

# Hibernating Bear: AP42-6 (CR), and AP59-4 (MC)

Middle School – Energy and Chemical Reactions

## TASK OVERVIEW

Students are presented with a scenario in which a bear is going into hibernation. They are given a model that represents the chemical reaction happening inside the bear that is involved in releasing energy to the bear. Students are tasked with describing what is shown in the model and using the model to explain why bears lose weight during hibernation.

## TARGETED DCIs, SEPs, AND CCCs

#### Disciplinary core ideas

• PS3.D-M.2: Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.

#### Science & engineering practices

• SEP6-M.2: Construct an explanation using models or representations.

#### Crosscutting concepts

- CCC5-E.2: Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems.
- CC4-M.2: Models can be used to represent systems and their interactions-such as inputs, processes, and outputs-and energy, matter, and information flows within systems.

#### **Related Performance Expectations**

 MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]

### TASK PERFORMANCE EXPECTATION

*Use a model to explain* how the unobservable process of <u>cellular respiration</u> results in bears obtaining <u>energy</u> during hibernation. *Use a model to explain* how <u>matter that</u> <u>flows into and out</u> of a bear during hibernation results in the bear losing mass.

#### LINK TO ONLINE VERSION

http://assess.bscs.org/i/test/602 (Along with AP31-6)

## Task

Prior to winter, black bears eat large quantities of food and gain up to 30 pounds of additional body weight. The food that the bears eat is made up of carbon-containing molecules such as glucose, carbohydrates, fats, and proteins. When winter begins, the bears go into dens or caves to hibernate. After several months of hibernation, they

wake up and leave their dens. Scientists who study hibernating bears have found that bears lose a quarter of their body weight during hibernation.



Black bear den, NPS Photo / Harlan Kredit

Observations of hibernating bears show that they breathe in and out during hibernation, but they do not eat, drink, or "go to the bathroom."

How is it possible for bears to stay alive during hibernation if they don't eat anything?

Below is a model showing one of the chemical reactions taking place inside a bear that will help you understand how bears can stay alive during hibernation.



Using the model, answer the following questions about the processes happening inside the bear during hibernation.



1. How was the oxygen that the bear breathed in used by the bear to get the energy needed to stay alive?

-----Multiple-choice Version of #1------

- 1. How was the oxygen that the bear breathed in used by the bear to get the energy needed to stay alive?
  - A. The oxygen that the bear breathed in reacted with other molecules inside the bear in reactions that release energy and produce carbon dioxide molecules.

- B. The oxygen that the bear breathed in reacted with other molecules inside the bear in reactions that release energy and produce water molecules.
- C. The oxygen that the bear breathed in reacted with other molecules inside the bear in reactions that release energy and produce both carbon dioxide and water molecules.
- D. The oxygen that the bear breathed in gave the bear energy. Oxygen was not involved in any of the chemical reactions.

#### -----Constructed-response Version of #2-----

2. Where did the carbon atoms that are in the carbon dioxide molecules that the bear breathed out come from?

------Multiple-choice Version of #2-----

- 2. Where did the carbon atoms that are in the carbon dioxide molecules that the bear breathed out come from?
  - A. The carbon-containing molecules from the food the bear ate
  - B. The oxygen molecules that the bear breathed in
  - C. The water molecules inside the bear's body

-----Constructed-response Version of #3-----

**3.** Use the model to explain how the bear got the energy that it needed to stay alive during hibernation. Be sure to describe the role that molecules and chemical reactions play.

------Multiple-choice Version of #3------

- **3.** Using the model, how did the bear get the energy that it needed to stay alive during hibernation?
  - A. The bear got energy from carbon-containing molecules from food. No other molecules were involved in this process.
  - B. The bear got energy from oxygen molecules it breathes in. No other molecules were involved in this process.
  - C. The bear got energy from water molecules in the bear's body. No other molecules were involved in this process.

- D. The bear got energy from reactions between carbon-containing molecules from food and oxygen molecules it breathed in.
- E. The bear got energy from reactions between carbon-containing molecules from food and water molecules in the bear's body.



A. Drauglis / flickr

#### -----Constructed-response Version of #4-----

4. Now think about the fact that the bear lost weight during hibernation. Use the model to write an explanation for what causes a bear to decrease in mass during hibernation. Think about the difference in masses of the molecules the bear breathes in and breathes out during hibernation. Be sure to refer to the model in your explanation.

------Multiple-choice Version of #4-----

- **4.** Now think about the fact that the bear lost weight during hibernation. Using the model, what caused the bear to decrease in mass during hibernation?
  - A. Some of the mass inside the bear was turned into energy during hibernation, causing the bear's mass to decrease.
  - B. The bear didn't eat during hibernation, and atoms from the food inside the bear were being destroyed, causing the bear's mass to decrease.
  - C. The bear breathed out more mass than it breathed in, causing the bear's mass to decrease while it hibernated.
  - D. The bear wasn't moving or exercising during hibernation, so the atoms that made up its muscles were being destroyed.

