DIGESTION SIMULATION IN THE DIGESTIVE TRACT

Teacher's guide

Subject: Biology

Learning topic: Digestive system

1. Learning outcomes

From the Syllabus - students will:

- Understand that, unlike plants, animals are not capable of producing organic substances (sugars, fats, and amino acids) from inorganic materials. They, like plants, require water, mineral substances, and certain other organic substances (vitamins) which they obtain from their food.
- Understand that nutrients are used to obtain energy for powering life processes (cellular respiration) and for building their own organic substances (biomass) while any unused nutrients are temporarily stored (glycogen, fat).
- Recognize the connection between the structure and function of the human digestive tract and understand that various parts of the digestive tract perform different tasks and comprehend the role of digestive glands.

Upon completing the practical, students will be able to:

- Identify and name the individual sections of the digestive tract and determine their roles.
- Describe the process of digestion in the digestive tract, from food intake to egestion.
- Understand how food is gradually digested and absorbed and explain this with a specific example.
- Understand the role of digestive glands.
- Explain where specific types of organic molecules are digested and how.

2. Theoretical background

The digestive tract of humans and other vertebrates is divided into a series of specialized organs that process food at various stages, from ingestion and digestion to nutrient absorption and egestion. Digestion begins with the intake of food in the oral cavity. Teeth in the mouth grind and mix food with saliva secreted by the salivary glands. This processed food then travels through the throat into the esophagus, a muscular tube that moves food towards the stomach through alternating contractions of circular and longitudinal muscles known as peristalsis. In the stomach, various substances are secreted from gastric glands, including hydrochloric acid to create an acidic environment, mucus to assist with food movement and protect the stomach lining, and the enzyme pepsin for protein breakdown. This results in a semi-liquid mixture of food and gastric juice, which moves into the small intestine. The small intestine is divided into three parts: the duodenum, jejunum, and ileum. The duodenum is primarily responsible for enzymatic digestion, while the later sections are involved in nutrient absorption. The inner surface of the small intestine is highly folded and villi are present, increasing its absorption capacity significantly. Nutrients are absorbed into the bloodstream through the cells of the intestinal lining and are transported to the liver, while fats are absorbed into the lymphatic system. The gallbladder and the pancreas have ducts opening into the duodenum. The pancreas secretes digestive enzymes to break down various organic molecules, and the liver produces bile, stored in the gallbladder, which contains bile salts acting as emulsifiers to aid fat digestion.

The digestive tract concludes with the large intestine, where water and certain ions are reabsorbed from undigested food, and feces are formed. Fecal matter accumulates in the rectum and is expelled from the body through the anus.

Sources: Belušič G., Dolenc Koce J., Turk M., Vittori M., Zalar P. 2021. Biologija 2: O zgradbi in delovanju organizmov. Učbenik za biologijo v gimnazijah in srednjih strokovnih šolah. Ljubljana, Mladinska knjiga: 139-144

Campbell N. A., Reece, J. B. 2012. Biologija 2: Zgradba in delovanje organizmov. Učbenik za gimnazije in srednje strokovne šole. Celovec, Mohorjeva založba.

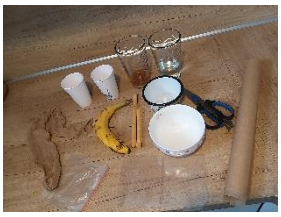
3. Materials and methods

The exercise is adapted from the following source: Nicholson D. 2019. Make a digestive system model using crackers and bananas. Accessed at: https://www.sciencefix.co.uk/2019/05/make-a-digestive-system-model-using-crackers-and-bananas/ (retrieved on September 10, 2023).

Duration of the practical: two 45-minute class session

Materials:

- 50 mL of wine/apple vinegar
- 50 mL of plain water
- half of a banana
- 4 small crackers
- 2 bowls
- 2 (3) paper cups
- a piece of baking paper (rolled into a funnel)
- 2 food/freezer bags with a seal (or without)
- 1 pair of pantyhose
- scissors



Methods:

1. Prepare all the necessary materials on the table.
2. Start by crushing the crackers and banana into smaller pieces and place them in a small food bag, adding plain water to it.

