

*Release of Spring 2022
MCAS Test Items
from the
High School Biology
Paper-Based Test*

**July 2022
Massachusetts Department of
Elementary and Secondary Education**



This document was prepared by the
Massachusetts Department of Elementary and Secondary Education
Jeffrey C. Riley
Commissioner

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Massachusetts Department of Elementary and Secondary Education
75 Pleasant Street, Malden, MA 02148-4906
Phone 781-338-3000 TTY: N.E.T. Relay 800-439-2370
www.doe.mass.edu



Overview of High School Biology Test

The spring 2022 high school Biology test was a next-generation assessment that was administered in two primary formats: a computer-based version and a paper-based version. The vast majority of students took the computer-based test. The paper-based test was offered as an accommodation for students with disabilities who are unable to use a computer, as well as for English learners who are new to the country and are unfamiliar with technology.

Most of the operational items on the high school Biology test were the same, regardless of whether a student took the computer-based version or the paper-based version. In places where a technology-enhanced item was used on the computer-based test, an adapted version of the item was created for use on the paper test. These adapted paper items were multiple-choice or multiple-select items that tested the same STE content and assessed the same standard as the technology-enhanced item.

This document displays released items from the paper-based test. Released items from the computer-based test are available on the MCAS Resource Center website at mcas.pearsonsupport.com/released-items.

Test Sessions and Content Overview

The high school Biology test was made up of two separate test sessions. Each session included selected-response questions and constructed-response questions. On the paper-based test, the selected-response questions were multiple-choice items and multiple-select items, in which students select the correct answer(s) from among several answer options.

Standards and Reporting Categories

The high school Biology test was based on learning standards in the April 2016 version of the *Massachusetts Science and Technology/Engineering Curriculum Framework*. These standards are grouped under the four content reporting categories listed below.

- Molecules to Organisms
- Heredity
- Evolution
- Ecosystems

The 2016 *Massachusetts Science and Technology/Engineering Curriculum Framework* is available on the Department website at www.doe.mass.edu/frameworks/current.html.

Some items on the high school Biology test are also reported as aligning to one of three MCAS Science and Engineering Practice Categories. The three practice categories are listed below.

- Practice Category A: Investigations and Questioning
- Practice Category B: Mathematics and Data
- Practice Category C: Evidence, Reasoning, and Modeling

More information about the practice categories is available on the Department website at www.doe.mass.edu/mcas/tdd/practice-categories.html.

The table at the conclusion of this document provides the following information about each released operational item: reporting category, standard covered, practice category covered (if any), item type, and item description. The correct answers for released selected-response questions are also displayed in the table.

Reference Materials

Each student taking the paper-based version of the high school Biology test had sole access to a calculator.

During both high school Biology test sessions, the use of bilingual word-to-word dictionaries was allowed for current and former English learner students.

High School Biology

SESSION 1

This session contains 21 questions.

Directions

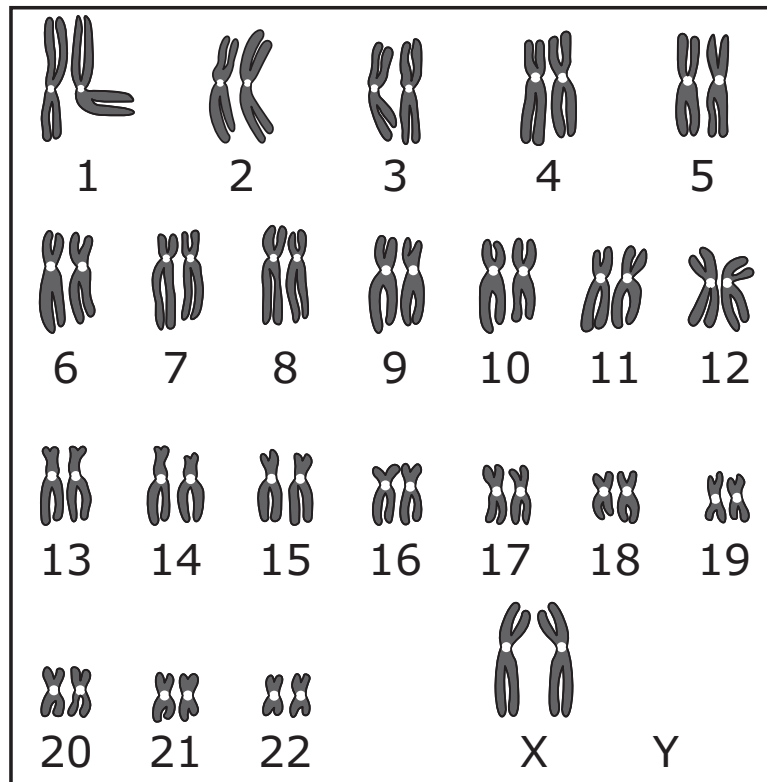
Read each question carefully and then answer it as well as you can. You must record all answers in this Test & Answer Booklet.

For some questions, you will mark your answers by filling in the circles in your Test & Answer Booklet. Make sure you darken the circles completely. Do not make any marks outside of the circles. If you need to change an answer, be sure to erase your first answer completely.

If a question asks you to show or explain your work, you must do so to receive full credit. Write your response in the space provided. Only responses written within the provided space will be scored.

- 1** Scientists are studying a drug to see how effective it is at reducing the production of usable energy in cells. What should the scientists measure to determine whether the drug is effective?
- Ⓐ the amount of ATP in cells
 - Ⓑ the amount of RNA in cells
 - Ⓒ the number of new cells produced by old cells
 - Ⓓ the number of nerve signals produced by cells

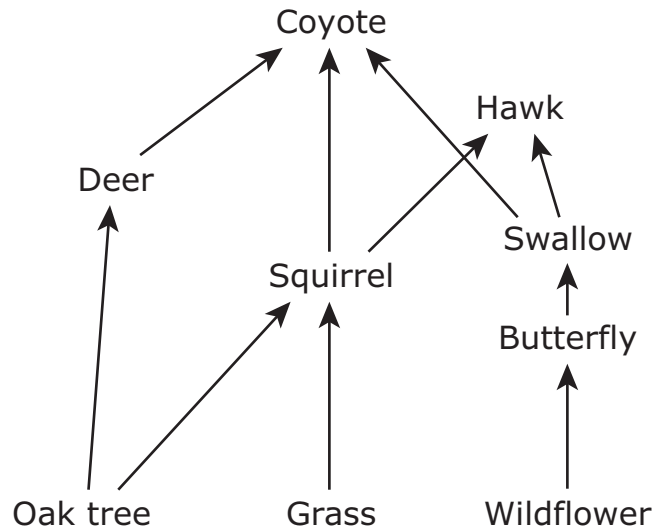
- 2 The karyotype diagram shows a full set of human chromosomes.



Which of the following describes the karyotype diagram?

- Ⓐ The karyotype diagram shows the diploid number of chromosomes that would be found in gametes of a human female.
- Ⓑ The karyotype diagram shows the haploid number of chromosomes that would be found in gametes of a human female.
- Ⓒ The karyotype diagram shows the diploid number of chromosomes that would be found in body cells of a human female.
- Ⓓ The karyotype diagram shows the haploid number of chromosomes that would be found in body cells of a human female.

- 3 Kudzu is an invasive plant that can grow as much as one foot in a day. A partial food web for an ecosystem is shown. Suppose kudzu invades this ecosystem.



Select the **three** organisms that would most likely compete with kudzu in this ecosystem.

