DC SCIENCE ASSESSMENT ITEM WRITING GUIDE

DC Science Assessment Biology

June 21, 2021

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Introduction

This document will review two item sets created for High School Biology Next Generation Science Standards (NGSS) assessment items in previous years. The documents 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 alignment for NGSS-aligned item sets.

How to Use This Tool

In this document, there are two item sets of six items each. This document details how each item is aligned with NGSS standards and Performance Level Descriptors (PLDs), and how the set as a whole meets 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.

Biology - Item Set 1 *Galápagos Finches*

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

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

DCI: LS4.C: Adaptation
Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.

SEP: Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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.

CCC: Cause and Effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

DCI: LS4.C: Adaptation
Changes in the physical environment, whether naturally occurring or human-induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.

Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

SEP: Engaging in Argument from Evidence
Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science.

Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.

CCC: Cause and Effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Performance Level Descriptors

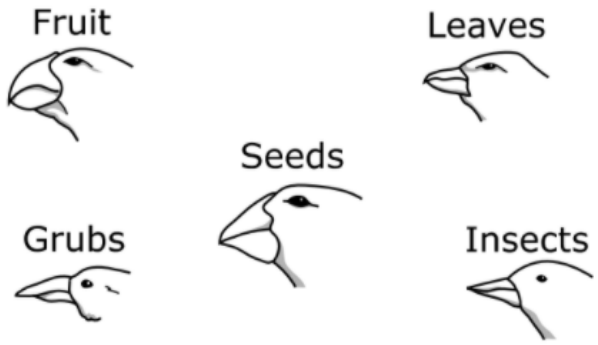
For a list of all performance level indicators, please see Appendix A.
This table shows the PEs, PLD level, and NGSS dimensions to which each of the 6 items in the cluster aligns.

ITEM	PE	PLD LEVEL	SEP	DCI	CCC
Item 1	HS-LS4-4	2	Constructing Explanations and Designing Solutions	LS4.C	
Item 2	HS-LS4-5	3		LS4.C	Cause and Effect
Item 3	HS-LS4-4	3		LS4.C	Cause and Effect
Item 4	HS-LS4-5	3	Engaging in Argument from Evidence	LS4.C	
Item 5	HS-LS4-5	3	Engaging in Argument from Evidence	LS4.C	
Item 6	HS-LS4-4	4	Constructing Explanations and Designing Solutions	LS4.C	Cause and Effect

Stimulus

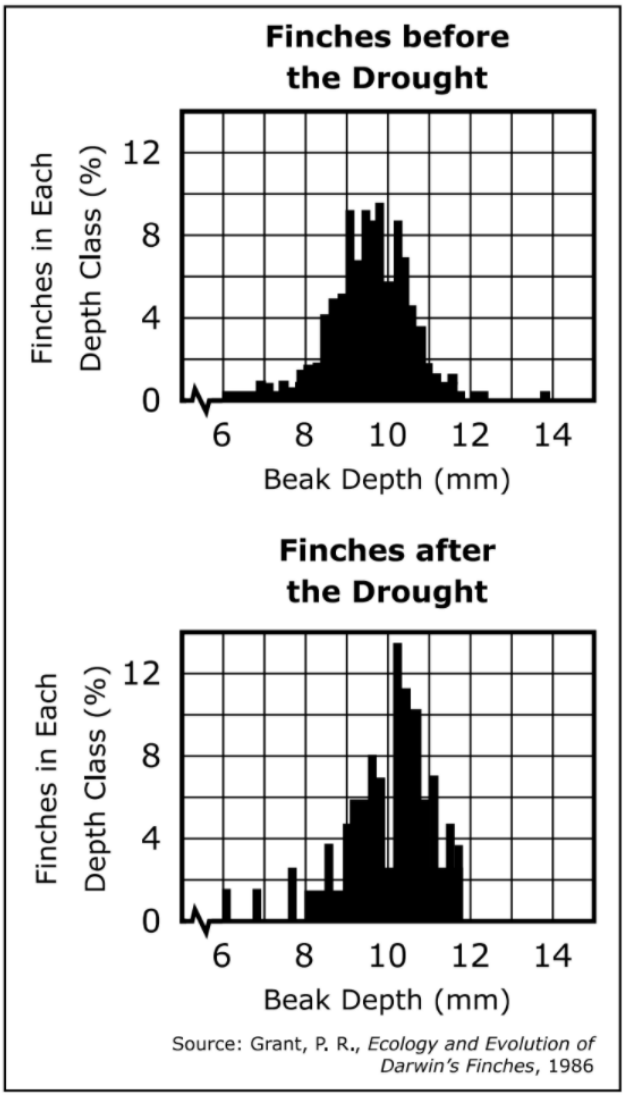
Students at a museum observed a special collection of birds with different-sized beaks. The students learned that the birds were all finches that had lived on the Galápagos Islands and that the finches likely had a common ancestor. The students wondered why the birds have such a variety of beak sizes. They learned that each type of beak is adapted to eating different types of food. For instance, beaks with a greater beak depth are better adapted to eating seeds that are larger and have thick shells. Beak depth is the measured distance between the top and bottom of the beak. Figure 1 shows the different types of beaks in Galápagos finches.

Figure 1. Different Beaks of the Galápagos Finches



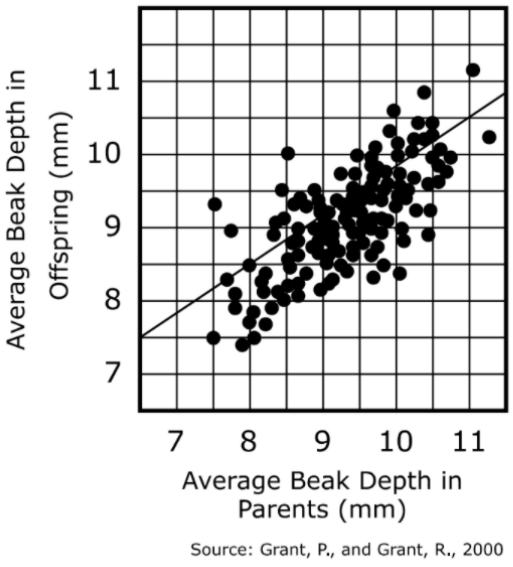
The students learn that the finches on the Galápagos Islands are isolated from other populations of finches on the mainland. Scientists have observed changes in the characteristics of the island finches over many years. During this time, the islands had a severe drought that killed off many finches. During the drought, all food sources for the finches were scarce. Among the few plants that still developed seeds, the number of seeds had decreased, and many were large with thick shells. Figure 2 shows how the average beak depth of finches changed after the drought.

Figure 2. Percentage of Finches by Beak Depth



The scientists also measured the average size of the beaks of finch parents and offspring over time. Figure 3 shows the average beak depth of finch offspring compared with the average beak depth of the parents.

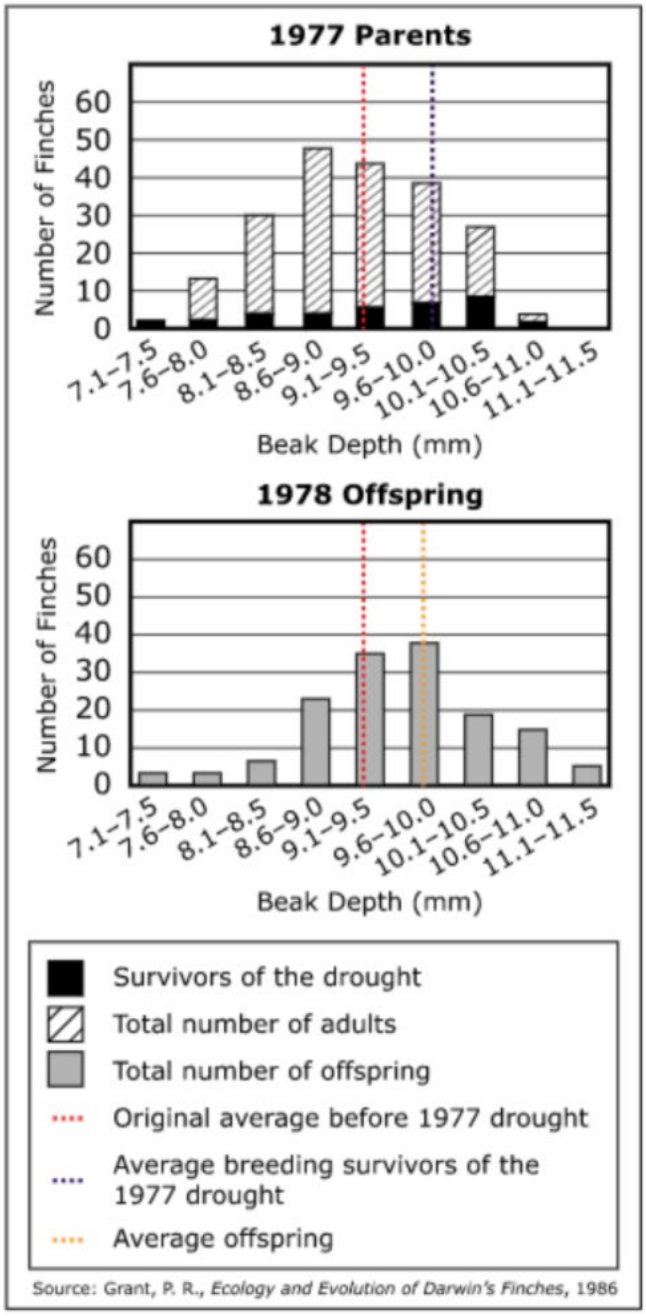
Figure 3. Comparison of Average Beak Depth in Finch Offspring and Parents



