Ohio | Department of Education

Ohio's State Tests

ITEM RELEASE

SPRING 2016

BIOLOGY

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Biology
Spring 2016 Item Release
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Question No.	Item Type	Content Strand	Content Statement	Answer Key	Points
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Content Summary and Answer Key

Question No.	Item Type	Content Strand	Content Statement	Answer Key	Points
18	Graphic Response	Cells	Cell Structure and Function	---	1 point
19	Multiple Choice	Diversity and Interdependence of Life	Classification systems are frameworks created by scientists for describing the vast diversity of organisms, indicating the degree of relatedness between organisms.	B	1 point
20	Graphic Response	Evolution	Diversity of Life	---	1 point
21	Multiple Choice	Evolution	Diversity of Life	B	1 point

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Question 1

Question and Scoring Guidelines

Question 1

DNA samples taken from rats from the same colony produce the four gel electrophoresis banding patterns shown. Determine the relationships between Rat A and the other three rats tested: B, C, and D.

Place relationship labels into the blank boxes under the electrophoresis patterns for rats B, C, and D.

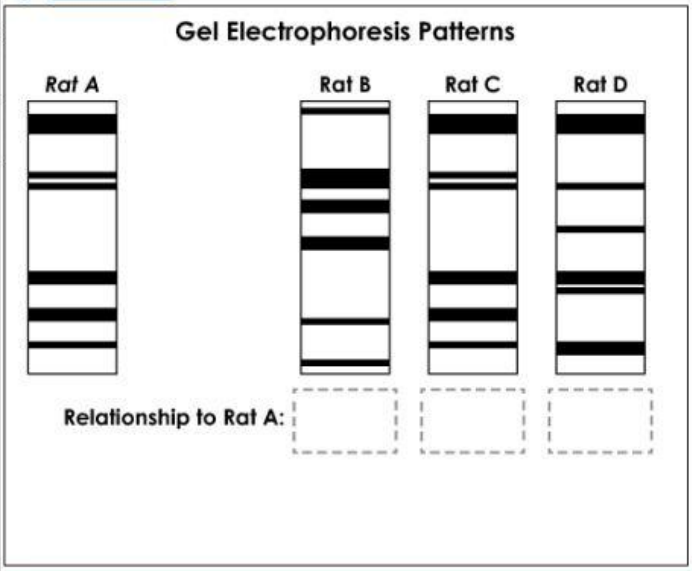
- Place only **one** label in each blank box.
- You may use each label more than once.

Identical Sibling

Sibling or parent

Unrelated

Delete



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- "Unrelated" placed below "Rat B";

  AND
- "Identical Sibling" placed below "Rat C";

  AND
- "Sibling or parent" placed below "Rat D" (1 point).

Alignment

Content Strand
Heredity

Content Statement
Modern Genetics

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.

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 infer genetic relationships between individuals by comparing DNA banding produced through gel electrophoresis. A rat is a diploid organism receiving 50% of its genetic material from each of its parent's gametes. By analyzing the bands created during gel electrophoresis, identical matches, parents and siblings can be identified. The appearance of similar bands provides evidence for the relationships between the rats. Rat B is unrelated because there are no similar banding patterns compared to Rat A. Rat C is identical to Rat A because the banding is identical. This means that Rat A and C are identical siblings. Rat D has 3 of the 6 bands that are identical to Rat A, which indicates that Rat D could be a parent or sibling.

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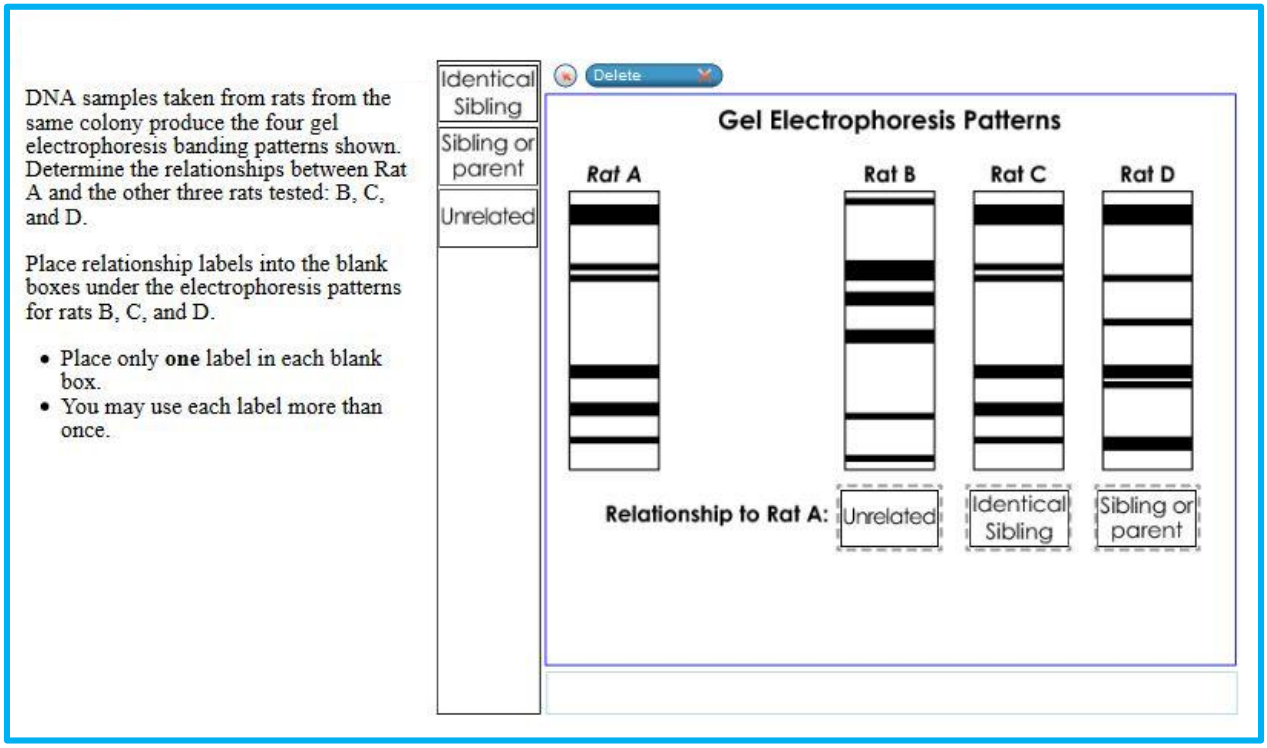
Question 1

Sample Responses

Sample Response: 1 point



Notes on Scoring

This response earns full credit (1 point). The response identifies the correct relationships of Rats B, C and D compared to Rat A.

Rat B is unrelated since the banding patterns do not match. Rat C is an identical sibling since the banding patterns are an exact match. Rat D is either a sibling or parent since 3 of the 6 band sequences are an exact match, based on the fact that rats are diploid and receive 50% of their genetic material from each parent's gamete.

Sample Response: 0 points

DNA samples taken from rats from the same colony produce the four gel electrophoresis banding patterns shown. Determine the relationships between Rat A and the other three rats tested: B, C, and D.

Place relationship labels into the blank boxes under the electrophoresis patterns for rats B, C, and D.

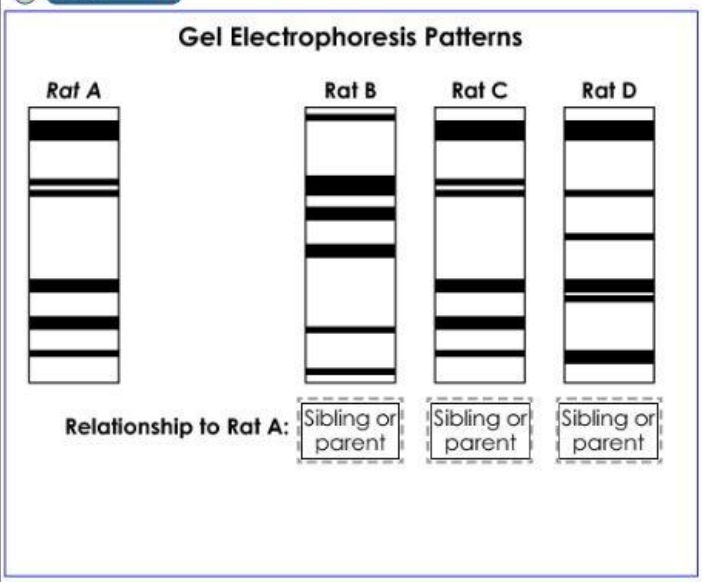
- Place only **one** label in each blank box.
- You may use each label more than once.

Identical Sibling

Sibling or parent

Unrelated

Delete



Notes on Scoring

This response earns no credit (0 points). The response incorrectly identifies the relationships of Rats B and C to Rat A.

The correct relationships are as follows:
Rat B is unrelated since the banding patterns do not match. Rat C is an identical sibling since the banding patterns are an exact match. Rat D is either a sibling or parent since 3 of the 6 band sequences are an exact match, based on the fact that rats are diploid and receive 50% of their genetic material from each parent's gamete.

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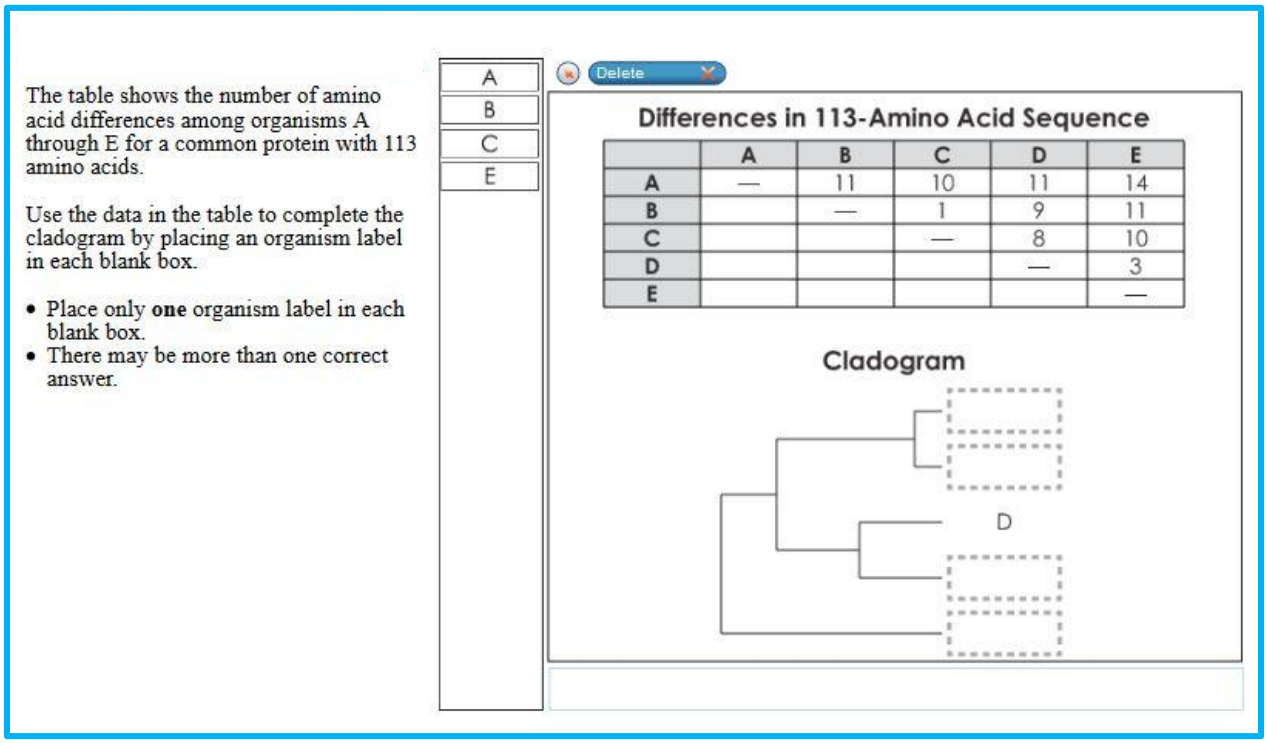
Question 2

Question and Scoring Guidelines

Question 2



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- "B" placed in top box and "C" placed in 2nd-from-top box OR "C" placed in top box and "B" placed in 2nd-from-top box;

  AND

- "E" placed in the box directly below "D";

  AND

- "A" placed in the bottom box (1 point).

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
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 evolutionary relationships based on comparisons of amino acid sequences. The more differences found in amino acid sequences, the more distantly related the organisms are to each other. The evidence is contained in the table, "Differences in 113-Amino Acid Sequence." Organism A and the fact that it does not have any differences is the base organism, which is annotated on a single lineage. Organisms B and C each differ from Organism A by 11 amino acids and are therefore closely related to each other and A. Organism E has the greatest number of amino acid differences and is thus the furthest removed from Organism A.

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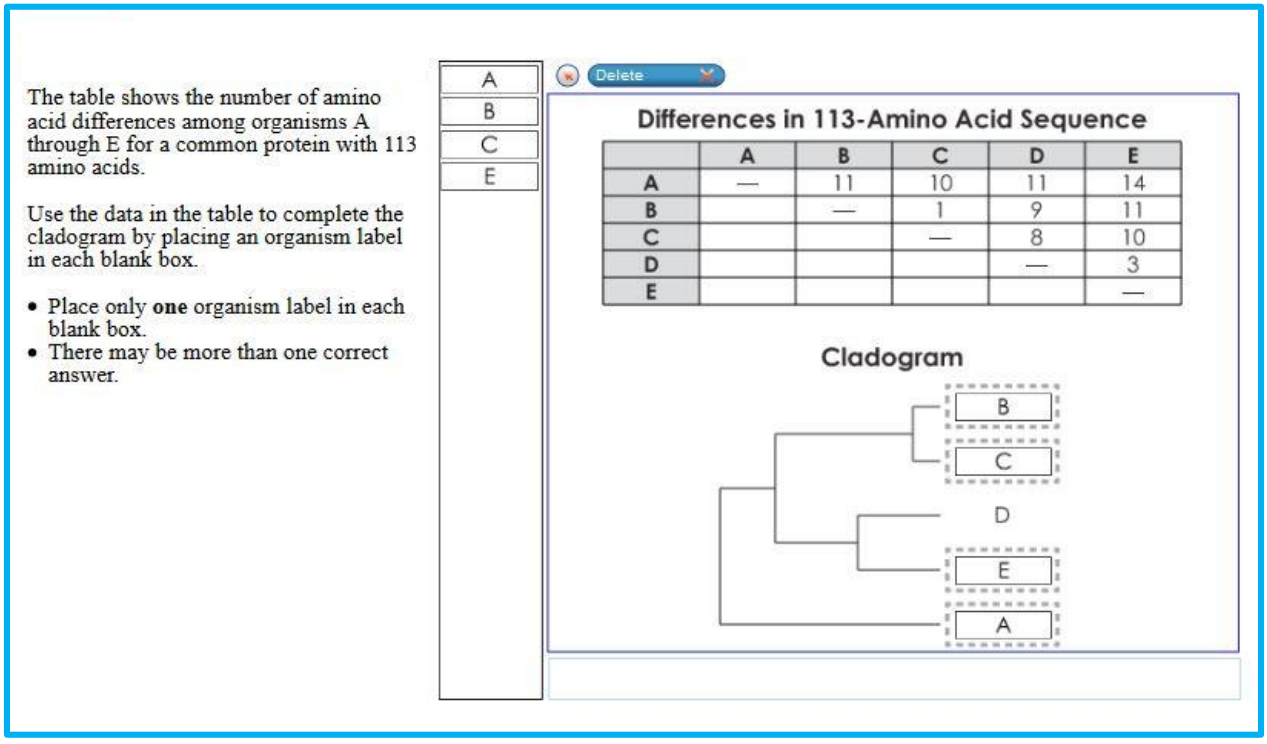
Question 2

