ASPECt
Assessing Students' Progress on the Energy Concept

Bees: AP32-6

Middle School – Energy and Chemical Reactions

TASK OVERVIEW

Students explain how bees can get energy from a sugar-water mixture by creating a molecular model showing how water, glucose, carbon dioxide, and oxygen molecules are involved in cellular respiration. Students then explain what happens to the numbers of each type of atom during the reaction and, if needed, revise their model to accurately show what happens during the reaction. Finally, students explain why bees can't get energy from just water alone and predict whether bees would be able to get energy by eating other sugar molecules, such as fructose.

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

- SEP2-M.6: Develop a model to describe unobservable mechanisms.
- SEP6-M.2: Construct an explanation using models or representations.

Crosscutting concepts

- CC5-M.1: Matter is conserved because atoms are conserved in physical and chemical processes.

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.]
- MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. [*Clarification Statement*: Emphasis is on the law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [*Assessment Boundary*: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]

TASK PERFORMANCE EXPECTATION

Create and revise a model to describe the cellular respiration process by which an organism gets energy and *to represent* that atoms are conserved during this chemical process. *Use a model to explain why* bees can't get energy from water alone and *predict* whether bees can get energy by consuming other sugar molecules, such as fructose.

LINK TO ONLINE VERSION

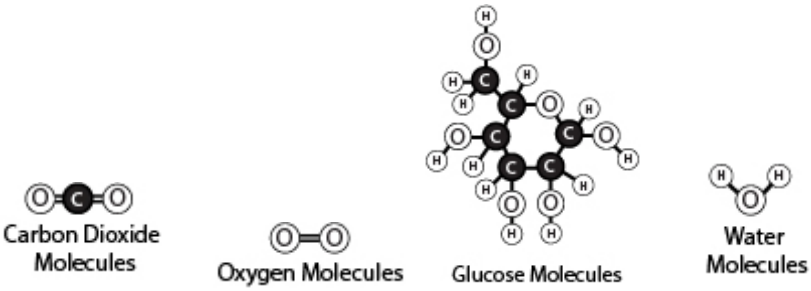
http://assess.bscs.org/i/test/601

Task

Bees survive the winter by eating honey that they have stored throughout the year. A beekeeper thinks her bees have not stored enough honey to survive the winter. To supplement the bees' honey supply during the winter, she feeds them a sugar-water mixture of water and glucose. She puts the mixture in a feeder (shown below) for the bees to eat.

Picture of a bee feeder taken by honeydrops on pixabay

She knows that bees, like all other organisms, get the energy that they need to survive from cellular respiration, a process that involves chemical reactions inside a bee's body that release energy. Below are several molecules that are involved in these chemical reactions.



Circles with letters denote the different types of atoms that make up these molecules.

1. Use the molecules to create a model showing the overall cellular respiration process that is taking place inside the bee.

   Your model should clearly show what molecules are reacting with each other and what molecules are produced after the reaction by using an arrow that point from the reactants to the products. Your model should also show how many molecules are reacting and how many molecules are produced.

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2. What happens to the number of each type of atom during this process?

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3. Does your model accurately show what happens to the number of each type of atom during this process? If not, revise your model. (Hint: Use one molecule of glucose and try adjusting the numbers of oxygen, carbon dioxide, and water molecules in the model.)

   A. Yes, my model accurately shows what happens to the number of each type of atom.

   B. No, I will revise my model.

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4. In addition to the sugar-water mixture, the beekeeper also provides the bees with plain water. Do you think the bees can get energy using the chemical process you modeled by drinking just the plain water without any sugar in it?

   A. Yes, bees can get energy by drinking plain water without any sugar in it.

   B. No, bees cannot get energy by drinking plain water without any sugar in it.

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5. Explain why you do or do not think bees can get energy by drinking plain water without any sugar in it. Use your model of the cellular respiration process to support your explanation.

