Summative Assessments

Science Practice Test Teacher Guide

NM-ASR

Elementary

COGNIA ASSESSMENTS

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Practice Test Items

Session 1: Items 1–12

Item 1: Standalone Item

Next Generation Science Standards Description

PE: 3-LS4-2: Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. [Clarification Statement: Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.]

SEP: Constructing Explanations and Designing Solutions: Use evidence (e.g., observations, patterns) to construct an explanation.

DCI: LS4.B: Natural Selection: Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.

CCC: Cause and Effect: Cause and effect relationships are routinely identified and used to explain change.

Item Type: Inline Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Med | DCI-Med | CCC-Med

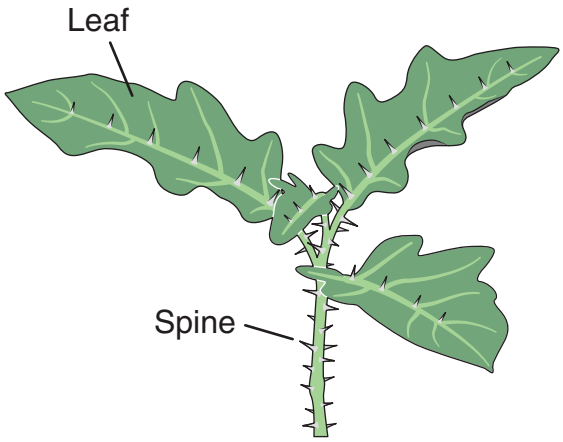
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use evidence to explain how variation in the number of spines on horse nettle plants provides a survival advantage. The item aligns to the SEP by asking the students to use evidence to construct an explanation. The item aligns to the DCI because students must use knowledge that differences in characteristics between individuals of the same species provide survival advantages. The item aligns to the CCC because students must use the cause and effect relationship between number of spines on horse nettle plants and likelihood of survival to construct their explanation.

Horse nettle plants have long spines on the stem and underneath the leaves as shown in the diagram. Caterpillars eat the leaves of horse nettle plants. After leaves have been eaten, new stems and leaves grow that have more spines than before.

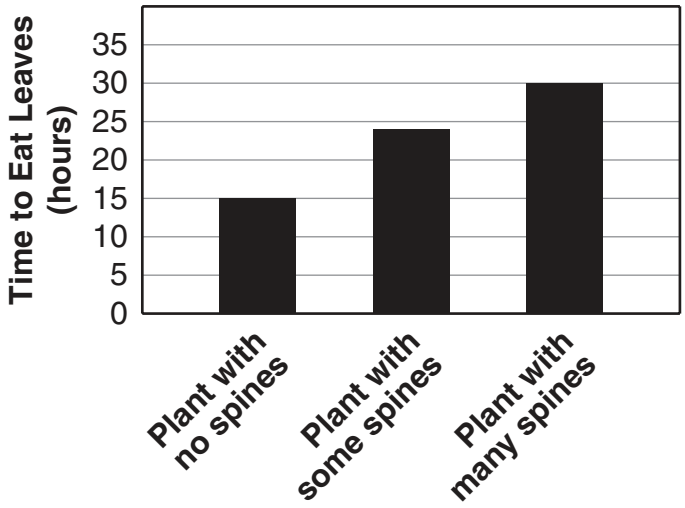
Horse Nettle Plant



To understand why this happens, Kim takes three horse nettle plants that each have three leaves. She removes all the spines from one plant and half the spines from the second plant. She leaves all the spines on the third plant. Then Kim puts one caterpillar on each plant and measures the time for the caterpillar to eat all three leaves on the plant.

The graph shows the results of Kim's investigation.

Time for Caterpillars to Eat Horse Nettle Leaves



The stimulus for this item begins by presenting the phenomenon that, after being eaten by caterpillars, horse nettle plants regrow stems and leaves with more spines. The hook is that a student wants to investigate why horse nettle plants regrow more spines after being eaten by caterpillars. The phenomenon and hook are grade-level appropriate because many students have observed insects and caterpillars eating plant leaves.

This question has two parts. Be sure to answer both parts of the question.

1. **Part a**

Select the words to complete a claim that is supported by the results of Kim's investigation.

Spines [increase, decrease] the survival of horse nettle plants because caterpillars eat leaves very slowly on horse nettle plants with [no, some, many] spines.

Part b

Which evidence supports the claim in Part (a)?

A Horse nettle plants without spines survive the best because caterpillars eat leaves without spines very quickly.

B Horse nettle plants with some spines survive the best because caterpillars prefer to eat leaves with many spines.

C Horse nettle plants survive with and without spines because caterpillars eat all the leaves in the same amount of time.

D Horse nettle plants with many spines survive the best because caterpillars eat fewer leaves in a day on plants with more spines.

Part a is aligned to the SEP, DCI, and CCC. Students use data from Kim's investigation and their content knowledge that differences in plant characteristics can increase survival to explain the cause and effect relationship between the number of spines on horse nettle plants and the likelihood of survival.

Part b is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how differences in plant characteristics can increase survival to describe how data from Kim's investigation is evidence that supports the cause and effect relationship between the number of spines on horse nettle plants and the likelihood of survival.

Scoring Key

Part a

Correct Response:
Spines [**increase**, decrease] the survival of horse nettle plants because caterpillars eat leaves very slowly on horse nettle plants with [no, some, **many**] spines.

Part b

Correct Response: D

Distractor Rationales

Part b

A The graph shows that caterpillars eat leaves on plants without spines in the least amount of time. This means that these plants are least likely to survive, not most likely to survive.

B The graph shows that caterpillars eat leaves with some spines at a moderate speed. This means that these plants have moderate survival chance, not the best survival chance.

C The graph shows that caterpillars eat leaves with different numbers of spines in different amounts of time.

D KEY: Caterpillars are likely to eat the fewest leaves on plants that have the most spines because caterpillars eat those leaves most slowly. Therefore, plants with more spines are most likely to survive.

WHAT FOLLOWS IS THE STIMULUS AND PBT VERSION OF THE PREVIOUS ITEM

Item 1: PBT Standalone Item

Next Generation Science Standards Description

PE: 3-LS4-2: Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. [Clarification Statement: Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.]

SEP: Constructing Explanations and Designing Solutions: Use evidence (e.g., observations, patterns) to construct an explanation.

DCI: LS4.B: Natural Selection: Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.

CCC: Cause and Effect: Cause and effect relationships are routinely identified and used to explain change.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Med | DCI-Med | CCC-Med

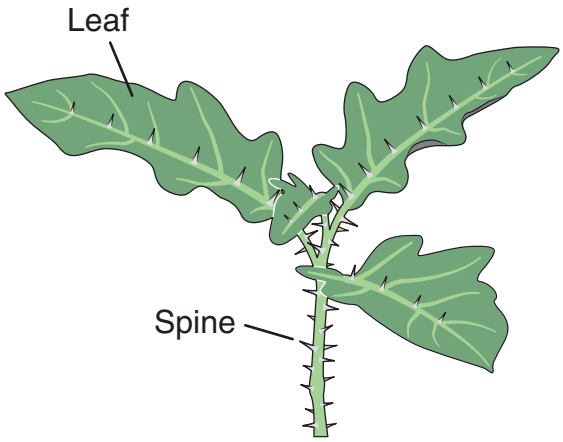
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use evidence to explain how variation in the number of spines on horse nettle plants provides a survival advantage. The item aligns to the SEP by asking the students to use evidence to construct an explanation. The item aligns to the DCI because students must use knowledge that differences in characteristics between individuals of the same species provide survival advantages. The item aligns to the CCC because students must use the cause and effect relationship between number of spines on horse nettle plants and likelihood of survival to construct their explanation.

Horse nettle plants have long spines on the stem and underneath the leaves as shown in the diagram. Caterpillars eat the leaves of horse nettle plants. After leaves have been eaten, new stems and leaves grow that have more spines than before.

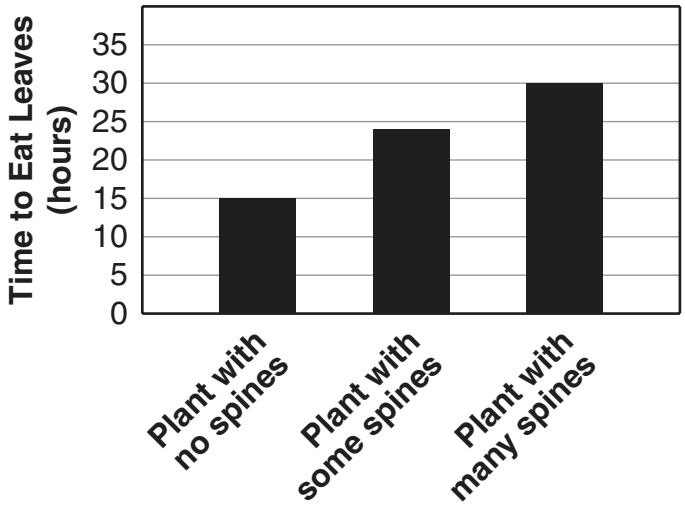
Horse Nettle Plant



To understand why this happens, Kim takes three horse nettle plants that each have three leaves. She removes all the spines from one plant and half the spines from the second plant. She leaves all the spines on the third plant. Then Kim puts one caterpillar on each plant and measures the time for the caterpillar to eat all three leaves on the plant.

The graph shows the results of Kim's investigation.

Time for Caterpillars to Eat Horse Nettle Leaves



The stimulus for this item begins by presenting the phenomenon that, after being eaten by caterpillars, horse nettle plants regrow stems and leaves with more spines. The hook is that a student wants to investigate why horse nettle plants regrow more spines after being eaten by caterpillars. The phenomenon and hook are grade-level appropriate because many students have observed insects and caterpillars eating plant leaves.

This question has two parts. Be sure to answer both parts of the question.

1. **Part a**

Which claim is supported by the results of Kim's investigation?

A Spines increase the survival of horse nettle plants because caterpillars eat leaves very slowly on horse nettle plants with no spines.

B Spines increase the survival of horse nettle plants because caterpillars eat leaves very slowly on horse nettle plants with many spines.

C Spines decrease the survival of horse nettle plants because caterpillars eat leaves very slowly on horse nettle plants with no spines.

D Spines decrease the survival of horse nettle plants because caterpillars eat leaves very slowly on horse nettle plants with many spines.

Part a is aligned to the SEP, DCI, and CCC. Students use data from Kim's investigation and their content knowledge that differences in plant characteristics can increase survival to explain the cause and effect relationship between the number of spines on horse nettle plants and the likelihood of survival.

Part b

Which evidence supports the claim in Part (a)?

A Horse nettle plants without spines survive the best because caterpillars eat leaves without spines very quickly.

B Horse nettle plants with some spines survive the best because caterpillars prefer to eat leaves with many spines.

C Horse nettle plants survive with and without spines because caterpillars eat all the leaves in the same amount of time.

D Horse nettle plants with many spines survive the best because caterpillars eat fewer leaves in a day on plants with more spines.

Part b is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how differences in plant characteristics can increase survival to describe how data from Kim's investigation is evidence that supports the cause and effect relationship between the number of spines on horse nettle plants and the likelihood of survival.

Scoring Key

Part a
Correct Response: B

Part b
Correct Response: D

Distractor Rationales

Part a

A The graph shows that caterpillars eat leaves very quickly when the plants have no spines. This would decrease these plants' survival.

B KEY: The graph shows that caterpillars take the most time to eat leaves on plants with many spines, so having spines increases the survival of the plants.

C If spines decreased survival of plants, then the time to eat a leaf would be shorter. The graph shows that caterpillars take a long time to eat leaves when the plants have spines.

D The graph shows that caterpillars eat leaves slowly when the plants have many spines, so having many spines increases, not decreases, the survival of the plants.

Part b

A The graph shows that caterpillars eat leaves on plants without spines in the least amount of time. This means that these plants are least likely to survive, not most likely to survive.

B The graph shows that caterpillars eat leaves with some spines at a moderate speed. This means that these plants have moderate survival chance, not the best survival chance.

C The graph shows that caterpillars eat leaves with different numbers of spines in different amounts of time.

D KEY: Caterpillars are likely to eat the fewest leaves on plants that have the most spines because caterpillars eat those leaves most slowly. Therefore, plants with more spines are most likely to survive.

Item 2: Standalone Item

Next Generation Science Standards Description

PE: 4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

SEP: Asking Questions and Defining Problems: Ask questions that can be investigated based on patterns such as cause and effect relationships.

DCI: LS4.B: Conservation of Energy and Energy Transfer: Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

CCC: Energy and Matter: Energy can be transferred in various ways and between objects.

Item Type: Multiple Choice—Multi-select

Cognitive Complexity: Stimulus-Med | SEP-Low | DCI-High | CCC-Low

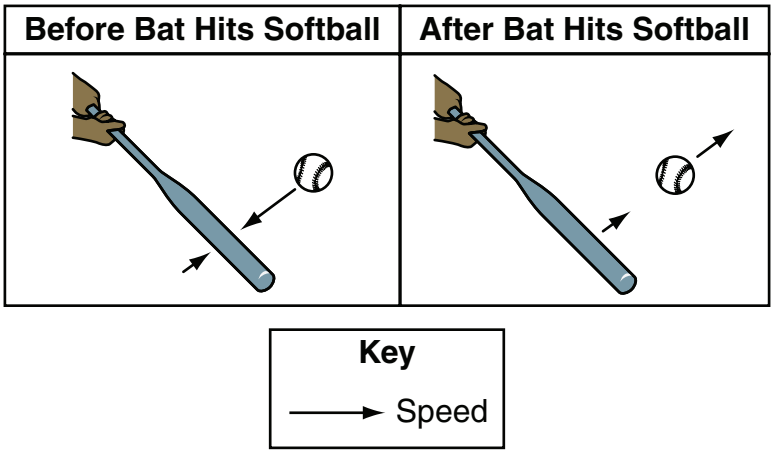
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to ask questions and predict changes in energy when a bat hits a softball. The item aligns to the SEP by asking students to select a question that can be investigated. The item aligns to the DCI because students must use knowledge that energy is transferred during a collision of the bat and a softball and that heat and sound can be produced. The item aligns to the CCC because students must identify the types of energy that are produced during the energy transfer when the bat hits the softball.

Mandy is on the softball team. She wants to learn about changes in energy that occur when the bat hits the softball. Mandy observes as her teammates hit the softball with the bat. She draws a diagram to show the motions of the ball and bat.

Motions of Bat and Softball



The stimulus for this item begins by presenting the phenomenon that there are energy changes when a bat hits a softball. The hook is that a student is on a softball team. The phenomenon and hook are grade-level appropriate because many students are familiar with the motions and sounds of softball games and some play the game.

This question has two parts. Be sure to answer both parts of the question.

2. **Part a**

Based on her observations and diagram, which question could Mandy investigate?

A How much energy does the bat transfer to the softball?

B Does using a heavier bat increase the speed of the softball?

C How does the speed of the softball affect the distance the ball travels?

D How much force is needed to make the bat move with twice the speed?

Part a is aligned to the SEP and DCI. Students decide which question can be investigated based on patterns in observations and a diagram by using their content knowledge of energy transfers during a collision.

Part b

Mandy predicts that some energy is transferred to the air when the bat hits the softball.

Which **two** types of energy are produced when the bat hits the softball?

A light energy

B sound energy

C thermal energy

D chemical energy

E electrical energy

Part b is aligned to the DCI and CCC. Students use their content knowledge that energy transfers during a collision can produce sound energy and thermal energy to identify types of energy that are produced during the energy transfer when a bat hits a softball.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: B, C

Distractor Rationales

Part a

A **KEY: The diagram shows the speed of the ball before and after being hit. She could investigate how much energy was transferred because she is given speeds in the diagram.**

B The diagram only shows one bat, so there is no information on what would happen if a heavier bat was used.

C The diagram only shows the speed of the ball, not how far the ball traveled. Answering this question would require information about distance.

D The diagram only shows the speed of the bat, not how much force the student used to make the bat move at that speed. Answering this question would require information about force.

Part b

A No light shines from the bat or ball when the bat hits the softball.

B **KEY: Sound energy is produced because there is a sound when the bat hits the softball.**

C **KEY: Thermal energy is produced. As the ball and softball rub against each other and stretch during the impact, friction makes them both slightly warmer.**

D When the bat hits the softball, no chemical changes occur.

E There is no spark or electrical current when the bat hits the softball.

Item 3: Standalone Item

Next Generation Science Standards Description

PE: 4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [*Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.*]

SEP: Developing and Using Models: Develop a model using an analogy, example, or abstract representation to describe a scientific principle.

DCI: PS4.A: Wave Properties: Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-High | DCI-Med | CCC-Low

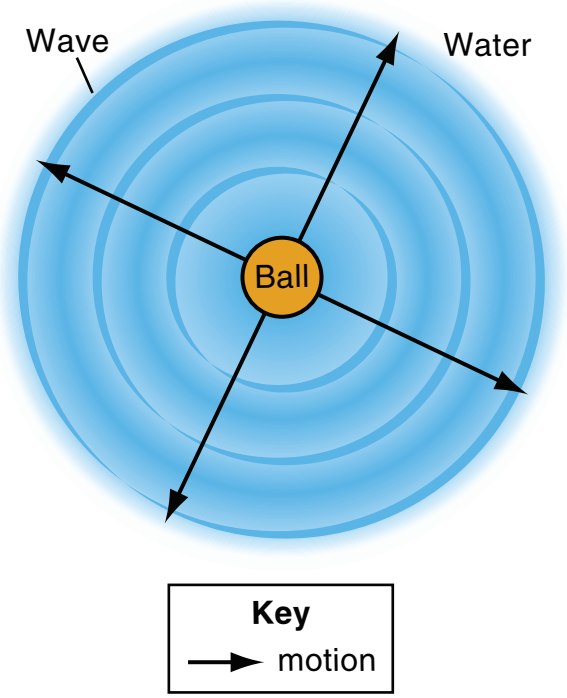
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to develop a model to describe patterns in water waves. The item aligns to the SEP by asking students to use an analogy to develop a physical model that describes how waves move. The item aligns to the DCI because students must use knowledge that waves make water go up and down in place when the waves move across the surface of water. The item aligns to the CCC because students must use patterns in wave movement to develop their model.

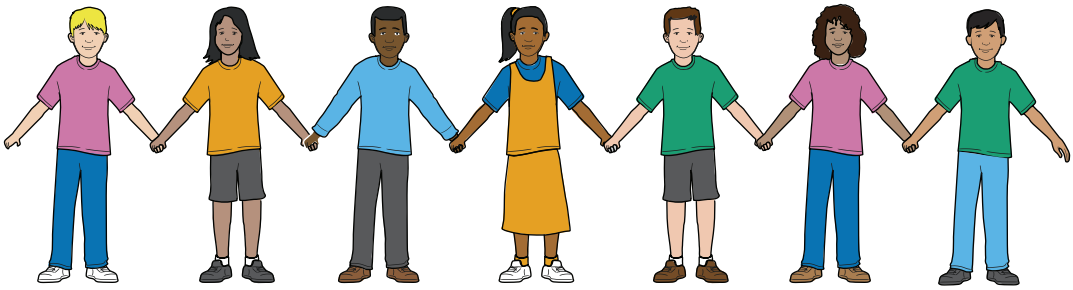
Kyria stands on a bridge and looks down at people throwing a ball into a lake. She observes that the ball hitting the water causes waves that move across the surface of the water. The diagram shows the waves that Kyria observes as she looks down on the lake.

Wave Observations



The next day at school, Kyria tells her friends about the ball and waves. Her friends decide to act like the waves in water. They hold hands and stand in a line, as shown in the diagram.

Wave Model



The stimulus for this item begins by presenting the phenomenon that a ball falling into a lake causes water waves. The hook is that a student is watching people throwing a ball into a lake. The phenomenon and hook are grade-level appropriate because many students have seen waves after an object is thrown into water.

This question has two parts. Be sure to answer both parts of the question.

3. **Part a**

How could the friends move so that their motion models the motion of the water waves that Kyria observed?

A The friends could all sit down at the same time.

B The friends could jump up and down in any order.

