
XVIII. Biology, High School

High School Biology Test

The spring 2013 high school 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.

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 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 English language learner 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 Which component of blood is directly responsible for transporting oxygen to body cells?

A. plasma
B. platelets
C. red blood cells
D. white blood cells

- 2 The table below provides information about the composition and function of four important molecules in living organisms.

Molecule	Composition	Function
1	amino acids	reaction catalyst
2	fatty acids	membrane component
3	monosaccharides	energy source
4	nucleotides	genetic information

Which of the molecules in this table is a carbohydrate?

A. 1
B. 2
C. 3
D. 4

- 3 Which of the following will **most likely** happen to a predator population if its prey population decreases?
- A. There will be no change in the predator population.
 - B. There will be a decrease in the predator population over time.
 - C. There will be an increase in the predator population over time.
 - D. There will be an immediate extinction of the predator population.

- 4 Fruit flies have hair-like bristles on the back side of their bodies. The bristles can be long or short. Flies with short bristles have two recessive alleles (**ss**) for the trait.

A fruit fly that is heterozygous for the bristle trait is crossed with a fruit fly that has short bristles. The cross produces 220 offspring.

How many of the offspring are expected to have short bristles?

- A. 0
- B. 55
- C. 110
- D. 220

- 5 In a plant called jimsonweed, flowers can be white or purple. A jimsonweed plant with white flowers is crossed with a jimsonweed plant with purple flowers. All of the offspring have purple flowers. Based on the results of the cross, which of the following statements most likely describes the alleles for flower color in jimsonweed?

- A. The allele for purple flowers is recessive to the allele for white flowers.
- B. The allele for purple flowers is dominant to the allele for white flowers.
- C. The allele for purple flowers has mutated more times than the allele for white flowers.
- D. The allele for purple flowers is on a different chromosome than the allele for white flowers.

- 6 At the end of 2009, there were 240 individuals in a particular coyote population. In 2010, scientists monitoring the population recorded 85 births and 68 deaths.
- A student used this data to calculate the size of the coyote population at the end of 2010. The student's calculation is shown below.

$$240 + 85 - 68 = 257$$

The actual number of coyotes at the end of 2010 was not 257; it was 294. Which of the following statements explains the difference between the calculated and actual population sizes?

- A. The calculation does not include coyote immigration and emigration.
- B. The calculation does not consider the life expectancy of the average coyote.
- C. The calculation does not consider the average number of coyote pups in a litter.
- D. The calculation does not include changes in the number of breeding adult coyotes.

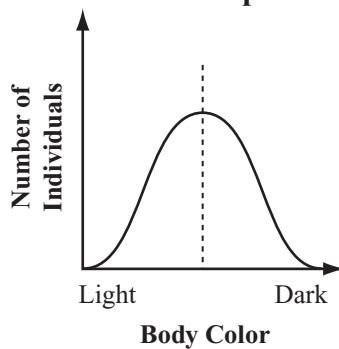
- 7 Which of the following carries nerve impulses from pressure receptors in the skin to the central nervous system?
- A. capillary
 - B. marrow
 - C. motor neuron
 - D. sensory neuron

The following section focuses on how natural selection could affect body colors of beetles in a population.

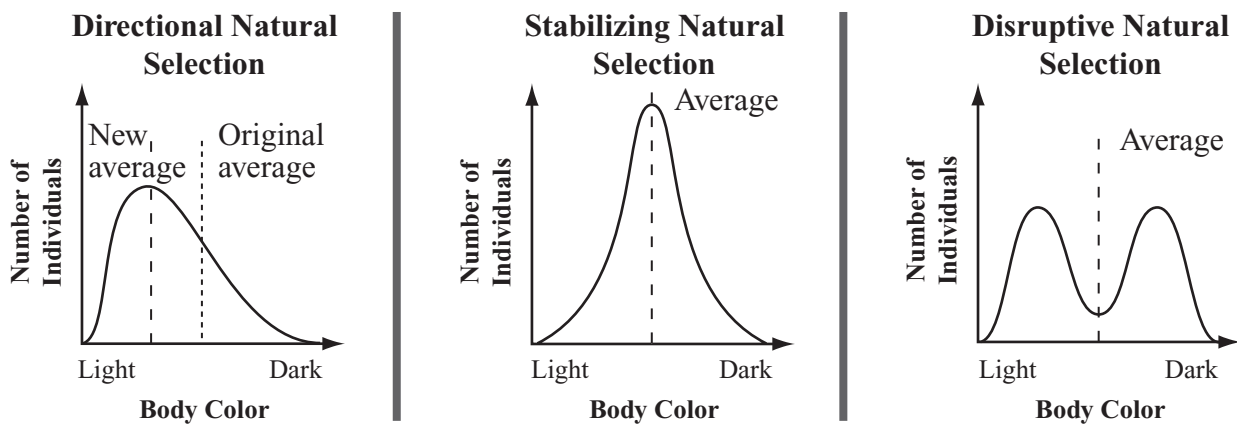
Read the information below and use it to answer the four multiple-choice questions and one open-response question that follow.