- Ⓐ butterfly
- Ⓑ coyote
- Ⓒ deer
- Ⓓ grass
- Ⓔ hawk
- Ⓕ oak tree
- Ⓖ squirrel
- Ⓗ swallow
- Ⓘ wildflower

- 4 A student created a model of a DNA sequence and its mRNA transcript, as shown.

DNA 3'–AGC CGT ATC–5'
mRNA 5'–TCG GCA TAG–3'

Another student found a mistake in the model.

Which of the following best describes how to correct the model?

- Ⓐ The thymine (T) nucleotides in the mRNA transcript should be replaced with uracil (U) nucleotides.
- Ⓑ The adenine (A) nucleotides in the mRNA transcript should be replaced with thymine (T) nucleotides.
- Ⓒ The thymine (T) nucleotides in the mRNA transcript should be replaced with cytosine (C) nucleotides.
- Ⓓ The cytosine (C) nucleotides in the mRNA transcript should be replaced with guanine (G) nucleotides.

- 5 The cell cycle includes the phases interphase, mitosis, and cytokinesis.

Which of the following tables correctly shows the description of each phase of the cell cycle?

Ⓐ Phases of the Cell Cycle

Interphase	Cell membranes form to divide a cell into two cells.
Mitosis	Chromosomes of a cell separate.
Cytokinesis	A cell develops and grows.

Ⓑ Phases of the Cell Cycle

Interphase	A cell develops and grows.
Mitosis	Cell membranes form to divide a cell into two cells.
Cytokinesis	Chromosomes of a cell separate.

Ⓒ Phases of the Cell Cycle

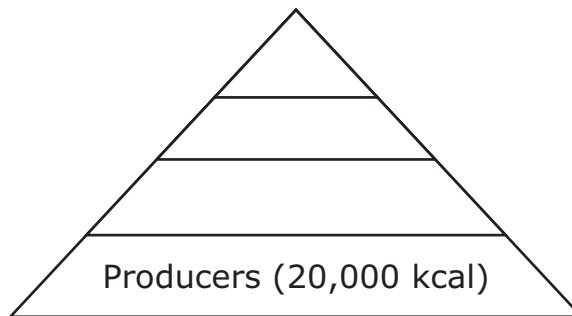
Interphase	A cell develops and grows.
Mitosis	Chromosomes of a cell separate.
Cytokinesis	Cell membranes form to divide a cell into two cells.

Ⓓ Phases of the Cell Cycle

Interphase	Chromosomes of a cell separate.
Mitosis	Cell membranes form to divide a cell into two cells.
Cytokinesis	A cell develops and grows.

This question has two parts.

- 6 An energy pyramid for an ecosystem is shown.



Part A

Based on the energy pyramid, how much energy would be stored in the tertiary consumers in this ecosystem?

- Ⓐ 2,000 kcal
- Ⓑ 200 kcal
- Ⓒ 20 kcal
- Ⓓ 2 kcal

Part B

Select **two** factors that are responsible for the inefficiency of energy transfer from one trophic level to another.

- Ⓐ Carnivores obtain energy from consumers only.
- Ⓑ Organisms lose energy to the environment as heat.
- Ⓒ Some parts of organisms are not eaten by consumers.
- Ⓓ Omnivores get energy from producers and consumers.

- 7 Which of the following **best** explains why bacteria are able to adapt to changing environmental conditions?
- Ⓐ Bacteria have DNA that rarely mutates in the population.
 - Ⓑ Bacteria reproduce rapidly, allowing mutations to increase in the population.
 - Ⓒ Bacteria reproduce asexually, causing little genetic variation in the population.
 - Ⓓ Bacteria exchange genetic material, which increases the number of chromosomes in the population.

- 8 Carbon cycles through living and nonliving parts of the environment. Three of the processes involved in the carbon cycle are photosynthesis, cellular respiration, and combustion.

Which of the following tables correctly identifies whether each process releases carbon to the environment or stores carbon as biomass?

Ⓐ

Releases Carbon	Stores Carbon
photosynthesis	cellular respiration
combustion	

Ⓑ

Releases Carbon	Stores Carbon
cellular respiration	photosynthesis
combustion	

Ⓒ

Releases Carbon	Stores Carbon
photosynthesis	cellular respiration
	combustion

Ⓓ

Releases Carbon	Stores Carbon
cellular respiration	photosynthesis
	combustion

- 9 Students learning about the respiratory system collected data on the gases inhaled and exhaled by a classmate. The table shows the data collected.

Gas	Percent in Inhaled Air	Percent in Exhaled Air
oxygen	21	16
carbon dioxide	0.04	4
nitrogen	79	79

Which of the following best explains the data in the table?

- Ⓐ The nose filters out nitrogen gas so only oxygen and carbon dioxide gases enter the lungs.
- Ⓑ The walls of the trachea allow only carbon dioxide gas and nitrogen gas to move out of the body.
- Ⓒ As air enters the larynx, it is warmed, causing some oxygen gas to be converted to carbon dioxide gas.
- Ⓓ As air enters the alveoli, some oxygen moves into the blood and some carbon dioxide moves out of the blood.

- 10 A Siamese cat has both dark and light fur on its body, as shown. The production of the protein that determines fur color is dependent upon temperature. The fur on the body of the cat is lighter colored because its body is warmer than its head, feet, and tail.



Which of the following **best** describes how fur color is determined in a Siamese cat?

- Ⓐ Fur color is determined only by genes and RNA sequences that code for temperature.
- Ⓑ Fur color is determined by proteins from the environment and the temperature of the genes.
- Ⓒ Fur color is determined by a gene that codes for a protein and by the temperature of the environment.
- Ⓓ Fur color is determined only by environmental factors that include genes and the temperature of the cat.

- 11 Some mammals do not have enamel on their teeth, but they have copies of a gene that helps regulate enamel formation. The gene is mutated so that enamel is not produced.

Which of the following **best** explains why these mammals have copies of a gene that codes for enamel?

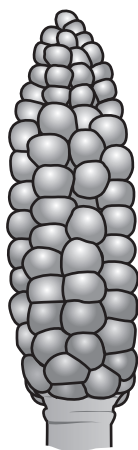
- Ⓐ These mammals are going to evolve to have extra copies of the gene in the future.
- Ⓑ These mammals might need to repair the gene and produce enamel if their current diet changes.
- Ⓒ These mammals would be in danger of becoming extinct without high gene diversity in their populations.
- Ⓓ These mammals are descended from mammals with enamel on their teeth and functional copies of the gene.

The following section focuses on the domestication of corn.

Read the information below and use it to answer the selected-response questions and constructed-response question that follow.

Corn is one of the most important crops grown in the United States. Corn, which is mostly starch, is used as a food source for humans and other animals.

Humans first developed corn as a food crop over 8000 years ago. These early farmers produced corn by selectively breeding a wild grass called teosinte. The kernels of teosinte have a hard coating that makes them difficult for humans to eat. A key step in developing corn as a food crop was selecting individual plants that produced kernels without this coating so that they could more easily be used as a food source. The illustrations show the kernels on an ear of corn and the kernels on an ear of teosinte.



Corn



Teosinte

Corn and teosinte share the scientific name *Zea mays*. A single gene with two alleles codes for kernel coating (**H**) or no kernel coating (**h**) in *Zea mays*. To determine the inheritance pattern of this gene, scientists crossed teosinte that is true-breeding (homozygous) for kernel coating and domestic corn that is true-breeding for no kernel coating to produce offspring with partially formed kernel coatings. The three phenotypes and their genotypes are shown in the table.

Phenotype	Genotype
kernel coating	HH
no kernel coating	hh
partially formed kernel coating	Hh

- 12 A student claims that the inheritance pattern for kernel coating is incomplete dominance.