C The friends could all move one step to the right at the same time.

D The friends could move their arms up and down in order from left to right.

Part a is aligned to the SEP and DCI. Students use their content knowledge that waves make water move up and down as the waves move across the surface of water to describe how Kyria's friends can model the motion of water waves.

Part b

Which evidence from the Wave Observations diagram supports the answer to Part (a)?

A The waves move water away from the ball.

B The waves move the ball through the water.

C The waves move toward the ball and into the water.

D The waves move through the water away from the ball.

Part b is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how waves across the surface of the lake to identify the pattern in wave movement that can be used to develop Kyria's physical model that describes how waves move.

Scoring Key

Part a
Correct Response: D

Part b
Correct Response: D

Distractor Rationales

Part a

A This motion would show water with no waves, not how water waves move through water.

B Waves move out uniformly from the center in all directions, not randomly.

C Waves move through water, the water does not move with the waves.

D KEY: This motion would show how waves move through water.

Part b

A The diagram shows that the waves, not the water, move away from the ball.

B The diagram shows that the waves, not the ball, move through the water.

C The diagram shows that the waves move away from, not toward, the ball, in all directions.

D KEY: The diagram shows that the waves move outward, away from the ball.

Item 4: Standalone Item

Next Generation Science Standards Description

PE: 3-LS1-1: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. [Clarification Statement: Changes organisms go through during their life form a pattern.] [*Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.*]

SEP: Developing and Using Models: Develop a model to describe phenomena.

DCI: LS1.B: Growth and Development of Organisms: Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.

CCC: Patterns: Patterns of change can be used to make predictions.

Item Type: Open-ended

Cognitive Complexity: Stimulus-Med | SEP-Med | DCI-Med | CCC-Med

Number of Points: 4

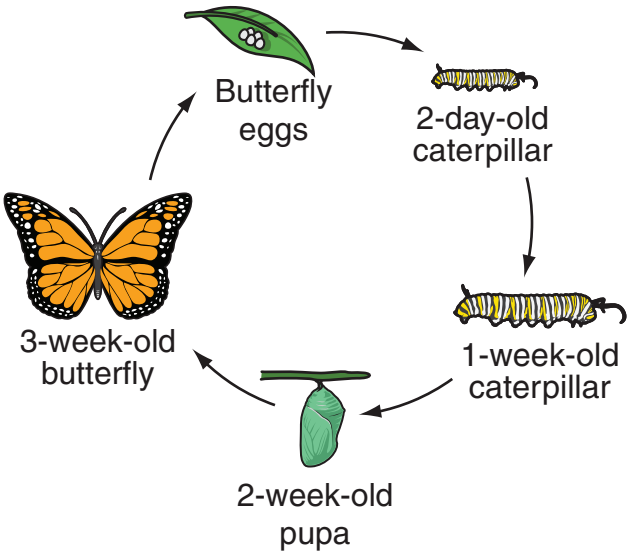
Item on next page

This item brings students into the story line by asking them to compare models of the life cycles of organisms with diverse life cycles. The item aligns to the SEP by asking students to use the life cycle models for butterfly and clownfish to develop verbal models that compare the life cycles of butterflies, clownfish, and parrots. The item aligns to the DCI because students must use knowledge that animals have unique and diverse life cycles. The item aligns to the CCC because students must use patterns of change in the life cycles of butterflies and clownfish to make predictions about the life cycle of parrots.

Hazel and Julian go to the zoo to see their favorite animals.

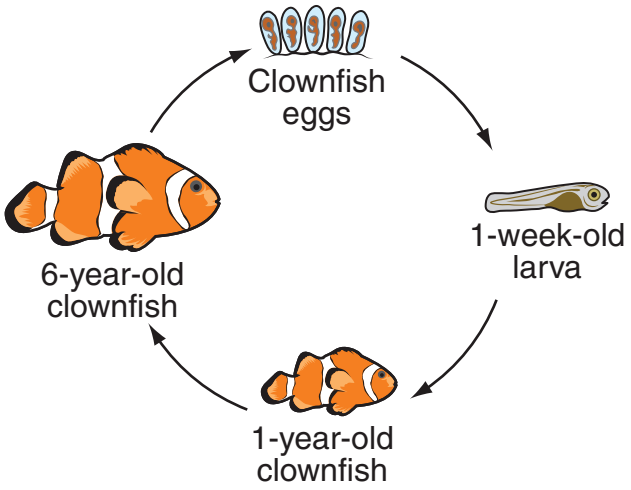
Hazel's favorite animals are insects like butterflies. She learns about the butterfly's life cycle and finds out that butterflies can live up to four weeks in a zoo. Hazel draws a model of the butterfly's life cycle using the information she learned. Hazel's model is shown in the diagram.

Butterfly Life Cycle Model



Julian's favorite animals at the zoo are fish like clownfish. Julian learns that clownfish can live up to 10 years in a zoo. Julian draws a model of the clownfish's life cycle using the information he learned. Julian's model is shown in the diagram.

Clownfish Life Cycle Model



The stimulus for this item begins by presenting the phenomena that butterflies and clownfish have different life cycles. The hook is that two students have favorite animals they like to observe at the zoo. The phenomenon and hook are grade-level appropriate because many students are familiar with butterflies and fish.

This question has two parts. Be sure to answer both parts of the question.

4. **a.** Based on the models, describe one way the butterfly and clownfish life cycles are alike and one way they are different.

Their friend Ruby's favorite animal is her pet parrot. Ruby's parrot is a bird that can live up to 30 years as a pet.

b. Identify which of the two life cycle models is most similar to the parrot's life cycle. Describe one way that animal's life cycle and the parrot's life cycle are alike and one way that animal's life cycle and the parrot's life cycle are different.

Part a is aligned to the SEP and DCI. Students use their content knowledge that animals have unique and diverse life cycles to develop a verbal model that compares the life cycle of butterflies and clownfish.

Part b is aligned to the DCI and CCC. Students use their content knowledge that animals have unique and diverse life cycles and patterns of change in butterfly and clownfish life cycles to make predictions about a parrot's life cycle.

The scoring rubric specifies how a four-point response uses the dimensions of the PE and provides detail about how different levels of response meet the requirements of specific tasks in the item. All open-ended standalone items are four-point items.

Scoring Rubric

Score	Description
4	The response demonstrates thorough use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response uses the models to describe one way the butterfly and clownfish life cycles are alike and one way they are different. The response also identifies which of the two life cycle models is most similar to the parrot's life cycle and describes one way that an animal's life cycle and the parrot's life cycle are alike and one way that an animal's life cycle and the parrot's life cycle are different. The response • clearly applies science and engineering practices to provide an explanation or solution; • provides a coherent and accurate explanation or solution based on disciplinary core ideas; • reflects thorough understanding of complex ideas and crosscutting concepts; and • effectively applies and demonstrates complete understanding of the three dimensions.
3	The response demonstrates sufficient use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response may lack some detail or information, or the response may contain minor errors in applying and demonstrating understanding of science and engineering practices, disciplinary core ideas, and crosscutting concepts.
2	The response demonstrates limited use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response may lack multiple details or information, or the response may contain major error(s) in applying and demonstrating understanding of science and engineering practices, disciplinary core ideas, and crosscutting concepts.
1	The response demonstrates minimal use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems.

Score	Description
0	The response is inaccurate, is irrelevant, or contains no evidence of use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems.
Blank	No response

Scoring Notes

a. The two life cycles are alike because both animals begin as eggs. Then they get bigger. They both grow up and become adults. Both the butterfly and the clownfish babies are called something different from their grown-up names. The baby butterflies are called caterpillars and the baby clownfish are called larvae. The two life cycles are different because when a butterfly is young it looks very different from its parents. The baby clownfish looks similar to a clownfish (both have tails) when it is born. It is just smaller and has no fins. It takes years for a clownfish to grow, but it lives a long time. A butterfly takes only weeks to grow and only lives for four weeks.

Note: Responses need only one of the many similarities and one of the many differences.

b. The parrot's life cycle is more like the clownfish. Both animals begin as eggs. After birth, both animals look similar to but smaller than parents. They both get larger. The cycles are different because the parrot takes a longer time to grow up than the clownfish. Clownfish start out without stripes and grow stripes while parrots do not.

Notes:

- *A student may use a drawing of the parrot's life cycle in his or her description of similarities and differences. If so, it should look similar to that of the clownfish and there must be a description or label of what the student intends to be similar and different. The drawings of the parrot do not have to look like parrots. Responses without drawings are also acceptable if a detailed description is provided.*
- *Students are not required to know anything about feather colors and how they change on parrots, so reasonable statements about color/pattern changes in feathers can be accepted.*
- *Students are not required to use the scientific understanding of metamorphosis, chrysalises, etc. in descriptions of butterfly life cycles.*

The scoring notes provide information expected for a full credit/four-point response. They are written using the type of language most likely to be used by students.

Items 5-8: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: 5-PS1-3: Make observations and measurements to identify materials based on their properties. [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [*Assessment Boundary: Assessment does not include density or distinguishing mass and weight.*]

SEP: Planning and Carrying Out Investigations: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

DCI: PS1.A: Structure and Properties of Matter: Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)

CCC: Scale, Proportion, and Quantity: Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

PE: 5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

SEP: Planning and Carrying Out Investigations: Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

DCI: PS1.B: Chemical Reactions: When two or more different substances are mixed, a new substance with different properties may be formed.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Cluster Overview: Investigating Gas Production

Item	Item Type	Alignment
5	Multiple Choice	5-PS1-3: SEP, DCI, CCC
6	Multiple Choice—Multiple Choice	5-PS1-3: SEP, DCI
7	Multiple Choice	5-PS1-4: DCI, CCC
8	Inline Choice—Multiple Choice	5-PS1-4: DCI, CCC
8 PBT	Multiple Choice—Multiple Choice	5-PS1-4: DCI, CCC

Stimulus and Items on next pages

The cluster consists of a phenomenon that allows overall item alignment across two PEs. While not every individual item in the cluster is three-dimensional, all items are at least two-dimensional, and collectively the whole cluster has strong alignment to all three dimensions of each PE.

Read the information. Then answer the questions that follow.

Investigating Gas Production

In class, a teacher demonstrates a chemical reaction by mixing vinegar and baking soda to produce bubbles of gas. Eliana wonders whether mixing other substances could also produce a gas. She decides to test different combinations of sugar, water, vinegar, and baking soda.

Some properties of these substances are shown in the table.

The stimulus for this cluster begins by presenting the phenomenon that mixing vinegar and baking soda produces gas bubbles. The hook is that a student is curious about what would happen if she mixed other substances. The phenomenon and hook are grade-level appropriate because many students have seen the bubbles produced by mixing vinegar and baking soda.

Properties of Substances

Substance	Color	Solid or Liquid	Attracted to a Magnet	Conducts Electricity
Sugar	White	Solid	No	No
Water	Clear	Liquid	No	Yes
Vinegar	Clear	Liquid	No	Yes
Baking soda	White	Solid	No	No

Investigation 1

Eliana mixes a small amount of each liquid and solid in a bowl and observes whether bubbles of gas are produced. Her observations are shown in the table.

Investigation 1 Observations

Liquid Used	Solid Used	Gas Produced
Water	Sugar	No
Water	Baking soda	No
Vinegar	Sugar	No
Vinegar	Baking soda	Yes

Investigation 2

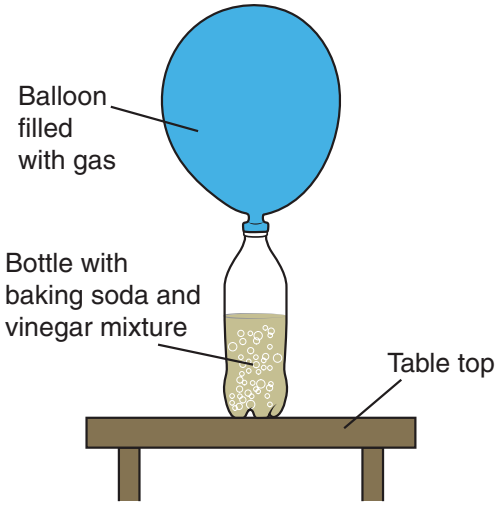
Next, Eliana wonders whether changing the amount of baking soda would change the amount of gas produced. To investigate, she follows these steps:

1. Record the mass of a balloon.
2. Pour 50 milliliters of vinegar into a bottle.

3. Put 5 milliliters of baking soda inside the balloon. Hold the balloon so that the baking soda stays inside the balloon and attach the open end of the balloon to the top of the bottle.
4. Lift the balloon so that the baking soda falls into the bottle with vinegar.
5. Wait one minute.
6. Carefully remove the balloon from the bottle without allowing any gas to escape.
7. Measure the mass of the balloon filled with gas.
8. Calculate the mass of gas produced by subtracting the mass of the balloon from the mass of the balloon filled with gas.
9. Repeat steps 1–8 until three trials have been completed.
10. Repeat steps 1–9 with 10 milliliters and 15 milliliters of baking soda.

The results of one trial are shown in the diagram.

Gas in a Balloon



Eliana's data are shown in the table.

Investigation 2 Data

Amount of Baking Soda (milliliters)	Mass of Gas Produced (grams)			Average Mass of Gas Produced (grams)
	Trial 1	Trial 2	Trial 3	
5	1.0	0.8	1.2	1.0
10	1.5	1.9	1.4	1.6
15	2.4	1.9	2.6	2.3

Item 5: Cluster Item

Next Generation Science Standards Description

PE: 5-PS1-3: Make observations and measurements to identify materials based on their properties. [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [*Assessment Boundary: Assessment does not include density or distinguishing mass and weight.*]

SEP: Planning and Carrying Out Investigations: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

DCI: PS1.A: Structure and Properties of Matter: Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)

CCC: Scale, Proportion, and Quantity: Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Low | DCI-Low | CCC-Low

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to describe whether measurements were needed to identify whether a gas was produced during an investigation. The item aligns to the SEP by asking students to describe whether measurements were needed to produce data during the investigation. The item aligns to the DCI because students must use knowledge that measurements of properties can be used to identify materials. The item aligns to the CCC because students must describe whether the student used standard units to measure any physical quantities during an investigation.

5. Eliana claims she does not need to use any measuring tools during investigation 1. Which sentence describes her claim?

A Her claim is correct because she does not measure the amount of gas produced.

B Her claim is correct because she mixes four different combinations of liquid and solid.

C Her claim is incorrect because she uses a beaker to measure the amount of liquid used.

D Her claim is incorrect because she uses a balance to measure the amount of solid used.

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge that measured properties can be used to identify materials to describe whether measurements of any physical quantities were needed to produce data that are evidence that mixing produced a gas.

Scoring Key

Correct Response: A

Distractor Rationales

A **KEY: In Investigation 1, Eliana observes bubbles of gas. She does not measure the amount of gas.**

B While Eliana does mix four combinations, there is no information that she carefully measures the mixtures. Without that information, mixing four different combinations does not support a claim about using measuring tools.

C In Investigation 1, Eliana uses "a small amount" of vinegar in a bowl. "A small amount" is not a measurement with a beaker.

D In Investigation 1, Eliana uses "a small amount" of baking soda in a bowl. "A small amount" is not a measurement made with a balance.

Item 6: Cluster Item

Next Generation Science Standards Description

PE: 5-PS1-3: Make observations and measurements to identify materials based on their properties. [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [*Assessment Boundary: Assessment does not include density or distinguishing mass and weight.*]

SEP: Planning and Carrying Out Investigations: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

DCI: PS1.A: Structure and Properties of Matter: Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Low | DCI-Low

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use properties of water, sugar, and vinegar to identify substances. The item aligns to the SEP by asking students to describe observations that can be used to identify substances. The item aligns to the DCI because students must use understanding of a variety of properties that can be used to identify substances.

This question has two parts. Be sure to answer both parts of the question.

6. **Part a**

Based on the properties in the table, how can Eliana tell whether a substance is water or sugar?

A The substance is sugar if the substance is a solid and conducts electricity.

B The substance is sugar if the substance is clear and is not attracted to a magnet.

C The substance is water if the substance is white and does not conduct electricity.

D The substance is water if the substance is liquid and is not attracted to a magnet.

Part a is aligned to the SEP and DCI. Students use their content knowledge that a variety of properties can be used to identify materials to describe observations that can be used to identify a substance as water or sugar.

Part b

Based on the observations from investigation 1, how can Eliana tell whether a substance is water or vinegar?

A The substance is water if gas is produced after sugar is added.

B The substance is vinegar if gas is produced after sugar is added.

C The substance is water if gas is produced after baking soda is added.

D The substance is vinegar if gas is produced after baking soda is added.

Part b is aligned to the SEP and DCI. Students use their content knowledge that a variety of properties can be used to identify materials to describe observations that can be used to identify a substance as water or vinegar.

Scoring Key

Part a
Correct Response: D

Part b
Correct Response: D

Distractor Rationales

Part a

A According to the table, sugar does not conduct electricity.

B According to the table, sugar is white, not clear.

C According to the table, water is clear, not white.

D KEY: According to the table, water is liquid and is not attracted to a magnet.

Part b

A Eliana did not observe a gas produced after sugar was added to water.

B The observations show that gas was produced when baking soda, not sugar, was added to water.

C No gas was produced after baking soda was added to water.

D KEY: Eliana observed a gas after baking soda was added to vinegar.

Item 7: Cluster Item

Next Generation Science Standards Description

PE: 5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

DCI: PS1.B: Chemical Reactions: When two or more different substances are mixed, a new substance with different properties may be formed.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Med | DCI-Med | CCC-Low

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to identify evidence from an investigation that can be used to support the claim that mixing vinegar and baking soda produces a new substance. The item aligns to the DCI because students must use knowledge that when substances are mixed, a new substance with different properties may be formed. The item aligns to the CCC because students must use the cause and effect relationship between new substances and different properties to identify evidence that supports the claim.

7. Which evidence from the investigations supports the claim that mixing vinegar and baking soda produces a new substance?

A A gas is produced when a liquid and a solid are mixed.

B When a liquid and solid are mixed, the mass does not change.

C The properties of substances stay the same when the substances are mixed.

D Different amounts of baking soda can be mixed with the same amount of vinegar.

This item is aligned to the DCI and CCC. Students use their content knowledge that a new substance will have properties different from the properties of the substances that were mixed and the cause and effect relationship between new substance and different properties to identify evidence that supports a claim.

Scoring Key

Correct Response: A

Distractor Rationales

A **KEY: There was no gas present before the liquid and solid were mixed, so the gas present after mixing vinegar and baking soda is a new substance.**

B Mass is conserved during chemical reactions and during physical mixing, so this does not necessarily support a claim that a new substance was produced.

C If substances are only physically mixed, then many of the properties stay the same. This statement does not support the claim that a new substance was produced.

D While true, this does not support a claim that mixing baking soda and vinegar produces a new substance.

Item 8: Cluster Item

Next Generation Science Standards Description

PE: 5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

DCI: PS1.B: Chemical Reactions: When two or more different substances are mixed, a new substance with different properties may be formed.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Item Type: Inline Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | DCI-Med | CCC-Low

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to identify evidence from an investigation that can be used to support the claim that mixing vinegar and baking soda results in a new substance that is a gas. The item aligns to the DCI because students must use knowledge that when substances are mixed, a new substance with different properties may be formed. The item aligns to the CCC because students must use the cause and effect relationship between new substances and different properties to identify evidence that supports the claim.

This question has two parts. Be sure to answer both parts of the question.

8. **Part a**

Eliana claims that when baking soda and vinegar are mixed, a new substance forms.

Select the phrase that describes an observation from investigation 2 that supports her claim.

After baking soda and vinegar are mixed, [baking soda disappears, bubbles form, vinegar stays a liquid, the mass increases].

Part b

Which observation is evidence that the new substance inside the balloon is a gas?

A The new substance filled the balloon.

B The new substance has more mass than the baking soda.

C The new substance takes up less space than the vinegar.

D The new substance increases as the baking soda increases.

Part a is aligned to the DCI and CCC. Students use their content knowledge that a new substance will have properties different from the properties of the substances that were mixed and the cause and effect relationship between new substance and different properties to identify an observation that supports a claim.

