DC SCIENCE ASSESSMENT ITEM WRITING GUIDE

DC Science Assessment Grade 8

June 21, 2021

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Introduction

This document will review two item sets developed for assessment of Next Generation Science Standards (NGSS) at grade 8. The document will discuss the alignment and features of the sets.

Purpose

The purpose of this document is to provide educators with examples and in-depth modeling of the necessary features of NGSS-aligned item sets.

How to Use This Tool

In this document, there are two item sets of six items each. This document will go into detail about how each item is aligned with NGSS standards and Performance Level Descriptors (PLDs), and how the sets meet specified criteria. Each item set in this document also has an associated classroom activity that relates to the standards for the item sets modeled.

The examples provided here may be a helpful guide during the development of your own NGSS-aligned item sets and classroom activities.

Grade 8 - Item Set 1 *Creek Flooding in Western Washington*

Performance Expectations (PEs) and Dimensions aligned to in this set

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).]

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.

SEP: Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
Analyze and interpret data to determine similarities and differences in findings.

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

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

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

SEP: Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).Construct 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.

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

Performance Level Descriptors

For a list of all performance level indicators, please see Appendix A.
This table shows the PEs, PLD level, and NGSS dimensions that each of the 6 items in the cluster aligns to.

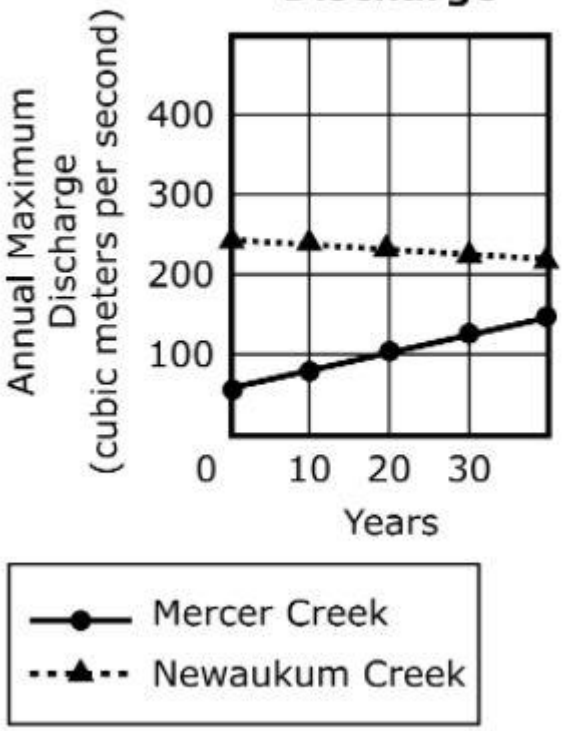
ITEM	PE	PLD LEVEL	SEP	DCI	CCC
Item 1	MS-ESS3-2	3	Analyzing and Interpreting Data	ESS3.B	Patterns
Item 2	MS-ESS3-4	2	Engaging in Argument from Evidence		Cause and Effect
Item 3	MS-ESS3-2	3	Analyzing and Interpreting Data	ESS3.B	Patterns
Item 4	MS-ESS3-4	3	Engaging in Argument from Evidence	ESS3.C	Cause and Effect
Item 5	MS-ESS3-4	3	Engaging in Argument from Evidence	ESS3.C	Cause and Effect
Item 6	MS-ESS3-2	3	Analyzing and Interpreting Data	ESS3.B	Patterns

Stimulus

Scientists studying Mercer Creek and Newaukum Creek in the state of Washington noticed that there was a difference in the flood risks for the two creeks. They compared the flood risks, land surfaces, and human population trends in the regions around the two creeks. The scientists plan to use the results of the study to design a solution to control flood risk in the affected communities.

The scientists studied the annual maximum discharge for the two creeks. Discharge is the volume of water moving down a creek per unit of time. This measurement shows the size of the largest flood year. Figure 1 shows the trends over time found in the annual maximum discharge study of the two creeks.

Figure 1. Annual Maximum Creek Discharge



Source: USGS, 2002

The scientists then compared the road densities of the regions around the two creeks. Road density is the number of kilometers of road per square kilometer of land. Table 1 compares the road densities of the two regions.

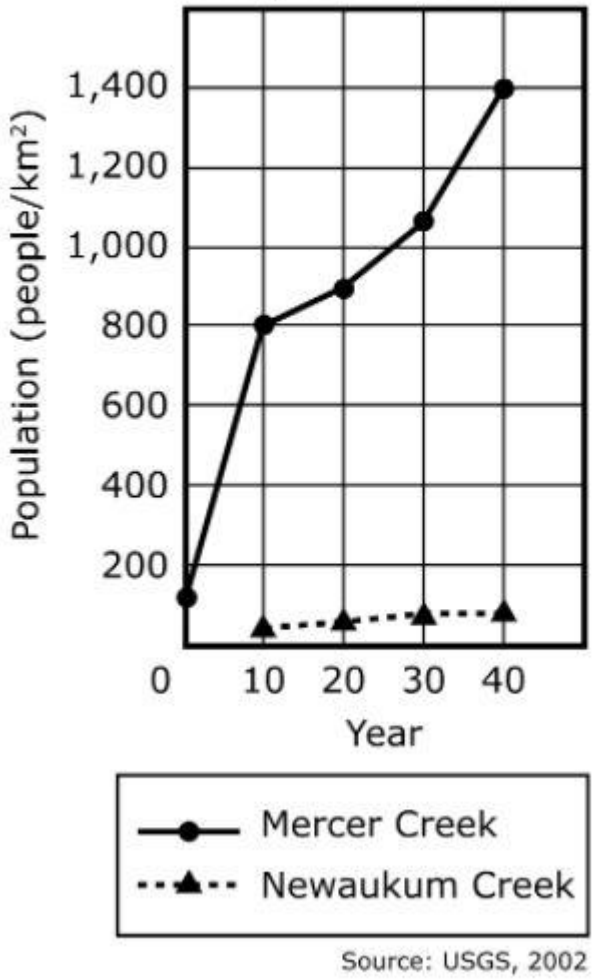
Table 1. Road Density Near the Creeks

Creek	Road Density (km/km^2)
Mercer Creek	9.1
Newaukum Creek	2.6

Source: USGS, 2002

Because the human population affects the road density in a region, the scientists next considered the human population in the regions around the creeks. Figure 2 shows the trends in the human population in the regions around the two creeks over time.

