Ohio’s State Tests

ITEM RELEASE

SPRING 2019

BIOLOGY
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<td></td>
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### Biology

**Spring 2019 Item Release**

**Content Summary and Answer Key**

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<th>Question No.*</th>
<th>Item Type</th>
<th>Content Strand</th>
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<th>Cognitive Demand</th>
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<tbody>
<tr>
<td>4</td>
<td>Multiple Choice</td>
<td>Cells</td>
<td>Cell Structure and Function</td>
<td>R</td>
<td>B</td>
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<tr>
<td>5</td>
<td>Graphic Response</td>
<td>Evolution</td>
<td>Mechanisms</td>
<td>C</td>
<td>---</td>
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<tr>
<td>7</td>
<td>Multiple Choice</td>
<td>Diversity and Interdependence of Life</td>
<td>Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.</td>
<td>R</td>
<td>C</td>
<td>1 point</td>
</tr>
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<td></td>
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<tr>
<td>13</td>
<td>Graphic Response</td>
<td>Diversity and Interdependence of Life</td>
<td>Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.</td>
<td>C</td>
<td>---</td>
<td>2 points</td>
</tr>
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<td>15</td>
<td>Multi-Interaction</td>
<td>Heredity</td>
<td>Genetic Mechanisms and Inheritance</td>
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<td>A; A</td>
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<tr>
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<td>Multiple Choice</td>
<td>Cells</td>
<td>Cellular Processes</td>
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<td>Modern Genetics</td>
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<td>21</td>
<td>Multiple Choice</td>
<td>Evolution</td>
<td>Diversity of Life</td>
<td>D</td>
<td>C</td>
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<tr>
<td>22</td>
<td>Multi-Interaction</td>
<td>Evolution</td>
<td>Mechanisms</td>
<td>D</td>
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<tr>
<td>27</td>
<td>Multi-Interaction</td>
<td>Cells</td>
<td>Cellular Processes</td>
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<td>Multi-Select</td>
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<td>Mechanisms</td>
<td>C</td>
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<td>35</td>
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<td>Modern Genetics</td>
<td>R</td>
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<td>Mechanisms</td>
<td>R</td>
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</table>

*The question number matches the item number in the Item Level Report in the Online Reporting System. The items are numbered sequentially in the practice site.*
<table>
<thead>
<tr>
<th>Question No.*</th>
<th>Item Type</th>
<th>Content Strand</th>
<th>Content Statement</th>
<th>Cognitive Demand</th>
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<tbody>
<tr>
<td>37</td>
<td>Multiple Choice</td>
<td>Diversity and Interdependence of Life</td>
<td>Ecosystems</td>
<td>R</td>
<td>A</td>
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<tr>
<td>39</td>
<td>Multiple Choice</td>
<td>Diversity and Interdependence of Life</td>
<td>Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.</td>
<td>R</td>
<td>B</td>
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<td>41</td>
<td>Graphic Response</td>
<td>Heredity</td>
<td>Mutations</td>
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<tr>
<td>42</td>
<td>Multi-Interaction</td>
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<td>Cell Structure and Function</td>
<td>C</td>
<td>C; B</td>
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<tr>
<td>43</td>
<td>Multiple Choice</td>
<td>Evolution</td>
<td>Diversity of Life</td>
<td>C</td>
<td>B</td>
<td>1 point</td>
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</tbody>
</table>

* The question number matches the item number in the Item Level Report in the Online Reporting System. The items are numbered sequentially in the practice site.
Cognitive Demands: Expectations for Learning

Cognitive demand refers to the type of thinking required of students to successfully engage with and solve the task. Ohio’s Cognitive Demands relate to current understanding and research about the ways people learn and are important aspects to the overall understanding of science concepts. As with all other frameworks and cognitive demand systems Ohio’s system has overlap between the categories. For example, Recalling Accurate Science is a component of all the other cognitive demands included in Ohio’s Learning Standards for Science.

<table>
<thead>
<tr>
<th>Cognitive Demand</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designing Technological/Engineering Solutions Using Science Concepts (T)</td>
<td>Requires students to solve science-based engineering or technological problems through application of scientific inquiry. Within given scientific constraints, propose or critique solutions, analyze and interpret technological and engineering problems, use science principles to anticipate effects of technological or engineering design, find solutions using science and engineering or technology, consider consequences and alternatives and/or integrate and synthesize scientific information.</td>
</tr>
<tr>
<td>Demonstrating Science Knowledge (D)</td>
<td>Requires students to use scientific practices and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather and organize data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments.</td>
</tr>
<tr>
<td>Interpreting and Communicating Science Concepts (C)</td>
<td>Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experience using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.</td>
</tr>
<tr>
<td>Recalling Accurate Science (R)</td>
<td>Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.</td>
</tr>
</tbody>
</table>
Biology
Spring 2019 Item Release
Question 4

Question and Scoring Guidelines
A student performs an experiment to study the transport of water in and out of cells. He uses clear, semi-permeable plastic bags to represent the cell membrane. The student places three plastic bags of the same size, each containing a 1% concentration sucrose solution, into three different beakers. One beaker contains distilled water, another beaker contains a 3% concentration sucrose solution, and the third beaker contains a 1% concentration sucrose solution. The diagram shows the student’s experimental setup, the plastic bag before it is placed in the beakers, and the appearance of the bags after an hour in each solution.

**Experimental Setup and Results**

Which statement provides a conclusion about the transport of water in and out of cells based on the results of the student’s experiment?

- A. Water moves freely both inside and outside the cell independent of the solute concentration.
- B. Water movement into the cell is dependent on the percent concentration of solutes both inside and outside the cell.
- C. Water transports solutes out of the cell to balance the percent concentration of solutes both inside and outside the cell.
- D. Water moves into the cell and solutes move out of the cell to ensure their concentration is balanced both inside and outside the cell.

**Points Possible: 1**

See **Alignment** for more detail.
Scoring Guidelines

Rationale for Option A: This is incorrect. Water does move freely in and out of the cell, but movement depends on the concentration of the solute inside and outside of the cell.

Rationale for Option B: Key – Movement of water is dependent on solute concentration and moves into the cell if the solute concentration is higher in the cell and moves out of the cell if the solute concentration is higher outside of the cell.

Rationale for Option C: This is incorrect. Solutes are not transported out of the plastic bags; only water moves in and out of them.

Rationale for Option D: This is incorrect. Solutes are not transported out of the plastic bags; water moves in and out based on the solute concentration.
**Alignment**

**Content Strand**  
Cells

**Content Statement**  
Cell Structure and Function

**Content Elaboration**  
The cell is a system that conducts a variety of functions associated with life. Every cell is covered by a membrane that controls what can enter and leave the cell. Within the cell are specialized parts for the transport of materials, energy transformation, protein building, waste disposal, information feedback and movement.

**Cognitive Demand**  
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

**Explanation of the Item**  
This item requires the student to recognize the effect of the movement of water in and out of the cell based on the concentrations of solution inside and outside the cell. A semi-permeable plastic bag containing a 1% concentration sucrose solution represents a cell. It is placed into three different environments; distilled water, 3% concentration sucrose solution and 1% concentration sucrose solution. Based on the concentrations, the movement of water into and out of the plastic bag will vary. When the bag is placed in distilled water, the net movement of water is into the bag due to concentration differences, causing it to swell. There is a higher concentration of solute inside the cell, so water moves in to create an equilibrium. When the bag is placed into a 3% concentration solution the net movement of water is out of the bag due to concentration differences, causing it to shrink. The concentration of solute outside of the bag is higher causing water to move out. When the bag is placed in a 1% concentration solution the movement of water into and out of the bag is in equilibrium keeping the bag the same size.
A student performs an experiment to study the transport of water in and out of cells. He uses clear, semi-permeable plastic bags to represent the cell membrane. The student places three plastic bags of the same size, each containing a 1% concentration sucrose solution, into three different beakers. One beaker contains distilled water, another beaker contains a 3% concentration sucrose solution, and the third beaker contains a 1% concentration sucrose solution. The diagram shows the student’s experimental setup, the plastic bag before it is placed in the beakers, and the appearance of the bags after an hour in each solution.

**Experimental Setup and Results**

Which statement provides a conclusion about the transport of water in and out of cells based on the results of the student’s experiment?

- A) Water moves freely both inside and outside the cell independent of the solute concentration.
- B) Water movement into the cell is dependent on the percent concentration of solutes both inside and outside the cell.
- C) Water transports solutes out of the cell to balance the percent concentration of solutes both inside and outside the cell.
- D) Water moves into the cell and solutes move out of the cell to ensure their concentration is balanced both inside and outside the cell.
An isolated population of seals experiences a bottleneck event over a period of time. Even after the bottleneck event ends, the genetic diversity of the population still shows its effects.

A. Use the Connect Line button to add a line segment to the graph showing the change in genetic diversity during the bottleneck event.

B. Use the Connect Line button to add a line segment to the graph showing the change in genetic diversity after the bottleneck event ends.

There may be more than one correct answer.

**Points Possible:** 1

See **Alignment** for more detail.
Scoring Guidelines

For this item, a full-credit response includes:

- only one two-segmented line drawn;
  
  AND

- the first segment of the line has a negative slope AND starts where the given red line intersects the “Bottleneck Event Begins” line AND ends above the x-axis on the “Bottleneck Event Ends” line;
  
  AND

- the second segment of the line ends to the right of the “Bottleneck Event Ends” line AND has a slope less steep than the slope of the first segment (the absolute value of the slope of the second segment is less than the absolute value of the first segment) (1 point).
Alignment
Content Strand
Evolution

Content Statement
Mechanisms

Content Elaboration
Biological evolution explains the natural origins for the diversity of life. Emphasis shifts from thinking in terms of selection of individuals with a particular trait to changing proportions of a trait in populations. The study of evolution must include Modern Synthesis, the unification of genetics and evolution and historical perspectives of evolutionary theory. The study of evolution must include gene flow, mutation, speciation, natural selection, genetic drift, sexual selection and Hardy Weinberg’s law.

Heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment. When an environment changes, the survival value of inherited characteristics may change. This may or may not cause a change in species that inhabit the environment. Formulate and revise explanations for gene flow and sexual selection based on real-world problems.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This item requires the student to graph the changes in genetic diversity during and after a population bottleneck. When the seals were isolated, the surviving seals genetic variation is smaller than the original population. The reduced genetic variation never rebounds because of the small numbers within the population. Over many generations, that genetic variation remains limited or decreases and that population may not be able to adapt to new selection pressures.
Sample Response: 1 point

An isolated population of seals experiences a bottleneck event over a period of time. Even after the bottleneck event ends, the genetic diversity of the population still shows its effects.