In a population of beetles, the body colors of individual beetles range from light to dark. The graph below shows the distribution of body colors in the current population.

Distribution of Body Colors in Current Population



In the future, the distribution of body colors in the beetle population could change in different ways as a result of natural selection, as shown in the graphs below.



In the directional natural selection graph, the curve shifts in the direction of the favored phenotype. This particular graph shows light body color being favored, but, depending on environmental conditions, dark body color might be favored.

In the stabilizing natural selection graph, the curve narrows to show the average phenotype is favored.

In the disruptive natural selection graph, the curve has two peaks to show the phenotypes at both ends of the graph are favored.

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 A species of ivy invades the beetles' current habitat and becomes the dominant form of vegetation. The color of the ivy's leaves is similar to the beetles' average color.
- Considering selective pressure on the beetles from predatory birds, which type of natural selection will **most likely** occur in this situation?
- A. disruptive
 - B. stabilizing
 - C. directional toward dark body color
 - D. directional toward light body color
- 9 Suppose scientists observe a shift in the distribution of body colors in the beetle population over time. Which of the following observations **best** supports the conclusion that the population has evolved?
- A. The reproductive rate for individual beetles has increased.
 - B. The size of the beetle population has increased significantly.
 - C. The sequences of body color genes are different among the individual beetles.
 - D. The frequencies of the alleles for body color in the beetle population have changed.
- 10 Which of the following situations will **most likely** lead to disruptive natural selection?
- A. the introduction of a competing insect species that has a light body color
 - B. the preference of female beetles to mate with only dark-colored male beetles
 - C. the outbreak of plant diseases that either produce dark spots on leaves or cause leaves to lose their color
 - D. the removal of almost all the vegetation from the habitat, exposing the light-colored soil underneath the vegetation
- 11 The current distribution for beetle body size is similar to the current distribution for body color. A bird population that preys on beetles arrives in the area. The birds have small beaks and therefore can eat only small beetles.
- Which type of natural selection will **most likely** occur in this situation?
- A. disruptive
 - B. stabilizing
 - C. directional toward large body size
 - D. directional toward small body size

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 Suppose a fire burns through the beetles' habitat, leaving the trees, soil, and some rocks charred black for several years. Most of the beetles and their predators survive the fire and continue to live in the habitat.

- a. Identify which beetle phenotype or phenotypes will most likely be favored in the habitat after the fire. Explain your answer.
- b. Identify the type of natural selection (directional, stabilizing, or disruptive) that will most likely act on the beetle population.

The type of natural selection you identified in part (b) will change the phenotype distribution in the beetle population.

- c. Using your knowledge of natural selection, explain how the change in phenotype distribution will occur.

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 A single nucleotide of DNA is composed of which of the following substances?

