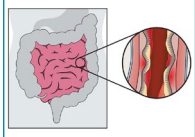

Digestive System Card Sort

hhmi | BioInteractive

Activity
Educator Materials

OVERVIEW

In this card activity, students investigate the functions of major digestive organs using the *Biomolecules on the Menu* Click & Learn. In Parts 1 and 2, they sort the organs into the order in which they function. In Part 3, they apply their understanding to different medical conditions that affect the digestive organs. In Part 4, they investigate the enzymes involved in digestion at the molecular level.

Additional information can be found on this resource's webpage, including suggested audience, estimated time, and curriculum connections.

This educator document contains multiple resources for implementing this activity with students, including the following (select links to go directly to each section in the document):

- teaching tips for using the "Student Handout," cards, and Click & Learn
- procedure for each part of the "Student Handout"
- assessment guidance, including sample answers for the questions in the "Student Handout"

KEY CONCEPTS

- The digestive system is a series of organs that work together to break down food into pieces small enough to be absorbed into the bloodstream.
- Digestive organs may physically (mechanically) break down food, produce secretions (like enzymes and acid) that chemically break down food, or both.
- As food passes through the organs of the digestive system, specific enzymes break down specific biomolecules into smaller pieces.
- Medical conditions that affect the organs of the digestive system can disrupt their functions.

STUDENT LEARNING TARGETS

- Describe the functions of the major organs of the digestive system.
- Relate how the digestive organs function in a sequence.
- Compare chemical and mechanical digestion, and discuss which organs perform each type of digestion.
- Predict how certain medical conditions might affect the process of digestion.
- Apply knowledge of word roots to determine the major enzymes involved in digesting carbohydrates, proteins, and fats.

PRIOR KNOWLEDGE

Students should:

- understand that carbohydrates, proteins, and fats can be found in food and are necessary to provide energy for the body
- be comfortable using "word roots" (e.g., prefixes and suffixes) to determine the meanings of words

MATERIALS

- access to the *Biomolecules on the Menu* Click & Learn
- copies of the "Student Handout"

- three sets of cards ("Organ Cards" for Parts 1 and 2, "Pathology Cards" for Part 3, "Enzyme Cards" for Part 4); refer to the "Using the Cards" section for more information.

TEACHING TIPS

USING THE "STUDENT HANDOUT"

The parts of the "Student Handout" are intended to be completed in order, using the *Biomolecules on the Menu* Click & Learn and the corresponding cards.

- Part 1 should be completed *before* engaging in the Click & Learn, using the **"Organ Cards**."
- Part 2 uses the Click & Learn and the **"Organ Cards**."
- Part 3 has students place the **"Pathology Cards"** alongside the "Organ Cards."
- Part 4 has students place the **"Enzyme Cards"** alongside the "Organ Cards."

Parts 1 and 2 can be completed in groups or individually. If working in groups, students should fill out the "Organ Cards" individually in Part 1 to ensure they investigate the functions of all the organs. They can then work together to put the organs in the correct order in Part 2.

For **Parts 3 and 4:**

- Either or both parts can be omitted if not appropriate for your course.
- These parts can be used in a variety of ways. For example:
  - Students may work individually to complete the parts.
  - Students may work together as a group to complete the entire activity.
  - Students could form "jigsaw groups" that each investigate one or two of the "Pathology Cards" (Part 3) or "Enzyme Cards" (Part 4). Different groups can be assigned to different cards, then discuss their findings with the class.
  - Students could complete these parts as an assessment or homework after finishing Part 2.
- Both parts depend upon knowledge acquired in Part 2, where students go through the Click & Learn.
  - Students can return to the Click & Learn as needed during these parts. However, the answers to the questions in Parts 3 and 4 are *not* explicitly stated in the Click & Learn; they are an extension/application of the information.
  - In Part 4, students may need to be prompted to think about the word roots in the enzyme names and to pay attention to the complexity of the molecules in the reactions.

USING THE CARDS

- You can either print or electronically share files for the cards from this resource's webpage.
  - PDF files are provided as printable options. For the card sets, print out each page separately, cut the cards out, and shuffle each set; you may wish to laminate them for repeated use. You can store the cards in labeled resealable bags or envelopes.
  - Individual card images (JPGs) are provided in the "Card Images" ZIP file. You can use a virtual whiteboarding or collaboration software (e.g., Google Slides, Miro, Mural, Whiteboard.fi) in which students can move and annotate card images.
- The number of card sets you will need depends on how you use the "Student Handout." For Parts 1 and 2, we recommend one set of "Organ Cards" per student. For Parts 3 and 4, you could have one set of "Pathology Cards" and "Enzyme Cards" per student or group.
- Having students sort the "Pathology Cards" is not strictly necessary for completion of Part 3. To save on time and potential printing costs, you could present these cards in a different format (for example, as a slideshow).

