Summative Assessments

Science Practice Test Teacher Guide

NM-ASR

Middle School

COGNIA ASSESSMENTS

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Practice Test Items

Session 1: Items 1–12

Item 1: Standalone Item

Next Generation Science Standards Description

PE: MS-ESS1-3: Analyze and interpret data to determine scale properties of objects in the solar system. [Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [*Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.*]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in findings.

DCI: ESS1.B: Earth and the Solar System: The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.

CCC: Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Med | 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 analyze data to compare scale properties of Venus and Earth. The item aligns to the SEP by asking students to analyze data to determine similarities and differences in properties of the planets. The item aligns to the DCI because students must use knowledge that the planets are in orbit around the Sun. The item aligns to the CCC because students must use the understanding that different properties are observed at different scales, from Earth and from space.

At a planetarium, Amy learns that Venus and Earth are sometimes called sister planets. To understand why, she begins to gather data on the planets. Some of the data on Venus are from observations that scientists made from Earth. Other data are from observations made by spacecraft sent to Venus beginning in the 1960s.

Amy decides to put the data into two tables, based on the source of the observations about Venus.

Earth-Based Observations

Data	Venus	Earth
Distance from Sun (10^8 km)	1.1	1.5
Diameter (km)	12,100	12,700
Mass (10^{24} kg)	4.9	6.0
Density (g/cm^3)	5.2	5.5
Surface gravity (m/s^2)	8.9	9.8

Space-Based Observations

Data	Venus	Earth
Daily surface temperature (°C)	465	10–20
Atmosphere	• 96.5% carbon dioxide • 3.5% nitrogen	• 78% nitrogen • 21% oxygen
Liquid water on surface	none	70% covered by oceans 4 km deep
Internal structure	• Core diameter 6,000 km • Mantle 3,000 km thick • Crust 10–20 km thick	• Core diameter 4,700 km • Mantle 2,900 km thick • Crust 5–30 km thick

The stimulus for this item begins by presenting the phenomenon that observations of planets from different distances show different properties. The hook is that from a distance, Venus and Earth appear to be "sister" planets with similar properties. The phenomenon and hook are grade-level appropriate because many students are interested in planets.

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

1. **Part a**

Which data are evidence that Earth and Venus are similar enough to be called sister planets?

A diameter and density

B mass and surface water

C atmosphere and internal structure

D surface gravity and daily surface temperature

Part b

Which statement describes a reason that the differences between Earth and Venus have only been discovered since the 1960s?

A The differences can only be observed from distances close to Venus.

B The differences have developed since space-based observations began.

C The differences result from changes in the way the spacecraft collect data.

D The differences are caused by processes that recently began to occur on Venus.

Part a is aligned to the SEP, DCI, and CCC. Students analyze data and compare two planets by using their content knowledge that Earth and Venus are planets orbiting the Sun and the understanding that different properties are observed at different scales.

Part b is aligned to the DCI and the CCC. Students use their content knowledge that Earth and Venus are planets in different orbits around the Sun to describe that some properties of a planet can only be observed close to the planet.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: A

Distractor Rationales

Part a

- **A KEY: Both diameters and densities are close (within 5%).**
- B While masses are similar, amounts of surface water are very different.
- C While internal structures are similar, atmospheres are very different.
- D While surface gravities are similar, surface temperatures are very different.

Part b

- **A KEY: These differences can only be observed close to the planet, not from Earth.**
- B Venus has not changed significantly since the 1960s: that is not the reason for the differences.
- C The differences result from differences on the two planets, not from the way the spacecraft collect data.
- D Processes on Venus have not changed significantly since the 1960s: that is not the reason for the differences.

Item 2: Standalone Item

Next Generation Science Standards Description

PE: MS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [*Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.*]

SEP: Using Mathematics and Computational Thinking: Use mathematical representations to describe and/or support scientific conclusions and design solutions.

DCI: PS4.A.: Wave Properties: A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

CCC: Patterns: Graphs and charts can be used to identify patterns in data.

Item Type: Inline Choice—Multiple Choice

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

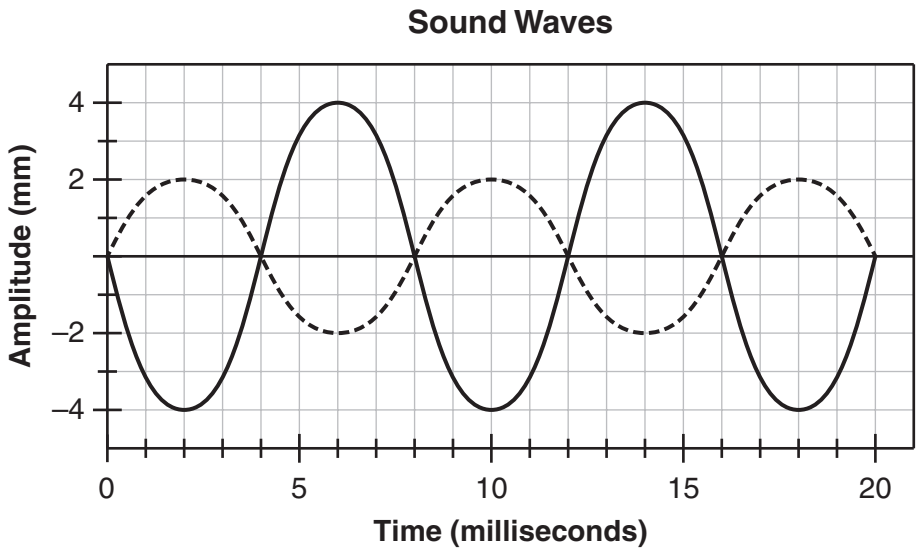
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use a graph of two sound waves to describe a model that uses wave amplitudes to compare wave energies. The item aligns to the SEP by asking students to use a graph of two waves to support conclusions. The item aligns to the DCI because students must use knowledge of the patterns in the graph that represent amplitude and frequency. The item aligns to the CCC because students must use a graph of two sound waves to identify patterns in wave amplitude and energy.

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

2. Elaine is researching the characteristics of sound waves as she listens to music. She finds a diagram that shows two sound waves.



The stimulus for this item begins by presenting the phenomenon that sound waves can have different amplitudes. The hook is that a student is listening to music. The phenomenon and hook are grade-level appropriate because many students listen to music and are familiar with sound waves.

Part a

Select the number that describes the sound waves in the diagram.

Wave 1 has [one-fourth, one-half, twice, four times] the energy of Wave 2.

Part a is aligned to the SEP, DCI, and CCC. Students use a graph to make a conclusion about the energy in two waves by using their content knowledge of the pattern that is the amplitude of a wave and identifying an amplitude pattern in a graph.

Part b

Elaine predicts that the energy in each sound wave would double if the frequency of the wave doubled.

Which statement describes her prediction?

A Her prediction is correct because the energy of a wave is proportional to the wave's frequency.

B Her prediction is incorrect because the energy of a wave is proportional to the square of the wave's frequency.

C Her prediction is correct because the energy of a wave is proportional to speed and a wave with twice the frequency has twice the speed.

D Her prediction is incorrect because the energy of a wave is proportional to the wavelength and a wave with twice the frequency has half the wavelength.

Part b is aligned to the SEP and DCI. Students use a graph of two waves to evaluate a prediction about the energy in sound waves by using their content knowledge of the pattern that is the frequency of a wave.

Scoring Key

Part a

Correct Response:
Wave 1 has [**one-fourth**, one-half, twice, four times] the energy of Wave 2.

Part b

Correct Response: A

Distractor Rationales

Part b

A **KEY: The energy and frequency of a wave are directly proportional.**

B Energy is proportional to square of amplitude, not frequency.

C The speed of a wave doesn't change when the frequency changes.

D While a wave with twice the frequency would have half the wavelength, energy is proportional to frequency, not wavelength. Energy is inversely proportional to wavelength.

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

Item 2: PBT Standalone Item

Next Generation Science Standards Description

PE: MS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [*Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.*]

SEP: Using Mathematics and Computational Thinking: Use mathematical representations to describe and/or support scientific conclusions and design solutions.

DCI: PS4.A.: Wave Properties: A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

CCC: Patterns: Graphs and charts can be used to identify patterns in data.

Item Type: Multiple Choice—Multiple Choice

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

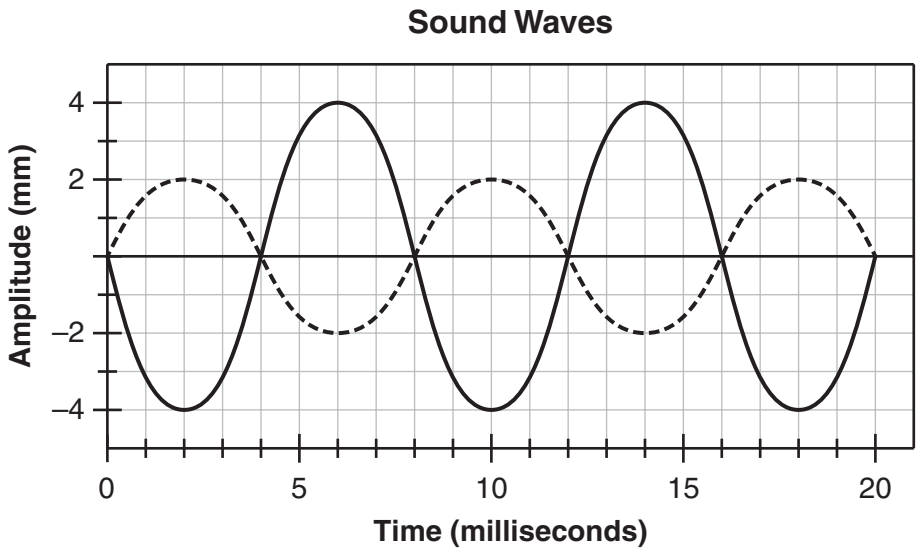
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use a graph of two sound waves to describe a model that uses wave amplitudes to compare wave energies. The item aligns to the SEP by asking students to use a graph of two waves to support conclusions. The item aligns to the DCI because students must use knowledge of the patterns in the graph that represent amplitude and frequency. The item aligns to the CCC because students must use a graph of two sound waves to identify patterns in wave amplitude and energy.

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

2. Elaine is researching the characteristics of sound waves as she listens to music. She finds a diagram that shows two sound waves.



The stimulus for this item begins by presenting the phenomenon that sound waves can have different amplitudes. The hook is that a student is listening to music. The phenomenon and hook are grade-level appropriate because many students listen to music and are familiar with sound waves.

Part a

Which statement describes the sound waves in the diagram?

A Wave 1 has one-fourth the energy of Wave 2.

B Wave 1 has one-half the energy of Wave 2.

C Wave 1 has twice the energy of Wave 2.

D Wave 1 has four times the energy of Wave 2.

Part a is aligned to the SEP, DCI, and CCC. Students use a graph to make a conclusion about the energy in two waves by using their content knowledge of the pattern that is the amplitude of a wave and identifying an amplitude pattern in a graph.

Part b
Elaine predicts that the energy in each sound wave would double if the frequency of the wave doubled.

Which statement describes her prediction?

A Her prediction is correct because the energy of a wave is proportional to the wave's frequency.

B Her prediction is incorrect because the energy of a wave is proportional to the square of the wave's frequency.

C Her prediction is correct because the energy of a wave is proportional to speed and a wave with twice the frequency has twice the speed.

D Her prediction is incorrect because the energy of a wave is proportional to the wavelength and a wave with twice the frequency has half the wavelength.

Part b is aligned to the SEP and DCI. Students use a graph of two waves to evaluate a prediction about the energy in sound waves by using their content knowledge of the pattern that is the frequency of a wave.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: A

Distractor Rationales

Part a

A **KEY: Wave 1 has one-half the amplitude of wave 2 and since energy is proportional to amplitude squared, wave 1 has one-fourth the energy of wave 2.**

B Energy is proportional to amplitude squared, not to amplitude.

C Wave 1 has less amplitude and so less, not more, energy than wave 2.

D Wave 2, not wave 1, would have 4 times the energy since wave 2 has twice the amplitude.

Part b

A **KEY: The energy and frequency of a wave are directly proportional.**

B Energy is proportional to square of amplitude, not frequency.

C The speed of a wave doesn't change when the frequency changes.

D While a wave with twice the frequency would have half the wavelength, energy is proportional to frequency, not wavelength. Energy is inversely proportional to wavelength.

Item 3: Standalone Item

Next Generation Science Standards Description

PE: MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.]

SEP: Constructing Explanations and Designing Solutions: Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.

DCI: LS4.B: Natural Selection: Natural selection leads to the predominance of certain traits in a population, and the suppression of others.

CCC: Cause and Effect: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Item Type: Multiple Choice—Inline Choice

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

Number of Points: 2

Item on next page

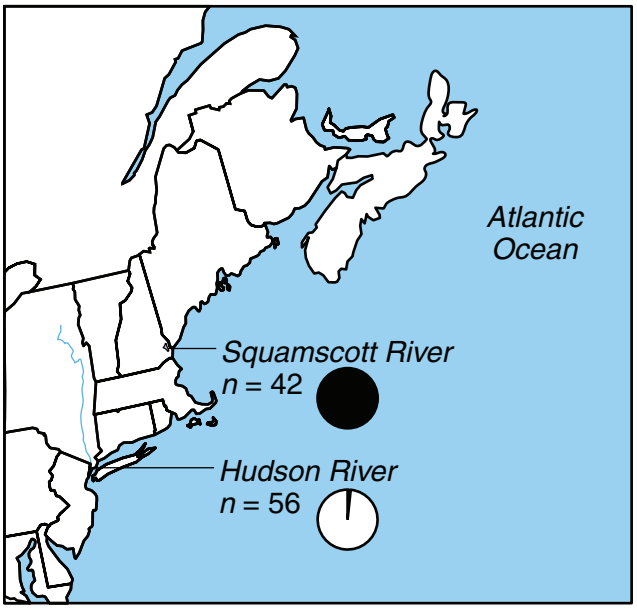
This item brings students into the story line by asking them to use evidence to explain how a genetic mutation increases some individuals' probability of surviving and reproducing in an environment with higher levels of PCB. The item aligns to the SEP by asking students to construct an explanation about a relationship between the frequency of the mutation and whether the fish live in a river with high levels of PCB. The item aligns to the DCI because students must use knowledge of how natural selection leads to the predominance of the genetic mutation in the population that lives in polluted water. The item aligns to the CCC because students must use cause and effect relationships between having the mutation, high levels of PCBs, and the probability of survival in their explanation.

Sara learns about a fish called the tomcod. She learns that some tomcod have a genetic mutation that keeps PCB from entering the tomcod's cells. PCB is a poison that can kill fish.

The tomcod lives in rivers near the Atlantic Ocean like the Hudson River and the Squamscott River. The Hudson River is polluted with the chemical PCB.

The map shows two tomcod populations in the Hudson and Squamscott Rivers and the relative number of fish with the mutation in each population.

Genetic Traits in Tomcod Fish



Key

n Number of tomcod studied

Without the genetic mutation

With the genetic mutation

The stimulus for this item begins by presenting the phenomenon that some fish have a genetic mutation that can keep the fish from being poisoned. The hook is that a student is learning about a specific species of fish and a specific poison. The phenomenon and hook are grade-level appropriate because many students are familiar with genetic mutations and environmental poisons.

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

3. **Part a**

Scientists are investigating how organisms become resistant to the harmful effects of PCB. Based on the map, which statement describes the effects of the mutation on the Hudson River tomcod population?

A Over time, the mutation has become more common in the population because having the mutation helps tomcod survive.

B Over time, the mutation will move to the Squamscott tomcod population because that population also needs the mutation.

C Over time, the mutation will pass from tomcod to other fish because tomcod with the mutation will mate with other species of fish.

D Over time, the mutation has become less common in the population because the mutation does not produce more food for tomcod.

Part a is aligned to the SEP, DCI, and CCC. Students explain the relationship between fish living in a river with high levels of PCB and the frequency of the genetic mutation by using their content knowledge of how natural selection can result in the predominance of the mutated gene and cause and effect relationships between high levels of PCBs, having the mutation, and increased probability of survival.

Part b

Scientists are considering transporting some of the Hudson River tomcod to the Squamscott River.

Select the words that describe a possible effect on the Squamscott River tomcod population.

Over time, [more, fewer] Squamscott tomcod will have the mutation if there are [low, high] levels of PCB in the Squamscott River.

Part b is aligned to the SEP, DCI, and CCC. Students explain how the level of PCB in a river will cause the frequency of the mutation to change over time by using their content knowledge of how natural selection can result in the predominance of the mutated gene and cause and effect relationships between higher levels of PCBs, the number of fish with the mutation, and increased probability of survival.

Scoring Key

Part a

Correct Response: A

Part b

Correct Response:
Over time, [**more**, fewer] Squamscott tomcod will have the mutation if there are [low, **high**] levels of PCB in the Squamscott River.

Distractor Rationales

Part a

A **KEY: Genetic variations that improve survival become more common in a population as more individuals with that variation survive and reproduce.**

B Mutations occur in individuals and are passed on during reproduction, not because an individual needs the mutation.

C Mutations are passed on during reproduction, but different species do not mate and produce offspring that could pass on the mutation.

D The mutation does not produce food but tomcod with the mutation are more likely to survive exposure to toxins like PCB.

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

Item 3: PBT Standalone Item

Next Generation Science Standards Description

PE: MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.]

SEP: Constructing Explanations and Designing Solutions: Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.

DCI: LS4.B: Natural Selection: Natural selection leads to the predominance of certain traits in a population, and the suppression of others.

CCC: Cause and Effect: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Item Type: Multiple Choice—Multiple Choice

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

Number of Points: 2

Item on next page

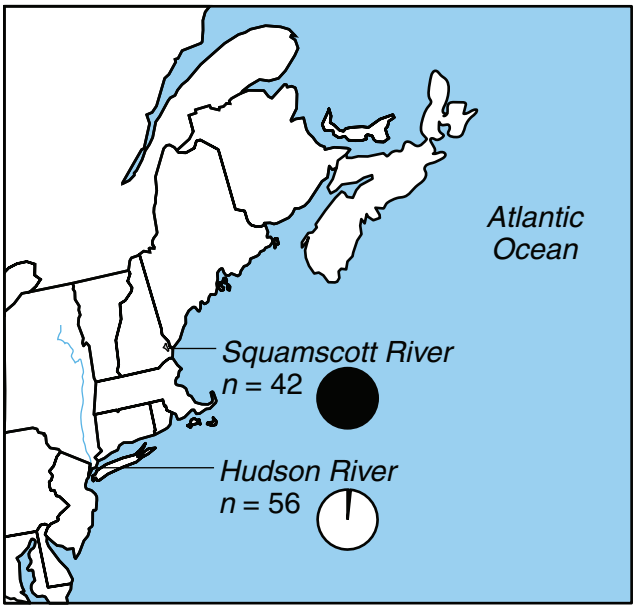
This item brings students into the story line by asking them to use evidence to explain how a genetic mutation increases some individuals' probability of surviving and reproducing in an environment with higher levels of PCB. The item aligns to the SEP by asking students to construct an explanation about a relationship between the frequency of the mutation and whether the fish live in a river with high levels of PCB. The item aligns to the DCI because students must use knowledge of how natural selection leads to the predominance of the genetic mutation in the population that lives in polluted water. The item aligns to the CCC because students must use cause and effect relationships between having the mutation, high levels of PCBs, and the probability of survival in their explanation.

Sara learns about a fish called the tomcod. She learns that some tomcod have a genetic mutation that keeps PCB from entering the tomcod's cells. PCB is a poison that can kill fish.

The tomcod lives in rivers near the Atlantic Ocean like the Hudson River and the Squamscott River. The Hudson River is polluted with the chemical PCB.

The map shows two tomcod populations in the Hudson and Squamscott Rivers and the relative number of fish with the mutation in each population.

Genetic Traits in Tomcod Fish



Key

n	Number of tomcod studied
■	Without the genetic mutation
□	With the genetic mutation

The stimulus for this item begins by presenting the phenomenon that some fish have a genetic mutation that can keep the fish from being poisoned. The hook is that a student is learning about a specific species of fish and a specific poison. The phenomenon and hook are grade-level appropriate because many students are familiar with genetic mutations and environmental poisons.

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

3. **Part a**

Scientists are investigating how organisms become resistant to the harmful effects of PCB.

Based on the map, which statement describes the effects of the mutation on the Hudson River tomcod population?

A Over time, the mutation has become more common in the population because having the mutation helps tomcod survive.

B Over time, the mutation will move to the Squamscott tomcod population because that population also needs the mutation.

C Over time, the mutation will pass from tomcod to other fish because tomcod with the mutation will mate with other species of fish.

D Over time, the mutation has become less common in the population because the mutation does not produce more food for tomcod.

Part a is aligned to the SEP, DCI, and CCC. Students explain the relationship between fish living in a river with high levels of PCB and the frequency of the genetic mutation by using their content knowledge of how natural selection can result in the predominance of the mutated gene and cause and effect relationships between high levels of PCBs, having the mutation, and increased probability of survival.