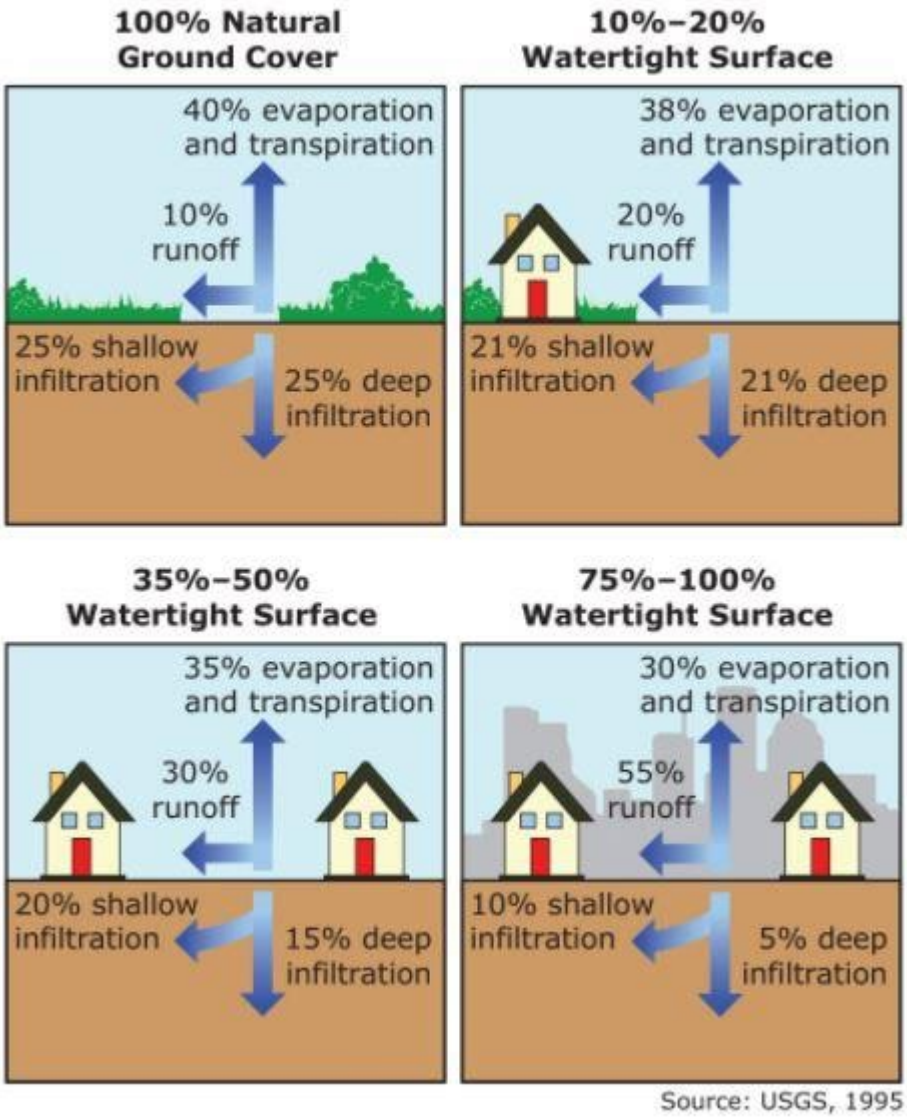
Figure 2. Population Density Near the Creeks



Source: USGS, 2002

Infiltration occurs when precipitation of surface runoff absorbs into the soil. The infiltration rate is the amount of water, in centimeters, that the surface absorbs per minute. The scientists created Figure 3 to show how land use affects the infiltration of rainwater from a storm. The percentages represent the proportion of rainwater that infiltrates the soil, enters the atmosphere, or becomes surface runoff. A watertight surface prevents water from being absorbed into the ground.

Figure 3. The Effects of Land Use on Rainwater Infiltration



Source: USGS, 1995

Finally, the scientists considered designing new road surfaces to reduce the flood risk around the creeks. Three different types of road surfaces and their infiltration rates are shown in Table 2.

Table 2. Infiltration Rate of Different Road Surfaces

Surface	Infiltration Rate (cm/min)
Porous asphalt	0.05
Dirt	0.14
Porous concrete	0.68

Source: American Society of Civil Engineers

Items

Item 1

Which flood-risk forecast is **best** supported by the trends shown in Figure 1?

- A. The flood risk will greatly decrease for both Mercer Creek and Newaukum Creek.
- B. The flood risk will continue to increase for both Mercer Creek and Newaukum Creek.
- C. The flood risk will greatly decrease for Mercer Creek and will stay about the same for Newaukum Creek.
- D. The flood risk will continue to increase for Mercer Creek and will decrease slightly for Newaukum Creek.

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).]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses data on the history of natural hazards and an understanding of related geologic forces to forecast the locations and likelihoods of future events in relation to a phenomenon.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student analyzes and interprets data to provide evidence for phenomena, to determine similarities and differences in findings, and/or to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses graphs, charts and/or images to identify quantitative patterns in data and/or identify cause and effect relationships in relation to the explanation of a phenomenon.

Metadata

NGSS PE Alignment	MS-ESS3-2
Dimensions	DCI: ESS3.B: Natural Hazards SEP: Analyzing and Interpreting Data CCC: Patterns
PLD Level	3
Points	1
Key	D
Calculator	No

Alignment Analysis

This item aligns to the DCI ESS3.B. For a PLD 3 item, "The student uses data on the history of natural hazards and an understanding of related geologic forces to forecast the locations and likelihoods of future events." In this case, the data in Figure 1 is being used to forecast the likelihood of future flooding events.

Additionally, the item has a SEP alignment with Analyzing and Interpreting Data. For a PLD 3 item, the student "interprets data to provide evidence for phenomena, to determine similarities and differences in findings." Here that is accomplished through the comparison between the two creeks.

Finally, the item has a CCC alignment with Patterns. For a PLD 3 item, the student needs to interpret patterns on graphs, as was done with the flood data in Figure 1.

Relationship to Stimulus

This item requires information from Figure 1 to be answered, including interpretation of the slope of that graph.

Relationship to Phenomenon

The phenomenon revolves around understanding the differences between the two creeks and the solutions that may solve the flooding problems. Being able to understand the likely future of the two areas is an important piece of crafting solutions.

Item 2

The students use Table 1 and Figure 2 to compare the trends in population and the trends in road development in the two regions. Which claim can the students correctly make?

- A. Both creek regions had stable populations, so the same amount of land was used to build roads in both creek regions.
- B. Both creek regions had population increases, so the same amount of land was used to build roads in both creek regions.
- C. Newaukum Creek had a more stable population, so more land was used to build roads in this region than in the Mercer Creek region.
- D. Mercer Creek had a larger population increase, so more land was used to build roads in this region than in the Newaukum Creek region.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
[Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Levels	SEP Statements
Level 2	The student makes a claim supported by relevant evidence in relation to an explanation or a model for a phenomenon.

Levels	CCC Statements
Level 2	The student identifies a cause and effect relationship in nature.

Metadata

NGSS PE Alignment	MS-ESS3-4
Dimensions	SEP: Engaging in Argument from Evidence CCC: Cause and Effect
PLD Level	2
Key	D
Points	1
Calculator	No

Alignment Analysis

This item aligns with the SEP at PLD 2. In this case, the claim is regarding a cause-and-effect relationship between population growth and road development. Data from Table 1 and Figure 2 provide the evidence for the claim.
For the CCC alignment with Cause and Effect, the relationship between population growth and road construction was identified.

Relationship to Stimulus

The stimulus is needed for the two sources of data, Table 1 and Figure 2, necessary to answer the item.

Relationship to Phenomenon

The phenomenon includes the need for a solution that will be affected by the trends in population and road construction.

Item 3

Use Table 1 and Figure 2 to predict the trends in human population and flood risk if road development increases in the Mercer Creek region.

Place a check mark in the circle to indicate your answer choice in each column.

	Human Population	**Flood Risk**
Will increase	○	○
Will decrease	○	○
Will stay the same	○	○

Rubric	
Score	Description
1	Human population: **Will increase** Flood risk: **Will increase**
0	The response is incorrect or irrelevant.

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).]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses data on the history of natural hazards and an understanding of related geologic forces to forecast the locations and likelihoods of future events in relation to a phenomenon.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student analyzes and interprets data to provide evidence for phenomena, to determine similarities and differences in findings, and/or to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses graphs, charts and/or images to identify quantitative patterns in data and/or identify cause and effect relationships in relation to the explanation of a phenomenon.