- A. adenine, guanine, and cytosine
- B. hydrogen, a phosphate group, and adenine
- C. ribose sugar, deoxyribose sugar, and thymine
- D. deoxyribose sugar, a phosphate group, and a nitrogenous base

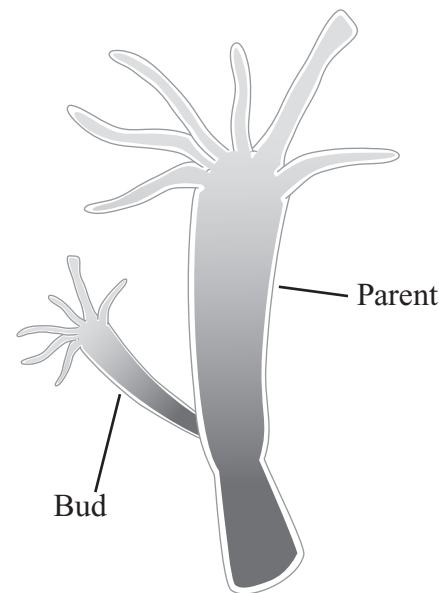
14 Examining a bone marrow sample could help a doctor diagnose problems with which of the following?

- A. sense of balance
- B. speed of reflexes
- C. production of blood cells
- D. filtering of wastes from blood

15 Which of the following organisms has the simplest cellular structure?

- A. bacterium
- B. earthworm
- C. mushroom
- D. sunflower

16 Hydras are organisms that can reproduce by forming buds. The buds detach and grow into new organisms with genetic material that is identical to the parent. A parent hydra with one bud is shown in the diagram below.

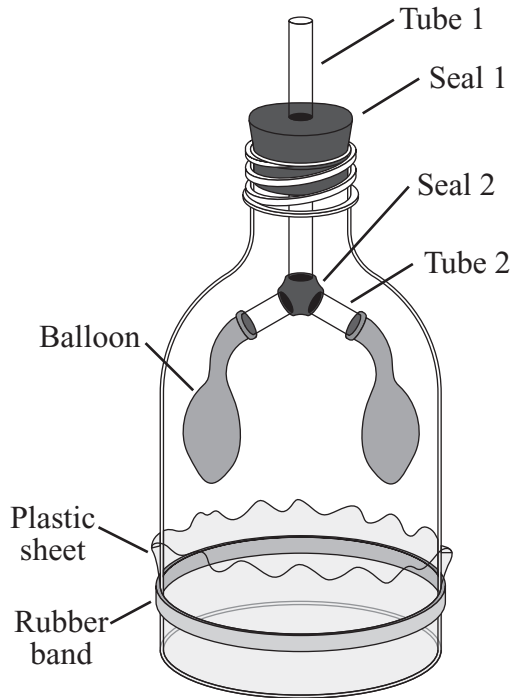


Which process is **directly** responsible for the formation of the bud on the hydra?

- A. cellular respiration
- B. mitosis
- C. osmosis
- D. spore development

- 17 Which of the following is an example of a mutation?
- A. A red blood cell loses its nucleus.
 - B. A zygote receives two X chromosomes.
 - C. A strand of mRNA is produced from DNA.
 - D. A nucleotide is missing in a replicated DNA strand.
- 18 Woodpeckers are birds that make holes in trees for various purposes, including finding food and making nests. In a small forest region of Southeast Asia, scientists have identified at least 14 different species of woodpeckers. Which of the following will **most likely** occur if most of the large mature trees in the forest region are cut down?
- A. The woodpecker populations will raise more young per nest.
 - B. The woodpecker populations will experience greater immigration.
 - C. The woodpecker populations will use new food sources and nesting sites.
 - D. The woodpecker populations will lack adequate resources and will decrease.
- 19 A scientist is examining a fossilized insect that may be an ancestor of modern dragonflies. Which of the following should the scientist compare to **best** determine how closely related the fossilized insect is to modern dragonflies?
- A. their diets
 - B. their habitats
 - C. their predators
 - D. their anatomies
- 20 Which of the following laws or principles states that the two alleles of a gene pair separate during gamete formation?
- A. law of segregation
 - B. principle of linkage
 - C. principle of dominance
 - D. law of independent assortment

- 21 A student built a model to demonstrate how air is moved into and out of the human respiratory system. A diagram of the student’s model is shown below.



Which of the following parts of the model is matched with the part of the respiratory system it represents?

- A. plastic sheet—lung
- B. balloon—larynx
- C. tube 1—trachea
- D. seal 2—pharynx

- 22 Which of the following happens when a phosphate-phosphate bond in an ATP molecule is broken?