A. Use the Connect Line button to add a line segment to the graph showing the change in genetic diversity during the bottleneck event.

B. Use the Connect Line button to add a line segment to the graph showing the change in genetic diversity after the bottleneck event ends.

• There may be more than one correct answer.

Notes on Scoring

This response earns full credit (1 point) because it correctly shows one two-segmented line that has a negative slope for both segments. It also shows a greater rate of decrease in genetic diversity during the bottleneck event and a slower rate of decrease following the event. This reflects an understanding that the genetic diversity will decrease when the bottleneck event begins and will continue for several generations.
Sample Response: 0 points

An isolated population of seals experiences a bottleneck event over a period of time. Even after the bottleneck event ends, the genetic diversity of the population still shows its effects.

A. Use the Connect Line button to add a line segment to the graph showing the change in genetic diversity during the bottleneck event.

B. Use the Connect Line button to add a line segment to the graph showing the change in genetic diversity after the bottleneck event ends.

- There may be more than one correct answer.

Notes on Scoring

This response earns no credit (0 points) because it shows one two-segmented line that has a negative slope followed by a positive slope. This reflects an understanding that the genetic diversity will decrease when the bottleneck event begins but fails to understand that the diversity will continue to decline for several generations after the bottleneck event ends.
Sample Response: 0 points

An isolated population of seals experiences a bottleneck event over a period of time. Even after the bottleneck event ends, the genetic diversity of the population still shows its effects.

A. Use the Connect Line button to add a line segment to the graph showing the change in genetic diversity during the bottleneck event.

B. Use the Connect Line button to add a line segment to the graph showing the change in genetic diversity after the bottleneck event ends.

• There may be more than one correct answer.

Notes on Scoring

This response earns no credit (0 points) because it shows one two-segmented line that has a positive slope followed by a negative slope. This reflects a lack of understanding that the genetic diversity will decrease when the bottleneck event begins and that the diversity will continue to decline for several generations after the bottleneck event.
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Question 7

Question and Scoring Guidelines
Question 7

The table shows the derived traits of five plant groups.

<table>
<thead>
<tr>
<th>Plant Group</th>
<th>Flowers</th>
<th>Seeds</th>
<th>Stomata</th>
<th>Vasculature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
<td></td>
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<td></td>
<td>x</td>
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<tr>
<td>4</td>
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<td>x</td>
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<tr>
<td>5</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Which trait was the earliest to appear among the plant groups?

- **A** flowers
- **B** seeds
- **C** stomata
- **D** vasculature

**Points Possible:** 1

See **Alignment** for more detail.
**Scoring Guidelines**

**Rationale for Option A:** This is incorrect. Flowers are a trait only seen in one group of plants, suggesting that they are the most recently evolved trait.

**Rationale for Option B:** This is incorrect. Seeds are shared by only two groups of plants, suggesting that seeds evolved later than stomata and vasculature.

**Rationale for Option C:** **Key** – Stomata are the trait shared by the most groups in the table, suggesting that they were the first trait to evolve.

**Rationale for Option D:** This is incorrect. While vasculature is shared by three groups of plants, fewer plant groups contain vasculature than stomata, suggesting it evolved more recently than stomata.
Alignment

Content Strand
Diversity and Interdependence of Life

Content Statement
Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.

Content Elaboration
Classification systems are frameworks developed by scientists for describing the diversity of organisms, indicating the degree of relatedness between organisms. Recent molecular-sequence data generally support earlier hypotheses regarding lineages of organisms based upon morphological comparisons. Both morphological comparisons and molecular evidence must be used to describe biodiversity (cladograms can be used to address this).

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

Explanation of the Item
This item requires the student to interpret a table of plant traits and identify the trait that evolved earliest among the plants shown. The trait that exists in the most plant groups is the trait that was the earliest to appear. Stomata are present in four out of five plants so it is an earliest common trait for the selected plant group. The next trait is vasculature followed by seeds and flowers.
Sample Response: 1 point

The table shows the derived traits of five plant groups.

**Derived Traits of Five Plant Groups**

<table>
<thead>
<tr>
<th>Plant Group</th>
<th>Flowers</th>
<th>Seeds</th>
<th>Stomata</th>
<th>Vasculature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
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</tr>
<tr>
<td>4</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

Which trait was the earliest to appear among the plant groups?

- [ ] A. flowers
- [x] B. seeds
- [ ] C. stomata
- [ ] D. vasculature
Question 13

A table of organisms and traits is shown. Use the data in the table to complete the cladogram.

<table>
<thead>
<tr>
<th>Traits</th>
<th>Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amniotic Egg</td>
<td>✓</td>
</tr>
<tr>
<td>Backbone</td>
<td>✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Eggs with Shells</td>
<td>✓</td>
</tr>
<tr>
<td>Four Limbs</td>
<td>✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Hair</td>
<td>✓ ✓ ✓ ✓ ✓</td>
</tr>
</tbody>
</table>

A. Move the correct organism letter into the appropriate blank box at the top of the cladogram.

B. Move the correct trait label into the appropriate blank box at the bottom of the cladogram.

Points Possible: 2

See Alignment for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- correct organisms (left to right) F, B, A, E, and D;
  OR
- correct organisms (left to right) F, B, E, A, and D (1 point);
  AND
- correct traits (left to right) “Four Limbs” AND “Eggs with Shells” (1 point).
Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.

Recent molecular-sequence data generally support earlier hypotheses regarding lineages of organisms based upon morphological comparisons. Both morphological comparisons and molecular evidence must be used to describe biodiversity (cladograms can be used to address this).

Explanation of the Item
This item requires the student to complete a cladogram based on the similarities and differences between traits. Organism F is the earliest ancestor because it only has a backbone. Organism B evolved after four limbs appeared in organisms. Hair was a trait for Organisms A and E (which can appear in any order), and the last trait to appear in organisms is egg (shelled) production, Organism D. Students must also correctly label the traits in the cladogram. Four limbs appeared before amniotic egg which is an earlier trait than eggs with shells.
Biology
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Question 13

Sample Responses
Sample Response: 2 points

Notes on Scoring

This response earns full credit (2 points) because it labels the organisms in the correct order on the cladogram. Organism F is the earliest ancestor because it only has a backbone. Organism B evolved after four limbs appeared in organisms. Hair was a trait for Organisms A and E (which can appear in any order), and the last trait to appear in organisms is eggs with shells, a trait of Organism D. The response also correctly labels the traits in the cladogram. Four limbs appeared before amniotic egg which is an earlier trait than eggs with shells.
Sample Response: 1 point

Notes on Scoring

This response earns partial credit (1 point) because it correctly labels the traits in the cladogram. Four limbs appeared before amniotic egg which is an earlier trait than eggs with shells. The response fails to label the organisms in order on the cladogram. Organism F is the earliest ancestor because it only has a backbone. Organism B evolved after four limbs appeared in organisms. Hair was a trait for Organisms A and E (which can appear in any order), and the last trait to appear in organisms is egg (shelled) production, Organism D.
Sample Response: 1 point

Notes on Scoring

This response earns partial credit (1 point) because it correctly labels the organisms in order on the cladogram. Organism F is the earliest ancestor because it only has a backbone. Organism B evolved after four limbs appeared in organisms. Hair was a trait for Organisms A and E (which can appear in any order), and the last trait to appear in organisms is egg (shelled) production, Organism D. The response fails to correctly label the traits in the cladogram.
Sample Response: 0 points

Notes on Scoring

This response earns no credit (0 points) because it incorrectly reverses the order of the organisms on the cladogram and also reverses the order traits appeared.
Sample Response: 0 points

Notes on Scoring

This response earns no credit (0 points) because it incorrectly labels the organisms on the top of the cladogram and also reverses the order traits appeared.
Biology
Spring 2019 Item Release

Question 15

Question and Scoring Guidelines
Question 15

The following question has two parts. First, answer part A. Then, answer part B.

Part A

A geneticist identifies cell types in four sexually reproducing organisms that display mutations. The results are shown in the table. A (+) symbol means a mutation was detected. A (−) symbol means no mutations were detected.

<table>
<thead>
<tr>
<th>Organism Tested</th>
<th>Skin</th>
<th>Stomach</th>
<th>Gamete</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>−</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>M</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>N</td>
<td>−</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>O</td>
<td>−</td>
<td>+</td>
<td>−</td>
</tr>
</tbody>
</table>

Which organisms will pass the mutations to their offspring?

A. L and M
B. L and O
C. N and M
D. N and O

Part B

Which statement describes evidence that supports your choice in part A?

A. Offspring genotypes are determined by gametes.
B. Offspring genotypes are determined by both somatic cells and gametes.
C. Independent assortment of alleles in somatic cells causes mutated genes to be passed on to offspring.
D. Mutations in somatic cells are highly inheritable because they transport nutrients throughout the organism.

Points Possible: 1

See Alignment for more detail.
Scoring Guidelines

Part A

**Rationale for Option A: Key** – Organism L and M have mutations in gametes, which will be passed to offspring. The mutation in the skin cell will not be passed onto the next generation.

**Rationale for Option B:** This is incorrect. Mutations in somatic cells (stomach) do not get passed on to offspring. The mutation in the gamete will be passed on to offspring. Only one organism will pass on its mutation.

**Rationale for Option C:** This is incorrect. Organism N won’t pass its mutations to offspring because it is a somatic cell.

**Rationale for Option D:** This is incorrect. Mutations in somatic cells do not get passed on to offspring.

**Part B**

**Rationale for Option A: Key** – Only gametes contribute genes to offspring.

**Rationale for Option B:** This is incorrect. Somatic cells’ genetic information does not get passed on to offspring.

**Rationale for Option C:** This is incorrect. Independent assortment in somatic cells does not affect which genes are passed on to offspring.