Sample Responses

Sample Response: 1 point

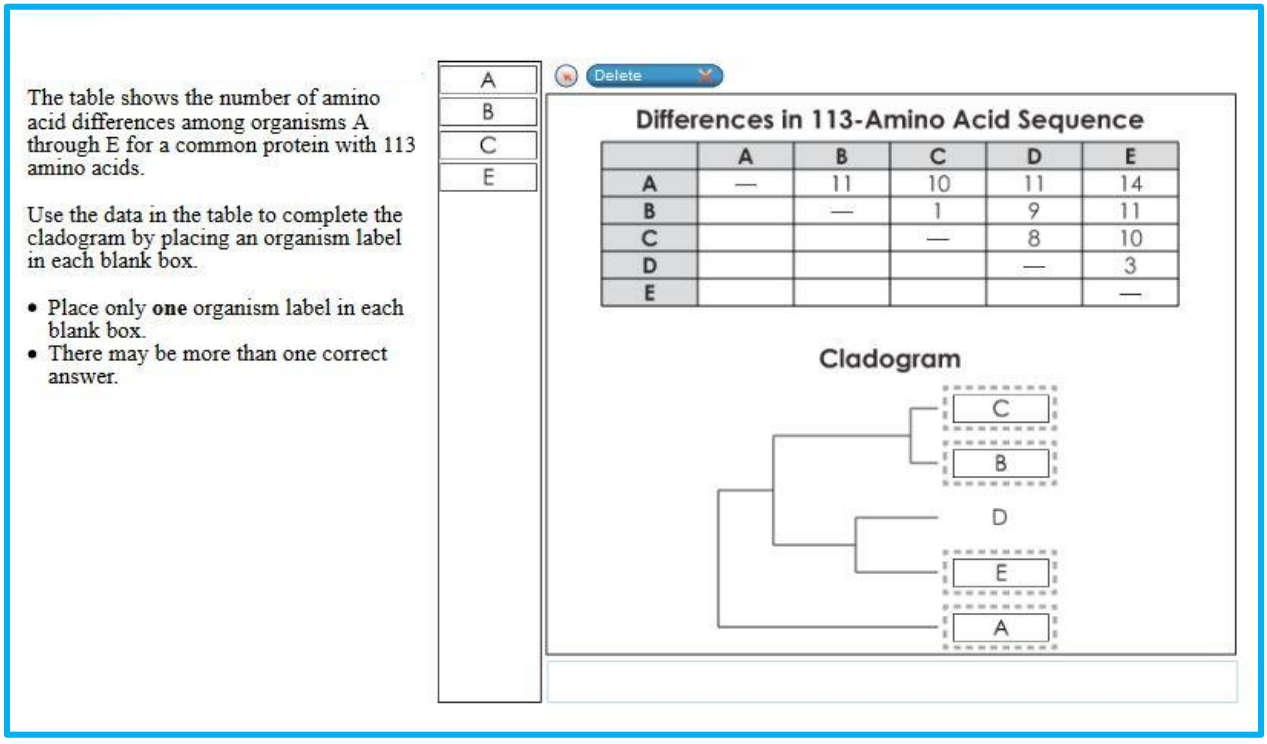


Notes on Scoring

This response earns full credit (1point). Using the cladogram, the student identifies the correct evolutionary relationships based on the amino acid sequences:

1. "B" is placed in the top box since it differs from "A" by 11 amino acid sequences;
2. "C" is placed in the 2nd-from-top box since it differs from "A" by 11(10+1) amino acid sequences;
3. "E" is placed in the box directly below "D" since it differs from "A" by 28 amino acid sequences; and
4. "A" is placed in the bottom box since it is the basis of the comparison to which the others are linked.

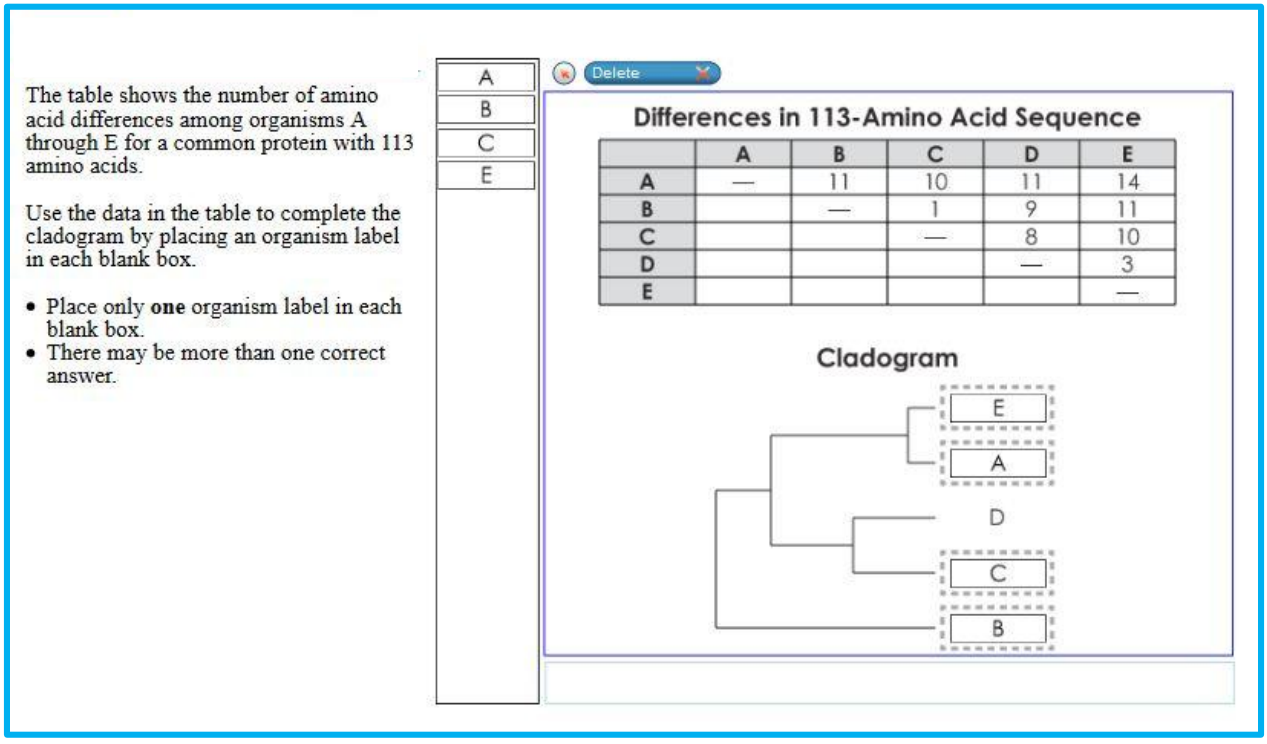
Sample Response: 1 point



Notes on Scoring

This response earns full credit (1 point). Using the cladogram, the student identifies the correct evolutionary relationships based on the amino acid sequences.

Sample Response: 0 points



Notes on Scoring

This response earns no credit (0 points). Using the cladogram, the student incorrectly identifies the evolutionary relationships based on the amino acid sequences.

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Question 3

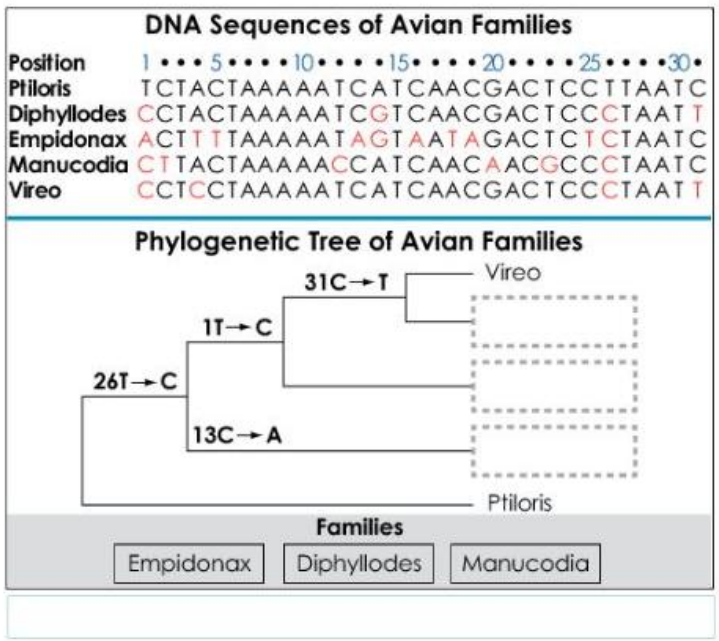
Question and Scoring Guidelines

Question 3

DNA sequences for a number of bird families in the order Passeriformes are shown. Differences in the DNA sequences between the Ptiloris family and other bird families in this order are highlighted in red.

An incomplete phylogenetic tree that notes important differences in the DNA among these bird families is also shown. Use the DNA sequence data to complete the phylogenetic tree.

Move each bird family label into the correct blank box in the phylogenetic tree.



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- "Diphyllodes" placed in the top box;

  AND
- "Manucodia" placed in the middle box;

  AND
- "Empidonax" placed in the bottom box (1 point).

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
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 use DNA sequence data to construct a cladogram of evolutionary relationships. The more differences found in the nitrogen base sequence, the more distantly related the organisms are to each other. The evidence is contained in the table, "DNA Sequences of Avian Families." The Avian family of Ptiloris is the base organism, which is annotated on a single lineage. The Avian families Vireo and Diphyllodes differ by 4 nitrogenous bases and are therefore the closest relatives to Ptiloris. The Avian family Manucodia differs from Ptiloris by 6 nitrogenous bases and is thus the next closest relative. Finally, the Avian family of Empidonax is the most distant relative with 10 different nitrogenous bases.

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Question 3

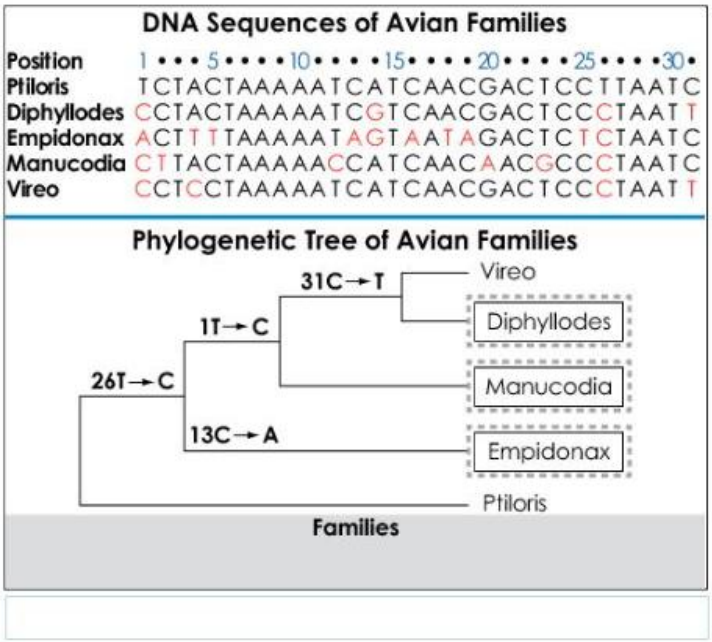
Sample Responses

Sample Response: 1 point

DNA sequences for a number of bird families in the order Passeriformes are shown. Differences in the DNA sequences between the Ptiloris family and other bird families in this order are highlighted in red.

An incomplete phylogenetic tree that notes important differences in the DNA among these bird families is also shown. Use the DNA sequence data to complete the phylogenetic tree.

Move each bird family label into the correct blank box in the phylogenetic tree.



Notes on Scoring

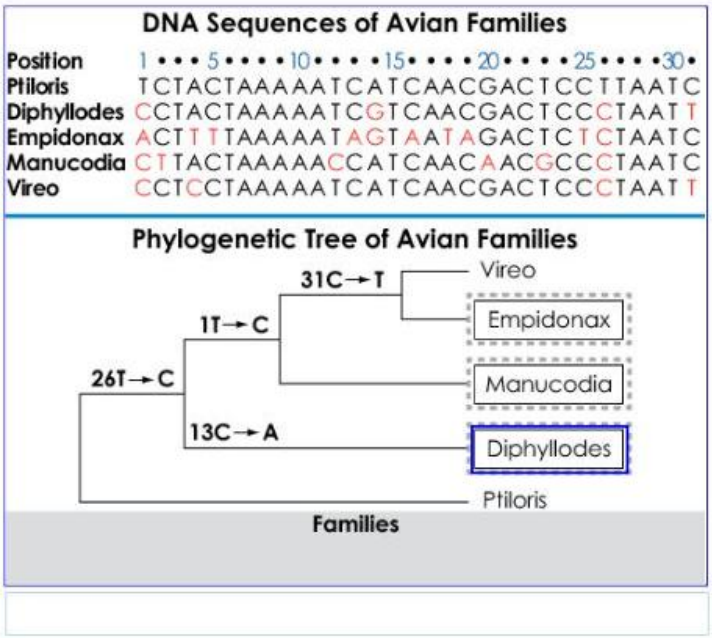
This response earns full credit (1 point). The response shows complete understanding of how to infer evolutionary relationships from DNA sequence data and how to depict these relationships in a cladogram.

Sample Response: 0 points

DNA sequences for a number of bird families in the order Passeriformes are shown. Differences in the DNA sequences between the Ptiloris family and other bird families in this order are highlighted in red.

An incomplete phylogenetic tree that notes important differences in the DNA among these bird families is also shown. Use the DNA sequence data to complete the phylogenetic tree.

Move each bird family label into the correct blank box in the phylogenetic tree.



Notes on Scoring

This response earns no credit (0 points). The response does not show understanding of how to infer evolutionary relationships from DNA sequence data and how to depict these relationships in a cladogram. The response does not make the connection that Vireo and Diphyllodes each differ from Ptiloris by 4 nucleic acid sites, a fact that initiates the correct order by showing that Vireo and Diphyllodes are closely related.

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Question 4

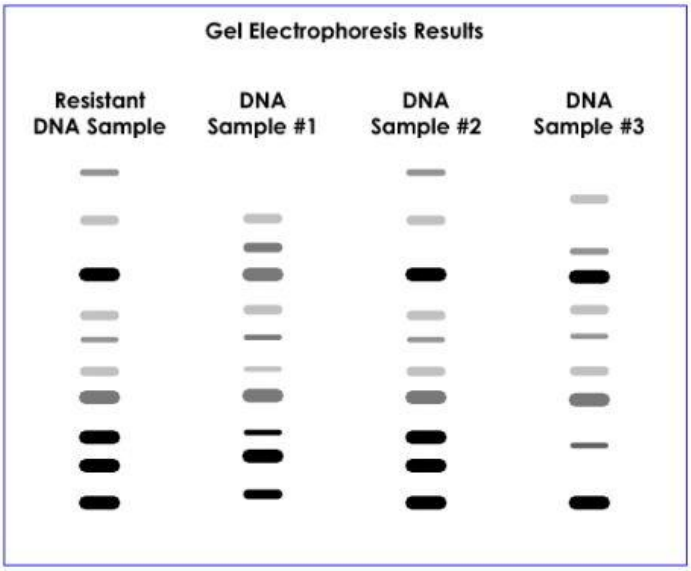
Question and Scoring Guidelines

Question 4

Scientists have found an allele of a plant gene that may protect plants from some types of insects. To determine whether this allele is present in other plants of the species or is a recent mutation, they conducted the following experiment:

- Isolate a sample of deoxyribonucleic acid (DNA) known to contain the allele from one plant that is unaffected by insects.
- Isolate a sample of DNA that may contain the allele from three plants of the same species growing in the same location.
- Treat the resistant DNA sample and the three DNA samples from the other plants with the same restriction enzymes to generate smaller segments of DNA.
- Load and run a gel electrophoresis to separate the DNA segments.
- Analyze the results of the gel electrophoresis.