Part b

Scientists are considering transporting some of the Hudson River tomcod to the Squamscott River.

Which statement describes a possible effect on the Squamscott River tomcod population?

A Over time, more Squamscott tomcod will have the mutation if there are low levels of PCB in the Squamscott River.

B Over time, more Squamscott tomcod will have the mutation if there are high levels of PCB in the Squamscott River.

C Over time, fewer Squamscott tomcod will have the mutation if there are low levels of PCB in the Squamscott River.

D Over time, fewer Squamscott tomcod will have the mutation if there are high levels of PCB in the Squamscott River.

Part b is aligned to the SEP, DCI, and CCC. Students explain how the level of PCB in a river will cause the frequency of the mutation to change over time by using their content knowledge of how natural selection can result in the predominance of the mutated gene and cause and effect relationships between higher levels of PCBs, the number of fish with the mutation, and increased probability of survival.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: B

Distractor Rationales

Part a

A **KEY: Genetic variations that improve survival become more common in a population as more individuals with that variation survive and reproduce.**

B Mutations occur in individuals and are passed on during reproduction, not because an individual needs the mutation.

C Mutations are passed on during reproduction, but different species do not mate and produce offspring that could pass on the mutation.

D The mutation does not produce food but tomcod with the mutation are more likely to survive exposure to toxins like PCB.

Part b

A Exposure to high, not low, levels of PCB is the selection pressure that increases the probability of inheriting the mutation.

B **KEY: High levels of PCB increase the probability that only tomcod that inherit the mutation will survive and reproduce.**

C No Squamscott tomcod have the mutation so that number cannot decrease over time. Low levels of PCB will not be a selective pressure and will not affect the number of tomcod with the mutation.

D Exposure to high levels of PCB is the selection pressure that will result in more, not fewer, Squamscott tomcod with the mutation.

Item 4: Standalone Item

Next Generation Science Standards Description

PE: MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [*Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.*]

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

DCI: ESS2.D: Weather and Climate:

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

CCC: Systems and System Models: Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Item Type: Open-ended

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

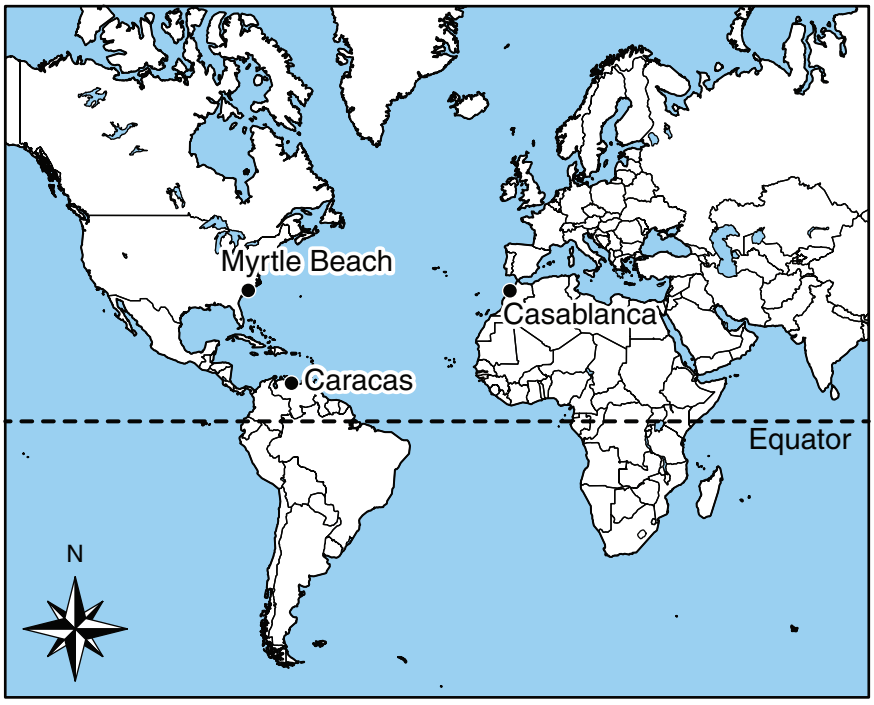
Number of Points: 4

Item on next page

This item brings students into the story line by asking them to develop and use a model that describes patterns in the climates in three cities that are caused by unequal heating of the Earth. The item aligns to the SEP by asking students to use and develop graphical models to explain differences in temperature in three cities. The item aligns to the DCI because students must use knowledge of how weather and climate at different locations and latitudes on Earth are influenced by interactions involving sunlight and ocean currents and by ocean currents that redistribute energy from the Sun. The item aligns to the CCC because students must use models to represent how energy from the Sun enters and interacts with Earth systems.

Rosanna's family is planning a vacation to a city on the ocean. Three places they are interested in visiting are Caracas, Venezuela; Myrtle Beach, South Carolina; and Casablanca, Morocco. The locations of these cities are shown on the map.

Possible Vacation Locations



Rosanna begins researching the climate in each city. The table shows the average high and low temperatures for each city.

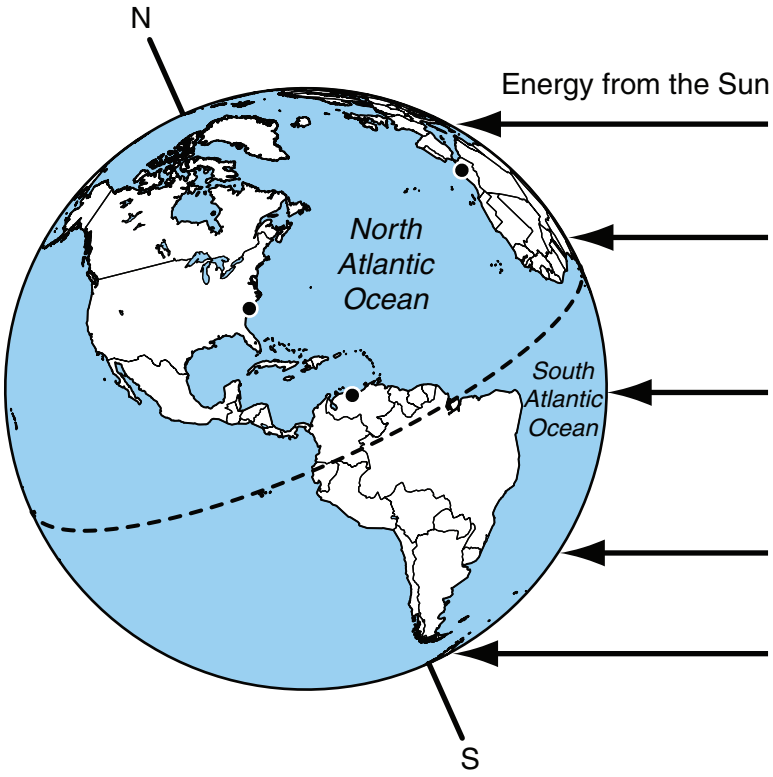
Average Yearly Temperatures

City	High Temperature (°C)	Low Temperature (°C)
Caracas	28.1	23.3
Myrtle Beach	24.5	13.1
Casablanca	20.2	13.6

The stimulus for this item begins by presenting the phenomenon that different locations on Earth have different climates. The hook is that a family is deciding where to go on vacation. The phenomenon and hook are grade-level appropriate because many students plan vacations and have read or watched movies about people who travel to locations around the world.

Rosanna wonders why three cities on the ocean have different average temperatures. She knows that energy from the Sun is a major factor that determines climate. She studies a model that shows energy from the Sun reaching Earth's surface. The diagram shows the model and the locations of the three cities.

Sun-Earth Model



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

4. **a.** Use the model to explain **one** reason for the difference in temperature between Caracas and Myrtle Beach.

Rosanna thinks that adding ocean current information to the model would help explain the temperature differences between the three cities.

b. Describe ocean currents that could be added to the model to provide another reason for the differences in temperature between the cities. Be sure to include the direction and temperature of the currents near Caracas, Myrtle Beach, and Casablanca.

c. Use the model to describe how energy from the Sun causes the ocean currents described in the answer to Part (b).

Part a is aligned to the SEP, DCI, and CCC. Students use the map and globe models that represent how energy from the Sun enters and interacts with Earth systems and their content knowledge of how climate at different latitudes is influenced by interactions involving sunlight to explain the difference in temperature between Caracas and Myrtle Beach.

Part b is aligned to the SEP, DCI, and CCC. Students describe how to add ocean currents to the globe model that represents how energy from the Sun interacts with the oceans by using their content knowledge of how climate at different latitudes is influenced by interactions involving sunlight and ocean currents in order to explain the difference in temperature between Caracas, Myrtle Beach, and Casablanca.

Part c is aligned to the SEP, DCI, and CCC. Students use the globe model and their content knowledge of how ocean currents redistribute energy from the Sun to explain how energy from the Sun interacts with Earth's oceans.

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 model to explain one reason for the difference in temperature between Caracas and Myrtle Beach. The response also describes ocean currents that could be added to the model to provide another reason for the differences in temperature between the cities and includes the direction and temperature of the currents near Caracas, Myrtle Beach, and Casablanca. 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

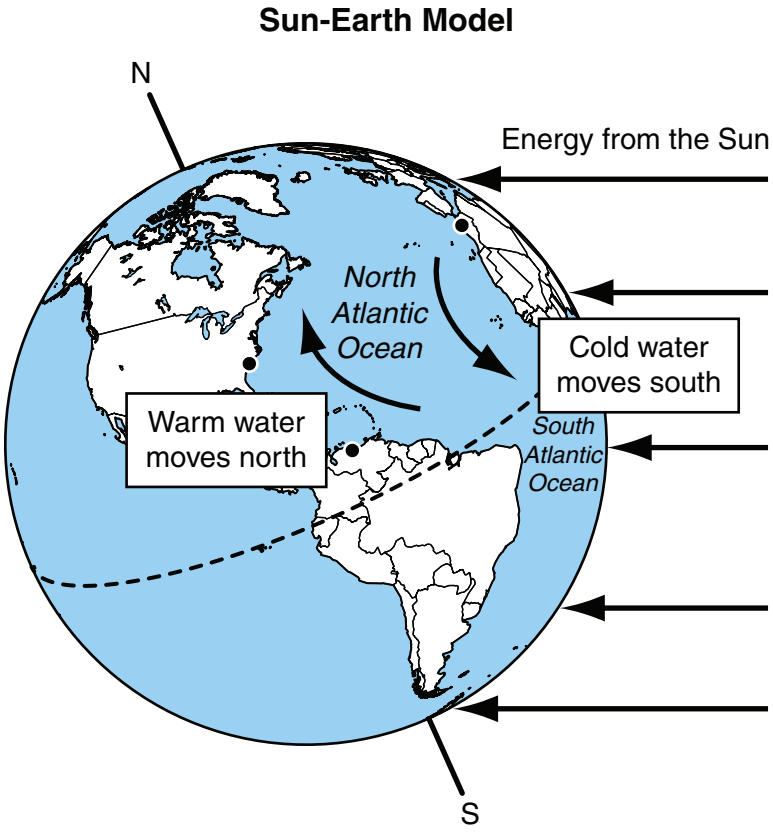
The scoring rubric specifies how a 4-point response uses the dimensions of the PE and provides detail about how different levels of response meet the requirements of specific tasks in the item. All open-ended standalone items are 4-point items.

Scoring Notes

a. The model shows that while the Sun's rays reach Caracas at an almost direct/perpendicular/90 degree angle, the rays reach Myrtle Beach at a more indirect/flatter/less than 90 degree angle. The farther a city is from the equator, the more the Sun's energy at a location is spread out across Earth's surface.

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.

b. In the North Atlantic ocean, warm water flows north from the equator from Caracas to Myrtle Beach. Cold water moved south from Casablanca toward the equator.



c. The ocean plays a major role and has a great effect on weather and climate. Energy from the Sun is absorbed by the ocean, released slowly over time, and then globally redistributed through wind and ocean currents. As warm water flows north from the equator, cold water flows south. Thermal energy moves from areas of high temperature to areas of low temperatures via conduction of heat from warmer objects (the warm water) to cooler objects (the cool land).

Items 5–8: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [*Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.*]

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

DCI: PS1.A: Structure and Properties of Matter:

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

CCC: Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

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

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

DCI: PS1.B: Chemical Reactions:

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants
- The total number of each type of atom is conserved, and thus the mass does not change.

CCC: Energy and Matter: Matter is conserved because atoms are conserved in physical and chemical processes.

Cluster Overview: Carbon Chemistry

Item	Item Type	Alignment
5	Multiple Choice	MS-PS1-5: SEP, DCI, CCC
6	Multiple Choice—Multiple Choice	MS-PS1-5: SEP, DCI, CCC
7	Multiple Choice	MS-PS1-1: SEP, DCI, CCC
8	Multiple Choice—Multiple Choice	MS-PS1-1: 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 all least two-dimensional, and collectively the whole cluster has strong alignment to all three dimensions of each PE.

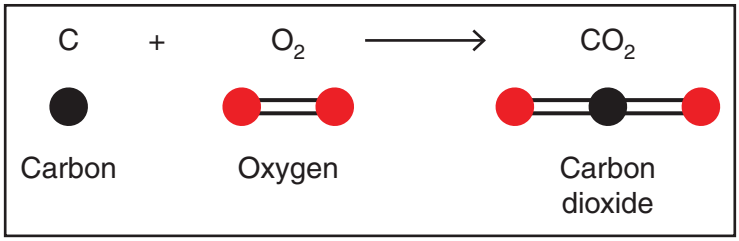
Read the information. Then answer the questions that follow.

Carbon Chemistry

Nico is surprised to learn that many substances with very different properties contain carbon atoms. He wonders how substances made only of carbon can be as different as the soft, gray graphite inside his pencil and the hard, shiny diamonds in jewelry.

He also wonders how adding oxygen can change carbon into colorless, odorless carbon dioxide gas. To help Nico understand how carbon dioxide forms from carbon and oxygen, his teacher gives him the model in the diagram.

Formation of Carbon Dioxide Model



Nico wants to use this model to understand how carbon can form substances as different as graphite, diamond, and carbon dioxide.

The stimulus for this cluster begins by presenting the phenomenon that substances made of carbon atoms can have different properties. The hook is that a student learns that pencil graphite and diamond jewelry are both made of carbon atoms. The phenomenon and hook are grade-level appropriate because students are familiar with different substances being made of atoms.

Item 5: Cluster Item

Next Generation Science Standards Description

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

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

DCI: PS1.B: Chemical Reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

CCC: Energy and Matter: Matter is conserved because atoms are conserved in physical and chemical processes.

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 use a model to describe that the chemical reaction between carbon and oxygen does not change the total number of atoms or the total mass. The item aligns to the SEP by asking students to use the model of a chemical reaction to describe what happens to individual atoms and molecules. The item aligns to the DCI because students must use knowledge that substances react chemically in characteristic ways, causing atoms to be regrouped into different molecules during a chemical process. The item aligns to the CCC because students must use the understanding that atoms are conserved in the chemical process that produces carbon dioxide.

5. Which statement is supported by the model in the diagram?

A Two carbon atoms and one oxygen molecule can form two carbon dioxide molecules.

B One carbon dioxide molecule can form from one carbon atom and one oxygen molecule.

C One carbon atom and one oxygen molecule have more mass than one carbon dioxide molecule.

D Two carbon dioxide molecules have less mass than two carbon atoms and two oxygen molecules.

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how atoms regroup during chemical reactions and the understanding that atoms are conserved during the chemical process that produces carbon dioxide to describe how the chemical equation shows the unobservable mechanisms that happen during a chemical reaction.

Scoring Key

Correct Response: B

Distractor Rationales

A Two carbon atoms can make two carbon dioxide molecules only if there are also two oxygen molecules, rather than one oxygen molecule.

B KEY: The model shows that one carbon atom plus one oxygen molecule form one carbon dioxide molecule.

C The mass before the reaction is the same as after the reaction, so the model shows that one carbon atom and one oxygen atom together have the same mass as one carbon dioxide molecule.

D Two carbon dioxide molecules will have the same mass as, not less mass than, the two carbon atoms and two oxygen molecules that formed them.

Item 6: Cluster Item

Next Generation Science Standards Description

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

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

DCI: PS1.B: Chemical Reactions:

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.

CCC: Energy and Matter: Matter is conserved because atoms are conserved in physical and chemical processes.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Low | 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 a model to describe that mass is conserved during the chemical reaction that produces carbon dioxide because the total number of atoms does not change. The item aligns to the SEP by asking students to use the model of a chemical reaction to describe the unobservable mechanism that causes the product of the reaction to have properties different from the reactants. The item aligns to the DCI because students must use knowledge that a chemical process regroups the same atoms into new substances with different properties. The item aligns to the CCC because students must use the understanding that mass is conserved because atoms are conserved in the chemical process that produces carbon dioxide.

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

6. **Part a**

How does the model in the diagram show that matter is conserved in chemical reactions?

A There are groups of atoms before and after the reaction.

B The reaction produces a new substance with new properties.

C The substances in the reaction form naturally from other substances.

D The same number of each type of atom is present before and after the reaction.

Part a is aligned to the SEP, DCI, and CCC. Students use their content knowledge that a chemical reaction conserves the total number of each type of atom to describe how the chemical equation that describes the unobservable mechanism of a chemical reaction shows that matter is conserved in the reaction.

Part b

Based on the model in the diagram, which statement describes a reason that carbon and carbon dioxide have different properties?

A The reaction produces new combinations of atoms.

B Carbon and oxygen are needed to form carbon dioxide.

C The properties of atoms change during a chemical reaction.

D Carbon dioxide is made of atoms that formed during the reaction.

Part b is aligned to the SEP and the DCI. Students use the chemical equation and their content knowledge that different groupings of atoms result in different properties to describe an unobservable mechanism.

Scoring Key

Part a
Correct Response: D

Part b
Correct Response: A

Distractor Rationales

Part a

A Having groups of atoms before and after the reaction does not show that matter is conserved unless the same number of each type of atom is in the groups before and the groups after the reaction.

B This is evidence that a chemical reaction occurred, not that the reaction conserves matter.

C The reaction may form substances naturally, but that is not enough to show that the reaction conserves matter.

D KEY: The same number of each element means the same total mass.

Part b

A KEY: New substances can have new properties.

B While true, this does not explain why carbon dioxide has properties that are different from the properties of carbon.

C The properties of groups of atoms, not atoms, change during a chemical reaction and the reason is that new groups of atoms form, not that the properties of atoms in the groups change.

D Atoms were rearranged, not formed, during the reaction and the rearrangement into new substances is the reason that carbon dioxide has different properties than carbon.

Item 7: Cluster Item

Next Generation Science Standards Description

PE: MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [*Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.*]

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

DCI: PS1.A: Structure and Properties of Matter: Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.

CCC: Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Low | 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 describe how a model can be used to describe the properties of three different substances that contain carbon atoms. The item aligns to the SEP by asking students to describe how developing a model of the atoms in graphite, diamond, and carbon dioxide can explain their different properties. The item aligns to the DCI because students must use knowledge that atoms in different substances combine in various ways. The item aligns to the CCC because students must use a model to describe the spatial arrangements of atoms that are too small to be seen.

7. Nico and his classmates want to use the model in the diagram to understand why graphite, diamond, and carbon dioxide have different properties.

Which statement **best** describes how making a model could help Nico understand why the substances have different properties?

A The properties of substances change over time.

B A substance is made of different kinds of atoms.

C The atoms in substances are too small to be seen.

D A model has the same properties as the substances.

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how atoms in different substances combine in different ways to describe how a model can be used to describe atoms that are too small to be seen and explain why graphite, diamond, and carbon dioxide have different properties.

Scoring Key

Correct Response: C

Distractor Rationales

A Even if true, this statement would not describe how a model explains why three substances that contain carbon have different properties right now.

B While true, this statement does not describe how a model is useful in understanding why substances made of different kinds of atoms have different properties.

C KEY: To understand properties, one must be able to visualize the arrangements of atoms that result in the properties of a substance. Because atoms are too small to see, a model is useful.

D Even if true, this statement would not describe how a model is useful in understanding why different substances have different properties.

Item 8: Cluster Item

Next Generation Science Standards Description

PE: MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [*Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.*]

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

DCI: PS1.A: Structure and Properties of Matter: Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.

Item Type: Multiple Choice—Multiple Choice

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

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to develop a model of the extended structure made by carbon atoms in graphite. This item aligns to the SEP by asking students to develop a graphical model that describes how atoms in graphite are arranged. This item aligns to the DCI because students must use the understanding that carbon atoms can combine in various ways.

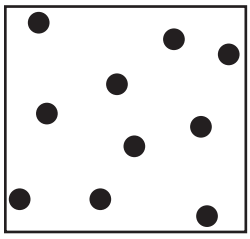
This question has two parts. Be sure to answer both parts of the question.

8. Nico draws a model of the graphite in his pencil.

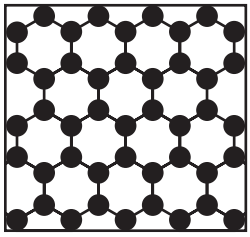
Part a

Which model shows the carbon atoms in graphite?

