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Introduction to the Practice Test Answer Guide

This California Science Test (CAST) practice test items scoring guide offers details about the items, student response types, correct responses, and related scoring considerations for the practice test items. These items have been selected to show some of the new approaches to measuring the California Next Generation Science Standards (CA NGSS) that can be found in the assessment. The practice test items are not fully representative of all possible item types included in the CAST. The practice test covers a selection of items from performance expectations in high school.

The following information is presented along with each item:

**Performance Expectations (PE) Code**: References the assessable evidence statements of what students should know and be able to do.

**Science and Engineering Practices (SEP)**: Descriptions of behaviors that scientists and engineers engage in as they investigate the natural world and design solutions, respectively.

**Disciplinary Core Ideas (DCI)**: Essential ideas in the science disciplines that all students should understand.

**Crosscutting Concepts (CCC)**: Interdisciplinary skills that unify the study of science and engineering through common application across fields.

**Depth of Knowledge (DOK)**: A measure of complexity that considers the students’ cognitive process in response to an item. (There are four DOK levels, with 4 being the highest.)

**Item-Level Claim Statement (ILCS)**: A brief statement that illustrates how an item aligns to the PE through at least two of the dimensions (An ILCS is included with each item to help item reviewers (1) identify the intent of the alignment, (2) determine if the alignment is appropriate and valid, and (3) identify the content reflected in item-level specifications.)

**Item and Stimulus**: Item represents the question being asked, while stimulus is supporting information, graphics, animation or simulation included with some items.

**Answer Key**: The expected student response or example response including score point value.

**Rubric and Exemplar**: Rubric explains what is needed for each score point. Exemplars give a sample response from a student.

While each item is aligned to a specific PE through its dimensions, certain items, based on their contexts, incorporate aspects of environmental literacy outlined in the Environmental Principles and Concepts adopted by the State Board of Education in 2004. The items in this practice test are not fully representative of the full range of ways items can incorporate environmental literacy.
High School Practice Test Items

Each item has a metadata table as shown. Metadata contains the specific information on the alignment of the item to the NGSS standards. The item number in the table preceding each item corresponds to the sequence number of the item as it appears in the practice test.

### Example of Metadata

<table>
<thead>
<tr>
<th>Item</th>
<th>Grade</th>
<th>PE</th>
<th>SEP</th>
<th>DCI</th>
<th>CCC</th>
<th>DOK</th>
</tr>
</thead>
</table>

**ILCS:** Construct an explanation based on evidence for how natural selection leads to changes in traits in populations.
### High School Braille Practice Test Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Grade</th>
<th>PE</th>
<th>SEP</th>
<th>DCI</th>
<th>CCC</th>
<th>DOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>High School</td>
<td>HS-LS4-4</td>
<td>6. Constructing Explanations and Designing Solutions</td>
<td>LS4.C Adaptation</td>
<td>2. Cause and Effect</td>
<td>3</td>
</tr>
</tbody>
</table>

**ILCS:** Construct an explanation based on evidence for how natural selection leads to changes in traits in populations.

The leaf beetle, *Chrysomela aeneicollis*, lives in the Sierra Nevada Mountains of California. Scientists studying the beetles found that exposure to high temperatures during the summer, when the eggs are laid and the larvae are developing, causes physiological stress. The impact is on metabolic enzymes and heat shock protein expression. One allele, *Pgi-4*, increased in frequency in the beetle population that was exposed to hotter, drier summers in the Sierra Nevada Mountains.

Complete the sentence about this change by selecting the correct words from the lists.

If the temperatures in the Sierra Nevada Mountains continue to increase, the frequency of the *Pgi-4* allele is expected to **increase** as a result of **natural selection**.

**Key:** First drop-down menu: increase. Second drop-down menu: natural selection. (1 point)
ILCS: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Students are investigating the relationship between human population density and biodiversity. The amount of forest cover was used as a measure of the biodiversity of an area. The students averaged human population density and forest cover from locations with a range of population densities. The graph shows the students’ results.

![Forest Cover and Human Population Density Graph]

**Part A**

Select a phrase from the list to complete the sentence.

Based on the graph, if the population density increases from 1 to 500 people/km², the forest cover will likely \( \text{______} \) in that area.

**Part B**

The students identified four resource management strategies intended to help preserve forest cover and maintain biodiversity. The students then ran computer simulations to graphically compare the different resource management strategies.

*Item continues on the next page.*
Which graph shows results for a resource management strategy that will best preserve forest cover as population density increases?

A

B

C

D

Key:
Part A: Drop-down menu: decrease by about 50%. (1 point)
Part B: B (1 point)
ILCS: Select the relevant components to complete the model by applying the scientific principle of nucleon conservation.

A uranium nucleus \(^{238}_{92}U\) decays into a thorium nucleus \(^{234}_{90}Th\) and another particle.

What is the other particle produced by the decay?

A \(^1_1H\)  
B \(^4_2He\)  
C \(^{119}_{46}Pd\)  
D \(^{234}_{90}Th\)

**Key:** B (1 point)
<table>
<thead>
<tr>
<th>Item</th>
<th>Grade</th>
<th>PE</th>
<th>SEP</th>
<th>DCI</th>
<th>CCC</th>
<th>DOK</th>
</tr>
</thead>
</table>

**ILCS:** Identify the design that will provide the best evidence to determine the amount and type of sediment entering the stream.

Students noticed that a nearby pond, fed by a single stream, was filling up with sediment. The students want to determine what factors are contributing to the amount and type of sediment entering the pond. Which investigation is **most likely** to produce data that will help answer their questions?

1. Measure the depth of the sediments in the center of the pond once a week during the school year.
2. Collect and measure the mass of particles carried by the stream in one minute and then in ten minutes.
3. Collect and measure the mass of clay particles, silt particles, sand grains, and small pebbles carried by the stream at different stream flow velocities.
4. Obtain samples from different depths in the sediments at the bottom of the pond and determine how the sizes and amounts of particles have changed over time.

**Key:** C (1 point)
**ILCS:** Construct an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules combine to form other large molecules.

A biochemist conducted an experiment to follow the movement of glucose molecules in animal cells. Glucose with radioactively labeled carbon atoms was added to a culture of liver cells growing in a Petri dish. Over the next 18 hours, the biochemist assessed selected biomolecules in the culture for radioactivity. The results are shown in the table.

<table>
<thead>
<tr>
<th>Biomolecule</th>
<th>3 Hours</th>
<th>6 Hours</th>
<th>9 Hours</th>
<th>12 Hours</th>
<th>15 Hours</th>
<th>18 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Glycogen</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

Explain how adding labeled glucose molecules to the culture resulted in labeled glycogen and describe what happened to the labeled glucose molecules during the 18-hour period. Enter your answer in the box provided.

*Rubric follows on the next page.*
2 point
Exemplar:
The glucose molecules were incorporated into (or stored in) glycogen within 6 hours. Some of the glucose molecules were broken down and used for energy. All of the labeled glucose was either used up (metabolized) or stored by 18 hours.

Rubric:
The response explains that glucose is incorporated into or turned into glycogen. AND

The response explains that it can be used/broken down for energy. Further, there must be an indication that these processes take time, which can be seen in the table.

1 point
Exemplar:
The glucose molecule was incorporated into (or turned into) glycogen within 6 hours. OR

Some of the glucose molecules were broken down and used for energy.

Rubric:
The response explains that glucose is incorporated into or turned into glycogen. OR

The response explains that it can be used/broken down for energy. Further, there must be an indication that these processes take time, which can be seen in the table.

0 point
Exemplar:
The glucose was turned into molecules other than glycogen. OR

The glucose molecules dissolved because they are radioactive.

Rubric:
A 0-point response attempts to answer the prompt but is incorrect.
**ILCS:** Describe how factors such as composition and temperature affect the rate of nuclear fusion and energy production.

