XVIII. Biology, High School

High School Biology Test

The spring 2018 high school Biology test was based on learning standards in the Biology content strand of the October 2006 version of the *Massachusetts Science and Technology/Engineering Curriculum Framework*. These learning standards appear in the 2006 framework, which is available on the Department website at www.doe.mass.edu/frameworks/archive.html. Massachusetts adopted a new curriculum framework in science and technology/engineering in 2016. A plan for transitioning the MCAS assessments to the new framework is available at www.doe.mass.edu/mcas/tdd/sci.html?section=transition.

Biology test results are reported under the following five MCAS reporting categories:

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

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.

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.

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

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 of the following statements describes how human traits are inherited?

A. Children receive half of their genes from each parent.

B. Only dominant traits are passed from parents to their children.

C. Traits skip a generation, passing directly from grandparents to their grandchildren.

D. Female children receive genes only from their mothers, and male children receive genes only from their fathers.

2 A cell membrane has a double layer of molecules. These molecules are made up of a phosphorus-containing "head" and two long, fatty acid "tails."

Which of the following **best** explains why the molecules are classified as lipids?

A. They contain phosphorus.

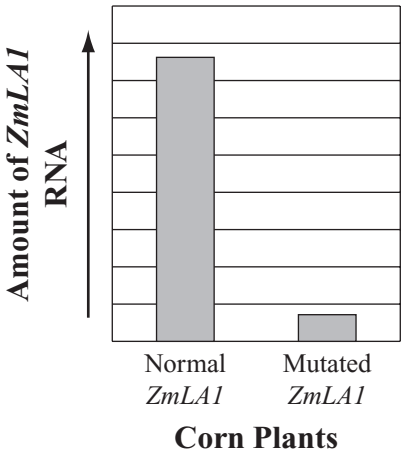
B. They form a double layer.

C. They are made up of fatty acids.

D. They are found in the cell membrane.

3 All corn plants contain the *ZmLA1* gene. Some corn plants contain a certain mutation in the *ZmLA1* gene. The graph below shows the amount of *ZmLA1* RNA produced in plants with the normal gene and in plants with the mutated gene.

Amount of *ZmLA1* RNA in Corn Plants



Based on the graph, what most likely happens in corn plant cells as a **direct** result of the mutated gene?

A. DNA replication increases.
B. Lipid production decreases.
C. Glucose synthesis increases.
D. Protein production decreases.

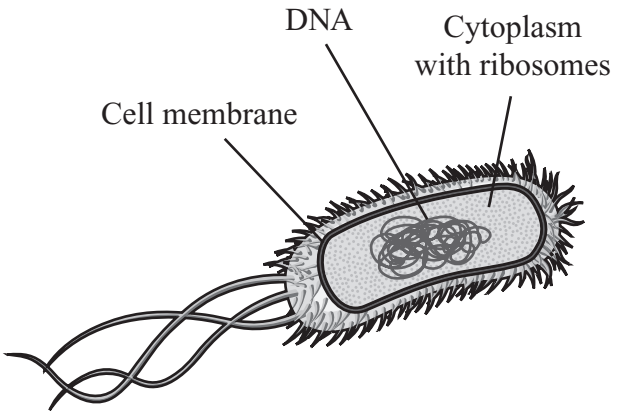
4 The growth of plants in many ecosystems is limited by the supply of nitrogen. Which of the following groups of organisms plays the largest role in moving nitrogen between the atmosphere and plants?

A. bacteria
B. earthworms
C. insects
D. protists

5 An unfertilized egg cell has six chromosomes. After fertilization, how many chromosomes should the zygote have?

A. 3
B. 6
C. 12
D. 24

6 The diagram below shows the structure of a bacterial cell.



Which of the following distinguishes this bacterial cell from eukaryotes?

A. The bacterial cell is a unicellular organism, and all eukaryotes are multicellular.

B. Ribosomes are found in the cytoplasm of the bacterial cell, and eukaryotes do not have ribosomes.

C. The bacterial cell has both a cell membrane and a cell wall, and eukaryotes have only cell membranes.

D. DNA in the bacterial cell is always in contact with the cytoplasm, and all eukaryotes have DNA located inside a nucleus.