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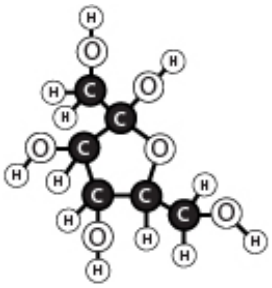
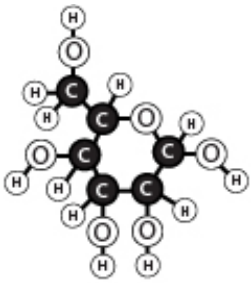
6. Honey contains water and several different sugar molecules in addition to glucose (such as fructose and sucrose).



Fructose Molecules



Glucose Molecules

Sucrose Molecules

Do you think bees can get energy from any of the other sugar molecules in honey, such as fructose and sucrose?

A. Yes, bees can get energy from the other sugar molecules in honey.

B. No, bees cannot get energy from the other sugar molecules in honey.

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7. Explain why you do or do not think bees can get energy from the other sugar molecules in honey. Use your model to support your explanation.

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

QUESTIONS 1 & 3

Use the molecules to create a model showing the overall cellular respiration process that is taking place inside the bee.

Your model should clearly show what molecules are reacting with each other and what molecules are produced after the reaction by using arrows that point from the reactants to the products. Your model should also show how many molecules are reacting and how many molecules are produced.

Does your model accurately show what happens to the number of each type of atom during this process? If not, revise your model. (Hint: Use one molecule of glucose and try adjusting the numbers of oxygen, carbon dioxide, and water molecules in the model.)

LEARNING GOAL

Learning Performance

- Create and revise a molecular model to represent the chemical reaction taking place inside the bees that give the bees energy making sure to show that the number of each type of atom stays the same.

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.
- SEP2-M.6: Develop a model to describe unobservable mechanisms.
- CC5-M.1: Matter is conserved because atoms are conserved in physical and chemical processes.

SCORING RUBRIC

Ideal Response

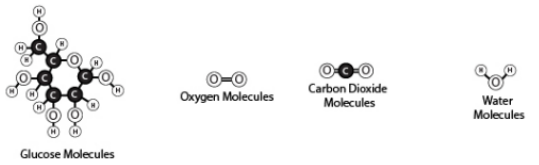
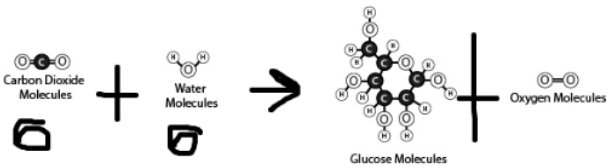
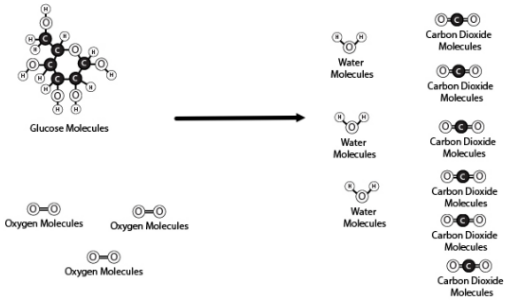
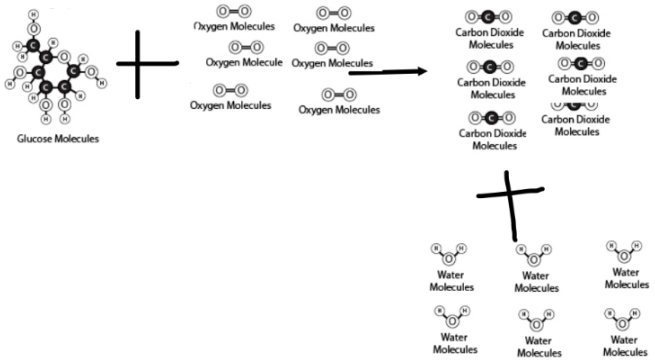
The student creates a model of a chemical reaction in which 1 glucose molecule and 6 oxygen molecules react to form 6 carbon dioxide molecules and 6 water molecules.