3. Seal the bag and crush its contents with your hands to create a pasty mixture.
4. Squeeze the mixture from the bag through the baking paper funnel into another food bag, placing it under the funnel. Add vinegar to this bag.

5. Further crush the contents of the bag into a thick mixture.

6. Cut the bottom edge of the bag to create a small hole and gradually pour the processed food into pantyhose, holding it over a bowl. You can use a paper cup to support the pantyhose.




7. By squeezing, extract the contents of the processed food through the pantyhose into the bowl. Ensure that all the liquid drains into the bowl, and the remainder stays in the pantyhose.

8. Transfer the remaining food, still in the pantyhose, into a paper cup. Cut a part of the pantyhose when transferring to allow the food to pass into the cup.

9. Use another paper cup to push the food in the cup through the hole at the bottom, allowing it to flow into the bowl below.


4. Giudelines for teacher

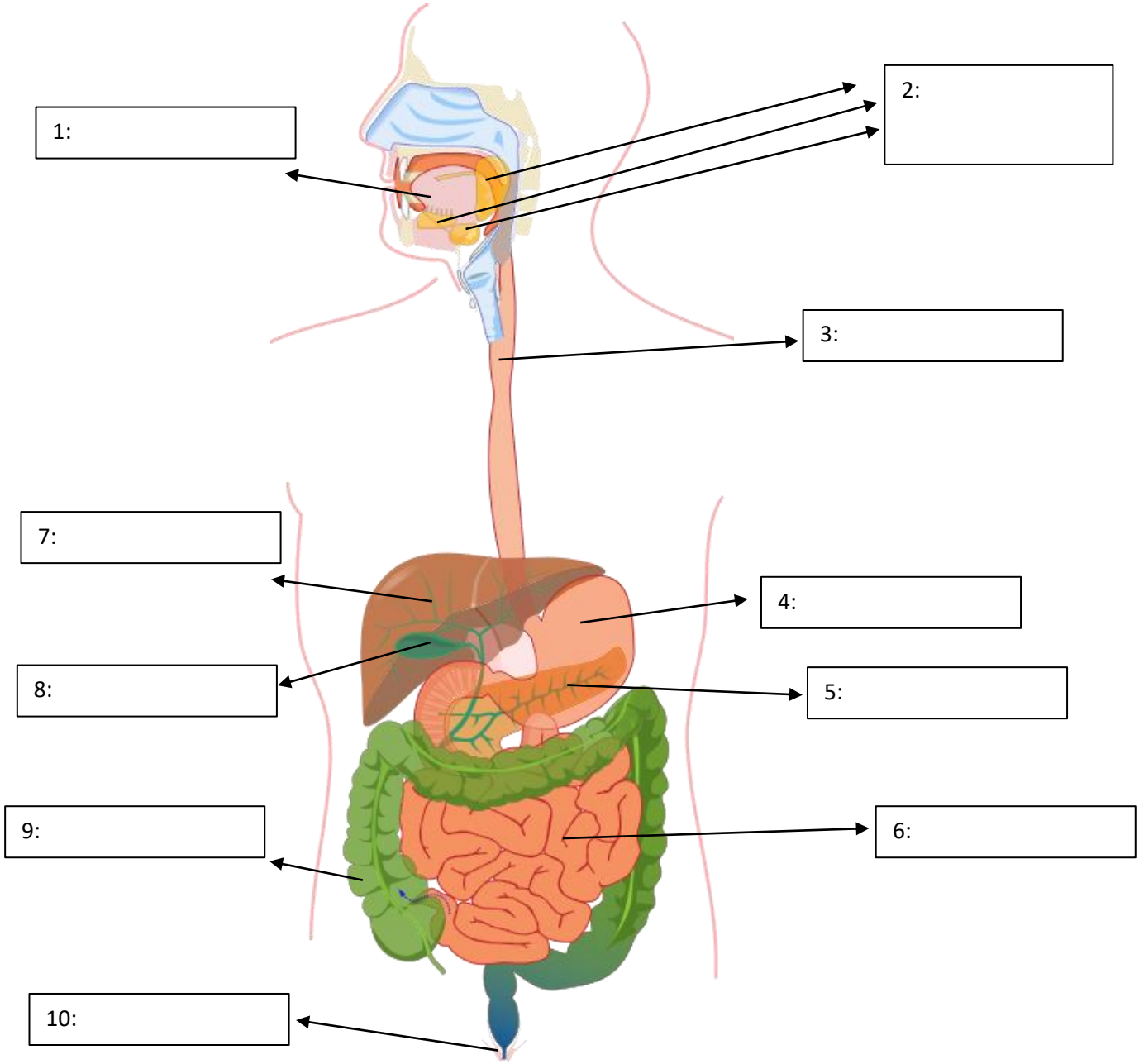
- This practical is suitable as a motivational activity before delving into the topic of the digestive system. This way, students can easily grasp the key processes that occur along the digestive tract. The practical can be supplemented with explanation and discussion.
- Divide the students into smaller groups of 4-5 students each.
- Each group should prepare all the necessary materials and perform the practical following the instructions.
- Students can either carry out the practical independently or go through each step with the teacher.
- To help them before starting the practical, the teacher can show a video demonstration. An example of the experiment is available on YouTube (https://www.youtube.com/watch?v=u9XVMiQq-n4).
- Students should answer questions on the worksheet as they complete the exercise.
- At the end of the practical, review the questions with the teacher and engage in a discussion about the functioning of the digestive system.

