XVIII. Biology, High School

High School Biology Test

The spring 2010 high school MCAS Biology test was based on learning standards in the Biology content strand of the Massachusetts *Science and Technology/Engineering Curriculum Framework* (2006). These learning standards appear on pages 54–58 of the *Framework*.

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

In test item analysis reports and on the Subject Area Subscore pages of the MCAS *School Reports* and *District Reports*, Biology test results are reported under the following five MCAS reporting categories:

- Biochemistry and Cell Biology
- Genetics
- Anatomy and Physiology
- Ecology
- Evolution and Biodiversity

Test Sessions

The MCAS high school Biology test included two separate test sessions, which were administered on consecutive days. Each session included multiple-choice and open-response questions.

Reference Materials and Tools

The high school Biology test was designed to be taken without the aid of a calculator. Students were allowed to have calculators with them during testing, but calculators were not needed to answer questions.

The use of bilingual word-to-word dictionaries was allowed for current and former limited English proficient students only, during both Biology test sessions. No other reference tools or materials were allowed.

Cross-Reference Information

The table at the conclusion of this chapter indicates each item's reporting category and the framework learning standard it assesses. The correct answers for multiple-choice questions are also displayed in the table.

Biology
Session 1

DIRECTIONS

This session contains twenty-one multiple-choice questions and two open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

1 Every year, monarch butterflies from Canada and the United States spend the winter in central Mexico. The dry and mild climate in Mexico allows the monarch butterflies to survive the winter.

One winter, a week of storms caused freezing temperatures and 43 cm of snow in Mexico. What was the most likely impact of these storms on the monarch butterflies?

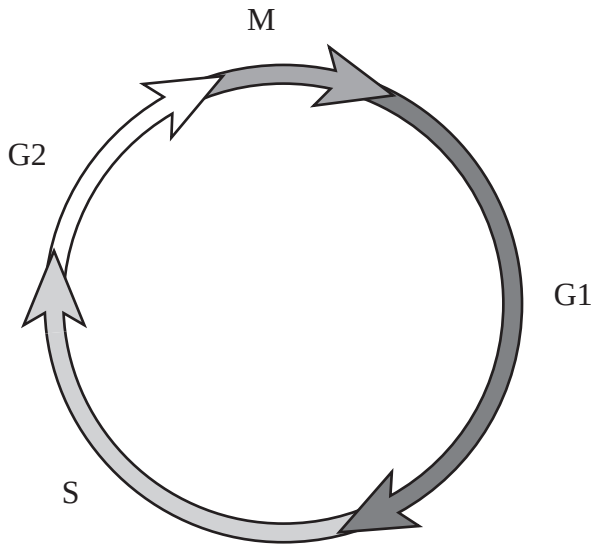
A. Monarch butterflies died in large numbers.

B. Monarch butterflies immediately migrated back to the United States.

C. Monarch butterflies did not migrate from Canada and the United States the next year.

D. Monarch butterflies evolved several new adaptations to survive the winter in Mexico.

2 The diagram below shows the cell cycle.



Which of the following activities occurs in the G1 phase?

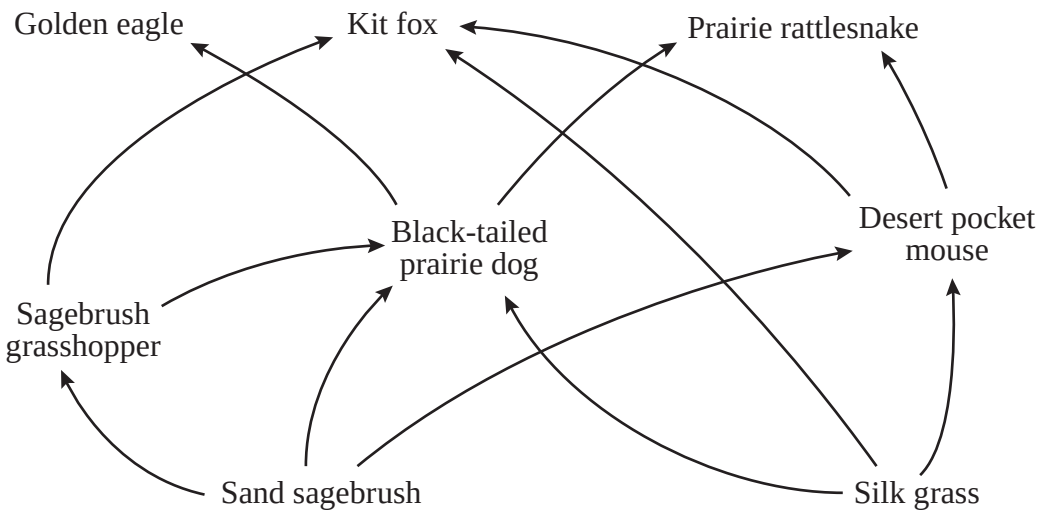
A. growth of the cell

B. replication of the DNA

C. formation of the mitotic spindle

D. breakdown of the nuclear membrane

3 Part of a desert food web is diagrammed below.



Which of the following will **most likely** result if all of the primary consumers are removed from this ecosystem?

