OAKS SCIENCE TEST

HS New Item Type Training Test Scoring Guide

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About the New Item Type Training Test Scoring Guide

The OAKS Science New Item Type Training Test Scoring Guide provides details about the items, student response types, correct responses, and related scoring considerations for the OAKS Science Test 2017-18 embedded field test items. The items selected for the New Item Type Training Test are designed to reflect:

- a broad coverage of standards
- a broad range of student response types.

It is important to note that the online New Item Type Training Test provides a representative sample of tasks, not all possible scenarios.

Within this guide, each item is presented with the following information:

- Standard: The 2014 Oregon Science Standard (NGSS Performance Expectation) the task/item is aligned to.
- Task Demands: A statement that explains what a student will be able to do in response to an item in order to provide evidence that they have met the standard. These statements guide item writers to ensure alignment to the 2014 Oregon Science Standards (NGSS Performance Expectations).
- Scoring Criteria: A statement that explains what a student will be able to do in response to a task simulation, question, or elicitation.
- Rubric: score point representations for student responses
- Static Presentation of the Stimulus: A static presentation of the stimulus field from the test administration system.
- Static Presentation of task/item: A static presentation of simulations, questions, elicitations, and student response areas within a task or item.

The following tasks are a representative sample of tasks that students can expect to experience when taking the Science OAKS test for High School. Each ‘criterion’ is scored separately toward the cumulative score rather than each ‘part’ or ‘task’.

Task 1 – Life Science

Standard

HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Task Demands

- Identify the outcome data that should be collected in an investigation to provide evidence that feedback mechanisms maintain homeostasis. This could include measurements and/or identifications of changes in the external environment, the response of the living system, stabilization/destabilization of the system's internal conditions, and/or the number of systems for which data are collected.
- Make and/or record observations about the external factors affecting systems interacting to maintain homeostasis, responses of living systems to external conditions, and/or stabilization/destabilization of the systems' internal conditions.
- Identify or describe the relationships, interactions, and/or processes that contribute to and/or participate in the feedback mechanisms maintaining homeostasis that lead to the observed data.
- Using the collected data, express or complete a casual chain explaining how the components of (a) mechanism(s) interact in response to a disturbance in equilibrium in order to maintain homeostasis. This may include indicating directions of causality in an incomplete model such as a flow chart or diagram, or completing cause and effect chains.
- Evaluate the sufficiency and limitations of data collected to explain the cause and effect mechanism(s) maintaining homeostasis.

Stimulus

People tend to get hungry at the same times each day. Feeling hungry goes away after eating.

Feeling hungry is one of the body's symptoms of abnormal blood sugar levels. Feeling hungry alerts the body to eat. The pancreas helps to regulate blood sugar levels by producing glucagon, a hormone that acts as a messenger molecule to send signals around the body. Glucose is the sugar that serves as the body's main source of energy. Sufficient levels of sugar are required for cells to have the energy needed to survive.

Your Task

In the questions that follow, you will plan and conduct an investigation to understand the processes and feedback mechanisms that cause periodic feelings of hunger.

Part A

Use the simulation to investigate the effects of eating on the levels of sugar and glucagon in normal, healthy adult test subjects.

In the simulation, subjects eat a normal meal at noon.

For each trial, select a Subject and a Measurement Time to take the subjects' blood levels. Then click Start to collect data.

- Take measurements to identify reliable patterns in the relationships among feeling hungry, eating, sugar, and glucagon levels.
- You may take up to **ten** measurements.
- Be sure your data table contains only the data that will help you identify a reliable pattern in the relationships among feeling hungry, eating, sugar, and glucagon levels.
- If you need to change your selections, click the trash can icon next to a row to delete the data from the row.

Subject A
Measurement Time 8:30AM

Start

Subject	Measurement Time	Sugar (mg/dL)	Glucagon (pg/mL)	Is Subject Hungry?

Scoring Criteria

Part A

- The student collected data from all three subjects, indicating understanding of how to plan and conduct a valid scientific investigation.
- The student selected at least one measurement immediately before the meal (10:30 am or 11:30 am) indicating understanding that fluctuations in blood sugar and glucagon levels are related to hunger.
- The student consistently collected data from immediately before the meal (10:30 am or 11:30 am) for two or three subjects tested, indicating understanding of how to properly plan and conduct a scientific investigation.
- The student selected at least one measurement right after the meal (12:30 pm), indicating understanding that fluctuations in blood sugar and glucagon levels are related to hunger and meal consumption.
- The student consistently collected data from immediately after the meal (12:30 pm) for two or three subjects tested, indicating understanding of how to properly plan and conduct a scientific investigation.
- The student selected at least one measurement later after the meal or earlier before the meal (8:30 am, 9:30 am, 1:30 pm, or 2:30 pm), indicating understanding of how to conduct a valid scientific investigation to explore how blood sugar and glucagon levels fluctuate with hunger and meal consumption.
- The student consistently collected data from later after the meal or earlier before the meal (8:30AM, 9:30AM, 1:30PM, or 2:30PM) for two or three subjects tested, providing some evidence that the student understands how to properly plan and conduct a scientific investigation.
- The student collected measurements from one subject at three time points consisting of immediately before the meal (10:30AM, 11:30AM), right after the meal (12:30PM), and later after the meal/earlier before the meal (8:30AM, 9:30AM, 1:30PM, or 2:30PM), providing some evidence that the student understands how to conduct a valid scientific investigation to explore how blood sugar and glucagon levels fluctuate with hunger and meal consumption.