- The teacher can enhance the practical by presenting the importance of a balanced diet, including nutrition disorders, gastrointestinal diseases, and related topics.

5. Questions and tasks for students

Answer the following questions:

1. Which section of the digestive tract does the first food bag represent, and what happens at this stage of digestion in humans? What did we represent with plain water?
2. Which part of the digestive tract does the baking paper funnel represent? Describe how food passes from this part to the next section of the digestive tract.
3. Which section of the digestive tract does the second bag represent, and why did we add vinegar?
4. What does the pantyhose represent, and what is the purpose of the bowl placed beneath it? Briefly describe the digestion process you represented in this part.
5. What does the paper cup, into which you transferred the food from the pantyhose, represent, and what happens to this food next?
6. Using the information you obtained during the exercise, describe the digestion process from food intake to elimination.
7. Complete the diagram below by naming the labeled organs that make up the digestive tract and writing their respective roles.



Source: Mariana Ruiz, Jmarchn, Wikimedia, available at:

https://jbo.wikipedia.org/wiki/datnyvei:Digestive_system_without_labels.svg (acquired on 29. 9. 2023)

The role of individual sections of the digestive tract:

1:	**6:**
2:	**7:**
3:	**8:**
4:	**9:**
5:	**10:**

8. In the case of the meal shown in the image below, describe the process of digestion in the digestive tract. Consider what happens in the individual sections of the digestive tract, where specific organic molecules present in the meal are broken down or enzymatically digested. The digestive pathway should include all the main processes of digestion and the roles of the different sections of the digestive tract.

Worksheet for students

WHAT HAPPENS TO FOOD IN THE DIGESTIVE TRACT?

Before starting the exercise, think about the following questions:

- What is the importance of nutrition for the human body?
- What happens to the food we consume?
- How is our digestive tract structured? What happens in its individual sections?
- Reflect on the importance of a balanced diet. What should a balanced meal look like?

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ACTIVITY DURATION: 2 school hours

MATERIALS

- 50 mL of wine/apple vinegar
- 50 mL of plain water
- half a banana
- 4 small crackers
- 2 bowls
- 2 (3) paper cups
- a roll of baking paper
- 2 food/freezer bags with a seal (or without)
- 1 pantyhose
- scissors

METHODS

1. Prepare all the necessary materials on the table.
2. Start by crushing the crackers and banana into smaller pieces and place them in a small food bag, adding plain water.

