

## Introduction

This poster describes findings from pilot testing three assessment items in middle school science for the topic of Matter and Energy in Living Systems.

Our goal is to develop assessment items that accurately assess student knowledge of key ideas related to the use of food as a source of building materials for growth and replacement of body structures.

**Key Idea:** All organisms need food as a source of molecules that provide chemical energy and building materials.

Students are expected to know that:

- Food consists of carbon-containing molecules in which carbon atoms are linked to other carbon atoms.
- These carbon-containing molecules serve as the building materials that organisms use for growth, repair, and replacement of body parts and provide the chemical energy needed to carry out various life functions.
- Materials that are not a source of both chemical energy and building materials are not food.

**Key Idea:** Animals use molecules from food to make complex molecules that become part of their body structures.

Students are expected to know that:

- Animals use some of the carbon-containing molecules from food to make complex molecules that are used in the growth and replacement of their body structures (such as muscle, bone, skin, and cells).
- During the process of making body structures, atoms of carbon-containing molecules from food are used to make carbohydrates, fats, and proteins that become part of an animal's body structures.
- These processes involve chemical reactions in which some of the atoms of molecules from food are rearranged, not simply the addition of substances from food.

Here, we describe how we use student data to:

1. Provide insight on students' understanding of specific concepts
2. Inform our revisions of items

Research questions:

- Do students see food as a source of building materials or primarily as an energy source?
- Do students make the link between the substance-level understanding of food as a source of building materials for growth and the molecular-level understanding of matter transformations (i.e., chemical reactions in which carbon atoms are rearranged)?

## Methodology

In spring 2007, pilot tests were administered to students in grades 6-8 from twelve school districts in eleven states. Students were asked to choose a correct answer and then respond in writing to additional questions about the assessment item, such as explaining why they thought each answer choice was correct or incorrect.

Student responses provide information on:

1. Whether students used the targeted ideas to answer the question or if they used other knowledge instead
2. Whether the item was comprehensible to students
3. Whether the answer choices were plausible to students
4. Alternative conceptions that students may have held

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# Probing Middle School Students' Understanding of Ideas About Matter Transformations in Living Systems Through Content-Aligned Assessment

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## Item 1

### Recognizing That Food is a Source of Energy and Building Materials

Which of the following statements is TRUE about food for plants and animals?

- A. Food is a source of both energy and building materials for plants and animals.**
- B. Food is a source of energy for plants and animals but not a source of building materials for plants and animals.
- C. Food is a source of building materials for plants and animals but not a source of energy for plants and animals.
- D. Food is needed to keep plants and animals alive, but it is not a source of energy or building materials for plants and animals.

#### Answer selections by students

	A*	B	C	D	Multiple	Not sure	Total
#	72	12	3	9	4	43	143
%	50.3	8.4	2.1	6.3	2.8	30.1	100

#### Students' explanations for why answer A was correct

[64 students provided written comments]

- 17% mentioned energy in their explanation but not building materials.

*"Food gives us energy."*

*"Both plants and animals need food to live and have energy"*

- 11% mentioned food as being needed for growth but did not demonstrate understanding of food as the source of material for growth.

*"Food gives them [plants and animals] energy and helps them grow."*

*"It turns into energy and helps the plant and animal grow."*

#### Unfamiliar vocabulary [N=143]

- 13% were unfamiliar with the term "building materials."

#### Implications for item revision

Clarify the terminology and provide examples of how food is used as a source of building materials:

- A. *Animals and plants need food as a source of energy and as a source of material for building body parts such as muscles in animals and leaves in plants.*

## Summary and Conclusions

Our results confirm that several of the tested ideas are unfamiliar to students.

1. Students focused on food as a source of energy [for growth] and had little knowledge of food as a source of matter for growth.
2. Even when the focus of the question was on growth, most students appeared to have a mental model that energy is extracted from food and what is left over is eliminated as waste.
3. Without an understanding of food as a source of matter for growth, students have difficulty with the idea that atoms of molecules from food are rearranged in chemical reactions before they become part of the body.