- A. Energy is released in a cell.
- B. Light energy is absorbed in a plant cell.
- C. Water is transported into an animal cell.
- D. Lysosome contents are released in a cell.

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** Catalase is an enzyme that protects cells from damage by helping convert the toxin hydrogen peroxide (H_2O_2) into water (H_2O) and oxygen (O_2). A student is investigating how different pH values and different temperatures affect catalase activity. The table below shows the student's data.

Catalase Experiment Data

Test Tube	Amount of Catalase (drops)	Amount of Hydrogen Peroxide (mL)	pH of Solution	Temperature of Solution ($^{\circ}\text{C}$)	Relative Rate of Reaction
1	10	3	1	5	no reaction
2	10	3	1	30	no reaction
3	10	3	1	60	no reaction
4	10	3	3	5	very slow reaction
5	10	3	3	30	slow reaction
6	10	3	3	60	no reaction
7	10	3	7	5	slow reaction
8	10	3	7	30	rapid reaction
9	10	3	7	60	no reaction

- Identify the test tube that **most likely** has physical conditions similar to the conditions in human cells. Explain your answer.
- Describe how catalase activity changes as pH decreases. Use data from the table to support your answer.
- Describe how catalase activity changes as temperature increases. Use data from the table to support your answer.
- Explain why temperature affects catalase activity in the way you described in part (c).

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 Two groups of organisms are found living on opposite sides of an island. An active volcano prevents each group from traveling to the opposite side of the island. Scientists want to know if these two groups of organisms belong to the same species.

The answer to which of the following questions would **most** help scientists determine whether the two groups belong to the same species?

- A. Do the two groups eat the same kinds of food?
- B. Are the two groups active at the same times each day?
- C. Can the two groups interbreed to produce fertile offspring?
- D. Do the two groups use similar anatomical structures for the same purpose?

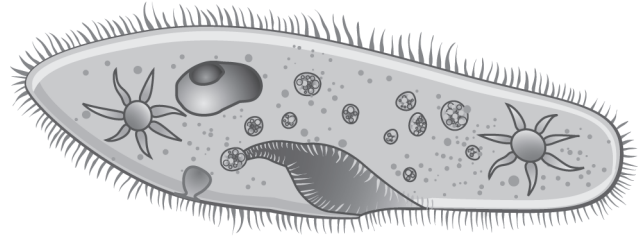
- 25 Chipmunks eat a variety of plant material, including acorns from oak trees. During certain years, oak trees produce much greater numbers of acorns than usual. These highly productive years are called mast years.

Which of the following is the **most direct** effect of a mast year on the chipmunk population in an area?

- A. The population size increases.
- B. The population has fewer predators.
- C. The population has a large number of emigrants.
- D. The population expands its territory into new habitats.

- 26 Which of the following statements describes a difference between photosynthesis and cellular respiration in plants?
- A. Photosynthesis occurs only during the day, whereas cellular respiration occurs only at night.
 - B. Photosynthesis involves only one reaction, whereas cellular respiration involves many steps.
 - C. Photosynthesis occurs only in cells containing chlorophyll, but cellular respiration occurs in all cells.
 - D. Photosynthesis converts light energy into chemical energy, but cellular respiration converts light energy into heat energy.

- 27 A single-celled organism that a student observed under a microscope is shown below.



Which of the following statements **best** describes this organism?

- A. The organism is eukaryotic because it has a plasma membrane.
- B. The organism is prokaryotic because it can reproduce asexually.
- C. The organism is prokaryotic because it can synthesize its own food.
- D. The organism is eukaryotic because it has membrane-bound organelles.