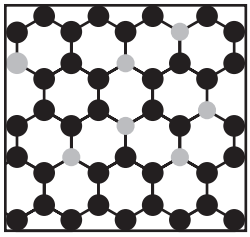
A



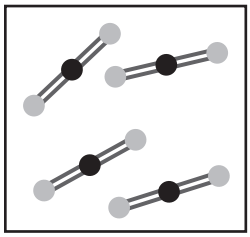
B



C



D



Part a is aligned to the SEP and the DCI. Students use their content knowledge that carbon atoms combine in various ways to identify the model that describes how atoms in graphite are arranged.

Part b

Which statement supports the model that Nico drew of the graphite in his pencil?

A The model shows that graphite is made of carbon and oxygen.

B The model shows that graphite was produced from other substances.

C The model shows that graphite is made of small structures in a repeating pattern.

D The model shows that graphite can be made into a long, thin shape inside a pencil.

Part b is aligned to the SEP and the DCI. Students use their content knowledge that carbon atoms combine in various ways to describe the extended structure of carbon atoms in their model.

Scoring Key

Part a
Correct Response: B

Part b
Correct Response: C

Distractor Rationales

Part a

A Although this model shows only one kind of atom (carbon), the atoms are not connected to each other as the atoms are in the solid graphite in Nico's pencil.

B KEY: This model shows repeating units of one type of atom.

C This model shows two types of atoms, not one type of atom.

D This model shows two types of atoms and is made of carbon dioxide molecules like the one in the model from Nico's teacher.

Part b

A Graphite contains only carbon atoms, and no oxygen atoms.

B The model shows how atoms are arranged in graphite, not how graphite was produced.

C KEY: The model shows many atoms that are all the same type of atom, connected to each other in a repeating structure.

D The student may think that graphite is made by connecting the carbon dioxide molecules in model D inside a pencil, but graphite is made of only one type of atom and individual atoms are much too small to form shapes based on individual bonds.

Items 9–12: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena.

DCI: LS2.A: Interdependent Relationships in Ecosystems:

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

PE: MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

SEP: Constructing Explanations and Designing Solutions: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

DCI: PS3.D: Energy in Chemical Processes and Everyday Life: Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.

CCC: Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Cluster Overview: Whales in Hot Water

Item	Item Type	Alignment
9	Multiple Choice—Multiple Choice	MS-LS1-6: SEP, DCI, CCC
10	Multi-select	MS-LS1-6: SEP, DCI, CCC
11	Drag and Drop—Multiple Choice	MS-LS2-1: SEP, DCI, CCC
11 PBT	Multiple Choice—Multiple Choice	MS-LS2-1: SEP, DCI, CCC
12	Multiple Choice	MS-LS2-1: SEP, DCI, CCC

The cluster consists of a phenomenon that allows overall item alignment across two PEs. Every item in the cluster is three-dimensional, and collectively the whole cluster aligns to all three dimensions of each PE.

Stimulus and Items on next pages

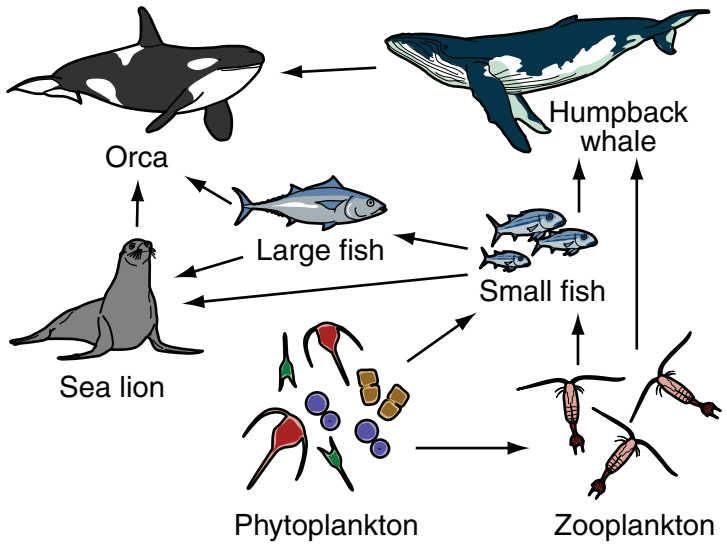
Read the information. Then answer the questions that follow.

Whales in Hot Water

Elias reads an article about the sudden deaths in 2016 of many different types of ocean organisms, including fish and marine mammals like sea lions and whales, along the west coast of the United States and Canada. He learns that in 2016, scientists observed a large zone of unusually warm water in the Pacific Ocean. The warm water caused uncommon species of plant-like phytoplankton to reproduce so quickly that their populations suddenly became very large. Some of the warm-water phytoplankton are toxic to organisms that live in cold ocean water, while others are less nutritious than the normal cold-water species of phytoplankton.

Although scientists are not certain of the specific cause of the sudden deaths, the feeding and reproductive cycles of cold-water ocean organisms were disrupted by the zone of unusually warm water. The diagram shows a cold-water ocean food web.

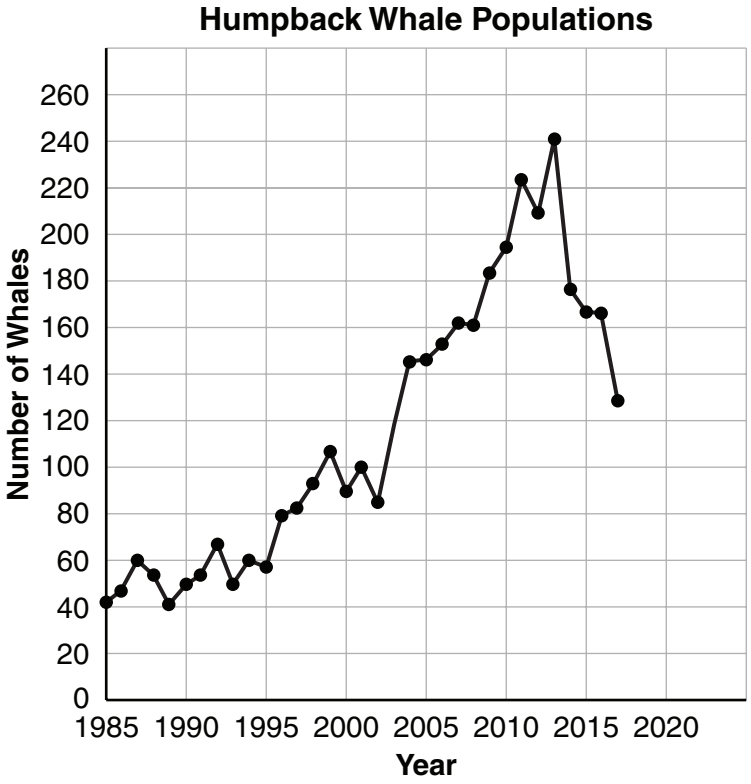
Cold-Water Ocean Food Web



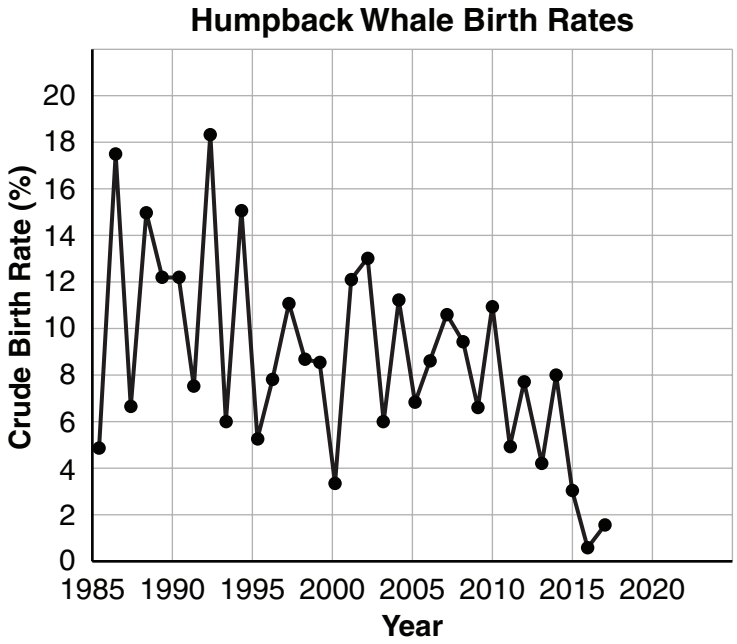
Elias goes whale watching in Alaska and observes a group of humpback whales feeding on a school of fish. The boat captain explains that humpback whales used to be hunted in oceans around the world. The whales were nearly extinct before they were protected in 1970 as an endangered species.

The stimulus for this cluster begins by presenting the phenomenon that ocean ecosystems are affected by changes in water temperature. The hook is that a student reads about the sudden deaths of many marine organisms. The phenomenon and hook are grade-level appropriate because many students are interested in marine mammals, especially humpback whales.

After the whale-watching trip, Elias finds a graph that shows the size of the humpback whale population in Glacier Bay and Icy Straight, Alaska, between 1985 and 2017.



Elias learns that scientists use crude birth rate to analyze humpback whale populations. Crude birth rate is the total number of whale calves divided by the total number of whales and is reported as a percentage. He finds a graph that shows the crude birth rates in the whale populations in Glacier Bay and Icy Straight, Alaska, between 1985 and 2017.



Item 9: Cluster Item

Next Generation Science Standards Description

PE: MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

SEP: Constructing Explanations and Designing Solutions: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

CCC: Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Item Type: Multiple Choice—Multiple Choice

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

Number of Points: 2

Item on next page

The item brings students into the story line by asking them to use evidence to construct an explanation of the role of photosynthesis in cycling matter and energy into and out of humpback whales. The item aligns to the SEP by asking students to construct an explanation based on evidence in a food web. The item aligns to the DCI because students must use knowledge that phytoplankton use light energy to make the food that is used by animals in the ecosystem. The item aligns to the CCC because students must use the understanding that the transfer of energy when humpback whales eat sugars that were originally made during photosynthesis drives the cycling of matter in a food web.

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

9. **Part a**

Which statement describes how humpback whales depend on photosynthesis to survive?

A Humpback whales use photosynthesis to provide energy to perform cellular functions.

B Phytoplankton use photosynthesis to produce sugars that are passed on to the prey of humpback whales.

C Photosynthesis in humpback whales uses solar energy to produce matter that phytoplankton need to grow.

D Humpback whales use photosynthesis to produce sugars that other organisms in the food web use for energy.

Part a is aligned to the DCI and the CCC. Students use their content knowledge that phytoplankton make sugars that whales use as food to describe how the transfer of energy when humpback whales eat sugars that were made during photosynthesis moves matter into the whales.

Part b

Which evidence from the food web diagram supports the answer to Part (a)?

A Humpback whales prey on large fish and sea lions.

B Humpback whales and sea lions are prey for orcas.

C Humpback whales eat large fish that eat zooplankton.

D Humpback whales eat small fish that eat phytoplankton.

Part b is aligned to the SEP, DCI, and CCC. Students explain how relationships between organisms in the food web are evidence that supports their description of how humpback whales get the energy they need by using their content knowledge of how whales and other animals in the food web use food made by phytoplankton.

Scoring Key

Part a
Correct Response: B
Part b
Correct Response: D

Distractor Rationales

Part a

A Phytoplankton, not humpback whales, use photosynthesis.

B KEY: Humpback whales get energy from their prey, which got their energy from producers like phytoplankton.

C Humpback whales are animals, not plants, and cannot use photosynthesis.

D Humpback whales get sugars from their food, not by using photosynthesis to produce sugars.

Part b

A The food web shows that humpback whales eat small fish and do not eat sea lions or large fish.

B While true, this does not explain how humpback whales depend on photosynthesis to survive.

C The food web shows that humpback whales eat large, not small, fish and that small fish, not large fish, eat zooplankton.

D KEY: The food web shows that the small fish that are food for humpback whales got their energy by eating phytoplankton, which got their energy from photosynthesis.

Item 10: Cluster Item

Next Generation Science Standards Description

PE: MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

SEP: Constructing Explanations and Designing Solutions: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

CCC: Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Item Type: Multi-select

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

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to use evidence to construct an explanation of how warmer water affects photosynthesis and the flow of matter and energy in the food web. The item aligns to the SEP by asking students to construct an explanation based on evidence in a food web. The item aligns to the DCI because students must use their knowledge that phytoplankton use light energy to make food for other organisms. This item aligns to the CCC because students must use the understanding that the transfer of energy when consumers eat sugars made during photosynthesis drives the cycling of matter in a food web.

10. Based on the diagram, which **two** statements explain how warm-water phytoplankton disrupt the food web?

A Warm-water phytoplankton add matter and energy that are available in the system for cold-water phytoplankton.

B Warm-water phytoplankton outcompete cold-water phytoplankton for carbon dioxide and nutrients needed for growth.

C Large fish and sea lions receive more matter and energy from warm-water phytoplankton than from cold-water phytoplankton.

D Zooplankton and small fish receive less matter and energy from warm-water phytoplankton than from cold-water phytoplankton.

E Harmful warm-water phytoplankton consume cold-water phytoplankton instead of using photosynthesis to produce matter and energy for the ecosystem.

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how phytoplankton make food for other organisms and their understanding of the transfer of energy when consumers eat sugars made during photosynthesis as evidence to explain how warm-water phytoplankton affect the food web.

Scoring Key

Correct Response: B, D

Distractor Rationales

A As the size of warm-water phytoplankton populations increase, less matter and energy, not more matter and energy, are available to cold-water plankton since some warm-water phytoplankton are toxic and others are less nutritious.

B KEY: As warm-water phytoplankton populations increase in size, they outcompete cold-water phytoplankton for the resources needed to survive and reproduce.

C There is no evidence that large fish and sea lions eat more warm-water phytoplankton, especially since these are cold-water organisms better adapted to cold-water phytoplankton.

D KEY: Small fish and zooplankton are cold-water organisms better adapted to cold-water phytoplankton, which will be less, not more, toxic to them and more, not less, nutritious for them.

E One type of phytoplankton does not consume other types: all phytoplankton are producers, not consumers, of energy in the form of food.

Item 11: Cluster Item

Next Generation Science Standards Description

PE: MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena.

DCI: LS2.A: Interdependent Relationships in Ecosystems:

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Item Type: Drag and Drop—Multiple Choice

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

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use crude birth rate data as evidence for the effects of resource availability on populations of organisms in a cold-water ocean ecosystem. The item aligns to the SEP by asking students to analyze and interpret graphical data to provide evidence of environmental factors that affect birth rates. The item aligns to the DCI because students must use knowledge of how organisms depend on environmental interactions with other organisms and with changes in water temperature and also compete with each other for food. The item aligns to the CCC because students must use the cause and effect relationship between access to resources and reproduction to explain the relationship between environmental factors and whale birth rates.

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

11. Elias wants to make a model that shows some of the interactions between humpback whales and their environment.

Part a

Complete the model to show the environmental factors that could have caused the humpback whale birth rates shown in the graph.

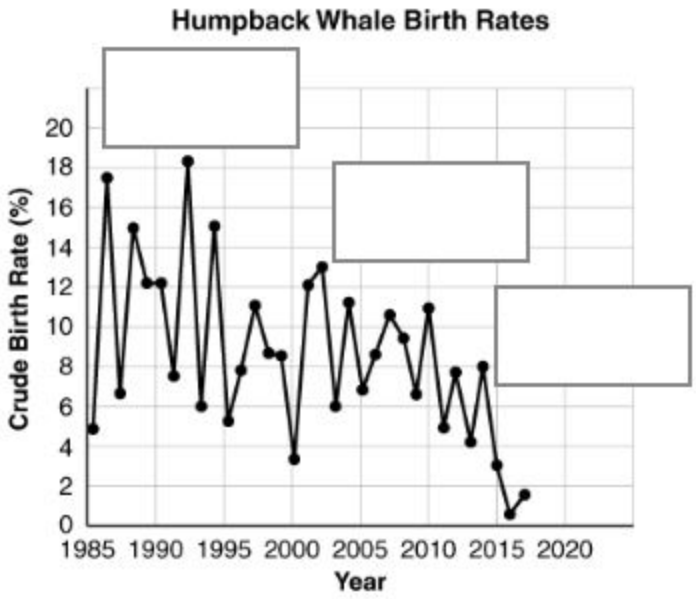
Select the factors and drag them into the correct spaces in the graph. Not all the factors will be used.

Increase in prey

Decrease in prey

Increase in warm-water phytoplankton

Decrease in warm-water phytoplankton



Part a is aligned to the SEP, DCI and the CCC. Students use their content knowledge of how organisms compete with each other for food and the cause and effect relationship between environmental factors and whale birth rates as evidence to interpret the birth rate data in the graph.

Part b

Which relationship between environmental factors and humpback whale birth rates is supported by the model in Part (a)?

A A decrease in warm-water phytoplankton caused whale reproduction to stop completely.

B An increase in warm-water phytoplankton caused more male whale deaths than female whale deaths.

C An increase in prey caused faster growth, so younger whales were able to leave the area to find more food.

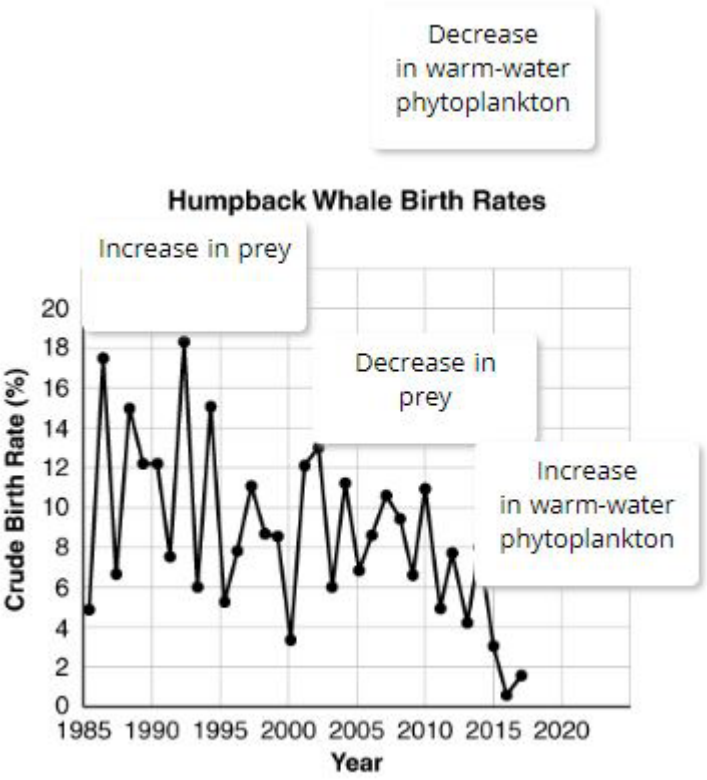
D A decrease in prey caused more competition, so whales had less energy to find mates and produce healthy offspring.

Part b is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how organisms depend on environmental interactions with other organisms and compete with each other for food and their interpretation of the data to explain the relationship between environmental factors and whale birth rates.

Scoring Key

Part a

Correct Response:



Part b

Correct Response: D

Distractor Rationales

Part b

A The graphs show that whale birth rates decreased when warm-water phytoplankton increased, not decreased.

B Pregnant females, not males, would be more likely to die when there is less food because warm-water phytoplankton disrupted the cold-water ocean food web.

C More prey and plenty of food may result in young whales growing faster, not leaving to find even more food.

D KEY: Less food would increase competition for resources which could result in lower birth rates.

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

Item 11: PBT Cluster Item

Next Generation Science Standards Description

PE: MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena.

DCI: LS2.A: Interdependent Relationships in Ecosystems:

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Item Type: Multiple Choice—Multiple Choice

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

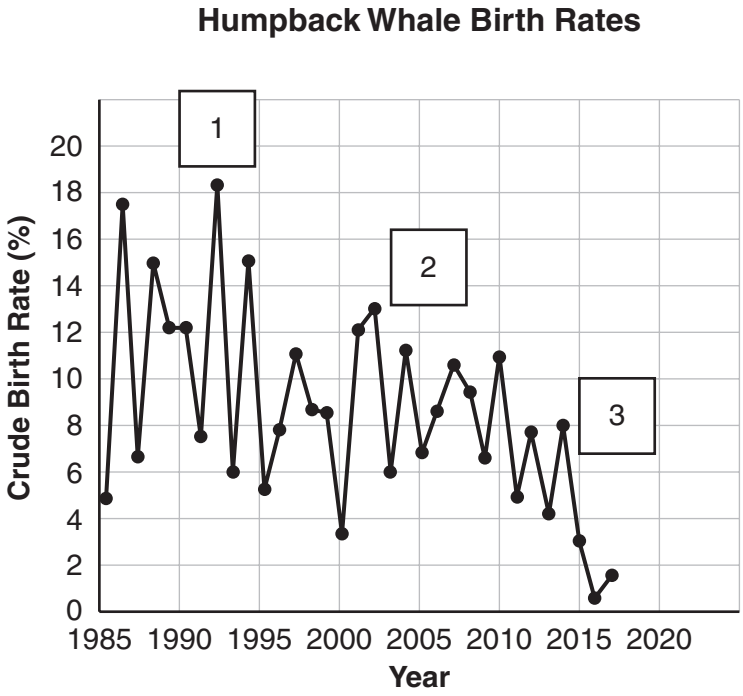
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to use crude birth rate data as evidence for the effects of resource availability on populations of organisms in a cold-water ocean ecosystem. The item aligns to the SEP by asking students to analyze and interpret graphical data to provide evidence of environmental factors that affect birth rates. The item aligns to the DCI because students must use knowledge of how organisms depend on environmental interactions with other organisms and with changes in water temperature and also compete with each other for food. The item aligns to the CCC because students must use the cause and effect relationship between access to resources and reproduction to explain the relationship between environmental factors and whale birth rates.