## Alignment to Targeted DCIs, SEPs, and CCCs and Scoring Rubrics

## **QUESTION 1**

How was the oxygen that the bear breathed in used by the bear to get the energy needed to stay alive?

## LEARNING GOAL

#### Learning Performance

• Use a model to construct (or identify) an explanation for how oxygen is used by a hibernating bear.

#### Targeted DCIs, SEP, and CCC

- PS3.D-M.2: Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.
- SEP6-M.2: Construct an explanation using models or representations.

#### **SCORING RUBRIC**

#### **Ideal Response**

Oxygen breathed in by the bear reacts with carbon-containing molecules from the bear's food to produce carbon dioxide molecules and water molecules.

#### Elements of a Correct Response

Categories	Elements
Student states or	Cellular respiration in plants and animals involve
uses a general	chemical reactions with oxygen that release stored
science idea	energy (i.e., oxygen is involved in a chemical reaction
	inside the bear or oxygen reacts with molecules of food).
	[ <i>Oxygen is a reactant</i> ]

OR		
Student selects the correct multiple-choice answer	C. The oxygen the bear breathes in reacts with other molecules inside the bear in reactions that release energy and produce both carbon dioxide and water molecules.	

#### Sample Student Responses

Student response	Scoring description
"he used his oxygen to breath in carbon dioxide then breath it out to get energy which happens in the respiratory system."	Score = 0 The response does not describe the oxygen being part of a chemical reaction.
"A chemical reaction happens between the oxygen molecules (when inhaled) and the food the bear ate turning into carbon dioxide and water."	Score = 1 The response correct explains the role oxygen plays in getting energy.

## **QUESTION 2**

What molecules were the source of the carbon atoms that are part of the carbon dioxide molecules that the bear breathed out?

## LEARNING GOAL

#### Learning Performance

• Use a model to identify the source of the carbon atoms that make up the carbon dioxide molecules.

#### Targeted DCIs, SEP, and CCC

- PS3.D-M.2: Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.
- SEP6-M.2: Construct an explanation using models or representations.

• CCC4-M.2: Models can be used to represent systems and their interactionssuch as inputs, processes, and outputs-and energy, matter, and information flows within systems.

#### **SCORING RUBRIC**

#### Ideal Response

The source of the carbon atoms in carbon dioxide was the carbon-containing molecules from the food the bear ate.

### Elements of a Correct Response

Categories	Elements
Student uses a general science idea	<ul> <li>Complex molecules containing carbon react with oxygen to produce carbon dioxide (i.e., the carbon atoms that make up the carbon dioxide molecules come from carbon-containing molecules from the bear's food).</li> <li>[<i>linking CO<sub>2</sub> &amp; food</i>]</li> </ul>
	Note: Just saying from inside the bear does not count. The student must be explicit about the atoms coming from the molecules from food.
OR	
Student selects the correct multiple-choice answer	A. The carbon-containing molecules from the food the bear ate

#### Sample Student Responses

Student response	Scoring description
"They came out from the oxygen molecules."	Score = 0
	The response does not indicate the correct source of the carbon atoms
"The carbon atoms came from the food that the	Score = 1
bear ate before hibernation."	The response indicates the correct source of the carbon atoms.

## **QUESTION 3**

Use the model to explain how the bear got the energy that it needed to stay alive during hibernation. Be sure to describe the role that chemical reactions play.

## LEARNING GOAL

#### Learning Performance

• Use a model to construct (or identify) an explanation for how the bear got energy during hibernation.

#### Targeted DCIs, SEP, and CCC

- PS3.D-M.2: Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.
- SEP6-M.2: Construct an explanation using models or representations.
- CCC4-M.2: Models can be used to represent systems and their interactionssuch as inputs, processes, and outputs-and energy, matter, and information flows within systems.

#### **SCORING RUBRIC**

#### **Ideal Response**

The bear got energy from a chemical reaction that occurred between carboncontaining molecules from food and oxygen molecules to form carbon dioxide and water.

#### Elements of a Correct Response

Categories	Elements
Student makes a	• The bear got energy from a chemical reaction, by
claim that answers	reacting food with oxygen, or by burning food.
the question	Note: The bear got energy from/by part of the claim can be implied.

Student uses a general science idea	• Complex molecules containing carbon react with oxygen (i.e., the reaction between carbon-containing molecules and oxygen releases energy for the bear). [ <i>cellular respiration</i> ]	
OR		
Student selects the correct multiple-choice answer	D. The bear got energy from reactions between carbon- containing molecules from food and oxygen molecules it breathed in.	

#### Sample Student Responses

Student response	Scoring description
"they eat lots of food before they go into hibernation"	Score = 0 The response does not describe the role that chemical reactions play.
"The bear got the energy it needed from the oxygen it first breathed that oxygen then went inside the bear and created a chemical reaction with the other chemicals inside the bear which are water molecules and carbon dioxide molecules then the carbon dioxide molecules are released from the bear as carbon dioxide"	Score = 1 The response includes a claim that the energy came from a chemical reaction, but it describes the wrong reaction.
"It used oxygen to complete cellular respiration, in which glucose from carbohydrates and oxygen are used to produce ATP and CO2. ATP is used as energy for the cells."	Score = 2 The response describes the chemical reaction that provides the bear energy.