A student is learning about the life cycles of low-mass and high-mass stars and creates a chart comparing the properties of the stars.

Complete the chart by placing a check mark in the box or boxes in each row to indicate if the property applies to low-mass stars, high-mass stars, or both.

<table>
<thead>
<tr>
<th>Low-mass stars</th>
<th>High-mass stars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has a higher core temperature during main sequence stage</td>
<td>[ ]</td>
</tr>
<tr>
<td>Spends a longer time on the main sequence</td>
<td>[ ]</td>
</tr>
<tr>
<td>Burns hydrogen at a faster rate during main sequence stage</td>
<td>[ ]</td>
</tr>
<tr>
<td>Spends the majority of its lifetime burning hydrogen in its core</td>
<td>[ ]</td>
</tr>
<tr>
<td>Can create elements heavier than iron during supernova event</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

**Key:** (1 point)
ILCS: Describe how wavelength is related to the change in the medium.

Laser light of wavelength 785 nm in air travels from air (index of refraction = 1) into a glass block (index of refraction = 1.5). The frequency of the light does not change when the light enters the glass. How does the wavelength of the light change, if at all, when the light enters the glass, and what reasoning supports this claim?

A. The wavelength stays the same, because the wavelength can only change if the frequency changes.

B. The wavelength stays the same, because the speed of light is constant and the frequency does not change.

C. The wavelength decreases, because the speed of the light in the glass is less than the speed of light in air and the frequency does not change.

D. The wavelength decreases, because the speed of the light in the glass is greater than the speed of light in air and if the speed increases, the wavelength must decrease.

Key: C (1 point)
ILCS: Calculate the predicted genotypic ratios of offspring.

In a particular species of plant, yellow seed color is dominant to green seed color. Two plants of this species that are heterozygous for seed color are crossed.

What is the predicted ratio for seed color in the offspring of this cross?

- A 1 yellow : 3 green
- B 1 yellow : 1 green
- C 3 yellow : 1 green
- D 3 yellow : 2 green

**Key:** C (1 point)
**ILCS:** Describe how a model illustrates or explains the internal and surface processes that produced a geological feature.

This diagram shows the boundary between the Indian Plate and the Eurasian Plate.

![Diagram of plate boundary](image)

Select the **best** terms from the lists to complete the following statements.

The mountains were formed as a result of the Indian Plate [ ] the Eurasian Plate.

Over time, the effects of [ ] will counteract the process that builds the mountains.

**Key:** First drop-down menu: colliding with. Second drop-down menu: weather and erosion. (1 point)
High School Practice Test Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Grade</th>
<th>PE</th>
<th>SEP</th>
<th>DCI</th>
<th>CCC</th>
<th>DOK</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>High School</td>
<td>HS-PS2-1</td>
<td>4. Analyzing and Interpreting Data</td>
<td>PS2.A Forces and Motion</td>
<td>2. Cause and Effect</td>
<td>2</td>
</tr>
</tbody>
</table>

**ILCS:** Identify the relationship between mass and acceleration.

A student performs an experiment in which a cart is pulled across a table by exerting a net force of 0.05 N on the cart. Different amounts of mass are added to the cart for each trial. The graph shows data from the experiment.

![Graph showing Mass vs. Acceleration](image)

Based on the results from the experiment, what claim can the student make about the relationship between net force, acceleration, and mass?

- Objects with smaller mass experience a larger acceleration and therefore a larger net force.
- Objects with larger mass experience a smaller acceleration and therefore a smaller net force.
- Objects with larger mass experience a smaller acceleration when the net force is the same.
- Objects with smaller mass experience a smaller acceleration when the net force is the same.

**Key:** C (1 point)
ILCS: Select questions that could help determine criteria or constraints for design solutions that will help in reducing carbon dioxide emissions. Identify different variations on the problem definition that highlight the concerns of the community.

For a certain farming community in California, a water shortage is predicted if the average global temperature rises by 1°C. The residents of this community rely on private vehicles powered by fossil fuels for transportation because there is no public transportation system. Farm vehicles powered by diesel fuel are used to harvest the crops and get them to market.

Residents of the farming community want to reduce their impact on global temperature increases by reducing their carbon dioxide (CO₂) emissions. They asked the town planners to propose some possible solutions that will address their transportation concerns and reduce the amount of CO₂ released into the atmosphere. Two potential solutions have been proposed:

- Solution 1: Restrict the use of private vehicles powered by fossil fuels on public roads.
- Solution 2: Promote vehicles powered by renewable energy sources to harvest the crops and get them to market.

**Part A**

Select **two** questions that residents of the farming community could ask to **quantitatively** evaluate the proposed solutions.

- Does this plan take into consideration damage to the crops caused by extreme weather events?
- Will this plan allow our community members to independently select oil suppliers?
- Will this plan increase our farming community’s access to new varieties of seeds?
- Does this plan allow the farms in our community to continue to be profitable?
- Does this plan allow for a significant reduction in the use of diesel fuel?

*Item continues on the next page.*
Part B

Place a check mark in the boxes to indicate whether each of the two potential solutions addresses the stated transportation concerns of the farming community, the global problem of increasing CO₂ emissions, or both.

<table>
<thead>
<tr>
<th>Addresses transportation concerns of farming community</th>
<th>Addresses global problem of increasing CO₂ emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution 1: Restrict the use of private vehicles powered by fossil fuels on public roads.</td>
<td>☐</td>
</tr>
<tr>
<td>Solution 2: Promote vehicles powered by renewable energy sources to harvest the crops and get them to market.</td>
<td>☑</td>
</tr>
</tbody>
</table>

Key:

Part A: Fourth and fifth options. (1 point)

Part B: (1 point)
ILCS: Identify components in a simulation that depict the effects of human activity on bird biodiversity.

**Environmental Principle II:** The long-term functioning and health of terrestrial, freshwater, coastal, and marine ecosystems are influenced by their relationships with human societies.

Students are given an assignment to design a simulation that will model effects of human activity on biodiversity in a particular town. A student decides to model changes in the biodiversity of bird species caused by human activity in a forested park next to the school. The park is home to many native bird species. Near the park is a housing development and an industrial area.

What **three** components should the students include in their simulation to **best** understand the effects of human activity on biodiversity?

- [ ] size of the park
- [ ] annual rainfall in the town
- [ ] number of native bird species in the park
- [ ] projected population growth in the town
- [ ] number of native herbivore species in the park

**Key:** First, third, and fourth options. (1 point)
**ILCS:** Predict changes to the Arctic sea ice based on probability and describe the patterns shown in the data over time.

Scientists studied the extent of Arctic sea ice from 1978 to 2016. Observations from selected years are shown in the maps. The white areas show the extent of the sea ice in November of the indicated year. The dark blue areas are ice-free ocean and the green areas are continents in all of the maps.

![Maps showing Arctic sea ice extent](image)

**Part A**

Based on the Arctic sea ice images from 1978 to 2016, what is most likely going to occur from 2017 to 2027?

- A. Arctic sea ice will move to other parts of the ocean.
- B. Arctic sea ice will freeze and melt at the same rate.
- C. Arctic sea ice will continue to melt at an increasing rate.
- D. Arctic sea ice will continue to expand until it exceeds its 1978 extent.

**Part B**

Use the lists to complete the statement.

Melting Arctic sea ice contributes to a positive feedback loop in the Arctic. As Arctic sea ice melts, □ □ sunlight is reflected and the temperature of the Arctic Ocean □ □.

**Key:**

Part A: C (1 point)

Part B: First drop-down menu: less. Second drop-down menu: increases. (1 point)
ILCS: Explain how the differing nucleotide sequences can cause red blood cells to differ in phenotype due to the proteins encoded by these sequences.

Sickle-cell disease is a group of genetic disorders that affect hemoglobin, which is the protein in red blood cells that binds to oxygen. The change to the hemoglobin molecule causes the red blood cells to have a crescent or sickled shape. The diagram shows a fragment of the DNA sequence for hemoglobin in a person without sickle-cell disease and in a person with the disease.