Which of the following pieces of evidence **best** supports the student's claim?

- Ⓐ Corn and teosinte share the scientific name *Zea mays*.
- Ⓑ Early farmers produced corn by selectively breeding teosinte.
- Ⓒ A single gene with two alleles codes for the presence or absence of kernel coating in *Zea mays*.
- Ⓓ The cross between domestic corn and teosinte produced offspring with partially formed kernel coatings.

- 13 Scientists crossed true-breeding corn and true-breeding teosinte to determine whether the plants produce fertile offspring. Which of the following questions was this experiment designed to answer?

- Ⓐ Are corn and teosinte different species?
- Ⓑ Do corn and teosinte both use seeds to reproduce?
- Ⓒ Can corn and teosinte plants grow in similar environments?
- Ⓓ Do corn plants contain more dominant alleles than teosinte plants do?

- 14 An insect called the European corn borer can reduce the amount of corn from corn crops. To protect corn from this insect, scientists genetically modified corn plants. The scientists inserted a gene into the genome of corn plants. The gene codes for the production of a toxin that can kill the corn borer.

What will **most likely** happen within the corn borer population over time?

- Ⓐ Corn borers will produce new genes and will become less common.
- Ⓑ Corn borers that can reproduce asexually will become more common.
- Ⓒ Corn borers that start eating other insects to avoid the toxin will become less common.
- Ⓓ Corn borers with resistance to the toxin will survive to reproduce and will become more common.

This question has two parts.

- 15** Scientists studied reproduction in corn and teosinte.

Part A

Select **two** types of cells that combine to produce offspring when a corn plant is crossed with a teosinte plant.

- Ⓐ egg
- Ⓑ leaf
- Ⓒ root
- Ⓓ stem
- Ⓔ sperm

Part B

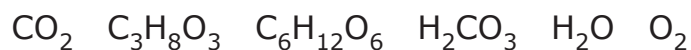
Corn kernels are fertilized seeds that develop into corn plants after they are planted. How does the number of chromosomes in a corn kernel cell compare to the number of chromosomes in the body cell of a corn plant?

- Ⓐ A corn kernel cell has half as many chromosomes as the body cell because the kernel is a gamete.
- Ⓑ A corn kernel cell has the same number of chromosomes as the body cell because the kernel developed from a zygote.
- Ⓒ A corn kernel cell has twice as many chromosomes as the body cell because the kernel developed from two corn plants.
- Ⓓ A corn kernel cell has no chromosomes and the body cell has a full set of chromosomes because chromosomes are produced as the corn plant grows.

This question has three parts. Write your response on the next page. Be sure to label each part of your response.

16 Corn plants produce their own food through a chemical process.

A. Using the chemical symbols below, complete the equation on the next page to show the chemical reaction corn plants use to make food. Each chemical symbol may be used once or not at all.



B. Identify the source that provides energy for the chemical reaction in Part A to occur.

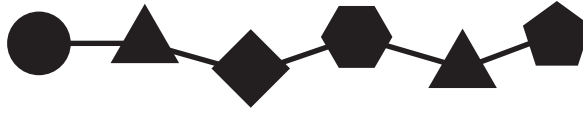
C. Describe how human cells use the products from the chemical reaction in Part A. Be sure to include the process that occurs at the cellular level.

16

A.

6 + 6 \rightarrow + 6

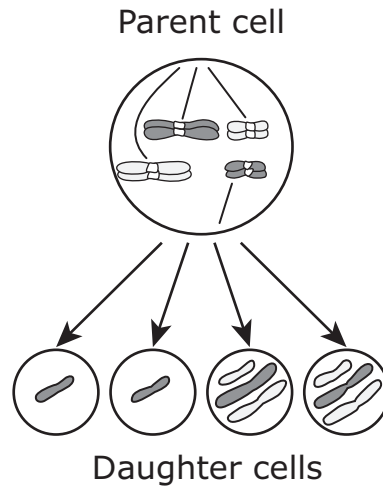
- 17 The diagram represents a chain of amino acids. The different shapes represent different amino acids.



A scientist wants to produce a single strand of DNA that codes for this amino acid chain. How many nucleotides will be in the DNA that the scientist produces?

- Ⓐ 5 nucleotides
- Ⓑ 6 nucleotides
- Ⓒ 12 nucleotides
- Ⓓ 18 nucleotides

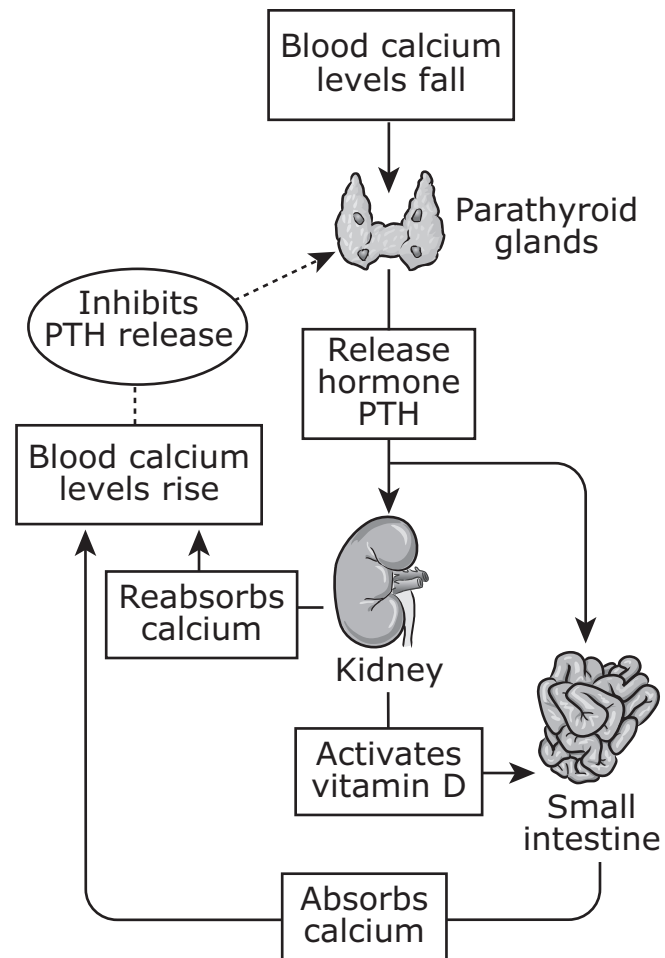
- 18 A scientist is studying the stages of meiosis in a cell that has two pairs of chromosomes. The diagram shows a parent cell and four daughter cells formed after meiosis.



Which of the following **best** explains what occurred in this parent cell?

- Ⓐ Abnormal meiosis occurred because half of the daughter cells are haploid and half of the daughter cells are diploid.
- Ⓑ Abnormal meiosis occurred because some daughter cells received more chromosomes than the other daughter cells.
- Ⓒ Normal meiosis occurred because some daughter cells received more dominant genes than the other daughter cells.
- Ⓓ Normal meiosis occurred because half of the daughter cells became egg cells and half of the daughter cells became sperm cells.

- 19 The diagram shows a feedback loop in the human body that helps maintain homeostasis.