Source: Grant, P., and Grant, R., 2000

The scientists used the average beak depths to determine how the beak depth might have been affected by the drought. Figure 4 shows the beak depth of the parents and offspring before and after the drought.

Figure 4. Average Beak Depth before and after Drought



Source: Grant, P. R., *Ecology and Evolution of Darwin's Finches*, 1986

Items

Item 1

Based on Figures 1 and 2, which type of beak is best suited to drought conditions?

- A. large-depth beak for eating seeds
- B. small-depth beak for eating leaves
- C. small-depth beak for eating insects
- D. medium-depth beak for eating fruit

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

Levels	DCI Statements
Level 2	The student describes that populations are dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment.

Levels	SEP Statements
Level 2	The student applies scientific ideas, principles, and/or evidence to explain phenomena.

Metadata

NGSS PE Alignment	HS-LS4-4
Dimensions	DCI: LS4.C: Adaptation SEP: Constructing Explanations and Designing Solutions
PLD Level	2
Points	1
Key	A
Calculator	No

Alignment Analysis

This item aligns with DCI LS4.C. For a PLD 2 item, "The student describes that populations are dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment." In this case, the student selects an anatomical feature, which is the beak characteristics of finches, and describes how it has adapted to drought conditions.

Additionally, the item has a SEP alignment with Constructing Explanations and Designing Solutions. For a PLD 2 item, the student applies scientific ideas and principles of adaptation to explain phenomena. The student must identify the beak type by reading the information and observing the data.

Relationship to Stimulus

This item requires information from Figures 1 and 2 because beak type is considered in terms of the observed beak depth after the drought.

Relationship to Phenomenon

The phenomenon at the start of this tab explains that the beaks of Galápagos finches have adapted for environmental conditions, which is what students are considering in the item.

Item 2

Based on Figure 4, how would the population of finches likely have changed if the drought had lasted more than five years?

- A. The population would have gradually decreased and then died out.
- B. The population would have rapidly increased and developed smaller beaks.
- C. The population would have decreased and have tended to have deeper beaks.
- D. The population would have increased when all finches switched to eating large seeds.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain how changes in the physical environment, whether naturally occurring or human-induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. The student uses evidence to explain that species become extinct because they can no longer survive and reproduce in their altered environment and that if members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses empirical evidence to differentiate cause and correlation and to make a claim about specific causes and effects.

Metadata

NGSS PE Alignment	HS-LS4-5
Dimensions	DCI: LS4.C: Adaptation CCC: Cause and Effect
PLD Level	3
Key	C
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS4.C. For a PLD 3 item the student uses evidence to explain how changes in the physical environment, in the case of a drought, have contributed to the decline of finch species. The evidence students use in this case is a bar graph showing the number of finches with varying beak depths before and after the drought.
For the CCC alignment, the cause is the drought and the effect is a decrease in finch populations despite the deeper beaks.

Relationship to Stimulus

The stimulus requires the use of Figure 4 which shows the beak depth of the parents and offspring before and after the drought.

Relationship to Phenomenon

The phenomenon is that the beak of Galápagos finches has adapted for environmental conditions, which is what students are considering in the item.

Item 3

A student claims that during drought conditions, finch parents with a survival advantage are more likely to have offspring survive to adulthood and reproduce. Complete the sentences supporting the student's claim.

Circle the correct answer from each list to complete the sentence.

Based on Figure 2, finches with [7.0–8.0 mm / 10.0–11.0 mm] beaks have about

[the same / two times the] chance of survival during a drought that they had in pre-drought conditions. This advantageous trait will be passed on to more offspring.

Rubric	
Score	Description
1	Based on Figure 2, finches with **10.0–11.0 mm** beaks have about **two times the** chance of survival during a drought that they had in pre-drought conditions. This advantageous trait will be passed on to more offspring.
0	The response is incorrect or irrelevant.

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that natural selection leads to adaptation and that the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses empirical evidence to differentiate cause and correlation and to make a claim about specific causes and effects.

Metadata

NGSS PE Alignment	HS-LS4-4
Dimensions	DCI: LS4.C: Adaptation CCC: Cause and Effect
PLD Level	3
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS4.C. For a PLD 3 item, the focus for this item is having the student use evidence, which in this case is a plot showing how the average beak depths have increased after drought as compared to the pre-drought period. Students use this evidence to explain that natural selection leads to adaptation and differential survival and reproduction of organisms in a population and how this advantageous heritable trait of longer beak depth is passed on the progeny leading to an increase in the proportion of individuals in future generations that have the trait. The test-taker uses evidence from Figure 2 to identify the cause, which is increased beak depth in this case, leading to an increase in the rate of survival of finches and an increase in the proportion of individuals with the favorable trait, thus meeting the CCC statement.

Relationship to Stimulus

Figure 2 of the stimulus shows how the average beak depth of finches changed after the drought.

Relationship to Phenomenon

Students identify the average beak depth of finches that survive the drought to reproduce. This is related to the phenomenon which is about how the Galápagos finches have adapted to the changing environmental conditions.

Item 4

A student claims that the drought contributed to the significant increase of finch offspring from parents with beak depths that provided a survival advantage.

Based on Figure 4, determine whether each piece of evidence supports this claim or does not support this claim.

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

	In 1977, the total number of finches with a beak depth 8.6–9.0 mm is more than the number of offspring in 1978 with the same beak depth.	In 1977, the total number of finches with a beak depth 8.6–9.0 mm was the highest in the population. In 1978, the number of offspring with a beak depth 9.6–10.0 mm was the highest in the population.	In 1977, the total number of finches with a beak depth 7.1–7.5 mm was nearly the same as the number of offspring in 1978 with the same beak depth.
Supports the Claim	○	○	○
Does Not Support the Claim	○	○	○

Rubric	
Score	Description
2	Supports the Claim • **In 1977, the total number of finches with a beak depth 8.6–9.0 mm was the highest in the population. In 1978, the number of offspring with a beak depth 9.6–10.0 mm was the highest in the population.** Does Not Support the Claim • **In 1977, the total number of finches with a beak depth 8.6–9.0 mm is more than the number of offspring in 1978 with the same beak depth.** • **In 1977, the total number of finches with a beak depth 7.1–7.5 mm was nearly the same as the number of offspring in 1978 with the same beak depth.**
0	The response is incorrect or irrelevant.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain how changes in the physical environment, whether naturally occurring or human-induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. The student uses evidence to explain that species become extinct because they can no longer survive and reproduce in their altered environment and that if members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student evaluates the evidence behind currently accepted explanations or solutions to determine the merits of arguments.

Metadata

NGSS PE Alignment	HS-LS4-5
Dimensions	DCI: LS4.C: Biodiversity SEP: Engaging in Argument from Evidence
PLD Level	3
Key	See rubric above
Points	2
Calculator	No

Alignment Analysis

This item aligns with DCI LS4.C. For a PLD 3 item, the student uses evidence to explain how naturally occurring changes in the physical environment such as drought conditions, contributed to an increase in finch offspring which were adapted to drought and had beak depths that offered a survival advantage.