**Part A**

### Normal Red Blood Cells

<table>
<thead>
<tr>
<th>DNA sequence</th>
<th>CAC</th>
<th>GTG</th>
<th>GAC</th>
<th>TGA</th>
<th>GGA</th>
<th>CTC</th>
<th>CTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino acid</td>
<td>Valine</td>
<td>Histidine</td>
<td>Leucine</td>
<td>Threonine</td>
<td>Proline</td>
<td>Glutamic acid</td>
<td>Glutamic acid</td>
</tr>
</tbody>
</table>

### Sickled Red Blood Cells

<table>
<thead>
<tr>
<th>DNA sequence</th>
<th>CAC</th>
<th>GTG</th>
<th>GAC</th>
<th>TGA</th>
<th>GGA</th>
<th>CAC</th>
<th>CTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino acid</td>
<td>Valine</td>
<td>Histidine</td>
<td>Leucine</td>
<td>Threonine</td>
<td>Proline</td>
<td>Valine</td>
<td>Glutamic acid</td>
</tr>
</tbody>
</table>

Complete the sentence using the lists.

The change in the DNA sequence produced □ □ instead of □ □, causing a normal red blood cell to be a sickled red blood cell.

*Item continues on the next page*
**Part B**

Complete the sentences by selecting terms from the lists that best explain how a change in the DNA sequence can cause sickle-cell disease.

Each amino acid in a protein is coded for by ▼ nucleotides in the DNA. In sickled red blood cells, ▼ occurred, causing a different hemoglobin protein to be produced.

**Key:**

**Part A:** First drop-down menu: valine. Second drop-down menu: glutamic acid. (1 point)

**Part B:** First drop-down menu: three. Second drop-down menu: a point mutation. (1 point)
ILCS: Identify patterns of damage caused by earthquakes in buildings of different heights based on data from a simulation.

A student uses a computer simulation to investigate the effect of earthquakes on buildings. The simulation shows damage to buildings of similar construction except for their height. The simulation settings and the data collected from the simulation are shown.

Type of soil — Soft clay
Magnitude of Earthquake — 8.0

<table>
<thead>
<tr>
<th>Height of Building</th>
<th>Degree of Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 floor</td>
<td>Minimal</td>
</tr>
<tr>
<td>3 floors</td>
<td>Minimal</td>
</tr>
<tr>
<td>5 floors</td>
<td>Severe</td>
</tr>
<tr>
<td>7 floors</td>
<td>Severe</td>
</tr>
<tr>
<td>9 floors</td>
<td>Severe</td>
</tr>
<tr>
<td>11 floors</td>
<td>Moderate</td>
</tr>
<tr>
<td>13 floors</td>
<td>Moderate</td>
</tr>
<tr>
<td>15 floors</td>
<td>Moderate</td>
</tr>
<tr>
<td>17 floors</td>
<td>Minimal</td>
</tr>
</tbody>
</table>

*Item continues on the next page*
Select terms from the lists to create a correct conclusion that is based on the simulation.

A building of a height of __ floors could be expected to receive a severe amount of damage.

The severe damage to certain buildings is most likely due to __.

**Key:** First drop-down menu: 8. Second drop-down menu: the frequency of the building vibrations. (1 point)
### Item 16

**Grade:** High School  
**PE:** HS-ESS1-4  
**SEP:** 5. Using Mathematics and Computational Thinking  
**DCI:** ESS1.B Earth and the Solar System  
**CCC:** 3. Scale, Proportion, and Quantity  
**DOK:** 2

**ILCS:** Evaluate how a comet’s acceleration and/or force of attraction between the Sun and comet change with respect to the change in the comet’s distance and/or mass.

A comet is in an elliptical orbit around the Sun. Select from the lists to **best** describe what happens at locations in the orbit where the comet is getting closer to the Sun.

As the comet approaches the Sun, the gravitational force between the comet and the Sun **increases** and the comet **speeds up**. (1 point)

**Key:** First drop-down menu: increases. Second drop-down menu: speeds up. (1 point)
ILCS: Describe the conditions under which a claim about temperature effect on sugar maple tree distribution can be supported.

Environmental Principle II: The long-term functioning and health of terrestrial, freshwater, coastal, and marine ecosystems are influenced by their relationships with human societies.

Results from a wide range of climate model simulations suggest that Earth’s average surface temperature could be between 1.1 and 5.4°C warmer in 2100 than it was in 2015. Some species, such as sugar maple trees, are adapted to survive cooler temperatures and have historically occupied northern parts of North America. Scientists claim that rising average temperatures will change the distribution of sugar maple trees in North America.

In addition to global surface temperature data, which data, if collected, would best support or refute the claim?

• The soil temperature should be measured daily for one year at two separate locations.
• Core samples of the largest sugar maple trees should be taken to determine how old the trees are.
• The total number of acres of forested land throughout the range of sugar maple trees should be recorded annually.
• Sample sites should be set up throughout the range of sugar maple trees and the number of sugar maple trees counted every five years.

Key: D (1 point)
ILCS: Select the best alternative solution from among multiple solutions of renewable resources, based on their strengths and weaknesses, in providing electricity.

A town council of a small town in Southern California investigates the use of renewable sources of energy to generate electricity. They research both solar panels and wind turbines and collect the data in the table. Neither turbines nor solar panels release CO₂ during their normal operation; however, CO₂ is emitted during their manufacture.

<table>
<thead>
<tr>
<th>Operational Factors</th>
<th>One Wind Turbine</th>
<th>40,000 Solar Panels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumed during manufacturing (in kWh)</td>
<td>4,300,000</td>
<td>23,100,000</td>
</tr>
<tr>
<td>Total mass of carbon dioxide (CO₂) released during manufacturing (in kg)</td>
<td>20,000</td>
<td>9,080,000</td>
</tr>
<tr>
<td>Total annual energy generated (in kWh/year)</td>
<td>6,400,000</td>
<td>6,400,000</td>
</tr>
<tr>
<td>Annual maintenance cost (in dollars)</td>
<td>140,000</td>
<td>0</td>
</tr>
</tbody>
</table>

The council determines that it requires about 40,000 solar panels to produce the same amount of energy per year as one wind turbine produces per year. Assume a 20-year lifetime for both turbines and solar panels.

Based on the table, complete these sentences by selecting the best phrases from the lists.

If the main goal of the town is to reduce the carbon dioxide (CO₂) released into the atmosphere, then the town council should select [ ] because the amount of CO₂ [ ] is lower.

If the main goal of the town is to reduce maintenance costs, then the town council should select [ ].

ILCS: Identify what is to be recorded as useful data for an investigation on the effect of exercise on heart rate.

Students in a class are designing an investigation to determine the effect running on a treadmill has on heart rate. They decide to have several students run for 20 minutes on a treadmill.

Which **two** data sets must the students collect in order to determine the effect exercise has on heart rate?

- the student’s age
- the student’s weight
- the student’s resting heart rate prior to exercising
- the student’s heart rate after running on the treadmill
- the distance the student can run on the treadmill in 20 minutes

**Key:** Third and fourth options. (1 point)
ILCS: Identify the best design from among multiple designs based on a prioritized list of criteria (e.g., maximize pollutant in wastewater, cost, aesthetics, etc.) on wastewater treatment capacities.

A small city in California is growing and needs to expand its wastewater treatment capacity. Currently the city has a treatment plant with open tanks that releases the treated effluent into a nearby creek. The city manager asks the wastewater treatment department to prioritize criteria for plans to expand the treatment plant.

The wastewater treatment department sets the following priorities in order of importance:

1. The system must be closed to reduce smell for nearby neighborhoods.
2. The operating costs must be under $340,000 per month.
3. The wastewater must be treated so that the nitrate ion concentration in the effluent does not exceed 0.5 mg/L to prevent algal blooms in the creek.