USING THE CLICK & LEARN

- Prompt students to hover over the bold, underlined terms in the *Biomolecules on the Menu* Click & Learn, which will reveal more information. That is where they will find some of the answers for the "Student Handout."
- This card activity focuses mostly on the "How is food digested" tab of the Click & Learn, which is about the organs of the digestive system. The other tabs of the Click & Learn are about nutrient delivery and metabolism, particularly cellular respiration. Additional BioInteractive resources that delve into these topics include animations on pyruvate dehydrogenase, glycolysis, ATP synthesis, the citric acid cycle, and the electron transport chain.
- The Click & Learn simplifies very complex information for a general audience. Refer to the "Educator Materials" on the Click & Learn's webpage for more information on the generalizations and assumptions on which this Click & Learn is based.

PROCEDURE

Distribute the cards to the students/groups. Instruct students on which parts of the "Student Handout" you want them to complete; summaries of each part are provided below.

PART 1: WHAT IS HAPPENING IN THE DIGESTIVE SYSTEM?

Students draw on their prior knowledge to put the "Organ Cards" (organs of the digestive system) in the order in which they function. They will revise their initial order after learning more in Part 2.

PART 2: DIGESTIVE ORGAN CARD SORT

Students use the *Biomolecules on the Menu* Click & Learn to fill out the "Organ Cards" as directed in Question 4 of the handout. For each organ, students should select "mechanical" or "chemical" digestion where appropriate. Note that some organs (like the mouth and the stomach) perform *both* mechanical and chemical digestion, while others (like the esophagus) perform neither type of digestion.

Once the "Organ Cards" are filled out, students put the organs in the order in which they function in the digestive system. They record this order in Question 5.

PART 3: DIGESTIVE SYSTEM PATHOLOGY

Students examine the "Pathology Cards" and predict which of the medical conditions shown will affect each of the digestive organs. They apply their knowledge by answering a series of questions about different conditions and their associated organs.

PART 4: DIGESTION AT THE MOLECULAR LEVEL

Students read about common word roots that appear in the names of enzymes and biomolecules. They first sort the "Enzyme Cards" based on the organs that release them in Question 17. They then sort the "Enzyme Cards" by the biomolecules (carbohydrate, protein, or fat) they act upon in Question 18.

In Question 19, students put the enzymes in the order in which they function to break down biomolecules. They then answer some additional questions about nutrient delivery and storage.

ASSESSMENT GUIDANCE

PART 1: WHAT IS HAPPENING IN THE DIGESTIVE SYSTEM?

1. The food you eat is quite different from your feces ("poop").

a. Brainstorm **three** ways in which food and feces differ.
Possible answers include different makeup of nutrients, amounts of bacteria, odor, etc.

b. Form a hypothesis about what the digestive system adds or removes when turning food into feces to account for these differences.
Answers will vary. If students previously said that feces have fewer nutrients than food, for example, they may hypothesize that the digestive system removes nutrients.

2. Without using any other resources, do your best to place the "Organ Cards" in the order in which they act upon food. List the order you chose using the letters found on the bottom left of each card.
The actual order is listed below, but students should be allowed to list the cards in any order at this point in the activity.
    1) ***D***
    2) ***C***
    3) ***A***
    4) ***B or E (Secretions from the pancreas, liver, and gallbladder act on the food in the small intestine, so students could that argue either B or E comes first.)***
    5) ***B or E***
    6) ***F***

3. How confident are you in the order you came up with? What do you still need to figure out?
Answers will vary. Students will compare their predicted order to the actual order in Question 6.

PART 2: DIGESTIVE ORGAN CARD SORT

4. Using the "How is food digested" tab of the *Biomolecules on the Menu* Click & Learn, complete each of the six "Organ Cards" as follows.
    a. Fill in the blank after "Organ:" with the organ's correct name.
    b. Describe the function of the organ where noted.
    c. Select the type of digestion (chemical and/or mechanical) performed by that organ. Some organs may perform one type of digestion, both types, or neither type.
    Refer to the following table for examples of completed card text. Biomolecules on the Menu provides more information.

