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Commissioner’s Foreword

Dear Colleagues:

The Massachusetts Department of Elementary and Secondary Education is committed to working in partnership with schools to support a system that will prepare all students to succeed as productive and contributing members of our democratic society and the global economy. To assist in achieving this goal, the Department regularly releases Massachusetts Comprehensive Assessment System (MCAS) test items to provide information about the kinds of knowledge and skills that students are expected to demonstrate. This publication contains all MCAS February Biology items on which student scores are based.

The Department has banked thousands of MCAS items that are currently posted on the Department website. These items, which are available at www.doe.mass.edu/mcas/testitems.html, will continue to be a rich resource for schools.

This publication is available only on the Department website. The test items can be printed from this site. I encourage educators to use the relevant sections of this document together with their test item analysis reports as guides for planning changes in curriculum and instruction that may be needed to support schools and districts in their efforts to improve student performance.

Thank you for your support as we work together to strengthen education for our students in Massachusetts.

Sincerely,

Mitchell D. Chester, Ed.D.
Commissioner of Elementary and Secondary Education
I. Document Purpose and Structure
**Document Purpose and Structure**

**Purpose**

The purpose of this document is to share with educators and the public all of the test items from the February 2014 MCAS Biology test on which student results are based. Local educators will be able to use this information to identify strengths and weaknesses in their curriculum and to plan instruction to more effectively meet their students’ individual needs.

This document is also intended to be used by school and district personnel as a companion document to test item analysis reports. The reports list, for the school accessing the report, the names of all enrolled students who took the February 2014 Biology test, as well as information about how each student answered each common test item in this document. The reports also label each item as multiple-choice or open-response and identify the item’s MCAS reporting category. Item numbers in this document correlate directly to the “Item Numbers” in the test item analysis reports.

**Structure**

Chapter II of this document contains information for the February 2014 Biology test and has three main sections. The first section introduces the chapter by listing the Massachusetts curriculum framework content strands assessed by the Biology MCAS test. These content strands are identical to the MCAS reporting categories under which test results are reported to schools and districts. The first section also provides the Web address for the *Science and Technology/Engineering Curriculum Framework* and the page numbers on which the learning standards assessed by the test items in the chapter can be found. In addition, there is a brief overview of the test (number of test sessions, types of items, reference materials allowed, and cross-referencing information).

The second section contains the test items used to generate February 2014 MCAS student results for Biology. The test items in this document are shown in the same order and basic format in which they were presented in the test booklet.

The final section of the chapter is a table that cross-references each item with its MCAS reporting category and with the framework standard it assesses. Correct answers to multiple-choice questions are also listed in the table.

Materials presented in this document are not formatted exactly as they appeared in student test booklets. For example, in order to present items most efficiently in this document, the following modifications have been made:

- Some fonts and/or font sizes may have been changed and/or reduced.
- Some graphics may have been reduced in size from their appearance in student test booklets; however, they maintain the same proportions in each case.
- All references to page numbers in answer booklets have been deleted from the directions that accompany test items.
II. February 2014 Biology Test
February 2014 Biology Test


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 English language learner students only, during both Biology test sessions. No other reference 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.

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1. The graph below shows the change in the size of a mammal population.

   [Population Size over Time graph]

   Which of the following statements could explain the change in population size in region X?
   - A. Birth rate is greater than death rate.
   - B. Emigration rate is greater than birth rate.
   - C. Death rate is greater than immigration rate.
   - D. Emigration rate is greater than immigration rate.

2. Human HLA genes have as many as 100 different alleles per gene. The alleles code for proteins that are involved in accepting or rejecting an organ following an organ transplant. Which of the following statements explains how this multiple allele inheritance pattern makes it difficult to match an organ donor with an organ recipient?
   - A. Each organ in a person’s body expresses a different allele.
   - B. The donor must have dominant alleles for the organ to be accepted.
   - C. The alleles cannot mutate in the recipient’s body after the transplant.
   - D. Most people do not have the same combination of alleles for the genes.

3. If the producers in a food web were removed, which of the following changes would most likely occur?
   - A. The entire food web would collapse over time.
   - B. The food web would depend on the decomposers for energy.
   - C. The consumers would begin making energy for the food web.
   - D. The populations of the remaining organisms in the food web would increase.
4. The diagram below shows a portion of the anatomy of the human arm.