Three different construction companies submit plans to expand the wastewater treatment plant.

**Part A**

This table shows the prioritized criteria and information about each plan. Use the information about each plan to select the plans that meet each criterion set by the city manager.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Plan A</th>
<th>Plan B</th>
<th>Plan C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority 1: Open or closed system</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Priority 2: Monthly operating costs for wastewater treatment plant</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Priority 3: Nitrate ion concentration in wastewater effluent</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
**Part B**

Select a plan from the list to complete the sentence.

Based on the prioritized order of the criteria, the city manager should accept  

---

**Key:**

**Part A:** (1 point)

<table>
<thead>
<tr>
<th>Priority 1: Open or closed system</th>
<th>Plan A Open $320,000 0.4 mg/L</th>
<th>Plan B Closed $335,000 0.6 mg/L</th>
<th>Plan C Closed $345,000 0.4 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Open or closed system)</td>
<td>☐</td>
<td>☑</td>
<td>☑</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Priority 2: Monthly operating costs for wastewater treatment plant</th>
<th>Plan A Open $320,000 0.4 mg/L</th>
<th>Plan B Closed $335,000 0.6 mg/L</th>
<th>Plan C Closed $345,000 0.4 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Lowest cost)</td>
<td>☑</td>
<td>☑</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Priority 3: Nitrate ion concentration in wastewater effluent</th>
<th>Plan A Open $320,000 0.4 mg/L</th>
<th>Plan B Closed $335,000 0.6 mg/L</th>
<th>Plan C Closed $345,000 0.4 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Lowest concentration)</td>
<td>☑</td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>

**Part B:** Plan B. (1 point)
<table>
<thead>
<tr>
<th>Item</th>
<th>Grade</th>
<th>PE</th>
<th>SEP</th>
<th>DCI</th>
<th>CCC</th>
<th>DOK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thinking</td>
<td>Ecosystems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ILCS:** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Students created a computer model of an ecosystem process to predict the density of different tree species in an area over 100 years. The graph shows the outcomes of the model for one of the tree species.

![Graph showing tree density over time.]

Complete the sentences by selecting from the lists. The process being modeled is **most likely** following a disturbance. In years 75 to 100, the population can **best** be described as having reached **capacity**.

**Key:** First drop-down menu: ecological succession. Second drop-down menu: carrying capacity. (1 point)
ILCS: Mathematically determine the properties of the system using the conservation of momentum of objects in the system.

A railroad car with a mass of 90,000 kg is traveling along a straight, horizontal track at a constant speed of 2 m/s. The car collides with a second railroad car, also with a mass of 90,000 kg, that is initially at rest. The railroad cars stick together after the collision.

What is the speed of the two railroad cars immediately after the collision?

- 0.5 m/s
- 1 m/s
- 2 m/s
- 4 m/s

**Key:** B (1 point)
ILCS: Match the described solutions to a provided list of broken-down criteria/constraints in order to reduce air pollution within the community.

In order to reduce air pollution, a particular community identifies three possible solutions. The community also proposes several criteria that the solutions must meet, including low cost and rapid impact. The three possible solutions are:

Solution 1: Begin phasing in renewable sources of electricity generation, which would involve building new types of power plants.
Solution 2: Encourage increased use of ride-sharing.
Solution 3: Encourage people to raise thermostat settings in the summer and lower them in the winter.

**Part A**

The community identified three constraints to help determine the best approach to reduce air pollution. For each of the three potential solutions, select the check box if the solution meets the constraint.

<table>
<thead>
<tr>
<th>Long time to implement change</th>
<th>Requires change in people’s behaviors</th>
<th>Provides benefits in a short time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution 1</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Solution 2</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Solution 3</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

*Item continues on the next page*
Part B

What additional information will be most helpful to the community to prioritize these approaches?

- the projected reduction in air pollution
- the projected cost savings of using renewable resources
- the number of homes projected to be built in the next 10 years
- the number of cars currently using electricity as an energy source

Key:

Part A: (1 point)

<table>
<thead>
<tr>
<th>Part A</th>
<th>Long time to implement change</th>
<th>Requires change in people’s behaviors</th>
<th>Provides benefits in a short time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution 1</td>
<td>☑</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Solution 2</td>
<td>☐</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Solution 3</td>
<td>☐</td>
<td>☑</td>
<td>☑</td>
</tr>
</tbody>
</table>

Part B: A (1 point)
ILCS: Identify the procedure that will produce the most relevant and reliable data in carrying out an investigation on attractive forces between particles.

**Part A**

A student is studying the attractive forces between particles within different substances. The student wants to determine the relative strengths of these forces for four solid substances: iodine, sulfur, tin, and zinc. What physical property of these substances would be **best** for the student to measure?

- density
- melting point
- solubility in water
- electrical conductivity

**Part B**

A physical property of a substance is often related to the strength of the attractions between the particles of the substance. In the table, identify whether each property is due to stronger or weaker attraction between particles in a substance.

<table>
<thead>
<tr>
<th>Due to stronger attractions between particles</th>
<th>Due to weaker attractions between particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>High boiling point</td>
<td>☐</td>
</tr>
<tr>
<td>High vapor pressure</td>
<td>☐</td>
</tr>
</tbody>
</table>
Key:
**Part A:** B (1 point)
**Part B:** (1 point)

<table>
<thead>
<tr>
<th></th>
<th>Due to stronger attractions between particles</th>
<th>Due to weaker attractions between particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>High boiling point</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>High vapor pressure</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
ILCS: Create a correct mathematical representation to determine the components of gravitational potential energy in the Earth-ball system and kinetic energy.

A student drops a tennis ball from the top of a building. Air resistance is negligible.

Explain how the student can determine the height of the building if the kinetic energy of the tennis ball is known when it hits the ground. In your explanation, use the terms kinetic energy, gravitational potential energy, acceleration due to gravity, mass, and height. Do not use equations. Enter your answer in the box provided.

Rubric follows on the next page.
2 point

Exemplar:
The kinetic energy (KE) of the ball at the bottom of the building is the same as the gravitational potential energy (GPE/PE) at the top of the building. The gravitational potential energy (GPE/PE) needs to be divided by the mass of the tennis ball and the acceleration due to gravity (or gravity) to find the height of the building.

Rubric:
The response says that the kinetic energy of the tennis ball at the bottom of the building is equal to the gravitational potential energy of the tennis ball at the top of the building. AND
The response says that the gravitational potential energy at the top of the building can be divided by the mass and acceleration due to gravity to find the height of the building.

1 point

Exemplar:
The kinetic energy (KE) of the ball at the bottom of the building is the same as the gravitational potential energy (GPE/PE) at the top of the building. OR
The gravitational potential energy (GPE/PE) needs to be divided by the mass of the tennis ball and the acceleration due to gravity (or gravity) to find the height of the building.

Rubric:
The response says that the kinetic energy of the tennis ball at the bottom of the building is equal to the gravitational potential energy of the tennis ball at the top of the building. OR
The response says that the gravitational potential energy at the top of the building can be divided by the mass and acceleration due to gravity to find the height of the building.

0 point

Exemplar:
The kinetic energy (KE) of the tennis ball at the bottom is not the same as the gravitational potential energy (GPE) of the ball at the top of the building. OR
Time how long it takes for the ball to fall to the ground. OR
Measure the height of the building with a meterstick.

Rubric:
A 0-point response attempts to answer the prompt but is incorrect.
ILCS: Identify the mechanisms and relationships among the inputs and outputs of photosynthesis.

A student conducted an experiment to measure the effect of light on photosynthesis. The student placed small, disk-shaped pieces of fresh-cut leaves into several dishes with a bicarbonate solution and exposed each dish to a different intensity of light. The student observed bubbles and the number of leaf pieces that floated after 15 minutes of light exposure. The data are shown in the graph.