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

11. Elias wants to make a model that shows some of the interactions between humpback whales and their environment. An incomplete model is shown in the diagram.



Part a

Which labels **best** complete the model?

A 1 = increase in prey
2 = decrease in prey
3 = increase in warm-water phytoplankton

B 1 = decrease in prey
2 = increase in warm-water phytoplankton
3 = decrease in warm-water phytoplankton

C 1 = increase in warm-water phytoplankton
2 = decrease in warm-water phytoplankton
3 = increase in prey

D 1 = decrease in warm-water phytoplankton
2 = increase in prey
3 = decrease in prey

Part a is aligned to the SEP, DCI and the CCC. Students use their content knowledge of how organisms compete with each other for food and the cause and effect relationship between environmental factors and whale birth rates as evidence to interpret the birth rate data in the graph.

Part b

Which relationship between environmental factors and humpback whale birth rates is supported by the model in Part (a)?

A A decrease in warm-water phytoplankton caused whale reproduction to stop completely.

B An increase in warm-water phytoplankton caused more male whale deaths than female whale deaths.

C An increase in prey caused faster growth, so younger whales were able to leave the area to find more food.

D A decrease in prey caused more competition, so whales had less energy to find mates and produce healthy offspring.

Part b is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how organisms depend on environmental interactions with other organisms and compete with each other for food and their interpretation of the data to explain the relationship between environmental factors and whale birth rates.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: D

Distractor Rationales

Part a

A **KEY. The birth rate is highest at 1, suggesting that more food is available for growth and reproduction. The birth rate has decreased by 2, suggesting that less food is available for growth and reproduction. At 3, toxic warm-water phytoplankton has increased, increasing competition among whales for less available nutritious food and decreasing whale survival and reproduction.**

B The birth rate is highest at 1, suggesting an increase, not a decrease, in prey. At 3, an increase, not decrease, in toxic warm-water phytoplankton would be expected to cause a decrease in birth rate.

C The birth rate is highest at 1, suggesting this was before, not when, toxic warm-water phytoplankton increased. The birth rate is lowest at 3, suggesting that there would be less, not more, food at that time.

D If there was an increase in prey at 2, the birth rate would have increased, not decreased.

Part b

A The graphs show that whale birth rates decreased when warm-water phytoplankton increased, not decreased.

B Pregnant females, not males, would be more likely to die when there is less food because warm-water phytoplankton disrupted the cold-water ocean food web.

C More prey and plenty of food may result in young whales growing faster, not leaving to find even more food.

D KEY: Less food would increase competition for resources, which could result in lower birth rates.

Item 12: Cluster Item

Next Generation Science Standards Description

PE: MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena.

DCI: LS2.A: Interdependent Relationships in Ecosystems:

- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.
- Growth of organisms and population increases are limited by access to resources.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Item Type: Multiple Choice

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

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to analyze data to provide evidence for the effects of resource availability on populations in the cold-water ocean ecosystem. The item aligns to the SEP by asking students to interpret data to provide evidence for a prediction about the effect of warmer water temperatures on a whale population. This item aligns to the DCI because students must use knowledge of how organisms depend on environmental interactions with other organisms and with water temperature, as well as knowledge of how population growth is limited by access to resources. The item aligns to the CCC because students use the cause and effect relationship between resource availability and the size of the whale population to make their prediction.

12. Elias wonders what would happen if warm water became the normal condition in this cold-water ocean ecosystem.

Which prediction is supported by the food web diagram and graph?

A The whale population would increase because warm water increases the amount of food available for cold-water species.

B The whale population would decrease because warm water decreases the amount of nutrient-rich food available for cold-water species.

C The whale population would increase because prey species are better able to survive and reproduce when water temperatures are warmer.

D The whale population would decrease because prey species are better able to survive and reproduce when water temperatures are normal.

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge of how populations are affected by environmental interactions and changes and analysis of the data about how warm water affects the food web to make a prediction about the effect of warmer water on the whale population.

Scoring Key

Correct Response: B

Distractor Rationales

A Warm-water phytoplankton are less, not more, nutritious so warm water decreases, not increases, the amount of food for humpback whales and the whale population would decrease, not increase, in size.

B KEY: Warm-water phytoplankton are less nutritious than cold-water phytoplankton so whales would have less food and populations would decrease in size.

C Cold-water prey are less, not more, likely to survive in warmer water, so warm water would decrease, not increase, the amount of food for whales and the population would decrease, not increase, in size.

D Normal water temperature for prey species are cold, not warm, water temperatures so cold, not warm, water would increase the amount of food for whales and cause the population to increase in size.

Session 2: Items 13–23

Item 13: Standalone Item

Next Generation Science Standards Description

PE: MS-LS4-3: Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [*Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.*]

SEP: Analyzing and Interpreting Data: Analyze displays of data to identify linear and nonlinear relationships.

DCI: LS4.A: Evidence of Common Ancestry and Diversity: Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.

CCC: Patterns: Graphs, charts, and images can be used to identify patterns in data.

Item Type: Multi-select—Multiple Choice

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

Number of Points: 2

Item on next page

The item brings students into the story line by asking them to identify relationships among animals by comparing patterns of similarities in the embryological development of the animals. The item aligns to the SEP by asking students to analyze diagrams of embryos at different stages of development to identify relationships among the animals. The item aligns to the DCI because students must use knowledge of how comparison of embryological development of different animal species reveals similarities that show relationships not evident in the adult animals. The item aligns to the CCC because students must use images of embryological development to identify patterns of development.

While Vanessa helps her grandmother feed the chickens, she notices a chicken embryo inside a broken egg. Vanessa observes that the chicken embryo has a long tail. She asks her grandmother why the embryo has a long tail, but an adult chicken does not. Her grandmother encourages her to learn more about how chickens develop.

Vanessa finds a table that shows how the embryos of several types of animals change before birth. The table also shows an adult of each type of animal.

Embryos and Adults

	Organism		
Stage	**Fish**	**Chicken**	**Pig**
1–Fertilized egg			
2–Embryo			
3–Embryo			
4–Embryo			
5–Adult			

The stimulus for this item begins by presenting the phenomenon that chicken embryos have long tails that adult chickens do not have. The hook is that a student sees an embryo inside a broken egg. The phenomenon and hook are grade-level appropriate because many students are familiar with chickens and eggs.

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

13. Part a

Vanessa observes similarities and differences in the organisms' patterns of growth at different stages of development.

Which **two** patterns are supported by the information in the table?

A The organisms look most similar just before birth.

B All the organisms have large heads in stage 2 and stage 3.

C The organisms become smaller between stage 3 and stage 4.

D All the organisms have relatively long tails in stage 2 and stage 3.

E Differences among the organisms increase from stage 1 to stage 5.

Part a is aligned to the SEP and CCC. Students use diagrams to identify patterns of development in embryos and relationships among embryos at different stages of development.

Part b

Which relationship among the organisms is supported by the patterns in Part (a)?

A The organisms have a common ancestor.

B The embryos of larger animals develop slowly.

C The organisms appeared on Earth at about the same time.

D The embryos spend different amounts of time at each stage of development.

Part b is aligned to the SEP, DCI, and CCC. Students use their content knowledge that comparison of embryological development reveals similarities that show relationships not seen in the adult animals and patterns in diagrams of developing embryos to identify relationships among the animals.

Scoring Key

Part a
Correct Response: D, E

Part b
Correct Response: A

Distractor Rationales

Part a

A The organisms look less similar as the embryo gets closer to birth, not more similar.

B Fish do not have large heads in stages 2 and 3.

C The table shows the embryos in stage 4 to be about the same size or larger, not smaller, than the embryos at stage 3.

D KEY: Tails can be seen in all the embryos in stages 2 and 3.

E KEY: The number of differences between organisms increases as the animals develop from fertilized eggs to adults.

Part b

A KEY: This statement best explains why embryos of different animals are similar at early stages of development.

B There is no information in the table about the amount of time needed for the embryos to develop.

C There is no information in the table about how long these organisms have existed on Earth.

D There is no information in the table about the amount of time the embryos are in each stage.

Item 14: Standalone Item

Next Generation Science Standards Description

PE: MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

SEP: Constructing Explanations and Designing Solutions: Apply scientific principles to design an object, tool, process or system.

DCI: ESS3.C: Human Impacts on Earth Systems:

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

CCC: Cause and Effect: Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

Item Type: Multiple Choice—Multiple Choice

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

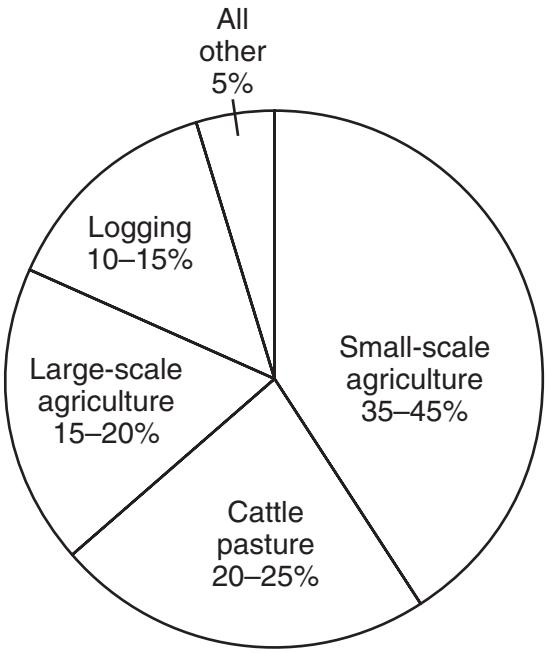
Number of Points: 2

Item on next page

This item brings students into the story line by asking them to apply scientific principles to the design of a method that could minimize the effect of deforestation on tropical areas. The item aligns to the SEP by asking students to apply scientific principles to design a process that can protect tropical forests. The item aligns to the DCI because students must use knowledge that human activities will continue to alter the biosphere unless the activities are engineered to decrease their negative impacts on the environment. The item aligns to the CCC because students must use the cause and effect relationship between changes in human activities and decreased human impact in their design.

While reading a book about rain forests, Becca learns that many of the zoo animals are from tropical areas on Earth, but that the animals' natural habitats are disappearing. After some research, Becca finds that these tropical areas used to have very large rain forests, but that the rain forests are disappearing as humans begin to use the land. The table and graph show types of human activities and their effects on the deforestation of tropical areas.

Human Activity	Estimated Effects
Small-scale agriculture	35–45%
Cattle pasture	20–25%
Large-scale agriculture	15–20%
Logging	10–15%
All other	5%



The stimulus for this item begins by presenting the phenomenon that the natural habitats of many animals are disappearing because of tropical deforestation. The hook is that a student is reading a book about tropical rainforests. The phenomenon and hook are grade-level appropriate because many students have seen zoo animals and are familiar with different natural habitats.

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

14. Part a

Based on the table and the graph, which change could cause the **most** positive impact on the forests in tropical areas?

A eating less meat from cattle

B growing crops that need less fertilizer

C encouraging more families to own farms

D building homes from materials other than wood

Part a is aligned to the DCI and CCC. Students use their content knowledge that human activities affect forests in tropical areas to determine which change in human activity would decrease human impact the most.

Part b

The human population is increasing quickly in tropical areas. Which solution could help reduce deforestation in these areas without hurting people?

A Bring small farms together to form larger farms in the forest.

B Teach people how to safely cook and store meat from cattle.

C Require that houses be built on land where forests are cut down.

D Find ways to use less farmland to grow the same amount of food.

Part b is aligned to the SEP, DCI, and CCC. Students apply scientific principles to identify a solution that can reduce deforestation without hurting people by using their content knowledge that human activities can be changed to reduce their impact in the environment and how changes in human activities could reduce the effects of deforestation.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: D

Distractor Rationales

Part a

A **KEY: Eating less meat would result in fewer cattle in pastures and decrease the second biggest piece of the circle graph.**

B There is no information about the amount of fertilizer used by small and large-scale agriculture.

C More families with farms would increase the amount of land used for small-scale farms, the largest piece of the circle graph, which would increase, not decrease, deforestation.

D Using less wood for homes could decrease logging, but logging results in less deforestation than cattle pastures or smallscale agriculture.

Part b

A Habitat fragmentation is a problem, but consolidating farms by removing fragments of forest between small farms to form larger farms would increase deforestation, not reduce deforestation.

B Teaching these skills would result in more, not less, deforestation by encouraging more people to use land for cattle pasture.

C This solution could result in more, not less, deforestation as more trees are cut down to clear land to build more houses.

D **KEY: Efficient use of existing farm land will provide more food from the same amount of land and decrease the need to cut down more forest.**

Item 15: Standalone Item

Next Generation Science Standards Description

PE: MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]

SEP: Engaging in Argument From Evidence: Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

DCI: LS1.B: Growth and Development of Organisms:

- Animals engage in characteristic behaviors that increase the odds of reproduction.
- Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.

CCC: Cause and Effect: Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Item Type: Open-ended

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

Number of Points: 4

Item on next page

This item brings students into the story line by asking them to use evidence to construct an argument that explains how the behavior of orchid bees and the structure of orchid flowers affect the probability of successful reproduction in the bees and orchids. The item aligns to the SEP by asking students to use evidence and scientific reasoning to support their argument. This item aligns to the DCI because students must use knowledge of characteristic behaviors of bees and specialized structures in orchid plants that increase the odds of reproduction. The item aligns to the CCC because students must use the cause and effect relationships between bee behavior, orchid structures, and the probability of reproductive success for bees and orchids to support their argument.

In class, Henry learns that all bees gather food and nesting materials from plants. He learns that orchid bees and orchid plants have a special relationship. Henry made a list of information about the relationship.

- The orchids that orchid bees visit do not make nesting materials or food that bees can eat.
- Male orchid bees choose to visit orchid plants that have flowers that produce fragrant oils with strong scents.
- Male orchid bees collect these fragrant oils and store them on their bodies.
- Female orchid bees are attracted to the scent of the fragrant oils on male orchid bees.
- Male and female orchid bees do not live together in a large hive. Female orchid bees mate with male orchid bees only once in their lifetime.
- Orchid plants are pollinated when male orchid bees carry pollen from flower to flower.

The stimulus for this item begins by presenting the phenomenon that orchid bees have a special relationship with orchid plants. The hook is that a student is learning about bees. The phenomenon and hook are grade-level appropriate because many students know that bees are pollinators.

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

15. **a.** Construct an argument that the behavior of individual orchid bees affects reproduction in the orchid bee population. Be sure to use information that Henry learned to support your argument.

One scientist argues that orchid plants have evolved to produce the specific scents that attract female orchid bees.

b. Support the scientist's claim with evidence that explains how the oil produced by an orchid plant affects the reproduction of the orchid species.

Part a is aligned to the SEP, DCI, and CCC. Students construct an argument using evidence and their content knowledge that animal behavior affects reproduction and the cause and effect relationship between bee behavior and increased reproductive success.

Part b is aligned to the SEP, DCI, and CCC. Students use evidence and their content knowledge that plants have specialized structures for reproduction to describe the cause and effect relationship between orchid structures and increased reproductive success.

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 constructs an argument that the behavior of individual orchid bees affects reproduction in the orchid bee population, uses information that Henry learned to support the argument, and supports the scientist's claim that orchid plants have evolved to produce the specific scents that attract female orchid bees with evidence that explains how one characteristic of an orchid plant affects the reproduction of the orchid species. 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 more attractive the scent collected by the male bee, the more likely it is that he will be chosen by a female. It is specifically important for them to find a good mate since female orchid bees usually mate just once in their lifetime.

b. Orchids have evolved to cater specifically to an orchid bee's preferences. The male bees are looking for oils to collect for an attractive scent. The plants make an oil to attract males who want to change their scent. As a male bee crawls into the flower of an orchid to search for and collect the perfume, the orchids get their pollen on the back of the male bee. The pollen is transported to the next flower of the same species that the bee visits. In this manner, the bee's pollination is more effective. Bees will look for other plants that make the same oil and more orchids that can reproduce with each other are pollinated with pollen from other orchids with the same scent.

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: MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*]

SEP: Planning and Carrying Out Investigations: Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

DCI: ESS2.C: The Roles of Water in Earth's Surface Processes: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

DCI: ESS2.D: Weather and Climate: Because these patterns are so complex, weather can only be predicted probabilistically.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

PE: MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [*Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.*]

SEP: Developing and Using Models: Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

DCI: ESS2.C: The Roles of Water in Earth's Surface Processes: Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.

DCI: ESS2.D: Weather and Climate:

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

CCC: Systems and System Models: Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Cluster Overview: Mediterranean Climate

Item	Item Type	Alignment
16	Multiple Choice	MS-ESS2-5: SEP, DCI, CCC
17	Multiple Choice	MS-ESS2-5: DCI, CCC
18	Multiple Choice—Multiple Choice	MS-ESS2-6: DCI, CCC
19	Multiple Choice—Multiple Choice	MS-ESS2-5: 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.

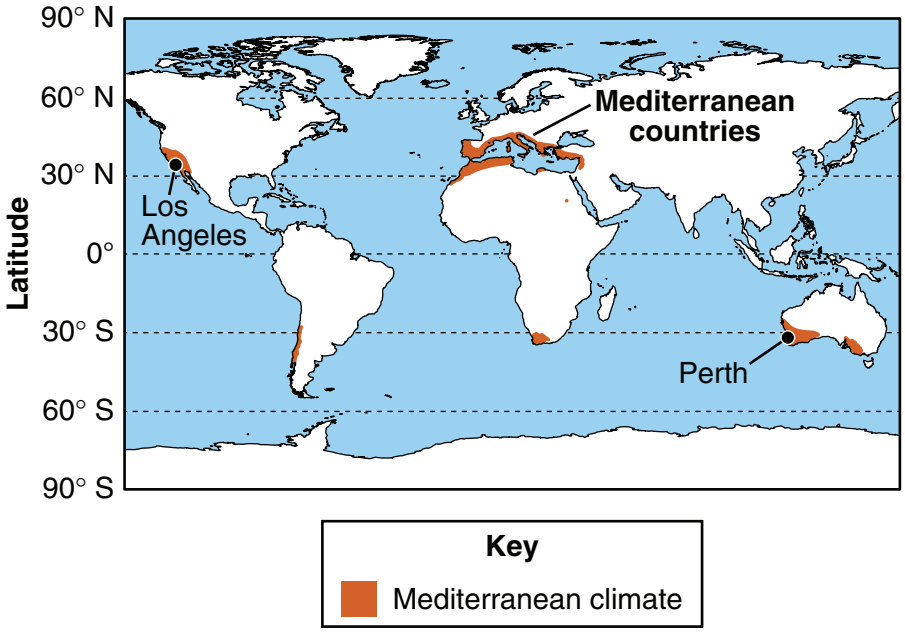
Read the information. Then answer the questions that follow.

Mediterranean Climate

Kevin lives in Los Angeles, California. When he visits a botanical garden, he sees that plants from all over the world are growing in the garden, including plants from Perth, Australia, where his uncle lives. The guidebook explains that Los Angeles has a Mediterranean climate and plants that grow well in Los Angeles also grow well in other locations with the same climate.

In the guidebook, Kevin finds a map that shows locations with a Mediterranean climate. He marks the locations of Los Angeles and Perth on the map.

Locations with a Mediterranean Climate



When he gets home, Kevin does some research. He finds that locations at similar latitudes have similar climates. For a Mediterranean climate, these locations are near a sea or ocean, and usually have warm, dry summers and mild, rainy winters.

Kevin learns that wind direction helps determine the weather, especially in locations like Los Angeles and Perth. Uneven heating of Earth's surface causes differences in air pressure. These pressure differences cause winds to blow.