Part b is aligned to the DCI and CCC. Students use their content knowledge that a new substance will have properties different from the properties of the substances that were mixed and the cause and effect relationship between new substance and different properties to identify an observation that supports a claim.

Scoring Key

Part a
Correct Response:
After baking soda and vinegar are mixed, [baking soda disappears, **bubbles form**, vinegar stays a liquid, the mass increases].

Part b
Correct Response: A

Distractor Rationales

Part b

A **KEY: Expanding to fill the balloon is a property of gases, a property that the baking soda and vinegar did not have.**

B Comparing the mass of baking soda and the new substance is not evidence that the new substance is a gas. Gases and solids can have different masses.

C Comparing the volume of vinegar and the new substance is not evidence that the new substance is a gas. Gases and liquids can have different volumes.

D Producing more of the new substance by adding more baking soda is not evidence that the new substance is a gas. This is generally true of products and reactants, as long as there are no limiting reactants.

WHAT FOLLOWS IS THE STIMULUS AND PBT VERSION OF THE PREVIOUS ITEM

Item 8: PBT Cluster Item

Next Generation Science Standards Description

PE: 5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

DCI: PS1.B: Chemical Reactions: When two or more different substances are mixed, a new substance with different properties may be formed.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | DCI-Med | CCC-Low

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to identify evidence from an investigation that can be used to support the claim that mixing vinegar and baking soda results in a new substance that is a gas. The item aligns to the DCI because students must use knowledge that when substances are mixed, a new substance with different properties may be formed. The item aligns to the CCC because students must use the cause and effect relationship between new substances and different properties to identify evidence that supports the claim.

This question has two parts. Be sure to answer both parts of the question.

8. **Part a**

Eliana claims that when baking soda and vinegar are mixed, a new substance forms.

Which statement describes an observation from investigation 2 that supports her claim?

A After baking soda and vinegar are mixed, bubbles form.

B After baking soda and vinegar are mixed, the mass increases.

C After baking soda and vinegar are mixed, vinegar stays a liquid.

D After baking soda and vinegar are mixed, baking soda disappears.

Part a is aligned to the DCI and CCC. Students use their content knowledge that a new substance will have properties different from the properties of the substances that were mixed and the cause and effect relationship between new substance and different properties to identify an observation that supports a claim.

Part b

Which observation is evidence that the new substance inside the balloon is a gas?

A The new substance filled the balloon.

B The new substance has more mass than the baking soda.

C The new substance takes up less space than the vinegar.

D The new substance increases as the baking soda increases.

Part b is aligned to the DCI and CCC. Students use their content knowledge that a new substance will have properties different from the properties of the substances that were mixed and the cause and effect relationship between new substance and different properties to identify an observation that supports a claim.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: A

Distractor Rationales

Part a

A **KEY: Bubbles show that there is a new substance. Bubbles are evidence of gas being produced, and there was no gas present before liquid vinegar and solid baking soda were mixed.**

B The mass of the baking soda and vinegar before mixing is equal to, not more than, the mass of all the substances after the chemical reaction. This is not evidence that a new substance formed.

C Baking soda disappears during the reaction with vinegar. This is the reason that a new substance formed, not evidence that a new substance formed.

D The apparent disappearance of the baking soda is the reason a new substance formed, not evidence that a new substance formed.

Part b

A **KEY: Expanding to fill the balloon is a property of gases, a property that the baking soda and vinegar did not have.**

B Comparing the mass of baking soda and the new substance is not evidence that the new substance is a gas. Gases and solids can have different masses.

C Comparing the volume of vinegar and the new substance is not evidence that the new substance is a gas. Gases and liquids can have different volumes.

D Producing more of the new substance by adding more baking soda is not evidence that the new substance is a gas. This is generally true of products and reactants, as long as there are no limiting reactants.

Items 9–12: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: 4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [*Assessment Boundary: Assessment is limited to a single form of weathering or erosion.*]

SEP: Planning and Carrying Out Investigations: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

DCI: ESS2.A Earth Materials and Systems: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.

DCI: ESS2.E: Biogeology: Living things affect the physical characteristics of their regions.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

PE: 4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to make sense of phenomena using logical reasoning.

DCI: ESS2.B: Plate Tectonics and Large-Scale System Interactions: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features in areas of Earth.

CCC: Patterns: Patterns can be used as evidence to support an explanation.

Cluster Overview: Volcanic Slopes

Item	Item Type	Alignment
9	Multiple Choice—Multiple Choice	4-ESS2-1: SEP, DCI, CCC
10	Multiple Choice	4-ESS2-1: SEP, DCI, CCC
11	Multiple Choice	4-ESS2-1: SEP, DCI, CCC
12	Text Entry—Multiple Choice	4-ESS2-1: SEP, DCI, CCC
12 PBT	Multiple Choice—Multiple Choice	4-ESS2-1: SEP, DCI, CCC

The cluster consists of a phenomenon that allows overall item alignment to the PE. Every item in the cluster is three-dimensional, which ensures the whole cluster has strong alignment to the PE.

Stimulus and Items on next pages

Read the information. Then answer the questions that follow.

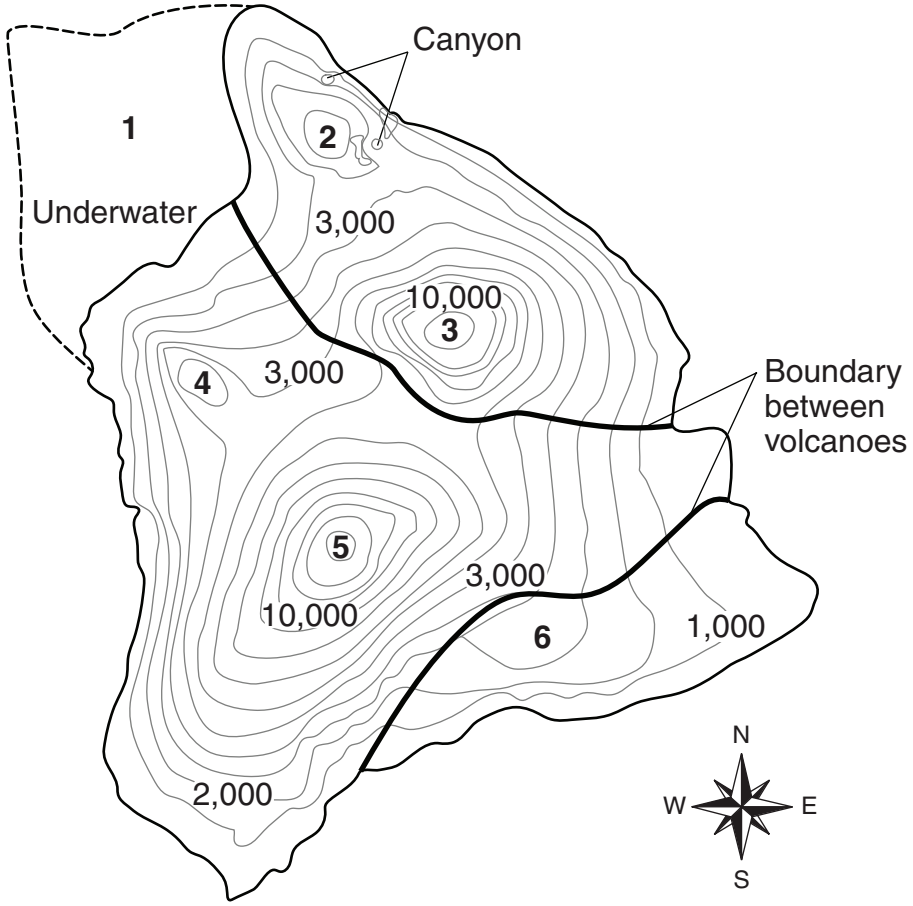
Volcanic Slopes

During a summer trip, Aiden visits a volcanic island. He learns that the island was formed by six volcanoes over millions of years. Aiden finds a topographic map that shows the location, elevation, and boundaries of each volcano. A topographic map shows differences in elevation. Each elevation line on the map shows locations that are the same height above sea level. The numbers represent kilometers above sea level.

The volcanoes on the map are labeled by numbers 1–6 in the order of age. The oldest volcano, volcano 1, is underwater. The youngest volcano, volcano 6, is still forming new parts of the island.

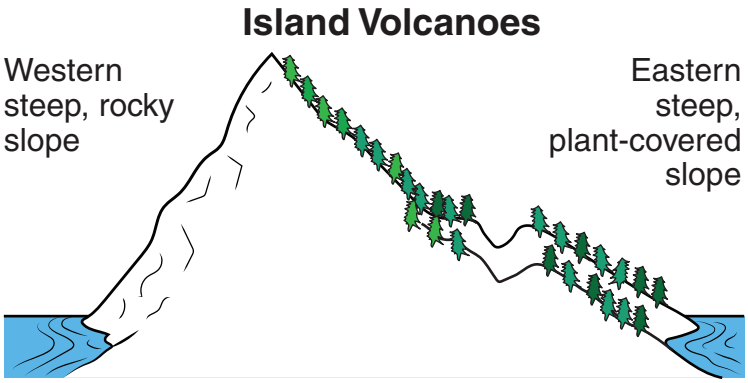
The stimulus for this cluster begins by presenting the phenomenon that volcanoes can form islands. The hook is that a student visits a volcanic island. The phenomenon and hook are grade-level appropriate because many students know about volcanoes and islands.

Island Volcanoes



The map shows canyons on two of the slopes of volcano 2. During his trip, Aiden goes for a walk on volcano 2. As he stands facing the volcano from the south, Aiden observes that the western slope of the volcano is steep and rocky with no canyon. The eastern slope of the volcano is not as steep, has a deep canyon, and is covered with plants.

Aiden draws a diagram that shows his observations. He plans an investigation to find out what caused the differences in the two slopes of the volcano.



Item 9: Cluster Item

Next Generation Science Standards Description

PE: 4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [*Assessment Boundary: Assessment is limited to a single form of weathering or erosion.*]

SEP: Planning and Carrying Out Investigations: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

DCI: ESS2.A: Earth Materials and Systems: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Med | DCI-Med | CCC-Med

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to describe data and measurements that provide evidence of the effect of rainwater on the rate of erosion. The item aligns to the SEP by asking students to describe data and measurements that would be evidence of how rain water affects the slope of a volcano. The item aligns to the DCI because students must use knowledge of how rainfall shapes the land by moving soils and sediments. The item aligns to the CCC because students must use the cause and effect relationship between water and soil erosion to describe useful data and helpful measurements.

This question has two parts. Be sure to answer both parts of the question.

9. Aiden wants to investigate how the motion of rainwater affects the slopes of a volcano. He wonders whether differences in erosion caused the differences he observed on the eastern and western slopes of volcano 2.

Part a

Which type of data would be **most** useful for Aiden to collect during his investigation?

A the amount of rain that falls on each slope of volcano 2

B the time of day when rain falls on each slope of volcano 2

C the time of year when rain falls on each slope of volcano 2

D the number of days that rain falls on each slope of volcano 2

Part a is aligned to the SEP and DCI. Students use their content knowledge of how rainfall shapes land by erosion to describe data that would be evidence of how rainwater affects the slope of a volcano.

Part b

Which measurement would be **most** helpful to Aiden during his investigation?

A Measure the number of days with rain on each slope of volcano 2 every year.

B Measure the time of day that rain begins and ends on the eastern slope of volcano 2.

C Measure the total number of rainstorms on the western slope of volcano 2 every year.

D Measure the amount of rainfall per hour on each slope of volcano 2 during a rainstorm.

Part b is aligned to the SEP, DCI, and CCC. Students use their knowledge of how rainfall shapes land by erosion that moves particles of soil and the cause and effect relationship between water and soil erosion to describe measurements that could be evidence of how rainwater affects the slope of a volcano.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: D

Distractor Rationales

Part a

A **KEY: More rain is likely to erode more soil. If more rain falls on one slope, the motion of more rainwater would explain why that slope is steeper.**

B Differences in the amount of rain, not what time of day the rain falls, would be more useful in explaining different amounts of erosion.

C Although plant cover could have seasonal variation, differences in the amount of rain would be more useful in explaining differences in slope than the time of year the rain falls.

D The total amount of rain would be more useful than the total number of days because many rainy days with only small amounts of rain each day could cause less erosion than a few very rainy days.

Part b

A Measuring the number of rainy days is less useful than measuring how quickly rain falls on a rainy day.

B This measurement will tell how many hours of rain, but this is less important than how much rain falls during those hours. Also, a measurement on only one slope of the volcano would not explain why the two slopes are different.

C The number of storms affects the amount of erosion, but measuring the amount of rain that falls every hour during each storm would be more helpful than measuring the number of storms.

D **KEY: There will be more erosion when more rainwater falls on the slopes during each hour of an intense rainstorm, so this measurement would be most helpful.**

Item 10: Cluster Item

Next Generation Science Standards Description

PE: 4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [*Assessment Boundary: Assessment is limited to a single form of weathering or erosion.*]

SEP: Planning and Carrying Out Investigations: Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.

DCI: ESS2.A: Earth Materials and Systems: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-High | DCI-High | CCC-Med

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to describe data that provide evidence of the effect of vegetation on different rates of erosion on the slopes of a volcano. The item aligns to the SEP by asking students to describe data needed to support a hypothesis that differences in erosion cause observed differences in the slopes of two volcanoes. The item aligns to the DCI because students must use knowledge of how rainfall shapes the land, the types of living things found in a region, and how plants prevent soil from being moved. The item aligns to the CCC because students must use cause and effect relationships between the amount of vegetation, the amount of rainfall, and the rate of soil erosion to identify evidence that supports the hypothesis.

10. Which additional evidence would **best** support Aiden's hypothesis that differences in erosion caused the observed differences on the eastern and western slopes of volcano 2?

A data showing that the western slope has less rainfall and less erosion than the eastern slope

B data showing that the western slope has less rainfall and more erosion than the eastern slope

C data showing that the western slope has more rainfall and less erosion than the eastern slope

D data showing that the western slope has more rainfall and more erosion than the eastern slope

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how rainfall shapes the land and that plants hold soil in place and cause and effect relationships between the amount of vegetation, the amount of rainfall, and the amount of soil erosion to describe data needed to support Aiden's hypothesis.

Scoring Key

Correct Response: B

Distractor Rationales

A These data would contradict the observed difference that the western slope is more eroded.

B KEY: Plants and other vegetation on the eastern slope help reduce soil erosion. The western slope has little vegetation, allowing rainfall to more easily erode the western side of the mountain.

C These data would contradict the observation that the western slope is more eroded.

D These data would contradict the observations of the vegetation on the mountain. The eastern slope has more vegetation, which indicates that there is likely more rainfall to support the vegetation on that side.

Item 11: Cluster Item

Next Generation Science Standards Description

PE: 4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to make sense of phenomena using logical reasoning.

DCI: ESS2.B: Plate Tectonics and Large-Scale System Interactions: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features in areas of Earth.

CCC: Patterns: Patterns can be used as evidence to support an explanation.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-High | DCI-Med | CCC-Med

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to analyze data from a topographic map to describe patterns in volcanoes on an island. The item aligns to the SEP by asking students to use logical reasoning to analyze and interpret data. The item aligns to the DCI because students must use knowledge that maps can be used to locate and compare features of volcanoes on an island. The item aligns to the CCC because students must use patterns in the topographic map to support their comparison of the volcanoes.

11. Which comparison is supported by the map?

A Volcano 2 is shorter than volcano 3.

B Volcano 2 is farther east than volcano 6.

C Volcano 2 has a larger area than volcano 5.

D Volcano 2 is farther from the ocean than volcano 4.

This item is aligned to the SEP, DCI, and CCC. Students analyze and interpret data by using their content knowledge of how to use a map to locate and compare features of volcanoes and their understanding of patterns in the topographic map to support their comparison of the volcanoes.

Scoring Key

Correct Response: A

Distractor Rationales

A **KEY: Volcano 2 has an elevation close to 3,000 feet, while volcano 3 has an elevation of close to 10,000 feet.**

B Volcano 2 is east, not west, of volcano 6.

C Volcano 2 is smaller, not larger, in area than volcano 5.

D Volcano 2 is closer to the ocean than volcano 4, not farther from the ocean.

Item 12: Cluster Item

Next Generation Science Standards Description

PE: 4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to make sense of phenomena using logical reasoning.

DCI: ESS2.B: Plate Tectonics and Large-Scale System Interactions: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features in areas of Earth.

CCC: Patterns: Patterns can be used as evidence to support an explanation.

Item Type: Text Entry—Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-High | DCI-Med | CCC-Med

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to analyze data from a topographic map to describe the pattern that identifies the steepest volcano on the island. The item aligns to the SEP by asking students to use logical reasoning to analyze and interpret data. The item aligns to the DCI because students must use knowledge that maps can be used to locate and compare features of volcanoes on an island. The item aligns to the CCC because students must use patterns in the topographic map to support their conclusion about which volcano is steepest.

This question has two parts. Be sure to answer both parts of the question.

12. After studying the map, Aiden concludes that other volcanoes have steeper slopes than volcano 2.

Part a

Identify the volcano with the steepest slopes.

Enter your answer in the space provided.

The volcano with the steepest slopes is volcano _____.

Part b

Which pattern from the map describes the volcano in Part (a)?

A This volcano has the most elevation lines.

B This volcano has the longest elevation lines.

C This volcano has elevation lines that are closest together.

D This volcano has elevation lines that cover the largest area.

Part a is aligned to the SEP and DCI. Students use their content knowledge of how to use the topographic map to locate and compare features of volcanoes and logical reasoning to interpret data in the map and identify the steepest volcano.

Part b is aligned to the SEP, DCI, and CCC. Students analyze and interpret elevation lines in the topographic map by using their content knowledge of how to use the map to compare features of volcanoes and their understanding of patterns in the topographic map to support their comparison of the volcanoes.

Scoring Key

Part a
Correct Response: 3

Part b
Correct Response: C

Distractor Rationales

Part b

A The number of elevation lines shows the height of the volcano, not the steepness of the slopes.

B The length of elevation lines shows the area, not the steepness, of the volcano.

C KEY: Lines closer together on a topographic map show that the slope is steeper. The volcano with the steepest slopes will have lines closest together.

D The area covered by elevation lines shows the shape and area of the volcano, not the steepness of the slopes.

WHAT FOLLOWS IS THE STIMULUS AND PBT VERSION OF THE PREVIOUS ITEM

Item 12: PBT Cluster Item

Next Generation Science Standards Description

PE: 4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features. [Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to make sense of phenomena using logical reasoning.

DCI: ESS2.B: Plate Tectonics and Large-Scale System Interactions: The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features in areas of Earth.

CCC: Patterns: Patterns can be used as evidence to support an explanation.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-High | DCI-Med | CCC-Med

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to analyze data from a topographic map to describe the pattern that identifies the steepest volcano on the island. The item aligns to the SEP by asking students to use logical reasoning to analyze and interpret data. The item aligns to the DCI because students must use knowledge that maps can be used to locate and compare features of volcanoes on an island. The item aligns to the CCC because students must use patterns in the topographic map to support their conclusion about which volcano is steepest.

This question has two parts. Be sure to answer both parts of the question.

12. After studying the map, Aiden concludes that other volcanoes have steeper slopes than volcano 2.

Part a

Which volcano on the map has the steepest slopes?

A 3

B 4

C 5

D 6

Part b

Which pattern from the map describes the volcano in Part (a)?

A This volcano has the most elevation lines.

B This volcano has the longest elevation lines.

C This volcano has elevation lines that are closest together.

D This volcano has elevation lines that cover the largest area.

Part a is aligned to the SEP and DCI. Students use their content knowledge of how to use the topographic map to locate and compare features of volcanoes and logical reasoning to interpret data in the map and identify the steepest volcano.

Part b is aligned to the SEP, DCI, and CCC. Students analyze and interpret elevation lines in the topographic map by using their content knowledge of how to use the map to compare features of volcanoes and their understanding of patterns in the topographic map to support their comparison of the volcanoes.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: C

Distractor Rationales

Part a

A KEY: The lines on the topographic map around volcano 3 are consistently closer together than the lines around the other volcanoes. This makes volcano 3 the steepest feature shown on the map.