Select the correct input and output from the lists that best represent the variables in the experiment. Each term is used only once.

Input:  

Output:  

Key: Input: Light energy. Output: O₂. (1 point)
ILCS: Identify the roles of various earth processes (e.g., plate tectonics and erosion) in the preservation and destruction of evidence about Earth history.

The Moon is thought to have formed shortly after the formation of Earth, and therefore the age of the Moon is comparable to that of Earth. The surface of the Moon is covered by ancient craters formed by impacts of small solar-system objects such as meteoroids, but the surface of Earth shows no such craters.

Which two statements are valid explanations for this observation?

- The Moon shielded Earth from impacts in the early solar system.
- Solar-system objects are more likely to impact satellites than planets.
- Geologic activity on Earth’s surface has destroyed evidence of impacts.
- The Moon has a very thin atmosphere, eliminating erosion due to weather.
- Earth’s atmosphere protected it from impacts by large solar-system objects.

**Key:** Third and fourth options. (1 point)
**ILCS:** Quantify the change in energy associated with the appropriate change in the relative orientation of the two objects.

Objects A and B, with opposite charges of \( +q \) and \( -q \), respectively, are initially held in position at a fixed distance apart. Object B is then released and allowed to move relative to object A.

If gravitational forces are negligible, which statement describes what happens when object B is released?

A. Object B moves toward object A, and the electric potential energy of the two charged objects increases.

B. Object B moves toward object A, and the electric potential energy of the two charged objects decreases.

C. Object B moves away from object A, and the electric potential energy of the two charged objects increases.

D. Object B moves away from object A, and the electric potential energy of the two charged objects decreases.

**Key:** B (1 point)
ILCS: Evaluate and refine solutions based on achieving a balance between overall environmental stability and human needs based on the accidental introduction of invasive species.

Cargo ships that transport goods require ballast water to remain safe and stable during their voyage. These ships collect water from their port of origin and release that same water at the final destination. The ballast water often contains aquatic organisms that are present in the water at the port of origin. The release of ballast water can introduce invasive species into an ecosystem. A regulatory agency is investigating several methods to prevent this from happening. The agency is interested in identifying solutions that meet the following criteria:

- Ensure that organisms are removed from ballast water
- Have minimal impact on the environment
- Are cost effective
- Are easy to implement

_item continues on the next page_
## Table: Method Comparison

<table>
<thead>
<tr>
<th>Method</th>
<th>Effectiveness in Removing Organisms</th>
<th>Environmental Impact</th>
<th>Ease of Implementation</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 1 Oxidizing chemical treatment</td>
<td>Effective</td>
<td>Very harmful to environment</td>
<td>Easy</td>
<td>High</td>
</tr>
<tr>
<td>Method 2 Nonoxidizing chemical treatment</td>
<td>Effective</td>
<td>Some impact to environment</td>
<td>Easy</td>
<td>Average</td>
</tr>
<tr>
<td>Method 3 Filtration</td>
<td>Very effective</td>
<td>Little impact to environment</td>
<td>Medium</td>
<td>Average</td>
</tr>
<tr>
<td>Method 4 Thermal treatment</td>
<td>Effective</td>
<td>No impact to environment</td>
<td>Hard</td>
<td>Average</td>
</tr>
<tr>
<td>Method 5 Alternative technologies</td>
<td>Not very effective</td>
<td>No impact to environment</td>
<td>Hard</td>
<td>Average</td>
</tr>
</tbody>
</table>

Based on the agency’s criteria, the three methods that offer the **best** solutions are Methods

- Option A: 1, 3, and 5.
- Option B: 2, 3, and 4.
- Option C: 1, 2, and 4.
- Option D: 2, 4, and 5.

**Key:** B (1 point)
### 30. High School

**Grade:** HS-PS2-3  
**SEP:** 6. Constructing Explanations and Designing Solutions  
**DCI:** PS2.A Forces and Motion  
**CCC:** 2. Cause and Effect  
**DOK:** 3

**ILCS:** Select the design solution that best meets the provided criteria about momentum and force during a collision.

A student is asked to evaluate two different bumper designs that will be used on bumper cars at a local amusement park. The bumpers have the same mass and are each attached to a test car that undergoes a controlled collision with a wall. The student measures the average impact force on each bumper during the collision and the duration of each collision. The student’s results are shown in the table.

<table>
<thead>
<tr>
<th>Design Number</th>
<th>Average Impact Force (N)</th>
<th>Duration of Impact (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design 1</td>
<td>980</td>
<td>0.15</td>
</tr>
<tr>
<td>Design 2</td>
<td>588</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Which design will provide better protection for a rider in a collision, and why?

- **A** Design 1, because the change in momentum of the test car is smaller.
- **B** Design 1, because the average impact force acting on the test car is larger for a shorter duration.
- **C** Design 2, because the change in momentum of the test car is smaller.
- **D** Design 2, because the average impact force acting on the test car is smaller for a longer duration.

**Key:** D (1 point)
ILCS: Explain the redshift pattern as indicating that more distant stars are moving away faster.

Scientists observe the light spectra from distant galaxies. The absorption lines in a spectrum from a galaxy moving away from Earth are observed to be shifted to longer wavelengths (redshift). The absorption lines from an approaching galaxy shift to shorter wavelengths (blueshift).

**Part A**

The chart represents the wavelengths of the hydrogen absorption lines along with the colors found on the electromagnetic spectrum as measured on Earth. Researchers studying three distant galaxies found that the hydrogen absorption lines from each galaxy were different compared to the laboratory reference spectral line.

<table>
<thead>
<tr>
<th>Blue</th>
<th>Red</th>
<th>Laboratory reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Galaxy 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Galaxy 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Galaxy 3</td>
</tr>
</tbody>
</table>

Complete the table by identifying whether the spectrum for each galaxy is redshift, blueshift, or no shift based on the galaxy’s wavelength.

<table>
<thead>
<tr>
<th>Redshift</th>
<th>Blueshift</th>
<th>No shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galaxy 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galaxy 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galaxy 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part B

Which **two** statements best explain how observations of the spectra of light from galaxies are used to support current theories of the origin and evolution of the Universe?

- Galaxies that are farther away tend to have larger redshifts.
- The blueshift observed from distant galaxies indicates that galaxies are colliding and forming new stars.
- The redshift observed from nearby galaxies indicates that most galaxies remain stationary relative to Earth.
- The blueshift observed from nearby galaxies indicates that the solar system is orbiting a black hole.
- The redshift observed from distant galaxies indicates that they are moving away faster than nearby galaxies.

**Key:**

**Part A:** (1 point)
- Galaxy 1 = Blueshift; (Checkbox 2)
- Galaxy 2 = No Shift; (Checkbox 6)
- Galaxy 3 = Redshift (Checkbox 7)

**Part B:** First and fifth options. (1 point)
In this performance task, you will answer six questions.

A family plans to purchase two Californian rabbits. Californian rabbits are white with black points (ears, nose, feet, and tail) and exhibit temperature-influenced color expression. The New Zealand rabbit is white in color with gray points (ears, nose, feet, and tail). The family finds a breeder who sells both breeds of rabbit: the Californian and the New Zealand.

The family purchases two eight-week-old Californian kits (baby rabbits) from this breeder. The family takes the kits home and places them outdoors (30°C) in a rabbit hutch. After a few weeks, both rabbits are white with gray points rather than black points. The family members wonder if they received the correct breed of rabbits.

The family starts to research the genetics of coat color in rabbits and learns that color expression in rabbit coats is primarily influenced by five different genes, all found on one chromosome. These five genes account for 144 different color variations found in rabbits.

In researching the genetics of Californian rabbit colors, the family learns that possible colors for the points include black and gray. The family then focuses its research on the $c$ gene (color gene) and the $d$ gene (dense-dilute gene).