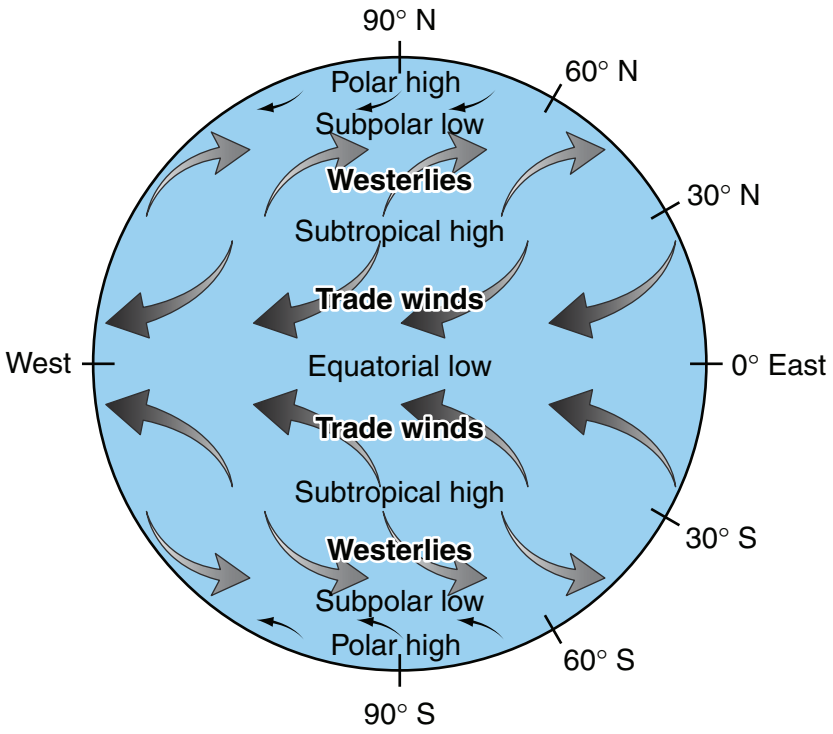
Between 30° latitude and 60° latitude, pressure differences cause winds to blow toward the poles, but Earth's rotation causes the winds to curve and blow from west to east. These winds are called westerlies.

The stimulus for this item begins with the phenomenon that different locations in the world can have the same climate. The hook is that a student's uncle in Australia lives where the climate is the same as the student's climate. The phenomenon and hook are grade-level appropriate because many students know that there are different climates in different parts of the world.

Below 30° latitude, pressure differences cause winds to blow toward the equator, but the winds are curved to blow from east to west by Earth's rotation. These winds are called trade winds.

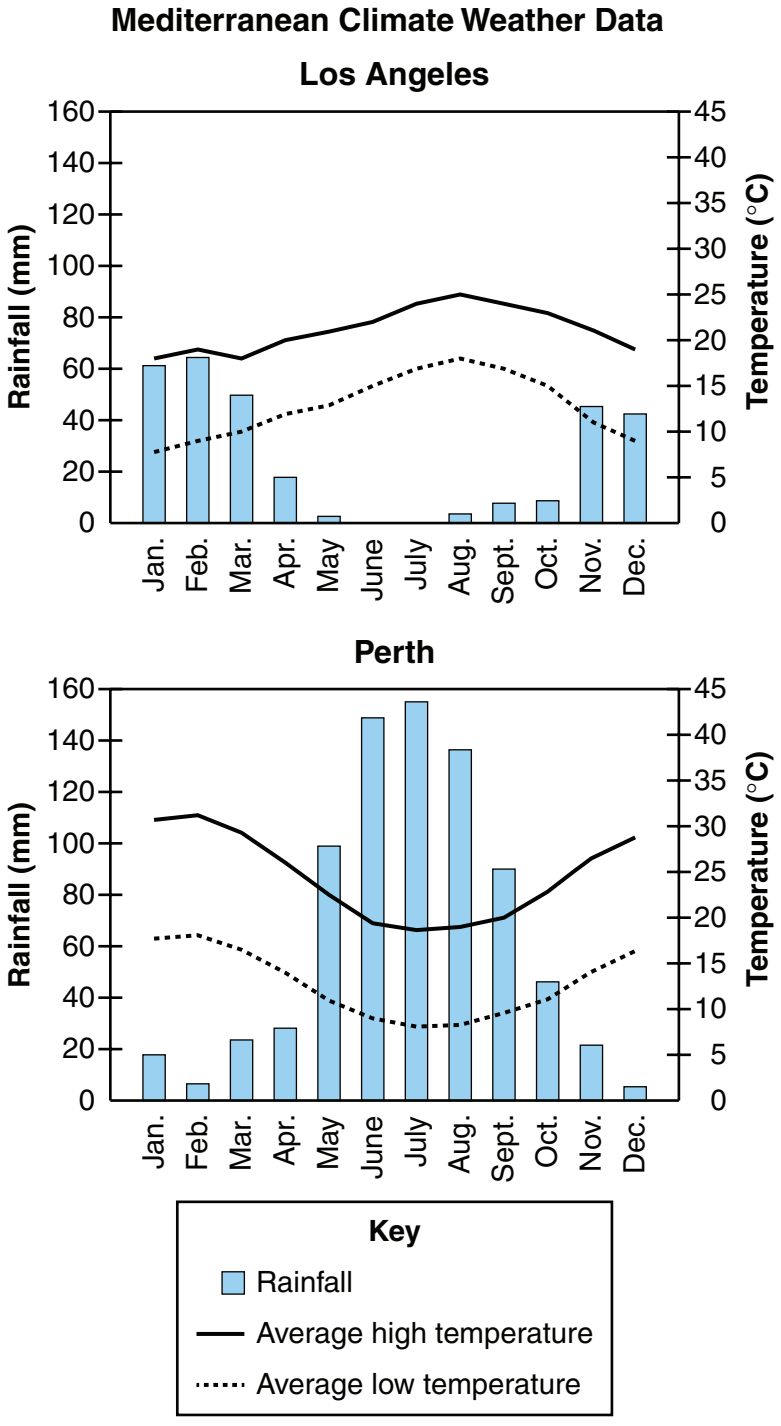
The diagram shows the directions of these winds and locations of high and low pressure.

Global Winds and Pressures



Kevin learns that during the winter, the westerlies bring rain and storms from the ocean to areas along the coast. During the summer, the subtropical highs move toward the poles and keep westerlies from reaching these areas.

Finally, to learn more about weather conditions in locations with a Mediterranean climate, Kevin finds graphs that show weather data for Los Angeles and Perth.



Item 16: Cluster Item

Next Generation Science Standards Description

PE: MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*]

SEP: Planning and Carrying Out Investigations: Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

DCI: ESS2.D: Weather and Climate: Because these patterns are so complex, weather can only be predicted probabilistically.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-High | 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 use data to provide evidence of changing weather conditions that mark the beginning of the rainy season. The item aligns to the SEP by asking students to select which data can be used to answer the question of when the rainy season will begin. The item aligns to the DCI because students must use knowledge that weather predictions are probabilistic. The item aligns to the CCC because students must use the cause and effect relationships among temperature, rainfall, and seasonal changes of climate to make their prediction.

16. The winter months in Perth are June, July, and August. Like other locations with a Mediterranean climate, Perth has mild, rainy winters.

Which weather data could provide evidence that the rainy season will soon begin in Perth?

A rising air temperatures

B rising ocean temperatures

C winds blowing from the northwest

D decreasing levels of humidity in the air

This item is aligned to the SEP, DCI, and CCC. Students use their content knowledge that weather predictions are probabilistic and data from the graphs and wind chart as evidence and cause and effect relationships among temperature, wind, and rainfall to predict when the rainy season in Perth will begin.

Scoring Key

Correct Response: C

Distractor Rationales

A The rainy season begins when air temperature begins decreasing, not increasing.

B The rainy season begins as winter approaches and temperatures begin decreasing, not increasing.

C KEY: Westerlies bring rain and storms.

D Humidity would increase, not decrease, as onshore winds increase and the rains begin.

Item 17: Cluster Item

Next Generation Science Standards Description

PE: MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*]

DCI: ESS2.C: The Roles of Water in Earth's Surface Processes: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Item Type: Multiple Choice

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

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to describe how air masses interact with a mountain slope to cause a rainy climate. The item aligns to the DCI because students must use knowledge that the complex pattern of air movement up a mountain slope next to an ocean is a major determinant of local weather patterns. The item aligns to the CCC because students must use the cause and effect relationship between increase in elevation and decrease in temperature to predict rainfall.

17. In some areas with a Mediterranean climate, mountains rise just beyond the coastline. During the rainy winter, rainfall varies greatly with distance from the ocean. Locations that are high on the slopes of mountains and face the ocean receive the most rainfall.

Which statement describes why these locations receive the most rain?

A Air at these locations causes changes in weather and precipitation.

B Air that has risen to these locations is cooler and releases more precipitation.

C Air that has risen to these locations has faster winds during rainstorms.

D Air at these locations receives enough sunlight to become warm enough for rain to fall.

This item is aligned to the DCI and CCC. Students use their content knowledge that the movement of air up a mountain slope next to an ocean affects local weather to describe the cause and effect relationship between increase in elevation and decrease in temperature that predicts why these locations receive the most rain.

Scoring Key

Correct Response: B

Distractor Rationales

A This statement is too vague to explain why these locations receive the most rain.

B KEY: Rising air cools until the temperature reaches the dew point and water precipitates out of the air.

C Even if this statement is true, the existence of faster winds during rainstorms doesn't explain why locations that are high on the slopes of mountains and face the ocean receive the most rainfall.

D Even if rain did fall when air becomes warm enough, locations that are low, not high, on the slopes of mountains and facing the warmer land, not the cooler ocean, would have the most rainfall.

Item 18: Cluster Item

Next Generation Science Standards Description

PE: MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [*Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.*]

DCI: ESS2.D: Weather and Climate: Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.

CCC: Systems and System Models: Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-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 describe how unequal heating of Earth's surface causes circulation patterns that determine regional climates. The item aligns to the DCI because students must use knowledge of how latitude, altitude, local geography, and interactions with living things influence climate. The item aligns to the CCC because students must use a model to represent how systems of air, water, and land interact and affect the flow of energy and matter that determines regional climates.

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

18. Kevin claims that all locations with a Mediterranean climate do not have exactly the same climate. He claims that the geography of the land can influence climate.

Part a

Which evidence could support Kevin's claim?

A Two cities at different latitudes are the same distance from the ocean and have the same climate.

B Two cities at the same latitude are different distances from the ocean and have the same climate.

C Two cities at different latitudes are at the same elevation above sea level and have different climates.

D Two cities at the same latitude are at different elevations above sea level and have different climates.

Part a is aligned to the DCI and CCC. Students use their content knowledge of how climate is influenced by how latitude, altitude, and distance from the ocean interact with the atmosphere and ocean to support a claim that local geography influences climate.

Part b

Which other factor could cause the climates in these locations to be **slightly** different?

A the average monthly wind speed at each location

B the average daily high and low temperatures at each location

C the amount of vegetation that covers the land at each location

D the amount of precipitation during each season at each location

Part b is aligned to the DCI and CCC. Students use their content knowledge that the interactions that determine local climate are influenced by how living things interact with the atmosphere and ocean.

Scoring Key

Part a
Correct Response: D

Part b
Correct Response: C

Distractor Rationales

Part a

A This would explain why cities at the same latitude have the same, not different, climates.

B This does not explain why cities at the same latitude have different, not the same, climates.

C This does not explain why cities at the same latitude, not different latitudes, have different climates.

D KEY: The difference in elevation above sea level could explain why cities at the same latitude have different climates.

Part b

A The speed of winds at a location is a result, not a cause, of climate.

B Average daily temperatures are a feature of a location's climate, not a reason for the climate.

C KEY: More vegetation can cause more rainfall, which causes more vegetation to grow, which causes more rain to fall. This is a positive feedback loop.

D The amount of precipitation in a location is a result of, not a cause of, the climate at that particular location.

Item 19: Cluster Item

Next Generation Science Standards Description

PE: MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*]

SEP: Planning and Carrying Out Investigations: Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

DCI: ESS2.C: The Roles of Water in Earth's Surface Processes: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

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 describe how weather data provide evidence for how the movement of subtropical highs toward the poles results in summer weather in Los Angeles. The item aligns to the SEP by asking students to use data to serve as evidence to support a scientific claim. The item aligns to the DCI because students must use knowledge of complex patterns of winds that move water in the atmosphere and determine local weather patterns. The item aligns to the CCC because students must use cause and effect relationships between the motions and interactions of air masses and changing weather conditions to support their claims.

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

19. Kevin studies the graph of weather data for Los Angeles and all that he learned during his research.

Part a

How do the data in the graph support the claim that subtropical highs move toward the poles during the summer?

A During the summer, Los Angeles has very little rain because westerlies do not bring rain and storms to the city.

B During the summer, Los Angeles has warm temperatures because high pressure brings high temperatures to the city.

C During the summer, Los Angeles has very little rain because low pressure causes rain to fall in the mountains outside the city.

D During the summer, Los Angeles has warm temperatures because trade winds blow warm air from Los Angeles toward the equator.

Part a is aligned to the SEP, DCI, and CCC. Students use their content knowledge that patterns of winds determine local weather patterns and data in the graph as evidence to support a claim about the cause and effect relationship that causes summer weather conditions in Los Angeles.

Part b

Which additional data could support the claim that air movements change weather conditions in Los Angeles?

A changes in air pressure before rainstorms

B changes in air temperature during rainstorms

C changes in wind direction before the Sun rises

D changes in wind speed as elevation increases

Part b is aligned to the SEP, DCI, and CCC. Students use their content knowledge that patterns in the movement of air and atmospheric water determine local weather patterns and the cause and effect relationship between air movements and changing weather conditions to identify data that would be evidence that support a claim about the cause of summer weather conditions in Los Angeles.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: A

Distractor Rationales

Part a

A **KEY: The graph shows little rain in the summer because the subtropical high moves the westerlies away from the city.**

B The graph shows warm temperatures in the summer because the subtropical high moves north of the city, not because high pressure is over the city.

C The graph shows little rain in the summer because the subtropical high moves north of the city, not because high pressure moved the rain to the mountains.

D The graph shows warm temperatures in the summer because warm air is being blown toward, not away from, the city.

Part b

A **KEY: Changes in air pressure while weather conditions are changing before a rainstorm would support a claim about moving air masses and changing weather conditions.**

B These data do not support the claim because these data are collected during rainstorms, not when weather conditions are changing.

C Changes in air movements as the Sun rises do not support a claim about air movements causing weather conditions to change.

D These data would support a claim about air movements and changes in elevation, not changes in weather conditions.

Items 20–23: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

SEP: Planning and Carrying Out Investigations: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

DCI: PS2.A: Forces and Motion:

- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

CCC: Stability and Change: Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

PE: MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

SEP: Engaging in Argument From Evidence: Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.

DCI: PS3.B: Conservation of Energy and Energy Transfer: When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

CCC: Energy and Matter: Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).

Cluster Overview: Roller Coasters

Item	Item Type	Alignment
20	Drag and Drop—Multiple Choice	MS-PS2-2: SEP, DCI
20 PBT	Multiple Choice—Multiple Choice	MS-PS2-2: SEP, DCI
21	Inline Choice	MS-PS2-2: SEP, DCI, CCC
21 PBT	Multiple Choice	MS-PS2-2: SEP, DCI, CCC
22	Hotspot—Multiple Choice	MS-PS3-5: SEP, DCI, CCC
22 PBT	Multiple Choice—Multiple Choice	MS-PS3-5: SEP, DCI, CCC
23	Multiple Choice	MS-PS3-5: SEP, DCI, CCC

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.

Stimulus and Items on next pages

Read the information. Then answer the questions that follow.

Roller Coasters

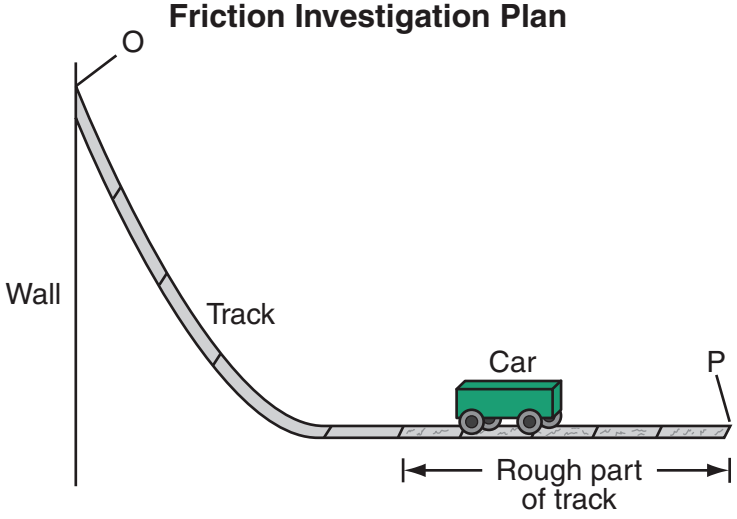
Edith and Andy enjoy going to an amusement park. Their favorite ride is the roller coaster because of all the changes in speed, direction, and height. They know that every change in speed is also a change in kinetic energy and that every change in height is also a change in gravitational energy.

They are fascinated that the roller coaster has enough energy at the top of the first hill to reach the end of the ride. They know that an engine applies the force needed to pull the roller coaster car to the top of the first hill. Then, at the end of the ride, a force stops the roller coaster car so that the riders can get off.

Andy and Edith wonder whether friction is the force that causes the roller coaster car to stop. They decide to use a toy car and pieces of track that have different amounts of friction to investigate how friction affects the car's motion.

They decide that Edith will hold one end of the track against the wall and put a toy car on the track at point O. When she lets go, the car will move down the track and across the rough part of the track. Andy will measure the time for the car to reach point P at the end of the track. The diagram shows their investigative setup.

Friction Investigation Plan



The stimulus for this cluster begins by presenting the phenomenon that at the top of the first hill, a roller coaster car has all the energy needed to reach the end of the ride. The hook is that students enjoy going to amusement parks. The phenomenon and hook are grade-level appropriate because many students go to amusement parks and have ridden on or watched others ride roller coasters.

Item 20: Cluster Item

Next Generation Science Standards Description

PE: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

SEP: Planning and Carrying Out Investigations: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

DCI: PS2.A: Forces and Motion: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.

Item Type: Drag and Drop—Multiple Choice

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

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 friction on a roller coaster car's motion. The item aligns to the SEP by asking students to identify the independent, dependent, and controlled variables and how many data are needed to support a claim. This item aligns to the DCI because students must use knowledge of the relationship between the sum of the forces acting on a car and the change in motion of the car.

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

20. As Edith and Andy consider how to collect data to investigate how friction affects motion, they think about how to carry out their investigation.

Part a

Complete the table to show the independent and dependent variables and which variables should be controlled.

Select the types of variable and drag them into the correct spaces in the table. Each type of variable can be used only once or more than once.

Variable	Type of Variable
Friction on track	
Height of track	
Length of track	
Mass of car	
Time to reach P	

Independent Variable

Dependent Variable

Controlled Variable

Part a is aligned to the SEP and the DCI. Students identify the independent, dependent, and controlled variables in their investigation by using their content knowledge of how the force of friction affects the motion of the car.

Part b

Which statement **best** describes what Edith and Andy must do in order to collect data to answer their investigative question?

A repeat the procedure with cars that are larger and smaller

B repeat the procedure with cars that move faster and slower

C repeat the procedure with tracks that start higher and lower on the wall

D repeat the procedure with tracks that exert more and less friction force on the cars

Part b is aligned to the SEP and the DCI. Students use their content knowledge that the force of friction affects the motion of the car to describe how they will collect data during their investigation.

Scoring Key

Part a

Variable	Type of Variable
Friction on track	Independent Variable
Height of track	Controlled Variable
Length of track	Controlled Variable
Mass of car	Controlled Variable
Time to reach P	Dependent Variable

Part b
Correct Response: D

Distractor Rationales

Part b

A This cannot be changed as part of a scientific investigation: it is unclear whether the student is thinking of the car being larger in terms of volume or height or mass. Volume and height are irrelevant and changing the mass will only have a small effect on the amount of friction between the rolling wheels and the track.

B The speed of the cars will be the dependent, not the independent, variable. The speed must be allowed to change as the amount of friction changes.

C Changing the height will change the amount of energy the cars start with. Edith and Andy are investigating the effect of different amounts of friction, not energy. The amount of energy at the start must be kept the same.

D KEY: The amount of friction is the independent variable that must be changed.

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

Item 20: PBT Cluster Item

Next Generation Science Standards Description

PE: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

SEP: Planning and Carrying Out Investigations: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

DCI: PS2.A: Forces and Motion: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.

Item Type: Multiple Choice—Multiple Choice

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

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 friction on a roller coaster car's motion. The item aligns to the SEP by asking students to identify the independent, dependent, and controlled variables and how many data are needed to support a claim. This item aligns to the DCI because students must use knowledge of the relationship between the sum of the forces acting on a car and the change in motion of the car.

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

20. As Edith and Andy consider how to collect data to investigate how friction affects motion, they think about how to carry out their investigation.

Part a

Which list correctly describes the variables in their investigation?

A independent variables: height of track, length of track, mass of car
dependent variable: time to reach P
controlled variable: friction on track

B independent variable: friction on track
dependent variable: time to reach P
controlled variables: height of track, length of track, mass of car

C independent variables: friction on track, time to reach P
dependent variables: height of track, length of track
controlled variable: mass of car

D independent variables: height of track, length of track
dependent variable: friction on track
controlled variables: mass of car, time to reach P

Part a is aligned to the SEP and the DCI. Students identify the independent, dependent, and controlled variables in their investigation by using their content knowledge of how the force of friction affects the motion of the car.

Part b

Which statement **best** describes what Edith and Andy must do in order to collect data to answer their investigative question?