3. Seal the bag and knead the contents with your hands to create a mushy mixture.
4. Squeeze the mixture from one food bag through a roll of baking paper into another food bag placed beneath the roll. Then, add vinegar to the second bag.

5. Knead the contents of the second bag to create a thick mixture.

6. Cut the bottom side of the bag to create a small hole and gradually pour the contents into a pantyhose held over a bowl. You can use a cup to support the pantyhose.



7. Squeeze the processed food through the pantyhose into the bowl. Make sure that all the liquid goes into the bowl, while the remaining portion remains in the pantyhose.


8. Transfer the remaining food from the pantyhose into a paper cup, making a small opening at the bottom of the cup with scissors. Place the cup in another bowl and cut a part of the pantyhose to transfer the food.
9. Use another paper cup to push the food in the cup through the hole so that it flows into the bowl beneath.



RESULTS AND DISCUSSION

1. Which section of the digestive tract does the first food bag represent, and what happens at this stage of digestion in humans? What did we simulate with plain water?

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2. Which section of the digestive tract does the roll of baking paper represent? Describe how food from this section moves to the next section of the digestive tract.

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3. Which section of the digestive tract does the second food bag represent, and why did we add vinegar? What were we trying to illustrate with this addition?

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4. What does the pantyhose represent, and what about the bowl placed underneath it? Briefly describe the digestion process you simulated in this part.

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5. What does the paper cup, into which you transferred the food from the pantyhose, represent, and what happens to this food in the subsequent stages?

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6. Using the information you acquired during the exercise, describe the process of digestion from the ingestion of food to excretion.

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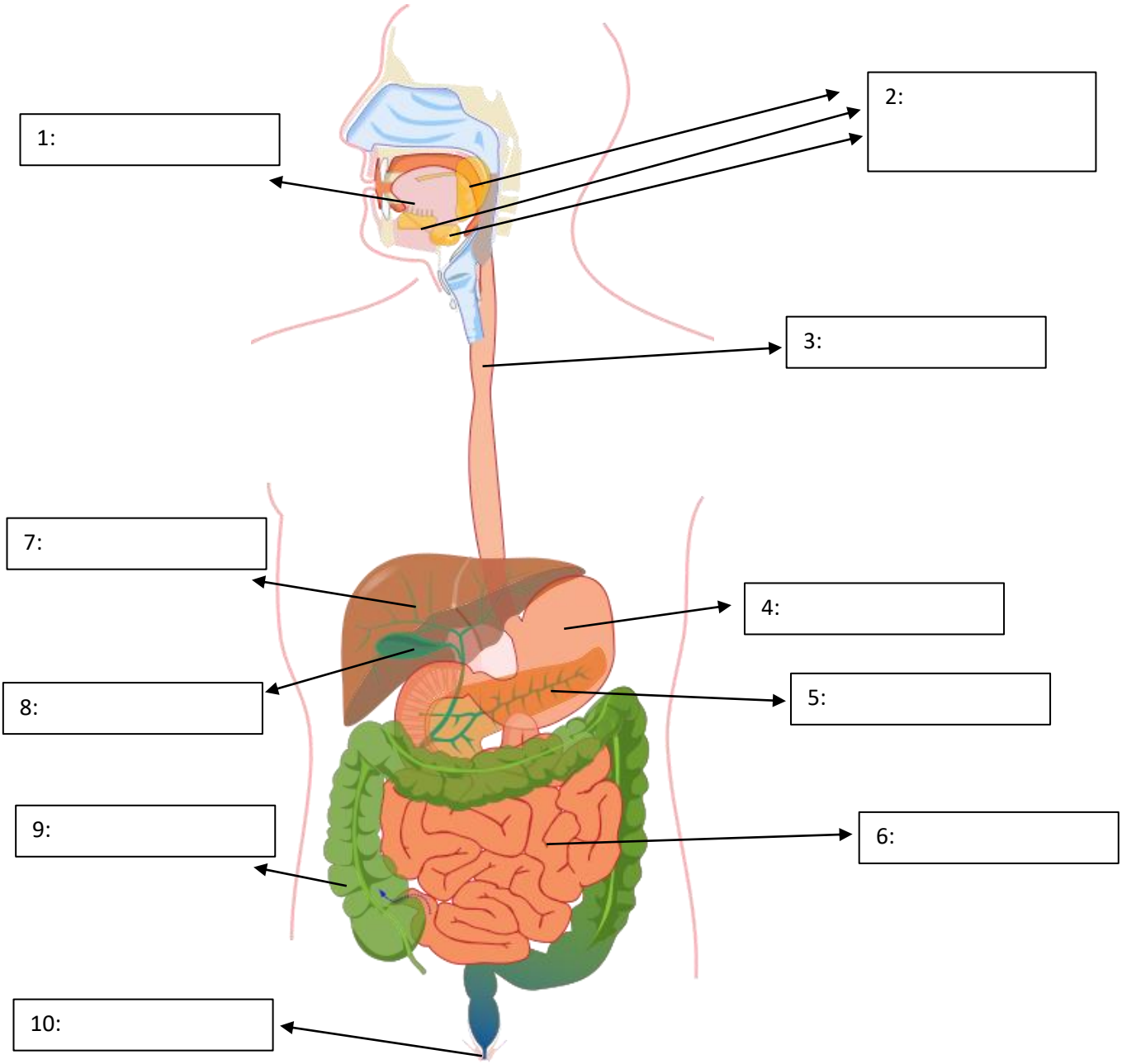
7. Complete the diagram below by naming the labeled organs that make up the digestive tract and writing down their roles.