Metadata

NGSS PE Alignment	MS-ESS3-2
Dimensions	DCI: ESS3.B: Natural Hazards SEP: Analyzing and Interpreting Data CCC: Patterns
PLD Level	3
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI ESS3.B. For a PLD 3 item, the student uses evidence from the flood data, population data, and changes in road density to forecast trends in human population and flood risk. As students are also analyzing data to identify patterns in relation to flooding, the CCC and SEP are addressed in a very integrated manner.

Relationship to Stimulus

The text of the stimulus provides evidence of the relationship between flooding and population increase that is used to answer this item.

Relationship to Phenomenon

Understanding of the causes of flooding is central here and is used to forecast future flooding, as well as provide context for potential solutions.

Item 4

Complete the argument about flood risk around the creeks.

Circle the correct answers from the lists to complete the sentences.

Based on Figure 3, as humans use more land resources for urban development, the amount of rainwater that infiltrates the soil

increases decreases stays the same	. This results in	an increase a decrease no change	in surface runoff.

Rubric	
Score	Description
2	Based on Figure 3, as humans use more land resources for urban development, the amount of rainwater that infiltrates the soil **decreases**. This results in **an increase** in surface runoff.
0	The response is incorrect or irrelevant.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student constructs arguments supported by evidence to support or refute an explanation or a model for a phenomenon.

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that 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.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses cause and effect relationships to explain phenomena.

Metadata

NGSS PE Alignment	MS-ESS3-4
Dimensions	DCI: ESS3.C: Human Impacts on Earth Systems SEP: Engaging in Argument from Evidence CCC: Cause and Effect
PLD Level	3
Key	See rubric above
Points	2
Calculator	No

Alignment Analysis

This item aligns with DCI ESS3.C For a PLD 3 item because students are using evidence from the stimulus to describe how human populations affect the consumption of natural resources and lead to negative effects on Earth.
For the SEP, students are required to use evidence from Figure 3 to support the model that increased road density has led to more flooding. Because the causes here are tied to increases in population, it aligns to the DCI, and students connect the increasing population to increases in negative impacts.

The CCC is covered because the cause (increased roads) and effect (increased flooding) relationship is used to explain the phenomenon.

Relationship to Stimulus

The model for infiltration in Figure 3 is essential to answering these questions, as well as the population and road data that show how things have changed over time.

Relationship to Phenomenon

This item is essential to explaining the increase in flooding and highlights the ideas that would need to be addressed to solve the problem.

Item 5

A student makes an argument that urbanization decreases the risk of floods that cause damage to land resources.

Based on the evidence in Figures 1, 2, and 3, determine whether the student's claim is supported.

Write the answers in the correct boxes. Not all answers will be used.

First Blank	Second Blank
A. is supported	C. an increasing annual maximum discharge
B. is not supported	D. more water infiltration at its surface

This claim [ ] by the evidence, because the evidence shows that the Mercer Creek region has [ ] compared with the Newaukum Creek region.

Rubric	
Score	Description
1	This claim **is not supported** by the evidence, because the evidence shows that the Mercer Creek region has **an increasing annual maximum discharge** compared with the Newaukum Creek region.
0	The response is incorrect or irrelevant.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student constructs arguments supported by evidence to support or refute an explanation or a model for a phenomenon.

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that 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.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses cause and effect relationships to explain phenomena.

Metadata

NGSS PE Alignment	MS-ESS3-4
Dimensions	DCI: ESS3.C: Human Impacts on Earth Systems SEP: Engaging in Argument from Evidence CCC: Cause and Effect
PLD Level	3
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns to DCI ESS3.C. For a PLD 3 item, the DCI alignment comes from the use of evidence (from Newaukum Creek) to explain the negative impacts of human actions (urbanization). Using this evidence also helps satisfy the SEP Engaging in Argument from Evidence. For the CCC, the cause (urbanization) and effect (flooding) are used to refute the proposed model.

Relationship to Stimulus

The student relies on the stimulus to produce evidence about specific areas and the changes in flooding over time.

Relationship to Phenomenon

This relates to the phenomenon because it clearly identifies the cause-and-effect relationships that would lead to the problem, and that would need to be considered in testing solutions to the flooding near these creeks.

Item 6 - Constructed Response

A major rainstorm occurred during late January in the regions of Mercer Creek and Newaukum Creek. The scientists monitored the water discharge for several days after the storm. They wanted to know why there were differences in the flooding trends between the two regions and how they could reduce the flooding risk.

- Explain how the trends in Figure 1 relate to the patterns of road density around the two creeks.
- Choose the road surface from Table 2 that will best control flooding, and explain why.
- Explain which creek region has a greater need to use this road surface.

Analyze the information carefully. Then write your answer in the space provided. Support your answer with details.

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).]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses data on the history of natural hazards and an understanding of related geologic forces to forecast the locations and likelihoods of future events in relation to a phenomenon.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student analyzes and interprets data to provide evidence for phenomena, to determine similarities and differences in findings, and/or to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses graphs, charts and/or images to identify quantitative patterns in data and/or identify cause and effect relationships in relation to the explanation of a phenomenon.

Exemplary Response

Bullet 1	Figure 1 shows that Mercer Creek's annual maximum creek discharge has been rapidly increasing over the past 40 years. This is likely due to the increasing road density in the region related to the rapidly increasing population density. As road density increases, rainwater infiltration of the ground decreases, so more rainwater runoff quickly flows into the creek. Newaukum Creek's annual maximum creek discharge has been slowly decreasing. The road density in that region is a lot lower by comparison due to the significantly lower population density.
Bullet 2	Porous concrete will best control flooding because it has the highest infiltration rate. This means that it quickly absorbs water into its surface.
Bullet 3	The Mercer Creek region has a much greater need for flood-control road surfaces than the Newaukum Creek region does. Mercer Creek has a greater road density, therefore the use of porous concrete for roads in this area would decrease the risk of flooding by allowing more water to be absorbed into the ground instead of running off into the creek and increasing creek discharge.

Metadata

NGSS PE Alignment	MS-ESS3.2
Dimensions	DCI: ESS3.B: Natural Hazards SEP: Analyzing and Interpreting Data CCC: Patterns
PLD Level	3
Key	See exemplary response above
Points	3
Calculator	No

Alignment Analysis

The first bullet best addresses the DCI, as the test-taker uses geological processes (infiltration) to explain a phenomenon and make predictions.

The SEP is hit because students must use patterns from Figures 1 and 2, along with data in Table 2 to determine the optimal solution - a more porous substance for road surfaces.

The students use the cause and effect relationship throughout (flooding caused by poor infiltration) to produce explanations, predictions, and solutions.

Relationship to Stimulus

The bullets here are tightly tied to the data on flood patterns, the porosity of different substances, and population change. They would be completely unanswerable without the cause and effect relationships established by the data in the stimulus.

Relationship to Phenomenon

This item allows the student to propose a solution to the problem stated in the phenomenon by choosing the best road surface for the areas near these creeks.

Notes about Constructed Response Items

Constructed response items are always aligned to all three dimensions. They require students to have an in-depth understanding of the phenomenon. The constructed response items require a mastery of all dimensions for a PLD level of at least 3, and preferably 4. Constructed response items should be answerable by the students within 5 minutes.

Analysis of Set as a Whole

This item cluster, as a whole, meets alignment requirements.