A. Prairie rattlesnakes will become herbivores.

B. Golden eagle and kit fox populations will decrease.

C. Sagebrush grasshoppers will consume soil bacteria.

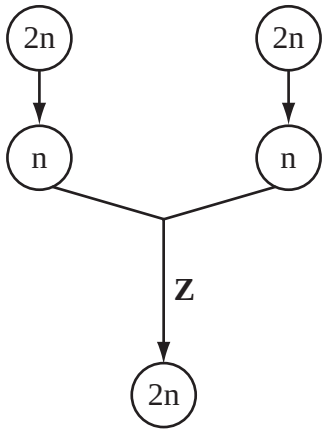
D. Silk grass and sand sagebrush populations will decrease.

4 A researcher is studying a particular disease-causing agent. The agent has a protein coat, but it lacks a nucleus, contains no other organelles, and can reproduce only when it is inside an animal cell.

The researcher should classify the agent as which of the following?

A. a bacterium
B. a fungus
C. a protist
D. a virus

5 The diagram below represents steps in sexual reproduction.



Which of the following occurs in the step labeled **Z**?

A. fertilization
B. meiosis
C. mitosis
D. translocation

6 A pedigree is a diagram that traces the inheritance of a trait through a family. Which of the following patterns is typical in a pedigree for an autosomal dominant trait?

A. The trait affects only males.
B. The trait appears in every generation.
C. The trait appears in only one-fourth of the individuals.
D. The trait affects all the individuals of the second generation.

7 A lab technician needs to determine whether cells in a test tube are prokaryotic or eukaryotic. The technician has several dyes she could use to stain the cells. Four of the dyes are described in the table below.

Dye	Test
acridine orange	stains DNA and RNA
osmium tetroxide	stains lipids
eosin	stains cell cytoplasm
Nile blue	stains cell nuclei

Which dye could the technician use to determine whether the cells are prokaryotic or eukaryotic?

A. acridine orange
B. osmium tetroxide
C. eosin
D. Nile blue

The following section focuses on sickle cell anemia.

Read the information below and use it to answer the four multiple-choice questions and one open-response question that follow.

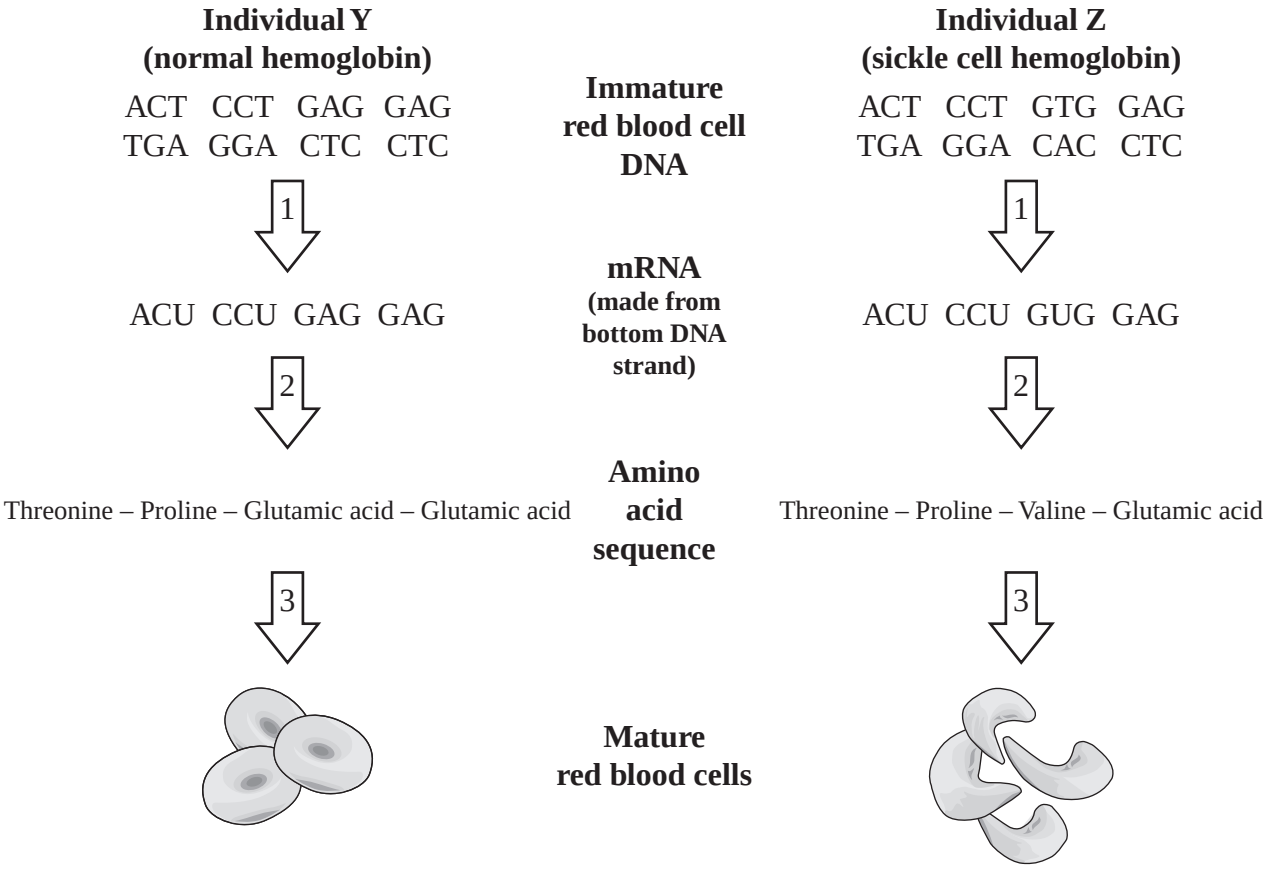
Sickle cell anemia is an autosomal recessive genetic disorder that affects thousands of people in the United States and millions worldwide. Sickle cell anemia commonly occurs in groups whose ancestors came from Africa, as well as South America, Cuba, Central America, Saudi Arabia, India, and the Mediterranean.