Rubric

Part A (8 points)

- All three subjects included in investigation (1 point).
- At least one measurement immediately before the meal (10:30AM, 11:30AM) (1 point).
- Measurements consistently from two or three subjects immediately before the meal (10:30AM, 11:30AM) throughout the investigation (1 point).
- At least one measurement immediately after the meal (12:30PM) (1 point).
- Measurements consistently from two or three subjects immediately after the meal (12:30PM) throughout investigation (1 point).
- At least on measurement later after the meal or earlier before the meal (8:30AM, 9:30AM, 1:30PM or 2:30PM) (1 point).

- Measurements consistently from two or three subjects later after the meal or earlier before the meal (8:30AM, 9:30AM, 1:30PM or 2:30PM) throughout investigation (1 point).
- Measurements from one subject at three time points consisting of immediately before the meal (10:30AM, 11:30AM), right after the meal (12:30PM), and later after the meal/earlier before the meal (8:30AM, 9:30AM, 1:30PM or 2:30PM) (1 point).

Part B

Using the data collected in part A, calculate the average sugar concentration and average glucagon concentration when the subject is hungry and not hungry.

Complete the table to compare the average sugar and glucagon levels for all subjects who are hungry compared to those who are not hungry.

- Round your answers to the nearest whole number.

	Average Sugar Concentration (mg/dL)	Average Glucagon Concentration (pg/mL)
The subject is hungry		
The subject is not hungry		

Scoring Criteria

Part B

- The student averaged the sugar concentration in the blood for the subjects in the investigation that were hungry, giving evidence of understanding of the type of data needed to serve as the basis for evidence.
- The student averaged the sugar concentration in the blood for the subjects in the investigation that were not hungry, giving evidence of understanding of the type of data needed to serve as the basis for evidence.
- The student averaged the glucagon concentration in the blood for the subjects in the investigation that were hungry, giving evidence of understanding of the type of data needed to serve as the basis for evidence.
- The student averaged the glucagon concentration in the blood for the subjects in the investigation that were hungry, giving evidence of understanding of the type of data needed to serve as the basis for evidence.

Rubric

Part B (4 points)

- Average of sugar concentration in the blood for the subjects in the investigation that were hungry rounded to the nearest whole number (1 point).

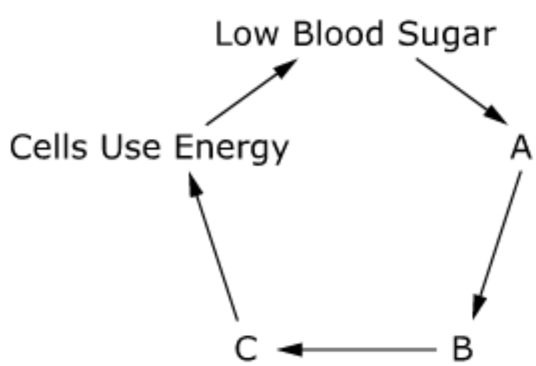
- Average of sugar concentration in the blood for the subjects in the investigation that were not hungry rounded to the nearest whole number (1 point).
- Average of glucagon concentration in the blood for the subjects in the investigation that were hungry rounded to the nearest whole number (1 point).
- Average of glucagon concentration in the blood for the subjects in the investigation that were not hungry rounded to the nearest whole number (1 point).

Part C

The flow chart shows the feedback mechanisms that help regulate blood sugar levels.

In the table, click on each letter to match it with **one** event that will occur next on the flow chart.

Blood Sugar Regulation Flow Chart



	A	B	C
Eat a meal	☐	☐	☐
Cells store energy	☐	☐	☐
Sugar produced	☐	☐	☐
Glucagon released	☐	☐	☐
Glucagon absorbed	☐	☐	☐
Body feels hungry	☐	☐	☐
Decrease in saliva	☐	☐	☐

Scoring Criteria

Part C

- The student selected that low blood sugar leads to glucagon release, indicating understanding of how feedback mechanisms act to stabilize a system.
- The students selected that glucagon release leads to the body feeling hungry, indicating understanding of how feedback mechanisms control homeostasis.
- The student selected that the body feeling hungry leads to eating a meal, indicating understanding that feedback mechanisms help control homeostasis.

Rubric

Part C (3 points)

- Low Blood Sugar leads to Glucagon Release (1 point);
    - AND
- Glucagon Release leads to Body Feels Hungry (1 point);
    - AND
- Body Feels Hungry leads to Eat a Meal (1 point).

Part D

How does the feedback mechanism that controls feeling hungry help to maintain homeostasis?

Ⓐ This process keeps glucagon levels elevated.

Ⓑ This process keeps glucagon in a healthy range.

Ⓒ This process keeps blood sugar levels elevated.

Ⓓ This process keeps blood sugar in a healthy range.

Scoring Criteria

Part D

- When asked how does the feedback mechanism that controls feeling hungry help maintain homeostasis the student selected “this process keeps blood sugar in a healthy range,” providing some evidence that the student understands that feedback mechanisms maintain homeostasis.

Rubric

Part D (1 point)

- This process keeps blood sugar in a healthy range (1 point).

Task 2- Physical Science

Standard

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of patterns of chemical properties.