B Lines on the topographic map around volcano 4 are closest together on the west and northwest sides, but not closer than the lines on the southwest side of volcano 3.

C Lines on the topographic map around volcano 5 are closest together on the southeast side, but not closer than the lines on the southwest side of volcano 3.

D Lines on the topographic map around volcano 6 are closest together on the south side, but not closer than the lines on the southwest side of volcano 3.

Part b

A The number of elevation lines shows the height of the volcano, not the steepness of the slopes.

B The length of elevation lines shows the area, not the steepness, of the volcano.

C KEY: Lines closer together on a topographic map show that the slope is steeper. The volcano with the steepest slopes will have lines closest together.

D The area covered by elevation lines shows the shape and area of the volcano, not the steepness of the slopes.

Session 2: Items 13–23

Item 13: Standalone Item

Next Generation Science Standards Description

PE: 3-ESS2-2: Obtain and combine information to describe climates in different regions of the world.

SEP: Obtaining, Evaluating, and Communicating Information: Obtain and combine information from books and other reliable media to explain phenomena.

DCI: ESS2.D: Weather and Climate: Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.

CCC: Patterns: Patterns of change can be used to make predictions.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-High | DCI-Low | CCC-Low

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to combine information to describe the climate of another country. The item aligns to the SEP by asking the students to combine weather and climate data that describe weather conditions in different climates. The item aligns to the DCI because students must use knowledge that climate describes an area's typical weather conditions. The item aligns to the CCC because students must use patterns of weather changes to make predictions about the climate of another country.

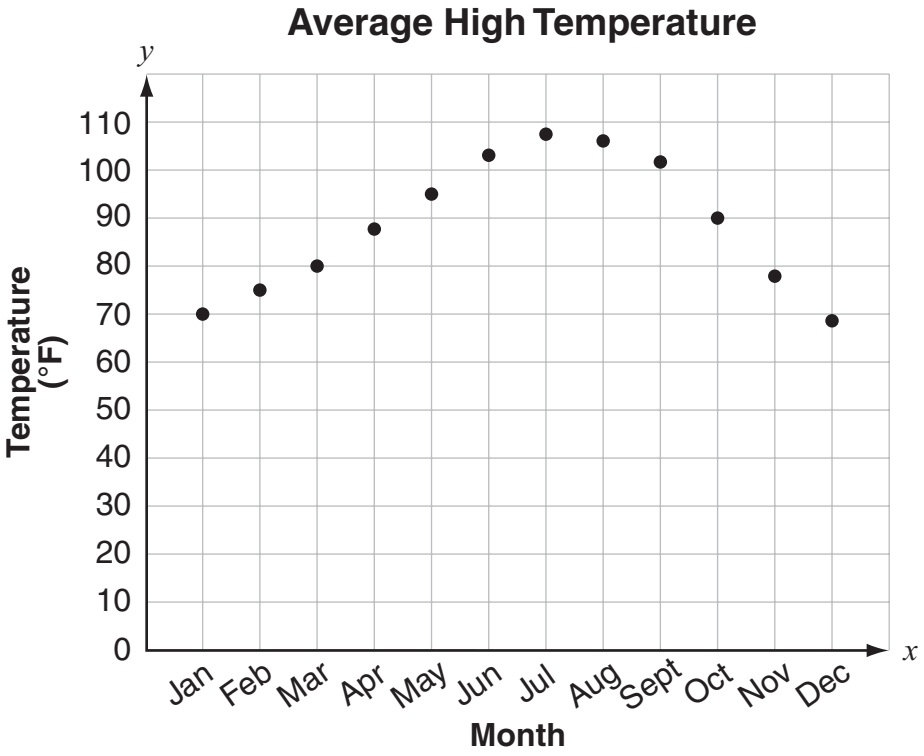
Sonia has a friend, Marisa, who lives in a country that has different weather conditions during the summer and winter than where Sonia lives. Sonia learns that different locations on Earth have different types of climate. She makes the table to show the typical weather conditions in different types of climates during the summer and winter months.

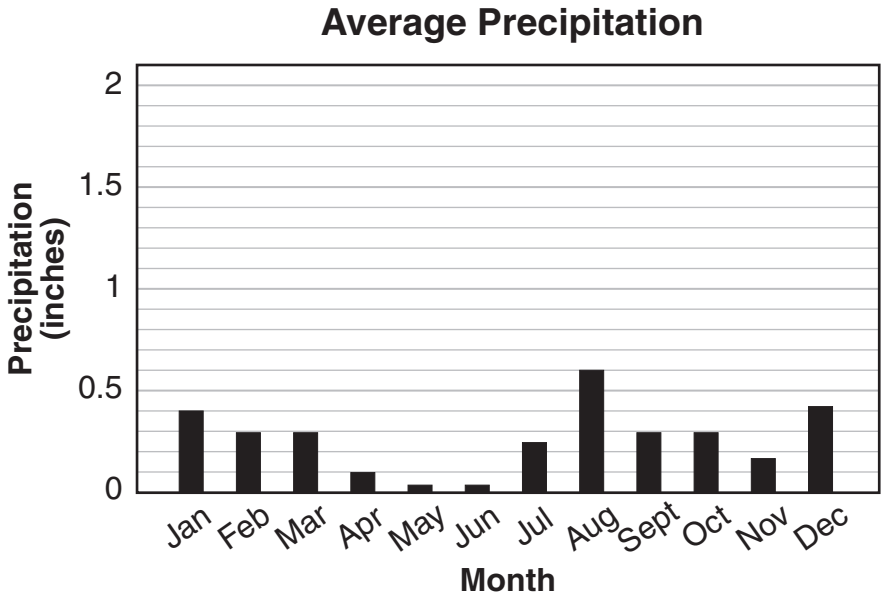
Weather and Climate

Type of Climate	Typical Summer Weather	Typical Winter Weather
Desert	Hot, dry	Warm, dry
Tropical	Hot, wet	Hot, wet
Temperate	Cool, dry	Cold, wet
Polar	Cool, dry	Cold, wet
Mediterranean	Hot, dry	Cool, wet
Mountain	Cold, wet	Cold, wet

The stimulus for this item begins by presenting the phenomenon that different locations on Earth have different climates. The hook is that a student has a friend who lives in another country with different summer and winter weather. The phenomenon and hook are grade-level appropriate because many students know about summer and winter weather and that different parts of the world can have different climates.

Marisa sends Sonia information about temperatures and precipitation where she lives. The graphs show the average temperature and precipitation throughout the year in Marisa's country.





This question has two parts. Be sure to answer both parts of the question.

13. **Part a**

Based on the table and graphs, which statement describes typical weather patterns in Marisa's country?

A Marisa's country has hot, dry summers.

B Marisa's country has cold, wet summers.

C Marisa's country has hot, wet weather all year.

D Marisa's country has cool, dry weather all year.

Part a is aligned to the SEP, DCI, and CCC. Students combine weather data and information about different climates and use their content knowledge that climates describe typical weather conditions to predict typical weather patterns in Marisa's country.

Part b

Based on the table and graphs, which type of climate does Marisa's country have?

A polar

B desert

C tropical

D mountain

Part b is aligned to the SEP, DCI, and CCC. Students combine weather data and information about different climates and use their content knowledge that climates describe typical weather conditions to predict the climate in Marisa's country.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: B

Distractor Rationales

Part a

A **KEY: One graph shows very little precipitation during June and July and only 0.6 inches during August. The other graph shows that the temperature is over 100°F during June, July, August, and parts of September.**

B The graph shows that temperatures are above 100°F during the summer months, and that there is very little rain during these months.

C The graph shows that May and June have almost no precipitation. No month has more than an inch of precipitation, and the temperature varies from an average of a mild 70°F in December and January to a hot 108°F in July.

D While the graph shows only small amounts of precipitation throughout the year, the graph shows that summer temperatures can be more than 100°F and even winter temperatures are above 70°F.

Part b

A Polar climates have cold wet winters. The temperatures in Marisa's country are never cold and there are no months with large amounts of precipitation.

B **KEY: Temperatures in desert climates are always warm or hot and there are no wet months. The temperature in Marisa's country is always warm or hot and every month has only a small amount of precipitation.**

C Tropical climates are always hot and wet. In Marisa's country, no month has a large amount of rain and some months have almost no rain.

D Mountain climates are always cold and wet. Summer temperatures in Marisa's country are hot, not cold, and every month has only a small amount of precipitation.

Item 14: Standalone Item

Next Generation Science Standards Description

PE: 4-LS1-2: Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. [Clarification Statement: Emphasis is on systems of information transfer.] [*Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.*]

SEP: Developing and Using Models: Use a model to test interactions concerning the functioning of a natural system.

DCI: LS1.D: Information Processing: Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.

CCC: Systems and System Models: A system can be described in terms of its components and their interactions.

Item Type: Multi-select—Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Low | DCI-Med | CCC-High

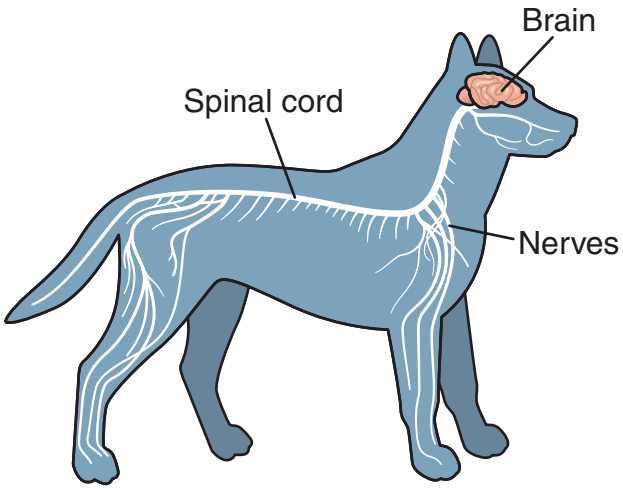
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use a model to describe how a puppy receives, processes, and responds to information. The item aligns to the SEP by asking the students to use a graphic model to describe the functioning of a puppy's nervous system. The item aligns to the DCI because students must use knowledge that different sense receptors receive different kinds of information that are processed by the animal's brain. The item aligns to the CCC because students must describe how the components of the puppy's nervous system interact.

Sam gets a puppy for his birthday. The puppy is interested in everything he sees. Sam learns that dogs use their nervous system to react to their environment. He draws a model of his puppy's nervous system.

Nervous System Model



The stimulus for this item begins by presenting the phenomenon that dogs use their nervous system to react to their environment. The hook is that a student gets a puppy for his birthday. The phenomenon and hook are grade-level appropriate because many students are familiar with dogs and puppies.

This question has two parts. Be sure to answer both parts of the question.

14. Part a

Based on the model, which **two** statements describe how the puppy's nervous system allows the puppy to react to the environment?

A The brain pumps blood to the dog's legs.

B Nerves help the dog's body stay in shape.

C Nerves carry information from the eyes to the brain.

D The spinal cord removes waste from the dog's body.

E The brain sends information to the tail to make the tail wag.

Part a is aligned to the SEP, DCI, and CCC. Students use the model and their content knowledge that the eyes are sense receptors that receive information that is processed by the brain to describe how parts of the nervous system interact to allow the puppy to react to the environment.

Part b

Sam's puppy sees a cat. Based on the model, which statement describes the path of information that results in the puppy chasing the cat?

A Information about the cat is sent to the brain. The brain sends signals to the legs so that the puppy can chase the cat.

B Information about the cat is sent to the nerves. The nerves send signals to the spinal cord to move the legs to chase the cat.

C Information about the cat is sent to the spinal cord. As the spinal cord removes waste, the puppy moves forward and chases the cat.

D Information about the cat is sent to the brain. The brain pumps blood through the spinal cord to the legs so that the puppy can chase the cat.

Part b is aligned to the SEP, DCI, and CCC. Students use the model and their content knowledge that the eyes are the sense receptors that receive information that is processed by the brain to describe how parts of the nervous system interact to allow the puppy to chase the cat.

Scoring Key

Part a
Correct Response: C, E

Part b
Correct Response: A

Distractor Rationales

Part a

A Although a student might think the model shows the circulatory system instead of the nervous system, the model shows nerves, not blood vessels, in the puppy's legs.

B A student might think that the model shows the puppy's skeleton which helps the puppy's body keep its shape, but the model shows nerves, not bones. A student might also think that nerves help the puppy exercise and stay in shape, but this does not describe how the puppy's nervous system allows the puppy to react to the environment.

C KEY: The model shows that the nervous system connects the puppy's brain to the rest of his body, including his eyes.

D Although a student might think that the spinal cord in the model is the puppy's intestines, the model shows nerves, not how the puppy's body removes waste.

E KEY: The model shows that the nervous system connects the puppy's brain to the rest of his body, including his tail.

Part b

A KEY: Information is sent from the eyes to the puppy's brain. Then a signal is sent from the brain to the puppy's legs.

B Information is sent from the eyes to the brain, not straight to the nerves. The nerves send signals that come from the brain, not the eyes.

C Information is sent from the eyes to the brain, not straight to the spinal cord. The puppy moves forward because the spinal cord sends signals to the legs, not because waste is expelled backward.

D The brain sends signals, not blood, through the spinal cord.

Item 15: Standalone Item

Next Generation Science Standards Description

PE: 3-ESS3-1: Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.]

SEP: Engaging in Argument From Evidence: Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

DCI: ESS3.B: Natural Hazards: A variety of natural hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Item Type: Open-ended

Cognitive Complexity: Stimulus-High | SEP-High | DCI-Low | CCC-Med

Number of Points: 4

Item on next page

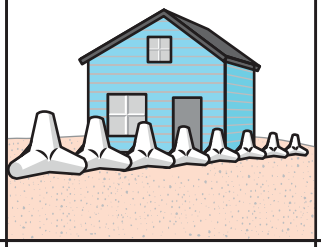
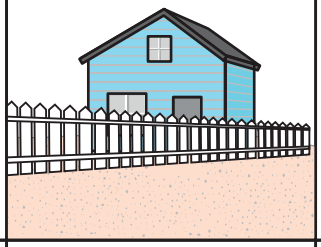
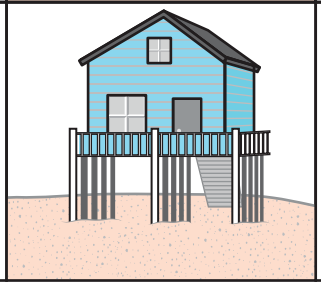
This item brings students into the story line by asking them to make a claim about how well three house designs reduce the impact of flooding caused by storm surges. The item aligns to the SEP by asking students to use evidence to make claims about the merits of the house designs by citing evidence about how well each design meets the criteria and constraints of the problem. The item aligns to the DCI because students must use knowledge that humans can take steps to reduce, though not eliminate, the impact of storm surges. The item aligns to the CCC because students must use the cause and effect relationship between storm surges and flooding to make their claims.

Sid lives in a new house by the ocean. He knows that hurricanes can cause strong ocean waves known as surges. Surges can break simple structures and cause flooding. Sid wants to protect his new house from flood damage due to surges. Sid wants to finish construction of the flood protection in three months.

Sid studies three designs for protecting his house from flood damage. He gives each design a score based on how well it reduces flood damage. The scores range from 1 to 100. A score of 100 means the design completely stops flood damage. Sid organizes the data in the table shown.

The stimulus for this item begins by presenting the phenomenon that hurricanes can cause surges and flood damage. The hook is that a student lives in a new house by the ocean. The phenomenon and hook are grade-level appropriate because many students have heard about hurricanes and flooding on the news.

Designs for Reducing Flood Damage

Name	Design	Score	How Long to Build?
Concrete pods		85	1 week
Wood fence		25	1 week
Concrete pillar		95	3 to 4 months

This question has three parts. Be sure to answer all three parts of the question.

15. **a.** The concrete pod design has a score of 85. Explain what this score means.

b. Describe what will likely happen if a strong wave hits the wood fence design.

c. Identify the design that **best** meets Sid's criteria. Explain your reasoning.

Part a is aligned to the SEP and DCI. Students use their content knowledge that humans can reduce, though not eliminate, the impact of surges on buildings to cite evidence about how well the concrete pod design reduces flood damage.

Part b is aligned to the SEP, DCI and CCC. Students use their content knowledge that humans can reduce, though not eliminate, the impact of surges on buildings and the cause and effect relationship between surges and flooding to make a claim about what will happen if a strong wave hits the wood fence.

Part c is aligned to the SEP, DCI and CCC. Students use their content knowledge that humans can reduce, though not eliminate, the impact of surges on buildings and the cause and effect relationship between surges and flooding to make a claim about which design best meets Sid's criteria.

Scoring Rubric

Score	Description
4	The response demonstrates thorough use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response explains what a score of 85 for the concrete pod design means, describes what will likely happen if a strong wave hits the wood fence design, and explains which design best meets Sid's criteria. The response • clearly applies science and engineering practices to provide an explanation or solution; • provides a coherent and accurate explanation or solution based on disciplinary core ideas; • reflects thorough understanding of complex ideas and crosscutting concepts; and • effectively applies and demonstrates complete understanding of the three dimensions.
3	The response demonstrates sufficient use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response may lack some detail or information, or the response may contain minor errors in applying and demonstrating understanding of science and engineering practices, disciplinary core ideas, and crosscutting concepts.
2	The response demonstrates limited use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response may lack multiple details or information, or the response may contain major error(s) in applying and demonstrating understanding of science and engineering practices, disciplinary core ideas, and crosscutting concepts.
1	The response demonstrates minimal use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems.
0	The response is inaccurate, is irrelevant, or contains no evidence of use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems.
Blank	No response

The scoring rubric specifies how a four-point response uses the dimensions of the PE and provides detail about how different levels of response meet the requirements of specific tasks in the item. All open-ended standalone items are four-point items.

Scoring Notes

a. A score of 85 means that the design can reduce a great deal of flood damage but cannot prevent some damage from occurring.

b. The waves will probably wash away the fence.

c. The best design for Sid is the concrete pillar design. This design has the highest score in Sid's ranking system. This is probably because the house is on pillars, and the water will flow under the house. And because the pillars are made of concrete, the pillars can stand up to the powerful waves. The timeline is also within Sid's design needs.

NOTE: Award credit for other designs if the selection is well explained.

The scoring notes provide information expected for a full credit/four-point response. They are written using the type of language most likely to be used by students.

Items 16–19: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: 3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]

SEP: Engaging in Argument From Evidence: Construct an argument with evidence.

DCI: LS4.C: Adaptation: For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

CCC: Cause and Effect: Cause and effect relationships are routinely identified and used to explain change.

PE: 3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.] [*Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]

SEP: Engaging in Argument From Evidence: Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

DCI: LS2.C: Ecosystem Dynamics, Functioning, and Resilience: When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.

DCI: LS2.D: Biodiversity and Humans: Populations live in a variety of habitats, and change in those habitats affects the organisms living there.

CCC: Systems and System Models: A system can be described in terms of its components and their interactions.

Cluster Overview: Surviving the Drought

Item	Item Type	Alignment
16	Multiple Choice	3-LS4-3; SEP, DCI, CCC
17	Multiple Choice	3-LS4-4; SEP, DCI, CCC
18	Multiple Choice—Multiple Choice	3-LS4-3; SEP, DCI
19	Multiple Choice—Multiple Choice	3-LS4-4; DCI, CCC

Stimulus and Items on next pages

The cluster consists of a phenomenon that allows overall item alignment across two PEs. While not every individual item in the cluster is three-dimensional, all items are at least two-dimensional, and collectively the whole cluster has strong alignment to all three dimensions of each PE.

Read the information. Then answer the questions that follow.

Surviving the Drought

Miguel's family has enjoyed his grandfather's garden for years. They enjoy the flowers and also the birds, butterflies, rabbits, and other animals that live in the garden.

This year, a drought is predicted for Miguel's area. There will be much less rainfall than normal. Miguel's grandfather grows many different types of plants in his garden and is worried that he will not be able to give all the plants enough extra water during the drought. He asks Miguel to investigate how much water the types of plants in his garden need to survive.