Sickle cell anemia is caused by a change in the hemoglobin protein in red blood cells. Sickle cell anemia results in paleness, fatigue, shortness of breath, and increased heart rate due to a deficiency in the oxygen-carrying component of the blood. When oxygen levels are low in an affected individual, the red blood cells become deformed into a curved, sickle shape. People with sickle cell anemia can experience swelling, pain, infection, and organ damage.

All individuals have two alleles for the gene that codes for the hemoglobin protein (Hb). Individuals with two **Hb A** alleles have normal, round red blood cells. Heterozygous individuals, with one **Hb A** allele and one **Hb S** allele, do not experience symptoms of the disease, but they may produce some sickle-shaped red blood cells. Individuals with two **Hb S** alleles have sickle cell anemia.

The diagrams to the right represent some of the steps in the formation of hemoglobin in two individuals, Y and Z. In these diagrams, only a small part of the hemoglobin gene sequence is represented.

Individual Y has two **Hb A** alleles and therefore produces normal red blood cells. Individual Z has two **Hb S** alleles and therefore produces sickle-shaped red blood cells.


Individual Y
(normal hemoglobin)
ACT CCT GAG GAG
TGA GGA CTC CTC
1
ACU CCU GAG GAG
2
Threonine – Proline – Glutamic acid – Glutamic acid
3
Immature red blood cell DNA
mRNA (made from bottom DNA strand)
Amino acid sequence
Mature red blood cells
Individual Z
(sickle cell hemoglobin)
ACT CCT GTG GAG
TGA GGA CAC CTC
1
ACU CCU GUG GAG
2
Threonine – Proline – Valine – Glutamic acid
3

Mark your answers to multiple-choice questions 8 through 11 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

8 Which of the following statements best describes why the change in only one DNA base of the hemoglobin gene results in a different protein product of the gene?

A. The change prevents mRNA from being made.

B. The change alters the amino acid sequence of the protein.

C. The change causes the blood cells to divide in an uncontrolled way.

D. The change creates a second strand of mRNA for each RNA molecule.

9 Which of the following cell structures carries out the process represented by the arrows labeled “2” in the diagrams?

A. mitochondrion

B. nucleus

C. ribosome

D. vacuole

10 Which of the following statements **best** summarizes a change that is represented by the arrows labeled “3” in the diagrams?

A. A nucleus is formed in each cell.

B. Each cell divides to form two daughter cells.

C. A chain of amino acids is folded to form a protein in each cell.

D. Proteins are transported through the plasma membrane of each cell.

11 Which of the following statements **best** compares individual Y and individual Z in terms of genotype and phenotype?

A. The individuals have the same genotype and the same phenotype.

B. The individuals have the same genotype but different phenotypes.

C. The individuals have different genotypes but the same phenotype.

D. The individuals have different genotypes and different phenotypes.

Question 12 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 12 in the space provided in your Student Answer Booklet.

12 In a bone marrow transplant, bone marrow from a healthy individual is transplanted into an individual with a blood disorder.

a. Explain why a successful bone marrow transplant could treat sickle cell anemia in an individual.

b. Suppose individual Z were treated for sickle cell anemia by receiving a bone marrow transplant. Could any children that individual Z has after the transplant inherit the gene for the sickle cell trait? Explain your answer.