Task Demands

- Use relationships identified in the data to predict properties of other chemical compounds/elements/mixtures.
- Identify patterns or evidence in the data that supports inferences about the properties of other chemical compounds/elements/mixtures.
- Organize and/or arrange (e.g., using illustrations and/or labels), or summarize data to highlight trends, patterns, or correlations.
- Articulate, describe, illustrate, or select the relationships, interactions, and/or processes to be explained. This may entail sorting relevant from irrelevant information or features.
- Use an explanation to predict the properties of other chemical compounds/elements/mixtures given a change in reagents or conditions.
- Generate/construct graphs, tables, or assemblages of illustrations and/or labels of data that document patterns, trends, or correlations relating to the periodic table. This may include sorting out distractors.

Stimulus

A piece of lithium is added to a beaker of water and it begins to fizz while a piece of sodium metal is added to another beaker of water and it gives off an orange flame and white smoke.

Lithium and sodium are both alkali metals. Lithium metal, when combined with water, produces lithium hydroxide and hydrogen gas:

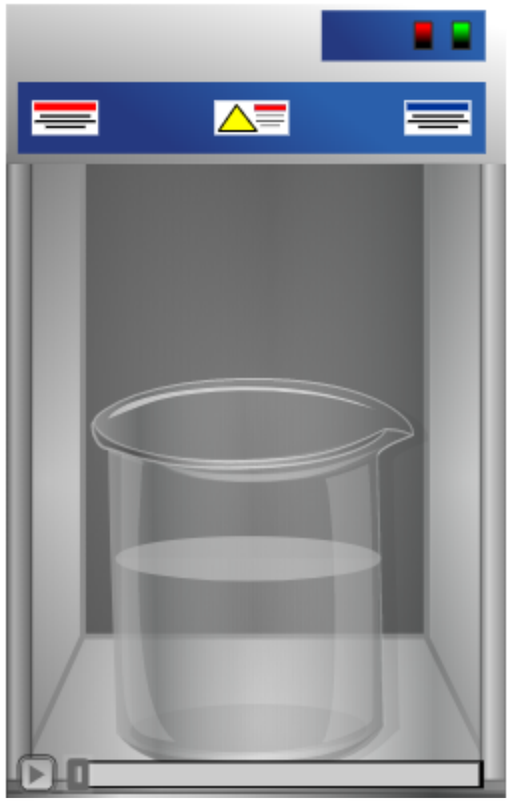
Figure 1. Reaction of Lithium and Water

$$2\ Li_{(s)} + 2\ H_2O_{(l)} \longrightarrow 2\ LiOH_{(aq)} + H_{2(g)}$$

States of Matter Key	
(aq)	aqueous
(g)	gas
(l)	liquid
(s)	solid

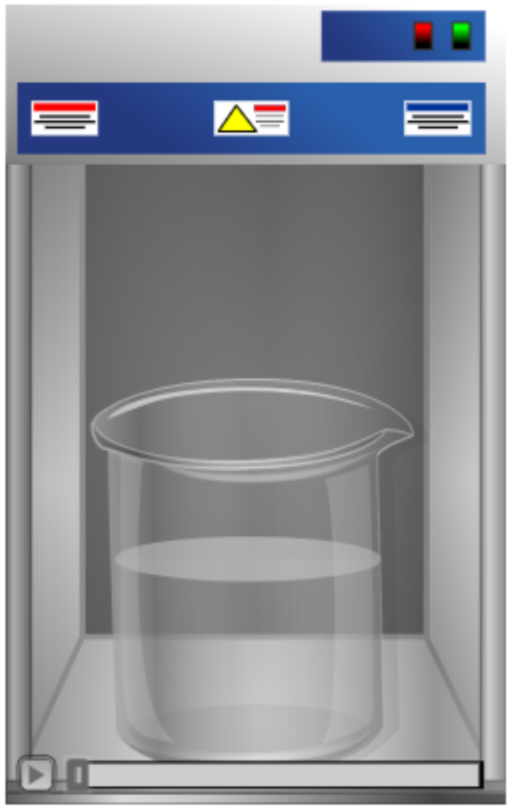
Click on the small gray arrow to run the animation to see how lithium metal reacts when combined with water.

Animation 1. Reaction of Lithium Metal



Sodium metal also reacts when combined with water. Click on the small gray arrow to run the animation to see how sodium metal reacts when combined with water.

Animation 2. Reaction of Sodium Metal



Lithium and sodium have different ionization energies. Elements with lower ionization energies make it easier for the outermost electron(s) to be removed and to participate in chemical reactions.

Table 1. Alkali Metals Ionization Energies

Element	Ionization Energy (kJ/mol)
Lithium	520
Sodium	496
Potassium	419
Rubidium	403
Cesium	376

Your Task

In the following questions, you will construct and revise explanations for the reactions of lithium and sodium with water.

Part A

Based on your observations in Animation 1 and Animation 2, select all of the properties that can be identified in the reactions of lithium and sodium with water.

- [ ] flammability
- [ ] boiling point
- [ ] reactivity with water
- [ ] electrical conductivity
- [ ] oxidation state
- [ ] electronegativity

<u>Scoring Criteria</u>

Part A

- The student selected “flammability” and none of the incorrect answers. This indicates an ability to record observations made in the reactions of lithium and sodium as shown in the animation.
- The student selected reactivity with water” and none of the incorrect answers. This indicates an ability to record observations made in the reactions of lithium and sodium as shown in the animation.

<u>Rubric</u>

Part A (2 points)

- “Reactivity with water” is indicated as observed during one of the reactions and no incorrect answers are chosen (1 point).
- “Flammability” is indicated as observed during one of the reactions and no incorrect answers are chosen (1 point).