**Rationale for Option D:** This is incorrect. The somatic cells do not transmit mutations to other parts of the body or to gametes.
Alignment

Content Strand
Heredity

Content Statement
Genetic Mechanisms and Inheritance

Content Elaboration
Life is specified by genomes. Each organism has a genome that contains all the biological information needed to build and maintain a living example of that organism. The biological information contained in a genome is encoded in its deoxyribonucleic acid (DNA) and is divided into discrete units called genes. Genes are segments of DNA molecules. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein. Inserting, deleting or substituting segments of DNA molecules can alter genes. An altered gene may be passed onto every cell that develops from it. The resulting features may help, harm or have little or no effect on the offspring’s success in its environments. Gene mutations (when they occur in gametes) can be passed on to offspring.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This item requires the student to select the organisms that will pass mutations to their offspring and identify the evidence that supports that selection. Mutations that occur in somatic cells will only be passed onto the cells that develop from the mutated cell within that organism. The next generation will not be affected. Mutations that occur in gametes will be passed onto the next generation because the gametes pass on genetic information to offspring.
The following question has two parts. First, answer part A. Then, answer part B.

Part A

A geneticist identifies cell types in four sexually reproducing organisms that display mutations. The results are shown in the table. A (+) symbol means a mutation was detected. A (−) symbol means no mutations were detected.

<table>
<thead>
<tr>
<th>Organism Tested</th>
<th>Skin</th>
<th>Stomach</th>
<th>Gamete</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
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</tr>
<tr>
<td>M</td>
<td>+</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>N</td>
<td>−</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>O</td>
<td>−</td>
<td>+</td>
<td>−</td>
</tr>
</tbody>
</table>

Which organisms will pass the mutations to their offspring?

- L and M
- L and O
- N and M
- N and O

Part B

Which statement describes evidence that supports your choice in part A?

- Offspring genotypes are determined by gametes.
- Offspring genotypes are determined by both somatic cells and gametes.
- Independent assortment of alleles in somatic cells causes mutated genes to be passed on to offspring.
- Mutations in somatic cells are highly inheritable because they transport nutrients throughout the organism.
Question 16

Chemosynthesis is a cellular process used by organisms in deep sea ecosystems in the absence of light. A chemical equation for chemosynthesis is shown.

**Chemosynthesis Equation**

\[ \text{H}_2\text{S} + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + \text{H}_2\text{SO}_4 \]

How is chemosynthesis different from photosynthesis?

A. Chemosynthesis requires carbon dioxide.
B. Chemosynthesis is used by autotrophic organisms.
C. Chemosynthesis produces energy in the form of sugars.
D. Chemosynthesis harvests energy from other chemical compounds.

Points Possible: 1

See Alignment for more detail.

Scoring Guidelines

**Rationale for Option A:** This is incorrect. Both chemosynthesis and photosynthesis use carbon dioxide as a reactant and the reactions cannot proceed in an environment without it.

**Rationale for Option B:** This is incorrect. Both chemosynthesis and photosynthesis are used by autotrophic organisms to produce their own energy.

**Rationale for Option C:** This is incorrect. Both chemosynthesis and photosynthesis generate energy in the form of sugars.

**Rationale for Option D:** Key – The energy required for chemosynthesis comes from chemical compounds and not sunlight. As a result, chemosynthetic organisms can live in environments without sunlight. Photosynthesis requires light energy to produce energy.
Alignment

Content Strand
Cells

Content Statement
Cellular Processes

Content Elaboration
Every cell is covered by a membrane that controls what can enter and leave the cell. Within the cell are specialized parts for the transport of materials, energy transformation, protein building, waste disposal, information feedback and movement. In addition to these basic cellular functions, most cells in multicellular organisms perform some specific functions that others do not. A living cell is composed of a small number of elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules. The essential functions of cells involve chemical reactions that involve water and carbohydrates, proteins, lipids and nucleic acids. A special group of proteins, enzymes, enables chemical reactions to occur within living systems.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This item requires the student to compare the processes of photosynthesis and chemosynthesis. Photosynthesis uses light energy to produce organic compounds. Chemosynthesis uses other compounds as the energy source.
Sample Response: 1 point

Chemosynthesis is a cellular process used by organisms in deep sea ecosystems in the absence of light. A chemical equation for chemosynthesis is shown.

**Chemosynthesis Equation**

$$H_2S + CO_2 + H_2O \rightarrow C_6H_{12}O_6 + H_2SO_4$$

How is chemosynthesis different from photosynthesis?

- A. Chemosynthesis requires carbon dioxide.
- B. Chemosynthesis is used by autotrophic organisms.
- C. Chemosynthesis produces energy in the form of sugars.
- D. Chemosynthesis harvests energy from other chemical compounds.
Biology
Spring 2019 Item Release

Question 17

Question and Scoring Guidelines
**Question 17**

*Coelatura* is a genus of freshwater mussels. A researcher collects five species of *Coelatura* from the Nile river. The researcher takes DNA samples of each species and performs gel electrophoresis to find genetic similarity between the species. The diagram shows the results of the gel electrophoresis.

![Coelatura Gel Electrophoresis Diagram]

Select the **two** pairs of species that share the greatest genetic similarity based on the results of the gel electrophoresis.

- [ ] *C. parreyssi* and *C. gaillardioli*
- [ ] *C. canopicus* and *C. prasidens*
- [ ] *C. prasidens* and *C. gaillardioli*
- [ ] *C. parreyssi* and *C. prasidens*
- [ ] *C. canopicus* and *C. aegyptiaca*

**Points Possible:** 1

See **Alignment** for more detail.
Scoring Guidelines

Rationale for the First Option: This is incorrect. These two mussels do not have similar banding patterns. C. gaillardoti’s banding pattern matches more with that of C. prasidens.

Rationale for the Second Option: This is incorrect. One of the species contains three DNA bands and the other contains four so they do not share greatest genetic similarity.

Rationale for the Third Option: Key – Both species share the greatest genetic similarity as they have three DNA bands of the same size.

Rationale for the Fourth Option: This is incorrect. Both species do not share the greatest genetic similarity as only one DNA band is similar for both the species.

Rationale for the Fifth Option: Key – Both species share the greatest genetic similarity compared to other species as C. aegyptiaca shares three of the four DNA bands with C. canopicus.
Alignment

Content Strand
Heredity

Content Statement
Modern Genetics

Content Elaboration
Life is specified by genomes. Each organism has a genome that contains all of the biological information needed to build and maintain a living example of that organism. The biological information contained in a genome is encoded in its deoxyribonucleic acid (DNA) and is divided into discrete units called genes. It is imperative that the technological developments that lead to the current knowledge of heredity be included in the study of heredity.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

Explanation of the Item
This item requires the student to use the results of a gel electrophoresis to find the genetic similarity between five species of Coelatura. The closer the patterning of DNA bands, the closer the genetic similarity.
*Coelatura* is a genus of freshwater mussels. A researcher collects five species of *Coelatura* from the Nile river. The researcher takes DNA samples of each species and performs gel electrophoresis to find genetic similarity between the species. The diagram shows the results of the gel electrophoresis.

### Coelatura Gel Electrophoresis

<table>
<thead>
<tr>
<th>Number of Base Pairs</th>
<th>Marker</th>
<th><em>C. parreyssi</em></th>
<th><em>C. gaillardi</em></th>
<th><em>C. canopicus</em></th>
<th><em>C. aegyptiaca</em></th>
<th><em>C. prasidens</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>5090</td>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>4072</td>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>3054</td>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>2036</td>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Select the **two** pairs of species that share the greatest genetic similarity based on the results of the gel electrophoresis.

- [ ] *C. parreyssi* and *C. gaillardi*
- [ ] *C. canopicus* and *C. prasidens*
- [X] *C. prasidens* and *C. gaillardi*
- [ ] *C. parreyssi* and *C. prasidens*
- [X] *C. canopicus* and *C. aegyptiaca*
Biology
Spring 2019 Item Release

Question 21

Question and Scoring Guidelines
Question 21

The European corn borer is a pest whose larvae cause damage to corn crops in the United States. Pesticides can be used to control the larvae. As an alternative, scientists have developed a genetically engineered form of corn called the Bt strain. It produces a toxin in its cells called Bt, which is poisonous to the corn borer larvae. Farmers who plant fields of Bt corn are required by law to plant fields of non-Bt corn nearby as well.

Which statement explains why farmers would be required to plant non-Bt corn near Bt corn?

A) To provide controls for Bt toxin experiments with corn borers
B) To keep corn borers from cross-pollinating Bt and non-Bt corn
C) To slow reproductive selection for a Bt toxin-resistant corn borer
D) To prevent movement of corn borers from Bt to non-Bt corn fields

Points Possible: 1

See Alignment for more detail.
Scoring Guidelines

Rationale for Option A: This is incorrect. While studies may be done using some farm fields, this would not explain why all farmers would be required by law to plant both types of corn.

Rationale for Option B: This is incorrect. Planting fields of Bt and non-Bt corn near each other would not prevent corn borers from cross-pollinating the two types of corn.

Rationale for Option C: Key – The presence of the Bt toxin would encourage natural selection for individuals that are resistant. Planting a field of non-Bt corn would help to slow the process by ensuring that heterozygous individuals remain in the population.

Rationale for Option D: Planting fields of Bt and non-Bt corn near each other would not prevent movement of corn borers between the two fields; it would enable the movement by placing the two fields in close proximity.
**Alignment**

**Content Strand**
Evolution

**Content Statement**
Diversity of Life

**Content Elaboration**
Natural selection is used to describe the process by which traits become more or less common in a population due to consistent environmental effects upon the survival or reproduction of the individual with the trait. Different phenotypes result from new combinations of existing genes or from mutations of genes in reproductive cells.

Heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment. When an environment changes, the survival value of inherited characteristics may change. This may or may not cause a change in species that inhabit the environment. Formulate and revise explanations for gene flow and sexual selection based on real-world problems.

**Cognitive Demand**
Demonstrating Science Knowledge (D)

Requires students to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather and organize data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments.

**Explanation of the Item**
This item requires the student to demonstrate an understanding that changes in gene frequency over time can result in the appearance of individuals with advantageous characteristics. The presence of the Bt toxin would encourage natural selection for individuals that are resistant. Planting a field of non-Bt corn would help to slow the process by ensuring that heterozygous individuals remain in the population.
The European corn borer is a pest whose larvae cause damage to corn crops in the United States. Pesticides can be used to control the larvae. As an alternative, scientists have developed a genetically engineered form of corn called the Bt strain. It produces a toxin in its cells called Bt, which is poisonous to the corn borer larvae. Farmers who plant fields of Bt corn are required by law to plant fields of non-Bt corn nearby as well.

Which statement explains why farmers would be required to plant non-Bt corn near Bt corn?