By selecting the data to support the claim, the students are Engaging in Argument from Evidence. The evidence in this case is the bar graph shown in the stimulus.

Relationship to Stimulus

The stimulus includes Figure 4, which shows the beak depth of the parents and offspring before and after the drought.

Relationship to Phenomenon

This item ties back into the idea of how the beak of Galápagos finches has adapted for environmental conditions.

Item 5

The students made three arguments based on the data in Figure 2 and Figure 3. Which arguments are supported by the data?

Write the correct answer in each box.

Supported	Not Supported

Finches with deeper beaks are well adapted to eating small seeds.

Finches with deeper beaks typically have offspring with deeper beaks.

Finches with deeper beaks have a survival advantage during droughts.

Rubric	
Score	Description
1	Not Supported by the Data • **Finches with deeper beaks are well adapted to eating small seeds.** Supported by the Data • **Finches with deeper beaks typically have offspring with deeper beaks.** • **Finches with deeper beaks have a survival advantage during droughts.**
0	The response is incorrect or irrelevant.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain how changes in the physical environment, whether naturally occurring or human-induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. The student uses evidence to explain that species become extinct because they can no longer survive and reproduce in their altered environment and that if members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student evaluates the evidence behind currently accepted explanations or solutions to determine the merits of arguments.

Metadata

NGSS PE Alignment	HS-LS4-5
Dimensions	DCI: LS4.C: Adaptation SEP: Engaging in Argument from Evidence
PLD Level	3
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS4.C. For a PLD 3 item, the student uses the data provided in the stimulus to support statements about how the finch population is altered when parents with advantageous traits for survival pass those traits to their offspring.

The SEP is aligned as the students engaged in argument by identifying statements that are supported and the statements that are not supported by evidence presented in the stimulus.

Relationship to Stimulus

Students used data from Figures 2 and 3 to complete the item. Figure 2 shows how the percentage of finches in the depth classes with higher depths increased. The bottom graph is more centered and less spread out than the top graph indicating a clear trend towards increase in finch populations with deeper beaks. Figure 3 shows a scatterplot with points forming a straight-line pattern indicating a strong positive correlation between parents with deeper beaks and offspring with deeper beaks.

Relationship to Phenomenon

This item is directly related to how the beaks of Galápagos finches have adapted for environmental conditions.

Item 6 - Constructed Response

A student considers a hypothetical scenario in which scientists observe an unanticipated decrease in the average depth of finch beaks during a drought in the Galápagos Islands.

- Use Figure 1 to explain one possible reason why this might happen.
- Predict how natural selection would affect the reproductive success of an individual finch with a smaller beak depth in this scenario.
- Use the data in Figure 3 to identify a cause and effect relationship between parent and offspring beak depth. Then explain how this relationship may affect the proportion of smaller beak depths to larger beak depths in future generations of finches within the hypothetical scenario.

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

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

Levels	DCI Statements
Level 4	In addition to the proficiencies described for Level 3, the student predicts the effects of natural selection both on an individual level in terms of the link between a trait and reproductive success and in terms of an increase in the proportion of individuals in future generations that have the trait and a decrease in the proportion of individuals that do not.

Levels	SEP Statements
Level 4	In addition to the proficiencies described for Level 3, the student applies scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion, taking into account possible unanticipated effects.

Levels	CCC Statements
Level 4	In addition to the proficiencies described for Level 3, the student describes empirical evidence that could be used to differentiate cause and correlation and to make a claim about specific causes and effects.

Exemplary Response

Bullet 1	Figure 1 indicates that finches have beaks that are adapted to their particular diets. In the scenario where beak depths are decreasing, there must be a survival advantage for having a smaller-depth beak. It may be possible that a new food source became available to those finches (or they somehow adapted to being able to eat the large seeds with thick shells).
Bullet 2	Natural selection will favor finches with traits beneficial for survival in a given environmental situation. If an individual finch with a smaller-depth beak has adequate access to a food source, it will have a greater chance for survival and reproduction.
Bullet 3	The data in Figure 3 show that finch parents typically have offspring of approximately the same beak depths according to the average value. If finches with a smaller-depth beak have greater success at surviving and reproducing than finches with a larger-depth beak, then there will be more offspring with similar, smaller beaks than with larger beaks. If this trend continues, future generations will have a greater proportion of finches with smaller-depth beaks. The evidence in Figure 3 supports a cause and effect relationship for this trend in the given scenario.

Metadata

NGSS PE Alignment	HS-LS4-4
Dimensions	DCI: LS4.C: Adaptation SEP: Constructing Explanations and Designing Solutions CCC: Cause and Effect
PLD Level	4
Key	See rubric above
Points	3
Calculator	No

Alignment Analysis

This item aligns with DCI LS4.C. For a PLD 4 item, the student predicts the effects of natural selection, both on an individual level in terms of the link between a trait and reproductive success and in terms of an increase in the proportion of individuals in future generations that have the trait and a decrease in the proportion of individuals that do not have the trait. This is addressed in the second bullet.

The SEP alignment in bullet one is due to the reasoning and explanation the student provides related to the stimulus. The CCC alignment in bullet three is due to the cause and effect nature of the phenomenon as supported by the data.

Relationship to Stimulus

Figures 1 and 3 of the stimulus are used in answering the question prompts. Figure 1 shows the different types of beaks and the types of food that are typical to finches with a particular beak type. Students will need to analyze Figure 1 to explain the possible reason for the hypothetical scenario described in the stem. Figure 3 shows a positive correlation between parent and offspring with deeper beaks. The students will extrapolate this correlation to the hypothetical scenario presented in the item stem.

Relationship to Phenomenon

The beaks of Galápagos finches have adapted for environmental conditions and this question looks at another possibility related to that phenomenon.

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. LS4.C is covered six times as the only DCI for both PEs. There is only one CCC for the set, Cause and Effect. It is used three times. Engaging in Argument from Evidence is covered two times and Constructing Explanations and Designing Solutions is covered twice as the two SEPs for the set.*

- *The items begin with a foundation of PLD 2 items (Items 1 - multiple choice item), then PLD 3 (Items 2-5 - all technology enhanced items), and then PLD 4 with the constructed response item at the end of the set. Note also that the set begins with two-dimensional items and finishes with items that are aligned to three dimensions.*

- *The set covers each PE in depth. All items prior to the final item provide opportunities for students to demonstrate skill with separate elements of the two Performance Expectations before applying these skills together.*

- *All the items in the set relate back to the phenomenon of how the beak of Galápagos finches has adapted for environmental conditions. Items 1 and 5 examine physical changes to the beak to help the finch obtain food after a drought. Item 2 looks at population changes due to changing environmental conditions. Items 3 and 6 are related to natural selection. Item 4 relates to the impact of environmental change.*

Aligned Classroom Task

Classroom Investigation to Support Mastery and Assessment of HS-LS4-4 and HS-LS4-5
Peppered Moth Simulation

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

Objectives:

1. Use evidence to explain that natural selection leads to adaptation and that the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-4, DCI, LS4.C, PLD 3)
2. Use evidence to explain how changes in the physical environment, whether naturally occurring or human-induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. The student uses evidence to explain that species become extinct because they can no longer survive and reproduce in their altered environment and that if members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS-LS4-5, DCI, LS4.C, PLD 3)
3. Use empirical evidence to differentiate cause and correlation and to make a claim about specific causes and effects. (HS-LS4-4, HS-LS4-5, CCC, PLD 3)
4. Make a quantitative and/or qualitative claim regarding dependent and independent variables and revise an explanation related to a phenomenon based on valid and reliable evidence obtained from a variety of sources. (HS-LS4-4, SEP, PLD 3)
5. Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS4-5, SEP, PLD 3)

Background

In England in the 1800s, peppered moths rapidly adapted in response to pollution. Prior to the industrial revolution, tree trunks in the area were light colored due to the presence of lichens. At that time, most of the peppered moths in the area were light colored with dark spots. After the industrial revolution, tree trunks became dark gray as they were covered with soot from factories. In the 45 years that followed, the dark variety of the peppered moth became increasingly more common.

Materials Needed

- White paper
- Newspaper
- Forceps
- Watch or clock with a second hand
- 30 identical white circles (made with a hole punch)
- 30 identical newspaper circles (made with a hole punch)

At least 2 students should participate.