Mark your answers to multiple-choice questions 13 through 22 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

13 About 70 years ago, cane toads were introduced to Australia. The toads are toxic to some species of snakes, such as *Dendrelaphis punctulatus*. The longer an individual snake is, the greater its chance of survival after eating a cane toad.

Which of the following did scientists **most likely** observe in the *D. punctulatus* snake population as a result of the presence of the cane toads?

A. The entire population was killed by the toads.

B. The entire population became resistant to the toads.

C. The average body length in the population increased.

D. The average body length in the population decreased.

14 Which of the following is a body system response that adjusts body temperature when it is higher than normal?

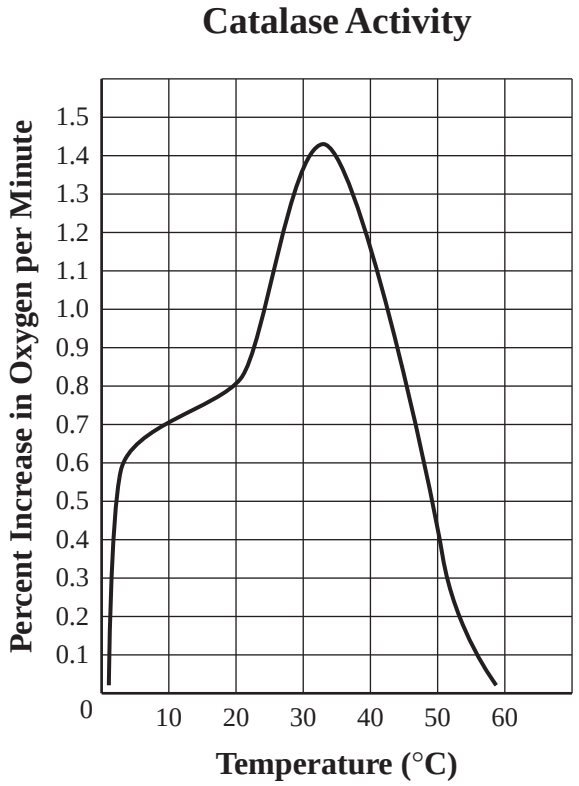
A. Breathing rate begins to decrease.

B. Blood vessels near the skin constrict.

C. Sweat glands produce and secrete sweat.

D. Hormones increase the metabolic rate of the liver.

15 The graph below shows the rate of activity for the enzyme catalase at different temperatures. Catalase helps convert hydrogen peroxide to oxygen and water. The rate of catalase activity is directly related to the percent increase in oxygen.



Based on the graph, which of the following conclusions can be made about the functioning of catalase?

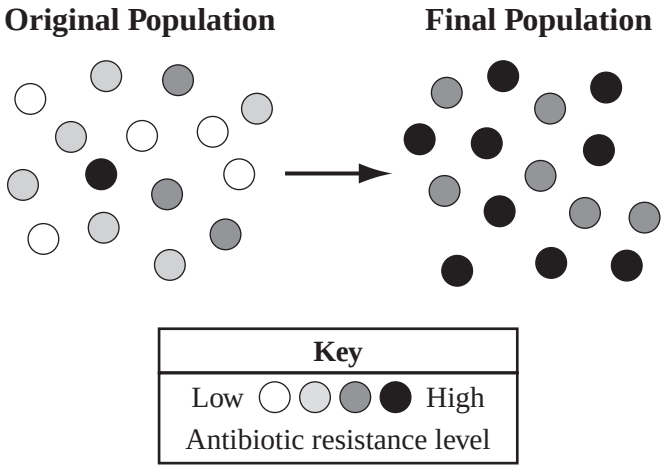
A. Catalase works best at 34°C.

B. Catalase is destroyed at 34°C.

C. Catalase cannot function at 51°C.

D. Catalase functions most efficiently at 51°C.

16 Antibiotic resistance can vary within a population of bacteria. The diagram below represents the changes in a population of bacteria as a result of exposure to an antibiotic over time.



The changes in the population are **most likely** the result of which of the following?

A. exponential growth

B. genetic crosses

C. immigration

D. natural selection

17 An inherited metabolic disorder called phenylketonuria (PKU) can result in serious problems in infancy. The chance that two parents who are heterozygous will have a child with PKU is 25%.

Which of the following terms **best** applies to the inheritance pattern for PKU?

A. codominant
B. dominant
C. recessive
D. sex-linked

18 Which of the following describes plant cells but **not** animal cells?

A. The nucleus contains the chromosomes.
B. The ribosomes assist in protein synthesis.
C. Plastids store starch made during photosynthesis.
D. Mitochondria produce energy through respiration.