Part B

Click on each blank box to select the word or phrase that **best** completes the statement.

All of the alkali metals have the same number of [▾], which suggests that they all have similar [▾]

The ionization energies of the alkali metals suggest that alkali metals [▾] reactivities when combined with water.

Scoring Criteria

Part B

- The student selected "valence electrons," indicating understanding of the outer electron states of alkali metals.
- The student selected "chemical properties," indicating understanding that the periodic table places those with similar chemical properties within columns.
- The student selected "all have different," indicating understanding of periodic trends relating to ionization energies and chemical reactivities with water.

Rubric

Part B (3 points)

- "Valence electrons" is selected in the first blank box (1 point).
- "Chemical properties" is selected in the second blank box (1 point).
- "All have different" is selected in the third blank box (1 point).

Part C

Predict the reactivity of other alkali metals with water by ordering the following alkali metals from 1 (least reactive) to 5 (most reactive).

	1	2	3	4	5
Cesium	☐	☐	☐	☐	☐
Lithium	☐	☐	☐	☐	☐
Potassium	☐	☐	☐	☐	☐
Rubidium	☐	☐	☐	☐	☐
Sodium	☐	☐	☐	☐	☐

Scoring Criteria

Part C

- The student selected “lithium, sodium, potassium, rubidium, and cesium” in that order, indicating understanding of trends and patterns within the periodic table.
- The student ordered sodium as more reactive than lithium, indicating understanding of the trend of ionization energies and how it relates to the chemical properties between these two elements in the same group.
- The student ordered potassium as more reactive than sodium, indicating understanding of the trend of ionization energies and how it relates to the chemical properties between these two elements in the same group.
- The student ordered rubidium as more reactive than potassium, indicating understanding of the trend of ionization energies and how it relates to the chemical properties between these two elements in the same group.
- The student ordered cesium as more reactive than rubidium, indicating understanding of the trend of ionization energies and how it relates to the chemical properties between these two elements in the same group.

Rubric

Part C (5 points)

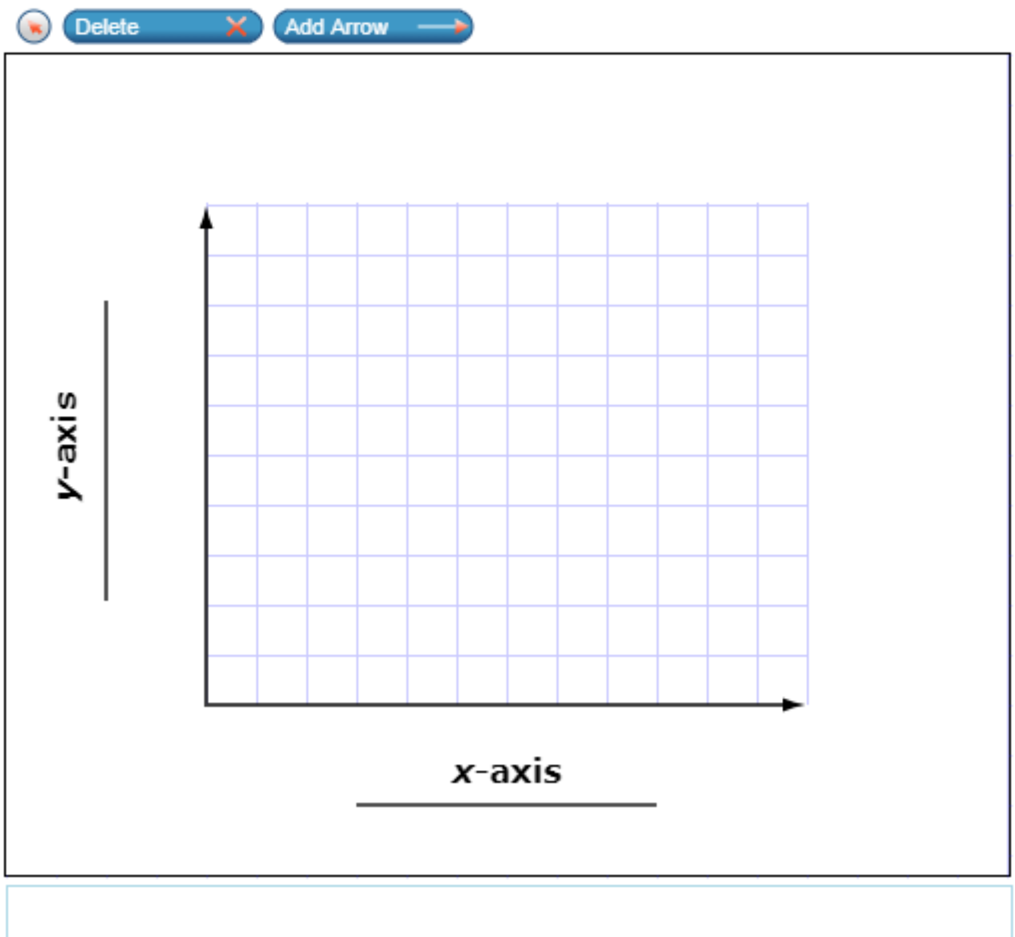
- Lithium (least reactive), sodium, potassium, rubidium, and cesium (most reactive) are listed respectively (1 point).
- Sodium indicated to be more reactive than lithium (1 point).
- Potassium indicated to be more reactive than sodium (1 point).
- Rubidium indicated to be more reactive than potassium (1 point).
- Cesium indicated to be more reactive than rubidium (1 point).