This table summarizes the genetic patterns and phenotypes of the $c$ gene and $d$ gene.

<table>
<thead>
<tr>
<th>Gene</th>
<th>Allele</th>
<th>Inheritance Pattern</th>
<th>Expressed Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c$ gene</td>
<td>$c^h$</td>
<td>Dominant</td>
<td>Himalayan (white body with colored points)</td>
</tr>
<tr>
<td>$c$ gene</td>
<td>$c$</td>
<td>Recessive</td>
<td>White without points (albino)</td>
</tr>
<tr>
<td>$d$ gene</td>
<td>$D$</td>
<td>Dominant</td>
<td>Black points (dense color)</td>
</tr>
<tr>
<td>$d$ gene</td>
<td>$d$</td>
<td>Recessive</td>
<td>Gray points (dilute color)</td>
</tr>
</tbody>
</table>

Based on the rabbits’ expressed phenotype of gray points, a member of the family argues that the rabbits’ genotype for the $c$ gene is $cc$. 
**ILCS:** Describe that crossing over is responsible for all of the variation in this rabbit species.

Based on this information, complete the sentence by selecting the best phrase from the list.

- [ ] is primarily responsible for the 144 different color variations found in rabbits.

**Key:** Drop-down menu: Crossing over during meiosis. (1 point)
ILCS: Select the question that challenges the argument about phenotype and genotype connections in this rabbit species.

Which scientifically correct question best challenges the family member’s argument?

A. Do the rabbits have the correct number of chromosomes and corresponding genes?

B. Does biological sex have any influence on the expression of the rabbits’ c gene?

C. Do the rabbits have a phenotype (albino) consistent with the cc genotype?

D. Does having the cc genotype affect the color of the rabbits’ coats?

Key: C (1 point)
In anticipation of a heat wave, the family members move the rabbits from their outdoor hutch (30°C) to an air-conditioned room (20°C) inside their home.

Several days after the rabbits were moved, their gray points turned black. The family decides to take the rabbits to a veterinarian who treats and also breeds Californian rabbits.

Refer to this table for genetic information about the \( c \) gene and \( d \) gene.

<table>
<thead>
<tr>
<th>Gene</th>
<th>Allele</th>
<th>Inheritance Pattern</th>
<th>Expressed Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>( c ) gene</td>
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<td>( c ) gene</td>
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</tr>
<tr>
<td>( d ) gene</td>
<td>( D )</td>
<td>Dominant</td>
<td>Black points (dense color)</td>
</tr>
<tr>
<td>( d ) gene</td>
<td>( d )</td>
<td>Recessive</td>
<td>Gray points (dilute color)</td>
</tr>
</tbody>
</table>

The family finds an online simulation that allows them to observe how temperature affects the rabbits’ point color, assuming that the rabbits have at least one copy of the Himalayan allele \( (c^h) \). Depending on the air temperature, the \( c^h \) allele controls point color expression by interacting with the \( d \) gene.

This table shows the simulation results for expressed point color in rabbits with the \( c^h \) allele.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>( DD )</th>
<th>( Dd )</th>
<th>( dd )</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°C</td>
<td>Black pointed</td>
<td>Black pointed</td>
<td>Gray pointed</td>
</tr>
<tr>
<td>30°C</td>
<td>Gray pointed</td>
<td>Gray pointed</td>
<td>Gray pointed</td>
</tr>
</tbody>
</table>
ILCS: Select questions that address the relationship between a chromosome and gene expression in this rabbit species.

Which **three** questions should the family ask their veterinarian that would **most likely** help the family understand the genetic basis for the recent color change of the rabbits?

- Is it possible for these rabbits to be heterozygous for the $c$ gene, since the rabbits seem to express the Himalayan allele ($c^h$)?

- Is it possible for these rabbits to be heterozygous for the $d$ gene, since they now have black points rather than gray points?

- Is it possible that the rabbits have eaten an unfamiliar food that has caused a change to their genetic make-up?

- Is it possible that the rabbits have contracted a parasite and this is affecting the expression of the $c$ gene?

- Is it possible that the lower temperature of the room had an effect on the expression of the $c$ gene?

**Key:** First, second, and fifth options. (1 point)
ILCS: Describe how the environmental conditions will impact the expression of the trait in this rabbit species.

Based on the simulation results and assuming that the rabbits inherited at least one Himalayan allele \((c^h)\), select the words from the lists that best complete the sentence.

Temperatures 30°C and higher will act on the \(\_\_\_\_\_\_\_\_\_\) of Californian rabbits and cause the expression of the \(\_\_\_\_\_\_\_\_\_\) phenotype even if the rabbits inherited a dominant allele for the gene.

**Key:** First drop-down menu: color gene. Second drop-down menu: gray-pointed. (1 point)
The two rabbits eventually mate and the female gives birth to six kits. The kits are being raised in a 20°C room. One kit is albino and five are black pointed.

A family member suggests using this Punnett square to model the inheritance of the \( d \) gene for the newborn kits.

\[
\begin{array}{cc}
D & d \\
\hline
d & Dd & dd \\
d & Dd & dd \\
\end{array}
\]

Refer to these tables for genetic and environmental information about the \( c \) gene and \( d \) gene.

**Inheritance Patterns of the \( c \) Gene and \( d \) Gene**

<table>
<thead>
<tr>
<th>Gene</th>
<th>Allele</th>
<th>Inheritance Pattern</th>
<th>Expressed Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
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<td>White without points (albino)</td>
</tr>
<tr>
<td>( d ) gene</td>
<td>( D )</td>
<td>Dominant</td>
<td>Black points (dense color)</td>
</tr>
<tr>
<td>( d ) gene</td>
<td>( d )</td>
<td>Recessive</td>
<td>Gray points (dilute color)</td>
</tr>
</tbody>
</table>

**Simulation Results**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>( DD )</th>
<th>( Dd )</th>
<th>( dd )</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°C</td>
<td>Black pointed</td>
<td>Black pointed</td>
<td>Gray pointed</td>
</tr>
<tr>
<td>30°C</td>
<td>Gray pointed</td>
<td>Gray pointed</td>
<td>Gray pointed</td>
</tr>
</tbody>
</table>
**ILCS:** Select a scientifically correct question that challenges the conclusions about the offspring phenotypes in this rabbit species.

Which scientifically correct question would **best** challenge the conclusions made about the kits’ genotypes from the suggested Punnett square?

- **A** Why is only one kit albino?
- **B** Why do only some of the kits have black points?
- **C** What are the genotypes of the two parent rabbits for the \( d \) gene?
- **D** Can you make a prediction of point color without knowing the genotype of the \( c \) gene?

**Key:** C (1 point)
ILCS: Explain that genetic variation depends on both environmental and genetic factors in this rabbit species.

**Based on the information in the tables, explain how both genetic and environmental factors can affect point color variation in Californian rabbits. Enter your answer in the box provided.**

**2 point**

**Exemplar:**

Genetic factors can affect point color variation because the color/phenotype expressed/shown depends partly on the alleles that are inherited. Environmental factors can affect point color variation because the temperature that the rabbit is exposed to/lives in, will influence/control the expression of its inherited alleles, altering/changing its phenotype/point color.

**Rubric:**

The response indicates that genetic factors affect point color variation because the specific phenotype expressed (black or gray) depends partly on the alleles that are inherited. AND

The response indicates that environmental factors can affect point color variation because the temperature that the rabbit is exposed to will influence the expression of its inherited alleles, thus altering its phenotype.

*Rubric continues on the next page.*
1 point

Exemplar:

Genes can affect the color because the color/phenotype expressed/shown depends partly on the alleles that are inherited. OR

The environment affects the color of the rabbit because the temperature that the rabbit lives in can make its color change. OR

The temperature change caused the rabbit’s points to change color. OR

The rabbit’s genes and the environment both affect the point color.