Click on the DNA sample(s) that has the same allele as the resistant plant.



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- "DNA Sample #2" selected (1 point).

Alignment

Content Strand
Evolution

Content Statement
Diversity of Life

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.

Recent molecular-sequence data generally, but not always, support earlier hypotheses regarding lineages of organisms based upon morphological comparisons.

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 analyze the results of a gel electrophoresis to classify a sample. The evidence is in the table, "Gel Electrophoresis Results," which compares the known base sample labeled "Resistant DNA Sample" with the unknown DNA samples labeled "DNA Sample [#1, #2 #3]." Through visual analysis of the gel electrophoresis results, it can be determined that "DNA Sample #2" is the only sample that matches the known "Resistant DNA Sample."

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Question 4

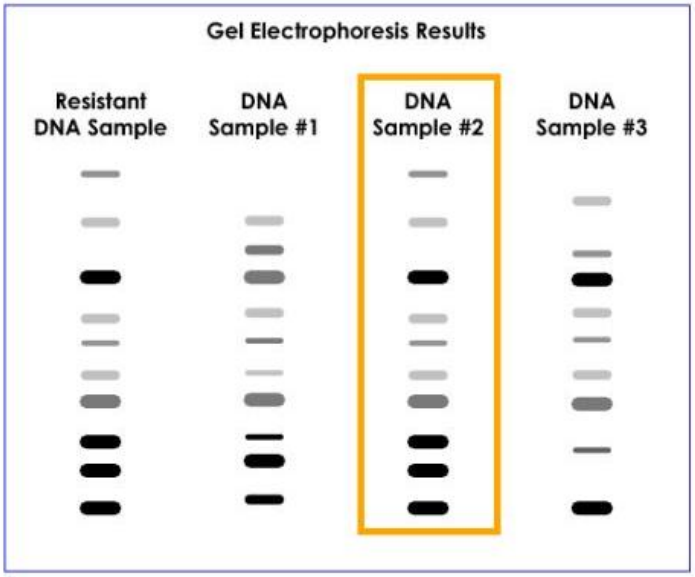
Sample Responses

Sample Response: 1 point

Scientists have found an allele of a plant gene that may protect plants from some types of insects. To determine whether this allele is present in other plants of the species or is a recent mutation, they conducted the following experiment:

- Isolate a sample of deoxyribonucleic acid (DNA) known to contain the allele from one plant that is unaffected by insects.
- Isolate a sample of DNA that may contain the allele from three plants of the same species growing in the same location.
- Treat the resistant DNA sample and the three DNA samples from the other plants with the same restriction enzymes to generate smaller segments of DNA.
- Load and run a gel electrophoresis to separate the DNA segments.
- Analyze the results of the gel electrophoresis.

Click on the DNA sample(s) that has the same allele as the resistant plant.



Notes on Scoring

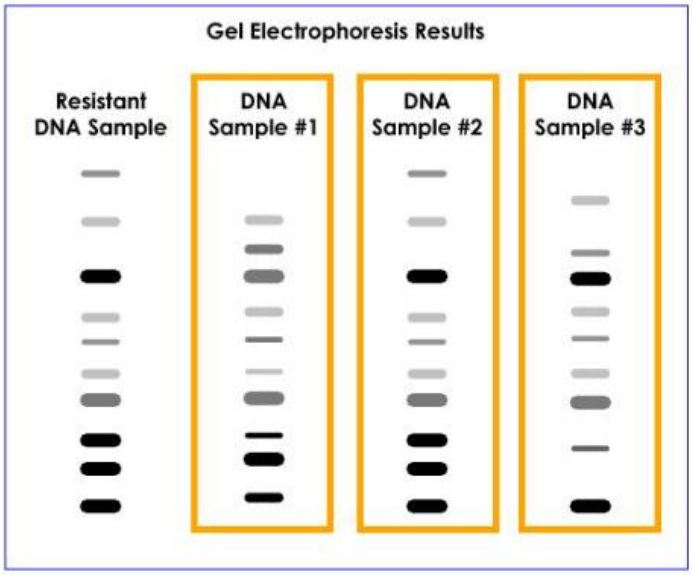
This response earns full credit (1 point). The student correctly identifies that "DNA Sample #2" is the only sample with the additional segment that matches the "Resistant DNA Sample."

Sample Response: 0 points

Scientists have found an allele of a plant gene that may protect plants from some types of insects. To determine whether this allele is present in other plants of the species or is a recent mutation, they conducted the following experiment:

- Isolate a sample of deoxyribonucleic acid (DNA) known to contain the allele from one plant that is unaffected by insects.
- Isolate a sample of DNA that may contain the allele from three plants of the same species growing in the same location.
- Treat the resistant DNA sample and the three DNA samples from the other plants with the same restriction enzymes to generate smaller segments of DNA.
- Load and run a gel electrophoresis to separate the DNA segments.
- Analyze the results of the gel electrophoresis.

Click on the DNA sample(s) that has the same allele as the resistant plant.



Notes on Scoring

This response earns no credit (0 points). The response incorrectly selects all three samples as matches for the "Resistant DNA Sample"; however, "DNA Sample #2" is the only sample with the additional segment that matches the "Resistant DNA Sample." "DNA Sample #1" and "DNA Sample #3" do not share the additional gene.

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Question 5

Question and Scoring Guidelines

Question 5

How could genetic engineering be used to produce a more successful crop in a hot, dry climate?

(A) Non-essential DNA could be removed from the genomes of the crop plants.

(B) DNA from plants adapted to dry areas could be added to the genomes of the crop plants.

(C) RNA from a variety of nonagricultural plants could be added to the genomes of the crop plants.

(D) mRNA transcripts of genes from dry weather crops could be added to the fertilizer used on the crop plants.

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. The removal of non-essential DNA would not increase the crops' ability to deal with hot, dry climates.

Rationale for Option B: **Key** – This would help the current plant exhibit traits of the plants that better tolerate a dry climate.

Rationale for Option C: This is incorrect. RNA from non-crop plants would not give the crop any advantages in hot, dry climates.

Rationale for Option D: This is incorrect. mRNA may be absorbed from the fertilizer, but it has no long-term ability to increase the crops' output in hot, dry climates.

Alignment

Content Strand
Heredity

Content Statement
Modern Genetics

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.

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 way that genetic engineering can be used to produce better crops. Through the process of genetic engineering, segments of DNA are replaced in an organism's genetic composition (DNA) to modify a physical trait, which provides the desired benefit to the engineered organism. In this specific question, the desired trait is drought resistance. This item assesses the student's ability to identify a way that genetic engineering can be used to produce more successful crops.

Sample Response: 1 point

How could genetic engineering be used to produce a more successful crop in a hot, dry climate?

- (A) Non-essential DNA could be removed from the genomes of the crop plants.
- ● DNA from plants adapted to dry areas could be added to the genomes of the crop plants.
- (C) RNA from a variety of nonagricultural plants could be added to the genomes of the crop plants.
- (D) mRNA transcripts of genes from dry weather crops could be added to the fertilizer used on the crop plants.

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Question 6

Question and Scoring Guidelines

Question 6

A mutation occurs in the DNA base sequence GGG GAG TTA, resulting in the base sequence GGA GAG TTA. Use the information in the table to determine the effect of this mutation on the amino acid chain produced.

Codons and Amino Acids

Codon	Amino Acid
UUU	Phenylalanine
UUA	Leucine
CUC	Leucine
CCC	Proline
CCU	Proline
AAA	Lysine
AAU	Asparagine

What is the effect, if any, of this mutation on the amino acid chain produced?

(A) Proline is now lysine and leucine is unchanged.

(B) Proline is now lysine and asparagine is unchanged.

(C) Proline is unchanged and asparagine is unchanged.

(D) Proline is unchanged and leucine is now phenylalanine.

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. This mutation does not cause a change to the amino acid sequence.

Rationale for Option B: This is incorrect. This mutation does not cause a change to the amino acid sequence.

Rationale for Option C: **Key** – This mutation does not cause a change to the amino acid sequence.

Rationale for Option D: This is incorrect. This mutation does not cause a change to the amino acid sequence.

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.

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 how a mutation in the DNA has affected the amino acid gene product. A codon, a 3-nitrogenous base sequence, codes for a specific amino acid. The table in this item, "Codons and Amino Acids," lists only 7 of the 64 codon examples and 5 of the 20 amino acids. As evidenced in the table, a mutation in a codon may or may not affect the amino acid(s) produced.

Sample Response: 1 point

A mutation occurs in the DNA base sequence GGG GAG TTA, resulting in the base sequence GGA GAG TTA. Use the information in the table to determine the effect of this mutation on the amino acid chain produced.

Codons and Amino Acids

Codon	Amino Acid
UUU	Phenylalanine
UUA	Leucine
CUC	Leucine
CCC	Proline
CCU	Proline
AAA	Lysine
AAU	Asparagine

What is the effect, if any, of this mutation on the amino acid chain produced?

Ⓐ Proline is now lysine and leucine is unchanged.

Ⓑ Proline is now lysine and asparagine is unchanged.

● Proline is unchanged and asparagine is unchanged.

Ⓓ Proline is unchanged and leucine is now phenylalanine.

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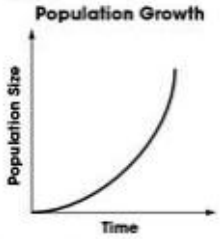
Question 7

Question and Scoring Guidelines

Question 7

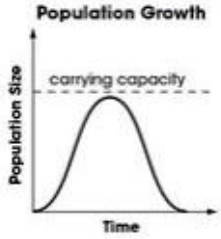
The graph shows the growth curve for a population of Ohio gray squirrels in a hypothetical environment that has no predators and no limit on resources.



In reality, natural environments will always have resource limitations.

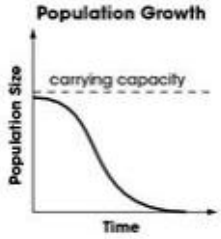
Which graph realistically predicts growth for a natural squirrel population with no predators?

Ⓐ



Ⓑ

Ⓒ



Ⓓ

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. This curve indicates that something else is being introduced to the environment that eventually lowers the size of the population.

Rationale for Option B: **Key** – As the number of individuals in a population exceeds the carrying capacity, the population size falls below the carrying capacity and eventually fluctuates around the carrying capacity.

Rationale for Option C: This is incorrect. A population size will not start at a number above zero.

Rationale for Option D: This is incorrect. This growth curve suggests that carrying capacity does not change a population's ability to grow exponentially.

Alignment

Content Strand
Diversity and Interdependence of Life

Content Statement
Ecosystems

Content Elaboration
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. Mathematical models can include exponential growth model and the logistic growth model. The simplest version of the logistic growth model is Population Growth Rate = rN (K-N) / K; the only new variable added to the exponential model is K for carrying capacity.

Cognitive Demand
Interpreting and Communicating Science Concepts (C)

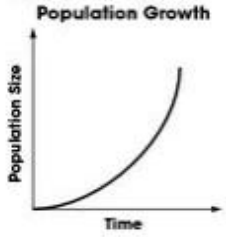
Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative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

Explanation of the Item

This item requires the student to communicate an understanding of how carrying capacity affects change in ecosystems over time. Carrying capacity is the maximum population size that resources in an environment can sustain for that specific population. A population will increase in number using a logistical curve until the carrying capacity is reached. Since environments will naturally fluctuate, the carrying capacity will also fluctuate around the theoretical limit marked by the dashed line.

Sample Response: 1 point

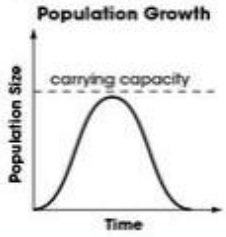
The graph shows the growth curve for a population of Ohio gray squirrels in a hypothetical environment that has no predators and no limit on resources.



In reality, natural environments will always have resource limitations.

Which graph realistically predicts growth for a natural squirrel population with no predators?

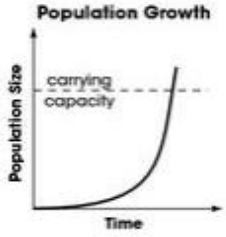
Ⓐ



●

Ⓒ

Ⓓ



Biology
Spring 2016 Item Release

Question 8

Question and Scoring Guidelines

Question 8

Scientists study anaerobic fermentation in yeast cells incubated at different temperatures.

The amount of carbon dioxide (CO_2) detected at each temperature in two trials is shown in the table.

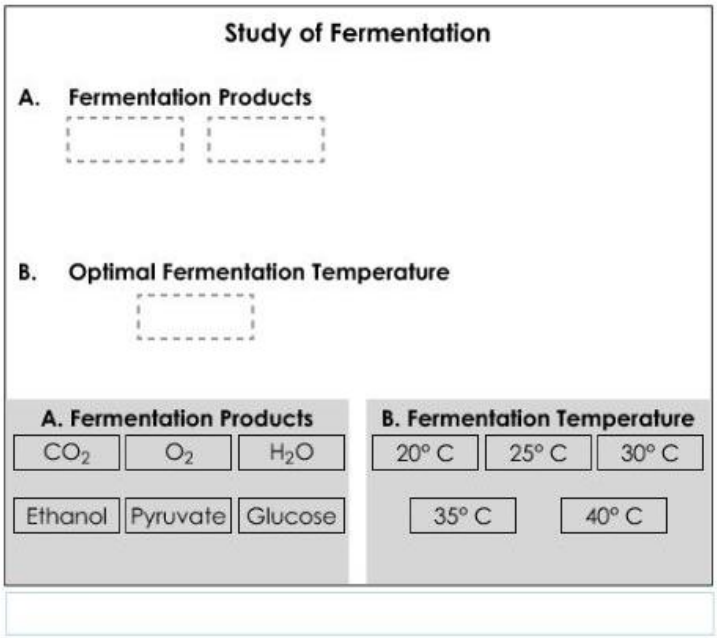
Anaerobic Fermentation Results

Temperature	Trial 1: Mass CO_2	Trial 2: Mass CO_2
20° C	1.81 g	1.94 g
25° C	2.91 g	2.75 g
30° C	4.10 g	4.06 g
35° C	5.17 g	4.97 g
40° C	2.23 g	1.91 g

A. Identify the products of fermentation by moving the product labels into the blank boxes.

B. Identify the optimal temperature for fermentation by moving a temperature label into the blank box.

- Move only **one** label into each blank box.



Points Possible: 2

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- For Part A: "Ethanol" and "CO_2" placed individually in the boxes (1 point); AND
- For Part B: "35° C" placed in the box (1 point).

Alignment

Content Strand
Cells

Content Statement
Cellular Processes

Content Elaboration
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 identify the products of fermentation in an oxygen-free environment and to identify the optimal temperature for fermentation based on the data provided. Fermentation is an anaerobic reaction where glucose in an aqueous solution results in energy, ethanol and carbon dioxide.