Part D

Using your response in part C, develop a graph that shows a pattern in the chemical reactivities of alkali metals. Choose the quantities that belong on the *x*- and *y*-axes and then use the Add Arrow tool to indicate the relationship.

The label for the *x*-axis should be [▾].

The label for the *y*-axis should be [▾].



Scoring Criteria

Part D

- The student selected "Group 1 Alkali Metals (Lowest to Highest Atomic Number)" and "Reactivity with water" as his or her axes, indicating understanding of patterns and graphical relationships within the periodic table.
- The student graphed a line with a positive slope OR also selected "Cesium (lease reactive), rubidium, potassium, sodium, lithium (most reactive)" as his or her sequence in part A,

indicating understanding of periodic trends and how these trends reflect patterns of outer electron states.

Rubric

Part D (2 points)

- "Group 1 Alkali Metals (Lowest to Highest Atomic Number" and "reactivity with water (Least Reactive to Most Reactive)" chosen as the x- and y-axes in any order (1 point).
- One line with a positive slope is indicated OR if the student listed the elements in exactly reverse order in part C, one line with a negative slope is indicated (1 point).

Part E

Click on each blank box to describe the pattern in the alkali metals' that you graphed in Part D.

The [▾] of the alkali metals increases as their [▾] [▾].

Scoring Criteria

Part E

- The student indicates that as the atomic number of alkali metals increase their reactivity with water increases. This indicates an ability to observe patterns in chemical properties.

Rubric

Part E (3 points)

- "The reactivity with water of the alkali metals increases as their atomic number increases" OR "the atomic number of their alkali metals increase as the reactivity with water increases" OR if the student listed the elements in exactly reverse order in part C "the reactivity with water of their alkali metals increases as the atomic number decreases" OR "the atomic number of the alkali metals increases as their reactivity with water decreases" (1 point)

Task 3- Life Science

Standard

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

Task Demands

- Organize or summarize the given data or evidence of population characteristics, environmental characteristics, and/or the relationships between them.
- Describe the cause and effect relationship between natural selection and adaptation using evidence. This may include assembling descriptions from illustrations or lists of options and distractors, or indicating directions of causality in a model or completing cause and effect chains.
- Describe, identify, or select evidence supporting or contradicting a claim about the role of adaptation in causing the phenomenon. The evidence may be generated by the students in a simulation.
- Given an appropriate explanation for a phenomenon, predict the effects of subsequent changes in environmental conditions on the population.
- Use evidence to construct an explanation of the adaptation of a species through natural selection. Evidence can be described, identified, or selected/assembled form lists with distractors. Explanations can be written, assembled by manipulating the components of a flow chart or model, or asse3mbled from lists of options that include distractors. Options and distractors should not be single words or short phrases; rather, they should be complete thoughts that, when correctly emplaced within a sentence or paragraph, work to provide evidence of a coherent train of thought.
- Identify and justify additional pieces of evidence that would help distinguish among competing hypotheses.

Stimulus

After a multiyear drought in California beginning in the year 2000, some wild mustard plants begin to flower earlier in the season.

To understand why, scientists analyzed data about the environment in California and a population of wild mustard plants.

Flowering mustard plants and their young offspring plants need plenty of water to grow. Table 1 shows the difference in average seasonal precipitation in the first and last 50 days of a typical growing season. A positive number indicates the amount of precipitation in centimeters (cm) above the average amount, and a negative number indicates the amount of precipitation below the average amount.

Table 1. Difference in Precipitation compared to the Long-Term Seasonal Averages

Year	Difference in Precipitation Days 1 – 50 (cm)	Difference in Precipitation Days 51 – 100 (cm)
1995	2.0	4.2
1996	0.0	3.5
1997	3.5	1.8
2000	2.5	-2.5
2001	-1.5	-0.2
2002	-0.5	-3.0
2003	1.1	-1.5
2004	-2.1	-2.0

Along with this data, the scientists also planted seeds collected in 1997 and 2004 from both locations in identical greenhouse conditions. Table 2 shows the number of days from germination to first flowering for all the seeds planted.

Table 2. Days to First Flowering

Seed Sample Collected	Days to First Flowering
From dry location in 1997	43
From dry location in 2004	41
From wet location in 1997	59
From wet location in 2004	47

Your Task

In the questions that follow, you will explain why seeds collected in 2004 flowered sooner than those collected in 1997.

Part A

Use Table 3 to summarize data that will be the **most** useful as you explain why seeds collected in 2004 flowered sooner than those collected in 1997.

Click each box and select a number or phrase to complete the table explaining why seeds collected in 2004 flowered sooner than those collected in 1997.

Table 3. Summary of Average Annual Precipitation

Years	Average Annual Precipitation
1995–	
–2004	

Scoring Criteria

Part A (4 points)

- The student selected "1997" to complete the first range of years indicating some ability to summarize the given data of change in average precipitation.
- The student selected a summary of the data consistent with the first range of years indicating some ability to summarize the given data of change in average precipitation.
- The student selected "2000" to complete the second range of years indicating some ability to summarize the given data of change in average precipitation.

- The student selected a summary of the data consistent with the second range of years indicating some ability to summarize the given data of change in average precipitation.

Part B

What is a short-term effect of the drought on the mustard plants?