- *As a set, all dimensions of both PEs are covered within the set. ESS3-2 and ESS3-4 are covered three times each, with the DCIs being touched on twice (ESS3.C) and three times (ESS3.B). The two SEPs, Engaging in Argument from Evidence and Analyzing and Interpreting Data, are covered three times each with every item touching on one of the SEPs. This was possible largely because a rich collection of graphs and data were incorporated into the set. The two CCCs for this set, Patterns and Cause and Effect, are similarly covered three times each, and throughout the set. These interplayed with each other, as the patterns in data revealed the cause and effect relationships used by students to understand the phenomenon.*

- *The items included a single PLD 2 item, Item 2 - a multiple choice item. The rest of the items are all written to level 3 PLDs: Item 1 - multiple choice; Items 3-5 - all technology enhanced items; and item 6, the constructed response item. Note also that the only two-dimensional item is present early in the set, with the rest of the items reaching all three dimensions.*

- *The set covers the PEs in depth. The connection to three dimensions in so many items is not required for these sets but was made possible by a combination of PEs that shared common threads. The fact that natural disasters were being made more prominent as a result of human actions, and that data was able to support the conclusion made much of this possible.*

- *All the items in the set relate to the phenomenon of increased flooding and the challenge of identifying effects that were traceable back to human actions. Items 1, 2, and 3 focus on forecasting future changes based on patterns in data and establishing the connections to the population. Items 4 and 5 focus more on the infiltration of different surfaces, which allows the test-taker to connect the dots in the final item, identifying the types of road surfaces that would be most helpful in mitigating these effects.*

Aligned Classroom Task

Classroom Investigation to Support Mastery and Assessment of MS-ESS3-2 and MS-ESS3-4
Simulation: Effects of Road Building on Flooding

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).]

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Objectives

1. Uses data on the history of natural hazards and an understanding of related geologic forces to forecast the locations and likelihoods of future events in relation to a phenomenon. (MS-ESS3-2, DCI ESS3.B, PLD 3)
2. Uses evidence to explain that 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. (MS-ESS3-4, DCI ESS3.C, PLD 3)
3. Uses graphs, charts and/or images to identify quantitative patterns in data and/or identify cause and effect relationships in relation to the explanation of a phenomenon. (MS-ESS3-2, CCC Patterns, PLD 3)
4. Uses cause and effect relationships to explain phenomena. (MS-ESS3-4, CCC Cause & Effect, PLD 3)
5. Analyzes and interprets data to provide evidence for phenomena, to determine similarities and differences in findings, and/or to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success. (MS-ESS3-2, SEP DATA, PLD 3)
6. Constructs arguments supported by evidence to support or refute an explanation or a model for a phenomenon. (MS-ESS3-4, SEP ARGUMENT, PLD 3)

Phenomenon

The flooding risk in an area increases as more homes and roads are built.

Background

Many factors affect whether or not a river floods its banks. The stability of the soils in the banks of the river affects the extent of erosion and flooding. If soils are less stable, they can erode and wash away more easily and water is less readily contained within the banks. The number of roads in an area can decrease the stability of soils in an area and contribute to erosion and flooding. This is partly, but not entirely, due to a decrease in vegetation as trees are cleared to build the road. More roads are needed in areas where the human population is greater. Humans need roads to reach homes in remote areas and to drive to and from home and work or shopping areas. More roads in an area will increase the risk of flooding.

Gather Materials

- Stream table with sand (a simple one can be purchased or constructed, see reference below)
- Running water source for the table
- Model homes to place at various locations near the model "river" in the sand
- Flat pieces of wood to use as "roads" in the model
- Model trees or plants

Tasks

1. Set up the stream table with a river running down the middle.
2. Observe the flow rate of the water that is needed to cause the "river" to flood its banks.
3. Add homes to the table, 1 by 1, on each side of the river. Build a "road" to each of the homes. From time to time, you will need to remove trees to build the road.
4. Each time a home and road are added, observe the flow rate of the water that is needed to cause the 'river' to flood its banks.
5. Students record their results in a table such as that shown below.

Number of Homes	Number of Roads	Flow Rate Needed to Cause Flooding

References

Build Your Own Stream Table Example 1

Build Your Own Stream Table Example 2

Grade 8 - Item Set 2 *How do Horseshoe Crabs Find Females?*

Performance Expectations (PEs) and Dimensions aligned to in this set.

MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]

[*Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]

DCI: LS1.A: Structure and Function

In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

SEP: Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.

CCC: Systems and System Models

Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

[*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]

DCI: LS1.D: Information Processing

Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

SEP: Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods.

Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used and describe how they are supported or not supported by evidence.

CCC: Cause and Effect

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

Performance Level Descriptors

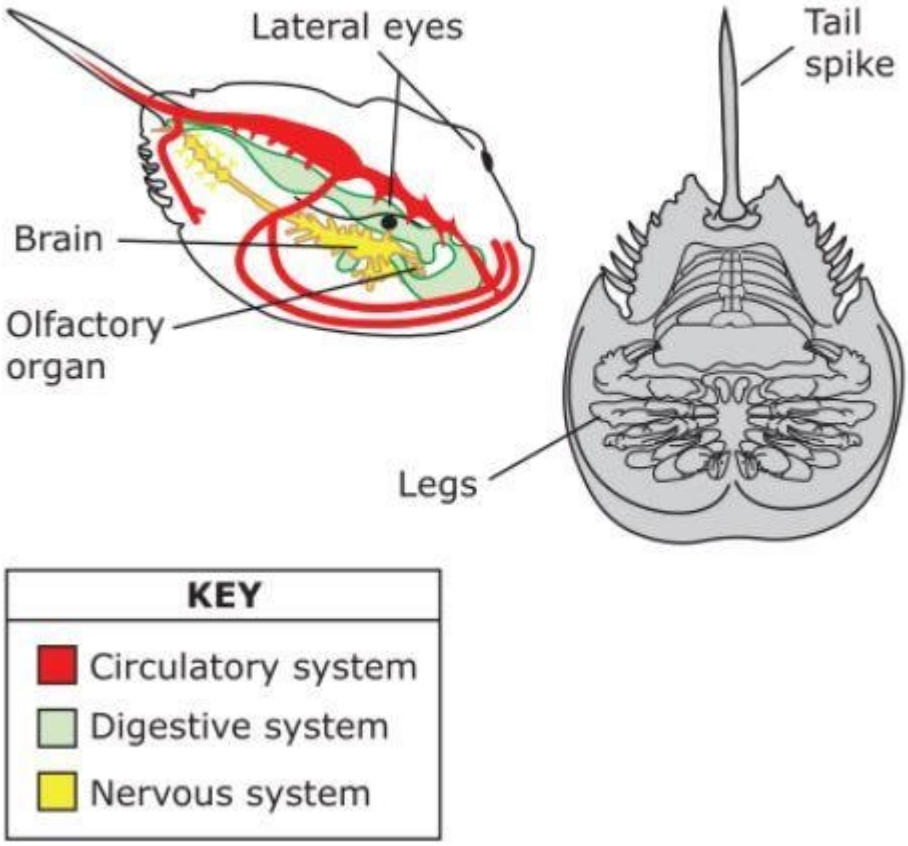
For a list of all performance level indicators, please see Appendix B.
This table describes item alignment to PEs, PLDs, and PLD level.