- 28 Yellow fever, encephalitis, and measles are diseases in humans. The disease-causing agents take over the machinery of the cells and use it to reproduce. Based on this information, the agents that cause these diseases are which of the following?
- A. fungi
 - B. ticks
 - C. viruses
 - D. worms
- 29 Many ranchers prefer cattle without horns. The presence or absence of horns is genetically determined. The allele for the absence of horns (**A**) is dominant to the allele for the presence of horns (**a**). A male with horns is mated with a heterozygous female without horns. What percentage of the offspring would be expected to have horns?
- A. 25%
 - B. 50%
 - C. 75%
 - D. 100%
- 30 The body structure of a reef-building coral consists of a hard skeleton covering soft tissue. Which of the following elements is most common in the coral's soft tissue?
- A. carbon
 - B. chlorine
 - C. sodium
 - D. zinc
- 31 Fossils of snakes with hind limbs but no forelimbs have been discovered. Which of the following conclusions is **best** supported by this fossil evidence?
- A. Snakes are likely to evolve limbs in the future.
 - B. Snakes are well adapted to live on land without limbs.
 - C. Snakes have evolved from an ancestral reptile with limbs.
 - D. Snakes are poor competitors compared to reptiles with limbs.

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** Sarah and her biological sister Danielle have some physical characteristics that are the same and some that are different, as shown in the table below.

	Sarah	Danielle
Eye Color	blue	brown
Natural Hair Color	light brown	dark brown
Ring Finger Length	shorter than index	shorter than index
Skin Tone	olive	olive

- Identify the molecule that stores the hereditary information for these characteristics in the chromosomes of every body cell.
- Identify the total number of chromosomes that should be in one of Sarah's body cells **and** the number of chromosomes that should have been contributed by each biological parent.
- Explain the roles of meiosis **and** fertilization in achieving the chromosome numbers you identified in part (b).
- Explain why Sarah and Danielle have some physical characteristics that are different from each other, even though they have the same biological parents.

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 When an extra nitrogenous base is inserted into the DNA sequence of a gene, the protein product of the gene is usually nonfunctional. Which of the following statements **best** explains why?

- A. The inserted base increases the rate of translation in the corresponding mRNA sequence.
- B. The inserted base causes the DNA sequence to be transcribed into the RNA in the opposite direction.
- C. The inserted base causes the codons in the mRNA sequence to be incorrect for the desired protein.
- D. The inserted base signals enzymes to translate the DNA sequence rather than the RNA sequence into the protein.

34 Some cell types contain thousands of mitochondria. These cells are likely to use large amounts of which of the following?

- A. ATP
- B. carbon dioxide
- C. DNA
- D. nitrogen

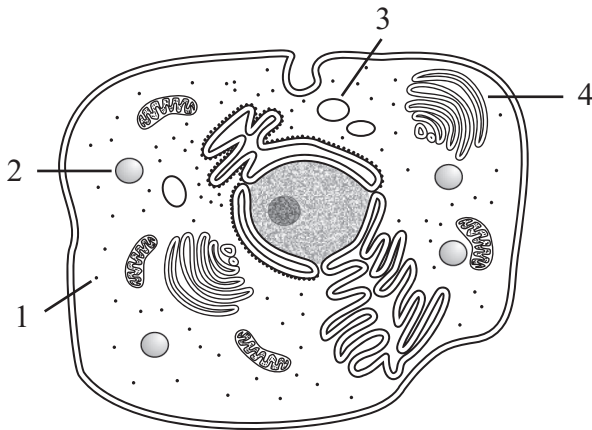
35 Turtles are classified in the order Testudines. Some turtles are aquatic and others are terrestrial. Aquatic turtles have webbed feet and short claws, but terrestrial turtles do not.

Which of the following statements **best** explains why aquatic turtles and terrestrial turtles are classified in the same order but have such different feet?

- A. Aquatic turtles evolved from fish, and terrestrial turtles evolved from reptiles.
- B. Aquatic turtles and terrestrial turtles have similar body plans, but they grow at different rates.
- C. Aquatic turtles interbred with different species, and terrestrial turtles bred only within their own species.
- D. Aquatic turtles and terrestrial turtles evolved from a common ancestor, but they have adapted to different environments.

- 36 In which of the following ways does the respiratory system help to maintain homeostasis during exercise?
- Reserves of oxygen are built up in the alveoli.
 - The pharynx supplies glucose so that the muscles can produce ATP.
 - Breathing rate is increased to exchange oxygen and carbon dioxide more rapidly.
 - The lungs release hemoglobin so that the blood can carry more oxygen to tissues.

- 37 The diagram below shows a cell with four of its parts numbered.



Which numbered part is a ribosome?