Ⓐ Drier conditions cause the mustard plants to slowly mature during Days 51–100.

Ⓑ Several of the mustard plants started to release seeds that will germinate during Days 1–50.

Ⓒ Mustard plants that flower in Days 51–100 are less likely to produce surviving offspring.

Ⓓ Mustard plants produced fewer seeds during Days 1–50 in response to the drier conditions.

<u>Scoring Criteria</u>

Part B (1 point)

- The student selects "Mustard plants that flower in Days 51-100 are less likely to produce surviving offspring," indicating some understanding of the given data of precipitation changes and flowering time.

Part C

Select a piece of evidence from the text to support your inference made in part B.

<u>Scoring Criteria</u>

Part C (1 point)

- Student selected a piece of evidence that supports their inference in Part B indicating some understanding of the cause of the change in flowering time of the mustard plants.

Part D

Click each box and select a phrase to complete the sentence and make an inference about the mustard plants in the wet location.

The drought caused a change in [▾], which led to a change in the [▾].

<u>Scoring Criteria</u>

Part D (2 points)

- The student selected “plant flowering time” for the first blank indicating some understanding of the effect of an environmental change on a population of mustard plants.
- The student selected “distribution of genes in the population” for the second blank indicating some understanding of the effect of an environmental change on a population of mustard plants.

Part E

Which statement **best** explains the change in the flowering time of the mustard plants?

Ⓐ The population of mustard plants were more affected by the changes in the precipitation because of the dry, sandy soil.

Ⓑ Mustard plants that had the adaptation to drier conditions were more likely to survive and reproduce in the drought.

Ⓒ There were similar species of plants in the same area in 2004 with which the mustard plants could crossbreed.

Ⓓ Genetic drift occurred in the population of mustard plants from the 1997 sample but not in the population from the 2004 sample.

Scoring Criteria

Part E (1 point)

- The student selected “Some of the plants had already developed earlier flowering times as an adaptation to drier conditions,” indicating some ability to infer the reason for the change in flowering time of mustard plants using the given evidence.

Part F

Select all the additional information needed to support the inference you selected in part E.

- ☐ sufficient evidence is provided
- ☐ the average amount of precipitation between the years of 1997 and 2004
- ☐ a comparison of the rate of survival to reproduction for the 1997 and 2004 plants
- ☐ genetic sequencing data that looks for genes from other plant species in the 2004 mustard plants
- ☐ genetic sequencing data to determine whether the changes to the flowering time are caused by genes

Scoring Criteria

Part F (1 point)

- The student selected "Sufficient evidence is provided," indicating an understanding that no additional evidence is needed to support the inference in part 3 and/or the additional evidence listed would not support the inference in part E.

Task 4- Earth and Space Science

Standard

HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.

Task Demands

- Organize and/or arrange (e.g., using illustration and or labels), summarize or make inferences about data to highlight trends, patterns, or correlations.
- Identify patterns of evidence in the data that supports inferences about the lifespan of the sun or the transfer of the energy from the sun to the earth.
- Select or identify from a collection of potential model components, including distractors, the components needed for a model that illustrates the lifespan of the sun or the transfer of energy from the sun to the earth.
- Manipulate the components of a model to demonstrate the changes, properties, processes, and/or events that relevant to the lifespan of the sun or the transfer of energy from the sun to earth.
- Identify missing components, relationships, or other limitations of the model.
- Make predictions about the effects of changes in the sun or in the transfer of energy from the sun to the earth. Predictions can be made by manipulating model components, completing illustration, or selecting from lists with distractors.

Stimulus

The habitable zone in our solar system currently contains both Earth and Mars. In the future, it may contain a different set of planets.

Many stars in the universe have solar systems around them. In solar systems of other stars, the habitable zone with "Earth-like" conditions varies based on the characteristics of the star at the center of the system.

Table 1 gives the characteristics of four Red Giant (RG), Main Sequence (MS) and Blue Giant (BG) stars relative to the sun.

Table 1. Characteristics of Stars

Star	Stellar Characteristics			
	Type	Radius	Surface Temperature	Luminosity
Aldebaran	RG	44	0.67	425.0
Arcturus	RG	26	0.70	200.0
Procyon	MS	2	1.12	7.70
Rigel	BG	78	1.72	66,000.0
Sun	MS	1	1.00	1.0

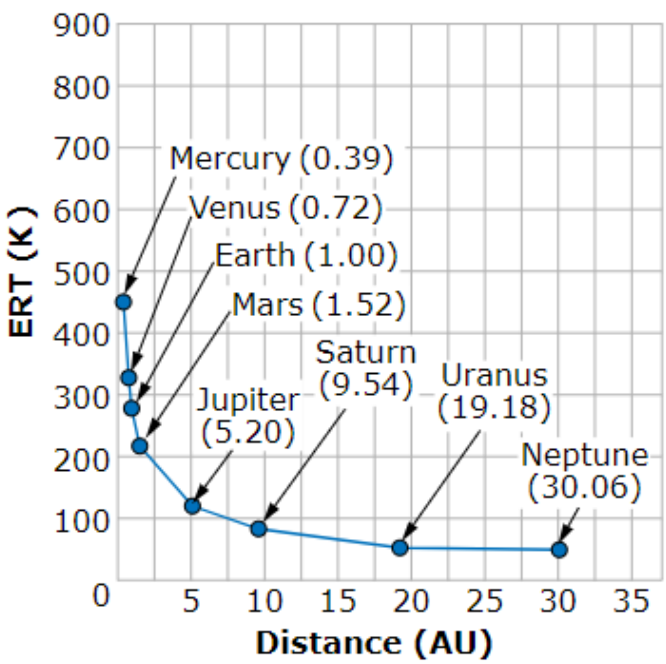
Table 2 lists the habitable zone boundaries for each star. The habitable zone is the range of orbits around a star within which water can exist in liquid form. The minimum and maximum boundary distance that defines each habitable zone is given in astronomical units (AU). The average distance between Earth and the sun is 1 AU.