ITEM	PE	PLD LEVEL	SEP	DCI	CCC
Item 1	MS-LS1-8	2	Obtaining, Evaluating, and Communicating Information	LS1.D	Cause and Effect
Item 2	MS-LS1-3	2	Engaging in Argument from Evidence	LS1.A	
Item 3	MS-LS1-3	3	Engaging in Argument from Evidence	LS1.A	Systems and System Models
Item 4	MS-LS1-8	3		LS1.D	Cause and Effect
Item 5	MS-LS1-8	3	Obtaining, Evaluating, and Communicating Information	LS1.D	
Item 6	MS-LS1-3	3	Engaging in Argument from Evidence	LS1.A	Systems and System Models

Stimulus

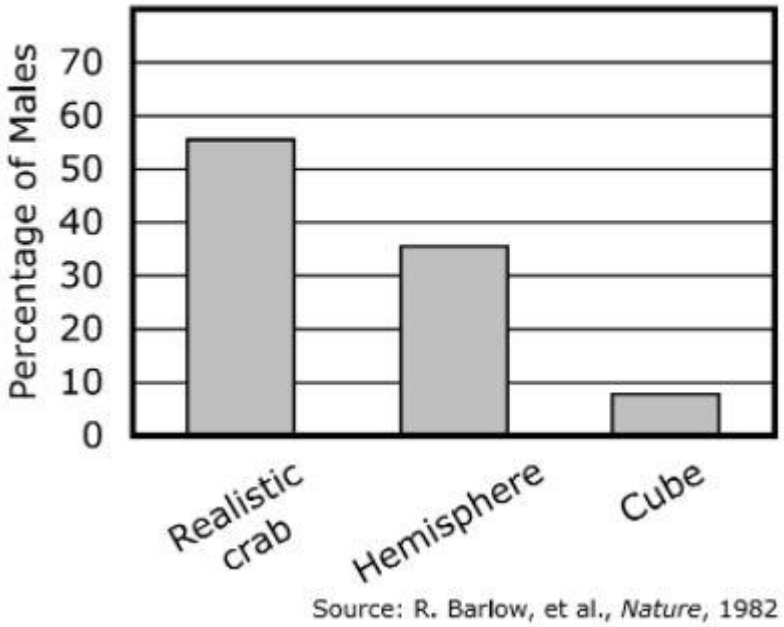
Students visiting the Chesapeake Bay are surprised to find a beach covered with horseshoe crabs. As the male crabs surround female crabs, the students wonder how the males find the females. By doing some research, the students learn that horseshoe crabs are a type of ocean organism. Each horseshoe crab has a hard outer shell, five pairs of walking legs, and a long tail spike. Each also has eight simple eyes, a pair of image-forming lateral compound eyes, and a large network of optic nerves. The olfactory organ is used to detect odors. Figure 1 shows the general anatomy of a horseshoe crab.

Figure 1. Horseshoe Crab Anatomy



The students read about a study that was conducted to test the idea that male crabs use vision to find females. In the study, scientists build three types of cement crab models. The first model was the shape of a real crab. The second model was in the shape of a hemisphere. The third model was shaped like a cube. The scientists placed the different models on the beach. Then they counted the number of male crabs that approached each model. Figure 2 shows the percentage of males that approached each model.

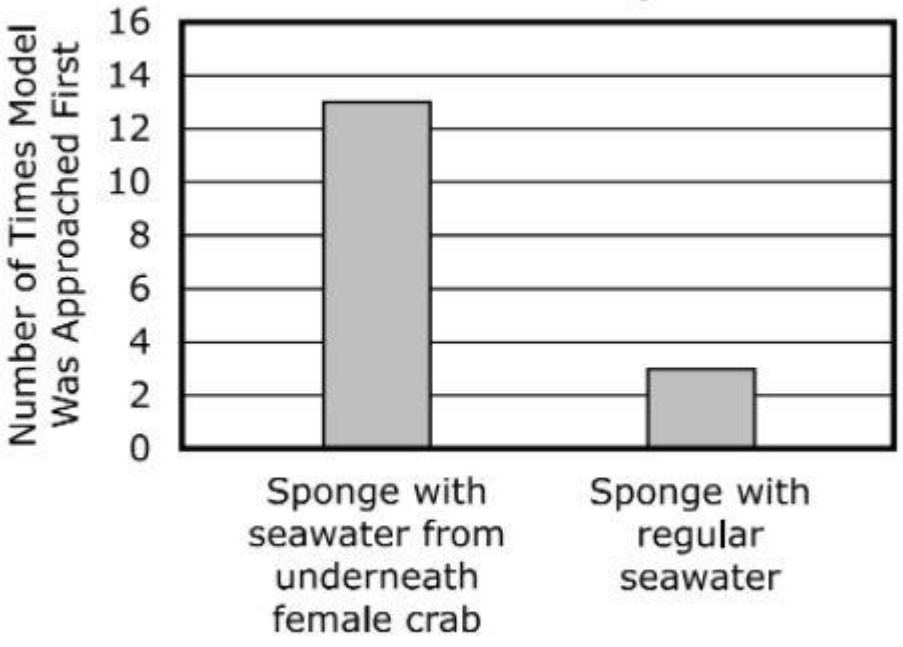
Figure 2. Shape of Horseshoe Crab Model Preference by Male Crabs



Source: R. Barlow, et al., *Nature*, 1982

The students read about another study that tested the theory that female crabs release a chemical scent, like perfume, that the males detect. Scientists placed two realistic concrete models of female crabs at the shoreline. Next, they used a household sponge to absorb water from underneath a real female crab. They placed this sponge under one of the realistic concrete models. Then they placed a sponge filled with regular seawater under the other realistic model. The scientists counted the number of times each model was approached first by the male crabs. Figure 3 shows their data.

Figure 3. Horseshoe Crab Chemical Scent Experiment



Source: K. Saunders, et al., *Current Zoology*, 2010

Items

Item 1

Based on Figure 2 and Figure 3, which conclusion can be reached about why realistic female crab models are approached by male crabs more often than other crab models are?

- A. Crabs respond to inputs from taste and smell.
- B. Crabs respond to inputs from vision and smell.
- C. Crabs respond to inputs from hearing and vision.
- D. Crabs respond to inputs from touch and hearing.

MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
[*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]

Levels	SEP Statements
Level 2	The student gathers, reads, and understands appropriate sources and assesses the credibility, accuracy, and possible bias in each.

Levels	DCI Statements
Level 2	The student explains that animals respond to sensory input.

Levels	CCC Statements
Level 2	The student identifies a cause and effect relationship in nature.

Metadata

NGSS PE Alignment	MS-LS1-8
Dimensions	DCI: LS1.D: Information Processing SEP: Obtaining, Evaluating, and Communicating Information CCC: Cause and Effect
PLD Level	2
Key	B
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.D. The DCI is clearly targeted because the sensory inputs of smell and vision are called out.
For a PLD 2 item, the stem text coincides well with the SEP, asking the student to synthesize information from multiple graphs to draw a conclusion.
The CCC is met because the cause (smells and appearance) is connected to the effect (locating female crabs).

Relationship to Stimulus

The stimulus is necessary in order to identify the specific olfactory inputs used by crabs in locating females.

Relationship to Phenomenon

This relates to the phenomenon because it identifies two possible answers to the phenomenon question.

Item 2

Which claim about the organization of a crab's cells, tissues, and organs is supported by the data in Figure 3?

- A. Specialized cells in the male crab are made of organs that communicate information from outside the crab.
- B. Tissues of the male crab are made of organs that work together in the nervous system to help the crab find new mates.
- C. Tissues and organs in the male crab nervous system are made of specialized cells that communicate information received from the environment.
- D. Specialized cells in the male crab are made of tissues that work together in the nervous system to communicate information between the senses and brain.

MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]
[*Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]

Levels	SEP Statements
Level 2	The student makes a claim supported by evidence in relation to an explanation or a model for a phenomenon.

Levels	DCI Statements
Level 2	The student explains that tissues and organs are made of cells and that these cells are specialized for particular body functions.