7 Lithops are multicellular organisms found in sandy soil in deserts. They have large, central vacuoles in their cells that store water.

Which of the following best classifies lithops?

A. They are bacteria because they store water.

B. They are animals because they are multicellular.

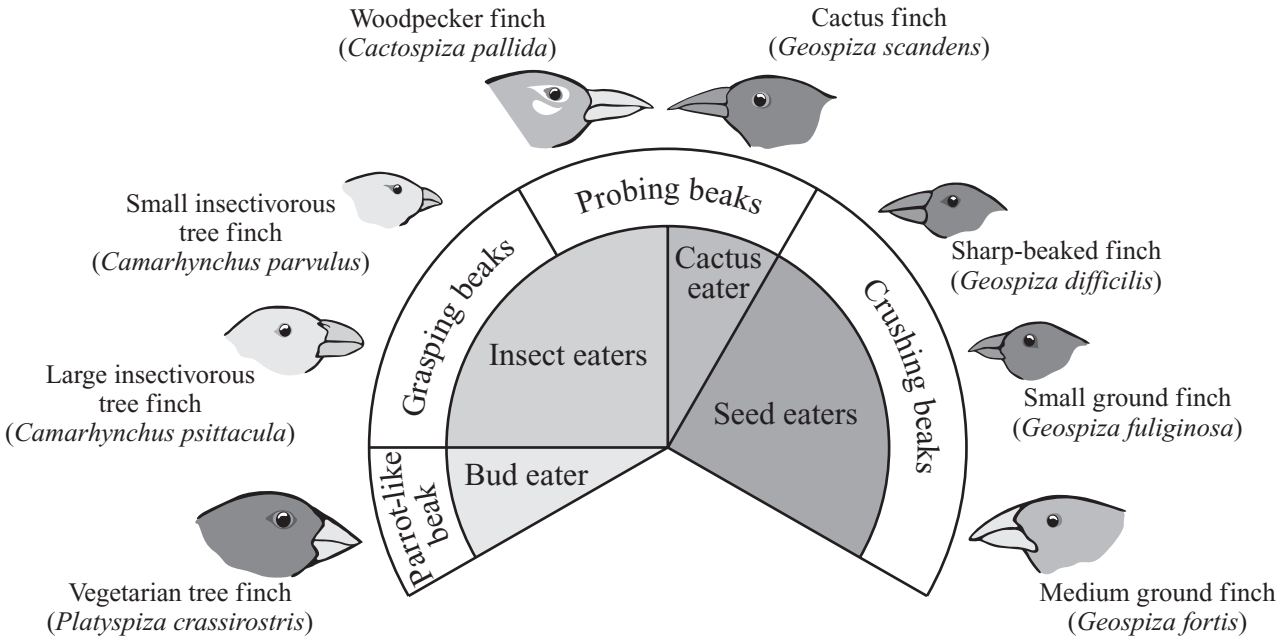
C. They are fungi because they are found in sandy soil.

D. They are plants because they have large, central vacuoles.

The following section focuses on the finches of the Galápagos Islands.

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

The Galápagos Islands are home to a group of bird species known as Darwin's finches. The diagram below shows eight of these finch species, organized according to the type of beak they have and their main source of food as adults.



Darwin's finches provide a classic example of the processes of evolution. Scientists have concluded that Darwin's finches evolved from a South American ancestor. The Galápagos Islands are located approximately 1000 km west of South America. These islands were never connected to the South American mainland or to each other. Scientists think that a small number of birds from the ancestral species must have either gotten lost or been blown to the islands by a storm. This original population then evolved on the islands, where there are many different niches and food sources.

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 According to the finch diagram, which of the following finches is a secondary consumer?

A. small insectivorous tree finch
B. cactus finch
C. sharp-beaked finch
D. medium ground finch

9 When living on the same island, which of the following finches **most likely** competes for food with the large insectivorous tree finch?

A. vegetarian tree finch
B. woodpecker finch
C. cactus finch
D. medium ground finch

10 Which of the following questions would a scientist **most likely** ask to determine whether various finch populations belong to one species?