Card	Organ	Function	Type of Digestion
E	***Mouth***	***Breaks down food using teeth and saliva.***	***Chemical, Mechanical***
C	***Esophagus***	***Transports food from the mouth to the stomach.***	***Neither***
A	***Stomach***	***Produces acid, mucus, and enzymes to break down food. Squeezes and mixes food with these substances.***	***Chemical, Mechanical***
B	***Liver, gallbladder, and pancreas***	***Release substances (such as bile, enzymes, and buffers) that help chemical digestion in the small intestine.***	***Chemical***
E	***Small intestine***	***Perform some of the final steps of digestion using enzymes, releasing nutrients to be absorbed into the bloodstream.***	***Chemical***

F	***Large intestine***	***Forms and eliminates feces. Has commensal bacteria that break down some undigested food molecules (like fiber).***	***Neither or Chemical (if you count bacterial action)***

5. Once you have completed the "Organ Cards," put them in the order in which food passes through them in the body. Set aside the card for the organ(s) that food does *not directly pass through.*
   a. List the *names* of the organs that food passes through, in order, below.
      1) ***Mouth***
      2) ***Esophagus***
      3) ***Stomach***
      4) ***Small intestine***
      5) ***Large intestine***

   b. List the organ(s) that food does not directly pass through.
      Pancreas, liver, gallbladder

   c. The secretions of the organ(s) in Part b must enter another organ to begin mixing with food. Put the card for the organ(s) in Part b next to the organ that the secretions enter, and write the name of that organ below.
      Small intestine

6. Did the order in Question 5 change from your predictions in Question 2? If so, how?
   Answers will vary based on students' predictions.

7. Investigate the content of feces by reading the "Large Intestine" section (under the "How is food digested?" tab) of the Click & Learn. What are feces made of?
   Feces include fiber, water, and commensal bacteria.

8. Most food items have a combination of carbohydrates, proteins, and fats. Feces has significantly lower levels of these biomolecules. Where do the biomolecules go when food is turned into feces?
   Most of the biomolecules are broken down into nutrients in the process of digestion. The nutrients are absorbed into the bloodstream.

PART 3: DIGESTIVE SYSTEM PATHOLOGY

9. Read the "Pathology Cards," then match the condition on each one with the "Organ Card" it most directly affects. Fill out the following table with your findings.

Digestive organ	**Example of a condition that affects the organ**
Mouth	***Gum disease***
Esophagus	***Gastroesophageal reflux***
Stomach	***Gastric ulcers***
Small intestine	***Dysentery***
Pancreas	***Pancreatitis***
Gallbladder	***Gallstones***

Large intestine	***Colorectal cancer***

10. Gum disease can result in tooth loss. This can affect the mouth's ability to perform which of the following types of digestion? ***Answer is A.***
    a. ***mechanical***
    b. chemical
    c. both mechanical and chemical

11. Uncontrolled gastroesophageal ("gastro" refers to the stomach, and "esophageal" to the esophagus) reflux would most likely affect which of the following processes? ***Answer is B.***
    a. release of bile
    b. ***passage of food into the stomach***
    c. passage of food into the large intestine

12. Gastric ulcers allow acid and enzymes produced by the stomach to make it past the layer of mucus lining the inner wall of the stomach. What is the role of mucus in the stomach? ***Answer is A.***
    a. ***Mucus protects the walls of the stomach.***
    b. Mucus breaks down proteins and fats.
    c. Mucus helps absorb nutrients into the bloodstream.

13. In some instances of dysentery, a person may have temporary lactose intolerance. People who are lactose intolerant cannot digest the carbohydrate, lactose, which is found in milk.
    a. Which organ do you think dysentery most affects?
    Small intestine

    b. Based on your knowledge about this organ's function, form a hypothesis about how dysentery might cause temporary lactose intolerance.
    Answers will vary. An example hypothesis might be that dysentery lowers the small intestine's production of enzymes (specifically brush border enzymes, including lactase) that are needed to digest lactose.