19 The fossil record supports which of the following descriptions of the evolution of life on Earth?

A. Life first appeared with the diversity found today.
B. The importance of natural selection diminished over time.
C. Complex organisms evolved from more simple organisms.
D. Large organisms appeared before single-celled organisms.

20 In a eukaryotic cell, which of the following processes directly involves DNA?

A. translation
B. cellular respiration
C. active transport of ions
D. replication of chromosomes

21 Heartburn is pain that occurs when acidic gastric juice is forced out of the upper end of the stomach. In which of the following organs does a person experience heartburn?

A. pancreas

B. esophagus

C. small intestine

D. large intestine

22 The size of a bird population increased by two percent in one year. Which of the following could have contributed to the population increase?

A. a decrease in the death rate of baby birds

B. an increase in the number of the birds' predators

C. an increase in the average number of parasites per bird

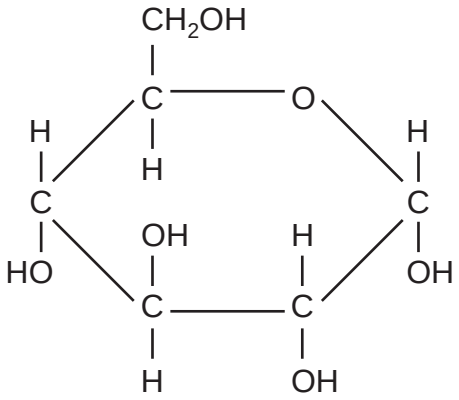
D. a decrease in the immigration of birds of the same species

Question 23 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 23 in the space provided in your Student Answer Booklet.

23 The diagram below shows the molecular structure of glucose.



Glucose is a simple carbohydrate that is important to living organisms.

a. Describe the primary function of glucose in cells.

b. Simple sugars like glucose can be used to make larger organic molecules. Identify **two** larger molecules made from simple sugars.

c. Identify a specific cellular process that would be affected by a glucose shortage, and discuss the effects of the shortage on the process you identified.

Biology
SESSION 2

DIRECTIONS

This session contains nineteen multiple-choice questions and three open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

24 In a molecule of double-stranded DNA, the amount of adenine present is always equal to the amount of

A. cytosine.

B. guanine.

C. thymine.

D. uracil.

25 Which of the following statements **best** explains why oxygen diffuses from the alveoli into the blood?

A. The diaphragm draws oxygen into the alveoli at a rapid speed.

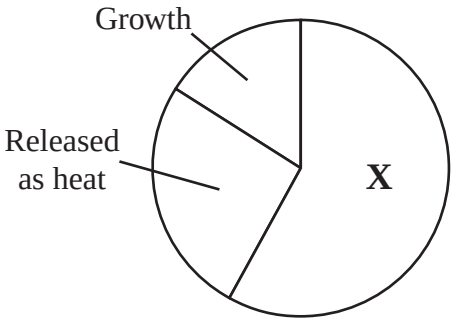
B. Alveoli cells contain hemoglobin to transfer gases to the blood.

C. The concentration of oxygen is greater in the alveoli than in the blood.

D. Red blood cells move one at a time through the capillaries surrounding the alveoli.

26 Plants absorb solar energy during photosynthesis. The graph below represents how this energy is distributed in some plants.

Energy Distribution



Which of the following statements describes what happens to the energy represented by the section labeled **X**?

A. It is recycled to the Sun.

B. It is consumed by decomposers.

C. It is lost to the soil and the atmosphere.

D. It is used for cellular respiration and maintenance.

27 Which of the following statements gives the **most likely** explanation for the presence of two very similar species of squirrels living on opposite sides of the Grand Canyon?

A. One squirrel traveled across the canyon and started a new population on the other side.

B. One squirrel traveled across the canyon and interbred with a different population on the other side.

C. Members of a single squirrel species were geographically separated by the formation of the canyon.

D. Members of two different squirrel species migrated from two different places to opposite sides of the canyon.

28 Energy for most chemical reactions in cells is supplied by which of the following molecules?

A. ATP
B. DNA
C. adrenaline
D. hemoglobin

29 When locust populations grow too large for an area, the individual locusts are crowded and food becomes scarce. In response to these conditions, some of the locusts leave the area and find a new habitat.

Which of the following terms **best** applies to the response of the locusts that leave for the new habitat?

A. commensalism
B. emigration
C. hibernation
D. mutualism

30 Which of the following statements **best** explains why offspring produced by sexual reproduction often look similar to, but not exactly the same as, their parents?

A. The offspring have genetic material from both the mother and the father.
B. The cells of the offspring contain all the dominant genes from the parents.
C. The cells of the offspring undergo mitosis many times as the offspring grow and develop.
D. The offspring have a period of embryonic development, rather than being born immediately after fertilization.

31 In traditional landscaping, leaves are raked off the ground and bagged. In which of the following ways does this practice most significantly disrupt natural nutrient cycling?