Tasks

1. Place a white sheet of paper on the table. One person will place 30 of the newspaper circles and 30 of the white circles on the paper in a random arrangement (as the other student looks away).
2. One student plays the role of the predator and picks up as many circles as possible in 15 seconds (as timed by the other student).
3. The other student counts the number of white circles and newspaper circles that remain. The number of each type of circle is doubled (this represents the next generation).
4. This process is repeated using 30 white circles on a newspaper background, 30 newspaper circles on a white background, and 30 newspaper circles on a newspaper background.
5. The students make a table and record their results.

Circle Counting Results

Generation	Populations Start on White Background				
	Starting Population		Final Populations (how many of the original were left)		
	Newspaper	White	Newspaper	White	Double these final numbers to get your starting population for the next generation.
1	30	30			
2					
3					
4					
5					

Generation	Populations Start on Newspaper Background				
	Starting Population		Final Populations (how many of the original were left)		
	Newspaper	White	Newspaper	White	Double these final numbers to get your starting population for the next generation.
1	30	30			
2					
3					
4					
5					

References:

1. Peppered Moth Simulation
2. Peppered Moth: Background Information

Biology - Item Set 2 *Albino Redwood Trees*

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

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms
The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

SEP: Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Use a model based on evidence to illustrate the relationships between systems or between components of a system.

CCC: Energy and Matter
Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms
The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.

As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

SEP: Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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.

CCC: Energy and Matter
Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

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	HS-LS1-5	2	Developing and Using Models	LS1.C	Energy and Matter
Item 2	HS-LS1-6	2		LS1.C	Energy and Matter
Item 3	HS-LS1-5	3	Developing and Using Models	LS1.C	
Item 4	HS-LS1-6	2	Constructing Explanations and Designing Solutions	LS1.C	
Item 5	HS-LS1-5	3	Developing and Using Models	LS1.C	Energy and Matter
Item 6	HS-LS1-6	3	Constructing Explanations and Designing Solutions	LS1.C	Energy and Matter

Stimulus

Albino redwood trees are white-leafed parasites that can grow only if they are attached to a host tree, as shown in Figure 1. Normal redwoods can live without a host.

A group of scientists investigated to explain why normal redwoods can live without a host, but albino redwoods cannot. First, the scientists identified how normal redwoods used matter from the carbon and nitrogen cycles. Figure 2 shows the role of normal redwoods in the carbon cycle. Figure 3 shows how normal redwoods use the products of the carbon and nitrogen cycles to form proteins.

Figure 1. Albino Redwood Growing on Normal Redwood

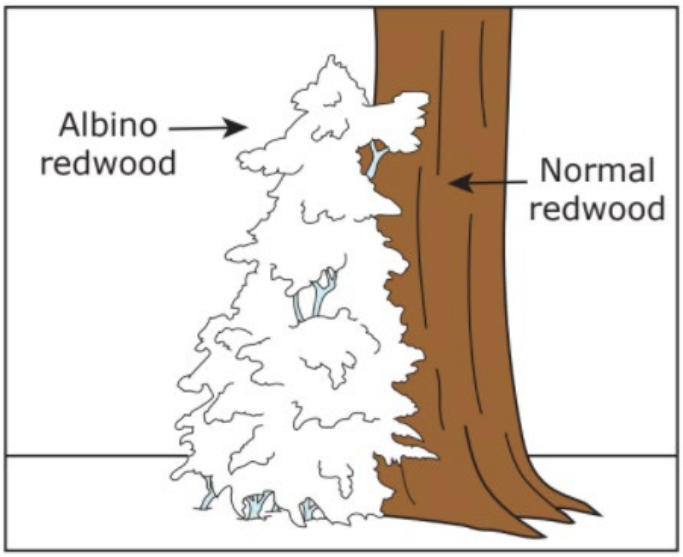
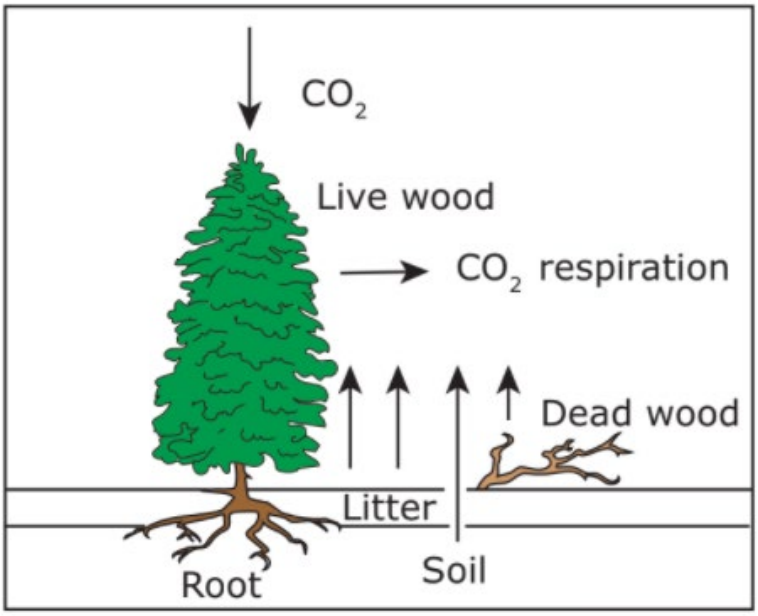
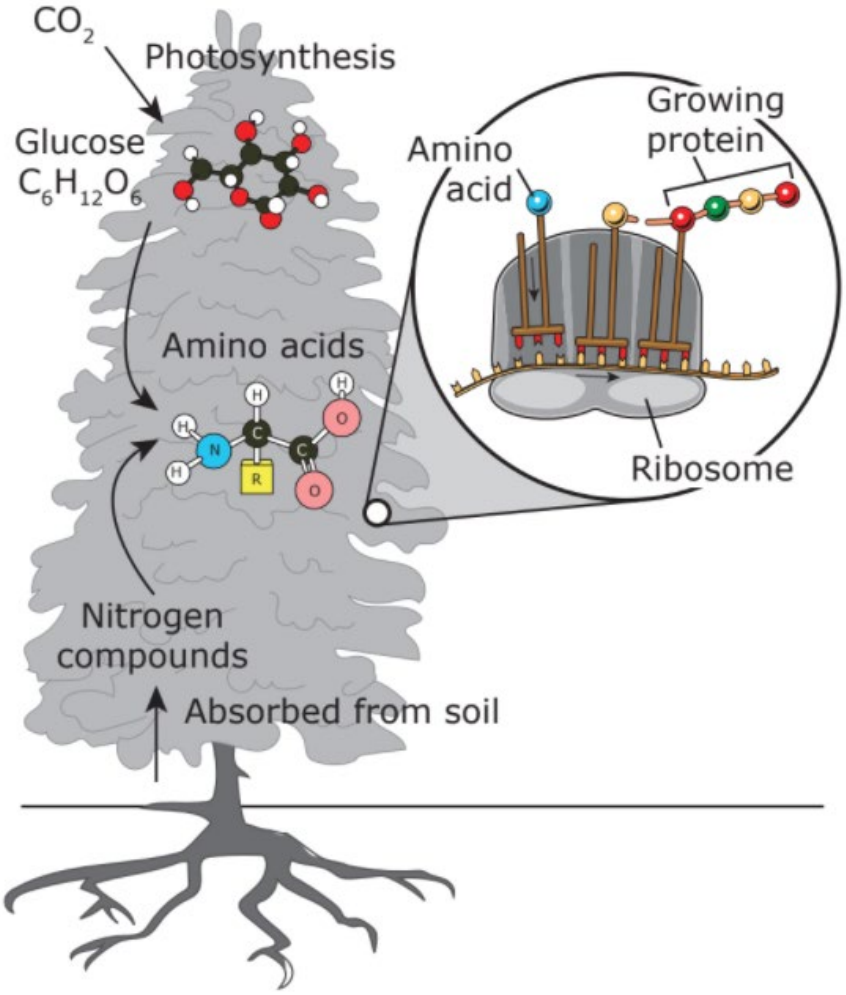