Metadata

NGSS PE Alignment	MS-LS1-3
Dimensions	SEP: Engaging in Argument from Evidence DCI:LS1.A: Structure and Function
PLD Level	2
Key	C
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.C. The claim being made is connected to the organization of structures within systems in the crabs, thus aligning to the DCI.

For a PLD 2 item, the student is required to make a specific claim about the crabs that is supported by the data in the stimulus, thus aligning to the SEP.

Relationship to Stimulus

The experimental set-up in the stimulus provides the necessary context for the student to understand different answer options.

Relationship to Phenomenon

This is related to the phenomenon because it helps construct an explanation of how different body systems work together in horseshoe crabs to find females.

Item 3

When a male crab approaches a realistic female crab model, systems within the male crab are interacting. Based on Figure 1, identify which system is activated for each process.

Circle the correct answers from the lists to complete the sentences.

The brain receives information from the eyes; the system that is activated by the eyes is the

nervous system
muscular system
digestive system

. Information is sent to the legs; the system that is activated in the legs is the

muscular system
respiratory system
excretory system

.

Rubric	
Score	Description
2	The student selects the correct answer choices for both sentences. • The brain receives information from the eyes; the system that is activated by the eyes is the **nervous system.** • Information is sent to the legs; the system that is activated in the legs is the **muscular system.**
0	The response is incorrect or irrelevant.

MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]

[*Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses arguments supported by evidence to support or refute an explanation or a model for a phenomenon.

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that systems are made of organs that work together and that the body is a system of interacting subsystems.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student explains that systems interact with other systems and that they may have subsystems and be part of larger complex systems.

Metadata

NGSS PE Alignment	MS-LS1-3
Dimensions	DCI: LS1.A: Structure and Function SEP: Engaging in Argument from Evidence CCC: Systems and System Models
PLD Level	3
Key	See rubric above
Points	2
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.A. The DCI is met because organs (eyes, legs) from different systems are shown to work together, also allowing the CCC to be met at this PLD level.

For a PLD 3 item, the SEP is met because the student uses the data in Figures 2 and 3 to support the model presented in Figure 1.

Relationship to Stimulus

The stimulus is needed to provide evidence about how systems are related.

Relationship to Phenomenon

The item specifically addresses the idea of systems working together, with muscular and nervous system cooperation helping explain the ability of male crabs to find females.

Item 4

Scientists use data from their experiments to support their hypotheses about how male horseshoe crabs find females. Based on Figure 3, construct a statement that provides a reasonable explanation for the crabs' behavior.

Circle the correct answers from the lists to complete the sentences.

Data from Figure 3 suggest that male crabs are attracted to

chemicals from
the shape of
the color of

the females. The sense receptors in the male crab respond to the input and send signals to the

eyes
brain
tail spike

. This influences the male crab's behavior.

Rubric	
Score	Description
1	The student correctly selects both drop-down answer choices. Data from Figure 3 suggest that male crabs are attracted to **chemicals from** the females. The sense receptors in the male crab respond to the input and send signals to the **brain**. This influences the male crab's behavior.
0	The response is incorrect or irrelevant.

MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
[*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that sensory receptors respond to different inputs and transmit them as signals that travel along nerve cells to the brain, where signals are processed, and that this results in immediate behaviors or memories.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses cause and effect relationships to explain phenomena.

Metadata

NGSS PE Alignment	MS-LS1-8
Dimensions	DCI: LS1.D: Information Processing CCC: Cause and Effect
PLD Level	3
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.D. For a PLD 3 item, the DCI alignment is present because the sense receptors are the centerpiece of the cause and effect relationship being described.

The CCC is met because a cause (receptor activation) and effect (information sent to the central nervous system) relationship is used to explain a phenomenon (crabs finding females).

Relationship to Stimulus

This item is only answerable through use of the data regarding crabs reacting to different stimuli as described in the stimulus.

Relationship to Phenomenon

This item helps to provide an answer to the question stated in the phenomenon by looking at the mechanisms on a system level.

Item 5

Consider the following statement: "Male horseshoe crabs surround female crabs because when the males' sense receptors receive certain inputs, that information is processed by the brain, resulting in attraction." Based on the data in Figure 2 and Figure 3, determine whether each piece of evidence (1) supports the statement or (2) does not support the statement.

Place a check mark in the circle to indicate your answer choice in each column.

	Male crabs can release a chemical scent.	Male crabs most often approached models that smelled like females.	Both male and female crabs have hard outer shells.
Supports the Statement	○	○	○
Does not Support the Statement	○	○	○

Rubric	
Score	Description
1	The student selects the correct answers in all three columns. Evidence: Male crabs can release a chemical scent. - **Does not support the statement** Evidence: Male crabs most often approached models that smelled like females. - **Supports the statement** Evidence: Both male and female crabs have hard outer shells. - **Does not support the statement**
0	The response is incorrect or irrelevant.

MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. [*Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.*]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that sensory receptors respond to different inputs and transmit them as signals that travel along nerve cells to the brain, where signals are processed, and that this results in immediate behaviors or memories.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student synthesizes qualitative and/or quantitative information from at least two credible sources and describes how the information is supported or not supported by evidence.

Metadata

NGSS PE Alignment	MS-LS1-8
Dimensions	DCI: LS1.D: Information Processing SEP: Obtaining, Evaluating, and Communicating Information
PLD Level	3
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.D. For a PLD 3 item, the DCI alignment is here because it clarifies the steps in the processes for crabs by highlighting the results of the experiment with crab models, as well as the idea that the chemicals are given off by females, rather than males.

The SEP alignment comes from the use of multiple tables in the stimulus.

Relationship to Stimulus

The questions here rely on an accurate analysis of the patterns shown in Figure 3.

Relationship to Phenomenon

The item clarifies some of the mechanisms in this phenomenon, including which gender produces chemicals.

Item 6 - Constructed Response

A student argues that because the male horseshoe crab has many eyes, it needs to rely only on its sense of vision to detect females.

- Decide whether the student's explanation is correct or incorrect. Support your argument with evidence from Figure 1, Figure 2, and Figure 3.
- Explain how the nervous system interacts with another body system of the horseshoe crab.
- Explain how the nervous system and other body systems of the horseshoe crab may be considered subsystems of a larger complex system.

Analyze the information carefully. Then write your answer in the space provided. Support your answer with details.

MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]

[*Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.*]

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses arguments supported by evidence to support or refute an explanation or a model for a phenomenon.

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that systems are made of organs that work together and that the body is a system of interacting subsystems.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student explains that systems interact with other systems and that they may have subsystems and be part of larger complex systems.

Exemplary Response

Bullet 1	This explanation is incorrect. A crab can use many sensory organs to locate females. Figure 1 shows that a crab has eyes for vision and an olfactory organ for smell. The data from Figure 2 show that males do use vision to discern the shapes of crab models, and the data from Figure 3 show that males are also able to detect smells emitted by females.
Bullet 2	The nervous system interacts with the digestive system by coordinating the mouth and stomach as food is being processed.
Bullet 3	The nervous system and digestive system may be considered as subsystems of the greater living system that is the horseshoe crab. *[Note: Any selected reasonable body system that interacts with the nervous system should receive credit as long as there is some correct justification in the explanation.]*

Metadata

NGSS PE Alignment	MS-LS1-3
Dimensions	DCI: LS1.A: Structure and Function SEP: Engaging in Argument from Evidence CCC: Systems and System Models
PLD Level	3
Key	See exemplary response above
Points	3
Calculator	No

Alignment Analysis

The SEP alignment is met because the student synthesizes evidence from multiple tables to address the claim about eyes in bullet 1.