- 1
- 2
- 3
- 4

- 38 The growth of most plants is limited by the amount of nitrogen available. Which of the following effects does low nitrogen availability **most likely** have on the carbon cycle?
- More carbon dioxide is taken up by plants.
 - Carbon dioxide is trapped in the soil around plants.
 - Less carbon dioxide is removed from the atmosphere.
 - Carbon dioxide is converted to carbonates by bacteria.

- 39 During the processes of respiration and photosynthesis in plant cells, what are the three primary elements that cycle between the mitochondria and chloroplasts?
- carbon, iron, and sulfur
 - hydrogen, carbon, and oxygen
 - carbon, nitrogen, and phosphorus
 - hydrogen, oxygen, and potassium

40 Which of the following processes relies **directly** on the complementary base pairing of nucleotides?

- A. synthesis of ATP
- B. replication of DNA
- C. formation of peptide bonds
- D. pairing of chromosomes in meiosis

41 Which of the following statements describes a way in which plant cells and animal cells are similar?

- A. Both types of cells are prokaryotic.
- B. Both types of cells are autotrophic.
- C. Both types of cells have cell walls.
- D. Both types of cells contain mitochondria.

- 42 The information below describes the most specific levels of classification that the mushroom sea squirt, *Sycozoa gaimardi*, shares with four other organisms.

- The mushroom sea squirt is in the same class as the common sea grape.
- The mushroom sea squirt is in the same family as the blue spot ascidian.
- The mushroom sea squirt is in the same order as the white speck tunicate.
- The mushroom sea squirt is in the same phylum as the starry skate.

To which of the four organisms is the mushroom sea squirt most closely related?

- A. common sea grape
- B. blue spot ascidian
- C. white speck tunicate
- D. starry skate

- 43 Tapeworms are sometimes found in the small intestines of sheep. A tapeworm attaches to the intestinal wall using suckers and then absorbs nutrients from the sheep's intestine.

Which of the following terms describes the relationship between the tapeworm and the sheep?

- A. competition
- B. herbivory
- C. parasitism
- D. predation

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.

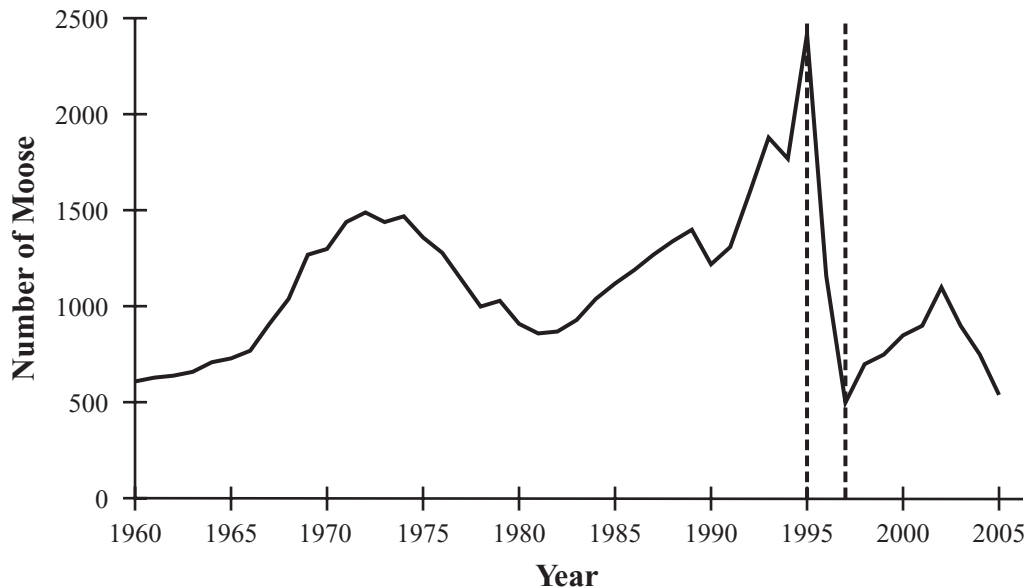
44 In red-green colorblindness, individuals cannot perceive the colors red and green in the same way as individuals with full color vision. Full color vision is coded by a dominant allele (**B**) on the X chromosome. Red-green colorblindness is caused by a recessive allele (**b**) on the X chromosome.