Figure 2. The Role of Normal Redwoods in the Carbon Cycle



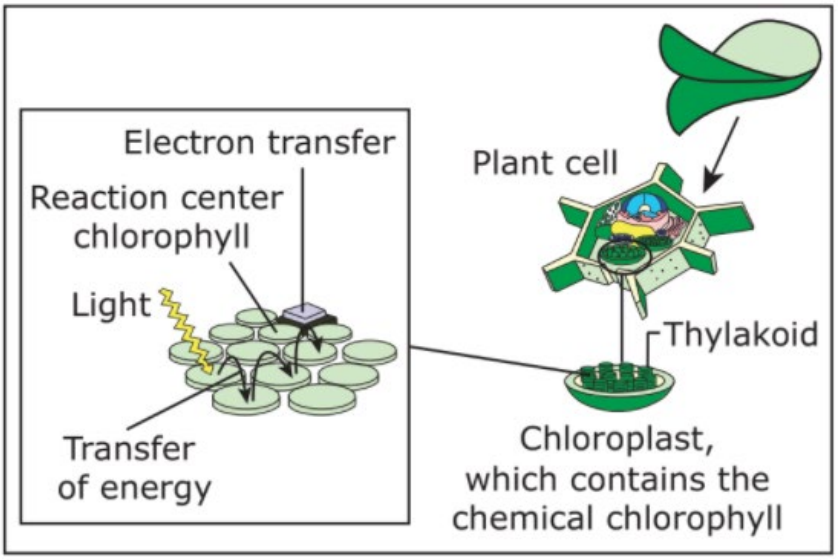
Source: C. Potter, *Open J. Ecol*, 2012

Figure 3. Production of Proteins in Plants



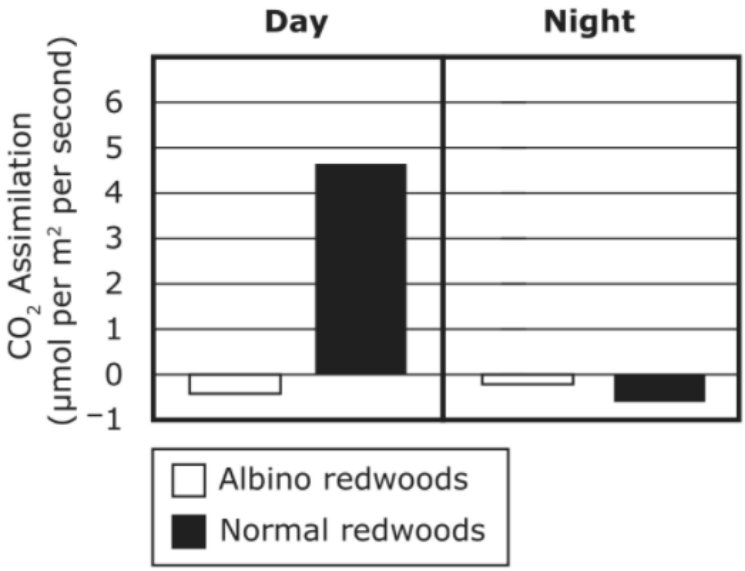
The scientists then compared the traits and anatomy of albino and normal redwoods. Albino redwoods have white leaves that are caused by a genetic mutation that blocks the production of chlorophyll. Normal redwoods have chlorophyll. Figure 4 shows the function of chlorophyll in plants.

Figure 4. The Role of Chlorophyll in Photosynthesis



Finally, the scientists investigated how the difference in levels of chlorophyll affected the assimilation of carbon by the two types of trees. Carbon assimilation is the amount of carbon dioxide a plant uses during photosynthesis. Negative carbon assimilation means that the plant releases more carbon dioxide than it used. Figure 5 compares carbon assimilation of albino and normal redwoods during the day and night.

Figure 5. Carbon Assimilation of Redwoods



Source: Pittermann et al., *PLOS One*, 2017

Items

Item 1

Based on the information in Figure 4, which statement best explains how the lack of chlorophyll affects energy and matter cycling in albino redwoods?

A. Albino redwoods cannot use chemical energy, so they use carbon dioxide directly to make proteins.

B. Albino redwoods cannot absorb or transfer light energy, so they cannot use carbon dioxide to produce glucose.

C. Albino redwoods can produce chemical energy only during the nighttime, so they absorb carbon dioxide only at night.

D. Albino redwoods can store light energy for only a short time, so they absorb more carbon dioxide than normal redwoods do.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]

Levels	DCI Statements
Level 2	The student explains that light and carbon dioxide are key to plant processes.

Levels	SEP Statements
Level 2	The student identifies models that are based on evidence and illustrate the relationships between systems or components of a system.

Levels	CCC Statements
Level 2	The student knows that changes in matter in a system can be described in terms of the flow of matter into that system.

Metadata

NGSS PE Alignment	HS-LS1-5
Dimensions	DCI: LS1.C: Organization for Matter and Energy Flow in Organisms SEP: Developing and Using Models CCC: Energy and Matter
PLD Level	2
Key	B
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.C. For a PLD 2 item, the students are expected to demonstrate an understanding that light and carbon dioxide are key to plant processes. Light energy is used by plants to assimilate carbon dioxide
In addition, the amount of energy and matter cycling present aligns with the CCC, Cause and Effect.
A model is used to figure out the answer which supports the SEP of Developing and Using Models.

Relationship to Stimulus

The stimulus is needed for this item because it discusses and models the uniqueness of the albino redwood. Figure 4 which shows how chlorophyll acts as a reaction center for the energy transfer reaction that forms the basis of photosynthesis is required to answer the question.

Relationship to Phenomenon

This relates back to the phenomenon because the item is about the cycling of matter and energy in an albino redwood.

Item 2

Based on Figure 3, how does carbon dioxide in the environment relate to the production of proteins in plants?

- A. The atoms in carbon dioxide are used to form glucose, and glucose reacts with nitrogen to form the building blocks of proteins.
- B. The carbon dioxide molecules react with glucose to form ATP, and ATP is used as energy to form the building blocks of proteins.
- C. The atoms in carbon dioxide are destroyed during photosynthesis, and these atoms are replaced by nitrogen during protein synthesis.
- D. The carbon dioxide molecules provide energy to produce glucose, and glucose reacts with nitrogen compounds during protein synthesis.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

Levels	DCI Statements
Level 2	The student identifies carbon-based molecules as products made up of smaller molecules, in relation to a phenomenon.

Levels	CCC Statements
Level 2	The student knows that changes in matter in a system can be described in terms of the flow of matter into that system.

Metadata

NGSS PE Alignment	HS-LS1-6
Dimensions	DCI: LS1.C: Organization for Matter and Energy Flow in Organisms CCC: Energy and Matter
PLD Level	2
Key	A
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.C. For a PLD 2 item, the student is required to demonstrate an understanding of how carbon dioxide is being used to make glucose, which along with nitrogen compounds from the soil, helps make proteins.
The CCC dimension is tied in as the focus of the item is on flow of matter between atmosphere, plant, and soil which is depicted in the stimulus linked to the item.

Relationship to Stimulus

Figure 3 is used as a model to support the item. The figure shows how matter in the form of carbon dioxide, nitrogen compounds, and proteins is processed in plants.

Relationship to Phenomenon

Albino redwoods are unique as they lack the photosynthetic apparatus. The knowledge of how the photosynthetic apparatus is critical to the production of proteins is imperative to understand how the lack of this apparatus may affect the albino redwoods.

Item 3

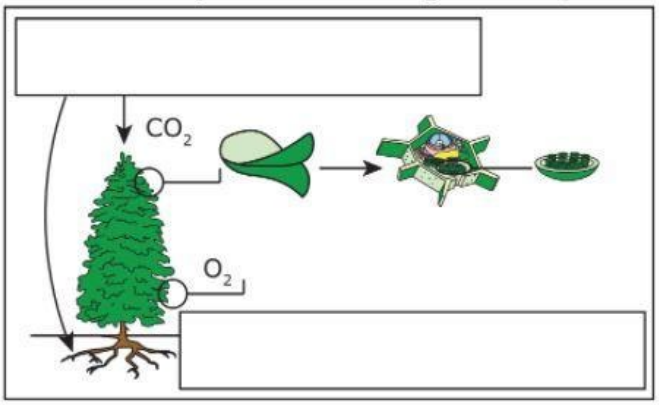
The scientists use a model to explain how the evidence in Figure 3 and Figure 4 relates to carbon cycling in normal redwoods during the day.