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Question 8

Sample Responses

Sample Response: 2 points

Scientists study anaerobic fermentation in yeast cells incubated at different temperatures.

The amount of carbon dioxide (CO_2) detected at each temperature in two trials is shown in the table.

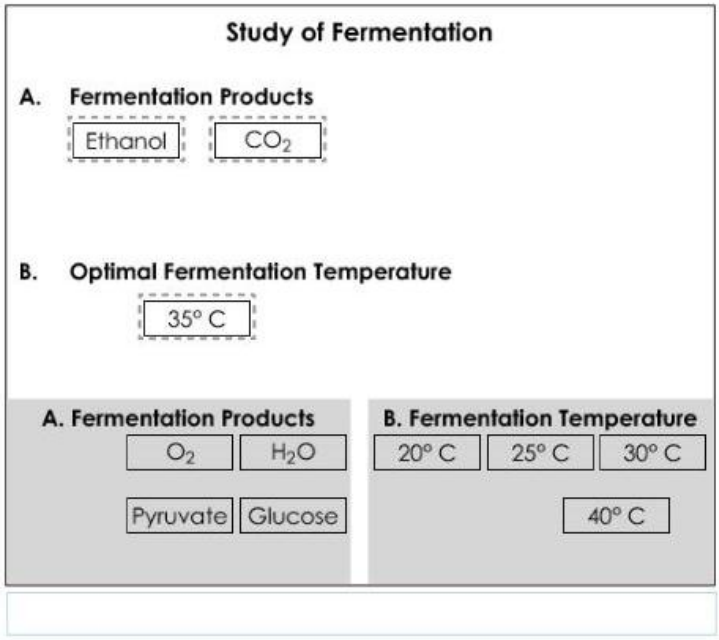
Anaerobic Fermentation Results

Temperature	Trial 1: Mass CO_2	Trial 2: Mass CO_2
20° C	1.81 g	1.94 g
25° C	2.91 g	2.75 g
30° C	4.10 g	4.06 g
35° C	5.17 g	4.97 g
40° C	2.23 g	1.91 g

A. Identify the products of fermentation by moving the product labels into the blank boxes.

B. Identify the optimal temperature for fermentation by moving a temperature label into the blank box.

- Move only **one** label into each blank box.



Notes on Scoring

This response earns full credit (2 points). The response correctly enters the products for fermentation in Part A ("Ethanol" and "CO_2") and correctly enters the optimal fermentation temperature in Part B ("35° C").

Sample Response: 1 point

Scientists study anaerobic fermentation in yeast cells incubated at different temperatures.

The amount of carbon dioxide (CO_2) detected at each temperature in two trials is shown in the table.

Anaerobic Fermentation Results

Temperature	Trial 1: Mass CO_2	Trial 2: Mass CO_2
20° C	1.81 g	1.94 g
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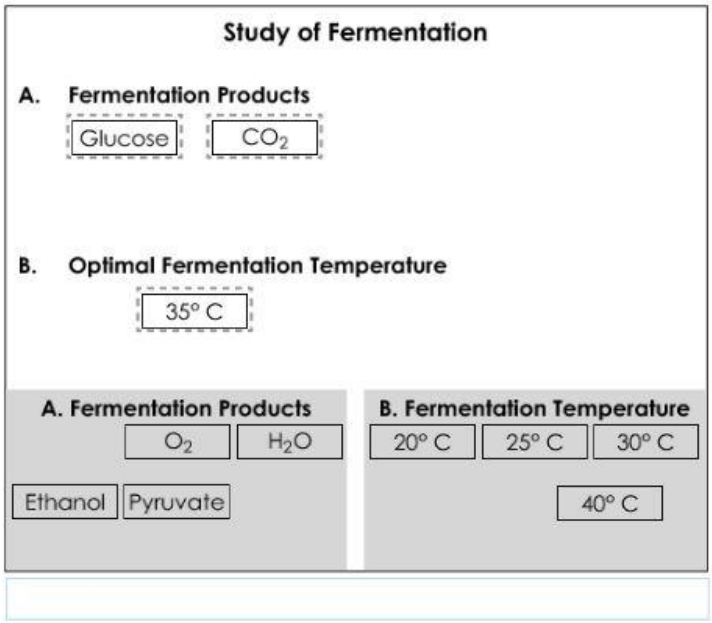
30° C	4.10 g	4.06 g
35° C	5.17 g	4.97 g
40° C	2.23 g	1.91 g

A. Identify the products of fermentation by moving the product labels into the blank boxes.

B. Identify the optimal temperature for fermentation by moving a temperature label into the blank box.

- Move only **one** label into each blank box.



Notes on Scoring

This response earns partial credit (1 point) because it incorrectly enters "Glucose" as a product of fermentation. Glucose is a reactant (consumed) during fermentation, not a product.

The response receives 1 point because the student correctly enters the optimal fermentation temperature in Part B ("35° C").

Sample Response: 1 point

Scientists study anaerobic fermentation in yeast cells incubated at different temperatures.

The amount of carbon dioxide (CO_2) detected at each temperature in two trials is shown in the table.

Anaerobic Fermentation Results

Temperature	Trial 1: Mass CO_2	Trial 2: Mass CO_2
20° C	1.81 g	1.94 g
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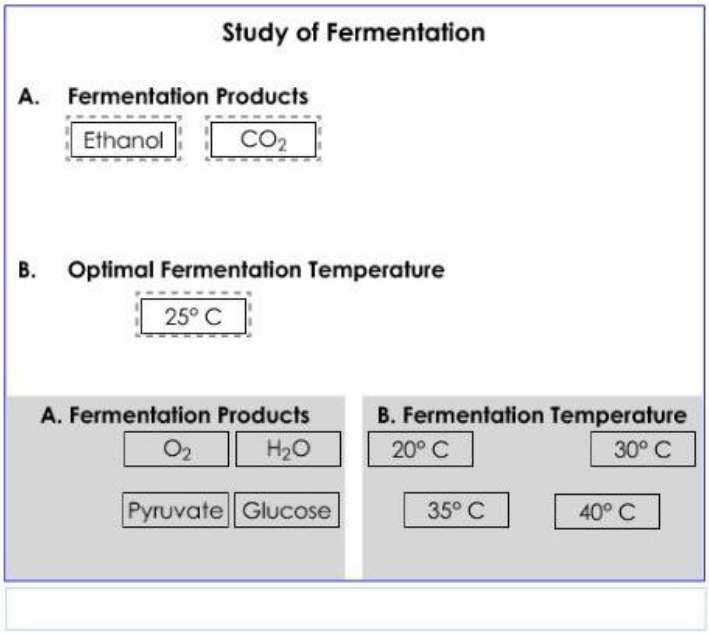
A. Identify the products of fermentation by moving the product labels into the blank boxes.

B. Identify the optimal temperature for fermentation by moving a temperature label into the blank box.

- Move only **one** label into each blank box.



Notes on Scoring

This response earns partial credit (1 point) because it incorrectly enters "25° C" as the optimal temperature for fermentation. In the chart in this item ("Anaerobic Fermentation Results") 25° C produced only 2.91g in trial 1 and 2.75g in trial 2, whereas at 35° C, 5.17g was produced in trial 1 and 4.97g was produced in trial 2. The optimal temperature produced the most CO_2.

The response receives 1 point because the student correctly enters fermentation products in Part A ("Ethanol" and "CO_2").

Sample Response: 0 points

Scientists study anaerobic fermentation in yeast cells incubated at different temperatures.

The amount of carbon dioxide (CO_2) detected at each temperature in two trials is shown in the table.

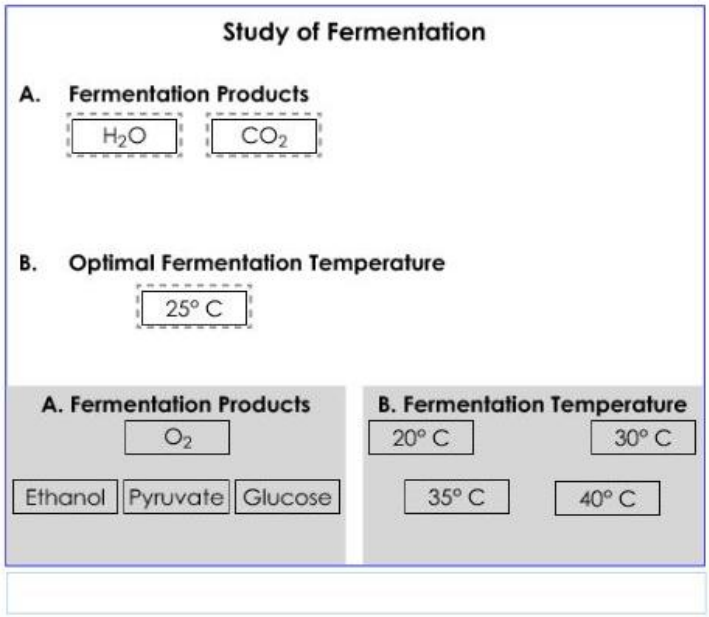
Anaerobic Fermentation Results

Temperature	Trial 1: Mass CO_2	Trial 2: Mass CO_2
20° C	1.81 g	1.94 g
25° C	2.91 g	2.75 g
30° C	4.10 g	4.06 g
35° C	5.17 g	4.97 g
40° C	2.23 g	1.91 g

A. Identify the products of fermentation by moving the product labels into the blank boxes.

B. Identify the optimal temperature for fermentation by moving a temperature label into the blank box.

- Move only **one** label into each blank box.



Notes on Scoring

This response earns no credit (0 points). The response incorrectly enters "H_2O" as a product of fermentation and "25° C" as the optimal temperature for fermentation. H_2O is a reactant in the fermentation reaction, not a product. Additionally, in the chart in this item ("Anaerobic Fermentation Results"), 25° C produced only 2.91g in trial 1 and 2.75g in trial 2, whereas at 35° C, 5.17g was produced in trial 1 and 4.97g was produced in trial 2. The optimal temperature produced the most CO_2.

Sample Response: 0 points

Scientists study anaerobic fermentation in yeast cells incubated at different temperatures.

The amount of carbon dioxide (CO_2) detected at each temperature in two trials is shown in the table.

Anaerobic Fermentation Results

Temperature	Trial 1: Mass CO_2	Trial 2: Mass CO_2
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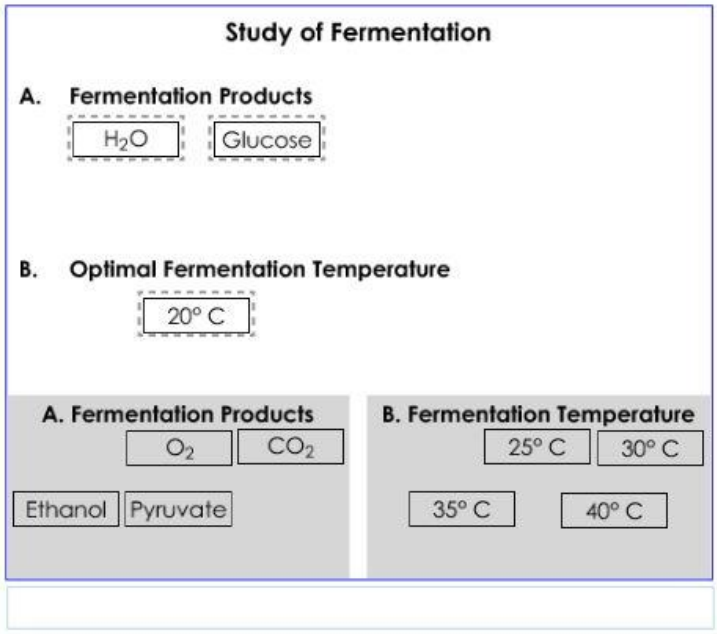
40° C	2.23 g	1.91 g

A. Identify the products of fermentation by moving the product labels into the blank boxes.

B. Identify the optimal temperature for fermentation by moving a temperature label into the blank box.

- Move only **one** label into each blank box.



Notes on Scoring

This response earns no credit (0 points). The response incorrectly enters "H_2O" and "Glucose" as products of fermentation and "20° C" as the optimal temperature for fermentation. H_2O and Glucose are reactants in the fermentation reaction, not products. Additionally, in the chart in this item ("Anaerobic Fermentation Results"), 20° C produced only 1.81g in trial 1 and 1.94g in trial 2, whereas at 35° C, 5.17g was produced in trial 1 and 4.97g was produced in trial 2. The optimal temperature produced the most CO_2.

Biology
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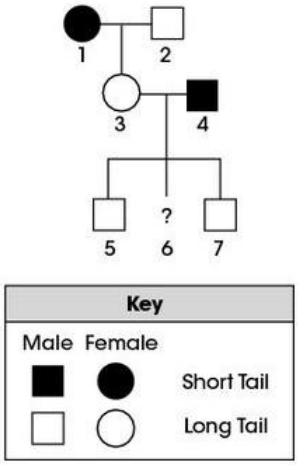
Question 9

Question and Scoring Guidelines

Question 9

In a particular species of mice, a single gene (B or b) determines tail length. The short-tail allele is sex-linked and dominant. Shading in the pedigree below indicates that an individual has a short tail. The pedigree shows the pattern of inheritance of the short-tail allele over three generations of mice.

Pedigree for Tail Length



Individual 6 is female. What is the genotype of individual 6?

(A) X^BX^b

(B) X^bX^b

(C) X^BY

(D) X^bY

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: **Key** – The female offspring receive one X-chromosome from the father. Since the father carries the dominant allele on his X-chromosome and the mother is homozygous recessive on both X-chromosomes, the female will be heterozygous dominant.

Rationale for Option B: This is incorrect. The female offspring receive one X-chromosome from the father. Since the father carries the dominant allele on his X-chromosome and the mother is homozygous recessive on both X-chromosomes, the female will be heterozygous dominant, not homozygous recessive.

Rationale for Option C: This is incorrect. The individual in question is a female and will not possess a Y-chromosome.

Rationale for Option D: This is incorrect. The individual in question is a female and will not possess a Y-chromosome.

Alignment

Content Strand
Heredity

Content Statement
Genetic Mechanisms and Inheritance

Content Elaboration
Genetic mechanisms, both classical and modern including incomplete dominance, sex-linked traits, goodness of fit test (Chi-square) and dihybrid crosses are investigated through real-world examples. Dihybrid crosses can be used to explore linkage groups. Gene interactions and phenotypic effects can be introduced using real-world examples (e.g. polygenic inheritance, epistasis, and pleiotropy).

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.

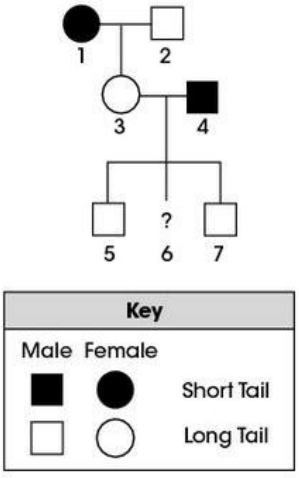
Explanation of the Item

This item requires the student to demonstrate an understanding of the genetic mechanisms of inheritance. In this scenario, the traits "B" (dominant for short-tailed) and "b" (recessive for long-tailed) are sex-linked. Since there is an affected female (XX), the traits must be linked to the sex chromosome X. Therefore, the genotype of "1" (affected female) must be either X^BX^B or X^BX^b, and the genotype for "2" (unaffected male) must be X^bY. The offspring of "1" and "2" is "3" (unaffected female), so her genotype must be X^bX^b, and the genotype of "1" must therefore be X^BX^b. Since "6" is the female offspring resulting from the mating of "3" (X^bX^b) and the affected male, "4" (X^BY), the genotype of "6" is X^BX^b because the X^B must be donated by the male parent ("4") and the X^b by the female parent ("3").