The stimulus for this cluster begins by presenting the phenomenon that some plants require more water than other plants. The hook is that a student has a grandfather who has a garden that is in an area where drought is predicted. The phenomenon and hook are grade-level appropriate because many students are familiar with drought conditions and gardens.

In his investigation, Miguel uses four different types of plants from his grandfather's garden. He plants 10 identical plants of each type in the same soil. He puts them in a location where they receive the same amount of sunshine. Once a week, Miguel gives each plant a very small amount of water. The table shows how many plants of each type are alive after three months.

Plant Survival Data

Type of Plant	Diagram of Plant	Number of Plants That Survived
Aloe vera		9
Fern		2
Coneflower		4
Rose		0

Based on the results of Miguel's investigation, Miguel's grandfather adds new types of plants to his garden that can survive with very little water. A year later, Miguel and his family are still enjoying the garden.

Item 16: Cluster Item

Next Generation Science Standards Description

PE: 3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]

SEP: Engaging in Argument From Evidence: Construct an argument with evidence.

DCI: LS4.C: Adaptation: For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

CCC: Cause and Effect: Cause and effect relationships are routinely identified and used to explain change.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Low | DCI-Low | CCC-Low

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to use data from an investigation to support a claim that in a habitat with little water, some plants can survive better than other plants. The item aligns to the SEP by asking students to use evidence to make a claim. The item aligns to the DCI because students must use knowledge that, for a particular environment, different organisms have different survival rates. The item aligns to the CCC because students must use the cause and effect relationship between the amount of water and the likelihood of plant survival to make their claim.

16. Which claim is supported by the data from Miguel's investigation?

A Some types of plants can survive in environments with no water.

B Some types of plants can survive in environments with only rainwater.

C Some types of plants can survive in environments with very little water.

D Some types of plants can survive in environments with large amounts of water.

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge that different plants have different survival rates in a particular environment and evidence from the investigation to support a claim about the cause-effect relationship between the amount of water and the likelihood of survival during a drought.

Scoring Key

Correct Response: C

Distractor Rationales

A All of the plants in the investigation were given some water.

B All of the plants in the investigation were given some water, in addition to whatever rainwater fell on the plants.

C KEY: Almost all of the aloe vera plants survived with very little water, but few of the other plants survived the same dry conditions.

D None of the plants in the investigation were given large amounts of water.

Item 17: Cluster Item

Next Generation Science Standards Description

PE: 3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.] [*Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]

SEP: Engaging in Argument From Evidence: Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

DCI: LS2.C: Ecosystem Dynamics, Functioning, and Resilience: When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.

CCC: Systems and System Models: A system can be described in terms of its components and their interactions.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Low | DCI-Med | CCC-Low

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to support a claim about the merit of adding drought-resistant plants to a garden during a drought. The item aligns to the SEP by asking students to support the claim with data about how well the solution meets the criteria of the problem. The item aligns to the DCI because students must use knowledge that when the environment changes, some organisms survive and reproduce. The item aligns to the CCC because students must use the understanding that the garden and drought are a system with components that interact.

17. Miguel claims that adding new types of plants to his grandfather's garden has solved the problem caused by the drought.

Which data would support his claim?

A The garden has more water than before the drought.

B The garden has fewer animals than before the drought.

C The garden has the same types of flowers as before the drought.

D The garden has the same number of plants as before the drought.

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge that when the environment changes, some plants survive and reproduce and the understanding that the plants in the garden and the drought interact as a system to identify data that support a claim about how well the new types of plants solve the problem caused by the drought.

Scoring Key

Correct Response: D

Distractor Rationales

A Adding new types of plants would add plants, not water, to the garden.

B Seeing fewer animals in the garden does not support the claim that adding new plants solved the problem caused by the drought.

C If the garden has the same types of flowers, then the new types of plants that were added did not survive and this does not support Miguel's claim.

D KEY: The problem was that plants could not survive the drought without using too much water. If the garden has the same total number of plants as before, then some of the new types of plants survived and replaced the plants which did not survive.

Item 18: Cluster Item

Next Generation Science Standards Description

PE: 3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]

SEP: Engaging in Argument From Evidence: Construct an argument with evidence.

DCI: LS4.C: Adaptation: For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Med | DCI-Low

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use data as evidence to make a claim about which plants can survive best in a garden during a drought. The item aligns to the SEP by asking students to use evidence to make the claim. The item aligns to the DCI because students must use the understanding that, for a particular environment, different organisms have different survival rates.

This question has two parts. Be sure to answer both parts of the question.

18. Part a

Based on the data from Miguel's investigation, which plants can Miguel claim are the **best** choices for his grandfather's garden during the drought?

A fern and rose

B aloe vera and fern

C coneflower and rose

D aloe vera and coneflower

Part a is aligned to the SEP and DCI. Students use their content knowledge that different plants have different survival rates in a particular environment and data from Miguel's investigation as evidence to make a claim about which plants are best for a garden during a drought.

Part b

Which data support the claim in Part (a)?

A These types of plants grew the fastest.

B These types of plants had the most flowers.

C These types of plants survived with very little water.

D These types of plants made the most food for animals.

Part b is aligned to the SEP and DCI. Students use their content knowledge that different plants have different survival rates in a particular environment to identify data that support the claim.

Scoring Key

Part a
Correct Response: D

Part b
Correct Response: C

Distractor Rationales

Part a

A Only 2 ferns and roses survived while 13 of the coneflower and aloe vera survived. Ferns and roses are less likely to survive a drought than coneflowers and aloe vera.

B Only 11 aloe vera and ferns survived while 13 of the coneflower and aloe vera survived. Ferns are less likely to survive a drought than coneflowers.

C Only 4 coneflowers and roses survived while 13 of the coneflower and aloe vera survived. Roses are less likely to survive a drought than aloe vera.

D KEY: Almost all of the aloe vera, and nearly half of the coneflowers survived an investigation with very little water. Coneflowers and aloe vera are more likely to survive a drought than ferns and roses.

Part b

A Miguel did not collect data on how quickly the plants grew. Plants that grow quickly are not necessarily best able to survive a drought.

B Miguel did not collect data on the number of flowers on each type of plant. Plants with the most flowers are not necessarily the best at surviving a drought.

C KEY: The data show that more (13) of these types of plants survived an investigation with very little water than did other types of plants (2).

D Miguel did not collect data on which plants provide food for animals. Plants most likely to be eaten by animals would not be good choices for the garden because they would be eaten even if they survived the drought.

Item 19: Cluster Item

Next Generation Science Standards Description

PE: 3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.] [*Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]

DCI: LS2.C: Ecosystem Dynamics, Functioning, and Resilience: When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die.

CCC: Systems and System Models: A system can be described in terms of its components and their interactions.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | DCI-Med | CCC-High

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to make a claim about the effect of adding drought-resistant plants to a garden on the animals that live in the garden. The item aligns to the DCI because students must use knowledge that when the environment changes, some organisms move to new locations. The item aligns to the CCC because students must use the understanding that the garden and drought are a system with components, including animals, that interact.

This question has two parts. Be sure to answer both parts of the question.

19. Miguel's grandfather observes that fewer animals live in the garden after he adds the new types of plants.

Part a

Which claim is supported by the grandfather's observation?

A Animals found more places in the garden to hide.

B Animals moved away from the garden to find food.

C Animals began to use the new types of plants for homes.

D Animals had more water because of the new types of plants.

Part a is aligned to the DCI and CCC. Students use their content knowledge that animals can move away from an area when the environment changes and the understanding that the components of the garden, plants and animals, interact as a system to make a claim that is supported by Miguel's grandfather's observation.

Part b

Which evidence would support the claim in Part (a)?

A The new types of plants use more water than the other plants.

B The new types of plants have a different taste than the other plants.

C The new types of plants are easier to build nests in than the other plants.

D The new types of plants are taller and have larger leaves than the other plants.

Part b is aligned to the DCI and CCC. Students use their content knowledge that animals can move away from an area when the environment and resource availability change and the understanding that the components of the garden, plants and animals, interact as a system to identify evidence that supports the claim.

Scoring Key

Part a
Correct Response: B

Part b
Correct Response: B

Distractor Rationales

Part a

A More hiding places could explain why more, not fewer, animals live in the garden, even if the animals are hidden.

B KEY: Animals would move away if they couldn't eat the new plants and the plants they could eat no longer survived in the garden.

C More homes would explain why more, not fewer, animals live in the garden.

D Even if the new plants use less of the available water, animals still might not have enough water to survive during a drought.

Part b

A The new types of plants use less, not more, water than the other plants. Even if the new plants used less water because they wasted less water or stored more water, this would not support a claim about the reason there are fewer animals in the garden.

B KEY: Animals eat plants for food. If the new plants have a bad taste, animals would not eat the new plants. This would mean animals have less food and would move away from the garden, which supports the grandfather's observation.

C Some animals use plants to build nests. If the new plants make building nests easier, then there would be more animals in the garden, not fewer animals.

D Some animals use plants to hide in. Taller plants with bigger leaves would provide more hiding places for animals in the garden. This would increase, not decrease, the number of animals in the garden.

Items 20–23: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: 4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

SEP: Constructing Explanations and Designing Solutions: Apply scientific ideas to solve design problems.

DCI: PS3.B: Conservation of Energy and Energy Transfer: Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.

DCI: PS3.D: Energy in Chemical Processes and Everyday Life: The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.

DCI: ETS1.A: Defining and Delimiting an Engineering Problem: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

CCC: Energy and Matter: Energy can be transferred in various ways and between objects.

PE: 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

SEP: Planning and Carrying Out Investigations: Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

DCI: PS3.A: Definitions of Energy: Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

DCI: PS3.B: Conservation of Energy and Energy Transfer:

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- Light also transfers energy from place to place.
- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.

CCC: Energy and Matter: Energy can be transferred in various ways and between objects.

Cluster Overview: Model House

Item	Item Type	Alignment
20	Multiple Choice—Multiple Choice	4-PS3-4: SEP, DCI
21	Multiple Choice	4-PS3-2: SEP, DCI, CCC
22	Multiple Choice—Multiple Choice	4-PS3-4: SEP, DCI
23	Inline Choice	4-PS3-4: SEP, DCI
23 PBT	Multiple Choice	4-PS3-4: SEP, DCI

Stimulus and Items on next pages

The cluster consists of a phenomenon that allows overall item alignment across two PEs. While not every individual item in the cluster is three-dimensional, all items are at least two-dimensional. The whole cluster has alignment to all three dimensions of 4-PS3-2, but no three-dimensional items that align to 4-PS3-4 were selected to be on the practice test.

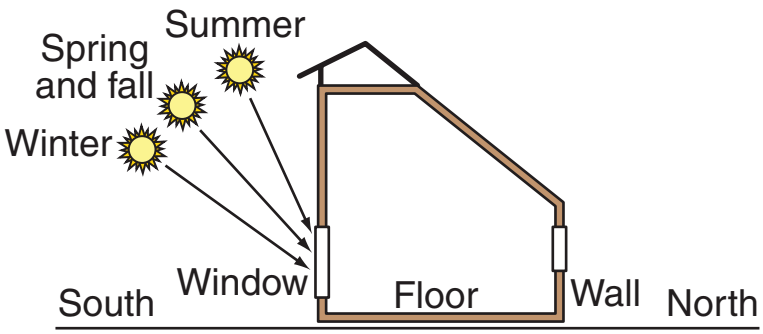
Read the information. Then answer the questions that follow.

Model House

Jaylinn wants to design a house. She wants the design to interact with sunlight in ways that make the inside of the house warm during winter and keep the inside of the house cool during summer.

Jaylinn learns that the Sun rises higher in the sky during summer days than winter days, as shown in the diagram.

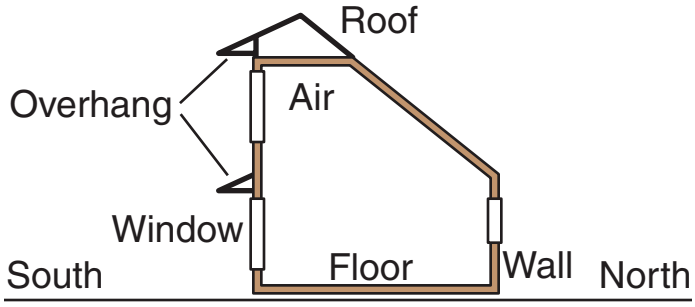
Height of Sun



She also observes that some houses have structures above windows on the south side of the house. The structures are called overhangs and keep some sunlight from entering the windows.

Jaylinn builds the model house shown in the diagram. The south side of the house has two glass windows with a wooden overhang above each window.

Model House



The stimulus for this cluster begins by presenting the phenomenon that the Sun rises to different heights at different times of year. The hook is that a student wants to design a house that uses sunlight to warm the house in winter and also keeps sunlight from warming the house in summer. The phenomenon and hook are grade-level appropriate because many students know that sunlight coming in through windows can warm the air inside.

Item 20: Cluster Item

Next Generation Science Standards Description

PE: 4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

SEP: Constructing Explanations and Designing Solutions: Apply scientific ideas to solve design problems.

DCI: ETS1.A: Defining and Delimiting an Engineering Problem: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-High | DCI-High

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to apply scientific ideas to the design of a house that converts light energy to thermal energy. The item aligns to the SEP by asking students to apply scientific ideas about the height of the Sun in winter to solve the problem of designing a model house that has windows and overhangs and will stay warm during the winter. The item aligns to the DCI because students must use the understanding that successful solutions are limited by constraints.

This question has two parts. Be sure to answer both parts of the question.

20. Jaylinn wants her design to use sunlight to warm the inside of the model house during winter.

Part a

Based on the Height of Sun diagram, how is the model house described in the Model House diagram designed to use sunlight to make the house warm during winter?

A The house has more windows on the south side than on the north side.

B There are overhangs above the windows on the south side of the house.

C Windows let sunlight into the south side and out of the north side of the house.

D Overhangs keep sunlight from entering the windows on the north side of the house.

Part a is aligned to the SEP and DCI. Students use their content knowledge that successful solutions are limited by constraints and apply scientific ideas about the height of the Sun in winter to describe how to design the windows and overhangs that keep the inside of the house warm during the winter.

Part b

Which statement describes how the model could be improved to make the inside of the model house warmer during winter?

A Increase the size of the windows so that more sunlight enters the house during winter.

B Decrease the size of the windows so that less sunlight enters the house during winter.

C Increase the size of the overhangs so that less sunlight enters the house during winter.

D Decrease the size of the overhangs so that more sunlight enters the house during winter.

Part b is aligned to the SEP and DCI. Students use their content knowledge that successful solutions are limited by constraints and apply scientific ideas about the height of the Sun in winter to explain how larger windows keep the inside of the house warmer during the winter.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: A

Distractor Rationales

Part a

A **KEY: More windows on the south side let in more sunlight. More light energy can be converted to more thermal energy.**

B Overhangs would block some sunlight even in the winter. Less sunlight would enter the house and the house would be cooler, not warmer.

C The diagram shows that sunlight enters windows on the south side, not on the north side, of the house.

D There are no overhangs on the north side of the house. Also, sunlight enters the windows on the south, not the north, side of the house.

Part b

A **KEY: Bigger windows will let more light into the house and make the house warmer.**

B In winter, you want more light to enter and warm the house. Having smaller windows would allow less, not more, light to enter the house.

C A bigger overhang will decrease the amount of sunlight that enters the house. If less light enters the house, the house will be cooler, not warmer.

D Overhangs stop light from entering the house when the Sun is high in the sky, but do not stop light from entering the house when the Sun is low. Making the overhangs smaller would not make the house warmer in the winter when the Sun is low in the sky, because the same amount of light would be able to enter the house.

Item 21: Cluster Item

Next Generation Science Standards Description

PE: 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

SEP: Planning and Carrying Out Investigations: Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

DCI: PS3.B: Conservation of Energy and Energy Transfer: Light also transfers energy from place to place.

CCC: Energy and Matter: Energy can be transferred in various ways and between objects.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Low | DCI-Med | CCC-Med

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to describe observations that would provide evidence that light can transfer energy from place to place inside the model house. The item aligns to the SEP by asking students to describe an observation that would be evidence of a transfer of energy. The item aligns to the DCI because students must use knowledge that light transfers energy from place to place. The item aligns to the CCC because students must use the understanding that energy is transferred in various ways between different objects.

21. Jaylinn wonders whether other energy transformations have happened while the model house is in the sunlight.

Which observation would be evidence of another energy transformation happening while the model house is in the sunlight?

A The walls inside the house become darker.

B The air inside the house becomes warmer.

C The windows let more sunlight enter the house.

D The shadows made by the overhangs become shorter.

This item is aligned to the SEP, DCI and CCC. Students use their content knowledge that light transfers energy from place to place and the understanding that energy is transferred in various ways between different objects to describe an observation that would be evidence that light energy in sunlight can be transformed into thermal energy in air.

Scoring Key

Correct Response: B

Distractor Rationales

A Darker walls might absorb more sunlight, but darker walls are not evidence of an energy transformation.

B KEY: Warmer air inside the house would be the result of transforming light energy into thermal energy.

C Letting more sunlight into the house would increase the amount of energy in the house but would not be evidence that energy was transformed.

D Changing lengths of shadows during the day are evidence that the Sun is in a different part of the sky, not that energy has been transformed.

Item 22: Cluster Item

Next Generation Science Standards Description

PE: 4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

SEP: Constructing Explanations and Designing Solutions: Apply scientific ideas to solve design problems.

DCI: ETS1.A: Defining and Delimiting an Engineering Problem: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-High | DCI-Med

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to apply scientific ideas to the design of a house that converts light energy to thermal energy. The item aligns to the SEP by asking students to apply scientific ideas about the height of the Sun in summer to solve the problem of designing a model house that has windows and overhangs and will stay cool in summer. The item aligns to the DCI because students must use the understanding that constraints limit how well successful solutions meet the criteria.

This question has two parts. Be sure to answer both parts of the question.

22. Jaylinn also wants the design to keep the inside of the model house cool during the summer.

Part a

Based on the Height of Sun diagram, how is the model house described in the Model House diagram designed to keep the inside of the house cool during the summer?

A The house has overhangs above the windows on the south side.

B The house has more windows on the south side than on the north side.

C Windows let sunlight into the south side and out of the north side of the house.

D Overhangs keep sunlight from entering the windows on the north side of the house.

Part a is aligned to the SEP and DCI. Students use their content knowledge that successful solutions are limited by constraints and apply scientific ideas about the height of the Sun in summer to describe how to design windows and overhangs that keep the inside of the house cool during the summer.

Part b

Which statement describes how the model could be improved to keep the inside of the model house cooler during summer?

A Make the windows larger so that less sunlight enters the house during summer.

B Make the overhangs larger so that less sunlight enters the house during summer.

C Make the windows smaller so that more sunlight enters the house during summer.

D Make the overhangs smaller so that more sunlight enters the house during summer.

Part b is aligned to the SEP and DCI. Students use their content knowledge that successful solutions are limited by constraints and apply scientific ideas about the height of the Sun in summer to explain how larger overhangs keep the inside of the house cooler during the summer.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: B

Distractor Rationales

Part a

A **KEY: The overhangs are designed to decrease the amount of sunlight that enters the house so that the house will be cooler during the summer.**

B Designing the house to have more windows on the south side lets in more sunlight and makes the house warmer, not cooler, during the summer.

C Based on the diagram, sunlight that enters a south window cannot go out a north window. Light energy that enters a south window is converted to thermal energy which makes the house warmer, not cooler.

D The diagram shows that sunlight enters windows on the south side, not on the north side, of the house.

Part b

A Larger windows let in more, not less, light, which makes the house warmer, not cooler.

B **KEY: Larger overhangs will allow less sunlight to enter the house. Less light energy will be converted to thermal energy and the house will be cooler.**

C Smaller windows would let in less, not more, sunlight.

D Smaller overhangs that let in more sunlight will make the house warmer, not cooler.

Item 23: Cluster Item

Next Generation Science Standards Description

PE: 4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

SEP: Constructing Explanations and Designing Solutions: Apply scientific ideas to solve design problems.