Complete the model with the process that occurs at each stage.

Write the correct answer in each box. Not all answers will be used.

- Intake of light, CO_2, and H_2O increases.
- Intake of light, CO_2, and H_2O decreases.
- Intake of light increases. Intake of CO_2 and H_2O decreases.
- Carbon assimilation increases. O_2 release increases.
- Carbon assimilation decreases. O_2 release decreases.
- Carbon assimilation increases. O_2 release decreases.

Photosynthesis During the Day



Rubric	
Score	Description
1	Gap 1: **Intake of light, CO_2, and H_2O increases.** Gap 2: **Carbon assimilation increases. O_2 release increases.**
0	The response is incorrect or irrelevant.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that photosynthesis converts light energy to stored chemical energy by converting carbon dioxide from the atmosphere and water into sugar and oxygen.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses models based on evidence to generate data, to illustrate, and/or to predict the relationships between systems or between components of a system.

Metadata

NGSS PE Alignment	HS-LS1-5
Dimensions	DCI: LS1.C: Organization for Matter and Energy Flow in Organisms SEP: Developing and Using Models
PLD Level	3
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.C. For a PLD 3 item, the student is required to analyze the evidence to explain how carbon dioxide, light energy and water are used during the daytime when photosynthesis remains the primary process in normal plants.

The item is tied to the SEP dimension because the student develops and uses a model to explain how light energy gets converted to stored chemical energy as carbon dioxide from the atmosphere combines with water to form glucose and oxygen.

Relationship to Stimulus

The stimulus is needed to answer the question as Figures 3 and 4 provide the evidence required to use an existing model. Figure 3 shows how chemical substances are processed during photosynthesis and Figure 4 shows how light energy is used by the photosynthetic apparatus present in plants.

Relationship to Phenomenon

Normal redwoods are compared to albino redwoods and students demonstrate their understanding of photosynthesis through the models provided.

Item 4

Based on Figure 4 and Figure 5, explain the trends for the normal redwood trees at night.

Circle the correct answer from each list to complete the sentence.

Carbon dioxide release in normal redwoods during the nighttime

increases
decreases
stays the same

compared to release during the daytime because the trees produce

a greater amount of glucose than
the same amount of glucose as
a smaller amount of glucose than

they use.

Rubric	
Score	Description
1	Carbon dioxide release in normal redwoods during the nighttime **increases** compared to release during the daytime because the trees produce **a smaller amount of glucose than** they use.
0	The response is incorrect or irrelevant.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

Levels	DCI Statements
Level 2	The student identifies carbon-based molecules as products made up of smaller molecules, in relation to a phenomenon.

Levels	SEP Statements
Level 2	The student applies scientific ideas, principles, and/or evidence to explain phenomena.

Metadata

NGSS PE Alignment	HS-LS1-6
Dimensions	DCI: LS1.C: Organization for Matter and Energy Flow in Organisms SEP: Constructing Explanations and Designing Solutions
PLD Level	2
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.C. For a PLD 2 item, the student demonstrates an understanding that photosynthesis is the primary plant process during daytime when light energy is available. This, however, is not the case at nighttime when less carbon dioxide is assimilated, and more carbon dioxide is released. Based on this understanding, the student explains the negative carbon assimilation by normal redwoods during nighttime.

The same explanation is also reflective of the SEP of Constructing Explanations and Designing Solutions.

Relationship to Stimulus

The student uses Figures 4 and 5 to help construct the explanation. Figure 4 shows how the photosynthetic apparatus is used to assimilate carbon dioxide. Figure 5 compares how carbon dioxide assimilation differs during day and night for the albino and normal redwoods.

Relationship to Phenomenon

The item requires the student to explain how normal redwoods assimilate differentially during day and night times. This is related to the larger phenomenon which is about understanding how the lack of photosynthetic apparatus in albino redwoods impacts their ability to assimilate carbon dioxide.

Item 5

Based on Figures 3, 4, and 5, determine how each type of redwood tree obtains the matter and energy needed to synthesize protein.

Write the correct answer in each box. Not all answers will be used.

A. produce glucose and oxygen from carbon dioxide, light, and water

B. consume glucose from other organisms and absorb oxygen from the air

C. absorb glucose, oxygen, and water directly from the environment

To obtain matter and energy for protein synthesis, albino redwoods [ ], while normal redwoods [ ].

Rubric	
Score	Description
1	To obtain matter and energy for protein synthesis, albino redwoods **consume glucose from other organisms and absorb oxygen from the air**, while normal redwoods **produce glucose and oxygen from carbon dioxide, light, and water**.
0	The response is incorrect or irrelevant.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [*Assessment Boundary: Assessment does not include specific biochemical steps.*]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that photosynthesis converts light energy to stored chemical energy by converting carbon dioxide from the atmosphere and water into sugar and oxygen.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses models based on evidence to generate data, to illustrate, and/or to predict the relationships between systems or between components of a system.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student knows that changes in matter and energy in a system can be described in terms of the flow of matter into, or out of, that system.

Metadata

NGSS PE Alignment	HS-LS1-5
Dimensions	DCI: LS1.C: Organization for Matter and Energy Flow in Organisms SEP: Developing and Using Models CCC: Energy and Matter
PLD Level	3
Key	See rubric above
Points	1
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.C. For a PLD 3 item, the student uses the evidence presented in the figures to compare how the energy needs of the albino redwoods and the normal redwood trees are met. The item simultaneously ties with the flow of matter in each type of redwood tree. As photosynthesis is the key process for energy and matter flow in plants, the stimuli provide evidence of how photosynthesis is impacted in each type of redwood tree.

For the SEP dimension, the relationships between the two types of trees are studied through the models such as diagrams and graphs.

For the CCC dimension, the changes in matter and energy are described in terms of the flow of chemical substances and flow of light energy and chemical energy taking place during photosynthesis.

Relationship to Stimulus

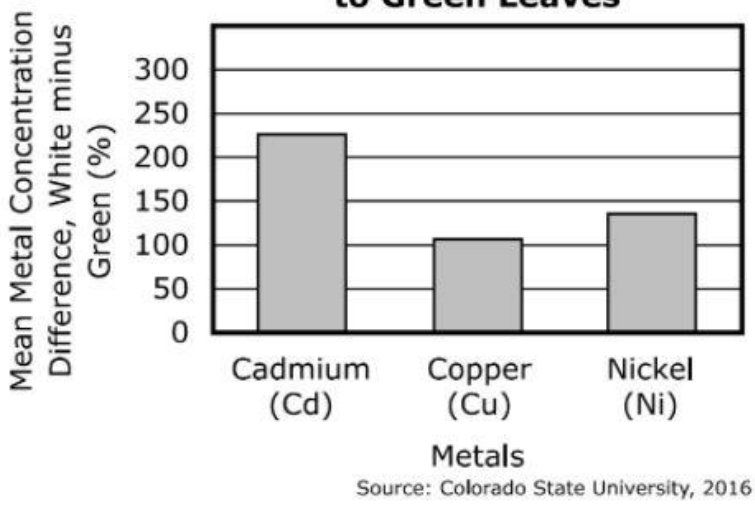
Figures 3, 4, and 5 are used to compare photosynthesis in the albino versus normal redwood. Figure 3 shows how chemical substances are assimilated in plants. Figure 4 shows how the photosynthesis apparatus uses light energy and Figure 5 is a bar graph that compares carbon assimilations during day and night in albino and normal redwood trees. These three stimuli are required to explain how each type of redwood meets its energy requirement and assimilates carbon.

Relationship to Phenomenon

The item is related to the phenomenon as it requires the student to explain how albino redwoods meet their energy requirements as compared to normal redwoods.

Item 6 - Constructed Response

Figure 6. Metal Concentrations in White Leaves Relative to Green Leaves



Source: Colorado State University, 2016

Redwood trees absorb cadmium, copper, and nickel from the soil through their roots. At high levels of absorption, these metals can build up in the leaves and cause damage to the chloroplasts.

A scientist investigated whether albino trees affect the cycling of toxic metals in their hosts. For this investigation, the scientist studied half-albino redwoods, which are trees that have both white leaves and green leaves. The scientist examined how half-albino trees distributed toxic metals by comparing the metal concentration in the white leaves with the concentration in the green leaves. The scientist then calculated the percentage difference in metal concentration. Figure 6 shows the results of the study.