Sample Response: 1 point

In a particular species of mice, a single gene (B or b) determines tail length. The short-tail allele is sex-linked and dominant. Shading in the pedigree below indicates that an individual has a short tail. The pedigree shows the pattern of inheritance of the short-tail allele over three generations of mice.

Pedigree for Tail Length



Individual 6 is female. What is the genotype of individual 6?

- ● X^BX^b
- Ⓑ X^bX^b
- Ⓒ X^BY
- Ⓓ X^bY

Biology
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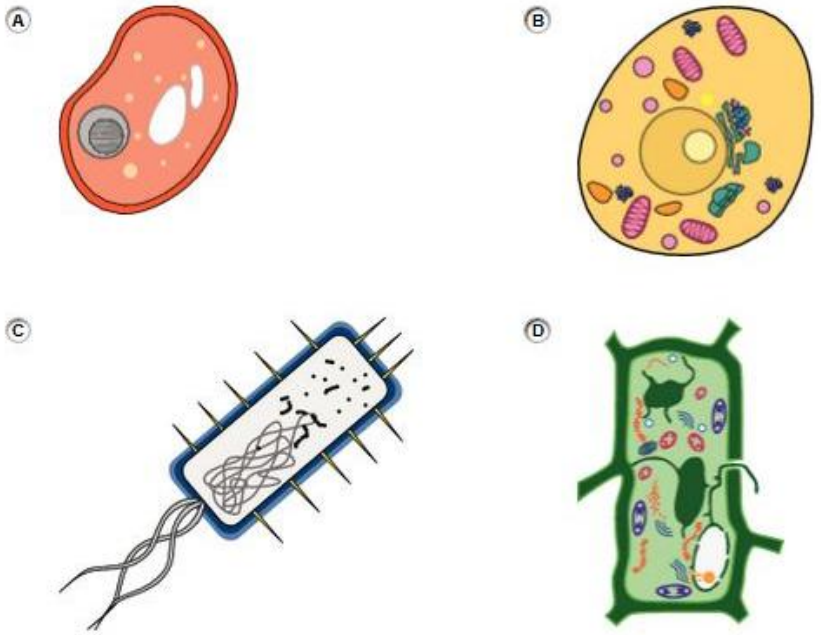
Question 10

Question and Scoring Guidelines

Question 10

A student is asked to draw four cells.

Which drawing is a representation of a prokaryotic cell?



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. This diagram is representative of a cell from a fungus.

Rationale for Option B: This is incorrect. This diagram shows an animal cell.

Rationale for Option C: **Key** – This cell has a cell wall but lacks internal membrane-bound compartments (organelles).

Rationale for Option D: This is incorrect. This diagram shows a plant cell.

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. Details of cellular processes such as photosynthesis, chemosynthesis, cellular respiration, cell division and differentiation are studied at this grade level. Additionally, cellular organelles studied are cytoskeleton, Golgi complex and endoplasmic reticulum.

From about 4 billion years ago to about 2 billion years ago, only simple, single-celled microorganisms are found in the fossil record. Once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.

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.

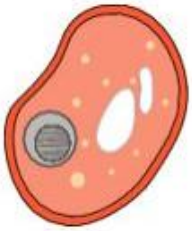
Explanation of the Item
This item requires the student to identify which cell is a prokaryotic cell. Since options A, B and D have membrane-bound organelles, option C must be a prokaryote.

Sample Response: 1 point

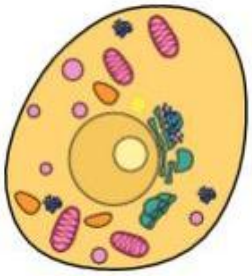
A student is asked to draw four cells.

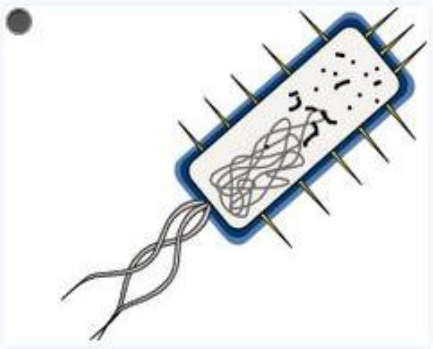
Which drawing is a representation of a prokaryotic cell?

A

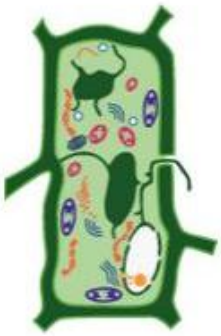


B





D



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Question 11

Question and Scoring Guidelines

Question 11

Some bacteria have developed a resistance to antibiotics through random mutations. One such mutation allows bacteria to produce enzymes that inactivate the antibiotics when they enter the bacteria.

Which statement describes how this mutation occurs?

(A) The mutation occurs when nucleic acids are replicated.

(B) The mutation occurs in chloroplasts during photosynthesis.

(C) The mutation occurs in mitochondria during cellular respiration.

(D) The mutation occurs when molecules move across the cell membrane.

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: **Key** – Enzymes are proteins produced from information coded in nucleic acids. A mutation that occurs during DNA replication can lead to the production of new enzymes.

Rationale for Option B: This is incorrect. Photosynthesis converts light energy into stored chemical energy; it does not cause mutations in DNA to occur.

Rationale for Option C: This is incorrect. Cellular respiration produces usable energy in the form of ATP from stored chemical energy in sugars; it does not cause mutations in DNA to occur.

Rationale for Option D: This is incorrect. The movement of molecules in and out of cells does not cause mutations in DNA to occur.

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.

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 communicate an understanding of the molecular basis of inheritance by selecting an explanation for how mutations occur. A genetic mutation is passed on to any cell that replicates from the parent cell through its DNA by mitosis. Only if the genetic mutation occurs in a gamete through meiosis will the mutation be passed on to the offspring.

Sample Response: 1 point

Some bacteria have developed a resistance to antibiotics through random mutations. One such mutation allows bacteria to produce enzymes that inactivate the antibiotics when they enter the bacteria.

Which statement describes how this mutation occurs?

- ● The mutation occurs when nucleic acids are replicated.
- Ⓑ The mutation occurs in chloroplasts during photosynthesis.
- Ⓒ The mutation occurs in mitochondria during cellular respiration.
- Ⓓ The mutation occurs when molecules move across the cell membrane.

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Question 12

Question and Scoring Guidelines

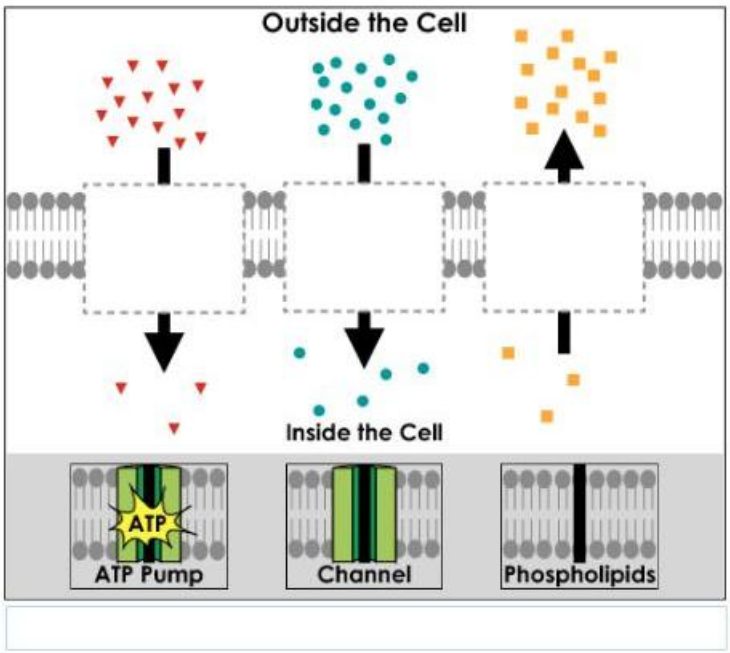
Question 12

The diagram shows an incomplete cross-section of a cell membrane. Three different particles are shown moving across the membrane into or out of the cell.

Key
O_2
Glucose
Na^+

Determine the appropriate transport mechanism of each particle and move the correct membrane segment into each blank box to complete the cross-section diagram.

- Move only **one** membrane segment into each box.



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- "Channel" placed in the left box;

  AND
- "Phospholipids" placed in the center box;

  AND
- "ATP Pump" placed in the right box (1 point).

Alignment

Content Strand
Cells

Content Statement
Cell Structure and Function

Content Elaboration
Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape. 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.

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 the correct membrane transport mechanism for different substances given the identity and concentration gradient of each substance.

- The "Channel" (protein channel) allows large-sized molecules, such as glucose, to cross. Since glucose is water soluble, it is transported through the protein channel with the concentration gradient (high concentration to low concentration) without the expenditure of energy.
- The "Phospholipids" (phospholipid layer) diffuse oxygen across the membrane without expenditure of energy using the concentration gradient (high concentration to lower concentration).
- The "ATP Pump" allows large-sized molecules such as sodium to be transported against the concentration gradient (low concentration to high concentration), requiring energy through expenditure of ATP.

Biology
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Question 12

Sample Responses

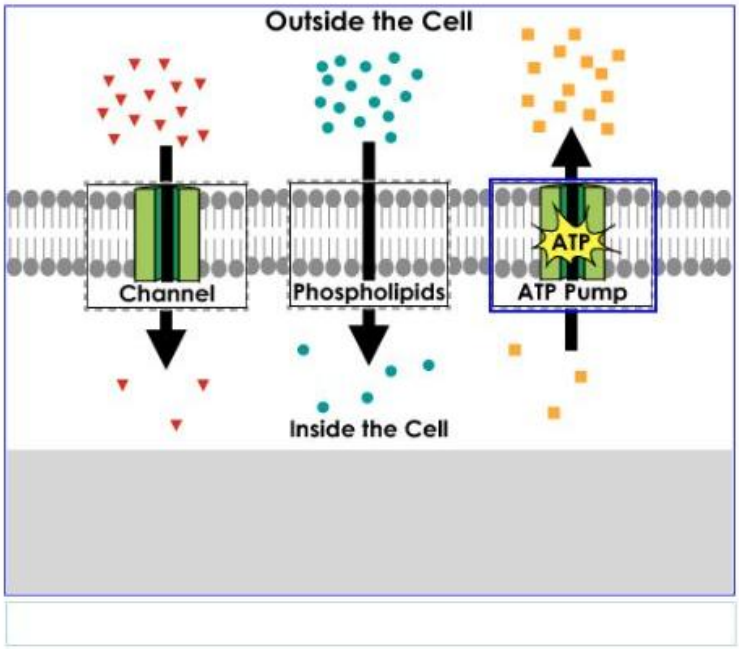
Sample Response: 1 point

The diagram shows an incomplete cross-section of a cell membrane. Three different particles are shown moving across the membrane into or out of the cell.

Key
- O_2
- Glucose
- Na^+

Determine the appropriate transport mechanism of each particle and move the correct membrane segment into each blank box to complete the cross-section diagram.

- Move only **one** membrane segment into each box.



Notes on Scoring

This response earns full credit (1 point) because the student correctly places the following:

- "Channel" in the left box, due to the large size of the glucose molecule and the fact that glucose is water soluble.
- "Phospholipids" in the center box, due to the fact that oxygen is diffusing across the phospholipids with the concentration gradient (high concentration to lower concentration).
- "ATP Pump" in the right box, due to the fact that sodium is being transported against the concentration gradient (low concentration to high concentration), requiring energy through expenditure of ATP.

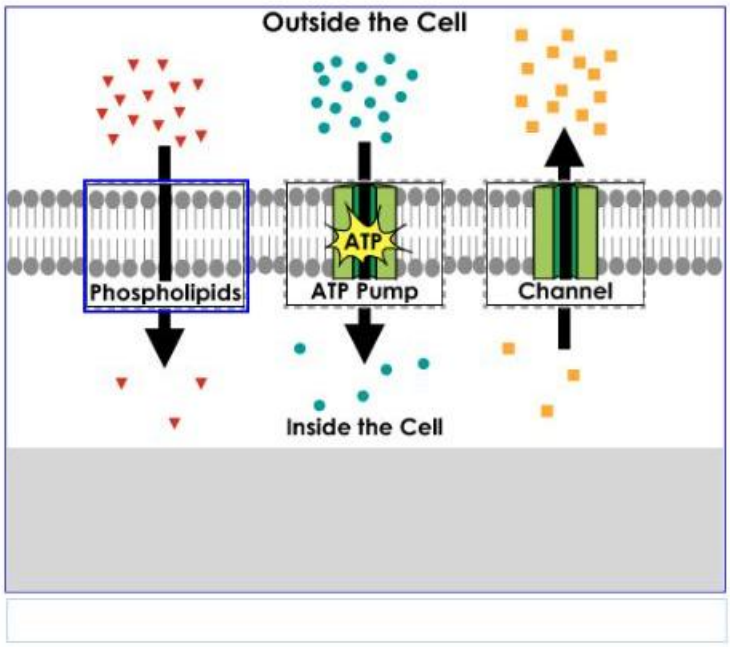
Sample Response: 0 points

The diagram shows an incomplete cross-section of a cell membrane. Three different particles are shown moving across the membrane into or out of the cell.

Key
● O_2
▼ Glucose
■ Na^+

Determine the appropriate transport mechanism of each particle and move the correct membrane segment into each blank box to complete the cross-section diagram.

- Move only **one** membrane segment into each box.



Notes on Scoring

This response earns no credit (0 points) because the student incorrectly places all three membrane segments in the boxes:

- Glucose, which is a large, water-soluble molecule, could not diffuse across a phospholipid membrane even with the concentration gradient.
- Oxygen would diffuse across the phospholipid membrane without the expenditure of ATP/energy.
- Sodium requires active transport and expenditure of ATP/energy since it is transported against the concentration gradient.

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Question 13

Question and Scoring Guidelines

Question 13

A biologist conducting a long-term field study noticed there were two types of mice in a valley. One type of mouse had webbed toes, and one type of mouse lacked webbed toes. A dam was built in the valley turning the land into a wetland. As the years passed, all mice living in the valley were found to have webbed toes. No mice were found with non-webbed toes.

Which statement best explains the observed change in the mouse population?

(A) Webbed toes in mice are controlled by the environment.

(B) The mice grew webbing to move more efficiently in the new environment.

(C) Webbed-toed mice survived better and reproduced more than mice without webbed toes.

(D) The increased water levels in the valley increased the mutation rate in the mouse population.

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. This is a misconception that a physical characteristic (e.g., webbed toes) is controlled by the environment. The trait must naturally occur in the population through genetic variation or mutation, and then it must provide a survival advantage allowing individuals with the trait to reproduce more successfully, impacting the population.

Rationale for Option B: This is incorrect. This is a misconception that a physical characteristic was grown due to change in the environment (e.g., webbing). The trait must naturally occur in the population through genetic variation or mutation, and then it must provide a survival advantage allowing individuals with the trait to reproduce more successfully, impacting the population.