Source: Mariana Ruiz, Jmarchn, Wikimedia, available at: https://jbo.wikipedia.org/wiki/datnyvei:Digestive_system_without_labels.svg (acquired on 29. 9. 2023)

The role of individual sections of the digestive tract:

1:	**6:**
2:	**7:**
3:	**8:**
4:	**9:**
5:	**10:**

8. Describe the digestion process in the digestive tract using the example of the meal shown in the diagram. Consider what happens in each section of the digestive tract, where certain organic molecules present in the meal are broken down or enzymatically digested. The digestive pathway should include all the main processes of nutrition or the roles of digestive tract sections.

Examples of suitable answers to the questions

1. Which section of the digestive tract does the first food bag represent, and what happens at this stage of digestion in humans? What did we illustrate with plain water?

The first food bag, into which we added food, represents the oral cavity, where mechanical digestion of food occurs with the help of teeth and the tongue. Plain water we added represents saliva, which is released from the salivary glands and contains the enzyme amylase, an enzyme that partially breaks down starch.

2. Which section of the digestive tract does the paper tube represent? Describe how food from this part passes into the next section of the digestive tract.

The paper tube represents the esophagus, which plays a role in transferring food to the stomach. The esophagus is a muscular tube with layers of circular and longitudinal muscles in its wall, which, through alternating contractions and relaxations in waves, move food boluses towards the stomach. Such muscular movement is called peristalsis.

3. Which section of the digestive tract does the second bag represent, and why did we add vinegar? What did we want to illustrate with this?

The second bag represents the stomach. We added vinegar to illustrate the acidic pH of the stomach or hydrochloric acid, which establishes an acidic environment in the stomach.

4. What does the pair of stockings represent, and what does the bowl beneath it represent? Briefly describe the digestion process you depicted in this part.

The pair of stockings represents the small intestine, and the bowl beneath it represents the body's cells into which digested molecules are absorbed. In the first part of the small intestine, the duodenum, located just after the stomach, final enzymatic digestion of food occurs with enzymes secreted by the pancreas and in the presence of bile, produced by the liver and stored in the gallbladder, and released into the duodenum. In the other two sections of the small intestine, the jejunum and the ileum, the absorption of nutrients takes place.

5. What does the paper cup, where you transferred the contents of the stockings, represent, and what happens to the food from this point onwards?