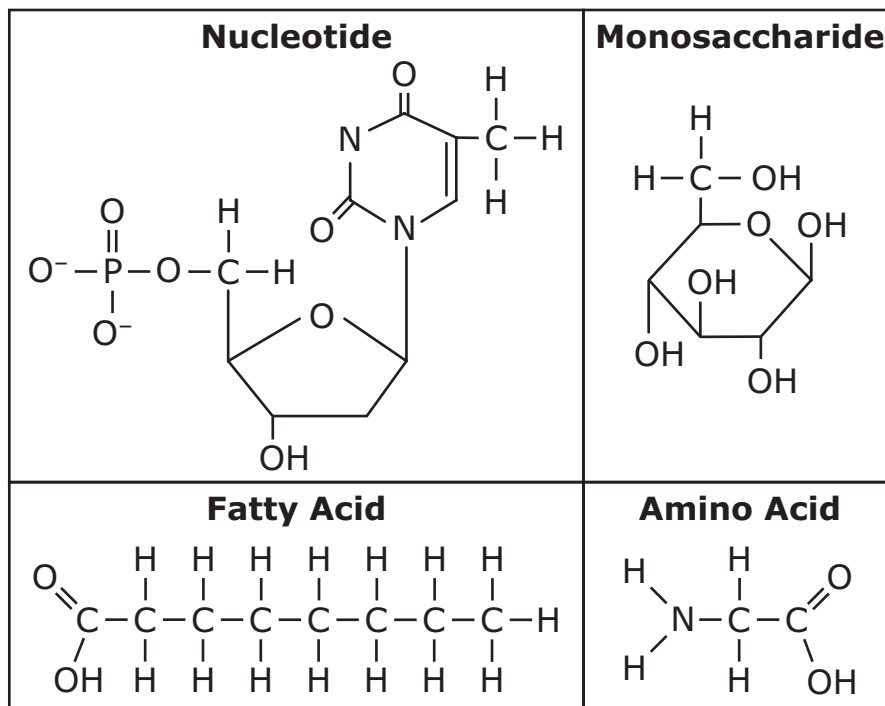
Which of the following is the **most likely** function of this feedback loop?

- Ⓐ conversion of calcium to PTH
- Ⓑ storage of calcium in the kidney
- Ⓒ regulation of calcium levels in the blood
- Ⓓ breakdown of calcium in the small intestine

This question has three parts. Write your response on the next page. Be sure to label each part of your response.

- 20 The diagram shows four monomers that make up organic macromolecules.

Monomers



- Identify the monomer that makes up carbohydrates. Describe one way cells use carbohydrates.
- Identify the monomer that makes up nucleic acids. Describe one way cells use nucleic acids.
- Identify the monomer that makes up lipids. Describe one way cells use lipids.

20

This question has four parts. Write your response on the next page. Be sure to label each part of your response.

- 21** A man and a woman plan to have a biological child. They want to determine the likelihood that their child will inherit a genetic condition that runs in both of their families. One gene with two alleles is responsible for the condition. The dominant allele (**A**) produces the normal phenotype, and the recessive allele (**a**) produces the genetic condition. Both the man and the woman have the normal phenotype.

- A. Using the allele symbols **A** and **a**, identify **all** possible genotypes of the man and **all** possible genotypes of the woman for this genetic condition.
- B. Using the allele symbols **A** and **a**, complete the Punnett square in Part B on the next page to show how the man and the woman can have a biological child with this genetic condition. Identify the percentage of offspring that are expected to have the genetic condition based on this Punnett square.

- C. After doing some research, they determine the genetic condition is X-linked.

Using the allele pairs **X^AX^A**, **X^AX^a**, **X^aX^a**, **X^AY**, and **X^aY**, identify **all** possible genotypes of the man and **all** possible genotypes of the woman. Each allele pair may be used once, more than once, or not at all.

- D. Complete the Punnett square in Part D on the next page with the parental genotypes identified in Part C that could produce a child with this X-linked genetic condition. Identify the percentage of males that are expected to have the genetic condition based on this Punnett square.

21

A.

B.

Percentage of offspring
expected to have
the genetic condition: _____

C.

Man:

Woman:

D.

Percentage of males
expected to have
the genetic condition: _____

High School Biology

SESSION 2

This session contains 21 questions.

Directions

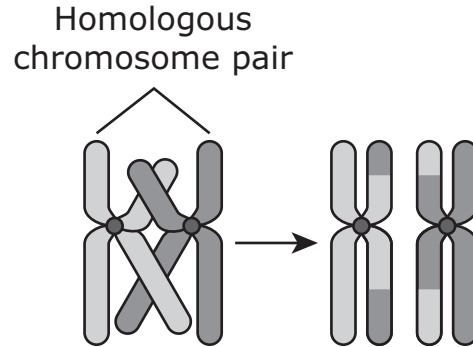
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- 22** Which of the following describes how diffusion helps maintain homeostasis in the body?
- Ⓐ Diffusion moves oxygen within nuclei to allow oxygen to be used by cells.
 - Ⓑ Diffusion moves oxygen within nuclei to allow oxygen to be removed by cells.
 - Ⓒ Diffusion moves oxygen across cell membranes to allow oxygen to be used by cells.
 - Ⓓ Diffusion moves oxygen across cell membranes to allow oxygen to be removed by cells.

- 23 The diagram represents the process of crossing over.



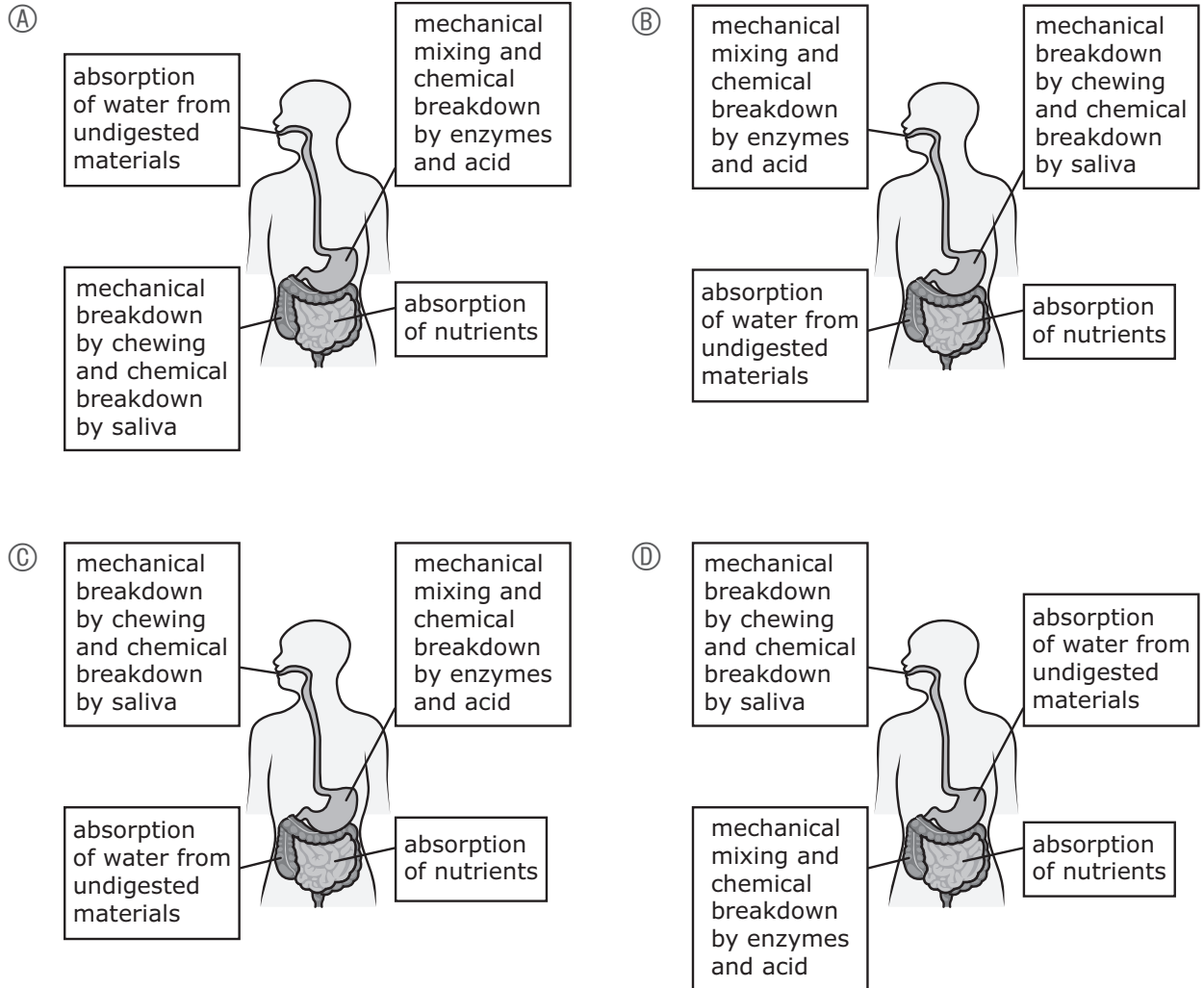
The diagram supports the claim that crossing over