A. To provide controls for Bt toxin experiments with corn borers
B. To keep corn borers from cross-pollinating Bt and non-Bt corn
C. To slow reproductive selection for a Bt toxin-resistant corn borer
D. To prevent movement of corn borers from Bt to non-Bt corn fields
Question 22

The following question has two parts. First, answer part A. Then, answer part B.

Part A

Scientists determine that longer hind leg length is directly correlated to faster running speed in rabbits. The scientists investigate how an introduced predator in the rabbits’ ecosystem affects the running speed of the rabbit population. The graph shows running speed data from the rabbit population and running speed data of the introduced predator.

Which graph shows the expected running speed of the rabbits selected for after 50 generations due to the introduced predator?
Part B

Click on the blank boxes and select the phenotype frequency within the rabbit population after 50 generations due to the introduction of the new predator.

- There may be more than one correct answer.

### Phenotype Frequency of Rabbits

<table>
<thead>
<tr>
<th>Time</th>
<th>Rabbit Phenotype Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short Hind Legs</td>
</tr>
<tr>
<td>Before predator introduction</td>
<td>20</td>
</tr>
<tr>
<td>After predator introduction</td>
<td>▼</td>
</tr>
</tbody>
</table>

**Drop down choices:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Rabbit Phenotype Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short Hind Legs</td>
</tr>
<tr>
<td>Before predator introduction</td>
<td>20</td>
</tr>
<tr>
<td>After predator introduction</td>
<td>▼</td>
</tr>
</tbody>
</table>

### Points Possible: 2

See **Alignment** for more detail.
Scoring Guidelines

For this item, a full-credit response includes:

- the graph that shows a distribution that is faster than the original population for Part A;
  
  AND

- the three phenotypic frequencies selected equal 100%;
  
  AND

- the percentage selected for “Long Hind Legs” is the greatest;
  
  AND

- the percentage selected for “Average Length Hind Legs is less than “Long Hind Legs” but more than “Short Hind Legs”;
  
  AND

- the percentage selected for “Short Hind Legs” is the least for Part B (2 points).

For this item, a partial-credit response includes:

- the graph that shows a distribution that is faster than the original population for Part A (1 point)

  OR

- the three phenotypic frequencies selected equal 100%;
  
  AND

- the percentage selected for “Long Hind Legs” is the greatest;
  
  AND

- the percentage selected for “Average Length Hind Legs is less than “Long Hind Legs” but more than “Short Hind Legs”;
  
  AND

- the percentage selected for “Short Hind Legs” is the least for Part B (1 point).
Alignment

Content Strand
Evolution

Content Statement
Mechanisms

Content Elaboration
Natural selection works on the phenotype.

Populations evolve over time. Evolution is the consequence of the interactions of:

1. The potential for a population to increase its numbers;
2. The genetic variability of offspring due to mutation and recombination of genes;
3. A finite supply of the resources required for life; and
4. The differential survival and reproduction of individuals with the specific phenotype.

Cognitive Demand
Demonstrating Science Knowledge (D)

Requires students to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather and organize data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments.
**Explanation of the Item**

This item requires the student to use mathematical reasoning in order to predict how a rabbit population changes over time due to selection pressures. In this case the introduced predator has a faster running speed. It is determined that rabbits with longer legs have a faster running speed than other rabbits in the population. A faster running speed could increase survival chances for rabbits. Rabbits with longer hind legs run faster which allows them to escape predators and reproduce passing on the longer hind leg length to future generations. The rabbits with shorter leg length that run slowest will be selected against with the introduction of a faster predator. After 50 generations graph A illustrates a distribution of faster rabbits than the original population for part A. In part B the three phenotypic frequencies selected should equal 100%. The percentage selected for long hind legs is the greatest. The percentage selected for average length hind legs is less than long hind legs but more than short hind legs. The percentage selected for short hind legs is the least.
Sample Response: 2 points

The following question has two parts. First, answer part A. Then, answer part B.

Part A

Scientists determine that longer hind leg length is directly correlated to faster running speed in rabbits. The scientists investigate how an introduced predator in the rabbits’ ecosystem affects the running speed of the rabbit population. The graph shows running speed data from the rabbit population and running speed data of the introduced predator.

Which graph shows the expected running speed of the rabbits selected for after 50 generations due to the introduced predator?
Part B

Click on the blank boxes and select the phenotype frequency within the rabbit population after 50 generations due to the introduction of the new predator.

- There may be more than one correct answer.

### Phenotype Frequency of Rabbits

<table>
<thead>
<tr>
<th>Time</th>
<th>Rabbit Phenotype Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short Hind Legs</td>
</tr>
<tr>
<td>Before predator introduction</td>
<td>20</td>
</tr>
<tr>
<td>After predator introduction</td>
<td>10 ▼</td>
</tr>
</tbody>
</table>

**Notes on Scoring**

This response earns full credit (2 points) because it correctly identifies a graph with a distribution of faster rabbits that is greater than the original rabbit population for part A.

In part B, the three phenotypic frequencies selected equal 100%. The percentage selected for long hind legs is the greatest. The percentage selected for average length hind legs is less than for long hind legs, but more than short hind legs. The percentage selected for short hind legs is the least.
Sample Response: 1 point

The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

Scientists determine that longer hind leg length is directly correlated to faster running speed in rabbits. The scientists investigate how an introduced predator in the rabbits' ecosystem affects the running speed of the rabbit population. The graph shows running speed data from the rabbit population and running speed data of the introduced predator.

Which graph shows the expected running speed of the rabbits selected for after 50 generations due to the introduced predator?
Notes on Scoring

This response earns partial credit (1 point) because it correctly identifies a graph with a distribution of faster rabbits that is greater than the original rabbit population for part A.

In part B, however, the percentage selected for long hind legs is not greater, but rather equal to the percentage selected for average hind legs. Equal frequencies do not indicate that the introduction of the predator resulted in an increase in faster rabbits within the population, which were caused by longer hind legs.
The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

Scientists determine that longer hind leg length is directly correlated to faster running speed in rabbits. The scientists investigate how an introduced predator in the rabbits’ ecosystem affects the running speed of the rabbit population. The graph shows running speed data from the rabbit population and running speed data of the introduced predator.

![Graph showing running speed of rabbits and predator speed](image)

**Key**
- Current Generation
- Predator Speed

Which graph shows the expected running speed of the rabbits selected for after 50 generations due to the introduced predator?
Part B

Click on the blank boxes and select the phenotype frequency within the rabbit population after 50 generations due to the introduction of the new predator.

- There may be more than one correct answer.

<table>
<thead>
<tr>
<th>Time</th>
<th>Short Hind Legs</th>
<th>Average Length Hind Legs</th>
<th>Long Hind Legs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before predator</td>
<td>20</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>introduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After predator</td>
<td>10 ✔</td>
<td>40 ✔</td>
<td>50 ✔</td>
</tr>
<tr>
<td>introduction</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes on Scoring

This response earns partial credit (1 point) for part B. The three phenotypic frequencies selected equal 100%. The percentage selected for long hind legs is the greatest. The percentage selected for average length hind legs is less than for long hind legs, but more than short hind legs. The percentage selected for short hind legs is the least.

No credit is awarded in part A because it fails to identify a graph with a distribution of faster rabbits that is greater than the original rabbit population for part A.
Sample Response: 0 points

The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

Scientists determine that longer hind leg length is directly correlated to faster running speed in rabbits. The scientists investigate how an introduced predator in the rabbits’ ecosystem affects the running speed of the rabbit population. The graph shows running speed data from the rabbit population and running speed data of the introduced predator.

![Graph showing running speed of rabbits with predator speed](image)

<table>
<thead>
<tr>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Generation</td>
</tr>
<tr>
<td>Predator Speed</td>
</tr>
</tbody>
</table>

Which graph shows the expected running speed of the rabbits selected for after 50 generations due to the introduced predator?
Notes on Scoring

This response earns no credit (0 points) because it does not identify a graph with a distribution of faster rabbits that is greater than the original rabbit population for part A.

In part B, the three phenotypic frequencies selected do not equal 100%. The percentage selected for long hind legs is not the greatest; the percentage for average length hind legs is not between the percentage for short hind legs and long hind legs; and the percentage selected for short hind legs is not the least.
Sample Response: 0 points

The following question has two parts. First, answer part A. Then, answer part B.

Part A
Scientists determine that longer hind leg length is directly correlated to faster running speed in rabbits. The scientists investigate how an introduced predator in the rabbits’ ecosystem affects the running speed of the rabbit population. The graph shows running speed data from the rabbit population and running speed data of the introduced predator.

Which graph shows the expected running speed of the rabbits selected for after 50 generations due to the introduced predator?
Part B

Click on the blank boxes and select the phenotype frequency within the rabbit population after 50 generations due to the introduction of the new predator.

- There may be more than one correct answer.

<table>
<thead>
<tr>
<th>Time</th>
<th>Rabbit Phenotype Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short Hind Legs</td>
</tr>
<tr>
<td>Before predator introduction</td>
<td>20</td>
</tr>
<tr>
<td>After predator introduction</td>
<td>60   ❑</td>
</tr>
</tbody>
</table>

Notes on Scoring

This response earns no credit (0 points) because it does not identify a graph with a distribution of faster rabbits that is greater than the original rabbit population for part A.

In part B, the percentage selected for long hind legs is the smallest of the three percentages and the greatest percentage is selected for short hind legs.
Biology
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Question 27

Question and Scoring Guidelines
Question 27

The following question has two parts. First, answer part A. Then, answer part B.

Part A

Students investigate how light intensity affects the rate of photosynthesis in an aquatic plant. Their setup is shown in the diagram.

---

The students place a light at different distances from the plant and record the number of bubbles produced. Their data are shown in the table.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Bubbles Produced per Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>124</td>
</tr>
<tr>
<td>0.2</td>
<td>124</td>
</tr>
<tr>
<td>0.3</td>
<td>84</td>
</tr>
<tr>
<td>0.4</td>
<td>31</td>
</tr>
<tr>
<td>0.5</td>
<td>6</td>
</tr>
</tbody>
</table>

Which inference is supported by the data?

A. The plant produces more oxygen as light intensity increases.
B. The plant takes in more water when the light intensity decreases.
C. The plant requires more energy for photosynthesis at lower light intensities.
D. The plant needs less carbon dioxide for photosynthesis at higher light intensities.
Which graph shows the relationship between the rate of photosynthesis and light intensity?