Rationale for Option C: **Key** – The trait (webbed toes) naturally occurred in the population and provided a survival advantage allowing individuals with the trait to reproduce more successfully, impacting the population.

Rationale for Option D: This is incorrect. This is a misconception that change in the environment (e.g., increased water levels) affects the mutation rate. The trait must naturally occur in the population through genetic variation or mutation, and *then* it must provide a survival advantage allowing individuals with the trait to reproduce more successfully, impacting the population.

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 determine the effect of environment on the survival of organisms through the process of natural selection. The process of natural selection requires a trait to exist within a population. It is the exhibition of this trait that provides the advantage that allows individuals with the trait to reach reproductive age. These individuals then produce more offspring than the individuals without the trait, thus increasing the frequency of the trait within the population. In this example, webbed toes offer an advantage in the changing environment, allowing those mice to out-reproduce the mice without the trait.

Sample Response: 1 point

A biologist conducting a long-term field study noticed there were two types of mice in a valley. One type of mouse had webbed toes, and one type of mouse lacked webbed toes. A dam was built in the valley turning the land into a wetland. As the years passed, all mice living in the valley were found to have webbed toes. No mice were found with non-webbed toes.

Which statement best explains the observed change in the mouse population?

Ⓐ Webbed toes in mice are controlled by the environment.

Ⓑ The mice grew webbing to move more efficiently in the new environment.

● Webbed-toed mice survived better and reproduced more than mice without webbed toes.

Ⓓ The increased water levels in the valley increased the mutation rate in the mouse population.

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Question 14

Question and Scoring Guidelines

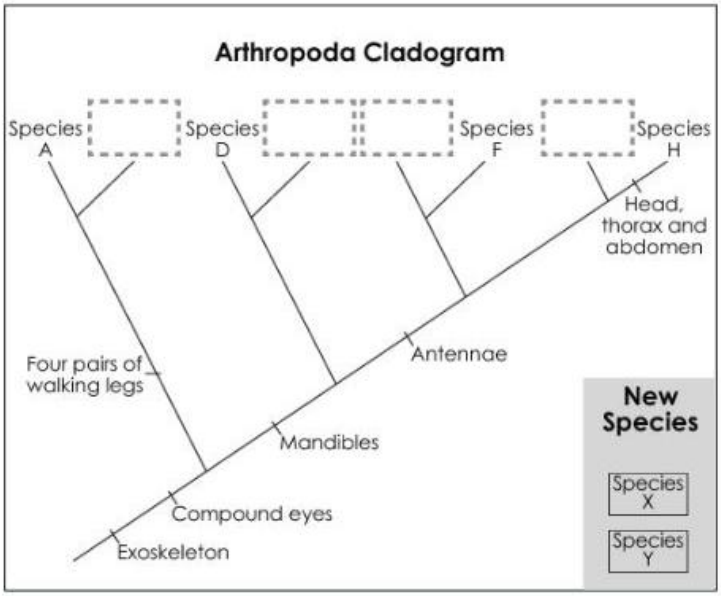
Question 14

A cladogram of several members of the phylum Arthropoda is shown. Two new species, X and Y, have recently been discovered. The table shows the traits that these two new species possess.

Trait	Species X	Species Y
Exoskeleton	Yes	Yes
Compound Eyes	Yes	Yes
Mandibles	Yes	Yes
Antennae	No	Yes

Move the Species X and Y labels into the appropriate blank boxes in the cladogram.

- There may be more than one correct answer.
- You do **not** need to fill all the boxes.



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- "Species X" placed in the 2nd box from the left;
  AND
- "Species Y" placed in the 3rd OR 4th box from the left (1 point).

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
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
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 place organisms in an existing cladogram based on the traits of the organisms. The evidence used to complete the cladogram is contained in the table. Species X exhibited the physical traits "Exoskeleton," "Compound Eyes" and "Mandibles." Species Y exhibited the same physical traits as Species X with the addition of "Antennae." The student must trace the emergence of the traits in order to properly position the species in the cladogram.

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Question 14

Sample Responses

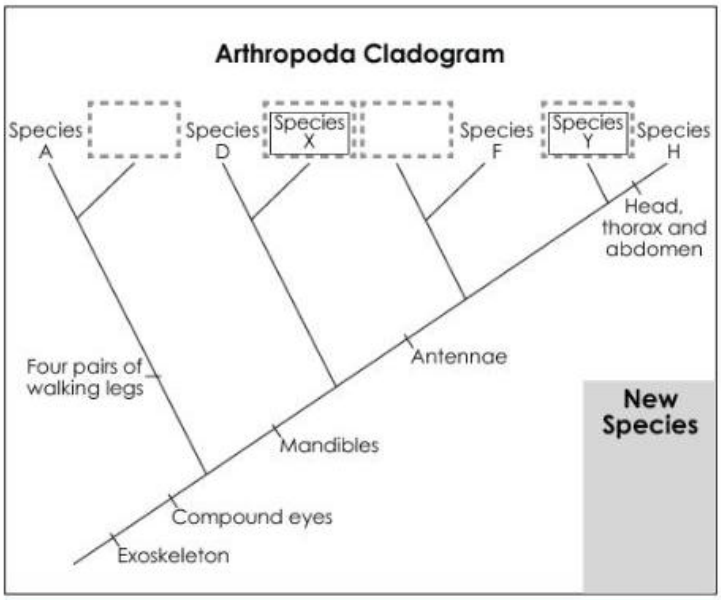
Sample Response: 1 point

A cladogram of several members of the phylum Arthropoda is shown. Two new species, X and Y, have recently been discovered. The table shows the traits that these two new species possess.

Trait	Species X	Species Y
Exoskeleton	Yes	Yes
Compound Eyes	Yes	Yes
Mandibles	Yes	Yes
Antennae	No	Yes

Move the Species X and Y labels into the appropriate blank boxes in the cladogram.

- There may be more than one correct answer.
- You do **not** need to fill all the boxes.



Notes on Scoring

This response earns full credit (1 point) because of the reasons below.

"Species X" was placed in the 2nd box from the left. The student correctly determined this by referring to the cladogram and tracing the physical characteristics of "Exoskeleton," "Compound Eyes" and "Mandibles." "Species X" does not have "Antennae," so the departure was between the two characteristics of "Mandibles" and "Antennae."

"Species Y" was placed in the 4th box from the left. The student correctly determined this by looking at the cladogram and tracing the physical characteristics. Since "Species Y" had the same three characteristics as "Species X" with the addition of "Antennae," the only available boxes for this species are the 3rd or 4th boxes from the left.

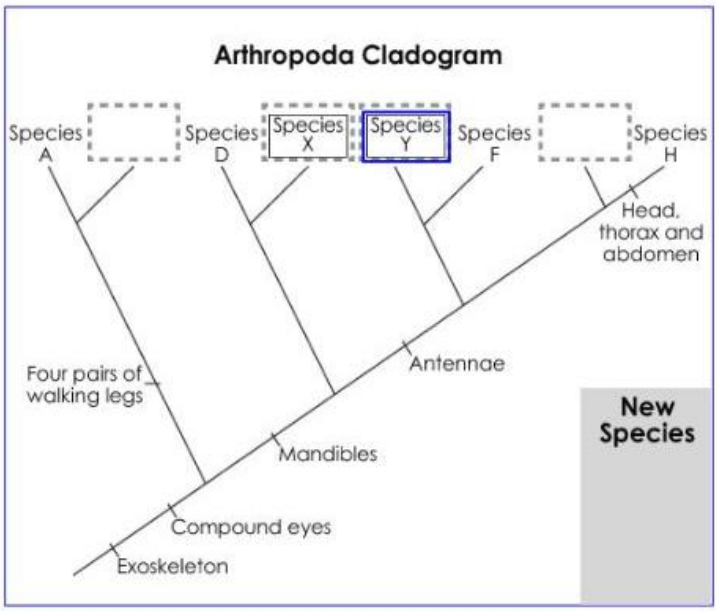
Sample Response: 1 point

A cladogram of several members of the phylum Arthropoda is shown. Two new species, X and Y, have recently been discovered. The table shows the traits that these two new species possess.

Trait	Species X	Species Y
Exoskeleton	Yes	Yes
Compound Eyes	Yes	Yes
Mandibles	Yes	Yes
Antennae	No	Yes

Move the Species X and Y labels into the appropriate blank boxes in the cladogram.

- There may be more than one correct answer.
- You do **not** need to fill all the boxes.



Notes on Scoring

This response earns full credit (1 point) because of the reasons below.

"Species X" was placed in the 2nd box from the left. The student correctly determined this by referring to the cladogram and tracing the physical characteristics of "Exoskeleton," "Compound Eyes" and "Mandibles." "Species X" does not have "Antennae," so the departure was between the two characteristics of "Mandibles" and "Antennae."

"Species Y" was placed in the 3rd box from the left. The student correctly determined this by looking at the cladogram and tracing the physical characteristics. Since "Species Y" had the same three characteristics as "Species X" with the addition of "Antennae," the only available boxes for this species are the 3rd or 4th boxes from the left.

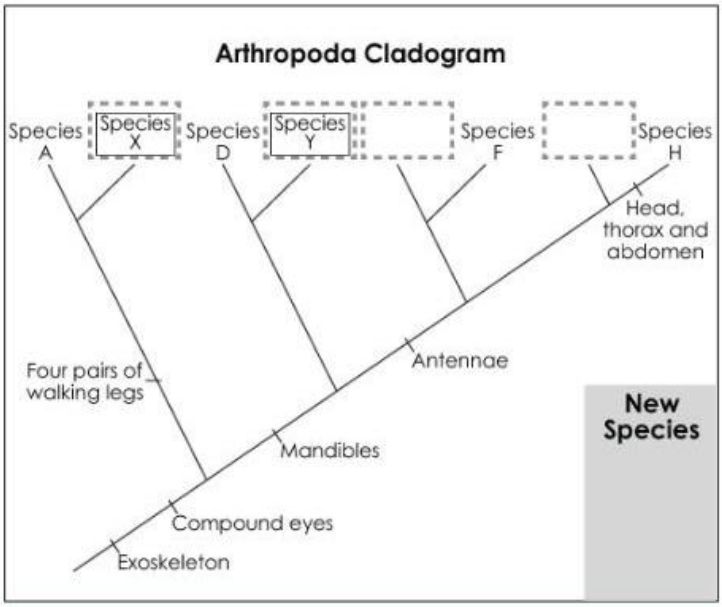
Sample Response: 0 points

A cladogram of several members of the phylum Arthropoda is shown. Two new species, X and Y, have recently been discovered. The table shows the traits that these two new species possess.

Trait	Species X	Species Y
Exoskeleton	Yes	Yes
Compound Eyes	Yes	Yes
Mandibles	Yes	Yes
Antennae	No	Yes

Move the Species X and Y labels into the appropriate blank boxes in the cladogram.

- There may be more than one correct answer.
- You do **not** need to fill all the boxes.



Notes on Scoring

This response earns no credit (0 points) because of the reasons below.

The student incorrectly places "Species X" in the 1st box from the left, omitting the physical characteristic of "Mandibles" that was exhibited.

The student also incorrectly places "Species Y" in the 2nd box from the left, omitting the physical characteristic of "Antennae" that was exhibited.

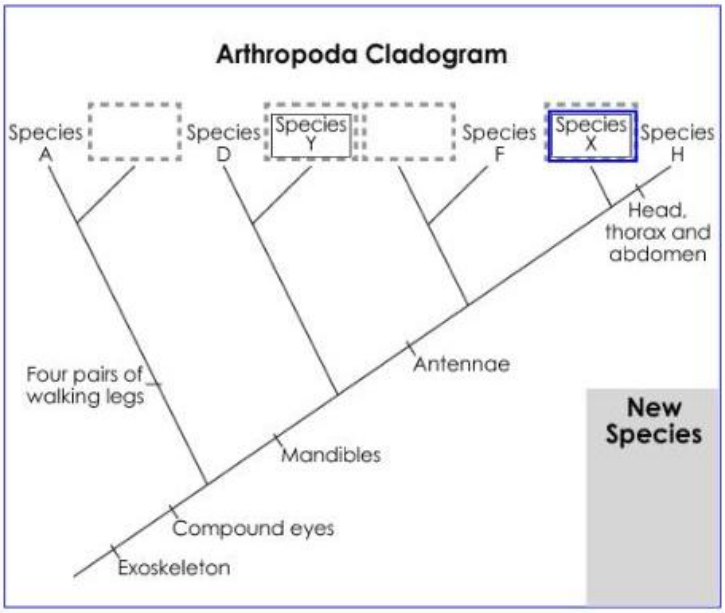
Sample Response: 0 points

A cladogram of several members of the phylum Arthropoda is shown. Two new species, X and Y, have recently been discovered. The table shows the traits that these two new species possess.

Trait	Species X	Species Y
Exoskeleton	Yes	Yes
Compound Eyes	Yes	Yes
Mandibles	Yes	Yes
Antennae	No	Yes

Move the Species X and Y labels into the appropriate blank boxes in the cladogram.

- There may be more than one correct answer.
- You do **not** need to fill all the boxes.



Notes on Scoring

This response earns no credit (0 points) because of the reasons below.

The student incorrectly places "Species Y" in the 2nd box from the left, omitting the physical characteristic of "Antennae" that was exhibited.

The student also incorrectly places "Species X" in the 4th box from the left, adding the physical characteristic of "Antennae" that was not exhibited.

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Question 15

Question and Scoring Guidelines

Question 15

Which pair of organelles works together to give structure and support in animal cells?

(A) cell wall and cytoplasm

(B) cytoskeleton and Golgi complex

(C) cell membrane and cytoskeleton

(D) endoplasmic reticulum and cell membrane

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. Cell walls are found in plant cells, not animal cells.

Rationale for Option B: This is incorrect. The Golgi complex does not aid in cell support.

Rationale for Option C: **Key** – The cell membrane and cytoskeleton work together to provide support and structure for animal cells.

Rationale for Option D: This is incorrect. The endoplasmic reticulum is not part of a cell structure.

Alignment

Content Strand
Cells

Content Statement
Cell Structure and Function

Content Elaboration
Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape. 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.

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 which organelles give structure and support to animal cells. The only pair of organelles listed that gives both structure and support in **animal cells** is the cell membrane and cytoplasm. The cell wall, although it does provide support, is only present in plant cells. The Golgi complex and endoplasmic reticulum do not have a support function.

Sample Response: 1 point

Which pair of organelles works together to give structure and support in animal cells?

- (A) cell wall and cytoplasm
- (B) cytoskeleton and Golgi complex
- ● cell membrane and cytoskeleton
- (D) endoplasmic reticulum and cell membrane

Biology
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Question 16

Question and Scoring Guidelines

Question 16

In most species, scientists have observed that related individuals share about 80% of the same genes. Cheetahs today, however, are known to share 99% of the same genes.

What does this lack of genetic diversity imply about the history of the cheetah population?

(A) Cheetahs never have experienced mutations.

(B) Cheetahs have experienced reproductive isolation.

(C) Cheetahs interbred with other large cat species.

(D) Cheetahs share a common ancestor with other large cat species.

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. Mutations would add to the genetic diversity if the mutation occurred in a gamete. The mutation would not be passed to the offspring if it occurred in a somatic cell.

Rationale for Option B: **Key** – Today's cheetah underwent a sharp decline in population, creating a genetic bottleneck. Today's cheetah genetic pool is based on these relatively few survivors. This bottleneck created a decrease in genetic diversity within the current cheetah population.