Elements of a Correct Response

Categories	Elements
Student's model includes the relevant components	• Oxygen molecules as a reactant of the overall reaction AND • Glucose molecules as a reactant of the overall reaction AND • Carbon dioxide molecules as a product of the overall reaction

	• Water molecules as a product reactant of the overall reaction (Optional because water is not an explicit product in the DCI) Note: Any molecule at the beginning of an arrow can be considered a reactant and any molecule at the end of an arrow can be considered a product.
Student's model shows the interactions between components	• The model shows atoms in molecules rearranging to form different molecules by showing that the reactant molecules are different than the product molecules, typically by using an arrow that points from the reactants to the products.
Student's model illustrates a crosscutting concept	• The type of atoms is conserved in the chemical reaction (i.e., both the starting and ending molecules are made up of carbon, hydrogen, and oxygen). AND • The number of each type of atoms are conserved in the chemical reaction (i.e., if the reactants are made up of 6 carbon atoms, then the products must be made up of 6 carbon atoms). o Note: The student's model must show the same number of each type of atom they use in the reaction.
Student's model correctly represents cellular respiration	• The student develops a model of the cellular respiration reaction by indicating that oxygen and glucose react to form water and carbon dioxide. Note: the reaction does not have to be balanced to receive this point.

Sample Student Responses

Student response	Scoring description
	Score = 0 The student only placed models of the molecules but did not develop a model of the cellular respiration process.
	Score = 1 The model does illustrate the rearrangement of atoms, but the process described is not cellular respiration.
	Score = 2 The model includes the correct components and interactions but the number of each type of atom is not conserved.
	Score = 3 The model illustrates the cellular respiration process and the conservation of atoms.

QUESTION 2

What happens to the number of each type of atom during this process?

LEARNING GOAL

Learning Performance

- Describe that the number of each type of atom is conserved during the cellular respiration process.

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.
- CC5-M.1: Matter is conserved because atoms are conserved in physical and chemical processes.

SCORING RUBRIC

Ideal Response

Cellular respiration involves chemical reactions therefore there is the same number of each type of atom before and after the process occurs.

Elements of a Correct Response

Categories	Elements
Student either states or uses a crosscutting concept	• Atoms are conserved during chemical processes (i.e., the number of each type of atom stays the same).

Sample Student Responses

Student response	Scoring description
"It decreases because some of the energy during respiration is transferred to thermal."	Score = 0 The response includes the incorrect idea that the number of atoms decreases during respiration.

"It stays the same because you cannot create or destroy the matter."	Score = 1 The response includes the correct crosscutting concept idea about the conservation of atoms.

QUESTIONS 4 & 5

In addition to the sugar-water mixture, the beekeeper also provides the bees with plain water. Do you think the bees can get energy using the chemical process you modeled by drinking just the plain water without any sugar in it?

A. Yes, bees can get energy by drinking plain water without any sugar in it.
B. No, bees cannot get energy by drinking plain water without any sugar in it.

Explain why you do or do not think bees can get energy by drinking plain water without any sugar in it. Use your model of the cellular respiration process to support your explanation.

LEARNING GOAL

Learning Performance

- Make a claim about whether bees can get energy from drinking only water and use a model to write an explanation that supports the claim.

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

B. No, bees cannot get energy by drinking plain water without any sugar in it.

Carbon-containing molecules (such as carbohydrates, fats, proteins) are required for organisms to get energy from cellular respiration. Water does not contain carbon so the bees cannot get energy by drinking water.

Elements of a Correct Response

Categories	Elements
Student chooses the correct multiple-choice claim	B. No, bees cannot get energy by drinking plain water without any sugar in it.
Student either states or uses a general science idea	• Within organisms, carbon-containing molecules (such as carbohydrates (glucose), fats, and or proteins) are used as fuel (i.e., bees need molecules that have carbon atoms to get energy or bees need glucose to get energy). o Note: bees need sugar is not enough. They must mention glucose or carbohydrates. • Fuels (such as carbohydrates (glucose), fats, and or proteins) are used in a process that release energy (i.e., bees react glucose and oxygen to release the energy they need to survive, or bees need glucose in order to start the process to release energy). Note: The student's model can be used to clarify their explanation if they mention it in their writing.
Student uses reasoning to link the science ideas to the claim	• Water molecules are not made up of carbon atoms and/or are not carbohydrates (glucose), fats, or proteins so the bees cannot get energy from drinking water.
Student does not refer to carbon atoms in their response but uses productive ideas related to food	• Organisms require food to get the energy they need to survive (i.e., glucose and other sugars are food for bees, sugar give the bees energy, or bees need sugar to survive). • Water is not a food so the bees cannot get energy from drinking water.