A. Do the various finches have similar average life spans?
B. Do the various finches often eat the same types of food?
C. Do the various finches have a wide range of average body sizes?
D. Do the various finches often mate and produce fertile offspring together?

11 The different finch beaks are the result of natural selection. Which of the following conditions was required for natural selection to occur in the Galápagos finches?

A. low death rates for the finches
B. low mutation rates in the finches
C. some genetic variation in the ancestral population
D. unequal numbers of males and females in the ancestral population

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 After studying the finch diagram, a student concluded that the cactus finch, sharp-beaked finch, small ground finch, and medium ground finch are more closely related to each other than to the other four finch species shown.

a. Describe the evidence from the diagram the student used to come to this conclusion.

The student hypothesized that the sharp-beaked finch, small ground finch, and medium ground finch are more closely related to each other than to the cactus finch.

b. Identify one type of scientific evidence, other than physical characteristics, that would help the student evaluate the hypothesis, **and** describe specifically how that evidence could support the hypothesis.

The finches on the Galápagos Islands share many physical characteristics; however, not all organisms with similar physical characteristics are closely related.

c. Explain how two organisms that are **not** closely related could evolve similar physical characteristics.

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 In the plant *Brassica rapa*, the allele for purple stem color (**P**) is dominant to the allele for green stem color (**p**). Students in a biology class cross-pollinated a heterozygous purple-stemmed plant (**Pp**) with a green-stemmed plant (**pp**). The 78 seeds produced from this cross were planted to form the F_1 generation.

Approximately how many purple-stemmed plants and how many green-stemmed plants are expected in the F_1 generation?

A. 0 purple-stemmed plants and 78 green-stemmed plants

B. 39 purple-stemmed plants and 39 green-stemmed plants

C. 58 purple-stemmed plants and 20 green-stemmed plants

D. 78 purple-stemmed plants and 0 green-stemmed plants

14 There are many fungus species that live inside plant tissues. What determines whether the relationship between a fungus and a plant is commensalism, mutualism, or parasitism?

A. where the fungus is located in the plant

B. how long the fungus survives in the plant

C. whether the fungus reproduces in the plant with spores, seeds, or runners

D. whether the effect of the fungus on the plant is neutral, positive, or negative

15 A student places four small aquatic snails in a test tube containing bromothymol blue solution. The solution will change color from blue to yellow if the carbon dioxide level increases. The student seals the test tube and notes that the solution is blue. After a few hours, the student observes that the solution is yellow.

What cellular process did the snails perform that caused the color of the solution to change?

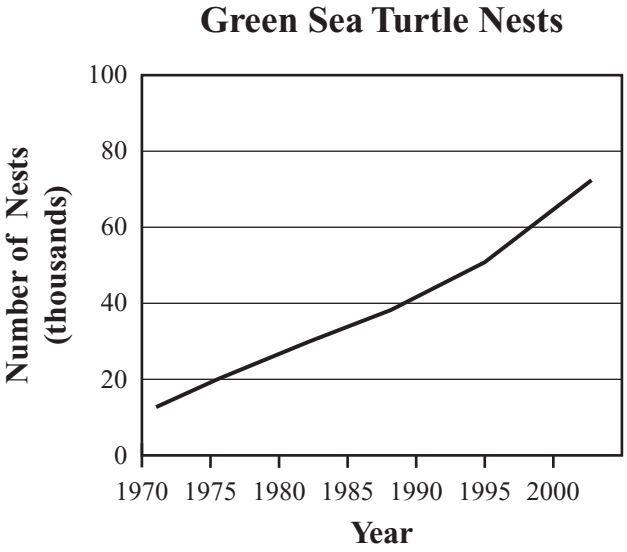
A. cellular respiration

B. chemical digestion

C. fermentation

D. photosynthesis

16 The green sea turtle is an endangered species. The graph below shows the estimated number of green sea turtle nests on a beach in Costa Rica between 1970 and 2003.



Based on the information in the graph, which of the following is the most likely way humans affected the green sea turtle population during this time?