A. It carries away microorganisms that can perform nitrogen fixation.
B. It reduces the rate of oxygen and carbon cycling via photosynthesis.
C. It prevents carbon, oxygen, and nitrogen from being returned to the soil.
D. It increases the amount of carbon dioxide that is released to the atmosphere.

Question 32 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 32 in the space provided in your Student Answer Booklet.

32 The table below shows the classifications of three different sea lions.

	California Sea Lion	**Galápagos Sea Lion**	**New Zealand Sea Lion**
Kingdom	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Chordata
Class	Mammalia	Mammalia	Mammalia
Order	Carnivora	Carnivora	Carnivora
Family	Otariidae	Otariidae	Otariidae
Genus	*Zalophus*	*Zalophus*	*Phocarctos*
Species	*californianus*	*wollebaeki*	*hookeri*

a. Identify which two of the sea lions are most closely related.

b. Justify your answer to part (a).

c. Describe and explain **two** types of evidence scientists would have used to determine the proper classifications of these three sea lions.

Mark your answers to multiple-choice questions 33 through 43 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

33 In the past 100 years, levels of atmospheric carbon dioxide have increased as the result of the burning of fossil fuels. Other processes in the carbon cycle have absorbed some of the carbon released by this combustion.

Which of the following **most likely** have absorbed excess carbon released by combustion?

A. animals
B. glaciers
C. plants
D. rocks

34 In fruit flies, the gene for eye color is located on the X chromosome, and the red eye allele (**R**) is dominant to the white eye allele (**r**). A female fly with genotype $\mathbf{X^RX^r}$ is mated with a male fly with genotype $\mathbf{X^rY}$.

Which of the following statements best describes the expected outcome of the cross?

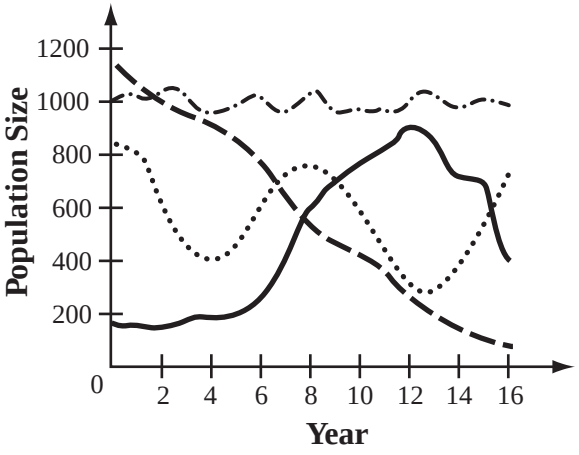
A. The chance of an offspring having red eyes is 75%.
B. The chance of an offspring having white eyes is 50%.
C. The chance that a male offspring will have white eyes is 0%.
D. The chance that a female offspring will have red eyes is 100%.

35 The Asian shore crab invaded parts of the eastern coast of the United States about 15 years ago. The Asian shore crab preys on blue mussels. In the time since the Asian shore crab arrived, the average shell thickness has increased in the blue mussel population.

Which of the following is the **most likely** reason that this increase in shell thickness has occurred?

A. Blue mussels with thick shells attract more crabs than mussels without thick shells.
B. Blue mussels with thick shells grow in larger colonies than mussels without thick shells.
C. Blue mussels with thick shells catch more food per day than mussels without thick shells.
D. Blue mussels with thick shells survive and reproduce more successfully than mussels without thick shells.

36 The graph below shows changes in the sizes of four animal populations over a 16-year period.



Key
Population 1
Population 2
Population 3
Population 4

In which population was birthrate most likely greater than death rate from year 8 to year 12?

A. population 1

B. population 2

C. population 3

D. population 4

37 The northern spotted owl is listed under the Endangered Species Act as a threatened species in its primary range of Washington, Oregon, and California. Which of the following **most likely** contributed to the northern spotted owl's population decline?