Which letter on the diagram indicates a tendon?
A. W  
B. X  
C. Y  
D. Z  

5. Peptidoglycan is a compound in the cell walls of many bacteria. Which of the following elements are most abundant in peptidoglycan?
A. aluminum and sodium  
B. carbon and hydrogen  
C. chlorine and iron  
D. iodine and potassium  

6. Scientists hypothesize that the microscopic organisms inside a termite’s gut are responsible for breaking down the wood that the termite eats. To support this hypothesis, research results should show that the microscopic organisms can produce which of the following?
A. ATP  
B. polysaccharides  
C. enzymes specific to cellulose  
D. nucleic acids that are double-stranded  

7. Within a prey population, which of the following is most immediately affected by the arrival of a new predator?
A. death rate  
B. evolution rate  
C. immigration rate  
D. maturation rate
The following section focuses on single-celled organisms.

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

Many different microscopic organisms can be found in pond ecosystems, including the three organisms shown in the diagrams below. The primary cellular structures in each of these single-celled organisms are labeled in the diagrams. Some of the structures are common to all three organisms and other structures are not.

(Note: Cells are not to scale.)
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. Based on the cellular structure of organism 3, which of the following is a characteristic of the organism?
   A. It can conduct photosynthesis.
   B. It can move around in its environment.
   C. It can produce male and female gametes.
   D. It can survive for long periods by storing food.

9. Which of the following is a function of the nucleus in organism 2?
   A. absorbing sunlight
   B. releasing usable energy
   C. storing genetic material
   D. producing food molecules

10. In the three organisms, what are synthesized by the ribosomes?
    A. carbohydrates
    B. lipids
    C. nucleic acids
    D. proteins

11. Which of the following identifies the organisms that are eukaryotic and gives the best explanation?
    A. organisms 1 and 2 only, because both have a nucleus
    B. organisms 2 and 3 only, because both use flagella
    C. organisms 1, 2, and 3, because they all have ribosomes
    D. organisms 1, 2, and 3, because they are all single celled
One of the three organisms can obtain energy through photosynthesis.

a. Based on the diagrams, identify which organism is able to perform photosynthesis. Explain your reasoning.

b. Identify the two reactants for photosynthesis.

c. Identify the structure shown in the diagram that stores a product of photosynthesis in this organism.

At times, this photosynthetic organism can switch to being heterotrophic.

d. Describe a condition that would favor this organism being heterotrophic. Explain your answer.
Penguins are powerful swimmers. Scientists have concluded that penguins evolved adaptations for powerful swimming early in their evolutionary history.

Which of the following pieces of evidence did scientists most likely use to make this conclusion?

A. DNA sequences of different penguin species
B. maps of the global distribution of penguin species
C. fossils showing the shape of ancient penguins’ wings and feathers
D. x-rays of the bone structure in modern penguins’ wings

Bluetongue virus causes severe disease in sheep and cattle. High levels of infection in livestock populations can threaten the livestock industry.

Which of the following statements best describes how a bluetongue virus particle reproduces in its sheep or cattle host?

A. The virus immediately kills the animal and then escapes to reproduce.
B. The virus makes spores that are shed on the ground with the animal’s wastes.
C. The virus uses the animal’s cellular machinery to reproduce inside the animal.
D. The virus releases eggs into the nutrient-rich environment of the animal’s digestive tract.

Two vegetable plants, swiss chard and beets, have the same scientific name, Beta vulgaris. Based on this information, which of the following statements describes these vegetables?

A. They cannot interbreed with each other.
B. They are the same species of organism.
C. They cannot grow under the same conditions.
D. They have identical numbers of leaves when fully grown.
17 Which of the following best describes the producers in a terrestrial food web?
A. They are at the highest trophic level.
B. They are not affected by decomposers.
C. They convert solar energy to chemical energy.
D. They obtain all their nutrients and energy from consumers.

18 A congenital cataract is a clouding of the lens of the eye that is present from birth. The mode of inheritance for one type of congenital cataract is autosomal dominant.

Suppose a man is heterozygous for this type of congenital cataract, and a woman does not have cataracts. If these two individuals have a child, what is the probability that the child will have this type of congenital cataract?