Rubric:

The response only indicates that genetic factors affect point color variation because the specific phenotype expressed (black or gray) depends partly on the alleles that are inherited. OR

The response only indicates that environmental factors can affect point color variation because the temperature that the rabbit is exposed to will influence the expression of its inherited alleles, thus altering its phenotype. OR

The response only indicates that a relationship exists between the rabbit’s genes and the environment but does not provide any reasoning.

0 point

Exemplar:

Neither genes nor environment affect point color variation. OR

The rabbit’s genes affect point color variation more than the environment. OR

The environment affects point color variation more than the rabbit’s genes. OR

Only the rabbit’s genes affect point color variation. OR

Only the environment affects point color variation.

Rubric:

A 0-point response attempts to answer the prompt but is incorrect.
In this performance task, you will answer six questions.

Silver carp are an invasive species of fish that is not native to the United States. However, populations of silver carp now inhabit the rivers of the United States and can be found throughout the Mississippi River system.

Silver carp feed on phytoplankton, including algae, consuming up to 20% of their body weight daily. Carp can lay hundreds of thousands of eggs at a time, several times a year. They are capable of jumping over barriers, including low dams, and can travel to new areas when flooding connects previously unconnected bodies of water.
ILCS: Use the data as evidence to support an explanation about an environmental problem involving this fish species.

Silver carp were intentionally introduced by humans to solve an environmental problem. Which claim is best supported by this information?

A. Silver carp were placed in fish farms to control the growth of algae.
B. Silver carp were used to introduce new genes into the native fish populations.
C. Silver carp were introduced to improve the natural beauty of the aquatic landscape.
D. Silver carp were introduced to help increase rates of photosynthesis because they support algae populations.

Key: A (1 point)
ILCS: Use the data as evidence to support an explanation about an environmental problem concerning this fish species.

Complete this sentence by selecting the **best** phrase from the list.

Silver carp in the Mississippi River are considered an invasive species and have altered the ecosystem of the river because they

**Key:** Drop-down menu: outcompete native fish species for food. (1 point)
Currently, there are several dams that control the movement of water between Lake Michigan and the Mississippi River. Each dam has a lock system to allow the movement of ships between the two areas.

A series of locks and dams enables river vessels to move up or down a river or canal from one water level to another. Boats and ships get through the waterway by going into a lock that is filled with water and that has moveable gates at each end. As a valve is opened, the water from the first lock flows into a second lock (or the next body of water if there is just one lock), raising or lowering the boat automatically. The boats continue until they reach the end of the dam and lock system.

The pictures show how a lock operates.

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Item continues on the next page.
The series of locks and dams has a two-fold benefit:
1. They help move large vessels up and down the river to Lake Michigan.
2. They help block the movement of carp farther up the river.

An additional method to stop the movement of silver carp into the Great Lakes would be to construct steel cables attached to the bottom of the canal. The cables would create a pulsating field of electricity that would discourage fish from passing through the barrier.

This map shows the location of the electric barrier and the lock and dams of the Chicago Area Waterway System.

<table>
<thead>
<tr>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Locks and Dams</td>
</tr>
<tr>
<td>★ Electric Barrier</td>
</tr>
<tr>
<td>- Ship Canal</td>
</tr>
</tbody>
</table>
### Item 40

<table>
<thead>
<tr>
<th>Item</th>
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<th>DOK</th>
</tr>
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</table>

**ILCS:** Provide justification for a design solution to mitigate the effects of an environmental problem as a result of this fish species.

Which **two** are the **most likely** reasons that the electric barriers are needed in addition to locks and dams to control the movement of silver carp?

- Silver carp are attracted to dams.
- The dams cannot prevent the movement of silver carp.
- When ships move through the locks, the silver carp can follow them.
- The electric barriers use renewable energy, while the locks are powered by fossil fuels.

**Key:** Second and third options. (1 point)
**ILCS:** Identify potential concerns from a proposed design solution for an environmental problem caused by restricting fish territory.

Although the electrical barrier acts to repel the silver carp, it is not perfect. Which statement **best** describes a disadvantage of the electric barrier solution?

- **A** The barrier is powered by renewable energy sources.
- **B** The barrier is too far from Lake Michigan to be effective in controlling silver carp populations.
- **C** Silver carp are not killed by the electricity; therefore, they might still get past the barrier and move into Lake Michigan.
- **D** All fish in the area will be prevented from moving past the barrier; therefore, eventually no fish will be found in Lake Michigan.

**Key:** C (1 point)
Recreational fishing is very popular in the Great Lakes, due to the many native species of desirable fish. It also provides billions of dollars and tens of thousands of jobs to the region. Silver carp are not considered desirable for recreational fishing; if they entered the Great Lakes, they would replace the native fish. This table summarizes the recreational fishing income from the Great Lakes.

<table>
<thead>
<tr>
<th>State</th>
<th>Jobs</th>
<th>Income Received</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
<td>1,500</td>
<td>$175,000,000</td>
</tr>
<tr>
<td>Indiana</td>
<td>4,200</td>
<td>$395,000,000</td>
</tr>
<tr>
<td>Michigan</td>
<td>8,300</td>
<td>$1,002,000,000</td>
</tr>
<tr>
<td>New York</td>
<td>3,300</td>
<td>$369,000,000</td>
</tr>
<tr>
<td>Ohio</td>
<td>9,900</td>
<td>$809,000,000</td>
</tr>
<tr>
<td>All States</td>
<td>58,000</td>
<td>$7,000,000,000</td>
</tr>
</tbody>
</table>

Local stakeholders claim that investing $228 million of federal funds to block silver carp from entering the Great Lakes would be beneficial for this region’s economy.
<table>
<thead>
<tr>
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<th>DCI</th>
<th>CCC</th>
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</thead>
<tbody>
<tr>
<td>42</td>
<td>High School</td>
<td>HS-ESS3-1</td>
<td>6. Constructing Explanations and Designing Solutions</td>
<td>ESS3.B Natural Hazards</td>
<td>2. Cause and Effect</td>
<td>2</td>
</tr>
</tbody>
</table>

**ILCS:** Identify aspects of the data that align to the claim about the effects of an environmental problem caused by the introduction of a new species.

Based on the data table, which **two states** would be **most affected** from the introduction of silver carp into the Great Lakes?

☐ Illinois
☐ Indiana
☐ Michigan
☐ New York
☐ Ohio

**Key:** Third and fifth options. (1 point)
ILCS: Identify (with reasoning) whether the data is sufficient to support the claim about this invasive fish species.

Use two pieces of evidence to support the investment of $228 million to block silver carp from entering the Great Lakes. Explain why the evidence supports such an investment. Enter your answer in the box provided.

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2 point
Exemplar:

Response should include any TWO of the following:

The Great Lakes/fishing industry makes/generates/brings in $7 billion per year so it would only take one year to recoup/get back the $228 million investment.

The silver carp would greatly reduce the fishing revenue/income because the economy is dependent on the fishing industry.

The silver carp would reduce/lower the number of jobs because the economy is dependent on the fishing industry.

If the silver carp were to enter/be introduced into the lakes, they would replace the native fish species, negatively disrupting/harming the ecosystem.

Rubric continues on the next page.
Rubric:

A 2-point response indicates any TWO of the following:

The fishing industry of the Great Lakes generates $7 billion in revenue per year so it would only take one year to recoup the $228 million investment.

The introduction of the silver carp would lower incoming revenue because the economy of the Great Lakes is heavily dependent on the fishing industry.

The introduction of the silver carp would reduce available jobs because the economy of the Great Lakes is heavily dependent on the fishing industry.

The introduction of the silver carp would disrupt the ecosystem by replacing native fish species.

1 point

Exemplar:

The Great Lakes/fishing industry makes/generates/brings in $7 billion per year so it would only take one year to get back the $228 million investment. OR

The silver carp would greatly reduce the fishing revenue/income because the economy is dependent on the fishing industry. OR

The silver carp would reduce/lower the number of jobs because the economy is dependent on the fishing industry. OR

If the silver carp were to enter/be introduced into the lakes, they would replace the native fish species, negatively disrupting/harming the ecosystem.