- Identify the phenotype of a female with the genotype $X^B X^b$.
- Identify the phenotype of a male with the genotype $X^B Y$.
- Draw a Punnett square for the cross $X^B X^b \times X^B Y$, **and** identify the following:
 - the percentage of offspring expected to be male and colorblind
 - the percentage of offspring expected to be female and colorblind
- Explain why red-green colorblindness occurs more frequently in males than in females.

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

- 45 Lake Superior is on the northern border of the continental United States. The graph below shows changes in the size of the moose population on an island in Lake Superior from 1960 to 2005. The island is in a remote location several miles off the northwest shore of the lake.

Moose Population, 1960–2005



- Explain why immigration and emigration are **not** likely to have an effect on the size of the island's moose population.
- Describe what happened to the size of the island's moose population from 1995 to 1997, **and** describe how the birth rate and the death rate must have compared during this time.
- Identify **two** different natural factors that could have contributed to the change in moose population size you described in part (b).
- Explain why **each** of the factors you identified in part (c) contributed to the change in moose population size.

High School Biology
Spring 2013 Released Items:
Reporting Categories, Standards, and Correct Answers*

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
1	320	<i>Anatomy and Physiology</i>	4.2	C
2	320	<i>Biochemistry and Cell Biology</i>	1.2	C
3	321	<i>Ecology</i>	6.3	B
4	321	<i>Genetics</i>	3.6	C
5	321	<i>Genetics</i>	3.4	B
6	322	<i>Ecology</i>	6.1	A
7	322	<i>Anatomy and Physiology</i>	4.4	D
8	324	<i>Evolution and Biodiversity</i>	5.3	B
9	324	<i>Evolution and Biodiversity</i>	5.1	D
10	324	<i>Evolution and Biodiversity</i>	5.3	C
11	324	<i>Ecology</i>	6.2	C
12	325	<i>Evolution and Biodiversity</i>	5.3	
13	326	<i>Genetics</i>	3.1	D
14	326	<i>Anatomy and Physiology</i>	4.5	C
15	326	<i>Biochemistry and Cell Biology</i>	2.2	A
16	326	<i>Biochemistry and Cell Biology</i>	2.6	B
17	327	<i>Genetics</i>	3.3	D
18	327	<i>Ecology</i>	6.2	D
19	327	<i>Evolution and Biodiversity</i>	5.1	D
20	327	<i>Genetics</i>	3.5	A
21	328	<i>Anatomy and Physiology</i>	4.3	C
22	328	<i>Biochemistry and Cell Biology</i>	2.5	A
23	329	<i>Biochemistry and Cell Biology</i>	1.3	
24	330	<i>Evolution and Biodiversity</i>	5.2	C
25	330	<i>Ecology</i>	6.2	A
26	331	<i>Biochemistry and Cell Biology</i>	2.4	C
27	331	<i>Biochemistry and Cell Biology</i>	2.2	D
28	332	<i>Biochemistry and Cell Biology</i>	2.8	C
29	332	<i>Genetics</i>	3.6	B
30	332	<i>Biochemistry and Cell Biology</i>	1.1	A
31	332	<i>Evolution and Biodiversity</i>	5.1	C
32	333	<i>Anatomy and Physiology</i>	4.6	
33	334	<i>Genetics</i>	3.3	C
34	334	<i>Biochemistry and Cell Biology</i>	2.1	A
35	334	<i>Evolution and Biodiversity</i>	5.1	D
36	335	<i>Anatomy and Physiology</i>	4.8	C
37	335	<i>Biochemistry and Cell Biology</i>	2.1	A
38	335	<i>Ecology</i>	6.4	C
39	335	<i>Ecology</i>	6.4	B

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
40	336	<i>Genetics</i>	3.2	B
41	336	<i>Biochemistry and Cell Biology</i>	2.3	D
42	337	<i>Evolution and Biodiversity</i>	5.2	B
43	337	<i>Ecology</i>	6.3	C
44	338	<i>Genetics</i>	3.4	
45	339	<i>Ecology</i>	6.1	

* 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.