A. $\frac{1}{4}$
B. $\frac{1}{2}$
C. $\frac{3}{4}$
D. 1

19 The graph below shows the changes in a wolf population and a moose population over 30 years.

Assume that conditions in the habitat remained similar to those in 1990. Based on the data, which of the following changes most likely occurred from 1990 to 2000?

A. The wolf population decreased unchecked.
B. The moose population increased unchecked.
C. The wolf population increased and the moose population decreased.
D. The moose population and the wolf population leveled off at their carrying capacities.
20. Which of the following helps to explain why X-linked recessive traits in humans occur more frequently in males than in females?
   A. Transcription of the X chromosome occurs often in males but rarely in females.
   B. Males and females have different sets of hormones that regulate the expression of traits.
   C. Males reach physical maturity more slowly than females, giving recessive traits more time to appear.
   D. Only one copy of the X chromosome is found in cells of males, but two copies are found in cells of females.

21. During exercise, a person’s muscles need a constant supply of ATP. To meet this need, the rate of which of the following processes increases?
   A. cellular respiration
   B. mitosis
   C. protein synthesis
   D. transcription

22. Fish, frogs, birds, and monkeys all have an embryonic stage in which structures called pharyngeal slits appear on the sides of the throat. In fish, these slits develop into gills, but in frogs, birds, and monkeys, these slits develop into other structures.

   Based on this information, which of the following is the best conclusion about the evolutionary histories of fish, frogs, birds, and monkeys?
   A. The animals evolved from a common ancestor.
   B. The animals did not develop lungs for breathing.
   C. The animals are not adapted to eat the same kinds of food.
   D. The animals have evolved similar developmental rates from fertilization to birth.
A certain species of snail shows variation in its shell coloring, from solid yellow shells to brown, banded shells. Birds are the main predator of this snail. A scientist observes populations of this snail in various habitats. She hypothesizes that the yellow-shelled snails are better camouflaged in grasslands than the brown-shelled snails are.

a. Based on the scientist’s hypothesis, describe how the percentage of yellow-shelled snails most likely compares with the percentage of brown-shelled snails in grasslands.

b. Assuming the scientist’s hypothesis is correct, explain how natural selection could have acted over time to produce the relative percentages of snails you described in part (a).

The scientist observes two new grassland habitats. In one grassland habitat, the percentages of yellow-shelled snails and brown-shelled snails match what the scientist expected based on her hypothesis. In the other grassland habitat, the percentages of yellow-shelled snails and brown-shelled snails are different from what she expected. The scientist plans to study the size of the bird populations in each habitat to try to explain her observations.

c. Explain the reasoning that supports the scientist’s plan to study the bird population sizes.
Seals and sea birds are native wildlife on Macquarie Island, located south of Australia. In the 1800s, humans introduced rats, rabbits, and cats to the island. The rabbits fed on the native plant species. The cats fed on the rats, rabbits, and sea birds. In the 1980s, the Australian government decided to remove all the cats from the island.

Which of the following was a direct, immediate effect of removing all the cats from the island?
A. a decrease in the seal populations
B. an increase in the plant populations
C. an increase in the rabbit populations
D. a decrease in the sea bird populations

Many enzymes are found in the cytoplasm of human body cells. These enzymes would be expected to function optimally at which of the following temperatures and pH values?
A. 0°C and pH 2
B. 12°C and pH 5
C. 37°C and pH 7
D. 80°C and pH 10

Crossing over is one event that can cause an offspring to have a phenotype that is different from its parents. Which of the following statements describes another event that can sometimes cause an offspring to have a phenotype that is different from its parents?
A. The offspring is produced by asexual reproduction.
B. Natural selection favors the offspring with specific genetic traits.
C. Dominant alleles are passed from the parents and expressed in the offspring.
D. A genetic mutation occurs in one of the parent gametes and is passed to the offspring.

Fructose, sucrose, and starch are all examples of
A. carbohydrates.
B. lipids.
C. nucleic acids.
D. proteins.
28 Which of the following statements describes the main purpose of digestion in the human body?
A. Digestion adds phosphate groups that can yield energy when food reaches body cells.
B. Digestion supplies free oxygen, carbon, and nitrogen atoms from food molecules for body cells.
C. Digestion removes all bacteria and toxins before food is absorbed into the blood and body cells.
D. Digestion changes food molecules into smaller molecules that can pass into the blood and be used by body cells.