Rubric:

The fishing industry of the Great Lakes generates $7 billion in revenue per year so it would only take one year to recoup the $228 million investment. OR

The introduction of the silver carp would lower incoming revenue because the economy of the Great Lakes is heavily dependent on the fishing industry. OR

The introduction of the silver carp would reduce available jobs because the economy of the Great Lakes is heavily dependent on the fishing industry. OR

The introduction of the silver carp would disrupt the ecosystem by replacing native fish species.

Rubric continues on the next page.
0 point

Exemplar:

Great Lakes fishermen can fish for the silver carp. OR

The government should not invest $228 million. OR

The evidence shows that the government should make the investment. OR

The ecosystem would not be affected by the silver carp.

Rubric:

A 0-point response attempts to answer the prompt but is incorrect.

In this performance task, you will answer seven questions.

Ammonia (NH₃) gas is needed to manufacture fertilizers. NH₃ is produced through an equilibrium reaction between nitrogen (N₂) and hydrogen (H₂) gases. At equilibrium, the rate of the forward reaction is equal to the rate of the reverse reaction. This is the chemical equation for the production of NH₃, including the heat of reaction, ∆H.

\[ N_2(g) + 3 \, H_2(g) \rightleftharpoons 2 \, NH_3(g) \quad \Delta H = -92 \, \text{kJ/mol} \]

A fertilizer manufacturer wants to increase profits by shifting the reaction to the right in order to maximize the amount of NH₃ produced. The manufacturer hires a chemical engineer to improve the production processes and increase NH₃ yields.

To start researching ways for improvement, the engineer considers Le Chatelier’s principle, which can be explained by this statement: "If a change in conditions causes a stress to a system at equilibrium, the system readjusts to restore the system to equilibrium."
ILCS: Identify the scientific principles that support the effectiveness of the changes to meet the criteria required by the engineer in manufacturing fertilizer.

Based on this information, what **two** changes to the system at equilibrium should the engineer suggest in order to increase the amount of NH₃ produced?

- Remove NH₃ from the reaction chamber as it is produced.
- Decrease the temperature of the reaction chamber.
- Increase the temperature of the reaction chamber.
- Remove H₂ from the reaction chamber.
- Remove N₂ from the reaction chamber.

**Key:** First and second options. (1 point)
High School Practice Test Items

<table>
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ILCS: Select the mathematical representation that predicts the mass of the other component based on a chemical reaction.

This is the chemical reaction for the production of NH₃.

\[
N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92 \text{ kJ/mol}
\]

The manufacturer explains to the engineer that the minimum production of NH₃ should be 102 grams at equilibrium.

This table shows the molar mass for each substance in the equilibrium reaction.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>Molar Mass (g/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₂</td>
<td>28</td>
</tr>
<tr>
<td>H₂</td>
<td>2</td>
</tr>
<tr>
<td>NH₃</td>
<td>17</td>
</tr>
</tbody>
</table>

Based on this information, select the correct number of grams for each reactant from the lists.

If 102 grams of NH₃ were produced, at least □ grams of N₂ and at least □ grams of H₂ would have been consumed during the reaction.

Key: First drop-down menu: 84. Second drop-down menu: 18. (1 point)
**ILCS:** Select the mathematical relationships that best demonstrate that atoms are conserved in the chemical reaction.

This is the chemical reaction for the production of NH₃.

\[ \text{N}_2(g) + 3 \text{H}_2(g) \rightleftharpoons 2 \text{NH}_3(g) \quad \Delta H = -92 \text{ kJ/mol} \]

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If 4 moles of N₂ and 12 moles of H₂ were consumed in the production of NH₃, how many moles of ammonia were produced?

- A 6 moles
- B 8 moles
- C 16 moles
- D 32 moles

**Key:** B (1 point)
The engineer suggests changing the temperature and pressure of the reaction chamber to increase the amount of NH$_3$ at equilibrium. The engineer shares data on alternative temperatures, pressures, and percent by volume of NH$_3$ at equilibrium, as shown on these graphs.

This is the chemical reaction for the production of NH$_3$.

$$N_2(g) + 3 \ H_2(g) \rightleftharpoons 2 \ NH_3(g) \quad \Delta H = -92 \ kJ/mol$$
ILCS: Select the change that best meets the criteria and justifies the change in temperature necessary for increasing the amount of fertilizer manufactured.

Based on these data, complete the sentences by selecting the best word or phrase from the lists.

To increase the amount of NH₃ at equilibrium at 200 atm, the manufacturer should decrease the temperature of the reaction chamber. This change in temperature would shift the reaction to the right because this equilibrium reaction is exothermic.

Key: First drop-down menu: decrease. Second drop-down menu: right. Third drop-down menu: exothermic. (1 point)
### ILCS: Identify the advantages and disadvantages for each change in fertilizer production.

Using the information in both graphs, select the check boxes to indicate whether each description is an advantage or a disadvantage for the overall production of fertilizer.

<table>
<thead>
<tr>
<th>Reduced reaction rates at low temperatures</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High purchase and maintenance costs for high pressure machines</td>
<td></td>
<td></td>
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<tr>
<td>Pressures higher than 200 atm at 400°C produce more than a 45% yield of NH₃ at equilibrium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperatures lower than 400°C at 200 atm produce more than a 40% yield of NH₃ at equilibrium</td>
<td></td>
<td></td>
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</table>

**Key:** (1 point)

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<td>✔️</td>
<td></td>
</tr>
</tbody>
</table>
ILCS: Identify the change to the system that will meet the criteria to maintain equilibrium.

Based on these data, what pressure would produce the **highest** amount of NH₃ at equilibrium at 400°C?

A 100 atm  
B 200 atm  
C 300 atm  
B 400 atm

**Key:** D (1 point)
**High School Practice Test Items**

<table>
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**ILCS**: Identify or describe the scientific principles that support the effectiveness of the change to meet the criteria to maintain equilibrium.

> Using Le Chatelier’s principle, explain how an increase in pressure in the system at a constant temperature and volume would also disrupt the equilibrium and increase the amount of NH₃ when equilibrium is restored. Enter your answer in the box provided.

---

**2 point**

**Exemplar:**

An increase in pressure would increase the frequency/number of collisions between molecules/reactants. The reaction will reduce the effect of this by shifting the equilibrium to the right and producing more ammonia/NH₃ because there are fewer molecules on the right side/with the products of the equation.

**Rubric:**

The response should indicate that an increase in pressure would increase the frequency of collisions between the reactant molecules. **AND**

The response should indicate that the equilibrium reactions want to reduce the effects of any changes, so the equilibrium will shift to the right, producing more ammonia to reduce the overall pressure of the system.

*Rubric continues on the next page.*
1 point

**Exemplar:**

An increase in pressure would increase the frequency/number of collisions between molecules/reactants. OR

The reaction will adjust for/compensate for/reduce effects of the increase in pressure by shifting the equilibrium to the right and producing more ammonia/NH$_3$. OR

The equilibrium will shift/move to the right, producing more ammonia/NH$_3$.

**Rubric:**

The response should indicate that an increase in pressure would increase the frequency of collisions between the reactant molecules. OR

The response should indicate that the equilibrium reactions want to reduce the effects of any changes, so the equilibrium will shift to the right producing more ammonia to reduce the overall pressure of the system.

0 point

**Exemplar:**

The percent yield of ammonia or NH$_3$ at equilibrium would not be affected by an increase in pressure. OR

An increase in pressure would decrease the frequency/number of collisions between molecules/reactants. OR

The equilibrium will shift to the left, producing less ammonia/NH$_3$.

**Rubric:**

A 0-point response attempts to answer the prompt but is incorrect.