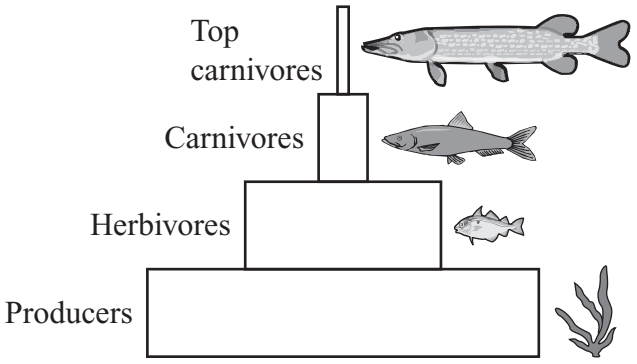
A. Humans passed laws preventing the collection of green sea turtles.

B. Humans collected more green sea turtle eggs for scientists to study.

C. Humans passed laws protecting animals that eat green sea turtle eggs.

D. Humans built more hotels on the beach where green sea turtles build nests.

17 The diagram below shows an energy pyramid for an aquatic ecosystem.



Which of the following statements **best** explains why the energy pyramid is narrowest at the top?

A. The organisms at the top of the pyramid are the most efficient feeders.

B. The organisms at the top of the pyramid have the largest population sizes.

C. The organisms at the top of the pyramid need only a small amount of energy for their metabolism.

D. The organisms at the top of the pyramid receive only a small fraction of the energy that originally enters the system.

18 The cartilage on the ends of long bones serves which of the following functions?

A. attaching the bones to muscles

B. connecting the bones to other bones

C. cushioning and resisting compression at joints

D. forming and storing red blood cells for the body

19 In cattle, the allele for no horns (**P**) is dominant to the allele for horns (**p**). The allele for cloven hooves (**C**) is dominant to the allele for mule feet (**c**). Cattle that are heterozygous for these traits are crossed. The Punnett square for this cross is shown below.

	PC	**Pc**	**pC**	**pc**
PC	**PPCC**	**PPCc**	**PpCC**	**PpCc**
Pc	**PPCc**	**PPcc**	**PpCc**	**Ppcc**
pC	**PpCC**	**PpCc**	**ppCC**	**ppCc**
pc	**PpCc**	**Ppcc**	**ppCc**	**ppcc**

What is the probability that an offspring will have the same phenotype as the parents?

A. $\frac{3}{16}$

B. $\frac{9}{16}$

C. $\frac{11}{16}$

D. $\frac{13}{16}$

20 During a running race, a person's breathing rate and heart rate increase. These changes most directly help the person do which of the following?

A. increase the rate of digestion
B. decrease the rate of gamete production
C. decrease the rate of protein synthesis in neurons
D. increase the rate of cellular respiration in mitochondria

21 In 1937, two male and six female ring-necked pheasants were introduced to an island off the coast of Washington state. The pheasants mainly ate wheat. The only known predators on the island were house cats, hawks, and owls. After five years, the pheasant population on the island had increased to 1,325 individuals. The population size then remained stable.

Which of the following most likely explains why the pheasant population size remained stable after five years?

A. The hawks learned to hunt only owls.
B. A limited amount of wheat grew on the island.
C. All the house cats that lived on the island died.
D. The original male and female ring-necked pheasants died.

22 In fruit flies, the gene for eye color is on the X chromosome. The allele for red eyes is dominant to the allele for white eyes. A researcher crosses a heterozygous red-eyed female fly ($\mathbf{X^RX^r}$) with a red-eyed male fly ($\mathbf{X^RY}$).

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

A. All the female and male offspring will have red eyes.
B. All the female and male offspring will have white eyes.
C. All the female offspring and half the male offspring will have red eyes.
D. Half the female offspring and all the male offspring will have white eyes.

Questions 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 A student in a kitchen does the following:

- smells something cooking in the oven
- walks to the oven
- sees a pizza
- takes the pizza out of the oven
- starts chewing the pizza
- tastes the pizza

The student's nervous system has a role in all these actions.

a. Describe the function of sensory neurons.

b. Identify **two** specific actions from the list above that require sensory neurons.

c. Describe the function of motor neurons.

d. Identify **two** specific actions from the list above that require motor neurons.

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 Which of the following does the human digestive system break down for the body's cells to use for energy, repair, and growth?