A.

B.

C.

D.
Scoring Guidelines

Part A

**Rationale for Option A:** **Key** – The plant performs photosynthesis at a greater rate when the light intensity is greatest. The number of bubbles indicates oxygen production.

**Rationale for Option B:** This is incorrect. There are no data regarding water exchange.

**Rationale for Option C:** This is incorrect. The rate of photosynthesis decreases, but the energy requirements do not change.

**Rationale for Option D:** This is incorrect. The plant would require a greater amount of carbon dioxide to photosynthesize at a greater rate.

Part B

**Rationale for Option A:** This is incorrect. According to the students’ data, the rate of photosynthesis decreases when the light moves farther from the plant.

**Rationale for Option B:** This is incorrect. According to the students’ data, the rate of photosynthesis decreases when the light moves farther from the plant and does not start at zero.

**Rationale for Option C:** **Key** – As the light moves farther from the plant, the rate of photosynthesis decreases.

**Rationale for Option D:** This is incorrect. The rate of photosynthesis changes as the light moves away from the plant. It does not remain constant because the number of bubbles decreases.
Alignment

Content Strand
Cells

Content Statement
Cellular Processes

Content Elaboration
Every cell is covered by a membrane that controls what can enter and leave the cell. Within the cell are specialized parts for the transport of materials, energy transformation, protein building, waste disposal, information feedback and movement. In addition to these basic cellular functions, most cells in multicellular organisms perform some specific functions that others do not. A living cell is composed of a small number of elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules. The essential functions of cells involve chemical reactions that involve water and carbohydrates, proteins, lipids and nucleic acids. A special group of proteins, enzymes, enables chemical reactions to occur within living systems.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This item requires the student to make an inference based on data from a photosynthesis experiment and to select the graph that explains the data. The closer the light is to the plant, the higher the rate of photosynthesis, resulting in more bubbles (oxygen) produced per minute.
Biology
Spring 2019 Item Release

Question 27

Sample Responses
Sample Response: 2 points

The following question has two parts. First, answer part A. Then, answer part B.

Part A

Students investigate how light intensity affects the rate of photosynthesis in an aquatic plant. Their setup is shown in the diagram.

![Light Intensity Investigation Diagram]

The students place a light at different distances from the plant and record the number of bubbles produced. Their data are shown in the table.

<table>
<thead>
<tr>
<th>Distance (m)</th>
<th>Bubbles Produced per Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>124</td>
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<tr>
<td>0.2</td>
<td>124</td>
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<tr>
<td>0.3</td>
<td>84</td>
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<tr>
<td>0.4</td>
<td>31</td>
</tr>
<tr>
<td>0.5</td>
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Which inference is supported by the data?

- The plant produces more oxygen as light intensity increases.
- The plant takes in more water when the light intensity decreases.
- The plant requires more energy for photosynthesis at lower light intensities.
- The plant needs less carbon dioxide for photosynthesis at higher light intensities.
Which graph shows the relationship between the rate of photosynthesis and light intensity?

A.

B.

C.

D.
Notes on Scoring

This response earns full credit (2 points) for correctly recognizing that photosynthesis will occur at a greater rate when the light intensity is greatest. The response also correctly identifies the graph that represents the rate of photosynthesis in the plant as the distance from the light increases. The rate of photosynthesis will decrease.
Sample Response: 1 point

The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

Students investigate how light intensity affects the rate of photosynthesis in an aquatic plant. Their setup is shown in the diagram.

![Light Intensity Investigation diagram](image)

The students place a light at different distances from the plant and record the number of bubbles produced. Their data are shown in the table.

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- The plant produces more oxygen as light intensity increases.
- The plant takes in more water when the light intensity decreases.
- The plant requires more energy for photosynthesis at lower light intensities.
- The plant needs less carbon dioxide for photosynthesis at higher light intensities.
Which graph shows the relationship between the rate of photosynthesis and light intensity?

A. [Graph A]

B. [Graph B]

C. [Graph C]
Notes on Scoring

This response earns partial credit (1 point) for correctly recognizing that photosynthesis will occur at a greater rate when the light intensity is greatest. The response fails to correctly identify the graph that represents the rate of photosynthesis in the plant as the distance from the light increases. The rate of photosynthesis will decrease, not remain constant, as the distance from the light increases.
Sample Response: 1 point

The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

Students investigate how light intensity affects the rate of photosynthesis in an aquatic plant. Their setup is shown in the diagram.

![Light Intensity Investigation](image)

The students place a light at different distances from the plant and record the number of bubbles produced. Their data are shown in the table.

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- The plant takes in more water when the light intensity decreases.
- The plant requires more energy for photosynthesis at lower light intensities.
- The plant needs less carbon dioxide for photosynthesis at higher light intensities.
Which graph shows the relationship between the rate of photosynthesis and light intensity?

A. 

B. 

C. 

D.
Notes on Scoring

This response earns partial credit (1 point) for correctly recognizing that photosynthesis will occur at a greater rate when the light intensity is greatest. The response fails to correctly identify the graph that represents the rate of photosynthesis in the plant as the distance from the light increases. The rate of photosynthesis will decrease, not start at zero and increase, as the distance from the light increases.
Sample Response: 0 points

The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

Students investigate how light intensity affects the rate of photosynthesis in an aquatic plant. Their setup is shown in the diagram.

![Light Intensity Investigation Diagram]

The students place a light at different distances from the plant and record the number of bubbles produced. Their data are shown in the table.

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Which inference is supported by the data?

**A** The plant produces more oxygen as light intensity increases.

**B** The plant takes in more water when the light intensity decreases.

**C** The plant requires more energy for photosynthesis at lower light intensities.

**D** The plant needs less carbon dioxide for photosynthesis at higher light intensities.
Which graph shows the relationship between the rate of photosynthesis and light intensity?
Notes on Scoring

This response earns no credit (0 points) for failing to recognize that photosynthesis will occur at a greater rate when the light intensity is greatest. Light provides the energy for photosynthesis to occur. The response also fails to correctly identify the graph that represents the rate of photosynthesis in the plant as the distance from the light increases. The rate of photosynthesis will decrease, not remain constant, as the distance from the light increases.
Question 29

A researcher conducts an investigation on fiddler crabs to understand the importance of claw size in mating. The male fiddler crabs have one normal-sized claw and one giant claw that they wave to attract female fiddler crabs. The female fiddler crabs have two small, same-sized claws. The researcher places 15 male crabs with different sized claws into an enclosure with conditions similar to those in their natural habitat. The researcher then releases 15 female crabs into the enclosure. The graph shows the percentage of male crabs of different claw size that successfully mated for three successive trials.

**Fiddler Crabs Investigation**

<table>
<thead>
<tr>
<th></th>
<th>First</th>
<th>Second</th>
<th>Third</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Mate</td>
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<td></td>
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</tbody>
</table>

**Key**

- Male Crabs with Larger Claws
- Male Crabs with Smaller Claws

**Investigative Trials**

Select the **two** statements that predict the outcome on the traits of male fiddler crabs in a population over time based on the results of the investigation.

- The percentage of males with larger claws will increase in the population.
- The percentage of males with smaller claws will continue to decrease in the population.
- The percentage of males with smaller claws will evolve to have claws that attract more female crabs.
- The percentage of males with varying claw sizes will remain constant, as both traits are selected for by female crabs.
- The percentage of male and female crabs with smaller claws will decrease, as smaller claws are selected against in mating.
Scoring Guidelines

Rationale for the First Option: **Key** – Since female crabs prefer males with larger claws, the percentage of larger-clawed males in the population will increase because their traits are passed onto the next generation.

Rationale for the Second Option: **Key** – Since males with smaller claws have a lower chance of finding a mate, they will reproduce less, transferring their traits to fewer offspring.

Rationale for the Third Option: This is incorrect. Individual organisms cannot choose to evolve to have more desirable traits to attract mates.

Rationale for the Fourth Option: This is incorrect. The percentage of males with smaller and larger claws will not be the same as sexual selection will increase the favorable trait in the population.

Rationale for the Fifth Option: This is incorrect. Since the female crabs have only smaller claws and they select the mate, their proportion will remain unchanged.

Points Possible: 1

See **Alignment** for more detail.
Alignment

Content Strand
Evolution

Content Statement
Mechanisms

Content Elaboration
Heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment. When an environment changes, the survival value of inherited characteristics may change. This may or may not cause a change in species that inhabit the environment. Formulate and revise explanations for gene flow and sexual selection based on real-world problems.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This item requires the student to analyze and interpret the effect of sexual selection on the occurrence of large claws for male fiddler crabs. The number of males with large claws increases in the population while the number of males with small claws decreases. Females select large clawed males passing that trait onto future generations.
Sample Response: 1 point

A researcher conducts an investigation on fiddler crabs to understand the importance of claw size in mating. The male fiddler crabs have one normal-sized claw and one giant claw that they wave to attract female fiddler crabs. The female fiddler crabs have two small, same-sized claws. The researcher places 15 male crabs with different sized claws into an enclosure with conditions similar to those in their natural habitat. The researcher then releases 15 female crabs into the enclosure. The graph shows the percentage of male crabs of different claw size that successfully mated for three successive trials.

**Fiddler Crabs Investigation**

![Chart showing mating success for different claw sizes across three trials]

**Key**
- Male Crabs with Larger Claws
- Male Crabs with Smaller Claws

**Investigative Trials**

Select the **two** statements that predict the outcome on the traits of male fiddler crabs in a population over time based on the results of the investigation.

- ✔️ The percentage of males with larger claws will increase in the population.
- ✔️ The percentage of males with smaller claws will continue to decrease in the population.
- ☐ The percentage of males with smaller claws will evolve to have claws that attract more female crabs.
- ☐ The percentage of males with varying claw sizes will remain constant, as both traits are selected for by female crabs.
- ☐ The percentage of male and female crabs with smaller claws will decrease, as smaller claws are selected against in mating.
Biology
Spring 2019 Item Release

Question 35

Question and Scoring Guidelines
Question 35

Scientists discover a new species of bacteria that has a similar genetic makeup as a previously studied bacterial species.

Which investigative tool should be used to genetically compare the new bacteria to the previously studied bacteria?

A. gene therapy
B. chi-squared test
C. gel electrophoresis
D. electron microscope

Points Possible: 1
See Alignment for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. Gene therapy is the process by which genes are inserted in the genome of an organism.