A. increases in rodent populations

B. loss of trees from forest habitat

C. prevention of wildfires in forests

D. decreases in mountain lion populations

38 Which of the following elements is **most** common in the tissues of plants?

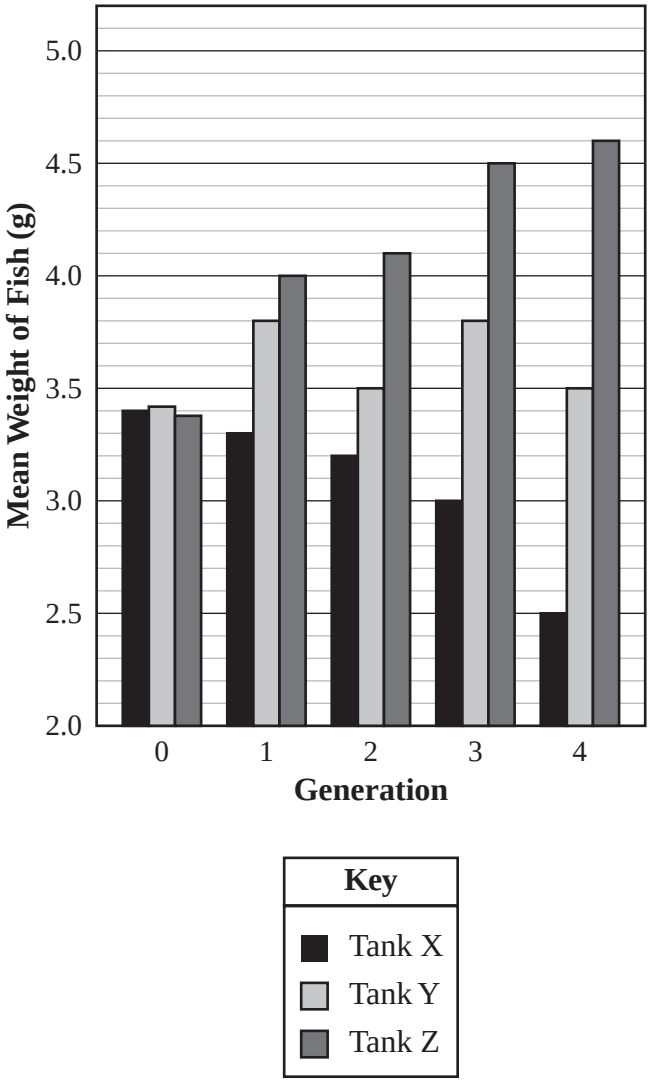
A. hydrogen

B. iron

C. potassium

D. sodium

39 To investigate selective pressures on fish populations, researchers set up three identical tanks, labeled X, Y, and Z. Each tank contained 1000 fish of the same species. Before the fish reproduced each generation, the researchers removed fish from some of the tanks. The graph below shows the changes in the mean weight of the fish in each tank over four generations.



Based on the graph, what did the researchers **most likely** do to tank Z each generation?

A. The researchers removed the 900 smallest fish.

B. The researchers removed the 900 largest fish.

C. The researchers removed 900 fish at random.

D. The researchers removed none of the fish.

40 If a cell's lysosomes were damaged, which of the following would **most likely** occur?

A. The cell would produce more proteins than it needs.

B. The cell would have chloroplasts that appear yellow rather than green.

C. The cell would be less able to break down molecules in its cytoplasm.

D. The cell would be less able to regulate the amount of fluid in its cytoplasm.

41 A species of parasitic fly follows the sounds that male crickets make with their wings. The flies deposit their larvae in the crickets' bodies. As the larvae develop and emerge from the crickets' bodies, the crickets die.

Researchers have discovered a genetic mutation in some crickets that changes their wing structure and makes them silent. The crickets with silent wings are found among crickets with normal wings when it is time to mate.

According to evolution by natural selection, which of the following will **most likely** occur in the cricket population, based on the selection pressure from the flies?

A. Male crickets with silent wings will increase in frequency.

B. The frequency of the silent wing mutation will stay the same.

C. Male crickets with normal wings will learn to make new sounds.

D. A new mutation will create spikes on the crickets' wings to keep the flies away.

42 Which of the following is a function of the liver?

A. removing toxic compounds from the blood

B. secreting digestive enzymes into the stomach

C. producing white blood cells to fight infections

D. converting food into smaller nutrient molecules

43 In humans, the appendix is small and is not needed for digestion. In rabbits, the appendix is well developed and is used in the digestion of plant fibers.

Which of the following provides the **best** scientific explanation for the presence of the appendix in both humans and rabbits?

A. Rabbits and humans live in environments with similar conditions.

B. Rabbits and humans are both eukaryotes with similar cell structures.

C. The appendix is evolving into a new type of organ in rabbits and humans.

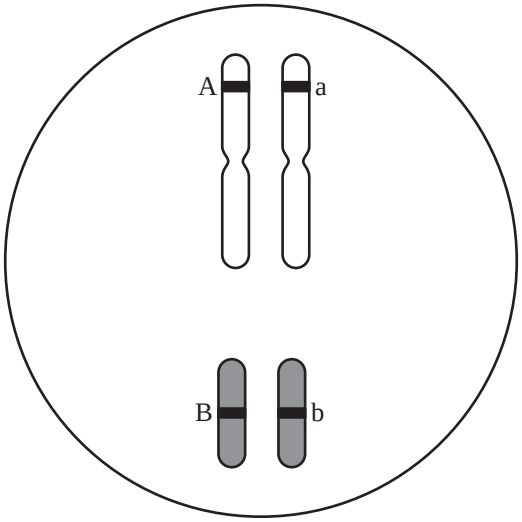
D. The appendix is inherited from a common ancestor of rabbits and humans.