30 A scientist wants to prevent a culture of live cells from producing a particular protein. Which of the following will the scientist most likely modify to prevent the production of the protein?
A. the DNA in the nucleus
B. an enzyme in the lysosomes
C. the polysaccharides in the cytoplasm
D. a phospholipid in the plasma membrane

29 Which of the following organisms are most closely related?
A. Asterias rubens and Asterias forbesi
B. Bubulcus ibis and Xenicibis xympithecus
C. Ophiderma salamandra and Salamandra algira
D. Ceanothus americanus and Lethocerus americanus

31 Which of the following statements best explains how forests reduce atmospheric carbon dioxide levels?
A. The roots of trees fix atmospheric carbon dioxide into the soil for use by the trees.
B. Soil bacteria in forests break down atmospheric carbon dioxide to produce fossil fuels.
C. Trees use atmospheric carbon dioxide during photosynthesis to form organic compounds.
D. Animals that live in forests consume atmospheric carbon dioxide during cellular respiration.
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 heart is part of the circulatory system.

a. Describe the primary function of the heart.

Medical researchers are working on developing artificial hearts. Three of the many requirements for the design of an artificial heart are listed below.

- An artificial heart must connect to the pulmonary artery (artery connected to the lungs).
- An artificial heart must connect to the superior vena cava and inferior vena cava (large veins).
- An artificial heart must be able to function at different speeds when a person is exercising and is at rest.

b. Describe how each of the requirements listed above would help the body of an individual with an artificial heart function normally.
Greenish warblers are songbirds found in Asia. The map below shows the distribution of five populations of greenish warblers around the Tibetan Plateau.

The similarities among the populations are described below.

- The traits of population 1 are most similar to those of populations 2 and 3.
- The traits of population 4 are most similar to those of population 2.
- The traits of population 5 are most similar to those of population 3.

Population 1 is the oldest population, while populations 4 and 5 are newer populations. Populations 4 and 5 do not interbreed.

Which of the following statements explains how the distribution of the bird populations most likely occurred?

A. The weakest birds in population 4 were outcompeted and forced to move east and south.
B. Birds in populations 2 and 3 interbred with other songbird species and changed the gene pool.
C. Birds in populations 4 and 5 migrated back to population 1’s habitat each year when it was time to breed.
D. Birds in population 1 expanded northward around each side of the plateau and accumulated differences over time.
34. Domestic horses have 64 chromosomes. How many chromosomes should be in an egg cell of a female horse?
   A. 16
   B. 32
   C. 64
   D. 128

35. Which of the following is the **best** example of the human body maintaining homeostasis?
   A. The heart beats using cardiac muscle.
   B. The breathing rate increases during exercise.
   C. The nose and ears contain cartilage for flexibility.
   D. The digestive system uses enzymes to break down food.

36. Which of the following are parts of the human nervous system?
   A. alveoli, trachea, larynx
   B. erythrocyte, plasma, capillary
   C. neuron, brain, spinal cord
   D. osteocyte, ligament, cartilage
Walking sticks are insects that live on plants. In one walking stick species, the insects may have either a striped body or a body without stripes.

In one region where these walking sticks live, the dominant vegetation is a plant with needle-like leaves that resemble the walking stick’s striped body. According to natural selection, which of the following is the most likely result if there are large numbers of walking stick predators in the region?

A. Walking sticks without stripes will reproduce faster.
B. Walking sticks with stripes will become more common.
C. Walking sticks will develop a new, spotted pattern for their bodies.
D. Walking sticks will live on rare plant species rather than the dominant species.

In pea plants, smooth pods are dominant to wrinkled pods, and green pods are dominant to yellow pods. Two pea plants with smooth green pods are crossed. Both plants are heterozygous for pod texture and pod color.

Which phenotype ratio in the offspring would best support the conclusion that the genes for pod texture and pod color are on different chromosomes?