Rationale for Option B: This is incorrect. The chi-squared test is used to analyze the distribution of alleles or phenotypes in a population.

Rationale for Option C: Key – Gel electrophoresis can be used to compare the sizes of pieces of DNA among related species.

Rationale for Option D: This is incorrect. Electron microscopes are used to observe structures or objects too small to be viewed effectively with a traditional light microscope.
Alignment

Content Strand
Heredity

Content Statement
Modern Genetics

Content Elaboration
Life is specified by genomes. Each organism has a genome that contains all of the biological information needed to build and maintain a living example of that organism. The biological information contained in a genome is encoded in its deoxyribonucleic acid (DNA) and is divided into discrete units called genes. It is imperative that the technological developments that lead to the current knowledge of heredity be included in the study of heredity.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

Explanation of the Item
This item requires the student to select the appropriate tool, method, or process to compare the genetic makeup of two closely related bacterial species. Gel electrophoresis allows the DNA to be processed to create a banding pattern that can be compared for relatedness.
Sample Response: 1 point

Scientists discover a new species of bacteria that has a similar genetic makeup as a previously studied bacterial species.

Which investigative tool should be used to genetically compare the new bacteria to the previously studied bacteria?

- [ ] (A) gene therapy
- [ ] (B) chi-squared test
- [x] (C) gel electrophoresis
- [ ] (D) electron microscope
Question 36

Two subspecies of tufted-ear squirrels have been observed near the Grand Canyon. Scientists believe that these two squirrels evolved from a common population of squirrels that lived in the ponderosa pine forests that once grew in what is now the Grand Canyon. The Kaibab squirrel is found on the north side of the canyon, and the Abert’s squirrel is found on the south side.

Tufted-Ear Squirrels

Kaibab Squirrel
(Sciurus aberti kaibabensis)

Abert’s Squirrel
(Sciurus aberti aberti)

Which statement explains the formation of the two subspecies from the original population of tufted-ear squirrels?

A. Similar selection pressures on each side of the canyon caused fur color mutations to occur in the two populations.

B. As the canyon formed and the ponderosa forests disappeared, the original population was split into two isolated populations.

C. The original population was able to find similar habitats in many small pockets of connected forests remaining around the Grand Canyon.

D. Natural land bridges connecting the two sides of the canyon allowed gene flow to occur between the populations after the ponderosa forests disappeared.

Points Possible: 1

See Alignment for more detail.
Scoring Guidelines

Rationale for Option A: This is incorrect. Natural selection does not cause mutations to occur.

Rationale for Option B: Key – Divergence of a species into subspecies or, eventually, new species occurs due to a restriction of gene flow between populations. Habitat isolation prevented the squirrels from mating and the populations evolved independently.

Rationale for Option C: This is incorrect. A similar habitat alone would not have led to speciation. Speciation is caused by a restriction of gene flow between populations.

Rationale for Option D: This is incorrect. Bridges connecting the populations would allow them to share a single gene pool, as genes would flow between them. These populations were isolated.
Alignment

Content Strand
Evolution

Content Statement
Mechanisms

Content Elaboration
Populations evolve over time. Evolution is the consequence of the interactions of:

1. The potential for a population to increase its numbers;
2. The genetic variability of offspring due to mutation and recombination of genes;
3. A finite supply of the resources required for life; and
4. The differential survival and reproduction of individuals with the specific phenotype. Mutations are described in the content elaboration for Heredity. Apply the knowledge of mutation and genetic drift to real-world examples.

Heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment. When an environment changes, the survival value of inherited characteristics may change. This may or may not cause a change in species that inhabit the environment. Formulate and revise explanations for gene flow and sexual selection based on real-world problems.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

Explanation of the Item
This item requires the student to identify a process that leads to the formation of two phenotypically distinct subspecies. Geographic isolation prevents gene flow between the Kaibab and Abert’s squirrels resulting in two subspecies.
Sample Response: 1 point

Two subspecies of tufted-ear squirrels have been observed near the Grand Canyon. Scientists believe that these two squirrels evolved from a common population of squirrels that lived in the ponderosa pine forests that once grew in what is now the Grand Canyon. The Kaibab squirrel is found on the north side of the canyon, and the Abert’s squirrel is found on the south side.

![Tufted-Ear Squirrels]

Which statement explains the formation of the two subspecies from the original population of tufted-ear squirrels?

(A) Similar selection pressures on each side of the canyon caused fur color mutations to occur in the two populations.

(B) As the canyon formed and the ponderosa forests disappeared, the original population was split into two isolated populations.

(C) The original population was able to find similar habitats in many small pockets of connected forests remaining around the Grand Canyon.

(D) Natural land bridges connecting the two sides of the canyon allowed gene flow to occur between the populations after the ponderosa forests disappeared.
Question 37

The graph shows the population growth of an organism over time.

What shift in population growth has occurred by point A?

A  The birth and death rates are equivalent.
B  The rate of emigration equals the death rate.
C  The population sizes of the organism and its predator are equalized.
D  There will be more food available than the population can consume.

Points Possible: 1

See Alignment for more detail.
Scoring Guidelines

**Rationale for Option A:** Key – Carrying capacity occurs when the death rate and birth rate in a population are equal.

**Rationale for Option B:** This is incorrect. Carrying capacity is not determined by the equivalence of the emigration and death rates.

**Rationale for Option C:** This is incorrect. If there is the same number of predators as prey, there will not be enough food for the predators.

**Rationale for Option D:** This is incorrect. If there is an unlimited food supply, the population is likely to continue to grow.
Alignment

Content Strand
Diversity and Interdependence of Life

Content Statement
Ecosystems

Content Elaboration
The great diversity of organisms and ecological niches they occupy result from more than 3.5 billion years of evolution. Some ecosystems can be reasonably persistent over hundreds or thousands of years. Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change as geological or biological conditions vary.

Mathematical graphing and algebraic knowledge (at the high school level) must be used to explain concepts of carrying capacity and homeostasis within biomes. Use real-time data to investigate population changes that occur locally or regionally. Carrying capacity is defined as the population equilibrium sized when births and deaths are equal; hence Population Growth Rate = zero.

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

Explanation of the Item
This item requires the student to understand the relationship between birth rate, death rate and carrying capacity. When the birth rate and death rate are equal, carrying capacity has been reached. The graph illustrates a population of organisms that have reached carrying capacity.
Sample Response: 1 point

The graph shows the population growth of an organism over time.

What shift in population growth has occurred by point A?

- The birth and death rates are equivalent.
- The rate of emigration equals the death rate.
- The population sizes of the organism and its predator are equalized.
- There will be more food available than the population can consume.
Biology
Spring 2019 Item Release

Question 39

Question and Scoring Guidelines
Question 39

The cladogram shows evolutionary relationships among seven organisms.

Cladogram of Evolutionary Relationships

Which grouping of organisms includes an ancestor and all of its descendants?

A  M – N – O
B  N – O – P
C  O – P – R
D  P – R – S

Points Possible: 1

See Alignment for more detail.
Scoring Guidelines

Rationale for Option A: This is incorrect. This grouping does not include all the descendants of M.

Rationale for Option B: Key – This grouping includes a most recent common ancestor and all the descendants of that common ancestor.

Rationale for Option C: This is incorrect. This grouping is paraphyletic. It does not include all the descendant groups.

Rationale for Option D: This is incorrect. This grouping is paraphyletic. It does not include all the descendant groups.
Alignment

Content Strand
Diversity and Interdependence of Life

Content Statement
Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.

Content Elaboration
Classification systems are frameworks developed by scientists for describing the diversity of organisms, indicating the degree of relatedness between organisms. Recent molecular-sequence data generally support earlier hypotheses regarding lineages of organisms based upon morphological comparisons. Both morphological comparisons and molecular evidence must be used to describe biodiversity (cladograms can be used to address this).

Cognitive Demand
Recalling Accurate Science (R)

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students’ knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

Explanation of the Item
This item requires the student to read a cladogram and identify the group which includes a most recent common ancestor and all of the descendants of that common ancestor. N-O-P includes a most recent common ancestor and all the descendants of that common ancestor.
The cladogram shows evolutionary relationships among seven organisms.

**Cladogram of Evolutionary Relationships**

Which grouping of organisms includes an ancestor and all of its descendants?

- A  M – N – O
- B  N – O – P
- C  O – P – R
- D  P – R – S
Question 41

A segment of DNA is shown, along with the resulting amino acid chain. Three mutant amino acid chains are also shown, each resulting from a single base mutation to the original DNA segment.

Identify the type of single base mutation in the original DNA segment that would cause each of the resulting mutant amino acid chains.

Place a label that identifies each type of mutation into the blank box next to each mutant amino acid chain.

- You may use each label more than once.
- Place only one label in each blank box.

Amino Acid Codon Chart

<table>
<thead>
<tr>
<th>Second Position</th>
<th>U</th>
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<th>G</th>
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Mutation Comparison

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<tr>
<td>Original Amino Acid Chain</td>
<td>Met</td>
<td>Cys</td>
<td>Arg</td>
<td>Leu</td>
<td>Lys</td>
</tr>
<tr>
<td>Mutant 1</td>
<td>Met</td>
<td>Trp</td>
<td>Gln</td>
<td>Ile</td>
<td>Glu</td>
</tr>
<tr>
<td>Mutant 2</td>
<td>Met</td>
<td>Trp</td>
<td>Arg</td>
<td>Leu</td>
<td>Lys</td>
</tr>
<tr>
<td>Mutant 3</td>
<td>Met</td>
<td>Cys</td>
<td>Ser</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Points Possible: 2

See Alignment for more detail.
Scoring Guidelines

For this item, a full-credit response includes:
• “Insertion” placed in the top box;
  AND
• “Substitution” placed in the middle box;
  AND
• “Deletion” placed in the bottom box (2 points).

For this item, a partial-credit response includes:
• any two labels placed correctly (1 point).
Alignment

Content Strand
Heredity

Content Statement
Mutations

Content Elaboration
Genes are segments of DNA molecules. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein. Inserting, deleting or substituting segments of DNA molecules can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm or have little or no effect on the offspring's success in its environments. Gene mutations (when they occur in gametes) can be passed on to offspring. Genes code for protein. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This item requires the student to determine what kind of mutation results in each of three mutant amino acid chains by comparing a wild type amino acid chain to each mutant chain. Mutant 1 had a nucleotide inserted which altered the remaining amino acid chain and the resulting protein. Mutant 2 experienced a substitution for a nucleotide which altered only one amino acid in the resulting chain. The protein produced will also be altered. Mutant 3 experienced a deletion of a nucleotide which altered one amino acid and then resulted in the stop codon ending the development of the amino acid chain.
Biology
Spring 2019 Item Release

Question 41

Sample Responses
Sample Response: 2 points

A segment of DNA is shown, along with the resulting amino acid chain. Three mutant amino acid chains are also shown, each resulting from a single base mutation to the original DNA segment.