- Ⓐ increases genetic variability.
- Ⓑ decreases genetic variability.
- Ⓒ maintains genetic variability.

What evidence from the diagram supports this claim?

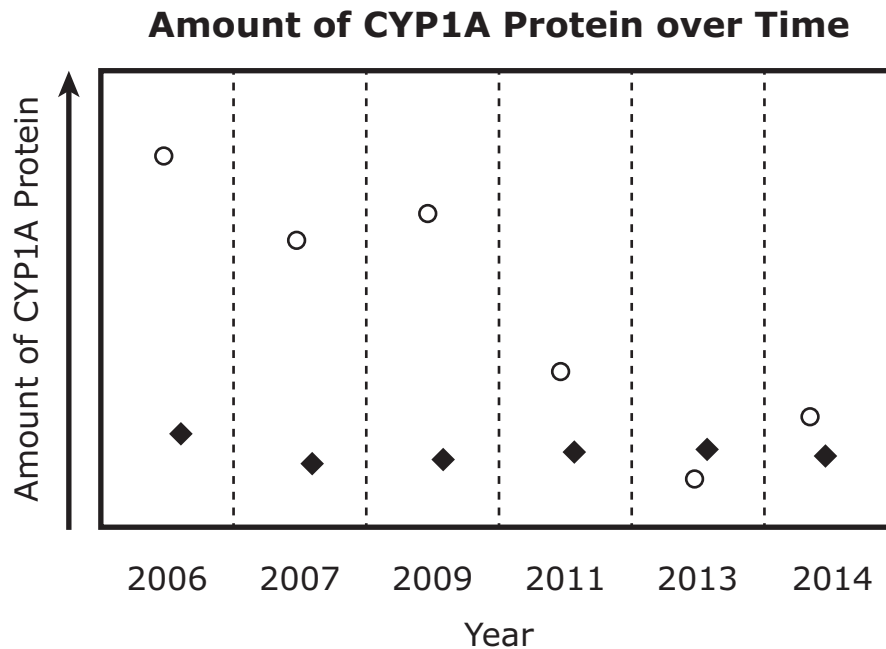
- Ⓐ Homologous chromosomes line up next to each other during crossing over.
- Ⓑ Homologous chromosomes exchange genetic material during crossing over.
- Ⓒ Homologous chromosomes become attached to each other during crossing over.

- 24 A student is building a model of the digestive system. Which of the following models correctly describes the primary digestive function of each structure?



This question has two parts.

- 25 CYP1A is a protein in organisms that breaks down toxic substances such as those found in oil. The amount of CYP1A protein in an organism depends on the expression of the *CYP1A* gene. Prior to 2006, there was a large oil spill off the coast of Alaska that affected many organisms. From 2006 to 2014, scientists measured the amount of CYP1A protein in ducks sampled from two populations. One population was exposed to oil from the spill, and the other population was not exposed to oil. The results are shown.



Key	
○	Ducks exposed to oil
◆	Ducks not exposed to oil

Part A

Which of the following best compares the amount of CYP1A protein in ducks exposed to oil to the amount in ducks not exposed to oil between 2006 and 2009?

- Ⓐ The ducks exposed to oil had a lower amount of CYP1A protein.
- Ⓑ The ducks exposed to oil had a higher amount of CYP1A protein.
- Ⓒ The ducks exposed to oil had the same amount of CYP1A protein.

Which of the following best compares the amount of CYP1A protein in ducks exposed to oil in 2014 to the amount in ducks exposed to oil in 2006?

- Ⓐ The amount of CYP1A protein in ducks exposed to oil was lower in 2014 because the amount of oil in the environment decreased.
- Ⓑ The amount of CYP1A protein in ducks exposed to oil was higher in 2014 because the amount of oil in the environment increased.
- Ⓒ The amount of CYP1A protein in ducks exposed to oil was the same because the amount of oil in the environment stayed the same.

Part B

The *CYP1A* gene codes for the CYP1A protein.

How is mRNA produced from the *CYP1A* gene?

- Ⓐ The *CYP1A* gene is replicated into mRNA.
- Ⓑ The *CYP1A* gene is translated into mRNA.
- Ⓒ The *CYP1A* gene is transcribed into mRNA.

How is the CYP1A protein produced from the mRNA?

- Ⓐ The mRNA is replicated to produce the CYP1A protein.
- Ⓑ The mRNA is translated to produce the CYP1A protein.
- Ⓒ The mRNA is transcribed to produce the CYP1A protein.

- 26 Most people are born with two kidneys. However, it is possible to live with only one kidney. Doctors recommend that people with one kidney have their urine tested at least once a year.

Which of the following are doctors **most likely** trying to determine when testing the urine of a person with only one kidney?

- Ⓐ that enough nutrients are dissolving in the blood
- Ⓑ that enough oxygen is being delivered throughout the body
- Ⓒ that enough red blood cells are being replaced in the blood
- Ⓓ that enough nitrogenous waste is being removed from the body

- 27 Table 1 shows a section of DNA and the same section after four different single-base mutations.

Table 1. Examples of Single-Base Mutations

Original DNA Strand	TAC GCC AAC GTG
Mutation 1	TAC GCC ATA CGT G
Mutation 2	TAC GCC ACG TG
Mutation 3	TAC GCC AAT GTG
Mutation 4	TAC GCC AAG GTG

Table 2 shows mRNA codons that code for some amino acids.

Table 2. mRNA Codons for Some Amino Acids

mRNA Codon	Amino Acid
AAC	Asn
AAG	Lys
AUG	Met
CAC	His
CGG	Arg
GCC	Ala
UUA	Leu
UUC	Phe
UUG	Leu

Which mutation would leave the phenotype of the organism unchanged?