The scientist wants to relate these data to albino redwoods that attach to a host tree. Use the information to complete the following tasks:

- Based on Figure 6, make a claim about the absorption of toxic metals in relation to albino redwood trees and normal redwood trees. Provide evidence to support your claim.
- Predict how the growth of an albino tree affects the health of the chloroplasts and how the health of the chloroplasts affect the tree's ability to produce protein and energy.
- Explain how the growth of the albino tree changes the flow of matter and energy into and out of the host plant.

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

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

Levels	DCI Statements
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that sugar molecules contain carbon, hydrogen, and oxygen atoms and that those atoms are used to make large, carbon-based molecules, such as proteins and DNA.

Levels	SEP Statements
Level 3	In addition to the proficiencies described for Level 2, the student makes a quantitative and/or qualitative claim regarding dependent and independent variables and/or revises an explanation related to a phenomenon based on valid and reliable evidence obtained from a variety of sources.

Levels	CCC Statements
Level 3	In addition to the proficiencies described for Level 2, the student knows that changes in matter and energy in a system can be described in terms of the flow of matter into, or out of, that system.

Exemplary Response

Bullet 1	Albino redwoods absorb more toxic metals in their leaves than do normal redwoods. This is supported by the graph which shows that the white leaves of the half-albino plants absorbed higher levels of toxic metals than the green leaves of the same plant.
Bullet 2	When the albino tree grows on the host plant, it could absorb and retain more toxic metals from the environment, which prevents damage to the chloroplasts in the host plant. Preservation of the chloroplasts is vital for matter and energy flow because chloroplasts are organelles in cells that take in light, carbon dioxide, and water and produce glucose and oxygen. This glucose is used to make biomolecules needed by the entire plant, including amino acids, which are the building blocks of protein. Glucose is used to produce energy so that the plant cells can perform vital life functions.
Bullet 3	Since albino trees cannot perform photosynthesis, they absorb some of the glucose that normal trees make. The host plant takes in carbon dioxide, water, and light energy to produce glucose. However, the host plant (the normal redwood) does not store or use all of the glucose it makes because some glucose is transferred to the albino redwood.

Metadata

NGSS PE Alignment	HS-LS1-6
Dimensions	DCI: LS1.C: Organization for Matter and Energy Flow in Organisms SEP: Constructing Explanations and Designing Solutions CCC: Energy and Matter
PLD Level	3
Key	See exemplary response above
Points	3
Calculator	No

Alignment Analysis

This item aligns with DCI LS1.C. For a PLD 3 item, the DCI is met by the second bullet as the student explains how glucose molecules are vital for the plants to perform the various cellular functions and to meet their own energy requirements. The SEP dimension is met by the first bullet as the student makes claims based on quantitative data about differential absorption of toxic metals by white vs green leaves.

The CCC dimension is met by the third bullet as the student explains how the growth of an albino redwood changes the flow of energy and matter in the host plant.

Relationship to Stimulus

The student relies heavily on the figures associated with this stimulus to understand the phenomenon. All figures are required to answer this question and make sense of the phenomenon as a whole.

Relationship to Phenomenon

The item is related to the phenomenon, as it requires the student to explain how the symbiotic relationship between albino and normal redwoods allow each type of plant to meet its energy goals.

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 half of the items in the set aligned to each. The single DCI is covered in all items. The SEP, Developing and Using Models, is used in half of the items. The SEP, Constructing Explanations and Designing Solutions, is met through the other half of the items. The CCC, Energy and Matter, is met in four of the items.*

- *These items progress from level 2 (items 1, 2, and 4) to level 3 (items 3, 5, and 6). In addition to increasing complexity (multiple choice to constructed response), the items also require higher-level tasks to be completed.*
  Note also that the set begins with two-dimensional items and finishes with items that are aligned to three dimensions.

- *The set covers each PE in depth. All items prior to the final item provide opportunities for students to demonstrate skill with separate elements of the two Performance Expectations before applying these skills together.*

- *All the items in the set relate back to the phenomenon of albino and normal redwoods as Items 1, 3, 4, and 5 focus on how matter and energy are cycled in the two types of redwoods. Items 2 and 6 relate to biomolecules, with item 6 taking a look at the impact of toxic metals.*

Aligned Classroom Task

Classroom Investigations to Support Mastery and Assessment of HS-LS1-5 and HS-LS1-6
Growing Mold on Bread

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]

Objectives

1. Use evidence to explain that photosynthesis converts light energy to stored chemical energy by converting carbon dioxide from the atmosphere and water into sugar and oxygen. (HS-LS1-5, DCI, PLD 3)
2. Use evidence to explain that sugar molecules contain carbon, hydrogen, and oxygen atoms and that those atoms are used to make large, carbon-based molecules, such as proteins and DNA. (HS-LS1-6, DCI, PLD 3)
3. Track the flow of matter and energy through different organizational levels of a living system. (HS-LS1-6, DCI, PLD 3)
4. Describe changes in matter and energy in a system in terms of the flow of matter into, or out of, that system. (HS-LS1-5, HS-LS1-6, CCC PLD 3)
5. Use models based on evidence to generate data, to illustrate, and/or to predict the relationships between systems or between components of a system. (HS-LS1-5, SEP, PLD 3)
6. Make a quantitative and/or qualitative claim regarding dependent and independent variables and/or revise an explanation related to a phenomenon based on valid and reliable evidence obtained from a variety of sources. (HS-LS1-6, SEP, PLD 3)

Background

Bread is made mostly of wheat, a photosynthetic plant. The glucose molecules in bread are a product of photosynthesis in the wheat plant. Mold is a fungal parasite that grows on bread when it ages in a moist environment. Mold grows by absorbing the glucose in bread. The absorbed glucose is broken down into carbon, hydrogen, and oxygen that the mold uses to make enzymes. These enzymes break down the larger organic molecules in the bread (and smaller organic molecules including glucose are produced). Glucose is used in cellular respiration. Cells in the mold use the energy from respiration to grow, and they combine the small organic molecules to make larger ones such as fats, proteins, and carbohydrates.

Gather materials

- Fresh bread (works better than store-bought)
- Spray bottle filled with water
- Ziploc bags

Tasks

1. Lightly spray a slice of bread with water from the spray bottle.
2. Place in a Ziploc bag and store in a warm, dark place.
3. Make daily observations and record the growth of mold (likely over 7-10 days). For quantitative observations, measure the diameters of the mold colonies as well as the number of colonies.

Daily Observations of Mold on Bread

Day	Observation of the Growth of Mold	Diameters of Mold Colonies	Number of Mold Colonies
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

[Note: The growth of wheat plants can be included as an added step if those are available. Grow 1 or 2 plants in the classroom and 1 or 2 plants in the dark. Monitor the plants over 2-3 weeks to demonstrate the effect of light.]

References:

(1) How to Grow Bread Mold
(2) Bread Mold Information

Appendix A

Performance Level Descriptors Set 1 Galápagos Finches

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. **[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]**	
Integrated Statement Levels	**Performance Level Descriptor**
Level 2	The student applies scientific ideas, principles and/or evidence to explain a phenomenon related to the fact that populations are dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment.
Level 3	In addition to the proficiencies described for Level 2, the student makes a quantitative and/or qualitative claim regarding dependent and independent variables; revises an explanation related to a phenomenon that involves natural selection leading to adaptation, and explains that the differential survival and reproduction of these organisms leads to an increase in the proportion of these individuals in future generations.
Level 4	In addition to the proficiencies described for Level 3, the student applies scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion related to a phenomenon involving the occurrence of natural selection and adaptation, both at the level of the individual organism and in the population as a whole.

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

DCI: LS4.C: Adaptation

Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.

Levels	DCI Statements
Level 2	The student describes that populations are dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment.
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that natural selection leads to adaptation and that the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.
Level 4	In addition to the proficiencies described for Level 3, the student predicts the effects of natural selection both on an individual level in terms of the link between a trait and reproductive success and in terms of an increase in the proportion of individuals in future generations that have the trait and a decrease in the proportion of individuals that do not.

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

SEP: Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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.