DCI: ETS1.A: Defining and Delimiting an Engineering Problem: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

Item Type: Inline Choice

Cognitive Complexity: Stimulus-Med | SEP-Med | DCI-Med

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to apply scientific ideas to refine the design of a house that converts light energy to thermal energy by adding tinted glass to the windows. The item aligns to the SEP by asking students to apply scientific ideas about how glass that lets in less sunlight affects the design of the model house. The item aligns to the DCI because students must use the understanding that constraints limit how well successful solutions meet the criteria.

23. Jaylinn observes that, in addition to overhangs above windows, some houses have windows with tinted[1] glass that is dark gray. Windows with tinted glass let less sunlight enter the house. Jaylinn wonders whether she should add tinted glass in the windows of her model house.

[1]**tinted:** darkened

Select the words to describe the effect of tinted glass on the inside of Jaylinn's model house.

The inside of the model house would be [warmer, cooler] during winter.

The inside of the model house would be [warmer, cooler] during summer.

This item is aligned to the SEP and DCI. Students use their content knowledge that successful solutions are limited by constraints and apply scientific ideas about glass that lets in less sunlight to describe how tinted glass in windows will affect the temperature inside the house during the winter and summer.

Scoring Key

Correct Response:
The inside of the model house would be [warmer, **cooler**] during winter.
The inside of the model house would be [warmer, **cooler**] during summer.

WHAT FOLLOWS IS THE STIMULUS AND PBT VERSION OF THE PREVIOUS ITEM

Item 23: PBT Cluster Item

Next Generation Science Standards Description

PE: 4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

SEP: Constructing Explanations and Designing Solutions: Apply scientific ideas to solve design problems.

DCI: ETS1.A: Defining and Delimiting an Engineering Problem: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Med | DCI-Med

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to apply scientific ideas to refine the design of a house that converts light energy to thermal energy by adding tinted glass to the windows. The item aligns to the SEP by asking students to apply scientific ideas about how glass that lets in less sunlight affects the design of the model house. The item aligns to the DCI because students must use the understanding that constraints limit how well successful solutions meet the criteria.

23. Jaylinn observes that, in addition to overhangs above windows, some houses have windows with tinted[1] glass that is dark gray. Windows with tinted glass let less sunlight enter the house. Jaylinn wonders whether she should add tinted glass in the windows of her model house.

[1]**tinted:** darkened

Which statement describes the effect of tinted glass on the inside of Jaylinn's house?

A The inside of the model house would be cooler during winter and warmer during summer.

B The inside of the model house would be cooler during winter and cooler during summer.

C The inside of the model house would be warmer during winter and cooler during summer.

D The inside of the model house would be warmer during winter and warmer during summer.

This item is aligned to the SEP and DCI. Students use their content knowledge that successful solutions are limited by constraints and apply scientific ideas about glass that lets in less sunlight to describe how tinted glass in windows will affect the temperature inside the house during the winter and summer.

Scoring Key

Correct Response: B

Distractor Rationales

A Tinted glass reduces the amount of sunlight that enters the house, so inside the house would be cooler, not warmer, during the summer.

B KEY: Tinted glass reduces the amount of sunlight that enters the house, so the house will be cooler inside during both winter and summer.

C Tinted glass reduces the amount of sunlight that enters the house, so inside the house would be cooler, not warmer, during the winter.

D Tinted glass reduces the amount of sunlight that enters the house, so the inside of the house would be cooler, not warmer, during both winter and summer.

Session 3: Items 24–35

Item 24: Standalone Item

Next Generation Science Standards Description

PE: 3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [*Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.*]

SEP: Planning and Carrying Out Investigations: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

DCI: PS2.A: Forces and Motion: Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.)

CCC: Cause and Effect: Cause and effect relationships are routinely identified.

Item Type: Inline Choice—Inline Choice

Cognitive Complexity: Stimulus-Low | SEP-Med | DCI-Med | CCC-Low

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to plan an investigation to provide evidence of the effect of balanced forces on a box. The item aligns to the SEP by asking students to plan an investigation to produce data that are evidence of the effect of balanced forces. The item aligns to the DCI because students must use knowledge that forces that sum to zero do not cause changes in the object's motion, while forces that do not sum to zero cause changes in the object's speed. The item aligns to the CCC because students must use the cause and effect relationship between force and change in motion to plan the investigation.

This question has two parts. Be sure to answer both parts of the question.

24. Ava observes that when she pushes a heavy box, she cannot push hard enough to make the box move. She also observes that when she and a friend push the box together, they can push hard enough to make the box move.

Part a

Select the word that describes the reason for Ava's observations.

When Ava pushes, the forces on the box are [balanced, unbalanced].

When Ava and her friend push, the forces on the box are [balanced, unbalanced].

Part b

Select the word or phrase that describes how Ava could investigate the effect of balanced forces on the box.

Use two forces that are [the same size, different sizes] to push the box from both sides. Observe that the motion of the box [changes, does not change].

Scoring Key

Part a

Correct Response:
When Ava pushes, the forces on the box are [**balanced**, unbalanced].
When Ava and her friend push, the forces on the box are [balanced, **unbalanced**].

Part b

Correct Response:
Use two forces that are [**the same size**, different sizes] to push the box from both sides. Observe that the motion of the box [changes, **does not change**].

The stimulus for this item begins by presenting the phenomenon that some forces will not make a heavy box move, while other forces can make the box move. The hook is that a student is trying to move a heavy box. The phenomenon and hook are grade-level appropriate because many students have experienced trying to move a heavy object.

Part a is aligned to the DCI and CCC. Students use the cause and effect relationship between force and change in motion and their content knowledge that balanced forces result in no change in motion and unbalanced forces cause changes in motion to explain Ava's observations.

Part b is aligned to the SEP, DCI and CCC. Students use their content knowledge that balanced forces result in no change in motion and the cause and effect relationship between force and change in motion to describe how to collect data that will be evidence of the effect of balanced forces.

WHAT FOLLOWS IS THE STIMULUS AND PBT VERSION OF THE PREVIOUS ITEM

Item 24: PBT Standalone Item

Next Generation Science Standards Description

PE: 3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [*Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.*]

SEP: Planning and Carrying Out Investigations: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

DCI: PS2.A: Forces and Motion: Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.)

CCC: Cause and Effect: Cause and effect relationships are routinely identified.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Med | DCI-Med | CCC-Low

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to plan an investigation to provide evidence of the effect of balanced forces on a box. The item aligns to the SEP by asking students to plan an investigation to produce data that are evidence of the effect of balanced forces. The item aligns to the DCI because students must use knowledge that forces that sum to zero do not cause changes in the object's motion, while forces that do not sum to zero cause changes in the object's speed. The item aligns to the CCC because students must use the cause and effect relationship between force and change in motion to plan the investigation.

This question has two parts. Be sure to answer both parts of the question.

24. Ava observes that when she pushes a heavy box, she cannot push hard enough to make the box move. She also observes that when she and a friend push the box together, they can push hard enough to make the box move.

Part a

Which statement describes the reason for Ava's observation?

A When Ava pushes, the forces on the box are balanced, and when Ava and her friend push, the forces on the box are balanced.

B When Ava pushes, the forces on the box are unbalanced, and when Ava and her friend push, the forces on the box are balanced.

C When Ava pushes, the forces on the box are unbalanced, and when Ava and her friend push, the forces on the box are unbalanced.

D When Ava pushes, the forces on the box are balanced, and when Ava and her friend push, the forces on the box are unbalanced.

Part b

Which plan **best** describes how Ava could investigate the effect of balanced forces on the box?

A Use two forces that are the same size to push the box from both sides, and then observe that the motion of the box changes.

B Use two forces that are different sizes to push the box from both sides, and then observe that the motion of the box changes.

C Use two forces that are the same size to push the box from both sides, and then observe that the motion of the box does not change.

D Use two forces that are different sizes to push the box from both sides, and then observe that the motion of the box does not change.

The stimulus for this item begins by presenting the phenomenon that some forces will not make a heavy box move, while other forces can make the box move. The hook is that a student is trying to move a heavy box. The phenomenon and hook are grade-level appropriate because many students have experienced trying to move a heavy box or other object.

Part a is aligned to the DCI and CCC. Students use the cause and effect relationship between force and change in motion and their content knowledge that balanced forces result in no change in motion and unbalanced forces cause changes in motion to explain Ava's observations.

Part b is aligned to the SEP, DCI and CCC. Students use their content knowledge that balanced forces result in no change in motion and the cause and effect relationship between force and change in motion to describe how to collect data that will be evidence of the effect of balanced forces.

Scoring Key

Part a
Correct Response: D

Part b
Correct Response: C

Distractor Rationales

Part a

A When Ava and her friend push the box, the forces are unbalanced, not balanced, and the box begins to move.

B When Ava pushes the box, the forces on the box are balanced, not unbalanced, and the box does not move. When Ava and her friend push the box, the forces are unbalanced, not balanced, and the box begins to move.

C When Ava pushes the box, the forces on the box are balanced, not unbalanced, and the box does not move.

D KEY: When Ava pushes the box, the forces on the box are balanced and the box does not move because all the forces on the box are balanced. When Ava and her friend push the box, the forces are unbalanced, not balanced, and the box begins to move because the forces on the box are not balanced.

Part b

A If the forces are the same size, she will not observe any change in motion.

B Using two forces that are different would be investigating unbalanced, not balanced, forces.

C KEY: If the forces are the same size and on opposite sides of the box, the forces will be balanced and the box will stay still and not begin to move.

D If the forces are different sizes, then the forces are unbalanced, not balanced, and the motion of the box will change, not stay the same.

Item 25: Standalone Item

Next Generation Science Standards Description

PE: 4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [*Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.*]

DCI: ESS3.B: Natural Hazards: A variety of natural hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-High | DCI-High | CCC-Med

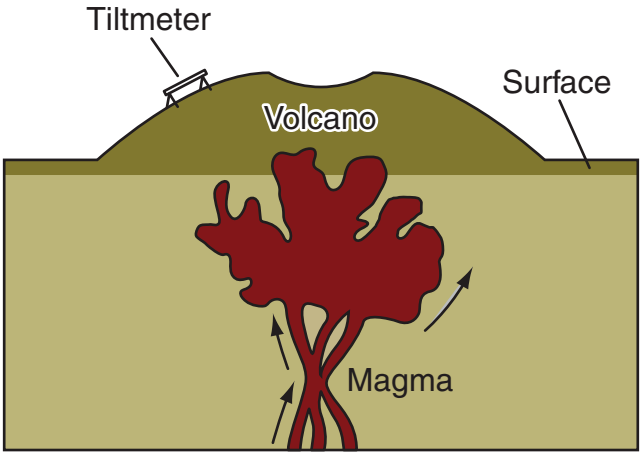
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to describe how a tiltmeter is a solution that can reduce the impact of volcanic eruptions on humans. The item aligns to the DCI because students must use knowledge that humans cannot eliminate the hazards caused by volcanic eruptions, but they can take steps to reduce the impact of eruptions. The item aligns to the CCC because students must use the cause and effect relationship between data from a tiltmeter and reducing the impact of volcanic eruptions.

Mario learns that scientists put a tool called a tiltmeter on a volcano to predict when the volcano will erupt. The tiltmeter measures changes in the shape of the volcano and sends that data to a computer. The diagram shows that a tiltmeter works because the shape of a volcano changes as magma moves up and causes the surface of the volcano to tilt.

Measuring the Shape of a Volcano



The stimulus for this item begins by presenting the phenomenon that the shape of a volcano changes when the volcano is about to erupt. The hook is that a student learns about a tool that can predict volcanic eruptions. The phenomenon and hook are grade-level appropriate because many students have heard about volcanic eruptions and their effects on people.

This question has two parts. Be sure to answer both parts of the question.

25. **Part a**

Which statement describes how using a tiltmeter could help save the lives of people who live near a volcano?

A Using a tiltmeter can warn people which direction magma will flow during an eruption.

B Using a tiltmeter can warn people to move away from the volcano during an eruption.

C Using a tiltmeter can decrease the number of people who need to be warned before an eruption.

D Using a tiltmeter can increase the time people have to move away from the volcano before an eruption.

Part a is aligned to the DCI and CCC. Students use their content knowledge that humans can take steps to reduce the impact of volcanic eruptions to describe a cause and effect relationship between using the tiltmeter and providing early warning of an eruption.

Part b

Which statement **best** describes how the data from a tiltmeter on one volcano could save the lives of people who live near another volcano?

A The data could show the shape of the volcano before the eruption.

B The data could show the direction magma moves during an eruption.

C The data could show the amount of magma released during an eruption.

D The data could show the time between a change in shape and an eruption.

Part b is aligned to the DCI and CCC. Students use their content knowledge that humans can take steps to reduce the impact of volcanic eruptions to describe a cause and effect relationship between data from the tiltmeter and saving lives when a volcano erupts.

Scoring Key

Part a
Correct Response: D

Part b
Correct Response: D

Distractor Rationales

Part a

A A tiltmeter measures change in the volcano's shape, not which direction lava will flow.

B A tiltmeter is used to provide information that can predict an eruption before an eruption happens, not during an eruption. Warnings must be given before, not during, an eruption.

C A tiltmeter does not change the number of people who could be affected by an eruption.

D KEY: A tiltmeter can measure small changes in a volcano's shape before there are other, more visible changes. This allows warnings to be given sooner than if warnings were based only on larger, more obvious changes.

Part b

A Data on changes in shape of a volcano, not data about the initial shape of the volcano, are used to predict eruptions.

B A tiltmeter measures change in a volcano's shape before an eruption, not which direction magma moves during an eruption.

C The amount of magma released varies from volcano to volcano, and from eruption to eruption. Also, a tiltmeter does not measure the amount of magma released during an eruption.

D KEY: The time between changes in shape measured by a tiltmeter on a volcano and the eruption of that volcano could be similar for another volcano.

Item 26: Standalone Item

Next Generation Science Standards Description

PE: 5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

SEP: Planning and Carrying Out Investigations: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.

DCI: PS1.B: Chemical Reactions: When two or more different substances are mixed, a new substance with different properties may be formed.

CCC: Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change.

Item Type: Multiple Choice—Multi-select

Cognitive Complexity: Stimulus-High | SEP-High | DCI-Low | CCC-Med

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to plan an investigation that tests for hard water by observing whether a solid forms when lime is added to the water. The item aligns to the SEP by asking students to plan an investigation that uses fair tests to produce data that could be evidence that a home has hard water. The item aligns to the DCI because students must use knowledge that when substances are mixed, a new substance with different properties may be formed. The item aligns to the CCC because students must use the cause and effect relationship between the substances mixed and the hardness of the water in the home to plan the investigation.

This question has two parts. Be sure to answer both parts of the question.

26. Raquel hears that some of the homes in her neighborhood have hard water. Hard water is water that contains dissolved calcium. Hard water can cause problems when calcium builds up in pipes and water cannot flow.

Raquel learns that lime is a mineral that usually dissolves in water but produces a solid when added to hard water. She wants to use lime to test whether her home has hard water.

Part a

Which measurement could Raquel use to test whether the water in her home is hard water?

A the amount of lime that she adds to her water

B the amount of calcium that dissolves in her water

C the amount of hard water in her neighbor's house

D the amount of solid in her water when she adds lime

Part b

Raquel wants to compare the water in her home to water in other buildings. Which **two** variables should Raquel keep the same during her investigation?

A the amount of water in each test

B the amount of calcium in the water

C the number of hours between tests

D the amount of lime added to the water

E the number of containers used during testing

The stimulus for this item begins by presenting the phenomenon that the water in some homes can clog the pipes. The hook is that a student hears that some homes in her neighborhood have this kind of water. The phenomenon and hook are grade-level appropriate because students use water from faucets and some students may have experience with pipes that are clogged or have reduced flow.

Part a is aligned to the SEP, DCI, and CCC. Students use their content knowledge that mixing substances can produce new substances with different properties and the cause and effect relationship between adding lime to hard water and producing a solid to describe data that could determine whether Raquel's home has hard water.

Part b is aligned to the SEP and DCI. Students use their content knowledge that mixing substances can produce new substances with different properties to describe variables that should be controlled so that testing for hard water is a fair test.

Scoring Key

Part a
Correct Response: D

Part b
Correct Response: A, D

Distractor Rationales

Part a

A Raquel does not add lime to her water. The amount of lime is the independent variable, not the dependent variable that she measures to determine whether her water is hard.

B Calcium is already dissolved in the water; this is what makes her water hard. Raquel cannot directly measure the amount of calcium that is dissolved, only the amount of calcium that becomes a solid during her investigation.

C Some of the homes in her neighborhood have hard water, but finding that her neighbor has hard water is not the way to test whether her water is hard.

D KEY: Adding lime to hard water produces a solid. If she adds lime and measures the amount of the solid that forms, then she will know that her home has hard water.

Part b

A KEY: Adding the same amount of lime to different amounts of water would change how much solid is produced. Raquel should add the same amount of lime to the same amount of water to find out whether the water is hard and a solid is produced.

B Calcium is already in the water in the buildings and cannot be kept the same. This is the dependent variable, not a variable Raquel can or should control.

C The results will be affected only by the amount of calcium dissolved in the water, not by the number of hours between Raquel's tests.

D KEY: Adding different amounts of lime to the same amount of water would change how much solid is produced. Raquel should add the same amount of lime to the same amount of water to find out whether the water is hard and a solid is produced.

E The results depend only on how hard the water is, not on how many containers the water is in.

Item 27: Standalone Item

Next Generation Science Standards Description

PE: 4-PS4-2: Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. [*Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.*]

SEP: Developing and Using Models: Develop a model to describe phenomena.

DCI: PS4.B: Electromagnetic Radiation: An object can be seen when light reflected from its surface enters the eyes.

CCC: Cause and Effect: Cause and effect relationships are routinely identified.

Item Type: Open-ended

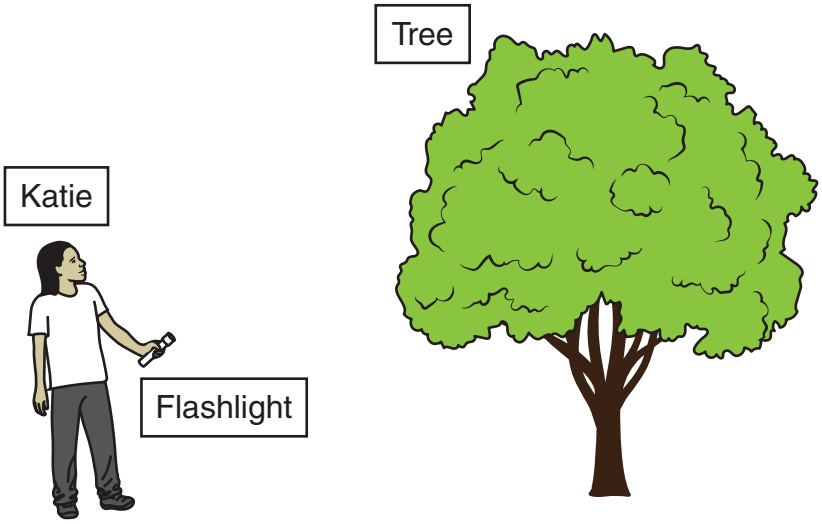
Cognitive Complexity: Stimulus-Low | SEP-High | DCI-High | CCC-High

Number of Points: 4

item on next page

This item brings students into the story line by asking them to develop a model to describe that light reflecting from a tree and entering a student's eye allows the student to see at night. The item aligns to the SEP by asking the students to develop a graphical model to describe how a student can see at night. The item aligns to the DCI because students must use knowledge that an object can be seen when reflected light from the object's surface enters the eyes. The item aligns to the CCC because students must use the cause and effect relationships between light reflecting from a tree object, light entering the eyes, and the student's ability to see the tree.

Katie and her friend are walking on a path in the woods at night. They use a flashlight to help them see the path and the trees next to the path. Katie wants to make a model that shows how she is able to see the tree. The diagram shows the objects to include in the model.



The stimulus for this item begins by presenting the phenomenon that people can use a flashlight to see at night. The hook is that a student and her friend are walking in the woods at night. The phenomenon and hook are grade-level appropriate because students are familiar with using flashlights to see in the dark.