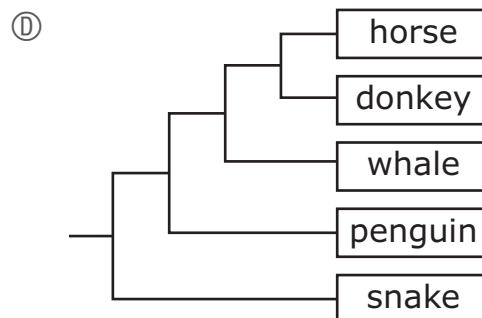
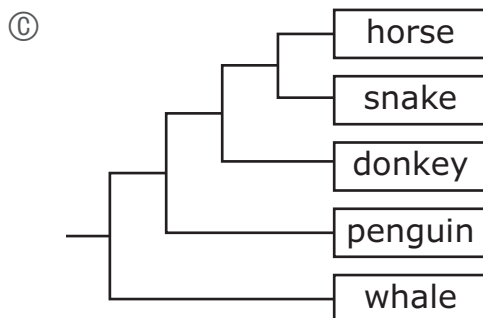
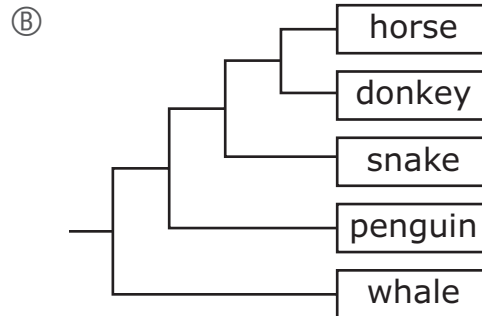
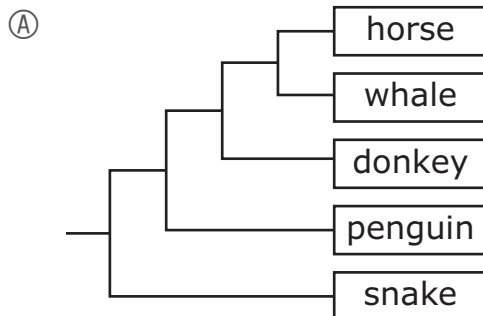
- Ⓐ mutation 1
- Ⓑ mutation 2
- Ⓒ mutation 3
- Ⓓ mutation 4

- 28 The amino acid sequence of a certain protein in a horse was compared to the amino acid sequence of the same protein in four other animals. The results of those comparisons are shown in the table.

Differences in Amino Acids

Animals Compared	Number of Amino Acids That Differ
horse and donkey	1
horse and penguin	13
horse and snake	21
horse and whale	5

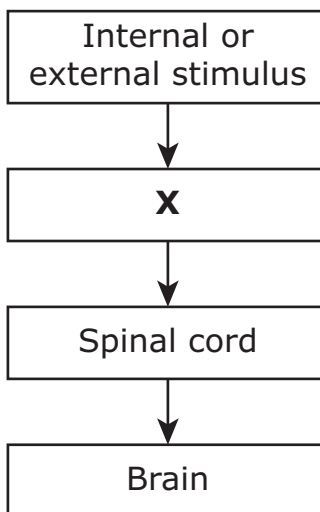
Based on the results, which diagram best shows the evolutionary relationships among these animals?



- 29** In a sample of double-stranded DNA, 20% of the nitrogenous bases are adenine (A). What percentage of the nitrogenous bases in the sample are cytosine (C)?
- Ⓐ 10%
 - Ⓑ 30%
 - Ⓒ 60%
 - Ⓓ 80%
- 30** Scientists have determined that the African savannah elephant and the African forest elephant are likely different species. Which of the following would provide the best evidence that the two types of elephant are different species?
- Ⓐ comparing the diet of each type of elephant
 - Ⓑ comparing the size of each type of elephant
 - Ⓒ comparing the habitat of each type of elephant
 - Ⓓ comparing the genome of each type of elephant

- 31 A lichen is made up of an alga and a fungus. Which of the following provides the **best** evidence that the relationship between the alga and the fungus in the lichen is mutualistic?
- Ⓐ The alga and the fungus belong to different kingdoms.
 - Ⓑ The alga and the fungus both require moist environments.
 - Ⓒ The alga is a simple unicellular organism, and the fungus is a complex multicellular organism.
 - Ⓓ The alga provides sugars for the fungus, and the fungus provides structure and protection for the alga.

- 32 The diagram shows a pathway in the human body.



Which structure is most likely represented by the **X** in the pathway?

- Ⓐ blood vessel
- Ⓑ endocrine gland
- Ⓒ sensory neuron
- Ⓓ smooth muscle

The following section focuses on white-nose syndrome in bats.

Read the information below and use it to answer the selected-response questions and constructed-response question that follow.

In North America, the populations of six species of bats have decreased by up to 99% since 2006. These decreases in population sizes are largely due to white-nose syndrome (WNS). WNS is caused by a fungus that infects the skin on bats' wings, ears, and noses. The infected skin, which often appears white, loses more water than healthy, normal skin.

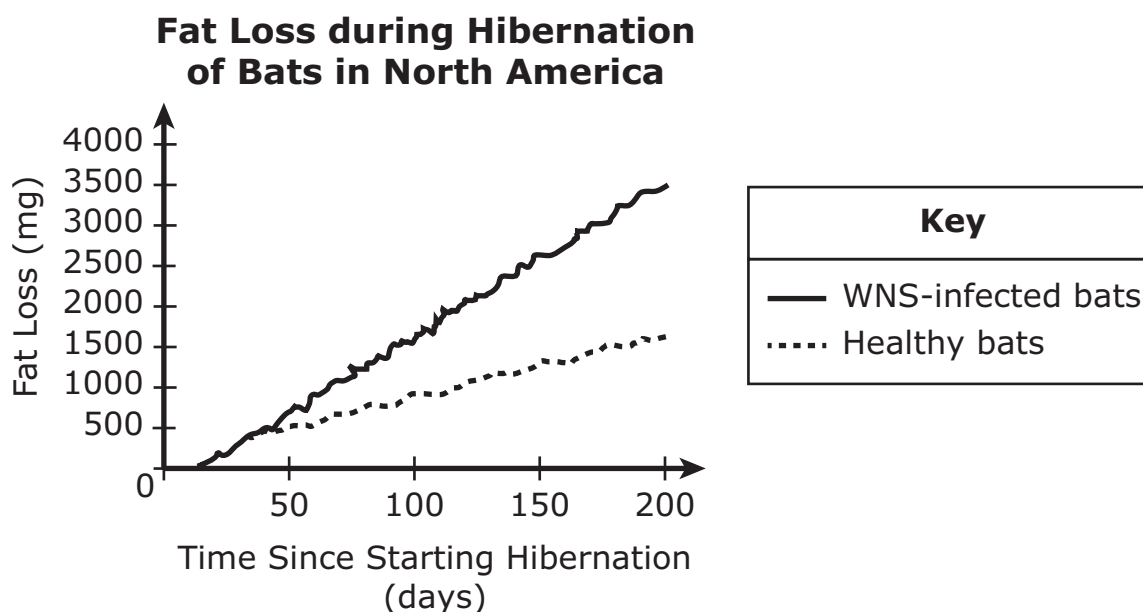
One species of bat affected by WNS is the little brown bat. This bat has a very small mass (about 14 g) and hunts for flying insects at night. Females typically give birth to one offspring per year.

In preparation for winter, little brown bats eat more insects to build up fat reserves in their bodies. In winter, they hibernate, which decreases body temperature, breathing rate, and metabolic rate. The bats do not eat while they are hibernating.

Little brown bats typically wake up only for brief periods of time during hibernation. When a bat does wake up, its body temperature increases as it flies around.

WNS affects the number of times that a bat wakes up during hibernation. Healthy bats wake up once every 20 days, and about 80% survive hibernation. Bats infected with WNS wake up once every 9 days, and only about 4% survive hibernation.

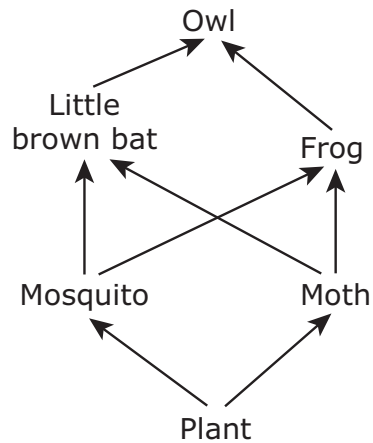
The graph shows the amount of fat lost during hibernation in healthy bats and in WNS-infected bats in North America.