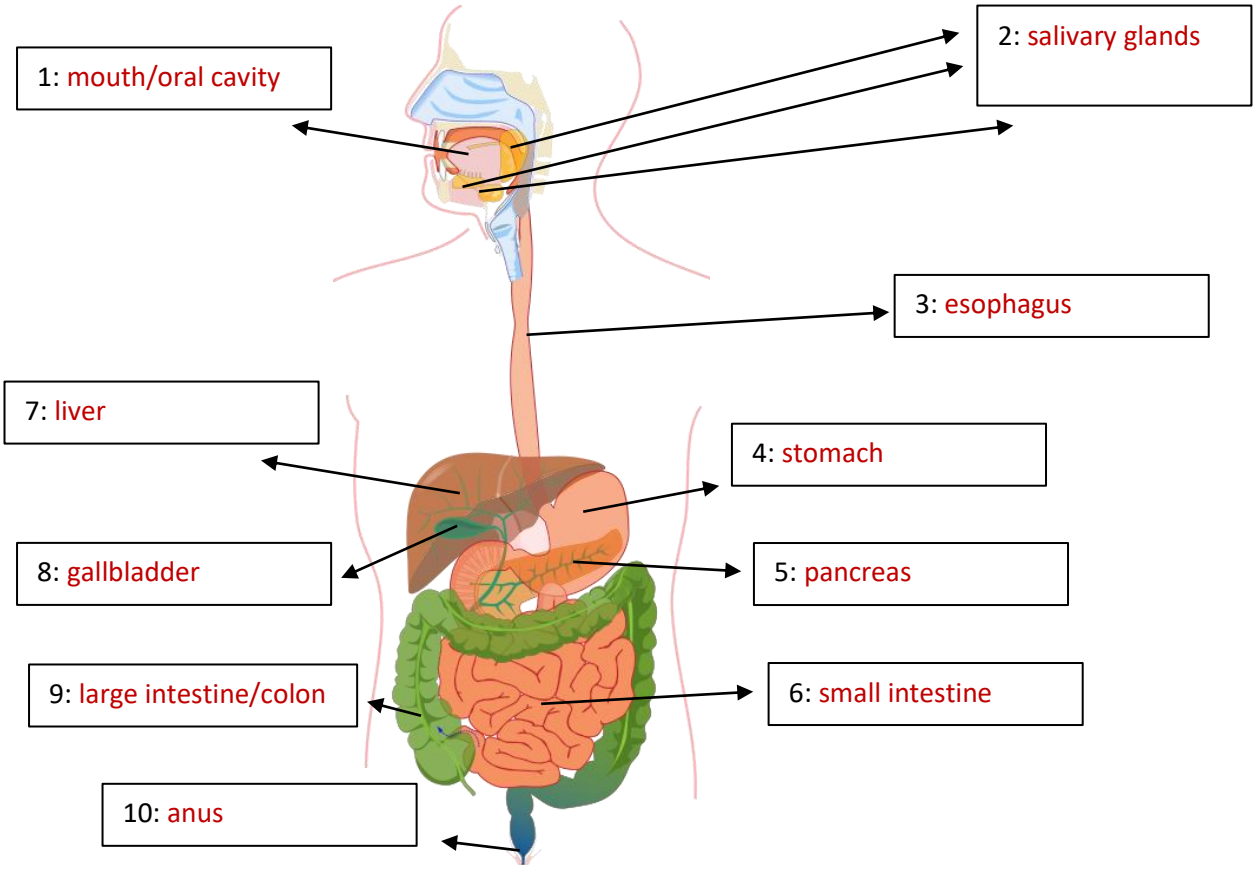
The paper cup represents the large intestine, where undigested substances travel. Here, water and some ions are absorbed, and undigested food forms solid waste along with various bacteria that inhabit the large intestine. The waste accumulates in the rectum and exits the body through the anus.

6. Using the information you obtained during the exercise, describe the process of digestion from the ingestion of food to excretion.