The DCI alignment is met in bullet 2, as the student needs to explain how systems interact in relation to the phenomenon.

The CCC is met in light of the systems thinking involved in answering the third bullet.

Relationship to Stimulus

This item asks for the student to reference tables across all three bullets, and sometimes relies on more than one bullet to produce responses.

Relationship to Phenomenon

The test taker is producing several parts of the greater explanation for the activity of crabs. This explanation has parts precisely because of the systems interacting to make the location of female crabs possible.

Notes about Constructed Response Items

Constructed Response items are always aligned to all three dimensions. They require students to have an in-depth understanding of the phenomenon. The constructed response items require a mastery of all dimensions at a PLD level of at least 3 and preferably 4. Constructed response items should be answerable by the students within 5 minutes.

Analysis of Set as a Whole

This item cluster, as a whole, meets alignment requirements.

- *This set was aligned to two different PEs, with three items in the set aligned to each. The DCIs are each covered (LS1.A in items 2, 3, and 6, and LS1.D in items 1, 4, and 5) with students constructing an understanding of the phenomenon through systems thinking for LS1.A, and more specifically connecting various systems through the nervous system, for LS1.D. The SEP of Obtaining, Evaluating, and Communicating Information is met as students work with interpreting data and observations from various experiments and need to synthesize the information to make judgments about statements throughout the set. The SEP, Engaging in Argument from Evidence, is met because multiple potentially competing explanations are at least plausible, and only addressed through careful use of the evidence. The CCCs are the center of the explanations, as systems thinking and cause and effect relationships are necessary to understand the actions of the crab, based on relationships seen in the data.*
- *These items progress from level 2 (items 1 and 2) to level 3 (items 3 through 6). In addition to increasing complexity (multiple choice to constructed response), the items also require higher-level tasks to be completed, with the final item requiring a more careful look at the systems working together in the phenomenon.*
- *The phenomenon in this set was intriguing, and the explanation would not have been obvious without the data in the stimulus, which carefully separated different possible cause and effect relationships. It is appropriate at the 8th-grade level for students to work with phenomena where multiple causes might be interacting with each other to produce a certain effect. It is particularly appropriate when dealing with PEs that are discussing interactions between different body systems.*

Aligned Classroom Task

Classroom Investigation to Support Mastery and Assessment of MS-LS1-3 and MS-LS1-8
A Rabbit Responds to the Presence of a Carrot

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

MS-LS1- 8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]

Objectives

1. Uses evidence to explain that systems are made of organs that work together and that the body is a system of interacting subsystems. (MS-LS1-3, DCI LS1.A, PLD 3)
2. Uses evidence to explain that sensory receptors respond to different inputs and transmit them as signals that travel along nerve cells to the brain, where signals are processed, and that this results in immediate behaviors or memories. (MS-LS1-8, DCI LS1.D, PLD 3)
3. Explains that systems interact with other systems and that they may have subsystems and be part of larger complex systems. (MS-LS1-3, CCC Systems and Systems Modeling, PLD 3)
4. Uses cause and effect relationships to explain phenomena. (MS-LS1-8, CCC C/E, PLD 3)
5. Uses arguments supported by evidence to support or refute an explanation or a model for a phenomenon. (MS-LS1-3, SEP Argument, PLD 3)
6. Synthesizes qualitative and/or quantitative information from at least two credible sources and describes how the information is supported or not supported by evidence. (MS-LS1-8, SEP Information, PLD 3)

Phenomenon

When a carrot is placed near a rabbit, the rabbit changes the direction it is hopping, goes to the carrot, and eats it. Over time, the rabbit grows.

Background

When a carrot is placed near a rabbit, the rabbit changes the direction it is hopping, goes to the carrot, and eats it. To do this, the rabbit must first see or smell the carrot. After the rabbit sees or smells the carrot, the information is sent to the brain via the optic nerve. The information is processed in the brain, and then the brain sends signals that cause the rabbit to change its direction of travel and move towards the carrot. The brain has sent information to the muscular system. The digestive system is also important as the rabbit eats the carrot. Literature searches for this subject are helpful in that they can be used to locate diagrams of rabbit eyes or body systems. [Note: Many combinations of animals and stimuli can be used for this, but ones that are easy for classroom environments are rabbits or hamsters, fish in aquariums, etc.]

Gather Materials

- Rabbit (or another animal for observation)
- Cage and bedding
- Carrots or other rabbit food
- Water to keep the rabbit healthy
- Computers or tablets to be used for searching information

Tasks

1. Place the carrot or rabbit food in the rabbit's cage.*
2. Observe any changes in the rabbit's direction of movement.
3. Watch as the rabbit eats the carrot.
4. The teacher removes the rabbit from the cage as often as is practical, perhaps weekly, and records the mass of the rabbit with a scale.
5. Results can be recorded in a table such as the ones below.

Day	Observations After the Carrot is Placed in the Rabbit's Cage

Day	Mass of the Rabbit (can be in grams, or kilograms as appropriate or convenient)

*Note: Though rabbits enjoy carrots, carrots are relatively high in sugar and can possibly upset the rabbit's gastrointestinal tract if too many are given. Rabbit food from the pet store is recommended as the routine way of feeding the rabbit (carrots can be used as treats on occasion for the purposes of this experiment). However, if the rabbit responds to the placement of food in the cage, that can also be used as the stimulus for the purposes of this experiment.

The class can discuss the events that are happening including (1) how the rabbit senses the stimulus, the carrot, (2) how information travels from the surface of the eye to the brain via the optic nerve, (3) how the brain processes the information, (4) how the brain sends the information to the muscular system to cause the rabbit to change its direction of travel, and (5) the systems involved as the rabbit eats the carrot (i.e. the muscular system for reaching the food and for chewing, and the digestive system as the rabbit eats the carrot).

Appendix A

Performance Level Descriptors Set 1 Creek Flooding in Western Washington

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).]

Integrated Statement Levels	Performance Level Descriptor
Level 2	The student constructs and uses graphical displays of data (maps, graphs, charts, and/or tables) and large data sets in relation to a phenomenon to compare findings and identify qualitative patterns in the history of natural hazards that can be used to forecast future events.
Level 3	In addition to the proficiencies described for Level 2, the student uses an understanding of geologic forces and analyzes and interprets data in relation to a phenomenon in order to identify quantitative patterns in data and/or to identify cause and effect relationships in the history of natural hazard. The student forecasts the locations and likelihoods of future events.
Level 4	In addition to the proficiencies described for Level 3, the student applies concepts of statistics and probability, including mean, median, mode, and variability, to: • analyze and characterize charts of data • using digital tools when feasible, and/or • considers limitations of data analysis (e.g., measurement error). The student seeks to improve the precision and accuracy of data with better technological tools and methods (e.g., multiple trials) in order to explain how data on the history of natural hazards can inform the development of technologies to mitigate the effects of natural hazards in relation to a design solution or the explanation of a phenomenon.

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).]

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.

Levels	DCI Statements
Level 2	The student explains that data on the history of natural hazards can be used to forecast future events.
Level 3	In addition to the proficiencies described for Level 2, the student uses data on the history of natural hazards and an understanding of related geologic forces to forecast the locations and likelihoods of future events in relation to a phenomenon.
Level 4	In addition to the proficiencies described for Level 3, the student relates data on the history of natural hazards to the development of technologies and uses this data to predict how technology can mitigate the effects of natural hazards in relation to a design solution or the explanation of a phenomenon.