- 33** During hibernation, how does the energy use of infected bats compare with the energy use of healthy bats?
- Ⓐ Infected bats use less energy than healthy bats because healthy bats have more periods of activity.
 - Ⓑ Infected bats use less energy than healthy bats because healthy bats generate ATP to produce body fat.
 - Ⓒ Infected bats use more energy than healthy bats because infected bats have more periods of activity.
 - Ⓓ Infected bats use more energy than healthy bats because infected bats generate ATP to produce body fat.
- 34** WNS causes damage to tissue on the wings, ears, and noses of bats. Which of the following processes most directly helps repair this damaged tissue?
- Ⓐ active transport
 - Ⓑ lipid storage
 - Ⓒ meiosis
 - Ⓓ mitosis
- 35** Which of the following could explain why a little brown bat population is slow to recover after many bats in the population die during an outbreak of WNS?
- Ⓐ The bats have a low birth rate.
 - Ⓑ The emigration rate of the bats decreases.
 - Ⓒ The immigration rates of bat predators decrease.
 - Ⓓ The flying insects that the bats eat have low death rates.

This question has two parts.

- 36 A partial food web for the little brown bat's ecosystem is shown.



Part A

According to the food web, little brown bats belong to which of the following trophic levels?

- Ⓐ producers
- Ⓑ primary consumers
- Ⓒ secondary consumers
- Ⓓ tertiary consumers

Part B

A decrease in the population size of which of the following organisms would **most** directly reduce the bats' ability to survive hibernation?

- Ⓐ frog
- Ⓑ moth
- Ⓒ owl
- Ⓓ plant

This question has two parts. Write your response on the next page. Be sure to label each part of your response.

- 37** The death rates of bats in North America are very high due to WNS.
- A. Describe how the genetic diversity of North American bats has most likely changed (increased, decreased, or stayed the same) since 2006. Explain your reasoning.
 - B. In a population of little brown bats infected with WNS, scientists found some bats that are resistant to WNS. Resistance to WNS may be inherited. If resistance to WNS is an inherited trait, will the trait increase, decrease, or stay the same in the population over time? Explain your reasoning using your knowledge of natural selection.

37

- 38** A scientist isolates a substance that is thought to be an enzyme. An experiment designed to answer which of the following questions would best determine whether the substance is an enzyme?
- Ⓐ Is the substance made of monosaccharides?
 - Ⓑ Can the substance easily move across a cell membrane?
 - Ⓒ Does the synthesis of the substance require the conversion of ATP to ADP?
 - Ⓓ Does the substance decrease the amount of time it takes for a reaction to take place?

- 39** A scientist is trying to develop a wheat plant that tolerates cold temperatures and is resistant to insect pests. The scientist has identified two types of wheat to cross-pollinate. One type has traits that make it tolerant of cold weather. The other type has traits that make it resistant to many insects.

Which of the following explains why the process of meiosis is important to the scientist's work?

- Ⓐ Meiosis reduces the chance of mutation during cross-pollination.
- Ⓑ Meiosis produces haploid sperm and egg cells needed for cross-pollination.
- Ⓒ Meiosis produces diploid cells with high genetic diversity during cross-pollination.
- Ⓓ Meiosis selects for offspring with the desired characteristics needed for cross-pollination.

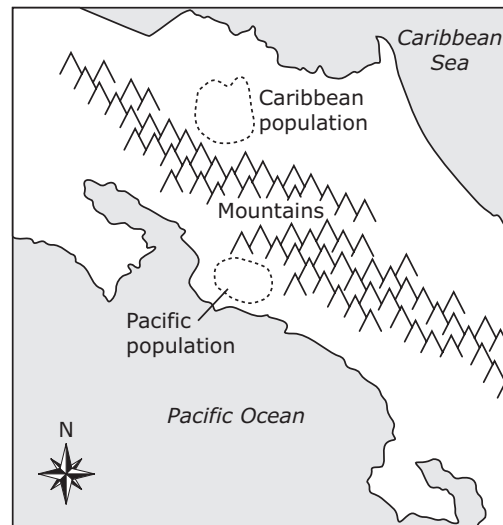
- 40 A biologist conducts an experiment to determine whether a fish is infected with a virus or a bacterium. The biologist takes a sample of cells from the fish and isolates the infectious agent. Next, the biologist sets up two test tubes. Test tube X contains nutrients and fish cells. Test tube Y contains nutrients but no fish cells. The infectious agent is then placed in the two test tubes. The biologist determines the infectious agent reproduced in one of the test tubes.

Which of the following will allow the biologist to determine whether the infectious agent is bacterial or viral?

- Ⓐ Viruses can only reproduce in test tube X.
- Ⓑ Viruses can only reproduce in test tube Y.
- Ⓒ Bacteria can only reproduce in test tube X.
- Ⓓ Bacteria can only reproduce in test tube Y.

This question has two parts.

- 41** Two populations of venomous snakes live in Central America. These two snake populations are the same species, but they are separated by a mountain range, as shown on the map.



Part A

Which of the following provides the best evidence that these two snake populations are geographically isolated?

- Ⓐ variation in the number of individuals in each population
- Ⓑ a difference in the temperature ranges of each population's habitat
- Ⓒ variation in the types of organisms sharing each population's habitat
- Ⓓ a difference in the protein composition of the venom in each population

Part B

Which of the following could be compared to determine whether the evidence identified in Part A was the result of reproductive isolation in these two snake populations?

- Ⓐ similar diets of individuals from each population
- Ⓑ similar fossilized structures of individuals from each population
- Ⓒ sequences of the same genes in individuals from each population
- Ⓓ stages of embryonic development in individuals from each population

This question has two parts. Write your response on the next page. Be sure to label each part of your response.

- 42** An invasive insect called the Asian longhorned beetle is threatening some forests in the United States. The beetle attacks and kills hardwood trees, including maple, elm, ash, poplar, willow, birch, and horse chestnut. The beetle larvae feed on the tissues inside the trees. As a result, the flow of water and nutrients in the trees is disrupted and the trees die. As adults, the beetles move to the outside of the trees.
- A. Based on this information, explain why the Asian longhorned beetle has the potential to become invasive over very large, widespread areas of the United States.
- B. Explain **three** ways that damage to trees from the Asian longhorned beetle could affect other organisms in the forest ecosystem. Be specific in your answers.