A repeat the procedure with cars that are larger and smaller

B repeat the procedure with cars that move faster and slower

C repeat the procedure with tracks that start higher and lower on the wall

D repeat the procedure with tracks that exert more and less friction force on the cars

Part b is aligned to the SEP and the DCI. Students use their content knowledge that the force of friction affects the motion of the car to describe how they will collect data during their investigation.

Scoring Key

Part a
Correct Response: B

Part b
Correct Response: D

Distractor Rationales

Part a

A The student has confused the independent and controlled variables.

B KEY: Students should change the amount of friction (independent variable) which will affect the measured time to reach P (dependent variable) and keep the height and length of the track and the mass of the car the same (controlled variables).

C There can be only one independent variable in a valid scientific investigation. The time for the car to reach P will be measured and so would be the dependent variable.

D There can be only one independent variable in a valid scientific investigation. The time for the car to reach P cannot be controlled; the time, not the amount of friction, will be the dependent variable that is measured.

Part b

A This cannot be changed as part of a scientific investigation: it is unclear whether the student is thinking of the car being larger in terms of volume or height or mass. Volume and height are irrelevant and changing the mass will only have a small effect on the amount of friction between the rolling wheels and the track.

B The speed of the cars will be the dependent, not the independent, variable. The speed must be allowed to change as the amount of friction changes.

C Changing the height will change the amount of energy the cars start with. Edith and Andy are investigating the effect of different amounts of friction, not energy. The amount of energy at the start must be kept the same.

D KEY: The amount of friction is the independent variable that must be changed.

Item 21: Cluster Item

Next Generation Science Standards Description

PE: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

SEP: Planning and Carrying Out Investigations: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

DCI: PS2.A: Forces and Motion: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.

CCC: Stability and Change: Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Item Type: Inline 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 predict how data from their investigation provide evidence that the change in a car's speed depends on the amount of friction on the car. The item aligns to the SEP by asking students to make a claim that would be supported by data from their investigation. The item aligns to the DCI because students must use knowledge of how the motion of an object is determined by the sum of the forces acting on the object. The item aligns to the CCC because students must explain changes in the cart's motion by examining changes in the force of friction on the cart.

21. As Andy and Edith discuss possible outcomes of their investigation, they make different claims about what will happen.

Select the words that complete a claim that will likely be supported by data collected during Andy and Edith's investigation.

As the force of friction on the track increases, the time for the car to reach point P will [increase, decrease] because the car's speed will [increase, decrease] more quickly.

This item is aligned to the SEP, DCI, and CCC. Students make a claim that would be supported by data from their investigation by using their content knowledge of how friction affects the motion of the car and how the amount of friction on the track can explain changes in the car's motion.

Scoring Key

Correct Response:
As the force of friction on the track increases, the time for the car to reach point P will [**increase**, decrease] because the car's speed will [increase, **decrease**] more quickly.

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

Item 21: PBT Cluster Item

Next Generation Science Standards Description

PE: MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

SEP: Planning and Carrying Out Investigations: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

DCI: PS2.A: Forces and Motion: The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.

CCC: Stability and Change: Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

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 predict how data from their investigation provide evidence that the change in a car's speed depends on the amount of friction on the car. The item aligns to the SEP by asking students to make a claim that would be supported by data from their investigation. The item aligns to the DCI because students must use knowledge of how the motion of an object is determined by the sum of the forces acting on the object. The item aligns to the CCC because students must explain changes in the cart's motion by examining changes in the force of friction on the cart.

21. As Andy and Edith discuss possible outcomes of their investigation, they make different claims about what will happen.

Which claim will likely be supported by data collected during Andy and Edith's investigation?

A As the force of friction on the track increases, the time for the car to reach point P will decrease because the car's speed will decrease more quickly.

B As the force of friction on the track increases, the time for the car to reach point P will decrease because the car's speed will increase more quickly.

C As the force of friction on the track increases, the time for the car to reach point P will increase because the car's speed will decrease more quickly.

D As the force of friction on the track increases, the time for the car to reach point P will increase because the car's speed will increase more quickly.

This item is aligned to the SEP, DCI, and CCC. Students make a claim that would be supported by data from their investigation by using their content knowledge of how friction affects the motion of the car and how the amount of friction on the track can explain changes in the car's motion.

Scoring Key

Correct Response: C

Distractor Rationales

A As friction increases, the car's speed decreases more quickly, the car will travel toward point P more slowly, and take more, not less, time to reach point P.

B As friction increases, the car's speed will decrease, not increase.

C KEY. As friction increases, the car's speed will decrease more quickly and the car will need more time to reach point P.

D As friction increases, the car's speed will decrease, not increase. If the car's speed did increase, the car would take less, not more, time to reach point P.

Item 22: Cluster Item

Next Generation Science Standards Description

PE: MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

SEP: Engaging in Argument From Evidence: Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.

DCI: PS3.B: Conservation of Energy and Energy Transfer: When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

CCC: Energy and Matter: Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).

Item Type: Hotspot—Multiple Choice

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

Number of Points: 2

Item on next page

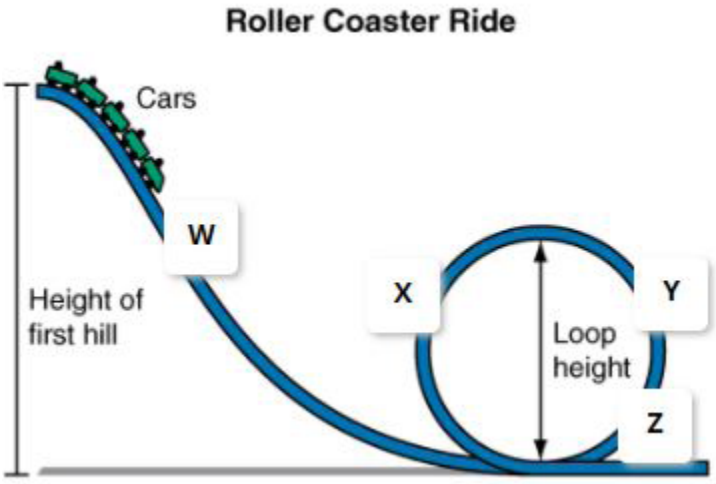
This item brings students into the story line by asking them to construct an argument about where energy is transferred to roller coaster cars. The item aligns to the SEP by asking students to use evidence to construct the argument. The item aligns to the DCI because students must use knowledge that when the motion energy of the cars changes, there is another change in energy at the same time. The item aligns to the CCC because students must use understanding of the different forms of energy during a roller coaster ride.

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

22. Part a

Edith and Andy know that the kinetic energy of the roller coaster cars changes during the ride. They draw a diagram to show part of a roller coaster ride.

Select **two** locations on the diagram that show where energy was being transferred to the roller coaster car.



Part a is aligned to the SEP, DCI, and CCC. Students construct an argument about where energy was being transferred to the cars by using their content knowledge that energy was being transferred to the cars when motion energy was increasing and the understanding that energy can take different forms during a roller coaster ride.

Part b

Which evidence supports the answer in Part (a)?

A At those locations, the mass of the roller coaster car was increasing.

B At those locations, the force on the roller coaster car was increasing.

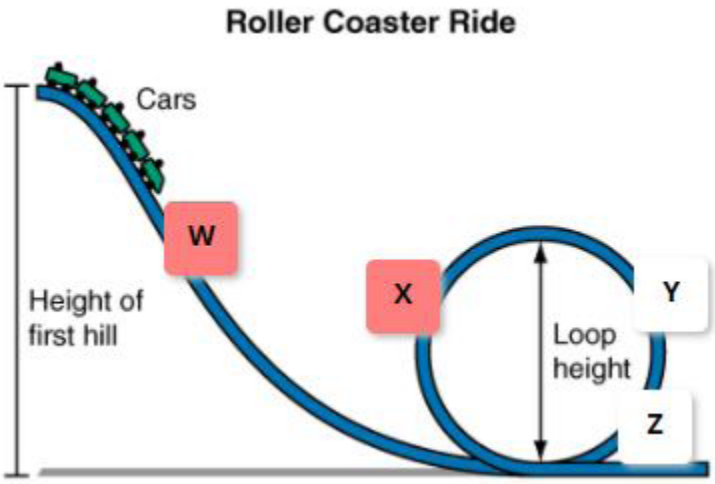
C At those locations, the height of the roller coaster car was decreasing.

D At those locations, the speed of the roller coaster car was decreasing.

Part b is aligned to the SEP, DCI, and CCC. Students identify evidence that supports their argument by using their content knowledge that another form of energy was decreasing when motion energy was increasing and their understanding of the different forms of energy during a roller coaster ride.

Scoring Key

Part a



Part b

Correct Response: C

Distractor Rationales

Part b

A The mass of the car was not changing during the ride.

B Air resistance could be increasing as speed increases at these points, but that would transfer energy from the car, not to the car.

C KEY: As the car went downhill, gravitational energy was being converted to kinetic energy of the car.

D A student who chooses locations where speed is decreasing will be choosing locations where energy was being transferred from the car, not to the car.

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

Item 22: PBT Cluster Item

Next Generation Science Standards Description

PE: MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

SEP: Engaging in Argument From Evidence: Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.

DCI: PS3.B: Conservation of Energy and Energy Transfer: When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

CCC: Energy and Matter: Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).

Item Type: Multiple Choice—Multiple Choice

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

Number of Points: 2

Item on next page

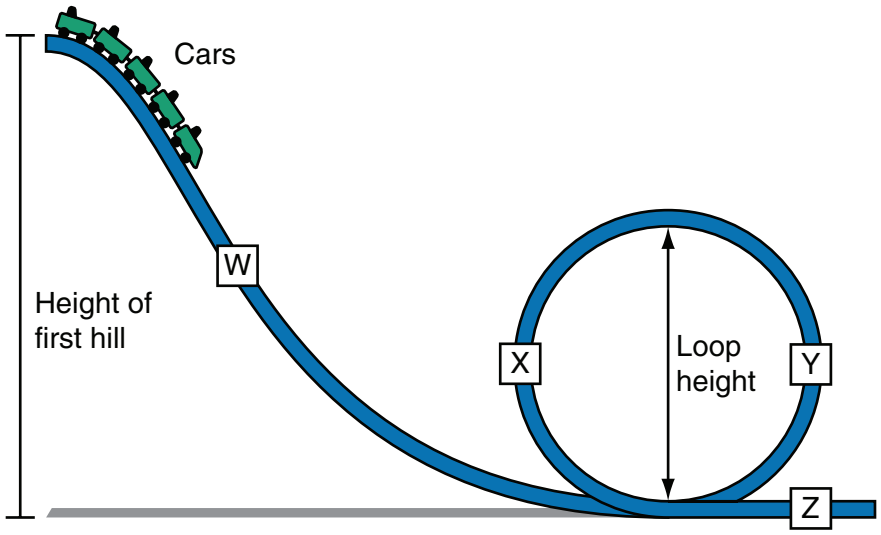
This item brings students into the story line by asking them to construct an argument about where energy is transferred to roller coaster cars. The item aligns to the SEP by asking students to use evidence to construct the argument. The item aligns to the DCI because students must use knowledge that when the motion energy of the cars changes, there is another change in energy at the same time. The item aligns to the CCC because students must use understanding of the different forms of energy during a roller coaster ride.

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

22. Part a

Edith and Andy know that the kinetic energy of the roller coaster cars changes during the ride. They draw a diagram to show part of a roller coaster ride.

Roller Coaster Ride



Which **two** locations on the diagram show where energy was being transferred to the roller coaster car?

A Y and Z

B Y and X

C W and X

D W and Z

Part a is aligned to the SEP, DCI, and CCC. Students construct an argument about where energy was being transferred to the cars by using their content knowledge that energy was being transferred to the cars when motion energy was increasing and the understanding that energy can take different forms during a roller coaster ride.

Part b

Which evidence supports the answer in Part (a)?

A At those locations, the mass of the roller coaster car was increasing.

B At those locations, the force on the roller coaster car was increasing.

C At those locations, the height of the roller coaster car was decreasing.

D At those locations, the speed of the roller coaster car was decreasing.

Part b is aligned to the SEP, DCI, and CCC. Students identify evidence that supports their argument by using their content knowledge that another form of energy was decreasing when motion energy was increasing and their understanding of the different forms of energy during a roller coaster ride.

Scoring Key

Part a
Correct Response: C

Part b
Correct Response: C

Distractor Rationales

Part a

A At locations Y and Z, energy was being transferred from, not to, the car by the gravitational field and friction.

B Energy was being transferred to the car at location X, but energy was being transferred from the car at location Y.

C KEY: Energy was being transferred to the car at both locations W and X as the car's speed and kinetic energy increased.

D Energy was being transferred to the car at location W, but energy was being transferred from the car at location Z.

Part b

A The mass of the car was not changing during the ride.

B Air resistance could be increasing as speed increases at these points, but that would transfer energy from the car, not to the car.

C KEY: As the car went downhill, gravitational energy was being converted to kinetic energy of the car.

D A student who chooses locations where speed is decreasing will be choosing locations where energy was being transferred from the car, not to the car.

Item 23: Cluster Item

Next Generation Science Standards Description

PE: MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [*Assessment Boundary: Assessment does not include calculations of energy.*]

SEP: Engaging in Argument From Evidence: Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.

DCI: PS3.B: Conservation of Energy and Energy Transfer: When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

CCC: Energy and Matter: Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-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 construct an argument about the transfer of energy that explains why a car feels warm after traveling along a track. The item aligns to the SEP by asking students to use evidence to construct the argument. The item aligns to the DCI because students must use knowledge that when the motion energy of the car changes, there is another change in energy at the same time. The item aligns to the CCC because students must use understanding of the different forms of energy as the car travels along the track.

23. During their investigation, immediately after the car reaches the end of the track, Andy picks up the car and observes that the car feels warm.

Which energy conversion explains Andy's observation?

A Kinetic energy was converted to thermal energy by friction.

B Thermal energy was converted to kinetic energy by gravity.

C Gravitational potential energy was converted to thermal energy by gravity.

D Thermal energy was converted to gravitational potential energy by friction.

Students construct an argument that explains why the car feels warm by using their content knowledge of how motion energy can be converted to other forms of energy and their understanding of the different forms of energy during a roller coaster ride.

Scoring Key

Correct Response: A

Distractor Rationales

A **KEY: The force of friction as the car moved along the track converted some of the kinetic energy to thermal energy, which increased the temperature of the car.**

B The force of gravity converted gravitational, not thermal, energy to kinetic energy. If thermal energy had been converted to another type of energy, the car would have felt cooler, not warm.

C The force of gravity converted gravitational energy to kinetic, not thermal, energy.

D The force of friction produced thermal energy as the final, not initial, type of energy.

Session 3: Items 24–35

Item 24: Standalone Item

Next Generation Science Standards Description

PE: MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [*Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.*]

SEP: Constructing Explanations and Designing Solutions: Apply scientific ideas or principles to design an object, tool, process or system.

DCI: PS2.A: Forces and Motion: For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).

CCC: Systems and System Models: Models can be used to represent systems and their interactions —such as inputs, processes, and outputs—and energy and matter flows within systems.

Item Type: Multiple Choice—Multiple Choice

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

Number of Points: 2

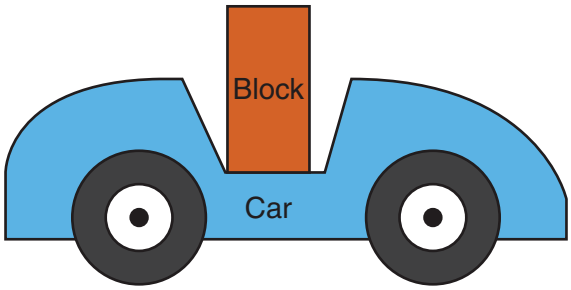
Item on next page

This item brings students into the story line by asking them to apply Newton's third law to using a seat belt to protect a car passenger during a collision. The item aligns to the SEP by asking students to apply scientific principles that were used to design seat belts. The item aligns to the DCI because students must use knowledge that the force exerted by the seat belt on the block is equal in strength and opposite in direction to the force that the block exerts on the seat belt. The item aligns to the CCC because students must use a graphical model to represent the car—seat belt—passenger system to understand interactions during a car collision.

Eric wants to understand how wearing seat belts in a car can keep people safe during collisions.

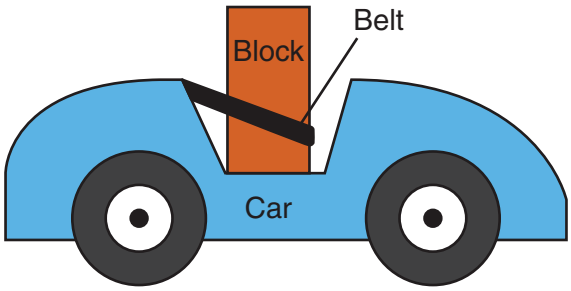
To investigate how a seat belt works, he puts a wooden block inside a toy car as shown in the diagram.

Block without Seat Belt



He pushes the car into a wall and observes that the block falls out of the car. Then he attaches a belt around the block as shown in the diagram.

Block with Seat Belt



He pushes the car into the same wall with the same force and observes that the block does not fall out of the car.

The stimulus for this item begins by presenting the phenomenon that seat belts in cars keep people safe during collisions. The hook is that a student decides to use a toy car and wooden block to investigate how a seat belt works. The phenomenon and hook are grade-level appropriate because all students should wear seat belts in cars and many students have done investigations with toy cars.

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

24. Part a

How does the belt keep the block from falling out of the car?

A The belt pushes the car forward before the collision.

B The belt pushes the block backward during the collision.

C The belt increases the stopping force on the block after the collision.

D The belt changes the direction of the force on the car during the collision.

Part b

Forces act in pairs that are equally strong but in opposite directions. Which force pair occurs during the collision with the wall?

A how hard the car pushes the block and how hard the car pulls on the belt

B how hard the wall pushes the car and how hard the belt pulls on the block

C how hard the belt pushes the block and how hard the block pulls on the belt

D how hard the block pulls on the belt and how hard the block pushes on the car

Part a is aligned to the SEP, DCI, and CCC. Students use their content knowledge of equal and opposite forces between pairs of interacting objects to explain how a seat belt is designed to interact with a block in a model of a system that represents interactions in a car—seat belt—passenger system during a collision.

Part b is aligned to the SEP, DCI, and CCC. Students use their content knowledge of equal and opposite forces between pairs of interacting objects to explain how a seat belt is designed to interact with a block in a system that is designed to model forces during car collisions.

Scoring Key

Part a
Correct Response: B

Part b
Correct Response: C

Distractor Rationales

Part a

A Eric, not the belt, pushed the car forward at the start. Inertia, which is not a force, keeps the car moving forward after Eric stops pushing.

B KEY: The belt pushes the block back (so that the block's inertia does not keep the block moving forward) so that the block's speed goes to zero as the car's speed goes to zero. This results in no relative motion and the block stays in the car.

C The force that stops the block during the collision could be less, not more, if the belt allows the block to move a little so that the block stops more slowly than had the block hit the wall or floor.

D The belt cannot change the force on the car: that force is caused by the collision of the car with the wall.

Part b

A How hard the car pushes the block and how hard the block pushes the car are one force pair. How hard the car pulls on the belt and how hard the belt pulls on the car are a different force pair.

B There cannot be a single force pair when the forces are between four different objects.

C KEY: The same two objects, the belt and the block, exert equal and opposite forces on each other.

D How hard the block pulls on the belt and how hard the belt, not the car, pulls on the block would be a force pair.

Item 25: Standalone Item

Next Generation Science Standards Description

PE: MS-LS3-2: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

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

DCI: LS3.B: Variation of Traits: In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems.

Item Type: Drag and Drop—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 develop and use a model to describe why sexual reproduction can result in puppies with brown fur when both parents have black fur. The item aligns to the SEP by asking students to develop and use a Punnett square to describe how parent alleles are passed on to offspring. The item aligns to the DCI because students must use knowledge that puppies have two alleles of each gene, one acquired from each parent. The item aligns to the CCC because students must use the cause and effect relationship between allele combinations and fur color to make their prediction.

Jessica's dog just had puppies. The parent dogs both have black fur, but some of the puppies have brown fur. Jessica wonders how that can happen. She learns that the gene that controls brown or black fur color in dogs has two alleles: dominant B and recessive b. If a dog has one or two dominant B alleles, the dog has black fur. If a dog has two recessive b alleles, the dog has brown fur.

The stimulus for this item begins by presenting the phenomenon that puppies can have different fur colors than their parents. The hook is that a student's dog just had puppies. The phenomenon and hook are grade-level appropriate because many students have seen dogs and puppies with different fur colors.

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

25. **Part a**

Jessica starts to make a model to show how parents with black fur can have puppies with brown fur. The diagram shows a partially completed Punnett square with the possible alleles of puppies born to parents that each have one B and one b allele.

Complete Jessica's model to show the other possible alleles of puppies born to these parents.

Select the alleles and drag them into the correct spaces in the model. Each pair of alleles may be used once, more than once, or not at all.