Table 2. Habitable Zone Boundaries

Star	Minimum Boundary Distance (AU)	Maximum Boundary Distance (AU)
Aldebaran	21.23	40.43
Arcturus	14.51	27.42
Procyon	2.53	4.39
Rigel	300.34	528.83
Sun	0.95	1.68

Effective radiation temperature (ERT) is one way to measure the amount of energy carried by radiation. The ERT at any location in a solar system depends on the amount of energy released by the parent star and the distance from the star. Figure 1 shows the ERT as a function of distance from the sun. The average distance between each planet and the sun is given in AU in the parentheses.

Figure 1. Effective Radiation Temperature vs. Distance



The sun is currently 4.5 billion years old. Scientists predict that the sun will change in many ways over the next 4.5 billion years. Table 3 shows the current and predicted characteristics of the sun during its lifetime.

Table 3. Current and Predicted Characteristics of the Sun at 4.5 Billion Years Old and 10 Billion Years Old

	Radius	Surface Temperature	Luminosity
Current	1	1.0	1
Predicted	100	0.6	500

Your Task

In the questions that follow, you will use evidence and manipulate the given mathematical models to explain why and how the sun's habitable zone will move in the future.

Part A

Complete the table to compare the distance and approximate ERT of the minimum and maximum boundaries of the sun's current habitable zone.

Sun's Current Habitable Zone	Distance (AU)	Approximate ERT (K)
Minimum Boundary		
Maximum Boundary		

Scoring Criteria

Part A

- The student entered 0/95 as the minimum boundary distance, demonstrating their ability to organize data to highlight correlations about the sun's current habitable zone.
- The student entered 1.68 as their maximum boundary distance, demonstrating their ability to organize data to highlight correlations about the sun's current habitable zone.

- The student entered a value between 290 and 310 as the ERT at the minimum boundary of the habitable zone, demonstrating their ability to organize data to highlight correlations about the sun's current habitable zone.
- The student entered a value between 190 and 210 as the ERT at the maximum boundary of the habitable zone, demonstrating their ability to organize data to highlight correlations about the sun's current habitable zone.

Rubric

Part A (4 points)

- 0.95 is entered as the distance of the minimum boundary (1 point).
- 1.68 is entered as the distance of the maximum boundary (1 point).
- Value between 290 and 310 is entered as the ERT for the minimum boundary (1 point).
- Value between 190 and 210 is entered as the ERT for the maximum boundary (1 point).

Part B

Select the boxes to show how the sun's characteristics change as it ages.

Sun Characteristic	Increases	Decreases	Remains the Same
Radius	☐	☐	☐
Surface Temperature	☐	☐	☐
Luminosity	☐	☐	☐

Scoring Criteria

Part B

- The student identified that the sun's radius will increase as the sun ages, providing some evidence of student's ability to identify evidence in the data that will support an inference about the changing habitable zone in our solar system.
- The student identified that the sun's surface temperature will decrease, providing some evidence of student's ability to identify evidence in the data that will support an inference about the changing habitable zone in our solar system.

Rubric

Part B (3 points)

- "Increases" selected for Radius (1 point).
- "Decreases" selected for Surface temperature (1 point).
- "Increases" selected for Luminosity (1 point).

Part C

Click on the box to select the characteristic that best completes the statement.

The stellar characteristic most correlated to a star's effective radiation temperature (ERT) is the star's [▾]

Scoring Criteria

Part C

- The student identified that a star's luminosity has the greatest effect on its effective radiation temperature, providing some evidence of the student's ability to make an inference about data to highlight correlations about a star's characteristics and the transfer of energy throughout a solar system.

Rubric

Part C (1 point)

- "Luminosity" is selected in the box (1 point).

Part D

Which bright star most likely has an ERT similar to the sun's predicted ERT at 10 billion years old?

Ⓐ Aldebaran

Ⓑ Arcturus

Ⓒ Procyon

Ⓓ Rigel

Scoring Criteria

Part D

- The student identified that Aldebaran is the star most like the predicted 10 BY old sun, providing some evidence of the student's ability to identify evidence in the data that supports an inference about the lifespan of the sun.