14. Pancreatitis can be caused by gallstones. This is because the pancreas and the gallbladder share a common opening that allows the substances they produce to enter the same organ. Which organ is this?
    Small intestine

15. If gallstones cause symptoms, the gallbladder is often removed. One of the reasons that people can survive gallbladder removal is because the gallbladder only *stores* bile. Which organ *produces* bile?
    Liver

16. One treatment for colorectal cancer is removal of the colon (the main part of the large intestine). Doctors attach the small intestine to the end of the large intestine (the rectum) instead. People who receive this treatment can continue their typical activities, just with some minor dietary considerations. Which of the following would be most affected by removal of the colon? ***Answer is B.***
    a. absorption of carbohydrates
    b. ***functions of commensal bacteria***
    c. digestion of fats

PART 4: DIGESTION ON THE MOLECULAR LEVEL

17. First, you will sort the "Enzyme Cards" based on organ.

a. For each card, fill in the **organ** that releases the enzyme. (Note that some organs release more than one enzyme.) Sometimes the organ will be indicated by the name of the enzyme. Other times, you may need to refer to the "How is food digested" tab of the *Biomolecules on the Menu* Click & Learn.
Refer to the following table for completed card text.

Enzyme	Organ released from	Acts upon
Salivary amylase	***Mouth****	***Carbohydrates***
Pancreatic amylase	***Pancreas***	***Carbohydrates***
Brush border amylases	***Small intestine***	***Carbohydrates***
Pepsin	***Stomach***	***Proteins***
Pancreatic proteolytic enzymes	***Pancreas***	***Proteins***
Brush border peptidases	***Small intestine***	***Proteins***
Lingual lipase	***Mouth****	***Fats***
Pancreatic lipase	***Pancreas***	***Fats***

****specifically the salivary glands in the mouth (not mentioned in the Click & Learn)***

b. Sort the "Enzyme Cards" by organ and fill out the following table.

Digestive organ	Enzymes released
Mouth	***Salivary amylase, lingual lipase***
Stomach	***Pepsin***
Pancreas	***Pancreatic amylase, pancreatic proteolytic enzymes, pancreatic lipase***
Small intestine	***Brush border amylases, brush border peptidases***

c. Which organ produces the most types of digestive enzymes?
Pancreas

d. The organ in Part b releases its enzymes into another organ of the digestive system. In this second organ, the enzymes act upon food particles. What is this second organ?
Small intestine

18. Next, you will sort the "Enzyme Cards" based on biomolecule.
    a. On each card, add a checkmark to the **biomolecule** each enzyme acts upon. Refer to the word roots listed above as needed.
    Refer to the table in Question 17a for the completed cards.

    b. Sort the "Enzyme Cards" by the biomolecule they act upon (carbohydrates, fats, or proteins) and fill out the following table.

Biomolecule	Enzymes that act upon it
Carbohydrates	***Salivary amylase, pancreatic amylase, brush border amylases***

Fats	***Lingual lipase, pancreatic lipase***
Proteins	***Pepsin, pancreatic proteolytic enzymes, brush border peptidases***

19. For the group of enzymes that act upon each biomolecule, sort the enzymes into the order in which they function to break down that biomolecule. Write the chemical reactions for breaking down fats and proteins below, using the standard format for chemical reactions. Carbohydrates are provided as an example.

Salivary amylase, Pancreatic amylase / ***Brush border amylases***

Complex carbohydrates, starch, disaccharides → **Disaccharides** → **Monosaccharides**

The chemical reaction for breaking down fats is as follows.

Lingual lipase / ***Pancreatic lipase***

Triglycerides → **Diglycerides** → **Monoglycerides, glycerol, fatty acids**

The chemical reaction for breaking down proteins is as follows.

Pepsin / ***Pancreatic proteolytic enzymes*** / ***Brush border peptidases***

Proteins → **Long polypeptides** → **Short polypeptides** → **Amino acids**

20. After digestion is complete, the smallest molecules (monoglycerides, glycerol, fatty acids, amino acids, and monosaccharides) can be converted to ATP in the cells of the body. How do these molecules travel from the small intestine to cells throughout the body?
They travel through the bloodstream.

21. When monosaccharides (like glucose), amino acids, and/or fatty acids are available in excess, enzymes in the cells can link them together into storage molecules. Navigate to the "Nutrients to Storage" section (under the "How are nutrients used for energy?" tab of the Click & Learn) and investigate the three types of storage molecules. Fill in the following table with the storage molecules that each nutrient is used to make.

Nutrient	**Storage molecule**
Glucose	***Glycogen***
Fatty acids	***Triglycerides***
Amino acids	***Proteins***

22. Why do you think it's important for the body to produce these storage molecules?
Answers may vary. Students may discuss that food is not always readily available to be broken down by the digestive system. In these cases, the body can break down storage molecules instead to get nutrients for ATP production.

CREDITS

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