BB	Bb	bb

	B	b
B		
b	Bb	bb

Part a is aligned to the SEP and the DCI. Students develop a model that describes how dogs pass alleles to puppies by using their content knowledge that each puppy has two alleles, one allele from each parent.

Part b

If the two parent dogs described in Part (a) have a litter of four puppies, what is the **most likely** number of puppies with brown fur?

A two, because both parents have one B allele and one b allele

B two, because there is a 50% chance of a puppy with Bb alleles

C one, because there is a 25% chance of a puppy with bb alleles

D one, because there is a 25% chance of a puppy with BB alleles

Part b is aligned to the SEP, DCI, and CCC. Students use their Punnett square model, their content knowledge that each puppy gets one allele from each parent, and the cause and effect relationship between allele combinations and fur color to predict how many puppies are likely to have brown fur.

Scoring Key

Part a

Correct Response:

	B	b
B	BB	Bb
b	Bb	bb

Part b

Correct Response: C

Distractor Rationales

Part b

A Students might think that because each parent has a 50/50 chance of passing on a brown allele, the puppies have a 50/50 chance of having brown fur.

B This is the percentage of heterozygous Bb puppies but these puppies will have black, not brown, fur.

C KEY: Since the Bb parents have black fur, only puppies without a B will have brown fur. One of the four squares is bb, so there is a 25% probability of a bb puppy with brown fur.

D This is the percentage of homozygous dominant puppies which have black, not brown, fur.

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

Item 25: PBT Standalone Item

Next Generation Science Standards Description

PE: MS-LS3-2: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

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

DCI: LS3.B: Variation of Traits: In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural systems.

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 develop and use a model to describe why sexual reproduction can result in puppies with brown fur when both parents have black fur. The item aligns to the SEP by asking students to develop and use a Punnett square to describe how parent alleles are passed on to offspring. The item aligns to the DCI because students must use knowledge that puppies have two alleles of each gene, one acquired from each parent. The item aligns to the CCC because students must use the cause and effect relationship between allele combinations and fur color to make their prediction.

Jessica's dog just had puppies. The parent dogs both have black fur, but some of the puppies have brown fur. Jessica wonders how that can happen. She learns that the gene that controls brown or black fur color in dogs has two alleles: dominant B and recessive b. If a dog has one or two dominant B alleles, the dog has black fur. If a dog has two recessive b alleles, the dog has brown fur.

The stimulus for this item begins by presenting the phenomenon that puppies can have different fur colors than their parents. The hook is that a student's dog just had puppies. The phenomenon and hook are grade-level appropriate because many students have seen dogs and puppies with different fur colors.

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

26. Jessica wants to make a model to show how parents with black fur can have puppies with brown fur.

Part a is aligned to the SEP and the DCI. Students develop a model that describes how dogs pass alleles to puppies by using their content knowledge that each puppy has two alleles, one allele from each parent.

Part a

Which model could Jessica make to **best** represent how parents with black fur can have puppies with brown fur?

A

	B	b
B	BB	Bb
b	Bb	bb

B

	B	B
B	BB	BB
b	Bb	Bb

C

	B	B
b	Bb	Bb
b	Bb	Bb

D

	b	b
B	Bb	Bb
b	bb	bb

Part b

If the two parent dogs described in Part (a) have a litter of four puppies, what is the **most likely** number of puppies with brown fur?

A two, because both parents have one B allele and one b allele

B two, because there is a 50% chance of a puppy with Bb alleles

C one, because there is a 25% chance of a puppy with bb alleles

D one, because there is a 25% chance of a puppy with BB alleles

Part b is aligned to the SEP, DCI, and CCC. Students use their Punnett square model, their content knowledge that each puppy gets one allele from each parent, and the cause and effect relationship between allele combinations and fur color to predict how many puppies are likely to have brown fur.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: C

Distractor Rationales

Part a

A **KEY: Each parent contributes one B or one b allele to each puppy.**

B The model shows that all the puppies that have these parents will be the same fur color as the parents, so none of the puppies will have brown fur.

C The model incorrectly shows that one of the parents has brown fur (bb), instead of both parents having black fur. The model also shows 0% probability of puppies with brown fur because all the puppies will have at least one B allele.

D The model incorrectly shows that one of the parents has brown fur (bb), instead of both parents having black fur.

Part b

A Students might think that because each parent has a 50/50 chance of passing on a brown allele, the puppies have a 50/50 chance of having brown fur.

B This is the percentage of heterozygous Bb puppies, but these puppies will have black, not brown, fur.

C **KEY: Since the Bb parents have black fur, only puppies without a B will have brown fur. One of the four squares is bb, so there is a 25% probability of a bb puppy with brown fur.**

D This is the percentage of homozygous dominant puppies which have black, not brown, fur.

Item 26: Standalone Item

Next Generation Science Standards Description

PE: MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [*Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.*]

SEP: Obtaining, Evaluating, and Communicating Information: Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.

DCI: PS4.C: Information Technologies and Instrumentation: Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.

Item Type: Multiple Choice—Multiple Choice

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

Number of Points: 2

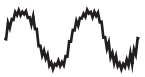
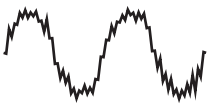
Item on next page

This item brings students into the story line by asking them to use scientific information about analog and digital phones to make and support claims that digital signals are a more reliable way to transmit information than analog signals. The item aligns to the SEP by asking students to integrate scientific information to support the claims. The item aligns to the DCI because students must use the understanding that digital signals are a more reliable way to transmit information.

Bruce tells his grandparents that a new cell phone has much better sound quality than an old telephone. A phone with better sound quality produces sounds that are close to the original sounds. Sound quality is poor when sounds are distorted and are different from the original sounds.

To learn more, Bruce finds that both cell phones and old telephones convert sound information into signals that are transmitted from one phone to another. He finds that telephones use analog signals and cell phones use digital signals. Information about analog and digital signals is shown in the table.

Telephone and Cell Phone Signals

Information	Analog Signals	Digital Signals
Signal that leaves speaker's phone		
Signal with distortion that reaches listener's phone		
Signal that listener's phone converts back to sound		

The table shows that the amplitude of analog signals varies smoothly, while the amplitude of digital signals does not. The table also shows the signals when they reach the listener's phone and after they have been converted to sound in the listener's phone.

The stimulus for this item begins by presenting the phenomenon that new cell phones have higher sound quality than old telephones. The hook is that a student is telling his grandparents about the types of phones. The phenomenon and hook are grade-level appropriate because many students have experience with sound quality during phone calls and may have discussed telephones with older adults.

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

27. **Part a**

Which claim is supported by data in the table?

A Noise does not affect digital signals.

B Information cannot be carried by analog signals.

C Analog signals are more distorted than digital signals.

D Digital signals are easier to transmit than analog signals.

Part a is aligned to the SEP and the DCI. Students make a claim that is supported by information and their content knowledge that digital signals are a more reliable way to transmit information.

Part b

Which statement is supported by the information Bruce found?

A Digital signals are easier to store than analog signals.

B Digital signals can be transmitted over longer distances than analog signals.

C Digital signals can be converted back to sound with all of the original characteristics.

D Digital signals contain more information about the original sound than analog signals.

Part b is aligned to the SEP and the DCI. Students use scientific information and their content knowledge that digital signals are a more reliable way to transmit information as evidence that supports a claim about digital signals.

Scoring Key

Part a
Correct Response: C

Part b
Correct Response: C

Distractor Rationales

Part a

A The data in the table show that noise distorts the digital signal during transmission.

B The data in the table show that both analog and digital signals can carry information and noise.

C KEY: The data show that noise distorts the analog signal during transmission and again in the phone before being converted back to sound, but the digital signal is only distorted during transmission.

D There are no data in the table about how easy the signals are to transmit.

Part b

A The table contains information about transmission and reception of signals, not about the storage of signals.

B The table contains information about how signals are distorted after transmission, not about how far the signals travel after transmission.

C KEY: The table shows that the digital signal with distortion can be restored to be identical to the original signal.

D There is no information in the table about the amount of information in the signals.

Item 27: Standalone Item

Next Generation Science Standards Description

PE: MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

SEP: Developing and Using Models: Develop a model to predict and/or describe phenomena

DCI: PS1.A: Structure and Properties of Matter:

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

DCI: PS3.A: Definitions of Energy: The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Item Type: Open-ended

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

Number of Points: 4

Item on next page

This item brings students into the story line by asking them to develop a model that describes how the volume of helium balloons changes when the addition or removal of thermal energy causes the motion and temperature of the helium atoms inside the balloons to change. The item aligns to the SEP by asking students to develop graphical models to describe how changes in the motion of helium atoms cause the balloons to shrink and expand when air temperature changes. The item aligns to both DCIs because students must use knowledge that gases are made of atoms that are moving relative to each other and that energy is transferred when there is a temperature difference between a balloon and the air around the balloon. The item aligns to the CCC because students must use cause and effect relationships between thermal energy transfer, particle motion, and temperature in their models and descriptions.

It is a very cold day in the middle of January and twin sisters Sara and Kara are excited to celebrate their birthday. They decide to buy helium-filled balloons for their birthday party. When they arrive at the store, they choose several large balloons.

As the girls walk home through the snow, they notice that the balloons shrink and become smaller even though there are no leaks in the balloons. However, after the girls take the balloons inside their home, the balloons return to their original size.

The girls wonder whether the change in the balloons was caused by the change in temperature. They find out that the temperature of the cold air outside their home is –2°C and the temperature of the warm air inside their home and the store is 21°C. They decide to use a model to show how temperature affects the size of a helium-filled balloon.

The stimulus for this item begins by presenting the phenomenon that the size of helium balloons depends on air temperature. The hook is that twin sisters are having a birthday with balloons. The phenomenon and hook are grade-level appropriate because many students have experience with balloons that shrink and expand.

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

28. **a.** Draw models to compare a helium-filled balloon in three locations: inside the store, outside during the walk home, and inside the home. In each model, be sure to include:

- the arrangement and spacing of the helium particles inside the balloon
- the temperature of the helium-filled balloon

b. Describe how the motion of the helium particles inside each balloon changes when the girls take the balloons out of the store to walk home. Be sure to include the reason for the change in motion.

c. Use your models and the motion of the helium particles to explain why the balloons become smaller during the walk home.

Part a is aligned to the SEP, DCI, and CCC. Students draw models that show the particles inside the balloons at different temperatures by using their content knowledge that gases are made of moving particles and that a temperature difference causes a transfer of energy and their understanding of the cause and effect relationship between temperature difference and energy transfer.

Part b is aligned to the DCI and CCC. Students use their content knowledge that gases are made of moving particles and that a temperature difference causes a transfer of energy and their understanding of the cause and effect relationship between temperature difference and energy transfer to describe the reason for changes in the balloon.

Part c is aligned to the SEP, DCI, and CCC. Students use their models and their content knowledge that gases are made of moving particles and the cause and effect relationship between decrease in temperature and change in particle motion to explain why the balloons shrink in colder air.

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 draws models to compare a helium-filled balloon in three locations: inside the store, outside during the walk home, and inside the home. Each model shows the arrangement, spacing, and motion of the helium atoms inside the balloon and the temperature of the helium-filled balloon. The response also describes what the models in part (a) show about the relationship between the temperature of the helium-filled balloon, the kinetic energy of the helium atoms, and the speed of the helium atoms, and uses the models to explain why the balloons are large inside the house and store but not outside during the walk home. 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.

Inside Home/Store T = 21°C	Outside During Walk Home T = –2°C
	

b. The particles move less/more slowly because (thermal) energy leaves the balloon/ the particles (atoms, helium) inside the balloon have less (kinetic) energy/ the temperature inside the balloon decreases.

c. In the colder balloon, the particles don't move as much and get closer together. The particles hit the balloon less hard and less often so the balloon gets smaller.

The scoring notes provide information expected for a full credit/4-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: MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

SEP: Constructing Explanations and Designing Solutions: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

DCI: PS3.D: Energy in Chemical Processes and Everyday Life: The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

CCC: Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

PE: MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.*]

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

DCI: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

CCC: Energy and Matter: The transfer of energy can be tracked as energy flows through a natural system.

Cluster Overview: Mushroom Matters

Item	Item Type	Alignment
28	Drag and Drop—Inline Choice	MS-LS2-3: SEP, DCI
28 PBT	Multiple Choice—Multiple Choice	MS-LS2-3: SEP, DCI
29	Multi-select	MS-LS2-3: DCI, CCC
30	Multiple Choice	MS-LS1-6: DCI, CCC
31	Multiple Choice—Inline Choice	MS-LS1-6: SEP, DCI, CCC
31 PBT	Multiple Choice—Multiple Choice	MS-LS1-6: SEP, DCI, CCC

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 alignment to all three dimensions of each PE.

Stimulus and Items on next pages

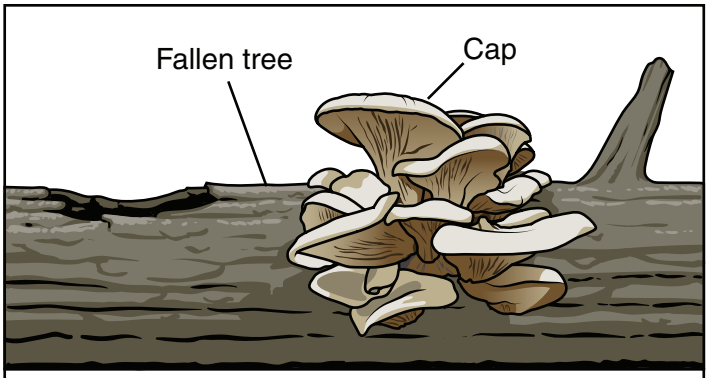
Read the information. Then answer the questions that follow.

Mushroom Matters

Xavier recently moved to a house near a forest. One day he notices large mushrooms growing on a fallen tree at the edge of the forest. He thinks this is strange because the mushrooms were not there the day before. He wonders how the mushrooms grew so quickly. He walks into the forest and observes many mushrooms that are growing on other fallen trees. He also observes a squirrel eating a mushroom. Xavier wonders about the role of mushrooms in the forest ecosystem.

Xavier researches mushrooms and learns that the mushrooms he observed are oyster mushrooms. He records some information about oyster mushrooms in the diagram.

Oyster Mushrooms



- Mushrooms often grow on fallen beech trees.
- Stems are inside the fallen tree.
- Caps are produced when conditions are favorable.
- Caps double in size every day until mature.

Xavier has many questions: How do mushrooms get energy from the fallen tree? How did the tree get the energy and mass to grow so tall? More generally, how do matter and energy move in this ecosystem near his new house?

The stimulus for this item begins by presenting the phenomenon that mushrooms can grow on a fallen tree. The hook is that a student recently moved to a house near the forest. The phenomenon and hook are grade-level appropriate because many students have seen forests, fallen trees, and growing mushrooms.

Item 28: Cluster Item

Next Generation Science Standards Description

PE: MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.*]

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

DCI: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Item Type: Drag and Drop—Inline Choice

Cognitive Complexity: Stimulus-Low | SEP-Med | DCI-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 living and nonliving parts of a forest ecosystem. The item aligns to the SEP by asking students to develop a graphical model to describe the movement of matter in the ecosystem. The item aligns to the DCI because students must use the knowledge that matter and atoms are cycled repeatedly during transfers between producers, consumers, decomposers, and nonliving parts of the ecosystem.

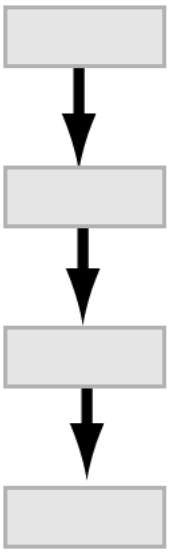
This question has two parts. Be sure to answer both parts of the question.

29. Xavier wants to make a model that shows how matter moves in the forest ecosystem.

Part a

Complete the model to show the movement of **matter** in the forest ecosystem.

Select the words and drag them into the correct spaces in the model. Not all words will be used.



Air
Mushroom
Soil
Squirrel
Sun
Tree

Part a is aligned to the SEP and the DCI. Students develop a model of the movement of matter by using their content knowledge of how matter is transferred between producers, consumers, decomposers, and nonliving parts of the ecosystem.

Part b

Select the words that describe matter in the forest ecosystem.

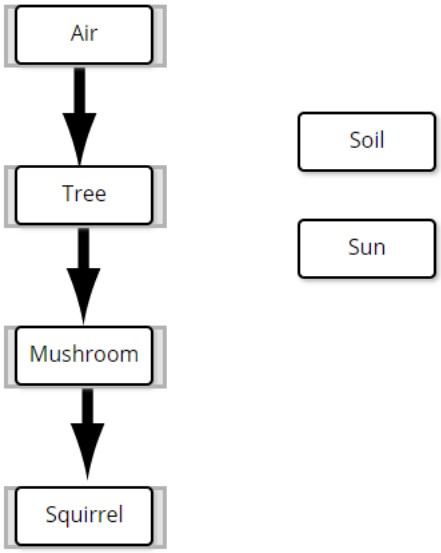
As matter moves through the ecosystem, the amount of matter [gets larger, gets smaller, stays the same].

Part b is aligned to the DCI. Students must use their content knowledge that as matter moves through the ecosystem, the atoms in the matter are repeatedly cycled in order to describe the forest ecosystem.

Scoring Key

Part a

Correct Response:



Part b

Correct Response:

As matter moves through the ecosystem, the amount of matter [gets larger, gets smaller, **stays the same**].

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

Item 28: PBT Cluster Item

Next Generation Science Standards Description

PE: MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.*]

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

DCI: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Item Type: Multiple Choice—Multiple Choice

Cognitive Complexity: Stimulus-Low | SEP-Med | DCI-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 living and nonliving parts of a forest ecosystem. The item aligns to the SEP by asking students to develop a graphical model to describe the movement of matter in the ecosystem. The item aligns to the DCI because students must use the knowledge that matter and atoms are cycled repeatedly during transfers between producers, consumers, decomposers, and nonliving parts of the ecosystem.

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

28. Xavier wants to make a model that shows how matter moves in the forest ecosystem.

Part a

Which model could Xavier make to **best** represent the movement of matter in the forest ecosystem?

A tree → air → soil → mushroom

B squirrel → air → mushroom → soil

C air → tree → mushroom → squirrel

D mushroom → air → squirrel → tree

Part a is aligned to the SEP and the DCI. Students develop a model of the movement of matter by using their content knowledge of how matter is transferred between producers, consumers, decomposers, and nonliving parts of the ecosystem.

Part b

Which statement **best** describes matter in the forest ecosystem?

A As matter moves through the ecosystem, the amount of matter gets larger.

B As matter moves through the ecosystem, the amount of matter gets smaller.

C As matter moves through the ecosystem, the number of atoms remains the same.

D As matter moves through the ecosystem, the types of atoms are constantly changing.

Part b is aligned to the DCI. Students must use their content knowledge that as matter moves through the ecosystem, the atoms in the matter are repeatedly cycled in order to describe the forest ecosystem.

Scoring Key

Part a
Correct Response: C

Part b
Correct Response: C

Distractor Rationales

Part a

A Matter is not transferred directly from air to soil.

B When a squirrel respires, carbon dioxide is released into the air, but mushrooms do not take in carbon dioxide from the air.

C KEY. Carbon dioxide in the air is taken in by trees during photosynthesis, which produces oxygen. Mushrooms use oxygen to perform cellular respiration and produce organic molecules. When a squirrel eats a mushroom, matter inside the mushroom is transferred to the squirrel.

D When a mushroom respires, carbon dioxide is released into the air, but squirrels do not take in carbon dioxide from the air.

Part b

A As matter moves through the ecosystem, matter moves into and out of objects and organisms but the objects and organisms do not add matter to the system.

B The amount of matter stays the same as matter moves through the ecosystem.

C KEY: The amount of matter stays the same as matter moves through the ecosystem, and therefore the number of atoms stays the same.

D The groupings of atoms change, but the types of atoms stay the same, as matter moves through objects and organisms in the ecosystem.

Item 29: Cluster Item

Next Generation Science Standards Description

PE: MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [*Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.*]

DCI: LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

CCC: Energy and Matter: The transfer of energy can be tracked as energy flows through a natural system.

Item Type: Multi-select

Cognitive Complexity: Stimulus-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 evaluate a claim about the cycling of matter and flow of energy among living and nonliving parts of a forest ecosystem. The item aligns to the DCI because students must use knowledge that matter is transferred into and out of the physical environment as matter and energy are transferred between producers and consumers in the ecosystem. The item aligns to the CCC because students must use energy flow through the ecosystem to track transfers of energy.

29. As Xavier thinks about the forest ecosystem, he claims that matter and energy move between living and nonliving parts of the ecosystem.

Which **four** pieces of evidence support Xavier's claim?

A Plants take in matter from the air.

B Plants take in energy from the Sun.

C Animals use energy from food to survive.

D Plants and animals need water to survive.

E Animals release waste matter as they grow.

This item is aligned to the DCI and CCC. Students identify evidence that supports a claim by using their content knowledge that matter is transferred into and out of the physical environment as matter and energy are transferred between plants and animals and the understanding that energy flow through the ecosystem can be used to track transfers of energy.