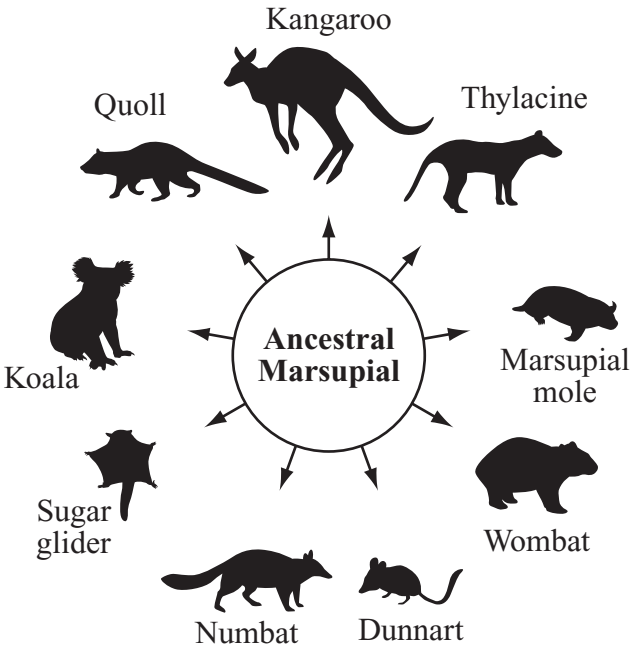
A. carbohydrates and fats only

B. carbohydrates, fats, and oxygen

C. carbohydrates and proteins only

D. carbohydrates, fats, and proteins

25 Marsupials are a type of mammal found on the continent of Australia. Marsupials are hypothesized to have descended from an ancestral marsupial species, as represented by the diagram below.



Which of the following conditions **most likely** caused the ancestral marsupial species to diversify into the many modern-day marsupial species found in Australia?

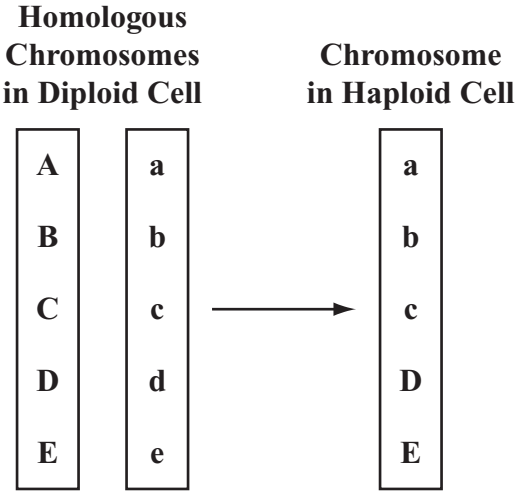
A. a variety of predators

B. hot climate conditions

C. a variety of environments

D. little competition for resources

26 The diagram below represents a pair of homologous chromosomes in a diploid cell, and the resulting chromosome in a haploid cell. The letters represent alleles of genes.



Why does the chromosome in the haploid cell have alleles from both of the chromosomes in the diploid cell?

A. Crossing over occurred during meiosis.

B. A mutation occurred during a viral infection.

C. Independent assortment occurred during fertilization.

D. Incomplete dominance occurred during gene expression.

27 Scientists studying human diseases often use animal models. For example, fruit flies have been used to study Alzheimer's disease. Scientists insert certain human genes found in patients with Alzheimer's disease into fruit flies and observe how these genes affect the fruit flies.

Where must the human gene be inserted for a fruit fly to produce offspring with this gene?

A. in the sex cells of the fly

B. on several proteins in a fly cell

C. in the nervous system of the fly

D. on several chromosomes in a fly cell

28 Snakes such as boa constrictors and pythons have tiny leg bones buried in their muscles. These leg bones are vestigial structures that have little or no known function in snakes.

Which **best** explains the presence of these vestigial structures in snakes?

A. Snakes evolved from organisms with legs.

B. Snakes are developing legs for walking on land.

C. Snakes born with an extra set of DNA develop legs as they mature.

D. Snakes have only one copy of the allele for legs in their chromosomes.

29 Placental mammals are one group of mammals. Using DNA evidence, scientists have concluded that the ancestor of placental mammals diverged from other mammal groups about 160 million years ago.