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

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

Analyze and interpret data to determine similarities and differences in findings.

Levels	SEP Statements
Level 2	The student constructs and uses graphical displays of data (maps, graphs, charts, and/or tables) and large data sets to compare findings.
Level 3	In addition to the proficiencies described for Level 2, the student analyzes and interprets data to provide evidence for phenomena, to determine similarities and differences in findings, and/or to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.
Level 4	In addition to the proficiencies described for Level 3, the student applies concepts of statistics and probability, including mean, median, mode, and variability, to analyze and characterize data, using digital tools when feasible; considers limitations of data analysis (e.g., measurement error); and/or seeks to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).

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).]

CCC: Patterns

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

Levels	CCC Statements
Level 2	The student uses graphs, charts and/or images to identify qualitative patterns in data in relation to the explanation of a phenomenon.
Level 3	In addition to the proficiencies described for Level 2, the student uses graphs, charts and/or images to identify quantitative patterns in data and/or identify cause and effect relationships in relation to the explanation of a phenomenon.
Level 4	In addition to the proficiencies described for Level 3, the student uses graphs, charts, and/or images to identify patterns in data, and/or cause and effect relationships in relation to the explanation of a phenomenon.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

[Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Integrated Statement Levels	Performance Level Descriptor
Level 2	The student makes a claim, citing evidence, related to the effect of human consumption of resources on Earth.
Level 3	In addition to the proficiencies described for Level 2, the student constructs arguments based on empirical evidence and scientific reasoning to support or refute an explanation that, unless the activities and technologies involved are engineered otherwise, an increase in human populations and per capita consumption of natural resources may result in negative environmental impacts.
Level 4	In addition to the proficiencies described for Level 3, the student evaluates and/or revises oral and/or written arguments based on empirical evidence and scientific reasoning to support or refute an explanation to predict the effect of changes of human populations and per-capita consumption of resources in an area, given changes to activities and technologies.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

[Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

DCI: ESS3.C: Human Impacts on Earth Systems

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.

Levels	DCI Statements
Level 2	The student explains that the human consumption of resources has a negative impact on Earth unless the activities and technologies involved are engineered otherwise.
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that 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.
Level 4	In addition to the proficiencies described for Level 3, the student predicts the effects of changes of human populations and per-capita consumption of resources in an area, given changes to activities and technologies.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

[Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

SEP: Engaging in Argument from Evidence

Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Levels	SEP Statements
Level 2	The student makes a claim supported by relevant evidence in relation to an explanation or a model for a phenomenon.
Level 3	In addition to the proficiencies described for Level 2, the student constructs arguments supported by evidence to support or refute an explanation or a model for a phenomenon.
Level 4	In addition to the proficiencies described for Level 3, the student evaluates and/or revises an argument supported by evidence in order to support or refute an explanation or a model for a phenomenon and/or compares and critiques two arguments on the same topic and analyzes whether they emphasize similar or different evidence and/or interpretations of facts.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

[Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

CCC: Systems and System Models

A system can be described in terms of its components and their interactions.

Levels	CCC Statements
Level 2	The student identifies a cause and effect relationship in nature.
Level 3	In addition to the proficiencies described for Level 2, the student uses cause and effect relationships to explain phenomena.
Level 4	In addition to the proficiencies described for Level 3, the student uses cause and effect relationships to predict changes in phenomena.

Appendix B

Performance Level Descriptors Set 2 How do horseshoe crabs find females?

MS-LS1-3. Use arguments supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]

[Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

Integrated Statement Levels	Performance Level Descriptor
Level 2	The student makes a claim, citing evidence, that tissues and organs are composed of cells and that these cells are specialized for particular body functions.
Level 3	In addition to the proficiencies described for Level 2, the student uses arguments supported by evidence to support or refute an explanation or a model for a phenomenon related to the fact that body systems are made of organs that work together and that the body is a system of interacting subsystems.
Level 4	In addition to the proficiencies described for Level 3, the student evaluates and/or revises an argument and/or compares and critiques two arguments using evidence to support or refute the explanation or the model of a phenomenon. In doing so, the student predicts how problems or difficulties with one body system may affect other body systems.

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]

[Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

DCI: LS1.A: Structure and Function

In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.

Levels	DCI Statements
Level 2	The student explains that tissues and organs are made of cells and that these cells are specialized for particular body functions
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that systems are made of organs that work together and that the body is a system of interacting subsystems.
Level 4	In addition to the proficiencies described for Level 3, the student predicts how problems or difficulties with one body system may affect other body systems.

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]

[Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

SEP: Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.

Levels	SEP Statements
Level 2	The student makes a claim supported by evidence in relation to an explanation or a model for a phenomenon.
Level 3	In addition to the proficiencies described for Level 2, the student uses arguments supported by evidence to support or refute an explanation or a model for a phenomenon.
Level 4	In addition to the proficiencies described for Level 3, the student evaluates and/or revises an argument supported by evidence in order to support or refute an explanation or a model for a phenomenon and/or compares and critiques at least two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

[Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.]

[Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

CCC: Systems and System Models

Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.

Levels	CCC Statements
Level 2	The student explains that systems are composed of parts.
Level 3	In addition to the proficiencies described for Level 2, the student explains that systems interact with other systems and that they may have subsystems and be part of larger complex systems.
Level 4	In addition to the proficiencies described for Level 3, the student predicts how a system may influence and affect other systems.

MS-LS1- 8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

[Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]

Integrated Statement Levels	Performance Level Descriptor
Level 2	The student gathers, reads, and understands appropriate sources, assesses the credibility, accuracy, and bias in each, and then communicates that animals change their behavior in response to sensory input.
Level 3	In addition to the proficiencies described for Level 2, the student synthesizes information from at least two credible sources to communicate that the response of sensory receptors to various inputs results in the transmission of signals that travel along nerve signals to the brain, where signals are processed, understands that this results in immediate behaviors or memories, and describes how the information is supported or not supported by evidence.
Level 4	In addition to the proficiencies described for Level 3, the student synthesizes qualitative and/or quantitative information from text and graphics to clarify claims using three or more credible sources and uses the information to predict how the response to a stimulus (the cause) changes an animal's behavior (the effect).

MS-LS1- 8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

[Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]

DCI: LS1.D Information Processing

Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

Levels	DCI Statements
Level 2	The student explains that animals respond to sensory input.
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that sensory receptors respond to different inputs and transmit them as signals that travel along nerve cells to the brain, where signals are processed, and that this results in immediate behaviors or memories.
Level 4	In addition to the proficiencies described for Level 3, the student predicts the change in an animal's behavior based on a stimulus.

MS-LS1- 8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

[Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]

SEP: Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.

Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

Levels	SEP Statements
Level 2	The student gathers, reads, and understands appropriate sources and assesses the credibility, accuracy, and possible bias in each.
Level 3	In addition to the proficiencies described for Level 2, the student synthesizes qualitative and/or quantitative information from at least two credible sources and describes how the information is supported or not supported by evidence.
Level 4	In addition to the proficiencies described for Level 3, the student synthesizes qualitative and/or quantitative information from text and graphics to evaluate claims using three or more credible sources.

MS-LS1- 8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

[Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]

CCC: Cause and Effect

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

Levels	CCC Statements
Level 2	The student identifies a cause and effect relationship in nature.
Level 3	In addition to the proficiencies described for Level 2, the student uses cause and effect relationships to explain phenomena.
Level 4	In addition to the proficiencies described for Level 3, the student uses cause and effect relationships to predict changes in phenomena.