Scoring Key

Correct Responses: A, B, D, E

Distractor Rationales

A **KEY: Living plants take in carbon dioxide from nonliving air.**

B **KEY: Living plants take in light energy from the nonliving Sun.**

C Both animals and the food they take in are, or were, living.

D **KEY: Living plants and animals take in nonliving water.**

E **KEY: Living animals breathe out nonliving carbon dioxide and other waste materials.**

Item 30: Cluster Item

Next Generation Science Standards Description

PE: MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

DCI: PS3.D: Energy in Chemical Processes and Everyday Life: The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

CCC: Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Item Type: Multiple Choice

Cognitive Complexity: Stimulus-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 describe the role of photosynthesis in the cycling of matter into trees. The item aligns to both DCIs because students must use knowledge of how plants use the energy from light and carbon dioxide from the atmosphere during photosynthesis to produce complex carbon-based organic molecules that are stored for growth. The item aligns to the CCC because students must use the understanding that the transfer of energy during photosynthesis drives the motion of matter into trees.

30. Which statement describes how trees get the matter that makes them so tall?

A Trees use carbon dioxide from the soil to make air and water molecules that are stored in the trees.

B Tree roots take in soil molecules that are used to make carbon dioxide molecules that are stored in the trees.

C Tree leaves take in oxygen and water molecules that are used to make new molecules that are stored in the trees.

D Trees use carbon dioxide from the air and water from the soil to make new molecules that are stored in the trees.

This item is aligned to the DCI and CCC. Students use the understanding that the transfer of energy during photosynthesis drives the motion of matter into trees and their content knowledge that trees use carbon dioxide taken in during photosynthesis to form carbon-containing molecules that are stored in the trees.

Scoring Key

Correct Response: D

Distractor Rationales

A Trees take in carbon dioxide from the air with their leaves, not from the soil with their roots. Trees do not store air molecules. Students who choose this option have the misconception that trees eat dirt.

B Trees do not make carbon dioxide from soil nor do they store carbon dioxide.

C Trees produce oxygen, they do not take in oxygen.

D KEY: During photosynthesis, trees use carbon dioxide and water that they take in to produce sugars that they store.

Item 31: Cluster Item

Next Generation Science Standards Description

PE: MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

SEP: Constructing Explanations and Designing Solutions: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D: Energy in Chemical Processes and Everyday Life: The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

CCC: Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Item Type: Multiple Choice—Inline Choice

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

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to construct an explanation based on the role of photosynthesis in the cycling of matter and flow of energy into and out of plants and animals in a forest ecosystem. The item aligns to the SEP by asking students to construct an explanation based on evidence. The item aligns to both DCIs because students must use knowledge of how plants use the energy from light and carbon dioxide from the atmosphere during photosynthesis to produce complex carbon-based organic molecules, some of which are stored for later use by animals. The item aligns to the CCC because students must use the understanding that the transfer of energy drives the cycling of the matter between plants and animals in the forest ecosystem.

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

31. Xavier thinks about energy and other parts of the forest ecosystem.

Part a

Which statement **best** describes how animals depend on plants for energy?

A Plants give off energy that animals use for protection.

B Plants take in energy that animals use for reproduction.

C Plants store energy in molecules that animals use for growth.

D Plants release energy in molecules that animals use for warmth.

Part b

Select the words that describe a reason for the answer in Part (a).

Plants get their energy directly from [sunlight, food].

Animals get their energy directly from [sunlight, food].

Part a is aligned to the SEP, DCI, and CCC. Students use their content knowledge that sugars made by plants during photosynthesis are later used by animals for food and the understanding that the transfer of energy drives the cycling of the matter between plants and animals as evidence to explain how energy from sunlight is transferred to animals in the sugars made by the plants.

Part b is aligned to the SEP and CCC. Students identify evidence that supports their explanation by using their understanding that sunlight provides energy for plants that is then transferred to animals to provide them with energy.

Scoring Key

Part a
Correct Response: C

Part b
Correct Response:
Plants get their energy directly from [**sunlight**, food].
Animals get their energy directly from [sunlight, **food**].

Distractor Rationales

Part a

A Plants take in energy that animals use for food.

B Animals do not use the energy in sunlight for reproduction.

C KEY: Animals get energy to grow from food that is produced by plants.

D Plants store energy in molecules that animals use.

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

Item 31: PBT Cluster Item

Next Generation Science Standards Description

PE: MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [*Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.*]

SEP: Constructing Explanations and Designing Solutions: Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D: Energy in Chemical Processes and Everyday Life: The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen.

CCC: Energy and Matter: Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Item Type: Multiple Choice—Multiple Choice

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

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to construct an explanation based on the role of photosynthesis in the cycling of matter and flow of energy into and out of plants and animals in a forest ecosystem. The item aligns to the SEP by asking students to construct an explanation based on evidence. The item aligns to both DCIs because students must use knowledge of how plants use the energy from light and carbon dioxide from the atmosphere during photosynthesis to produce complex carbon-based organic molecules, some of which are stored for later use by animals. The item aligns to the CCC because students must use the understanding that the transfer of energy drives the cycling of the matter between plants and animals in the forest ecosystem.

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

31. Xavier thinks about energy and other parts of the forest ecosystem.

Part a

Which statement **best** describes how animals depend on plants for energy?

A Plants give off energy that animals use for protection.

B Plants take in energy that animals use for reproduction.

C Plants store energy in molecules that animals use for growth.

D Plants release energy in molecules that animals use for warmth.

Part b

Which statement describes a reason for the answer in Part (a)?

A Plants get their energy directly from food, and animals get their energy directly from sunlight.

B Plants get their energy directly from sunlight, and animals get their energy directly from food.

C Plants get their energy directly from food, and animals get their energy directly from food.

D Plants get their energy directly from sunlight, and animals get their energy directly from sunlight.

Part a is aligned to the SEP, DCI, and CCC. Students use their content knowledge that sugars made by plants during photosynthesis are later used by animals for food and the understanding that the transfer of energy drives the cycling of the matter between plants and animals as evidence to explain how energy from sunlight is transferred to animals in the sugars made by the plants.

Part b is aligned to the SEP and CCC. Students identify evidence that supports their explanation by using their understanding that sunlight provides energy for plants that is then transferred to animals to provide them with energy.

Scoring Key

Part a
Correct Response: C

Part b
Correct Response: B

Distractor Rationales

Part a

A Plants take in energy that animals use for food.

B Animals do not use the energy in sunlight for reproduction.

C KEY: Animals get energy to grow from food that is produced by plants.

D Plants store energy in molecules that animals use.

Part b

A Plants get their energy directly from sunlight and animals get their energy from food.

B KEY: Plants get the energy they need to live from sunlight, while animals get the energy they need to live from food.

C Plants get their energy from sunlight, not food.

D Animals get their energy directly from food, not sunlight.

Items 32–35: Cluster: Stimulus and Items

Next Generation Science Standards Description

PE: MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*]

SEP: Planning and Carrying Out Investigations: Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

DCI: ESS2.C: The Roles of Water in Earth's Surface Processes: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

DCI: ESS2.D: Weather and Climate: Because these patterns are so complex, weather can only be predicted probabilistically.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural **or designed systems.**

PE: MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in findings.

DCI: ESS3.B: Natural Hazards: Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.

CCC: Patterns: Graphs, charts, and images can be used to identify patterns in data.

Cluster Overview: Severe Weather

Item	Item Type	Alignment
32	Multiple Choice	MS-ESS2-5: DCI, CCC
33	Multi-select	MS-ESS3-2: SEP, DCI, CCC
34	Multiple Choice—Multiple Choice	MS-ESS2-5: SEP, DCI
35	Multiple Choice—Multiple Choice	MS-ESS2-5: 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, and collectively the whole cluster has strong alignment to all three dimensions of each PE.

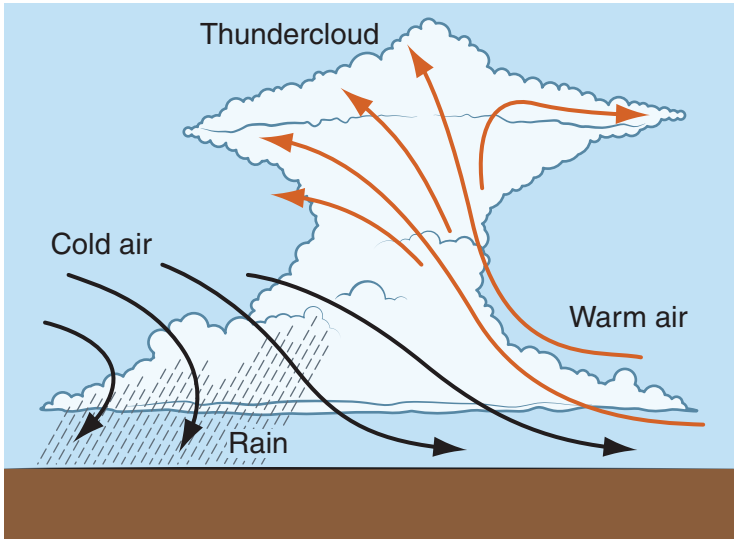
Read the information. Then answer the questions that follow.

Severe Weather

Brian hears on the radio that a powerful thunderstorm is predicted to arrive in his neighborhood. His family prepares for the storm by making sure they have flashlights with new batteries, fresh water, and a first aid kit. Shortly after the thunderstorm arrives, Brian's neighborhood loses electrical power for several hours because of tree branches that were blown onto power lines. Brian wonders how scientists were able to predict that a thunderstorm was going to occur. When the power returns, Brian researches how thunderstorms form.

He finds out that a thunderstorm can happen when a cold air mass and a warm air mass collide. The warm air rises over the cold air, as shown in the diagram.

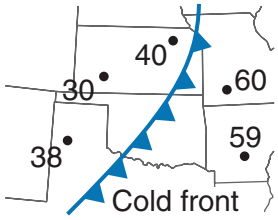
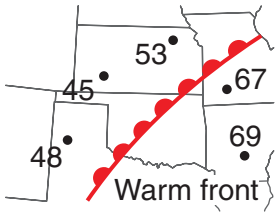
Thunderstorm Formation

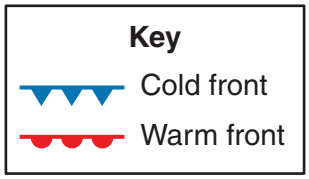


The stimulus for this cluster begins by presenting the phenomenon that powerful thunderstorms can be predicted. The hook is that a student hears about a predicted storm that then causes his neighborhood to lose power. The phenomenon and hook are grade-level appropriate because many students have experienced or heard about powerful storms that cause power outages.

Brian decides to investigate the weather changes that cause different types of storms. He found a table with weather maps and information about different types of weather changes.

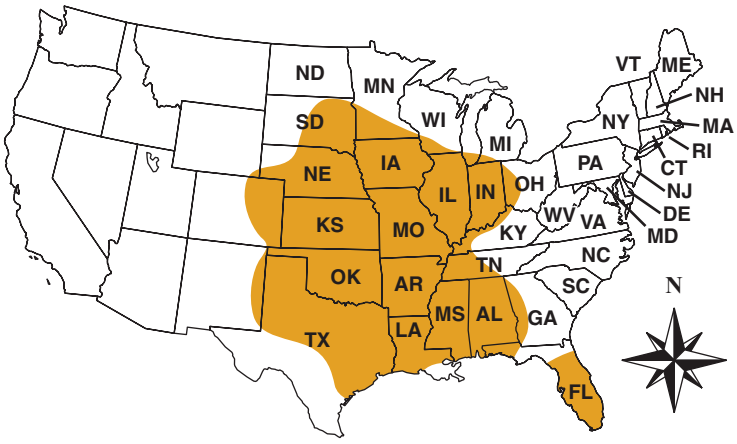
Weather Changes

Cause	Type of Change	Weather Map
Cold front	• Lower temperature after the front • Thunderstorm	
Warm front	• Warmer temperature after the front • Light rain	



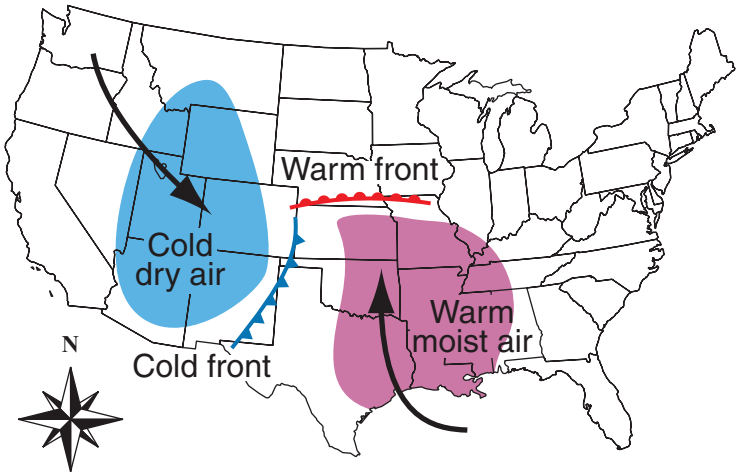
The next day, Brian travels to Oklahoma to visit a friend and finds that his friend's city is under a tornado warning. Brian's friend tells him that Oklahoma is part of "Tornado Alley" and that tornadoes are air masses that can be a few kilometers wide and have very strong winds rotating at very high speeds. Tornado Alley, the region of the United States with the most tornadoes, is shaded dark gray on the map.

Tornadoes in the United States



Tornadoes often happen in areas with thunderstorms, but not all areas that have thunderstorms have tornadoes. Air masses that move in opposite directions across the United States frequently meet in Tornado Alley. The diagram shows how colliding air masses can form tornadoes.

Tornado Formation



Item 32: Cluster Item

Next Generation Science Standards Description

PE: MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*]

DCI: ESS2.C: The Roles of Water in Earth's Surface Processes: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

CCC: Cause and Effect: Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Item Type: Multiple Choice

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

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to use evidence to describe how the motions and interactions of air masses result in the formation of a thunderstorm. The item aligns to the DCI because students must use knowledge that local weather patterns are determined by winds causing water in the atmosphere to move. The item aligns to the CCC because students must use cause and effect relationships between air temperature, humidity, and air movement to explain how a thunderstorm forms.

32. Which description of thunderstorm formation is supported by the diagram?

A As warm air moves over cold air, the air cools and holds less water.

B As warm air moves over cold air, the air warms and becomes a cloud.

C As cold air moves under warm air, the air cools and moves more slowly.

D As cold air moves under warm air, the air warms and falls toward the ground.

This item is aligned to the DCI and the CCC. Students describe a cause and effect relationship that results in the thunderstorm formation by using their content knowledge of how local weather patterns are determined by winds that move water in the atmosphere.

Scoring Key

Correct Response: A

Distractor Rationales

A **KEY: As warm air rises, some of the water vapor in the air cools and condenses and falls as rain.**

B Rising air becomes cooler, not warmer, and the cloud forms as water in cooler air condenses and becomes the liquid water droplets that form a cloud.

C Falling air would become warmer, not cooler. This falling air causes powerful and fast, not slow, wind.

D If the air did become warmer, the air would rise, not fall.

Item 33: Cluster Item

Next Generation Science Standards Description

PE: MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in findings.

DCI: ESS3.B: Natural Hazards: Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.

CCC: Patterns: Graphs, charts, and images can be used to identify patterns in data.

Item Type: Multi-select

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

Number of Points: 1

Item on next page

This item brings students into the story line by asking them to use data to predict when a tornado might form. The item aligns to the SEP by asking students to analyze and interpret data in order to determine similarities in the weather conditions that precede tornadoes. The item aligns to the DCI because students must use knowledge that the history of tornado formation in a region can help forecast the likelihood of future tornadoes. The item aligns to the CCC because students must use maps and diagrams to identify patterns in data and make their prediction.

33. After visiting his friend in Oklahoma during a tornado warning, Brian wants to be able to predict the likelihood of a tornado forming on a given day.

Based on the Tornado Formation diagram, which **three** weather conditions could lead Brian to predict that a tornado might form?

A low humidity

B high humidity

C cool temperatures

D warm temperatures

E cold air mass moving in

F moist air mass moving out

This item is aligned to the SEP, DCI, and CCC. Students analyze and interpret data to determine weather conditions that predict tornado formation by using their content knowledge of the history of tornado formation based on patterns in maps that can be used to make predictions.

Scoring Key

Correct Responses: B, D, E

Distractor Rationales

A Tornado Alley and the formation diagram overlap where air is moist, not dry.

B KEY: Tornado Alley and the formation diagram overlap where air is moist and humidity is high.

C Tornado Alley and the formation diagram overlap where air is warm, not cool.

D KEY: Tornado Alley and the formation diagram overlap where air is warm.

E KEY: Tornado Alley and the formation diagram overlap where a cold front is moving in.

F Tornado Alley and the formation diagram overlap where a warm front is moving in, not out.

Item 34: Cluster Item

Next Generation Science Standards Description

PE: MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [*Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.*]

SEP: Planning and Carrying Out Investigations: Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

DCI: ESS2.C: The Roles of Water in Earth's Surface Processes: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

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 identify data that provide evidence of what causes air masses to move. The item aligns to the SEP by asking students to describe which data could serve as evidence to answer the question of what causes air masses to move. The item aligns to the DCI because students must use the understanding that changes in air pressure determine local weather patterns.

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

34. **Part a**

Which factor causes air masses to move?

A differences in rainfall

B differences in humidity

C differences in pressure

D differences in wind speed

Part a is aligned to the DCI. Students identify the cause of air mass motion by using their content knowledge that differences in air pressure cause changes in wind.

Part b

Which data could Brian collect to support the answer to Part (a)?

A data showing the speeds of warm and cold air masses

B data showing that the air is more humid after a rainstorm

C data showing the amount of rainfall when air masses collide

D data showing that warm air and cold air have different pressures

Part b is aligned to the SEP and the DCI. Students use their content knowledge of the pattern of changes in wind caused by changes in air pressure as temperature changes to identify data they could collect and use as evidence to answer the question about what causes air masses to move.

Scoring Key

Part a
Correct Response: C

Part b
Correct Response: D

Distractor Rationales

Part a

A Rain is caused by a change in weather which is caused by moving air masses. Rain is the result of moving air masses, not the reason the air masses move.

B Humidity changes because air masses are moving. Changing humidity does not cause air masses to move.

C KEY: Air moves from higher to lower pressure, so a difference in pressure causes air to move toward lower pressure.

D Differences in wind speed happen because the motion of air masses is changing, not vice versa.

Part b

A These data would describe the motion, not the cause of the motion.

B These data do not explain the motion of the air masses that caused the rainstorm.

C These data would give information about the amount of water in the air masses, but no information on why the air masses were moving before they collided.

D KEY: The pressure differences that make air masses move are caused by temperature differences, which are caused by the uneven heating of Earth.

Item 35: Cluster Item

Next Generation Science Standards Description

PE: MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

SEP: Analyzing and Interpreting Data: Analyze and interpret data to determine similarities and differences in findings.

DCI: ESS3.B: Natural Hazards: Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.

Item Type: Multiple Choice—Multiple Choice

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

Number of Points: 2

Item on next page

This item brings students into the story line by asking them to consider how data on thunderstorms and tornadoes can inform the use of high-resolution radar technology to mitigate the effects of these weather hazards on communities and states. The item aligns to the SEP by asking students to analyze and interpret data to determine how and where the improved technology should be used. The item aligns to the DCI because students must use knowledge of how mapping historical data can help forecast the locations and likelihood of future thunderstorms and tornadoes.

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

35. High-resolution radar technology is used to detect thunderstorms and tornadoes.

Part a

Which statement describes a possible impact of high-resolution radar technology on communities?

A The technology can give people more time to move to a shelter.

B The technology can provide communities more resources to build shelters.

C The technology can decrease the number of people who live near the storms.

D The technology can increase the sizes of the air masses involved in the storms.

Part a is aligned to the DCI. Students use their content knowledge of the importance of forecasting future storms to describe an effect of using improved technology to mitigate the effect of thunderstorms.

Part b

Which state could benefit the **most** from high-resolution radar technology?

A Ohio (OH)

B Arkansas (AR)

C Tennessee (TN)

D North Dakota (ND)

Part b is aligned to the SEP and the DCI. Students use their content knowledge that historical data in thunderstorms and tornadoes can help forecast the locations and likelihood of future storms and can be analyzed and interpreted to determine the state most likely to benefit from improved detection technology.

Scoring Key

Part a
Correct Response: A

Part b
Correct Response: B

Distractor Rationales

Part a

- **A KEY: Better detection could warn people sooner and give them more time to move to a shelter.**
- B Better detection cannot provide more funding or shelters.
- C Better detection could make people more confident and increase, not decrease, the number of people who live near storms.
- D Better detection cannot change the size of air masses that move across the country.

Part b

- A Fewer tornadoes happen in OH than in states inside Tornado Alley.
- **B KEY: AR is completely inside Tornado Alley.**
- C TN is only partially inside Tornado Alley, so there will be fewer tornadoes in TN than in AR.
- D Like OH, ND is not in Tornado Alley and so has few tornadoes.