Rationale for Option C: This is incorrect. By the definition of a species, cheetahs cannot interbreed with other species of large cats. If possible, this would add to the genetic diversity rather than subtract from it.

Rationale for Option D: This is incorrect. Sharing a common ancestor would have no effect on the cheetah's genetic diversity.

Alignment

Content Strand
Evolution

Content Statement
Diversity of Life

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
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 recall factors that limit the genetic diversity within a population. Today's cheetahs underwent a sharp decline in population, creating a genetic bottleneck. Today's cheetah genetic pool is based on relatively few survivors. This bottleneck created a decrease in genetic diversity within the current cheetah population.

Sample Response: 1 point

In most species, scientists have observed that related individuals share about 80% of the same genes. Cheetahs today, however, are known to share 99% of the same genes.

What does this lack of genetic diversity imply about the history of the cheetah population?

- (A) Cheetahs never have experienced mutations.
- ● Cheetahs have experienced reproductive isolation.
- (C) Cheetahs interbred with other large cat species.
- (D) Cheetahs share a common ancestor with other large cat species.

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Question 17

Question and Scoring Guidelines

Question 17

A group of students studied four different cell specimens under a microscope and recorded information about each cell in this table.

Characteristics of Four Cell Specimens

Cell Specimen	Cell Wall	Cell Membrane	Chloroplasts	DNA in Nucleus
Cell 1	Yes	Yes	Yes	Yes
Cell 2	No	Yes	No	Yes
Cell 3	Yes	Yes	No	No
Cell 4	No	Yes	No	Yes

Which cell specimen is a prokaryote?

Ⓐ Cell 1

Ⓑ Cell 2

Ⓒ Cell 3

Ⓓ Cell 4

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. The characteristics of this cell are typical of a plant cell.

Rationale for Option B: This is incorrect. The characteristics of this cell are typical of an animal cell.

Rationale for Option C: **Key** – The characteristics of this cell are typical of a prokaryote.

Rationale for Option D: This is incorrect. The characteristics of this cell are typical of a fungus.

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. Details of cellular processes such as photosynthesis, chemosynthesis, cellular respiration, cell division and differentiation are studied at this grade level. Additionally, cellular organelles studied are cytoskeleton, Golgi complex and endoplasmic reticulum.

From about 4 billion years ago to about 2 billion years ago, only simple, single-celled microorganisms are found in the fossil record. Once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.

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 distinguish a prokaryotic cell from other cell types based on its features. Prokaryotic cells are the most ancient life forms on Earth. Although they do have DNA used to transfer genetic information, the DNA is found in a nucleoid (nucleus-like). Prokaryotes do not have membrane-bound organelles, such as a true nucleus or chloroplasts. A true nucleus and membrane-bound organelles are traits of eukaryotes.

Sample Response: 1 point

A group of students studied four different cell specimens under a microscope and recorded information about each cell in this table.

Characteristics of Four Cell Specimens

Cell Specimen	Cell Wall	Cell Membrane	Chloroplasts	DNA in Nucleus
Cell 1	Yes	Yes	Yes	Yes
Cell 2	No	Yes	No	Yes
Cell 3	Yes	Yes	No	No
Cell 4	No	Yes	No	Yes

Which cell specimen is a prokaryote?

Ⓐ Cell 1

Ⓑ Cell 2

● Cell 3

Ⓓ Cell 4

Biology
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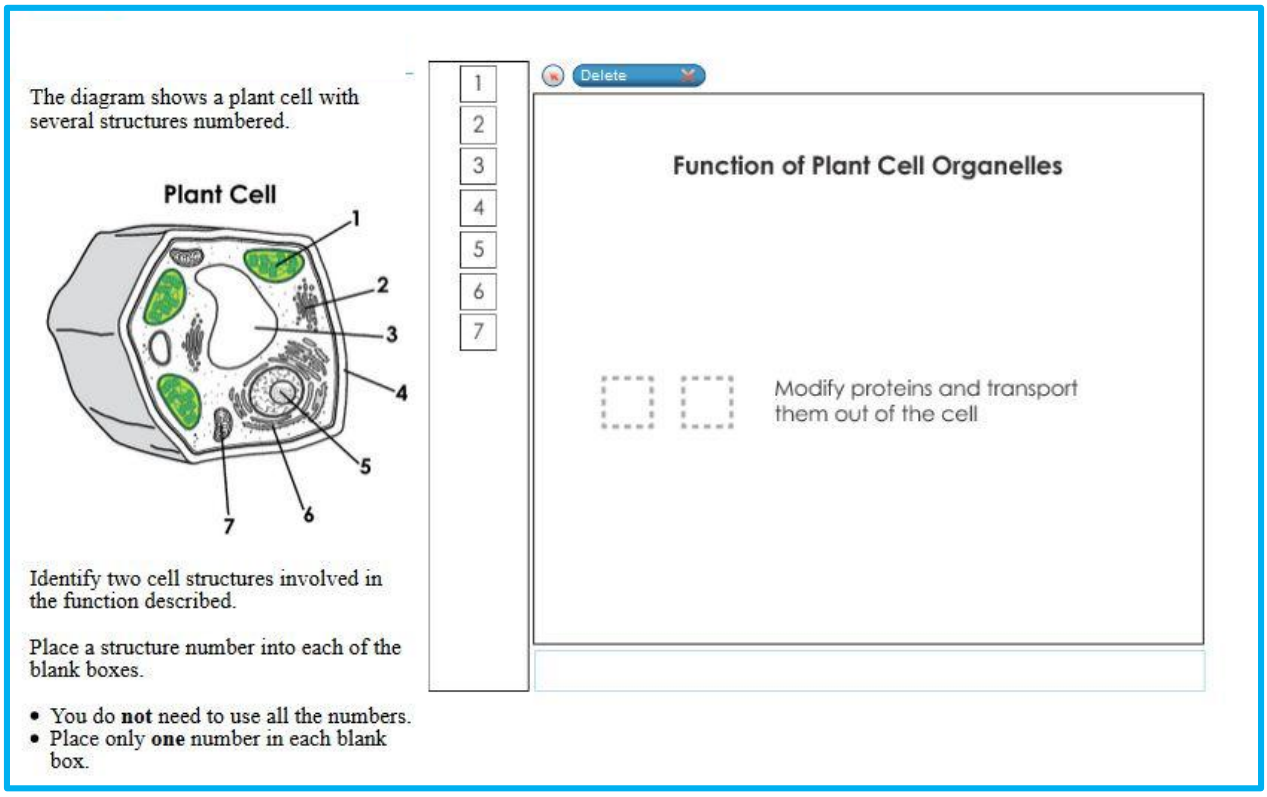
Question 18

Question and Scoring Guidelines

Question 18



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- A "2" and a "6" placed individually in the boxes (1 point).

Alignment

Content Strand
Cells

Content Statement
Cell Structure and Function

Content Elaboration
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.

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 plant cell structures that perform various functions. Plant Cells are eukaryotes, which exhibit membrane-bound organelles. The numbered organelles shown are: "1," a chloroplast that contains chlorophyll and the site of photosynthesis; "2," the Golgi body, which is responsible for the modification, sorting and packaging of proteins; "3," a vacuole responsible for temporary storage; "4," the outermost layer of a plant cell, which is the cell wall, responsible for rigid structure and support; "5," the nucleus, which is the control center of the cell, housing the DNA; "6," the endoplasmic reticulum, which is responsible for the transport of proteins and materials; and "7," the mitochondria, which is responsible for the conversion of glucose to ATP and is the "energy plant" of the cell. Mitochondria have their own heredity information and can self-replicate.

Biology
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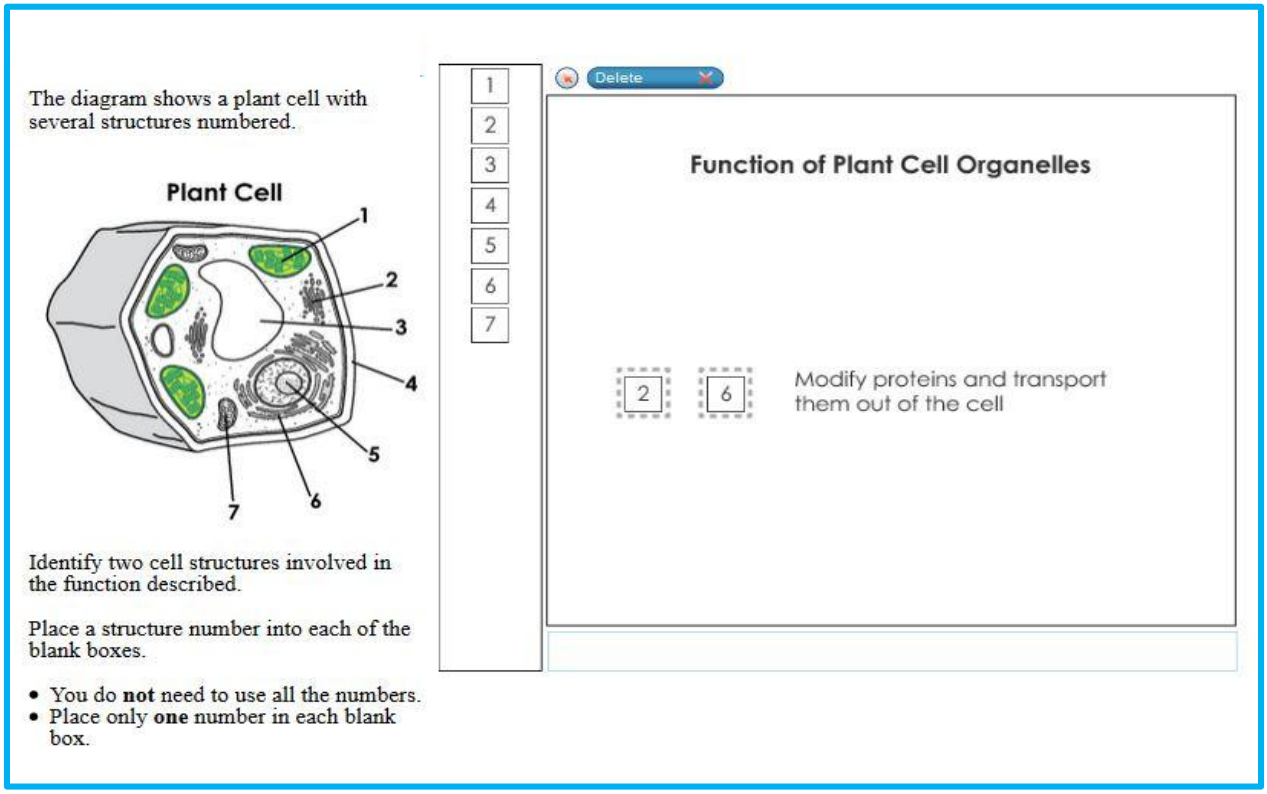
Question 18

Sample Responses

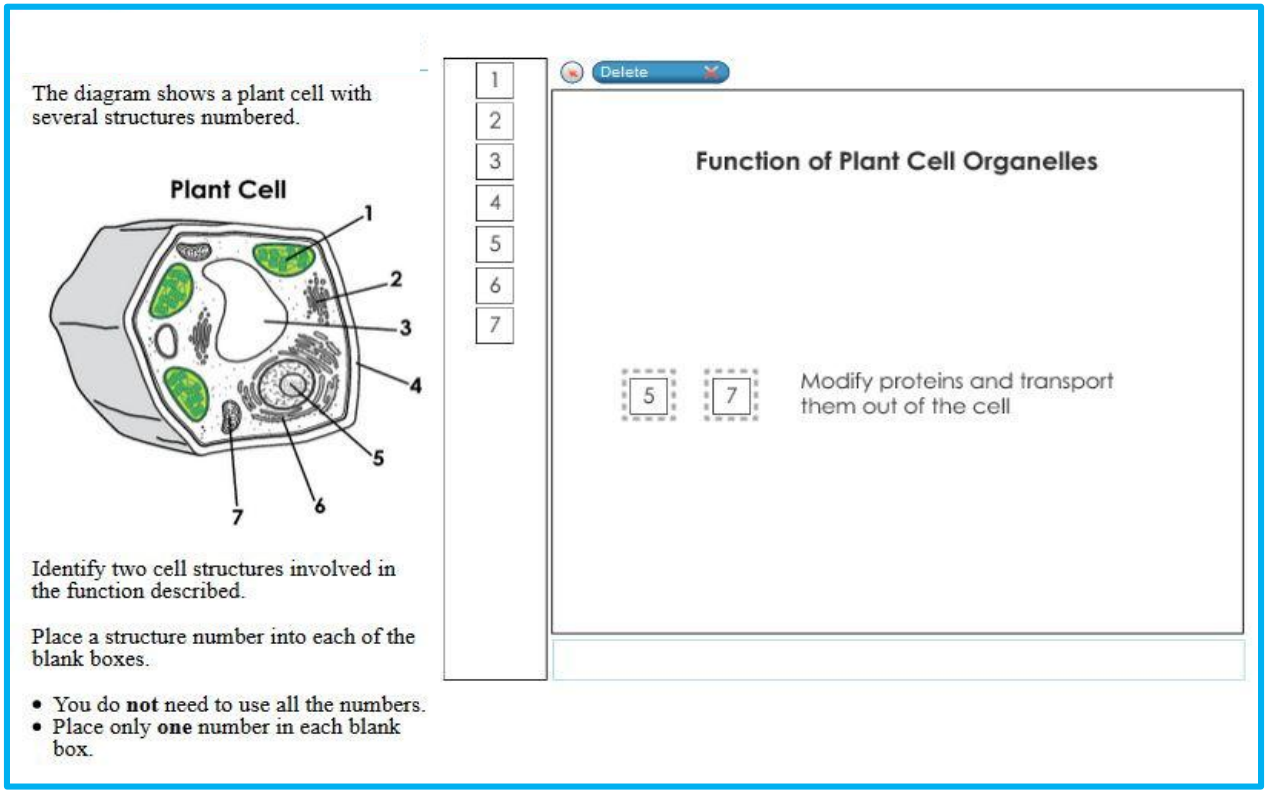
Sample Response: 1 point



Notes on Scoring

This response earns full credit (1 point) because the student correctly places a "2," identifying the Golgi body, and a "6," identifying the rough endoplasmic reticulum, individually in the boxes.