## Item 2

### Connecting Food with Growth at the Substance Level

For an animal to grow, what must happen to the food that it eats?

- A. The food must be broken down into simpler substances that become part of the animal's body.**
- B. The food must be broken down into simpler substances, all of which leave the animal's body.
- C. The food must be changed completely into energy in the animal's body.
- D. The food must be changed into energy or eliminated as waste.

#### Implications for item revision

1. Remove reference to food being "broken down" to improve alignment with the key idea and eliminate use of non-targeted knowledge being used to evaluate the answers.
2. Clarify answer A so that students do not reject it because they interpret it to mean that all food becomes part of an animal's body.
  - A. *Some of the food is changed into new substances that become part of the animal's body.*
3. Include the term "waste" in answer B since a number of students focused on waste in their written responses.
  - B. *All the food is changed into waste...*
4. Incorporate similar answer structure in other choices.
  - C. *All of the food is changed into energy...*
  - D. *Some of the food is changed into energy, and the rest...*
5. Re-word the stem to focus more on what happens to food as growth occurs (i.e., the addition of matter).
  - As an animal grows...*

#### Answer selections by students

	A*	B	C	D	Multiple	Not sure	Total
#	54	25	23	157	25	73	357
%	15.1	7.0	6.4	44.0	7.0	20.4	100

#### Students' explanations for why answer A was correct

[55 students provided written comments]

- 18% focused on food being "broken down."

*"It has to be broken down so it can be used."*

- 5% referred to "digestion."

*"The digestive tract breaks down foods."*

- 9% selected the correct answer because they thought that substances from food became part of the body.

#### Students' explanations for why answer A was incorrect

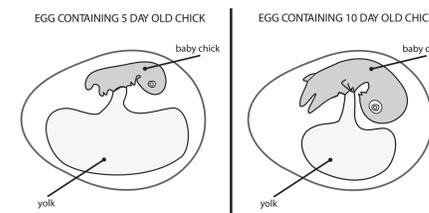
[128 students provided written comments]

- 32% stated that food does not become part of the body, or that food provides energy (6%) or is turned into energy and waste (4%) instead.
- Of students stating that food did not become part of the body, 79% selected answer D (energy or waste).
- 27% said that "not all" food becomes part of the body or that some food is eliminated from the body as waste. These students may still have understood that some food is used as a source of material for growth.

## Item 3

### Connecting Food with Growth at the Molecular Level

The yolk inside an egg is a source of food for a growing chick. As the chick grows, the yolk gets smaller. Why does the yolk get smaller?



- A. The yolk gets smaller to make room for the growing chick.
- B. The yolk gets smaller because some of the molecules from the yolk become part of the chick's body unchanged.
- C. The yolk gets smaller because the molecules from the yolk are used by the chick to live and grow even though none of the molecules from the yolk become part of the chick's body.
- D. The yolk gets smaller because some of the molecules from the yolk are broken down and reassembled into molecules that become part of the chick's body.**

#### Answer selections by students

	A	B	C	D*	Multiple	Not sure	Total
#	10	3	28	12	5	6	64
%	15.4	4.7	43.8	18.8	7.8	9.4	100

#### Students' explanations for why answer D was correct

[12 students provided written comments]

- No student explicitly confirmed an understanding of the yolk as a source of molecules that are reassembled into new molecules.

*"The yolk became part of the chick's body."*

*"The chick uses yolk to create its body."*

#### Students' explanations for why answer D was incorrect

[27 students provided written comments]

- 30% rejected the idea of anything from the yolk becoming part of the chick's body.

*"The yolk does not become part of the chick's body in any form or way, it's just used for food for the chick."*

- 19% explained that molecules cannot be broken down or reassembled.

#### Unfamiliar vocabulary [N=64]

- 13% of students did not understand the use of "unchanged" in answer B.

#### Implications for item revision

1. Remove "broken down" from the item.

*D. ... some of the molecules from the yolk are reassembled into new molecules that become ...*

2. Clarify answer C so that students do not select it because they interpret it to mean that molecules from the yolk do not become part of the body without being chemically changed.

*C. ... none of the atoms of the molecules from the yolk become part...*