The analysis of which of the following types of evidence would **best** verify this conclusion?

A. behaviors
B. cells
C. diets
D. fossils

30 In the ocean, some bacteria break down oil instead of glucose for energy. There is often a low concentration of oxygen in the areas where these bacteria are found.

Which of the following statements **best** explains why the oxygen concentration is often low where these bacteria are found?

A. The bacteria develop cell nuclei in the presence of the oil.
B. The bacteria perform a process similar to photosynthesis with the oil.
C. The bacteria use oxygen and release carbon dioxide as they break down the oil.
D. The bacteria make their membranes more permeable to oxygen as they break down the oil.

31 The New England cottontail is the only rabbit native to New England. Current populations are small and isolated because of habitat loss. Scientists are concerned about the possible extinction of the New England cottontail.

Which of the following statements explains why having small and isolated populations puts these rabbits at risk for extinction?

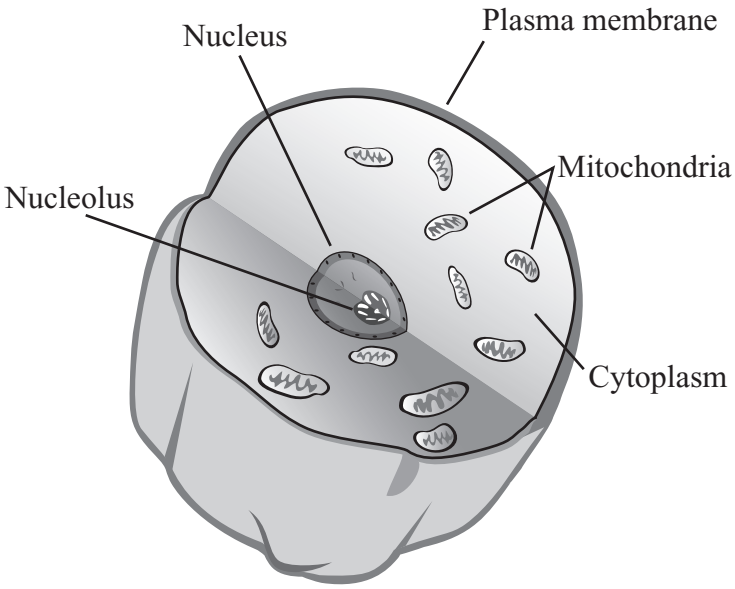
A. Diet requirements of the rabbits are changed, making the emigration rate increase.
B. Male-to-female ratios in the populations are changed, making the birth rate fall to zero.
C. Immigration is increased, making it harder for the rabbits to successfully compete for resources.
D. Genetic variation is decreased, making the populations less able to adapt to environmental changes.

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 Clara made a model of an animal cell for science class. Her model is shown below.



a. Identify **two** animal cell structures that are missing from Clara's model.

b. Describe the function of **each** cell structure you identified in part (a).

The model contains a large number of mitochondria.

c. Identify the main role of mitochondria in animal cells.

d. Identify one type of animal cell that typically contains large numbers of mitochondria.

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 The table below shows taxonomic information for the gray wolf and four other species.

	Gray Wolf	Species 1	Species 2	Species 3	Species 4
Kingdom	Animalia	Animalia	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Chordata	Chordata	Anthropoda
Class	Mammalia	Mammalia	Mammalia	Mammalia	Insecta
Order	Carnivora	Carnivora	Carnivora	Rodentia	Diptera
Family	Canidae	Felidae	Canidae	Geomyidae	Muscidae
Genus	*Canis*	*Felis*	*Vulpes*	*Thomomys*	*Musca*
Species	*lupus*	*catus*	*vulpes*	*bottae*	*domestica*

Based on this information, which of the following lists the species in order from most closely related to least closely related to the gray wolf?

A. 1, 2, 3, 4

B. 1, 2, 4, 3

C. 2, 1, 3, 4

D. 2, 1, 4, 3

34 Valvular stenosis is a condition in which the heart valves are stiff and do not open completely. In people with this condition, blood flow to the body is decreased.

How will valvular stenosis **most likely** affect body cells?