The digestion of food begins with the intake of food in the mouth. Food is crushed with teeth and mixed with saliva produced by the salivary glands, which contains mucus and the enzyme amylase, partially breaking down starch. Once processed, we swallow the food, and it travels to the stomach via the esophagus, where mechanical and enzymatic digestion takes place. Gastric glands secrete various substances, such as hydrochloric acid, mucus, and pepsinogen, which, in the presence of the acidic stomach contents, converts into active pepsin, breaking down proteins. From the stomach, food enters the small intestine, where most enzymatic digestion and nutrient absorption occur. In the duodenum, which is the first part of the small intestine located after the stomach, pancreatic enzymes such as lipase, amylase, trypsin, and nucleases are

released, along with bile stored in the gallbladder. In the jejunum and ileum, the other two sections of the small intestine, nutrient absorption takes place. The intestinal lining is highly folded into villi, and the membrane of the mucosal cells forms finger-like projections called microvilli, further increasing the absorptive surface area. This vast surface area enables more efficient transfer of substances from the intestines to the bloodstream. Undigested food from the small intestine travels to the last part, the large intestine. Here, water and some ions are absorbed, and solid waste is formed. This waste is then stored in the rectum and exits the body through the anal canal.

7. Complete the image below by naming the labeled organs that make up the digestive tract and write down their functions at each section.



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The role of individual sections of the digestive tract:

1: Mechanical processing of food (teeth, tongue), mixing with saliva secreted by salivary glands.
2: Secretion of saliva containing mucus to facilitate the passage of food through the esophagus; saliva also contains the enzyme amylase, which partially breaks down starch.
3: Transfer of food to the stomach through peristaltic contractions of circular and longitudinal muscles.
4: Storage of food, mechanical and enzymatic digestion of food (proteins), secretion of mucus, acid, enzymes, hormones, and absorption of certain substances.

5: Neutralization of gastric acid, secretion of enzymes for the breakdown of all organic molecules and hormones.
6: Enzymatic digestion of all organic molecules, secretion of mucus, hormones, and absorption of nutrients.
7: Metabolism (metabolism) of nutrients, nutrient storage, detoxification, and bile production.
8: Collection and storage of bile from the liver (bile acts as an emulsifier, breaking down fats into small droplets).
9: Absorption of water and ions, formation of feces.
10: Egestion of undigested food.

8. Describe the digestion process in the digestive tract using the example of the meal shown in the diagram. Consider what happens in each section of the digestive tract, where certain organic molecules present in the meal are broken down or enzymatically digested. The digestive pathway should include all the main processes of nutrition or the roles of digestive tract sections.

Digestion begins in the oral cavity, where all components of the meal are mechanically processed with the help of teeth and saliva. Additionally, there is enzymatic digestion of starch (rice) due to the presence of the enzyme amylase. The food then travels through the throat into the esophagus, where it moves towards the stomach through peristaltic contractions of circular and longitudinal muscles. In the stomach, both mechanical and enzymatic processing of food occurs. Enzymes begin the breakdown of proteins (cheese, chicken). The food subsequently moves into the small intestine. In the first part, the duodenum, there is enzymatic digestion of all components of the meal. Pancreatic enzymes released into the duodenum from the pancreas include enzymes for breaking down proteins, lipids, nucleic acids, and carbohydrates. The duodenum also receives bile from the gallbladder. Bile, produced in the liver, emulsifies fats into smaller droplets, increasing the surface area for the action of pancreatic enzymes. Molecules are broken down into basic building blocks. In the following two sections, the jejunum and the ileum, nutrient absorption takes place. Undigested food travels to the large intestine, where water and some ions are absorbed, and feces are formed. The fiber present in green beans, rice, and berries may enter the large intestine undigested or only partially digested, and can be utilized by bacteria through the process of fermentation. This results in the production of various beneficial molecules. Undigested food in the form of feces accumulates in the rectum and eventually leaves the body through the anal opening (anus).

Prepared by Eva Šajn, biology teacher