Sample Student Responses

Student response	Scoring description
Student selects A and wrote "Bees can get energy by drinking plain water without any sugar in it because theres water in cellular respiration."	Score = 0 The student selected the incorrect claim and provided an incorrect explanation.
Student selects B and wrote "I think that without sugar bees would not get enough energy."	Score = 1 The student receives a point for selecting the correct claim but no other points because they did not provide a correct explanation.
Student selects B and wrote "Glucose is required for cellular respiration, so drinking water without sugar in it will not allow cellular respiration to occur."	Score = 2 The student receives points for selecting the correct claim and for including the idea that glucose is needed for cellular respiration.
Student selects B and wrote "The bees need glucose because they need the carbon for energy, if they only have water they won't have that carbon that gives them the energy."	Score = 3 The student receives points for selecting the correct claim and providing a well-reasoned explanation.

QUESTIONS 6 & 7

Do you think bees can get energy from any of the other sugar molecules in honey, such as fructose and sucrose?

A. Yes, bees can get energy from the other sugar molecules in honey.
B. No, bees cannot get energy from the other sugar molecules in honey.

Explain why you do or do not think bees can get energy from the other sugar molecules in honey. Use your model to support your explanation.

LEARNING GOAL

Learning Performance

- Make a claim about whether bees can get energy from the other sugars in honey and use a model to write an explanation that supports the claim.

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

A. Yes, bees can get energy from other sugar molecules in honey.

Cellular respiration can occur by a reaction with other sugars with oxygen to release energy because those sugars are carbon-containing molecules like glucose.

Elements of a Correct Response

Categories	Elements
Student makes a valid claim	A. Yes, bees can get energy from the other sugar molecules in honey.
Student cites evidence	• Sucrose and fructose are made up of the same types of atoms as glucose (i.e., carbon) or they can be converted to glucose.
Student either states or uses a general science idea	• Within organisms, certain carbon-containing molecules (such as carbohydrates (glucose), fats, and or proteins) are used as a fuel in process that releases energy (i.e., bees need molecules like sugars to use in cellular respiration).
Student uses reasoning to link the evidence and/or science ideas to the claim	• Bees can get energy from fructose and sucrose because they contain o the same atoms needed in the process of cellular respiration (i.e., carbon), or

	○ the same types of atoms as glucose (i.e., carbon).
Student does not refer to carbon atoms in their response but uses productive ideas related to food	• Organisms require food to get the energy they need to survive (i.e., glucose and other sugars are food for bees or bees need glucose and other sugars to survive).

Sample Student Responses

Student response	Scoring description
Student selects B and wrote "I don't think they can get energy from any other type of sugar in honey because that is a lot of sugar already."	Score = 0 The student selected the incorrect claim and provided an incorrect explanation.
Student selects A and wrote "I think they can because when they get energy from just sugar, there have to be some other molecules in sugar that they get their energy from."	Score = 1 The student receives a point for selecting the correct claim but no other points because they did not provide a correct explanation.
Student selects A and wrote "Because many of the sugars share common atoms."	Score = 2 The student receives points for selecting the correct claim and for citing that the molecules are made up of the same atoms.
Student selects A and wrote "I think that the bees can get energy from other sugar molecules in honey because they look to have about the same atoms. So, I think that they might be able to substitute glucose in cellular respiration."	Score = 3 The student receives points for selecting the correct claim, for citing that the molecules are made up of the same atoms and for using reasoning to link this evidence to the claim.

Student selects A and wrote "Cellular respiration is a chemical reaction that requires carbon-containing molecules. The sucrose and fructose both contain the same types of atoms as glucose, so the bees should be able to get energy from reacting the sucrose or fructose with oxygen."	Score = 4 The student receives points for selecting the correct claim and linking science ideas and evidence to the claim.

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