## **QUESTION 4**

Now think about the fact that the bear lost weight during hibernation. Use the model to write an explanation for what causes a bear to decrease in mass during hibernation. Think about the difference in masses of the molecules the bear breathes in and breathes out during hibernation. Be sure to refer to the model in your explanation.

## LEARNING GOAL

#### Learning Performance

• Use a model to construct (or identify) an explanation for how the bear lost weight during hibernation by considering the difference in mass between the inputs and outputs of the bear.

#### Targeted DCIs, SEP, and CCC

- PS3.D-M.2: Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.
- SEP6-M.2: Construct an explanation using models or representations.
- CCC5-E.2: Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems.
- CCC4-M.2: Models can be used to represent systems and their interactionssuch as inputs, processes, and outputs-and energy, matter, and information flows within systems.

### **SCORING RUBRIC**

#### **Ideal Response**

As seen in the model, the bear breathes in oxygen and breaths out carbon dioxide. Carbon dioxide (CO2) has more mass than oxygen (O2) since it contains a carbon atom in addition to two oxygen atoms. The breathing in of oxygen and out of carbon dioxide results in a net loss of mass for the bear as carbon atoms leave the bear. Over time this results in the bear's losing weight.

#### OR

During hibernation the bear breathes in oxygen which react with reacts with carboncontaining molecules that were already part of the bear system. Carbon atoms from these carbon-containing molecules are used to form carbon dioxide which leaves the bear system when the bear breathes out. This leads to a loss of mass.

## Elements of a Correct Response

Categories	Elements	
Student makes a	The bear decreased in mass/lost weight because	
claim that answers the question	<ul> <li>Matter/atoms that was/were once part of the bear's body left/is no longer part of the bear's body.</li> </ul>	
	o the bear exhaled more mass than it took in.	
	<u>Note</u> : Students who explicitly state that matter is destroyed or not conserved should not receive the claim point.	
Student uses the	The bear breathes in oxygen molecules.	
crosscutting concept	• The bear breathes out carbon dioxide molecules.	
matter into and out	• The bear breathes out water molecules. (optional)	
of a system to provide evidence.		
Student states or	• Carbon dioxide has more mass than oxygen. [ <i>mass</i> ]	
uses science ideas	• Complex molecules containing carbon react with oxygen to produce carbon dioxide (i.e., Carbon-based food molecules already inside the bear are involved in a reaction that produces carbon dioxide). [ <i>cellular respiration</i> ]	
Student uses reasoning to link crosscutting concepts to the claim	<ul> <li>There is a net loss of mass (weight, atoms, or matter) from the bear during hibernation because oxygen is entering the bear and carbon dioxide is leaving the bear, and carbon dioxide is heavier than oxygen.</li> <li>OR</li> </ul>	
	• The carbon atoms that leave the body as part of carbon dioxide came from carbon-based molecules that were part of the bear's body, therefore, there is a net loss of mass (weight or atoms) from the bear during hibernation.	
OR		
Student selects the correct multiple- choice answer	C. The bear breathed out more mass than it breathed in causing the bear's mass to decrease while it hibernated.	

## Sample Student Responses

Student response	Scoring description
"Because the bear was in hibernation it wouldn't	Score = 0
have been eating food, this would lead to the bear not getting much carbon from the food it usually eats."	The response does not include the elements in the rubric. It explains the weight loss by saying the bear is not eating.
"the bear didn't eat for a long time which will	Score = 1
and out they're taking in certain molecules and pushing others out that could cause them to be heavier at the start of hibernation."	The response makes a claim but does not include crosscutting concepts, science ideas, or reasoning to support the claim.
"When the bear breathed in oxygen, it exhaled	Score = 2
carbon dioxide. This lead to a decrease of carbon atoms in the bear's body from the food that the bear ate before hibernation."	The response makes a claim and uses crosscutting concepts of the flow of matter, but it does not include reasoning with science ideas.
"I think that when the bear breathes in the	Score = 3
oxygen and during the chemical reaction shown above a carbon containing molecule from the food the bear ate before hibernation is "connected" with the oxygen molecules. This means that every time the bear exhales, it is exhaling that oxygen joined with the carbon containing molecule. Overtime I think that exhaling enough of those carbon containing molecules, the bear will start to lose weight."	The response includes a claim, crosscutting concepts, and science ideas, but it does not get the reasoning point because of a lack of clarity in describing the chemical reactions, in particular, not saying that it is the "atoms" of carbon and oxygen that are reacting.
"The bear lost weight during hibernation because it's body was using the stored food to produce different forms of energy like ATP (short	Score = 4 The response includes all the elements in the rubric
term) and ADP (long term) energy. The bear's body needed to use the carbon and the glucose molecules from the food combined with oxygen to start that chemical reaction that will produce energy. Also, as the bear is breathing in oxygen molecules, it is also breathing out carbon dioxide molecules, which have more mass. Together, these processes caused the bear to lose weight."	

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