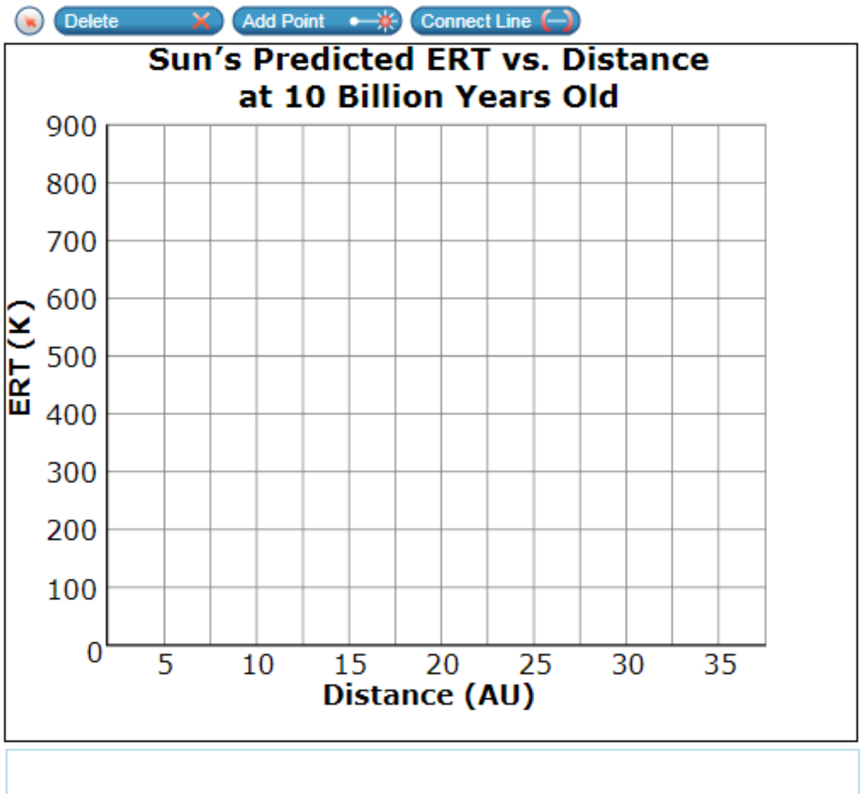
Rubric

Part D (1 point)

- "Aldebaran" is selected in part D (1 point).

Part E

Use the Connect Line tool to construct a graphical model of the effective radiation temperature (ERT) over distance for the sun at 10 billion years old.



<u>Scoring Criteria</u>

Part E

- The student plotted a graph for a star brighter than the sun with a single curve with a y-intercept greater than 450 K OR for a star fainter than the sun with a single curve with a y-intercept less than 450 K if they chose Procyon for Part D, providing some evidence of the student's ability to make an inference about data to highlight correlations about a star's characteristics and the transfer of energy throughout a solar system.
- The student plotted an ERT vs. distance graph as a single curve with a continually decreasing slope, providing some evidence of the student's ability to make an inference about data to highlight correlations about a star's characteristics and the transfer of energy throughout a solar system.
- The student graphed a line between 300 K and 200 K between 20 AU and 40 AU OR at distances that match the habitable zone for the star selected in Part D, providing some evidence of the student's ability to construct a model capable of illustrating the sun's transfer of energy to the earth and beyond.

<u>Rubric</u>

Part E (3 points)

- “Aldebaran” OR “Arcturus” OR “Rigel” is selected in Part D;
    - AND
- Graph is drawn with y-intercept point at a y-value greater than 450;
- OR
- “Procyon” is selected in Part D;
    - AND
- Graph is drawn with y-intercept point at a y-value less than 450 (1 point).
- Slope of lines graphed to the right of 10 AU are less negative than the slope of the lines to the left of 10 AU (1 point).
- At least one line is drawn between y-values of approximately 200 and 300 at the distances that match the habitable zone of the star selected in Part D (1 point).

Part F

Using the evidence and mathematical models, predict the size of the habitable zone of our solar system when the sun is 10 billion years old. Enter the values in the table.

	Approximate Lower Limit (AU)	Approximate Upper Limit (AU)
Future Habitable Zone		

<u>Scoring Criteria</u>

Part F

- The student entered a value between 20 and 22 AU for the lower limit of the habitable zone OR a value that matches the lower limit of the habitable zone for the star chosen in Part D, providing evidence that the student manipulated the mathematical models to demonstrate the changes in our solar system relevant to the lifespan of the sun and the transfer of energy from the sun to Earth and other planets.
- The student entered a value between 39 and 41 AU for the upper limit of the habitable zone OR a value that matches the upper limit of the habitable zone for the star chosen in Part D, providing evidence that the student manipulated the mathematical models to demonstrate the changes in our solar system relevant to the lifespan of the sun and the transfer of energy from the sun to Earth and other planets.

<u>Rubric</u>

Part F (2 points)

- Value between 20 and 22 selected for the lower limit (1 point).
- Value between39 and 41 selected for the upper limit (1 point).

Part G

Select the boxes to identify the planet or planets included in the habitable zone of our solar system when the sun is 10 billion years old.

Planets	Included in New Habitable Zone
Mercury	☐
Venus	☐
Earth	☐
Mars	☐
Jupiter	☐
Saturn	☐
Uranus	☐
Neptune	☐
No Planets	☐

Scoring Criteria

Part G

- The student identified that Neptune is included in the 10 billion year habitable zone OR identified planet membership based on the star selected in Part D, providing some evidence of student's ability to manipulate the mathematical models to make predictions about the lifespan of the sun and the energy transfer to Earth and other planets in our solar system.

Rubric

Part G (1 point)

- "Aldebaran" is selected in Part D
    - AND
- "Neptune" is selected for "Included in New Habitable Zone"
- OR
- "Arcturus" is selected in Part D
    - AND
- "Uranus" is selected for "Included in New Habitable Zone"
- OR
- "Procyon" is selected in Part D
    - AND
- "Jupiter" is selected for "Included in New Habitable Zone"
- OR
- "Rigel" is selected in Part D
    - AND

- “No planets” is selected for “Included in New Habitable Zone” (1 point).