → rectum → anus → small intestine
→ large intestine
 - B. mouth → stomach → esophagus → rectum → anus → small intestine
→ large intestine
 - C. mouth → esophagus → stomach → small intestine → large intestine
→ rectum → anus
 - D. mouth → esophagus → stomach → small intestine → anus
→ large intestine → rectum

14. How do nutrients from digested food reach the blood?
- by passing through the esophagus into the blood
 - by being absorbed into the blood through the blood vessels
 - by being absorbed into the blood through the walls of the lungs
 - by passing through the small intestine into the large intestine, then into the blood
15. What will happen to the undigested food that pass through the digestive tract?
- goes to the pancreas to await disposal
 - enters to the stomach and await disposal
 - goes to small intestine and await disposal
 - moves down to the large intestine and await disposal



Additional Activities

Activity 9: Now I Know!

The digestive system is an important part of our body. It helps our body breaks down bulk of food, absorb essential nutrients from what we eat and even get rid of its waste product. Digestive system may suffer complications that ranges from mild to severe so it is important to recognize common problems related to digestion.

Directions: Create an infographic of the digestive system - parts and functions as well as the disorders that you might be getting from malfunction of some organs of the system.

Note: An ***infographic*** is a collection of images, diagrams, and text that provides an easy-to-understand general idea of a topic. Most *infographics* use prominent and attractive illustrations to converse the facts quickly and clearly.

Scoring Rubric (per square)	
2 points	Discussions and illustrations are complete with no misconception.
1 point	Discussions and illustrations are incomplete with minor misconception.
0 point	There is no discussion and illustration shown



Answer Key

What I Know

1. D 6. C 11. B
2. A 7. B 12. D
3. C 8. D 13. A
4. C 9. D 14. A
5. A 10. D 15. C

What's In

1. Mouth 8. Pancreas
2. Tongue 9. Small intestine
3. Teeth 10. Large intestine
4. Saliva 11. Rectum
5. Pharynx 12. Anus
6. Esophagus 13. Food
7. Stomach 14. Liver
15. Gall bladder

Activity 1. Tummy Puzzle!

1. Mouth 8. Pancreas
2. Tongue 9. Small intestine
3. Teeth 10. Large intestine
4. Saliva 11. Rectum
5. Pharynx 12. Anus
6. Esophagus 13. Food
7. Stomach 14. Liver
15. Gall bladder

What's New

1. The token represent the food that was eaten.
2. The boxes on the board game represents the different organs of digestive system.
3. The directions on some of the boxes describe the physical and chemical conditions that affect proper functioning of digestive system.

Activity 2. A Gutsy Game

1. The token represent the food that was eaten.
2. The boxes on the board game represents the different organs of digestive system.
3. The directions on some of the boxes describe the physical and chemical conditions that affect proper functioning of digestive system.

Activity 3 Pick Me Up!

1. B
2. C
3. E
4. F
5. H

What's More

Activity 4. Match Me!

1. B 2. D 3. E
4. F 5. A 6. C

Activity 5. I Fill You!

1. MOUTH
2. ESOPHAGUS
3. STOMACH
4. SMALL INTESTINE
5. LARGE INTESTINE
6. RECTUM
7. ANUS

2.) Possible answers are

box 1: Amylase
box 2: pepsin
box 3: Maltase, Lactase and peptidase, lipase

3.) It turns large fat droplets into smaller ones and stores them in the gall bladder.

Activity 6. Share It!

Possible Answers/Key terms:

1. When food, drink or any substances enters into the mouth.
2. When food is in the mouth, stomach and small intestine it will undergo mechanical and chemical digestion that breaks down large insoluble food molecules into smaller water-soluble food molecules for easy absorption of the cells.

Down:

1. Pancreas
Intestine
3. Ingestion
4. Liver
5. Tongue
7. Small Intestine
8. Ileum

Across:

2. Large
9. Gall Bladder
10. Rectum
11. Anus
14. Bile
15. Amylase
17. Duodenum
19. Esophagus

Activity 7. Gutsy word

defecation.
5. The undigested food stored in the rectum called feces are pushed out of the body through the anus by defecation.

3. Absorption of nutrients passed the soluble food molecules in the lining of the small intestine through the villi.
4. The villi and microvilli are important because it increases the surface area for absorption of nutrients from the food that we ate.

What I Can Do

Activity 8. I Create You Gullet!

Scoring Rubric (per square)	
2 points	Discussions and illustrations are complete with no misconception.
1 point	Discussions and illustrations are incomplete with minor misconception.
0 point	There is no discussion and illustration shown

Additional Activity: Now I Know!

Scoring Rubric (per square)	
2 points	Discussions and illustrations are complete with no misconception.
1 point	Discussions and illustrations are incomplete with minor misconception.
0 point	There is no discussion and illustration shown

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