A. Body cells will produce less water than usual.

B. Body cells will receive less oxygen than usual.

C. Body cells will store more nutrients than usual.

D. Body cells will produce more waste products than usual.

35 When proteins are broken down, phenylalanine is sometimes produced. Phenylalanine contains the elements carbon, nitrogen, hydrogen, and oxygen.

Phenylalanine is which type of compound?

A. amino acid

B. fatty acid

C. monosaccharide

D. phospholipid

36 Which of the following describes how DNA determines genetic inheritance?

A. A single nucleotide codes for a genetic trait.

B. A pair of complementary nucleotides codes for a genetic trait.

C. A set of three nucleotides in a specific order codes for a genetic trait.

D. A long sequence of nucleotides in a specific order codes for a genetic trait.

37 Plants in floodplains often get covered by water during floods. Some plants survive the floods because they can continue photosynthesis underwater. However, the plants' rates of photosynthesis are much lower underwater than above water.

Which of the following helps to explain why the rates of photosynthesis are lower underwater than above water?

A. There is too much oxygen in the water.

B. There is no carbon dioxide in the water.

C. The chloroplasts do not function underwater.

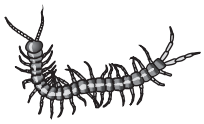
D. The available light is less intense underwater.

38 In humans, one form of night blindness is an inherited condition that affects far more males than females. Males with one copy of the allele for this form of night blindness will have the condition, but females must have two copies of the allele to have the condition.

Which of the following best describes the allele that codes for this form of night blindness?

A. recessive on the X chromosome
B. polygenic on the X chromosome
C. dominant on the Y chromosome
D. codominant on the Y chromosome

39 Images of the embryo and adult stages of three different organisms are shown below.

Organism	Embryo	Adult
grasshopper		
spider		
centipede		

Which of the following is the best conclusion that can be drawn from this evidence?

A. Having similar embryos indicates that these organisms eat the same types of food.
B. Having similar embryos indicates that these organisms live in a similar environment.
C. Having similar embryos indicates that these organisms share a recent common ancestor.
D. Having similar embryos indicates that a certain protein controls how many legs the adult organisms will have.

40 What directly supplies the energy a cell needs for activities such as moving its cilia or transporting molecules against a concentration gradient?

A. ATP
B. hemoglobin
C. RNA
D. triglycerides

41 Bacteria that live in the digestive systems of cows help break down the plants that cows eat, providing nutrients to cows. The digestive systems of cows offer a safe environment in which the bacteria can live and reproduce.

Which type of relationship exists between the bacteria and the cows?

A. commensalism
B. mutualism
C. parasitism
D. predation

42 Methylation is a process that can add methyl (CH_3) groups to DNA. A gene containing methylated nucleotides often cannot be transcribed. As a result, proteins will not be produced.

Which of the following cellular processes is most **directly** affected by DNA methylation?

A. mRNA production
B. nitrogen fixation
C. replication
D. respiration

43 Because most nerve cells do not typically undergo mitosis, they are generally not capable of which of the following?

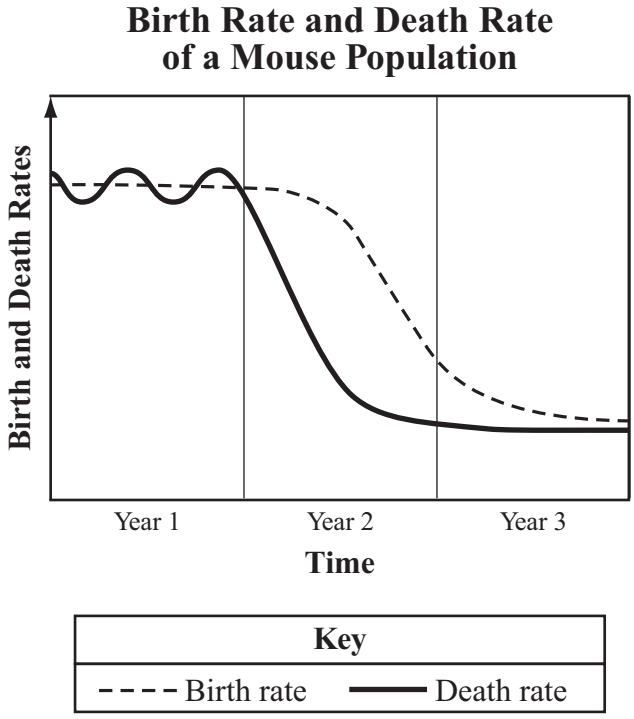
A. producing enzymes
B. generating more nerve cells
C. performing cellular respiration
D. transporting ions against a concentration gradient