Identify the type of single base mutation in the original DNA segment that would cause each of the resulting mutant amino acid chains.

Place a label that identifies each type of mutation into the blank box next to each mutant amino acid chain.

- You may use each label more than once.
- Place only one label in each blank box.

<table>
<thead>
<tr>
<th>Amino Acid Codon Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Second Position</strong></td>
</tr>
<tr>
<td>U</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>U</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>G</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Third Position</strong> (3’ end)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>U</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>G</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Original DNA</strong></th>
<th>TAC</th>
<th>ACG</th>
<th>TCT</th>
<th>AAC</th>
<th>T1T</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original Amino Acid Chain</strong></td>
<td>Met</td>
<td>Cys</td>
<td>Arg</td>
<td>Leu</td>
<td>Lys</td>
</tr>
<tr>
<td><strong>Mutant 1</strong></td>
<td>Met</td>
<td>Trp</td>
<td>Gln</td>
<td>Ile</td>
<td>Glu</td>
</tr>
<tr>
<td><strong>Mutant 2</strong></td>
<td>Met</td>
<td>Trp</td>
<td>Arg</td>
<td>LeU</td>
<td>Lys</td>
</tr>
<tr>
<td><strong>Mutant 3</strong></td>
<td>Met</td>
<td>Cys</td>
<td>Ser</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Types of mutations:
- Insertion
- Substitution
- Deletion
Notes on Scoring

This response earns full credit (2 points) for correctly identifying the type of mutation that occurred in three amino acid chains. Mutant 1 had a nucleotide inserted which altered the remaining amino acid chain and the protein produced. Mutant 2 experienced a substitution for a nucleotide which altered only one amino acid in the resulting chain. The protein produced will also be altered. Mutant 3 experienced a deletion of a nucleotide which altered one amino acid and then resulted in the stop codon ending the development of the amino acid chain.
Sample Response: 1 point

A segment of DNA is shown, along with the resulting amino acid chain. Three mutant amino acid chains are also shown, each resulting from a single base mutation to the original DNA segment.

Identify the type of single base mutation in the original DNA segment that would cause each of the resulting mutant amino acid chains.

Place a label that identifies each type of mutation into the blank box next to each mutant amino acid chain.

- You may use each label more than once.
- Place only one label in each blank box.

Amino Acid Codon Chart

<table>
<thead>
<tr>
<th>First Position</th>
<th>Second Position</th>
<th>Third Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
<td>U</td>
</tr>
<tr>
<td>G</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>G</td>
<td>A</td>
</tr>
<tr>
<td>C</td>
<td>U</td>
<td>G</td>
</tr>
<tr>
<td>A</td>
<td>G</td>
<td>U</td>
</tr>
<tr>
<td>G</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>G</td>
<td>G</td>
<td>G</td>
</tr>
</tbody>
</table>

Original DNA: TAC, ACG, TCT, AAC, TTT

Original Amino Acid Chain: Met, Cys, Arg, Leu, Lys

Mutant 1: Met, Trp, Gln, Ile, Glu

Substitution

Mutant 2: Met, Trp, Arg, LeU, Lys

Substitution

Mutant 3: Met, Cys, Ser

Deletion
Notes on Scoring

This response earns partial credit (1 point) for correctly identifying two types of mutation, mutants 2 and 3. Mutant 1 had a nucleotide inserted which altered the entire amino acid chain which will alter the protein produced. Mutant 2 experienced a substitution for a nucleotide which altered only one amino acid in the resulting chain. The protein produced will also be altered. Mutant 3 experienced a deletion of a nucleotide which altered one amino acid and resulted in the stop codon ending the development of the amino acid chain.
Sample Response: 1 point

A segment of DNA is shown, along with the resulting amino acid chain. Three mutant amino acid chains are also shown, each resulting from a single base mutation to the original DNA segment.

Identify the type of single base mutation in the original DNA segment that would cause each of the resulting mutant amino acid chains.

Place a label that identifies each type of mutation into the blank box next to each mutant amino acid chain.

- You may use each label more than once.
- Place only one label in each blank box.

**Amino Acid Codon Chart**

<table>
<thead>
<tr>
<th>First Position (5' end)</th>
<th>Second Position</th>
<th>Third Position (3' end)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U</td>
<td>UC</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>UCAG</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>UCAAG</td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>UCAAGU</td>
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<tr>
<td></td>
<td></td>
<td>UCAGUCA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UCAAGUCU</td>
</tr>
</tbody>
</table>

**Mutation Comparison**

<table>
<thead>
<tr>
<th>Original DNA</th>
<th>TAC</th>
<th>ACG</th>
<th>TCT</th>
<th>AAC</th>
<th>TTT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Amino Acid Chain</td>
<td>Met</td>
<td>Cys</td>
<td>Arg</td>
<td>Leu</td>
<td>Lys</td>
</tr>
<tr>
<td>Mutant 1</td>
<td>Met</td>
<td>Trp</td>
<td>Gln</td>
<td>Ile</td>
<td>Glu</td>
</tr>
<tr>
<td>Mutant 2</td>
<td>Met</td>
<td>Trp</td>
<td>Arg</td>
<td>Leu</td>
<td>Lys</td>
</tr>
<tr>
<td>Mutant 3</td>
<td>Met</td>
<td>Cys</td>
<td>Ser</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Insertion
- Deletion
Notes on Scoring

This response earns partial credit (1 point) for correctly identifying two types of mutation, mutants 1 and 3. Mutant 1 had a nucleotide inserted which altered the remaining amino acid chain and the protein produced. Mutant 2 experienced a substitution for a nucleotide which altered only one amino acid in the resulting chain. The protein produced will also be altered. Mutant 3 experienced a deletion of a nucleotide which altered one amino acid and then resulted in the stop codon ending the development of the amino acid chain.
Sample Response: 0 points

A segment of DNA is shown, along with the resulting amino acid chain. Three mutant amino acid chains are also shown, each resulting from a single base mutation to the original DNA segment.

Identify the type of single base mutation in the original DNA segment that would cause each of the resulting mutant amino acid chains.

Place a label that identifies each type of mutation into the blank box next to each mutant amino acid chain.

- You may use each label more than once.
- Place only one label in each blank box.

Amino Acid Codon Chart

<table>
<thead>
<tr>
<th>First Position</th>
<th>Second Position</th>
<th>Third Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>U</td>
<td>G</td>
</tr>
<tr>
<td>G</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>U</td>
<td>Leu</td>
<td>Stop</td>
</tr>
<tr>
<td>U</td>
<td>Leu</td>
<td>Stop</td>
</tr>
<tr>
<td>U</td>
<td>Leu</td>
<td>Stop</td>
</tr>
<tr>
<td>C</td>
<td>Leu</td>
<td>Stop</td>
</tr>
<tr>
<td>C</td>
<td>Leu</td>
<td>Stop</td>
</tr>
<tr>
<td>C</td>
<td>Leu</td>
<td>Stop</td>
</tr>
<tr>
<td>T</td>
<td>Ser</td>
<td>Cys</td>
</tr>
<tr>
<td>T</td>
<td>Ser</td>
<td>Cys</td>
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<tr>
<td>T</td>
<td>Ser</td>
<td>Cys</td>
</tr>
<tr>
<td>C</td>
<td>Pro</td>
<td>His</td>
</tr>
<tr>
<td>C</td>
<td>Pro</td>
<td>His</td>
</tr>
<tr>
<td>C</td>
<td>Pro</td>
<td>His</td>
</tr>
<tr>
<td>A</td>
<td>Thr</td>
<td>Asn</td>
</tr>
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<td>A</td>
<td>Thr</td>
<td>Asn</td>
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<td>Asn</td>
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<td>Asp</td>
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<td>Asp</td>
</tr>
<tr>
<td>G</td>
<td>Ala</td>
<td>Asp</td>
</tr>
<tr>
<td>T</td>
<td>Tyr</td>
<td>Cys</td>
</tr>
<tr>
<td>T</td>
<td>Tyr</td>
<td>Cys</td>
</tr>
<tr>
<td>T</td>
<td>Tyr</td>
<td>Cys</td>
</tr>
<tr>
<td>C</td>
<td>Pro</td>
<td>His</td>
</tr>
<tr>
<td>C</td>
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<tr>
<td>C</td>
<td>Pro</td>
<td>His</td>
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<td>A</td>
<td>Thr</td>
<td>Asn</td>
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<tr>
<td>A</td>
<td>Thr</td>
<td>Asn</td>
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<tr>
<td>A</td>
<td>Thr</td>
<td>Asn</td>
</tr>
<tr>
<td>G</td>
<td>Ala</td>
<td>Asp</td>
</tr>
<tr>
<td>G</td>
<td>Ala</td>
<td>Asp</td>
</tr>
<tr>
<td>G</td>
<td>Ala</td>
<td>Asp</td>
</tr>
</tbody>
</table>

Mutation Comparison

<table>
<thead>
<tr>
<th>Original DNA</th>
<th>TAC</th>
<th>ACG</th>
<th>TCT</th>
<th>AAC</th>
<th>TTT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Amino Acid Chain</td>
<td>Met</td>
<td>Cys</td>
<td>Arg</td>
<td>Leu</td>
<td>Lys</td>
</tr>
<tr>
<td>Mutant 1</td>
<td>Met</td>
<td>Trp</td>
<td>Gln</td>
<td>Ile</td>
<td>Glu</td>
</tr>
<tr>
<td>Mutant 2</td>
<td>Met</td>
<td>Trp</td>
<td>Arg</td>
<td>Leu</td>
<td>Lys</td>
</tr>
<tr>
<td>Mutant 3</td>
<td>Met</td>
<td>Cys</td>
<td>Ser</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Notes on Scoring

This response earns no credit (0 points) for incorrectly identifying two types of mutation, mutant 1 and 2. Mutant 1 had a nucleotide inserted which altered the remaining amino acid chain and the protein produced. Mutant 2 experienced a substitution for a nucleotide which altered only one amino acid in the resulting chain. The protein produced will also be altered. Mutant 3 experienced a deletion of a nucleotide which altered one amino acid and then resulted in the stop codon ending the development of the amino acid chain.
Sample Response: 0 points

A segment of DNA is shown, along with the resulting amino acid chain. Three mutant amino acid chains are also shown, each resulting from a single base mutation to the original DNA segment.