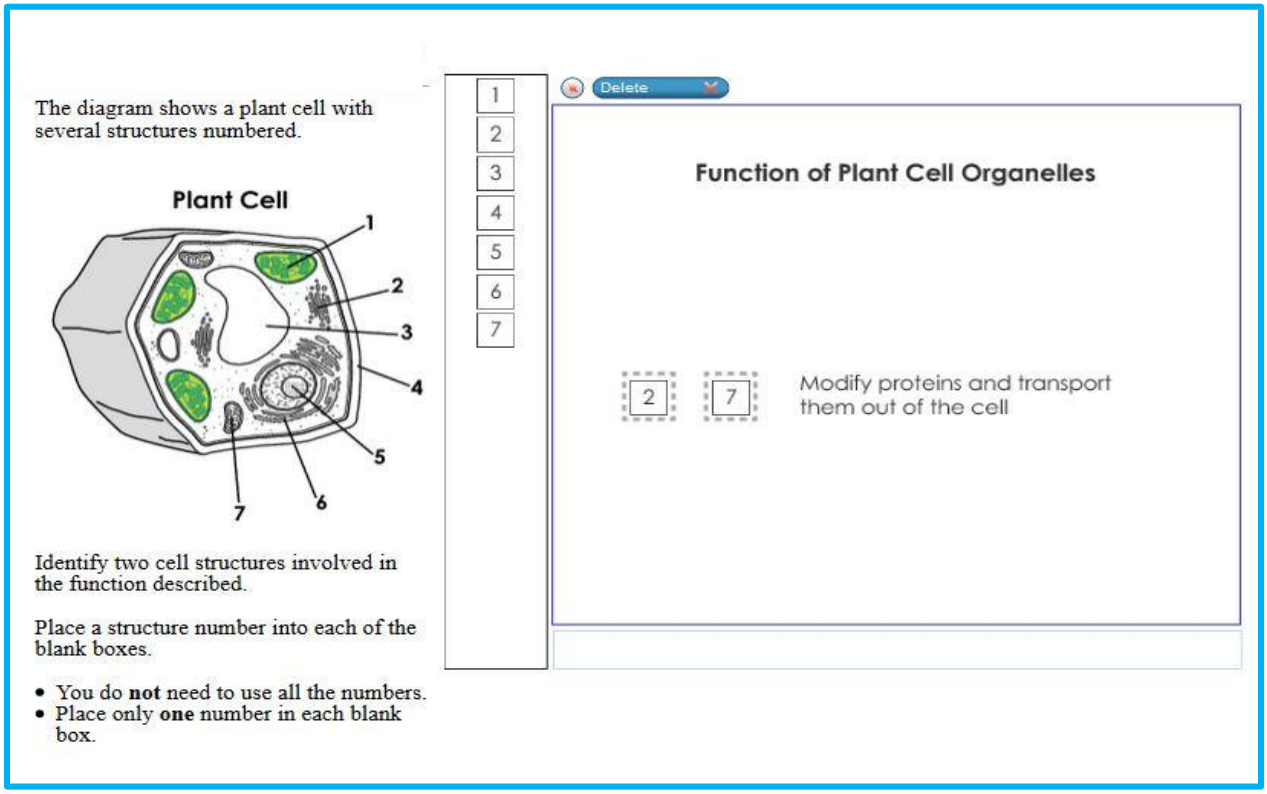
Sample Response: 0 points



Notes on Scoring

This response earns no credit (0 points) because the student incorrectly identifies the nucleus ("5") and mitochondrion ("7") as organelles that modify and transport proteins out of the cell.

Sample Response: 0 points



Notes on Scoring

This response earns no credit (0 points) because the student incorrectly identifies the mitochondrion ("7") as an organelle that can modify and transport proteins out of the cell. The student correctly identifies the Golgi body ("2") as an organelle that can modify and transport proteins out of the cell; however, the student must identify both organelles correctly in order to receive credit.

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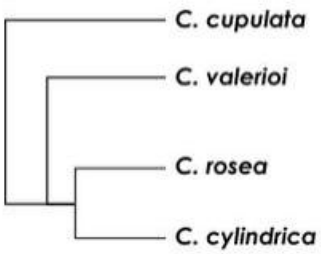
Question 19

Question and Scoring Guidelines

Question 19

Scientists construct the cladogram shown, of plants in the genus *Clusia*, based on evidence collected from DNA analysis.

Clusia Plant Cladogram



Which conclusion is supported by the cladogram?

(A) *C. valerioi* and *C. rosea* are the most closely related of the four species.

(B) *C. rosea* and *C. cylindrica* are the most closely related of the four species.

(C) *C. cupulata* and *C. valerioi* are the most closely related of the four species.

(D) *C. cupulata* and *C. cylindrica* are the most closely related of the four species.

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. While *C. valerioi* and *C. rosea* are more closely related to each other than to *C. cupulata*, *C. cylindrica* is more closely related to *C. rosea* since they are nested more closely in the cladogram that was constructed based on DNA sequences.

Rationale for Option B: **Key** – *C. rosea* and *C. cylindrica* are nested the most closely in the cladogram that was constructed based on DNA sequences, so they would be the most closely related of the species, based on the cladogram.

Rationale for Option C: This is incorrect. *C. cupulata* is the least closely related to the other three species in the cladogram based on the links presented in the cladogram. The general positioning of *C. cupulata* at the top does not indicate relatedness of the species.

Rationale for Option D: This is incorrect. All four of the species come from the same genus *Clusia*. *C. rosea* and *C. cylindrica* are nested the most closely in the cladogram that was constructed based on DNA sequences, so they would be the most closely related of the four species.

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
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
Interpreting and Communicating Science Concepts (C)

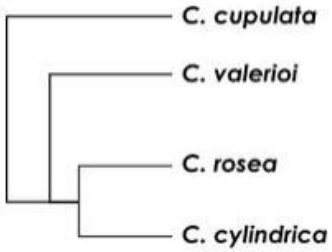
Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative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

Explanation of the Item
This item requires the student to interpret a cladogram to determine the relatedness of species. The cladogram was constructed based on DNA sequences. *C. rosea* and *C. cylindrica* are nested the most closely and share a common ancestor, so they would be the most closely related of the species based on their placement in the cladogram.

Sample Response: 1 point

Scientists construct the cladogram shown, of plants in the genus *Clusia*, based on evidence collected from DNA analysis.

Clusia Plant Cladogram



Which conclusion is supported by the cladogram?

- (A) *C. valerioi* and *C. rosea* are the most closely related of the four species.
- ● *C. rosea* and *C. cylindrica* are the most closely related of the four species.
- (C) *C. cupulata* and *C. valerioi* are the most closely related of the four species.
- (D) *C. cupulata* and *C. cylindrica* are the most closely related of the four species.

Biology
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Question 20

Question and Scoring Guidelines

Question 20

A population of stone crabs is composed equally of three phenotypes:

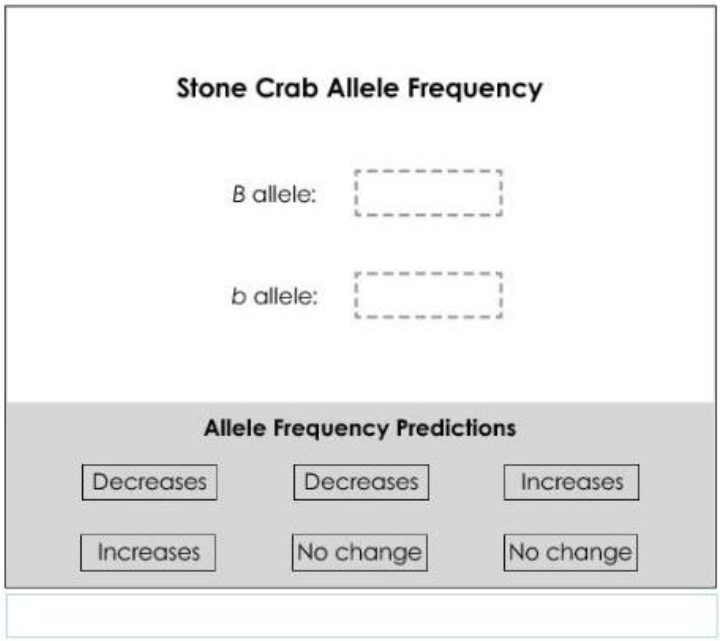
- dark brown (BB)
- medium brown (Bb)
- light brown (bb)

The crabs' color is controlled by incomplete dominance.

An introduced crab predator favors medium brown crabs, while avoiding the dark brown and light brown crabs. Predict how this selection pressure will affect the relative frequencies of the *B* and *b* alleles in future generations of crabs. Assume all other selection pressures remain the same, and that there is no migration of crabs into or out of the population.

Move a prediction label into the blank box next to each allele.

- Move only **one** label into each blank box.
- You do **not** need to use all the labels.



Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

For this item, a full-credit response includes:

- "No change" placed next to "*B* allele";
  AND
- "No change" placed next to "*b* allele" (1 point).

Alignment

Content Strand
Evolution

Content Statement
Diversity of Life

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. Misconceptions about population growth capacity, interspecies and intra-species competition for resources, and what occurs when a species immigrates to or emigrates from ecosystems are included in this topic. Technology must be used to access real-time/authentic data to study population changes and growth in specific locations.

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 use knowledge of incomplete dominance to predict the changes in allele frequencies in a population. Since the heterozygous condition of medium brown (Bb) is being selected by predation, there is a 1:1 reduction in the alleles. Therefore, the relative frequencies would not change.

Biology
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Question 20

Sample Responses

Sample Response: 1 point

A population of stone crabs is composed equally of three phenotypes:

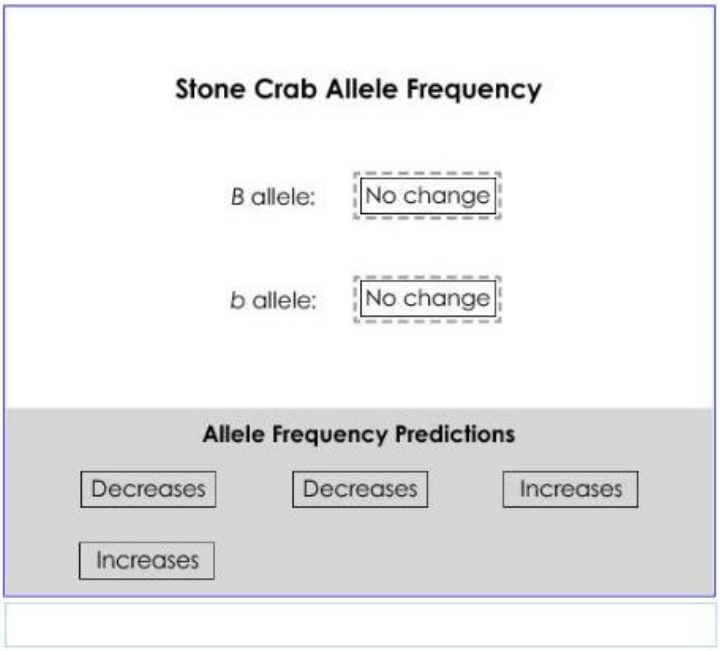
- dark brown (BB)
- medium brown (Bb)
- light brown (bb)

The crabs' color is controlled by incomplete dominance.

An introduced crab predator favors medium brown crabs, while avoiding the dark brown and light brown crabs. Predict how this selection pressure will affect the relative frequencies of the *B* and *b* alleles in future generations of crabs. Assume all other selection pressures remain the same, and that there is no migration of crabs into or out of the population.

Move a prediction label into the blank box next to each allele.

- Move only **one** label into each blank box.
- You do **not** need to use all the labels.



Notes on Scoring

This response earns full credit (1 point) because the student correctly places "No change" next to "*B* allele," and "No change" next to "*b* allele."

Sample Response: 0 points

A population of stone crabs is composed equally of three phenotypes:

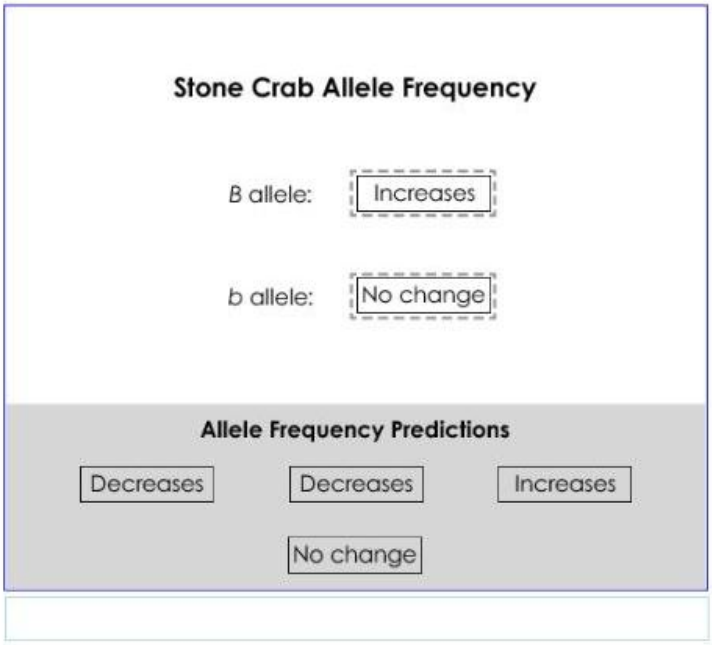
- dark brown (BB)
- medium brown (Bb)
- light brown (bb)

The crabs' color is controlled by incomplete dominance.

An introduced crab predator favors medium brown crabs, while avoiding the dark brown and light brown crabs. Predict how this selection pressure will affect the relative frequencies of the *B* and *b* alleles in future generations of crabs. Assume all other selection pressures remain the same, and that there is no migration of crabs into or out of the population.

Move a prediction label into the blank box next to each allele.

- Move only **one** label into each blank box.
- You do **not** need to use all the labels.



Notes on Scoring

This response earns no credit (0 points) because the student incorrectly places "Increases" next to "*B* allele." "*B* allele" would stay the same, not increase.

Biology
Spring 2016 Item Release

Question 21

Question and Scoring Guidelines

Question 21

Rabbits were introduced to Australia in the 1800s. They rapidly overpopulated because they had few natural predators in the area. To control their population, scientists introduced a rabbit-specific virus into the population, and their numbers greatly decreased. However, after several generations, the rabbit population began to increase again.

Which statement explains the new increase in the number of rabbits?

(A) The rabbits interbred with native rabbit species.

(B) Some of the rabbits had a natural immunity to the virus.

(C) Some of the rabbits learned to survive even though they were sick.

(D) The rabbits were able to have more offspring by changing their reproductive cycles.

Points Possible: 1

See **Alignment** for more detail.

Scoring Guidelines

Rationale for Option A: This is incorrect. According to the given information, rabbits were introduced to Australia; therefore, there are no native rabbit species with which to breed.

Rationale for Option B: **Key** – Rabbits with the advantageous characteristic of being immune or partially immune to the virus would be able to survive and reproduce, passing this advantage to their offspring. The population of rabbits would begin to increase again.

Rationale for Option C: This is incorrect. An organism cannot "learn" to survive a disease or infection.

Rationale for Option D: This is incorrect. Organisms cannot change their reproductive cycles at will.

Alignment

Content Strand
Evolution

Content Statement
Diversity of Life

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. Misconceptions about population growth capacity, interspecies and intra-species competition for resources, and what occurs when a species immigrates to or emigrates from ecosystems are included in this topic. Technology must be used to access real-time/authentic data to study population changes and growth in specific locations.

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 understand how genetic variation within a species can enable individuals with advantageous characteristics to survive. The process of natural selection requires a trait (e.g., resistance to a virus) to exist within a population. It is the exhibition of this trait that provides the advantage that allows individuals with the trait to reach reproductive age. These individuals then produce more offspring than the individuals without the trait, which increases the frequency of the trait within the population. In this example, the viral resistance offered an advantage in the changing environment, allowing those rabbits to out-reproduce the rabbits without the trait.

Sample Response: 1 point

Rabbits were introduced to Australia in the 1800s. They rapidly overpopulated because they had few natural predators in the area. To control their population, scientists introduced a rabbit-specific virus into the population, and their numbers greatly decreased. However, after several generations, the rabbit population began to increase again.

Which statement explains the new increase in the number of rabbits?

- (A) The rabbits interbred with native rabbit species.
- ● Some of the rabbits had a natural immunity to the virus.
- (C) Some of the rabbits learned to survive even though they were sick.
- (D) The rabbits were able to have more offspring by changing their reproductive cycles.