This question has three parts. Be sure to answer all three parts of the question.

27. **a.** Use the objects in the diagram to draw a model that shows how Katie is able to see the tree. Draw arrows to show the path of light.

b. Based on the path of light shown in your model, describe how Katie is able to see the tree.

c. Predict how well Katie will be able to see the tree if there is thick fog in the woods. Use your model in part (a) to explain your reasoning.

Part a is aligned to the SEP, DCI, and CCC. Students use their content knowledge that an object can be seen when reflected light from the object's surface enters the eyes and the cause and effect relationships between light reflecting from a tree, light entering the eyes, and the student's ability to see the tree to develop a model to describe how Katie can see the tree.

Part b is aligned to the DCI and CCC. Students use their content knowledge that an object can be seen when reflected light from the object's surface enters the eyes and the cause and effect relationships between light from the flashlight reflecting from a tree and the reflected light entering Katie's eyes to describe how Katie is able to see the tree.

Part c is aligned to the SEP, DCI, and CCC. Students use their content knowledge that an object can be seen when reflected light from the object's surface enters the eyes and the cause and effect relationships between the amount of light from the flashlight that reflects from a tree and the amount of reflected light that enters Katie's eyes to include thick fog in their model and predict how well Katie can see the tree when there is a thick fog.

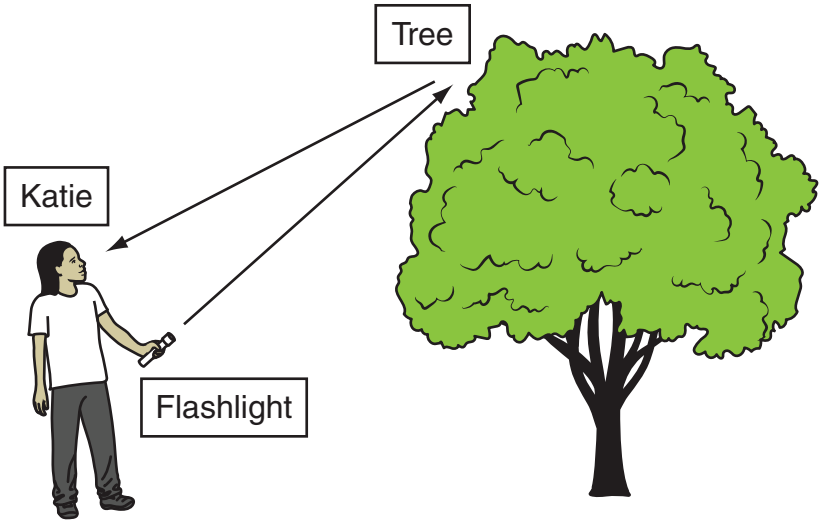
Scoring Rubric

Score	Description
4	The response demonstrates thorough use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response uses the objects and arrows showing the path of light to draw a model that shows how Katie is able to see the tree and uses the model to describe how Katie is able to see the tree. The response also predicts how well Katie will be able to see the tree if there is thick fog in the woods. The response • clearly applies science and engineering practices to provide an explanation or solution; • provides a coherent and accurate explanation or solution based on disciplinary core ideas; • reflects thorough understanding of complex ideas and crosscutting concepts; and • effectively applies and demonstrates complete understanding of the three dimensions.
3	The response demonstrates sufficient use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response may lack some detail or information, or the response may contain minor errors in applying and demonstrating understanding of science and engineering practices, disciplinary core ideas, and crosscutting concepts.
2	The response demonstrates limited use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems. The response may lack multiple details or information, or the response may contain major error(s) in applying and demonstrating understanding of science and engineering practices, disciplinary core ideas, and crosscutting concepts.
1	The response demonstrates minimal use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems.
0	The response is inaccurate, is irrelevant, or contains no evidence of use of the three dimensions to make sense of scientific phenomena and/or to design solutions to problems.
Blank	No response

The scoring rubric specifies how a 4-point response uses the dimensions of the PE and provides detail about how different levels of response meet the requirements of specific tasks in the item. All open-ended standalone items are 4-point items.

Scoring Notes

a. The model should look similar to the following: one arrow pointing from the flashlight toward the tree and one arrow pointing from the tree toward the person's head. Angles of incidence and reflection do not have to be equal. The arrows do not have to begin on the objects. The arrows do not have to meet at the same place on the tree. Students do not have to include objects in the drawing.



b. For Katie to see the tree, light must travel from a light source to the tree and then reflect off the tree and travel to Katie's eyes.

c. In thick fog, Katie will not be able to see the tree as well. The model shows that light must travel from the flashlight to the tree and then reflect off the tree to Katie's eyes. Thick fog would block some of the light from traveling this path. Less light from the flashlight will reach the tree, thus less light from the tree will reach Katie's eyes. The tree will be less bright, more blurry. Light scattered away from the direct path will make the fog bright, which will make the tree harder to see.

NOTE: Students do not need to refer back to the model for part c.

The scoring notes provide information expected for a full credit/four-point response. They are written using the type of language most likely to be used by students.

Items 28–31: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

SEP: Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.

DCI: ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Cluster Overview: Changing Shadows

Item	Item Type	Alignment
28	Inline Choice—Multiple Choice	5-ESS1-2: SEP, DCI, CCC
28 PBT	Multiple Choice—Multiple Choice	5-ESS1-2: SEP, DCI, CCC
29	Order	5-ESS1-2: SEP, DCI, CCC
29 PBT	Multiple Choice	5-ESS1-2: SEP, DCI, CCC
30	Drag and Drop	5-ESS1-2: SEP, DCI, CCC
30 PBT	Multiple Choice	5-ESS1-2: SEP, DCI, CCC
31	Multiple Choice—Multiple Choice	5-ESS1-2: SEP, DCI, CCC

The cluster consists of a phenomenon that allows overall item alignment to the PE. Every item in the cluster is three-dimensional which ensures the whole cluster has strong alignment to the PE.

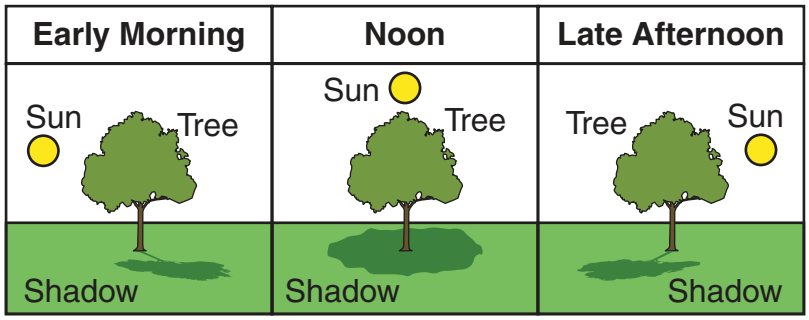
Stimulus and Items on next pages

Read the information. Then answer the questions that follow.

Changing Shadows

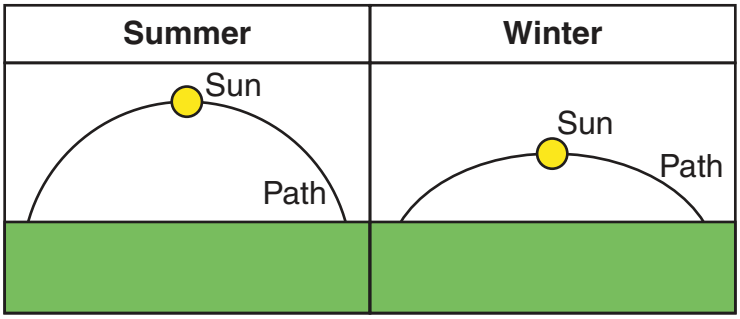
One summer day, Amelia walks past a tall tree in a park several times. She observes that the shadow of the tree changes during the day. She records her observations in the diagram.

Observed Tree Shadows



Amelia studies the path of the Sun across the sky during summer and winter as shown.

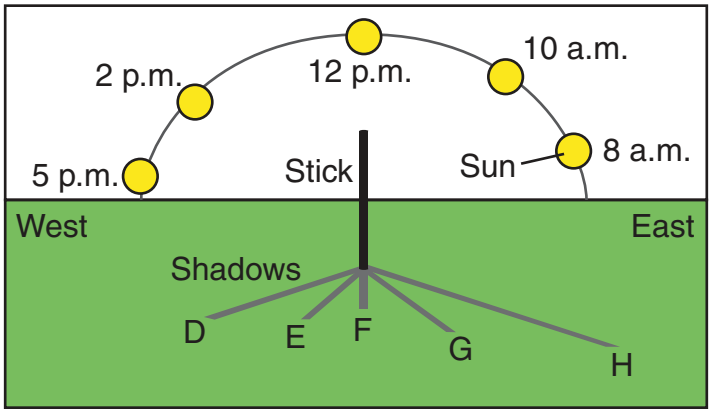
Path of the Sun



The stimulus for this cluster begins by presenting the phenomenon that the shadow of a tree changes during the day. The hook is that a student walks past the same tree several times during one day. The phenomenon and hook are grade-level appropriate because many students have observed that the shadows of objects change during the day.

Amelia decides to collect her own data on how shadow direction and shadow length change during the day. She puts a stick into the ground in a park near her home and observes the direction and length of the stick's shadow at different times on a summer day. The diagram shows the directions and lengths of five shadows Amelia observed.

Observed Stick Shadows



Finally, Amelia records the lengths of five shadows in a table.

Shadow Lengths

Shadow	Time	Shadow Length (centimeters)
D	8 a.m.	60
E	10 a.m.	20
F	12 p.m.	10
G	2 p.m.	30
H	5 p.m.	110

Item 28: Cluster Item

Next Generation Science Standards Description

PE: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

SEP: Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.

DCI: ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Item Type: Inline Choice—Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-Med | DCI-Med | CCC-Med

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to analyze data in graphical displays to explain patterns of daily changes in the direction of shadows. The item aligns to the SEP by asking students to analyze patterns in graphical data to determine relationships between the motion of a shadow and the motion of the Sun. The item aligns to the DCI because students must use knowledge that the rotation of Earth about an axis causes an observable pattern in the daily changes in the direction of a shadow. The item aligns to the CCC because students must analyze similarities and differences in patterns to explain the relationship between the motion of a shadow, the motion of the Sun, and Earth's rotation on its axis.

This question has two parts. Be sure to answer both parts of the question.

28. Part a

Based on the five shadows that Amelia observed, select the words that describe the motion of the shadow and the Sun.

The direction of the shadow of the stick moves from [east to west, west to east] as the Sun appears to move from [east to west, west to east].

Part b

Which motion causes the motion of the shadow?

A Earth orbits the Sun once every day.

B Earth orbits the Sun once every year.

C Earth rotates on its axis once every day.

D Earth rotates on its axis once every year.

Part a is aligned to the SEP and CCC. Students analyze similarities and differences in patterns in graphical data to describe the relationship between the motion of a shadow and the motion of the Sun.

Part b is aligned to the SEP and DCI. Students use their content knowledge that the rotation of Earth about an axis causes an observable pattern in the daily changes in the direction of a shadow to describe the relationship between the rotation of Earth on its axis every day and the motion of a shadow during the day.

Scoring Key

Part a

Correct Response:
The direction of the shadow of the stick moves from [east to west, **west to east**] as the Sun appears to move from [**east to west**, west to east].

Part b

Correct Response: C

Distractor Rationales

Part b

A This orbital motion does not cause the tree's shadow to change during one day because Earth orbits the Sun once every year, not once every day.

B This orbiting motion causes seasonal changes in shadows. This motion is not large enough during one day to cause the tree's shadow to change as Amelia observed during one day.

C KEY: The rotational motion causes the Sun to appear to move from east to west during the day. This causes the observed motion of the tree's shadow.

D If this rotational motion occurred, the motion would cause the observed motion of the tree's shadow to occur once a year, not once a day.

WHAT FOLLOWS IS THE STIMULUS AND PBT VERSION OF THE PREVIOUS ITEM

Item 28: PBT Cluster Item

Next Generation Science Standards Description

PE: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

SEP: Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.

DCI: ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-Med | DCI-Med | CCC-Med

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to analyze data in graphical displays to explain patterns of daily changes in the direction of shadows. The item aligns to the SEP by asking students to analyze patterns in graphical data to determine relationships between the motion of a shadow and the motion of the Sun. The item aligns to the DCI because students must use knowledge that the rotation of Earth about an axis causes an observable pattern in the daily changes in the direction of a shadow. The item aligns to the CCC because students must analyze similarities and differences in patterns to explain the relationship between the motion of a shadow, the motion of the Sun, and Earth's rotation on its axis.

This question has two parts. Be sure to answer both parts of the question.

28. **Part a**

Based on the five shadows that Amelia observed, which statement describes the motion of the shadow and the Sun?

A The direction of the shadow of the stick moves from east to west as the Sun appears to move from east to west.

B The direction of the shadow of the stick moves from east to west as the Sun appears to move from west to east.

C The direction of the shadow of the stick moves from west to east as the Sun appears to move from east to west.

D The direction of the shadow of the stick moves from west to east as the Sun appears to move from west to east.

Part a is aligned to the SEP and CCC. Students analyze similarities and differences in patterns in graphical data to describe the relationship between the motion of a shadow and the motion of the Sun.

Part b

Which motion causes the motion of the shadow?

A Earth orbits the Sun once every day.

B Earth orbits the Sun once every year.

C Earth rotates on its axis once every day.

D Earth rotates on its axis once every year.

Part b is aligned to the SEP and DCI. Students use their content knowledge that the rotation of Earth about an axis causes an observable pattern in the daily changes in the direction of a shadow to describe the relationship between the rotation of Earth on its axis every day and the motion of a shadow during the day.

Scoring Key

Part a
Correct Response: C

Part b
Correct Response: C

Distractor Rationales

Part a

A The shadow of the stick moves in the opposite, not in the same, direction as the Sun.

B The student reversed the direction of the shadow's motion and the direction of the Sun's motion.

C KEY: The diagram shows that the stick's shadow moves from west to east and the Sun moves from east to west.

D The shadow of the stick moves in the opposite direction, not the same direction, as the Sun. Also, the Sun moves from east to west, not from west to east.

Part b

A This orbital motion does not cause the tree's shadow to change during one day because Earth orbits the Sun once every year, not once every day.

B This orbiting motion causes seasonal changes in shadows. This motion is not large enough during one day to cause the tree's shadow to change as Amelia observed during one day.

C KEY: The rotational motion causes the Sun to appear to move from east to west during the day. This causes the observed motion of the tree's shadow.

D If this rotational motion occurred, the motion would cause the observed motion of the tree's shadow to occur once a year, not once a day.

Item 29: Cluster Item

Next Generation Science Standards Description

PE: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

SEP: Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.

DCI: ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Item Type: Order

Cognitive Complexity: Stimulus-Low | SEP-Low | DCI-Low | CCC-Low

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to analyze data in graphical displays to reveal patterns of daily changes in the length of shadows. The item aligns to the SEP by asking students to analyze patterns in graphical data to determine relationships between the length of a shadow and the time of day. The item aligns to the DCI because students must use knowledge of the observable pattern of daily changes in the length of a shadow. The item aligns to the CCC because students must analyze similarities and differences in patterns to explain the relationship between the length of a shadow and the time of day.

29. Put the stick's shadows in order from shortest to longest. Select each shadow and drag it to the correct position in the sequence.

Shortest

shadow at 8 a.m.

shadow at 10 a.m.

shadow at 2 p.m.

shadow at 5 p.m.

shadow at 12 p.m.

Longest

This item is aligned to the SEP, DCI, and CCC. Students analyze graphical data to reveal patterns that indicate the relationship between shadow length and time of day by using their content knowledge of the observable pattern of daily changes in the length of a shadow and similarities and differences in the daily pattern of shadow lengths.

Scoring Key

Correct Response:
Shortest
shadow at 12 p.m.
shadow at 10 a.m.
shadow at 2 p.m.
shadow at 8 a.m.
shadow at 5 p.m.
Longest

WHAT FOLLOWS IS THE STIMULUS AND PBT VERSION OF THE PREVIOUS ITEM

Item 29: PBT Cluster Item

Next Generation Science Standards Description

PE: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

SEP: Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.

DCI: ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Low | DCI-Low | CCC-Low

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to analyze data in graphical displays to reveal patterns of daily changes in the length of shadows. The item aligns to the SEP by asking students to analyze patterns in graphical data to determine relationships between the length of a shadow and the time of day. The item aligns to the DCI because students must use knowledge of the observable pattern of daily changes in the length of a shadow. The item aligns to the CCC because students must analyze similarities and differences in patterns to explain the relationship between the length of a shadow and the time of day.

29. Which sequence represents the stick's shadows ordered from shortest to longest?

A 5 p.m. → 2 p.m. → 12 p.m. → 10 a.m. → 8 a.m.

B 10 a.m. → 12 p.m. → 2 p.m. → 8 a.m. → 5 p.m.

C 12 p.m. → 10 a.m. → 2 p.m. → 8 a.m. → 5 p.m.

D 5 p.m. → 8 a.m. → 2 p.m. → 10 a.m. → 12 p.m.

This item is aligned to the SEP, DCI, and CCC. Students analyze graphical data to reveal patterns that indicate the relationship between shadow length and time of day by using their content knowledge of the observable pattern of daily changes in the length of a shadow and similarities and differences in the daily pattern of shadow lengths.

Scoring Key

Correct Response: C

Distractor Rationales

A The shadow is longest, not shortest, at 5 p.m. and the shadow at 8 a.m. is not as long as the shadow at 5 p.m.

B The shadow at 10 a.m. is longer than the shadow at 12 p.m.

C KEY: The shadow length table shows that the shadow length is shortest at 12 p.m. and longest at 5 p.m.

D The student ordered the stick shadows from longest to shortest, not from shortest to longest.

Item 30: Cluster Item

Next Generation Science Standards Description

PE: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

SEP: Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.

DCI: ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Item Type: Drag and Drop

Cognitive Complexity: Stimulus-Med | SEP-Med | DCI-Low | CCC-Med

Number of Points: 1

Item on next page

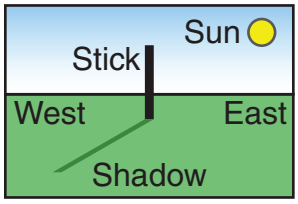
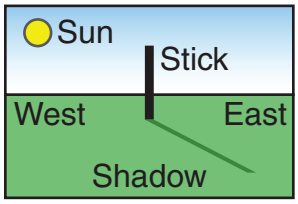
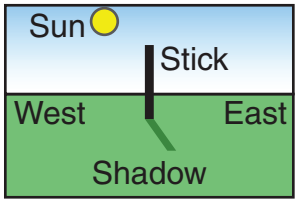
This item brings students into the story line by asking them to analyze data in graphical displays to reveal patterns of daily changes in the length and direction of shadows. The item aligns to the SEP by asking students to analyze patterns in graphical data to determine relationships between the length and direction of a shadow and the time of day. The item aligns to the DCI because students must use knowledge of the observable pattern of daily changes in the length and direction of shadows. The item aligns to the CCC because students must analyze similarities and differences in patterns to explain the relationship between the length and direction of a shadow and the time of day.

30. Although Amelia did not record the lengths in the table, she also observed the length of the stick's shadow at three other times that day.

Based on the pattern in Amelia's observations of the stick's shadow, complete the table to show the time of the day Amelia observed each shadow.

Select the times and drag them into the correct spaces in the table.

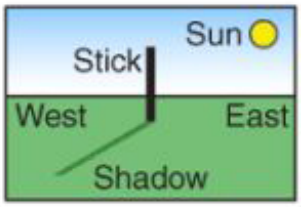
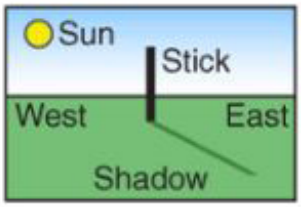
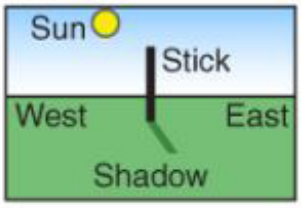
9 a.m. | 1 p.m. | 3 p.m.