Levels	SEP Statements
Level 2	The student applies scientific ideas, principles, and/or evidence to provide an explanation of phenomena.
Level 3	In addition to the proficiencies described for Level 2, the student makes a quantitative and/or qualitative claim regarding dependent and independent variables and revises an explanation related to a phenomenon based on valid and reliable evidence obtained from a variety of sources.
Level 4	In addition to the proficiencies described for Level 3, the student applies scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion, taking into account possible unanticipated effects.

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

CCC: Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Levels	CCC Statements
Level 2	The student describes the relationship between cause and effect.
Level 3	In addition to the proficiencies described for Level 2, the student uses empirical evidence to differentiate cause and correlation and to make a claim about specific causes and effects.
Level 4	In addition to the proficiencies described for Level 3, the student describes empirical evidence that could be used to differentiate cause and correlation and to make a claim about specific causes and effects.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

Integrated Statement Levels	Performance Level Descriptor
Level 2	The student uses evidence to support a currently accepted explanation in relation to the cause of the possible extinction of a species in response to physical changes in the environment.
Level 3	In addition to the proficiencies described for Level 2, the student evaluates and uses empirical evidence behind currently accepted explanations related to whether changes in the physical environment have caused, or are correlated with, the expansion of some species, the speciation and divergence of some species, and/or the decline or extinction of some species.
Level 4	In addition to the proficiencies described for Level 3, the student describes empirical evidence that could be used to revise and compare competing explanations related to whether changes in the physical environment have caused, or are correlated with, the expansion of some species, the speciation and divergence of some species, and/or the decline or extinction of some species.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

DCI: LS4.C: Adaptation

Changes in the physical environment, whether naturally occurring or human-induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species.

Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.

Levels	DCI Statements
Level 2	The student describes how species may become extinct in response to physical changes in the environment.
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain how changes in the physical environment, whether naturally occurring or human-induced, have contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline—and sometimes the extinction—of some species. The student uses evidence to explain that species become extinct because they can no longer survive and reproduce in their altered environment and that if members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.
Level 4	In addition to the proficiencies described for Level 3, the student predicts the way in which a change in the physical environment will affect a given species—either adaptation, speciation, or extinction—and/or evaluates explanations for the change in a given species that may have occurred as a result of a change in the physical environment.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

SEP: Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science.

Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.

Levels	SEP Statements
Level 2	The student uses evidence to support currently accepted explanations or solutions to determine the merits of arguments.
Level 3	In addition to the proficiencies described for Level 2, the student evaluates the evidence behind currently accepted explanations or solutions to determine the merits of arguments.
Level 4	In addition to the proficiencies described for Level 3, the student revises and/or compares competing explanations or solutions based on claims, evidence, and reasoning in order to improve the merits of arguments.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

[Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

CCC: Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Levels	CCC Statements
Level 2	The student describes the relationship between cause and effect.
Level 3	In addition to the proficiencies described for Level 2, the student uses empirical evidence to differentiate cause and correlation and to make a claim about specific causes and effects.
Level 4	In addition to the proficiencies described for Level 3, the student describes empirical evidence that could be used to differentiate cause and correlation and to make a claim about specific causes and effects.

Appendix B

Performance Level Descriptors Set 2 Albino Redwoods

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]

[Assessment Boundary: Assessment does not include specific biochemical steps.]

Integrated Statement Levels	Performance Level Descriptor
Level 2	The student identifies models that show that carbon dioxide from the atmosphere and light from the Sun are key to plant processes.
Level 3	In addition to the proficiencies described for Level 2, the student uses models based on evidence to generate data, to illustrate, and/or to predict that photosynthesis converts light energy into stored chemical energy by converting carbon dioxide from the atmosphere and water into sugar and oxygen.
Level 4	In addition to the proficiencies described for Level 3, the student uses evidence to evaluate the merits, limitations, and reliability of two different models of the flow of matter and energy within a plant system and its components in order to select or to revise a model that best fits the evidence or design criteria.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]

[Assessment Boundary: Assessment does not include specific biochemical steps.]

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms

The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

Levels	DCI Statements
Level 2	The student explains that light and carbon dioxide are key to plant processes.
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that photosynthesis converts light energy to stored chemical energy by converting carbon dioxide from the atmosphere and water into sugar and oxygen.
Level 4	In addition to the proficiencies described for Level 3, the student uses evidence to explain that glucose is the sugar produced during photosynthesis and that the carbon and oxygen atoms present in glucose were originally present in carbon dioxide and water.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]

[Assessment Boundary: Assessment does not include specific biochemical steps.]

SEP: Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Use a model based on evidence to illustrate the relationships between systems or between components of a system.

Levels	SEP Statements
Level 2	The student identifies models that are based on evidence and illustrate the relationships between systems or components of a system.
Level 3	In addition to the proficiencies described for Level 2, the student uses models based on evidence to generate data, to illustrate, and/or to predict the relationships between systems or between components of a system.
Level 4	In addition to the proficiencies described for Level 3, the student uses evidence to evaluate the merits, limitations, and reliability of two different models of the relationships between systems or between components of a system, in order to select or revise a model that best fits the evidence or design criteria.

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

[Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]

[Assessment Boundary: Assessment does not include specific biochemical steps.]

CCC: Energy and Matter

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Levels	CCC Statements
Level 2	The student knows that changes in matter in a system can be described in terms of the flow of matter into that system.
Level 3	In addition to the proficiencies described for Level 2, the student knows that changes in matter and energy in a system can be described in terms of the flow of matter into, or out of, that system.
Level 4	In addition to the proficiencies described for Level 3, the student predicts changes in matter and/or energy within a system that result from changes in energy and matter that flows into, and/or out of, that system.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.]

[*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

Integrated Statement Levels	Performance Level Descriptor
Level 2	The student applies scientific ideas, principles, and/or evidence to provide an explanation of the changes that molecules undergo when they are recombined to assemble larger, carbon-based molecules.
Level 3	In addition to the proficiencies described for Level 2, the student uses valid and reliable evidence obtained from a variety of sources to make a quantitative or qualitative claim regarding dependent and independent variables and/or revises an explanation of how energy and matter flow when sugar molecules containing carbon, hydrogen, and oxygen are used to make the components of large, carbon-based molecules, such as protein and DNA.
Level 4	In addition to the proficiencies described for Level 3, the student applies scientific reasoning, theory, and/or models to assess data to predict the energy and/or matter flow and the specific recombination of reactant atoms and/or portions of molecules that occur when the assembly of large, carbon-based molecules from sugar molecule reactants occurs.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.]

[*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

DCI: LS1.C: Organization for Matter and Energy Flow in Organisms

The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.

As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.

Levels	DCI Statements
Level 2	The student identifies carbon-based molecules as products made up of smaller molecules, in relation to a phenomenon. The student explains that chemical elements can be recombined in different ways to form different products, in relation to a phenomenon.
Level 3	In addition to the proficiencies described for Level 2, the student uses evidence to explain that sugar molecules contain carbon, hydrogen, and oxygen atoms, and that those atoms are used to make large, carbon-based molecules, such as proteins and DNA. In addition to the proficiencies described for Level 2, the student uses evidence to track the flow of matter and energy through different organizational levels of a living system.
Level 4	In addition to the proficiencies described for Level 3, the student correlates specific reactant atoms and/or portions of molecules with specific atoms and/or portions of molecules in products (i.e. tracing a particular atom as it becomes part of larger molecules as it undergoes various biological processes). In addition to the proficiencies described for Level 3, the student predicts the flow of matter and energy through different organizational levels of a living system.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.]

[*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

SEP: Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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.

Levels	SEP Statements
Level 2	The student applies scientific ideas, principles, and/or evidence to provide an explanation of phenomena.
Level 3	In addition to the proficiencies described for Level 2, the student makes a quantitative and/or qualitative claim regarding dependent and independent variables and/or revises an explanation related to a phenomenon based on valid and reliable evidence obtained from a variety of sources.
Level 4	In addition to the proficiencies described for Level 3, the student applies scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion, taking into account possible unanticipated effects.

HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

[Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.]

[*Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.*]

CCC: Energy and Matter

Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Levels	CCC Statements
Level 2	The student knows that changes in matter in a system can be described in terms of the flow of matter into that system.
Level 3	In addition to the proficiencies described for Level 2, the student knows that changes in matter and energy in a system can be described in terms of the flow of matter into, or out of, that system.
Level 4	In addition to the proficiencies described for Level 3, the student predicts changes in matter and/or energy within a system that result from changes in energy and matter that flows into, and/or out of, that system.