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High School Biology

Spring 2022 Released Operational Items

PBT Item No.	Page No.	Reporting Category	Standard	Science and Engineering Practice Category	Item Type*	Item Description	Correct Answer**
1	3	<i>Molecules to Organisms</i>	HS.LS.1.7	A. Investigations and Questioning	SR	Determine which measurement would best support a claim about usable energy in cells.	A
2	4	<i>Heredity</i>	HS.LS.3.1	C. Evidence, Reasoning, and Modeling	SR	Describe the chromosomes shown in a karyotype diagram.	C
3	5	<i>Ecology</i>	HS.LS.2.6	C. Evidence, Reasoning, and Modeling	SR	Analyze a food web to identify organisms that compete with an invasive species in an ecosystem.	D,F,I
4	6	<i>Molecules to Organisms</i>	HS.LS.1.1	C. Evidence, Reasoning, and Modeling	SR	Describe how a model of mRNA should be revised to replace nucleotides that were transcribed incorrectly.	A
5	7	<i>Molecules to Organisms</i>	HS.LS.1.4	None	SR	Determine which table shows processes occurring during three phases of the cell cycle.	C
6	8	<i>Ecology</i>	HS.LS.2.4	B. Mathematics and Data	SR	Calculate the amount of energy transferred between trophic levels and identify two factors that limit the amount of energy transferred.	C;B,C
7	9	<i>Evolution</i>	HS.LS.4.4	None	SR	Explain why bacteria are able to adapt to changing environments.	B
8	10	<i>Ecology</i>	HS.LS.2.5	None	SR	Determine whether carbon atoms are stored as biomass or released into the environment for three carbon cycle processes.	B
9	11	<i>Molecules to Organisms</i>	HS.LS.1.2	B. Mathematics and Data	SR	Analyze data to explain the movement of gases between the circulatory and respiratory systems.	D
10	12	<i>Heredity</i>	HS.LS.3.4	None	SR	Determine that a particular characteristic is a result of both genetics and the environment.	C
11	13	<i>Evolution</i>	HS.LS.4.1	None	SR	Explain how modern organisms can inherit genes that no longer function even though their ancestors had a functional version of the gene.	D
12	15	<i>Heredity</i>	HS.LS.3.3	C. Evidence, Reasoning, and Modeling	SR	Use evidence from genetic crosses to support a claim about the inheritance pattern of a particular trait.	D
13	15	<i>Evolution</i>	HS.LS.4.5	A. Investigations and Questioning	SR	Identify a question that scientists can answer by analyzing the results of a cross-breeding experiment.	A
14	16	<i>Evolution</i>	HS.LS.4.2	C. Evidence, Reasoning, and Modeling	SR	Describe how a particular trait in a population will change over time when a resource in the environment changes.	D
15	17	<i>Heredity</i>	HS.LS.3.1	C. Evidence, Reasoning, and Modeling	SR	Identify the types of cells that combine to produce an offspring and compare the number of chromosomes in a gamete to a body cell.	A,E;B
16	18	<i>Molecules to Organisms</i>	HS.LS.1.5	C. Evidence, Reasoning, and Modeling	CR	Complete a model of photosynthesis, identify the source of energy for photosynthesis, and describe how the products of photosynthesis are used in a human cell.	
17	20	<i>Molecules to Organisms</i>	HS.LS.1.1	B. Mathematics and Data	SR	Analyze a model to determine the number of DNA nucleotides that code for a chain of amino acids.	D
18	21	<i>Heredity</i>	HS.LS.3.1	C. Evidence, Reasoning, and Modeling	SR	Analyze a diagram to determine whether normal meiosis occurred and use evidence to support the claim.	B
19	22	<i>Molecules to Organisms</i>	HS.LS.1.3	C. Evidence, Reasoning, and Modeling	SR	Analyze a model of a feedback loop to describe the function of the feedback loop.	C
20	24	<i>Molecules to Organisms</i>	HS.LS.1.6	C. Evidence, Reasoning, and Modeling	CR	Use models to identify which monomers make up organic macromolecules and describe how these organic macromolecules are used in cells.	
21	26	<i>Heredity</i>	HS.LS.3.3	C. Evidence, Reasoning, and Modeling	CR	Identify possible parental genotypes for a dominant-recessive genetic condition and a x-linked genetic condition and complete Punnett squares to determine the expected percentages of offspring that will inherit the conditions.	

PBT Item No.	Page No.	Reporting Category	Standard	Science and Engineering Practice Category	Item Type*	Item Description	Correct Answer**
22	29	<i>Molecules to Organisms</i>	HS.LS.1.3	None	SR	Describe how the process of diffusion helps to maintain homeostasis in cells.	C
23	30	<i>Heredity</i>	HS.LS.3.2	C. Evidence, Reasoning, and Modeling	SR	Use evidence from a model to support a claim that meiosis increases genetic variability.	A;B
24	31	<i>Molecules to Organisms</i>	HS.LS.1.2	C. Evidence, Reasoning, and Modeling	SR	Determine which model shows the functions of three parts of the digestive system.	C
25	32	<i>Heredity</i>	HS.LS.3.4	B. Mathematics and Data	SR	Analyze data to determine the effect of an environmental factor on the expression of a gene and describe how a gene is expressed to produce a protein.	B,A;C,B
26	34	<i>Molecules to Organisms</i>	HS.LS.1.2	A. Investigations and Questioning	SR	Determine one piece of evidence that would show a kidney is functioning normally.	D
27	35	<i>Heredity</i>	HS.LS.3.2	B. Mathematics and Data	SR	Analyze four single-base mutations and their resulting codons to determine which mutation would not result in a phenotypic change.	C
28	36	<i>Evolution</i>	HS.LS.4.1	C. Evidence, Reasoning, and Modeling	SR	Use differences in amino acid sequences to determine the evolutionary relatedness of several species.	D
29	37	<i>Molecules to Organisms</i>	HS.LS.1.4	B. Mathematics and Data	SR	Determine the percentage of a nitrogenous base in a sample of DNA when given the percentage of another nitrogenous base in the same sample.	B
30	37	<i>Evolution</i>	HS.LS.4.1	C. Evidence, Reasoning, and Modeling	SR	Identify which type of evidence would best support a claim that two organisms are different species.	D
31	38	<i>Ecology</i>	HS.LS.2.1	None	SR	Determine which evidence is most useful for identifying a mutualistic relationship between two organisms.	D
32	38	<i>Molecules to Organisms</i>	HS.LS.1.2	C. Evidence, Reasoning, and Modeling	SR	Complete a model to show a pathway in the nervous system.	C
33	40	<i>Molecules to Organisms</i>	HS.LS.1.7	B. Mathematics and Data	SR	Analyze data to make a claim about the energy use of organisms.	C
34	40	<i>Molecules to Organisms</i>	HS.LS.1.4	None	SR	Identify the cellular process that is responsible for tissue growth and repair.	D
35	40	<i>Ecology</i>	HS.LS.2.1	C. Evidence, Reasoning, and Modeling	SR	Explain how the carrying capacity of a population can be affected by a certain biotic factor.	A
36	41	<i>Ecology</i>	HS.LS.2.4	C. Evidence, Reasoning, and Modeling	SR	Identify the trophic level of an organism in a food web and analyze the food web to determine how a decrease in one population would affect other populations in the ecosystem.	C;B
37	42	<i>Evolution</i>	HS.LS.4.2	None	CR	Describe how genetic diversity of a population changed as the population decreased and explain how a trait can become more common in a population over time.	
38	44	<i>Molecules to Organisms</i>	HS.LS.1.1	A. Investigations and Questioning	SR	Identify a question that could be asked to determine whether a substance is an enzyme.	D
39	45	<i>Heredity</i>	HS.LS.3.2	C. Evidence, Reasoning, and Modeling	SR	Explain the importance of meiosis for a certain type of plant.	B
40	46	<i>Evolution</i>	HS.LS.4.4	A. Investigations and Questioning	SR	Analyze research data to determine whether an infection is bacterial or viral.	A
41	47	<i>Evolution</i>	HS.LS.4.5	C. Evidence, Reasoning, and Modeling	SR	Determine the best evidence that two populations are geographically isolated from each other and determine what evidence could be used to show that reproductive isolation occurred.	D;C
42	48	<i>Ecology</i>	HS.LS.2.7	None	CR	Explain how an organism can become an invasive species over a large area and explain how damage caused by an invasive species can affect other species in the ecosystem.	

* Science and Technology/Engineering item types are: selected-response (SR) and constructed-response (CR).

** Answers are provided here for selected-response items only. Sample responses and scoring guidelines for constructed-response items will be posted to the Department's website later this year.