Questions 44 and 45 are open-response questions.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF EACH QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 44 in the space provided in your Student Answer Booklet.

44 Gregor Mendel developed an understanding of heredity through his experiments with pea plants. The diagram below shows a cell with two pairs of homologous chromosomes and a genotype of **AaBb**.

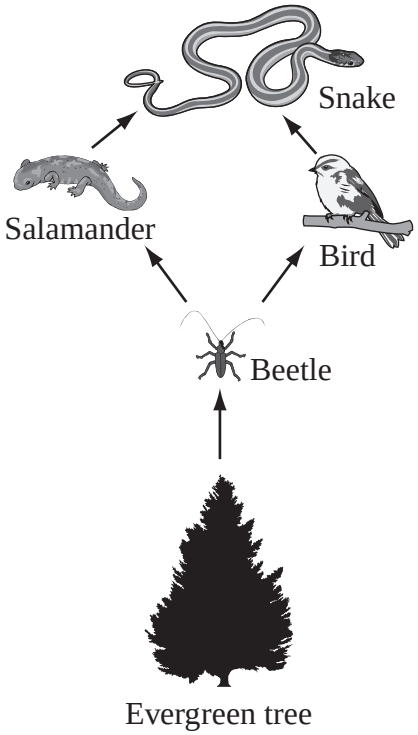


a. Identify all the possible allele combinations that could be formed if this cell undergoes meiosis.

b. Identify one of Mendel's laws that is illustrated when you write out these allele combinations. Explain this law.

Write your answer to question 45 in the space provided in your Student Answer Booklet.

45 A small part of a food web for a forest ecosystem is shown below.



a. Classify each of the five organisms in the food web as a producer, a primary consumer, a secondary consumer, or a tertiary consumer.

b. Identify the type of ecological relationship between salamanders and birds in this food web.

c. Suppose there is a significant decrease in the bird population. Based on the relationships in the food web, explain why it would be difficult for ecologists to predict what would happen to the size of the salamander population.

High School Biology
Spring 2010 Released Items:
Reporting Categories, Standards, and Correct Answers*

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
1	287	*Ecology*	6.2	A
2	287	*Biochemistry and Cell Biology*	2.6	A
3	288	*Ecology*	6.3	B
4	289	*Biochemistry and Cell Biology*	2.8	D
5	289	*Biochemistry and Cell Biology*	2.7	A
6	289	*Genetics*	3.4	B
7	289	*Biochemistry and Cell Biology*	2.2	D
8	292	*Genetics*	3.3	B
9	292	*Biochemistry and Cell Biology*	2.1	C
10	292	*Genetics*	3.2	C
11	292	*Genetics*	3.3	D
12	293	*Anatomy and Physiology*	4.5	
13	294	*Evolution and Biodiversity*	5.3	C
14	294	*Anatomy and Physiology*	4.8	C
15	295	*Biochemistry and Cell Biology*	1.3	A
16	295	*Evolution and Biodiversity*	5.1	D
17	296	*Genetics*	3.4	C
18	296	*Biochemistry and Cell Biology*	2.3	C
19	296	*Evolution and Biodiversity*	5.1	C
20	296	*Genetics*	3.2	D
21	297	*Anatomy and Physiology*	4.1	B
22	297	*Ecology*	6.1	A
23	298	*Biochemistry and Cell Biology*	1.2	
24	299	*Genetics*	3.1	C
25	299	*Anatomy and Physiology*	4.3	C
26	300	*Biochemistry and Cell Biology*	2.4	D
27	300	*Evolution and Biodiversity*	5.2	C
28	301	*Biochemistry and Cell Biology*	2.5	A
29	301	*Ecology*	6.1	B
30	301	*Anatomy and Physiology*	4.6	A
31	301	*Ecology*	6.4	C
32	302	*Evolution and Biodiversity*	5.2	
33	303	*Ecology*	6.4	C
34	303	*Genetics*	3.6	B
35	303	*Evolution and Biodiversity*	5.3	D
36	304	*Ecology*	6.1	C
37	304	*Ecology*	6.2	B
38	304	*Biochemistry and Cell Biology*	1.1	A
39	305	*Evolution and Biodiversity*	5.3	A
40	306	*Biochemistry and Cell Biology*	2.1	C
41	306	*Evolution and Biodiversity*	5.3	A
42	307	*Anatomy and Physiology*	4.2	A

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
43	307	*Evolution and Biodiversity*	5.1	D
44	308	*Genetics*	3.5	
45	309	*Ecology*	6.3	

***** Answers are provided here for multiple-choice items only. Sample responses and scoring guidelines for open-response items, which are indicated by shaded cells, will be posted to the Department's website later this year.