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 The graph below shows the birth rate and the death rate of a mouse population over a three-year period. The immigration rate and the emigration rate of the population are equal.



a. Describe what happens to the size of the population for **each** year shown on the graph. Explain your answers.

b. Identify **three** factors that could affect the death rate of the mouse population, and explain why each factor affects the death rate.

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

45 Corn kernels can be high in starch (starchy) or high in sugar (sweet). The allele for starchy kernels (**H**) is dominant to the allele for sweet kernels (**h**).

Each kernel on an ear of corn represents an individual offspring. A particular ear of corn has 92 starchy kernels and 88 sweet kernels.

a. What are the **most likely** genotypes of the parent corn plants that produced this particular ear of corn?

b. Explain how you determined the genotypes of the parent corn plants in part (a). Draw a Punnett square for the cross to support your answer.

c. Identify the genotypes for two corn plants that, when crossed, will produce plants with 100% starchy kernels.

High School Biology
Spring 2018 Released Items:
Reporting Categories, Standards, and Correct Answers*

Item No.	Page No.	Reporting Category	2006 Standard	Correct Answer (MC)*
1	380	*Anatomy and Physiology*	4.6	A
2	380	*Biochemistry and Cell Biology*	1.2	C
3	381	*Genetics*	3.2	D
4	381	*Ecology*	6.4	A
5	381	*Biochemistry and Cell Biology*	2.7	C
6	382	*Biochemistry and Cell Biology*	2.2	D
7	382	*Biochemistry and Cell Biology*	2.3	D
8	384	*Ecology*	6.3	A
9	384	*Ecology*	6.3	B
10	384	*Evolution and Biodiversity*	5.2	D
11	384	*Evolution and Biodiversity*	5.3	C
12	385	*Evolution and Biodiversity*	5.1	
13	386	*Genetics*	3.6	B
14	386	*Ecology*	6.3	D
15	387	*Biochemistry and Cell Biology*	2.4	A
16	387	*Ecology*	6.2	A
17	388	*Ecology*	6.3	D
18	388	*Anatomy and Physiology*	4.5	C
19	388	*Genetics*	3.5	B
20	389	*Anatomy and Physiology*	4.8	D
21	389	*Ecology*	6.2	B
22	389	*Genetics*	3.6	C
23	390	*Anatomy and Physiology*	4.4	
24	391	*Anatomy and Physiology*	4.1	D
25	391	*Evolution and Biodiversity*	5.3	C
26	392	*Biochemistry and Cell Biology*	2.7	A
27	392	*Genetics*	3.3	A
28	392	*Evolution and Biodiversity*	5.1	A
29	393	*Evolution and Biodiversity*	5.1	D
30	393	*Biochemistry and Cell Biology*	2.4	C
31	393	*Ecology*	6.2	D
32	394	*Biochemistry and Cell Biology*	2.1	
33	395	*Evolution and Biodiversity*	5.2	C
34	396	*Anatomy and Physiology*	4.2	B
35	396	*Biochemistry and Cell Biology*	1.2	A

Item No.	Page No.	Reporting Category	2006 Standard	Correct Answer (MC)*
36	397	*Genetics*	3.1	D
37	397	*Biochemistry and Cell Biology*	2.4	D
38	398	*Genetics*	3.4	A
39	398	*Evolution and Biodiversity*	5.1	C
40	399	*Biochemistry and Cell Biology*	2.5	A
41	399	*Ecology*	6.3	B
42	399	*Genetics*	3.2	A
43	399	*Biochemistry and Cell Biology*	2.6	B
44	400	*Ecology*	6.1	
45	401	*Genetics*	3.6	

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