A. 6 smooth green : 6 smooth yellow : 2 wrinkled green : 2 wrinkled yellow
B. 8 smooth green : 0 smooth yellow : 0 wrinkled green : 8 wrinkled yellow
C. 9 smooth green : 3 smooth yellow : 3 wrinkled green : 1 wrinkled yellow
D. 16 smooth green : 0 smooth yellow : 0 wrinkled green : 0 wrinkled yellow
In a sample of double-stranded DNA, 30% of the nitrogenous bases are thymine. What percentage of the nitrogenous bases in the sample are adenine?

A. 20%
B. 30%
C. 60%
D. 70%

The pictures below show three plant species that look similar. Which of the following types of evidence would best determine whether the species are recently descended from a common ancestor?

A. DNA sequences
B. flowering times
C. habitat distributions
D. stem lengths
41 A scientist observes two butterflies with similar wing patterns. Which of the following observations would best show that the two butterflies belong to the same species?
A. The butterflies share a habitat.
B. The butterflies pollinate the same flowers.
C. The butterflies mate with each other and produce fertile offspring.
D. The butterflies make a chrysalis and not a cocoon for metamorphosis.

42 A woman with green eyes and a man with blue eyes have one biological child. Which of the following statements describes the child’s inheritance of her genes for eye color?
A. The child inherited genes for eye color from her father only.
B. The child inherited genes for eye color from her mother only.
C. The child inherited more genes for eye color from her mother than her father.
D. The child inherited an equal number of genes for eye color from her mother and her father.

43 Which of the following statements explains why the insertion of a nucleotide in a DNA sequence could result in a phenotypic change in an organism?
A. Fatty acids would no longer attach to the DNA strands to transcribe the DNA.
B. The DNA would no longer fit through the nuclear membrane to get to ribosomes for translation.
C. The sequence of nitrogenous bases in the DNA would no longer code for the correct amino acids.
D. Antibodies would no longer recognize the DNA as belonging to the cell and would destroy the DNA.
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 table below lists the ecological roles of several organisms in a desert ecosystem.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Ecological Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>cactus</td>
<td>producer</td>
</tr>
<tr>
<td>cricket</td>
<td>primary consumer</td>
</tr>
<tr>
<td>lizard</td>
<td>secondary consumer</td>
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<td>rat</td>
<td>primary consumer</td>
</tr>
<tr>
<td>snake</td>
<td>secondary consumer</td>
</tr>
<tr>
<td>yucca</td>
<td>producer</td>
</tr>
</tbody>
</table>

An energy pyramid shows how energy flows between different groups of organisms in an ecosystem. An incomplete energy pyramid is shown below.

![Energy Pyramid Diagram]

a. Copy the energy pyramid into your Student Answer Booklet. Fill in the pyramid with the desert organism(s) that belong in each level. Be sure to include all six desert organisms from the table in your pyramid.

b. Describe the roles of primary consumers and secondary consumers in all ecosystems.

c. Is there more energy available for organisms in the top level of the pyramid (X) or the bottom level of the pyramid (Z)? Explain your answer.
Write your answer to question 45 in the space provided in your Student Answer Booklet.

People may be Rh-positive or Rh-negative for their blood types. Rh-positive individuals have Rh factors, or markers, on the surface of their red blood cells. Rh-negative individuals do not have these markers.

Several genes code for Rh factors. The \( D \) allele, which codes for one type of Rh marker, is responsible for the majority of Rh-positive phenotypes. Because of this, the \( D \) and \( d \) alleles are often used to describe Rh blood type inheritance.

Determining Rh blood type inheritance is especially important when an Rh-negative woman is pregnant. If the baby is Rh-positive, the woman is treated with a special medicine so she does not produce antibodies that attack the baby’s red blood cells.

a. Using the given allele symbols, identify the genotype of an Rh-negative woman.

b. Draw Punnett squares to represent all the different crosses in which an Rh-negative woman could have an Rh-positive baby.

c. For each Punnett square you drew in part (b), determine the percent chance that the baby will be Rh-positive.
**Biology**

February 2014 Released Items:
Reporting Categories, Standards, and Correct Answers*

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Page No.</th>
<th>Reporting Category</th>
<th>Standard</th>
<th>Correct Answer (MC)</th>
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* Answers are provided here for multiple-choice items only.