Shadow of the Stick	Time of the Day
	
	
	

This item is aligned to the SEP, DCI, and CCC. Students analyze graphical data to reveal patterns that indicate the relationship between time of day and shadow length and direction by using their content knowledge of the observable pattern of daily changes in the length and direction of shadows and similarities and differences in the daily pattern of shadow directions and lengths.

Scoring Key

Correct Response:

Shadow of the Stick	Time of the Day
	9 a.m.
	3 p.m.
	1 p.m.

WHAT FOLLOWS IS THE STIMULUS AND PBT VERSION OF THE PREVIOUS ITEM

Item 30: PBT Cluster Item

Next Generation Science Standards Description

PE: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

SEP: Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.

DCI: ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Med | DCI-Low | CCC-Med

Number of Points: 1

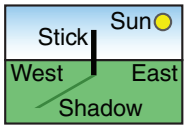
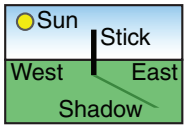
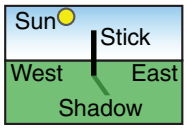
Item on next page

This item brings students into the story line by asking them to analyze data in graphical displays to reveal patterns of daily changes in the length and direction of shadows. The item aligns to the SEP by asking students to analyze patterns in graphical data to determine relationships between the length and direction of a shadow and the time of day. The item aligns to the DCI because students must use knowledge of the observable pattern of daily changes in the length and direction of shadows. The item aligns to the CCC because students must analyze similarities and differences in patterns to explain the relationship between the length and direction of a shadow and the time of day.

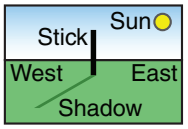
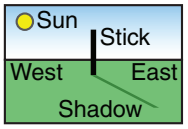
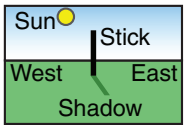
30. Although Amelia did not record the lengths in the table, she also observed the length of the stick's shadow at three other times that day.

Based on the pattern in Amelia's observations of the stick's shadow, which table shows the time of the day Amelia observed each shadow?

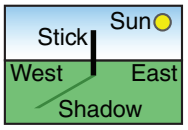
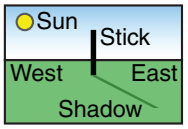
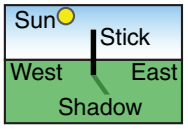
A

Shadow of the Stick	Time of the Day
	3 p.m.
	1 p.m.
	9 a.m.

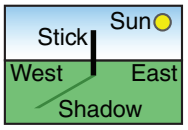
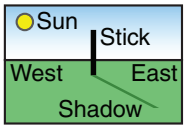
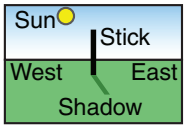
B

Shadow of the Stick	Time of the Day
	1 p.m.
	3 p.m.
	9 a.m.

C

Shadow of the Stick	Time of the Day
	9 a.m.
	3 p.m.
	1 p.m.

D

Shadow of the Stick	Time of the Day
	1 p.m.
	9 a.m.
	3 p.m.

This item is aligned to the SEP, DCI, and CCC. Students analyze graphical data to reveal patterns that indicate the relationship between time of day and shadow length and direction by using their content knowledge of the observable pattern of daily changes in the length and direction of shadows and similarities and differences in the daily pattern of shadow directions and lengths.

Scoring Key

Correct Response: C

Distractor Rationales

A Amelia observed the Sun in the east during the morning, not at 3 p.m. She also observed the Sun in the west during the afternoon, not at 9 a.m.

B Amelia observed the Sun in the west, not in the east, not at 1 p.m. She also observed the Sun in the west during the afternoon, not at 9 a.m.

C KEY: Amelia observed the Sun in the east during the morning, at 9 a.m. and in the west during the afternoon, at 3 p.m. Because the Sun moves from east to west during the day, the Sun is farther west at 3 p.m. than at 1 p.m.

D Amelia observed the Sun in the west during the afternoon, not at 9 a.m. She also observed the Sun in the east during the morning, not at 1 p.m.

Item 31: Cluster Item

Next Generation Science Standards Description

PE: 5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

SEP: Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.

DCI: ESS1.B: Earth and the Solar System: The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.

CCC: Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-High | SEP-High | DCI-Low | CCC-High

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to analyze data in graphical displays to explain patterns of seasonal changes in the length of shadows. The item aligns to the SEP by asking students to analyze patterns in graphical data to determine the relationship between the length of a shadow and the time of year. The item aligns to the DCI because students must use knowledge of observable patterns of changes in the daily path of the Sun at different times of the year. The item aligns to the CCC because students must analyze similarities and differences in patterns to explain the relationships among the length of a shadow, the position of the Sun, and the time of year.

This question has two parts. Be sure to answer both parts of the question.

31. Amelia makes a claim about how long the stick's shadow would be if she observed her stick on a winter day.

Part a

Which claim is supported by what Amelia learned about the path of the Sun?

A In winter, the shadows during the middle of the day will be longer than in summer.

B In winter, the shadows when the Sun is rising and setting will be longer than in summer.

C In winter, the shadows will be longer in the morning and shorter in the afternoon than in summer.

D In winter, the shadows will be shorter in the morning and longer in the afternoon than in summer.

Part b

Which statement **best** explains the difference between shadows in summer and winter?

A Earth is closer to the Sun in winter than in summer.

B Earth is on opposite sides of the Sun in winter and in summer.

C The Sun's path across the sky is lower in winter than in summer.

D The Sun moves from east to west across the sky in winter and in summer.

Part a is aligned to the SEP, DCI, and CCC. Students analyze graphical data to reveal patterns that support a claim about the relationship between time of day and shadow length in winter and summer by using their content knowledge of an observable pattern of changes in the daily path of the Sun in summer and winter and similarities and differences in the daily patterns of the path of the Sun and shadow lengths.

Part b is aligned to the SEP, DCI, and CCC. Students analyze graphical data to reveal patterns that indicate the relationship between time of day and shadow length in winter and summer by using their content knowledge of an observable pattern of changes in the daily path of the Sun in summer and winter and similarities and differences in the daily patterns of the path of the Sun and shadow lengths.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: C

Distractor Rationales

Part a

A **KEY: In winter, the Sun would be lower in the sky. Shadows are longer when the Sun is lower in the sky.**

B These shadows will be the same length in winter as in summer. At sunrise and sunset, the Sun is at the horizon. The length of the shadow depends on the height of the Sun above the horizon, not the time the Sun is at a particular height above the horizon.

C During the winter, the lower path of the Sun will result in longer, not shorter, shadows during the afternoon.

D During the winter, the lower path of the Sun will result in longer, not shorter, shadows during the morning.

Part b

A The height of the Sun's path across the sky is determined by the tilt of Earth's axis, not by Earth's distance from the Sun. Earth is also closest to the Sun during the winter months in the Northern Hemisphere and furthest from the Sun during the winter months in the Southern Hemisphere.

B Earth's axis stays tilted in the same direction as Earth orbits the Sun. One part of Earth has winter when Earth's axis is tilted away from that part. This happens when Earth is on one side of the Sun and is the reason that the Sun's path across the sky is lower and shadows are longer. Without a tilted axis, there would be no change in seasons, even though Earth is on opposite sides of the Sun.

C **KEY: The Sun casts longer shadows when the Sun is closer to the horizon. The shadows are longer in the winter because the Sun is lower in the sky all day.**

D This east to west movement of the Sun affects the direction of shadow movement, not the length of the shadows.

Items 32–35: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: 5-LS1-1: Support an argument that plants get the materials they need for growth chiefly from air and water. [Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]

SEP: Engaging in Argument From Evidence: Support an argument with evidence, data, and/or a model

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants acquire their material for growth chiefly from air and water.

CCC: Energy and Matter: Matter is transported into, out of, and within systems.

PE: 5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [*Assessment Boundary: Assessment does not include molecular explanations.*]

SEP: Developing and Using Models: Develop a model to describe phenomena.

DCI: LS2.A: Interdependent Relationships in Ecosystems: The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles)some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.

DCI: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.

CCC: Systems and System Models: A system can be described in terms of its components and their interactions.

Cluster Overview: Trees

Item	Item Type	Alignment
32	Multiple Choice	5-LS2-1: DCI, CCC
33	Multi-select—Multiple Choice	5-LS2-1: SEP, DCI, CCC
34	Multiple Choice	5-LS1-1: SEP, DCI, CCC
35	Multiple Choice—Multiple Choice	5-LS1-1: SEP, DCI, CCC

Stimulus and Items on next pages

The cluster consists of a phenomenon that allows overall item alignment across two PEs. While not every individual item in the cluster is three-dimensional, all items are at least two-dimensional, and collectively the whole cluster has strong alignment to all three dimensions of each PE.

Read the information. Then answer the questions that follow.

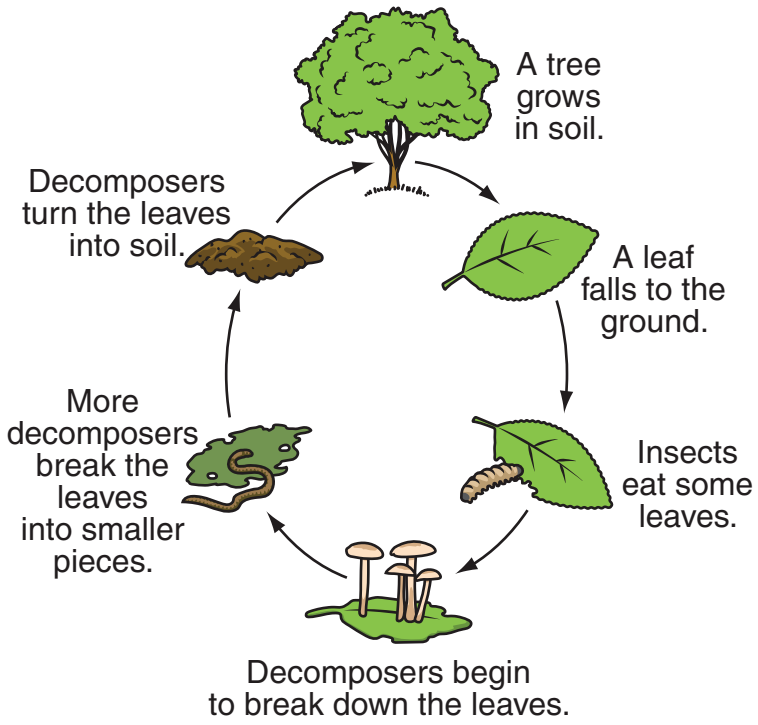
Trees

Mr. Garcia shows Natalie the decaying plants that are turning into soil inside the compost bin in his garden. He tells her that he plans to spread the soil around the trees in his garden to help them grow.

Natalie thinks about Mr. Garcia's compost bin and how trees grow. She draws a model to show how matter from trees becomes part of the soil. Her model is shown in the diagram.

The stimulus for this cluster begins by presenting the phenomenon that decaying plants can turn into soil in a compost bin. The hook is that a student has a neighbor with a compost bin. The phenomenon and hook are grade-level appropriate because many students have heard of composting and using compost to help plants grow.

Tree Growth Model



Natalie asks Mr. Garcia whether soil becomes part of trees as they grow. He tells her about a scientist who conducted an investigation long ago. The scientist measured the mass of a small tree. Then he measured the mass of dry soil that he put into a container and planted the small tree in the container. He took care of the tree as the tree grew larger. Five years later, the scientist took the tree out of the container and dried the soil. Then he measured the mass of the tree and the dry soil again. The table shows the results of the scientist's investigation.

Tree Growth Data

When Mass Was Measured	Mass of Tree (kg)	Mass of Dry Soil (kg)
When planted	2	91
Five years later	77	91

Item 32: Cluster Item

Next Generation Science Standards Description

PE: 5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [*Assessment Boundary: Assessment does not include molecular explanations.*]

DCI: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.

CCC: Systems and System Models: A system can be described in terms of its components and their interactions.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Med | DCI-Low | CCC-Low

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to describe the movement of matter between soil and trees. The item aligns to the DCI because students must use knowledge of how matter cycles between the soil and plants. The item aligns to the CCC because students must use the understanding that trees and soil are interacting components of a system.

32. Which statement **best** describes how soil helps trees grow?

A Trees take in food from the soil.

B Trees take in matter from the soil.

C Trees take in energy from the soil.

D Trees take in organisms from the soil.

This item is aligned to the DCI and CCC. Students use their content knowledge of how matter cycles between soil and plants to describe that trees and soil are interacting parts of a system.

Scoring Key

Correct Response: B

Distractor Rationales

A Trees do not eat soil. They take in matter from the air and convert that matter into food.

B KEY: Trees take in some of the matter that they need from the soil.

C Trees take in energy from sunlight, not from the soil.

D Trees do take in organisms from the soil, but trees do not rely on these organisms to help them grow.

Item 33: Cluster Item

Next Generation Science Standards Description

PE: 5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [*Assessment Boundary: Assessment does not include molecular explanations.*]

SEP: Developing and Using Models: Develop a model to describe phenomena.

DCI: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.

CCC: Systems and System Models: A system can be described in terms of its components and their interactions.

Item Type: Multi-select—Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Med | DCI-Low | CCC-Med

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to develop a model to describe the movement of matter among plants, animals, and decomposers and the environment. The item aligns to the SEP by asking students to develop a graphical model to describe how the organisms interact with the environment. The item aligns to the DCI because students must use knowledge that organisms obtain gases and water from the environment. The item aligns to the CCC because students must describe organisms and their environment as interacting components of a system.

This question has two parts. Be sure to answer both parts of the question.

33. **Part a**

Mr. Garcia tells Natalie that some of the matter that organisms need to live is not included in her model.

Which **two** types of matter does Natalie need to add to her model?

A air

B water

C plants

D animals

E sunlight

Part a is aligned to the SEP, DCI and CCC. Students use their content knowledge that organisms obtain gases and water from the environment and that organisms and their environment are interacting parts of a system to develop Natalie's model by adding nonliving types of matter to the model.

Part b

Which statement supports the answer to Part (a)?

A Organisms exchange matter with each other.

B Organisms exchange matter with their environment.

C Organisms grow when they take in matter from food.

D Organisms transfer matter from one place to another as they move.

Part b is aligned to the DCI and CCC. Students use their content knowledge that organisms obtain gases and water from the environment to describe how organisms and their environment are interacting parts of a system.

Scoring Key

Part a
Correct Response: A, B

Part b
Correct Response: B

Distractor Rationales

Part a

- **A KEY: Plants use matter in air to make food. This matter is transferred to insects and decomposers and back to the environment.**
- **B KEY: Plants use matter in water to make food. This matter is transferred to insects and decomposers and back to the environment.**
- C A tree is a plant which is made of matter, but a tree is already present in the model.
- D Insects are animals which are made of matter, but insects are already in the model.
- E Sunlight is energy, not matter.

Part b

- A Organisms in the model already exchange matter, so this does not support a choice of what to add to the model.
- **B KEY: Air and water are in the environment and organisms exchange gases and liquids with the environment. This supports adding air and water to the model.**
- C An insect is shown eating a tree leaf in the model. This means that exchanges of matter in the form of food are already included in the model.
- D Organisms do move matter when they move their bodies in an ecosystem, but this does not explain why two types of matter should be added to the model.

Item 34: Cluster Item

Next Generation Science Standards Description

PE: 5-LS1-1: Support an argument that plants get the materials they need for growth chiefly from air and water. [Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]

SEP: Engaging in Argument From Evidence: Support an argument with evidence, data, and/or a model

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants acquire their material for growth chiefly from air and water.

CCC: Energy and Matter: Matter is transported into, out of, and within systems.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Low | DCI-Low | CCC-Low

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to support an argument that trees get materials they need for growth from air. The item aligns to the SEP by asking students to use evidence to support the argument. The item aligns to the DCI because students must use knowledge that plants acquire their material for growth from air. The item aligns to the CCC because students must use the understanding that trees are systems and that matter is transported into trees.

34. Natalie has heard that trees that are planted in the ground and completely wrapped in clear plastic do not grow. What is the **most likely** reason that trees wrapped in plastic do not grow?

A These trees do not have roots.

B These trees do not have leaves.

C These trees do not absorb sunlight.

D These trees do not absorb matter from air.

This item is aligned to the SEP, DCI and CCC. Students use their content knowledge that trees acquire material they need to grow from air and the understanding that matter is transported into trees to support an argument about why trees wrapped in plastic do not grow.

Scoring Key

Correct Response: D

Distractor Rationales

A Trees that are planted in the ground have roots even when the trees are completely wrapped in plastic.

B Trees that are planted in the ground have leaves. When the trees are first wrapped in plastic, the leaves are still green and growing.

C Sunlight passes through clear plastic and can shine on the green leaves of the trees. This means that the trees can absorb sunlight inside the plastic, at least while the leaves are alive.

D KEY: Plants take in matter from the air to make food. A tree completely wrapped in plastic cannot take in matter from the air.

Item 35: Cluster Item

Next Generation Science Standards Description

PE: 5-LS1-1: Support an argument that plants get the materials they need for growth chiefly from air and water. [Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]

SEP: Engaging in Argument From Evidence: Support an argument with evidence, data, and/or a model

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants acquire their material for growth chiefly from air and water.

CCC: Energy and Matter: Matter is transported into, out of, and within systems.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | SEP-Low | DCI-Med | CCC-Low

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to support a claim that trees get materials they need for growth from water. The item aligns to the SEP by asking students to evaluate a claim that trees left near a window for months will grow. The item aligns to the DCI because students must use knowledge that plants acquire their material for growth from water. The item aligns to the CCC because students must use the understanding that trees are systems and matter is transported into trees.

This question has two parts. Be sure to answer both parts of the question.

35. Natalie decides to repeat the scientist's investigation using a smaller tree in a smaller container. She measures the mass of the tree and container and then plants the tree in the container. Natalie plans to put the tree near a window in the garage and leave the tree alone. After three months, she will come back and measure the mass of the tree and container again.

Natalie claims that her tree will grow taller and wider during the three months in the garage.

Part a

Which sentence describes Natalie's claim?

A The claim is correct because trees need light to grow.

B The claim is incorrect because trees need water to grow.

C The claim is correct because trees need to be in soil to grow.

D The claim is incorrect because trees need to be outside to grow.

Part a is aligned to the SEP, DCI and CCC. Students use their content knowledge that trees acquire material they need to grow from water and the understanding that matter is transported into trees to evaluate the claim that trees left near a window for months will grow.

Part b

Which change could Natalie make to her investigation to help her tree grow faster?

A giving the tree some water twice a week

B adding some soil to the container twice a week

C moving the tree closer to the window twice a week

D taking the container outside of the garage twice a week

Part b is aligned to the SEP, DCI and CCC. Students use their content knowledge that trees acquire material they need to grow from water and the understanding that matter is transported into trees to support the argument that trees will grow faster if given water.

Scoring Key

Part a
Correct Response: B

Part b
Correct Response: A

Distractor Rationales

Part a

A Trees do need light to grow, and the tree in the garage will receive light from the window. Yet the claim is incorrect because trees also need water and Natalie says that she will leave the tree alone. The tree will not grow taller and wider if left without water for three months.

B KEY: The claim is incorrect because if Natalie leaves the tree alone for three months, the tree will not get the water that the tree needs to grow taller and wider.

C Trees do need soil to grow, and the tree in the garage will be planted in soil. The claim is incorrect because trees also need water to grow. After three months without water, the tree may be dead and is unlikely to grow taller and wider.

D The tree in the garage has air and soil and sunlight, just like trees outside. Having no water is what will prevent the tree from growing taller and wider.

Part b

A KEY: The tree needs water to grow. Natalie is already making sure that the tree gets soil, the air, and light in the garage. If she waters the tree, the tree is more likely to grow taller and wider.

B More soil will not help the tree grow faster if the tree is not also given water.

C Moving the tree to get more light will not help the tree grow faster if the tree still needs water.

D Taking the tree outside during a rain could help, but taking the tree outside when there is no rain will not help. The problem with Natalie's investigative plan is not that the tree is inside the garage, but that the tree is not given any water.