Identify the type of single base mutation in the original DNA segment that would cause each of the resulting mutant amino acid chains.

Place a label that identifies each type of mutation into the blank box next to each mutant amino acid chain.

- You may use each label more than once.
- Place only one label in each blank box.

**Notes on Scoring**

This response earns no credit (0 points) for incorrectly identifying all types of mutations.
Biology
Spring 2019 Item Release

Question 42

Question and Scoring Guidelines
Question 42

The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

The graph shows the relative enzymatic activity among four different enzymes.

![Graph showing enzymatic activity vs pH](image)

Which enzyme would be most efficient in an environment where the pH level can fluctuate between acidic and basic?

- A: enzyme A
- B: enzyme B
- C: enzyme C
- D: enzyme D

**Part B**

What would happen if enzyme A was placed in an environment with a pH of 9?

- A: Enzyme A would become more efficient.
- B: Enzyme A would slow or stop functioning.
- C: Enzyme A would be transformed back into RNA.
- D: Enzyme A would become the substrate for enzyme D.
Scoring Guidelines

Part A

Rationale for Option A: This is incorrect. Enzyme A only shows activity in acidic environments.

Rationale for Option B: This is incorrect. Enzyme B only shows activity in acidic environments.

Rationale for Option C: Key – Enzyme C is active in a range of acidic to basic environments.

Rationale for Option D: This is incorrect. Enzyme D is mostly active in basic environments.

Part B

Rationale for Option A: This is incorrect. The efficiency of Enzyme A would not only decrease, but it could potentially stop functioning altogether.

Rationale for Option B: Key – The extremely basic environment would cause a change to the shape of the enzyme, causing it to denature, which would prevent it from binding to molecules.

Rationale for Option C: This is incorrect. RNA is a nucleic acid. Enzymes are proteins. RNA and enzymes are different macromolecules that do not change into one another.

Rationale for Option D: This is incorrect. Enzyme A would not function in an acidic environment nor would it become a substrate for Enzyme D.
Content Strand
Cells

Content Statement
Cell Structure and Function

Content Elaboration
The essential functions of cells involve chemical reactions that involve water and carbohydrates, proteins, lipids and nucleic acids. A special group of proteins, enzymes, enables chemical reactions to occur within living systems. Cell functions are regulated. Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Most cells function within a narrow range of temperature and pH. At very low temperatures, reaction rates are slow. High temperatures and/or extremes of pH can irreversibly change the structure of most protein molecules. Even small changes in pH can alter how molecules interact.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This item requires the student to analyze the activity of different enzymes at different pH levels and infer information. Enzyme C is active in a range of acidic to basic environments. Enzyme A is active in strong acidic environments and if placed in a basic environment it would stop functioning.
Sample Response: 2 points

The following question has two parts. First, answer part A. Then, answer part B.

Part A

The graph shows the relative enzymatic activity among four different enzymes.

Which enzyme would be most efficient in an environment where the pH level can fluctuate between acidic and basic?

A enzyme A  
B enzyme B  
C enzyme C  
D enzyme D

Part B

What would happen if enzyme A was placed in an environment with a pH of 9?

A Enzyme A would become more efficient.  
B Enzyme A would slow or stop functioning.  
C Enzyme A would be transformed back into RNA.  
D Enzyme A would become the substrate for enzyme D.
Notes on Scoring

This response earns full credit (2 points) for correctly selecting the enzyme that is the most efficient in a fluctuating environment, Enzyme C. This response also correctly selects the action of enzyme A if placed in an alkaline environment. Enzyme A would stop functioning. Based on the enzyme activity in the chart, enzyme A is effective in highly acidic environments.
Sample Response: 1 point

The following question has two parts. First, answer part A. Then, answer part B.

Part A

The graph shows the relative enzymatic activity among four different enzymes.

Which enzyme would be most efficient in an environment where the pH level can fluctuate between acidic and basic?

A  enzyme A
B  enzyme B
C  enzyme C
D  enzyme D

Part B

What would happen if enzyme A was placed in an environment with a pH of 9?

A  Enzyme A would become more efficient.
B  Enzyme A would slow or stop functioning.
C  Enzyme A would be transformed back into RNA.
D  Enzyme A would become the substrate for enzyme D.
Notes on Scoring

This response earns partial credit (1 point) for correctly selecting enzyme C as being the most efficient in a fluctuating acidic and basic environment. The response incorrectly predicts the outcome on enzyme A if placed in an alkaline environment. The enzyme would stop functioning.
The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

The graph shows the relative enzymatic activity among four different enzymes.

Which enzyme would be **most** efficient in an environment where the pH level can fluctuate between acidic and basic?

- A  enzyme A
- B  enzyme B
- C  enzyme C
- D  enzyme D

**Part B**

What would happen if enzyme A was placed in an environment with a pH of 9?

- A  Enzyme A would become more efficient.
- B  Enzyme A would slow or stop functioning.
- C  Enzyme A would be transformed back into RNA.
- D  Enzyme A would become the substrate for enzyme D.
Notes on Scoring

This response earns partial credit (1 point) for correctly selecting enzyme C as being the most efficient in a fluctuating acidic and basic environment. The response incorrectly predicts the outcome on enzyme A if placed in an alkaline environment. The enzyme would stop functioning.
The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

The graph shows the relative enzymatic activity among four different enzymes.

Which enzyme would be **most** efficient in an environment where the pH level can fluctuate between acidic and basic?

- **A** enzyme A
- **B** enzyme B
- **C** enzyme C
- **D** enzyme D

**Part B**

What would happen if enzyme A was placed in an environment with a pH of 9?

- **A** Enzyme A would become more efficient.
- **B** Enzyme A would slow or stop functioning.
- **C** Enzyme A would be transformed back into RNA.
- **D** Enzyme A would become the substrate for enzyme D.
Notes on Scoring

This response earns no credit (0 points) for incorrectly selecting enzyme D as being the most efficient in a fluctuating acidic and basic environment. The response incorrectly predicts the outcome on enzyme A if placed in an alkaline environment. The enzyme would stop functioning.
The following question has two parts. First, answer part A. Then, answer part B.

**Part A**

The graph shows the relative enzymatic activity among four different enzymes.

Which enzyme would be **most** efficient in an environment where the pH level can fluctuate between acidic and basic?

- A  enzyme A
- B  enzyme B
- C  enzyme C
- D  enzyme D

**Part B**

What would happen if enzyme A was placed in an environment with a pH of 9?

- A  Enzyme A would become more efficient.
- B  Enzyme A would slow or stop functioning.
- C  Enzyme A would be transformed back into RNA.
- D  Enzyme A would become the substrate for enzyme D.
Notes on Scoring

This response earns no credit (0 points) for incorrectly selecting enzyme D as being the most efficient in a fluctuating acidic and basic environment. The response incorrectly predicts the outcome on enzyme A if placed in an alkaline environment. The enzyme would stop functioning.
Biology
Spring 2019 Item Release

Question 43

Question and Scoring Guidelines
Question 43

Scientists observe that four desert lizard species eat insects as part of their diet. The table shows the percentages of each lizard’s diet that are made up of different insects.

<table>
<thead>
<tr>
<th>Lizard Species</th>
<th>Ants</th>
<th>Locusts</th>
<th>Beetles</th>
<th>Termites</th>
<th>Larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>N</td>
<td>20</td>
<td>40</td>
<td>30</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>O</td>
<td>0</td>
<td>30</td>
<td>10</td>
<td>30</td>
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</tr>
<tr>
<td>P</td>
<td>90</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Which statement could explain the dietary specialization of lizard species P?

A. Lizard P has more genetic variability than lizards M, N, and O.
B. Lizard P occupies a different ecological niche than lizards M, N, and O.
C. Each lizard chose to have adaptations that allow them to exploit different resources.
D. Ants have a smaller population than the locust, beetle, termite, and larvae populations.

Points Possible: 1

See Alignment for more detail.
Scoring Guidelines

Rationale for Option A: This is incorrect. Dietary specialization alone does not necessarily correlate to genetic variability.

Rationale for Option B: Key – Populations of organisms can experience subtle changes in phenotype and behavior due to resource partitioning among different niches within an ecosystem.

Rationale for Option C: This is incorrect. Species cannot choose to adapt in order to exploit new resources.

Rationale for Option D: This is incorrect. The size of the population does not drive an organism to be more dependent on it as a resource for food.
Content Elaboration
Populations evolve over time. Evolution is the consequence of the interactions of:

1. The potential for a population to increase its numbers;
2. The genetic variability of offspring due to mutation and recombination of genes;
3. A finite supply of the resources required for life; and
4. The differential survival and reproduction of individuals with the specific phenotype.

Heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment. When an environment changes, the survival value of inherited characteristics may change. This may or may not cause a change in species that inhabit the environment. Formulate and revise explanations for gene flow and sexual selection based on real-world problems.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

Explanation of the Item
This item requires the student to identify an explanation that supports the dietary specialization among lizards in the same ecosystem. Each insect occupies a specific niche. Populations of organisms can experience subtle changes in phenotype and behavior due to resource partitioning among different niches within an ecosystem. In this item, lizard P occupies a different ecological niche than lizards, M, N, and O based on insect consumption data.
Sample Response: 1 point

Scientists observe that four desert lizard species eat insects as part of their diet. The table shows the percentages of each lizard’s diet that are made up of different insects.

<table>
<thead>
<tr>
<th>Lizard Species</th>
<th>Ants</th>
<th>Locusts</th>
<th>Beetles</th>
<th>Termites</th>
<th>Larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>N</td>
<td>20</td>
<td>40</td>
<td>30</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>O</td>
<td>0</td>
<td>30</td>
<td>10</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>P</td>
<td>90</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Which statement could explain the dietary specialization of lizard species P?

- A. Lizard P has more genetic variability than lizards M, N, and O.
- B. Lizard P occupies a different ecological niche than lizards M, N, and O.
- C. Each lizard chose to have adaptations that allow them to exploit different resources.
- D. Ants have a smaller population than the locust, beetle, termite, and larvae populations.