
XVIII. Biology, High School

High School Biology Test

The spring 2011 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.

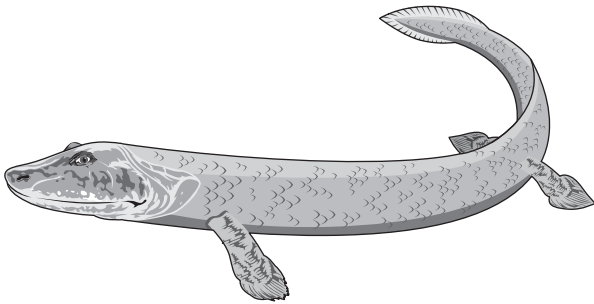
Biology

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 In 2006, scientists discovered fossilized skeletons of an animal with several interesting features. Fossil evidence indicated that the animal not only had scales, fins, and gills, but also had lungs, a full set of ribs, and limb bones arranged to support the animal's weight. The illustration below shows what the animal, called *Tiktaalik*, probably looked like based on the fossil evidence.



Which of the following statements **best** explains why the *Tiktaalik* fossils are an important piece of evidence for evolution?

- A. They include skeletons of both males and females.
- B. They are complete skeletons of a carnivorous animal.
- C. They allow scientists to estimate the animal's lifespan.
- D. They show a transitional form between fish and land-dwelling vertebrates.
- 2 Which of the following matches a cell organelle with its function?
- A. chloroplast—movement
- B. nucleus—cell regulation
- C. vacuole—energy production
- D. mitochondrion—photosynthesis
- 3 Joints are most important for which of the following functions of the human skeletal system?
- A. protection
- B. movement
- C. storage of minerals
- D. blood cell formation

4 Until recently, the myrtle warbler and the Audubon's warbler were thought to be separate species of birds because the males have very different appearances. Which of the following observations **most likely** led to the reclassification of these warblers as one species?

- A. The myrtle warbler and the Audubon's warbler have the same diet.
- B. The myrtle warbler and the Audubon's warbler lay the same number of eggs.
- C. The myrtle warbler and the Audubon's warbler have overlapping geographical ranges.
- D. The myrtle warbler and the Audubon's warbler interbreed and produce fertile offspring.

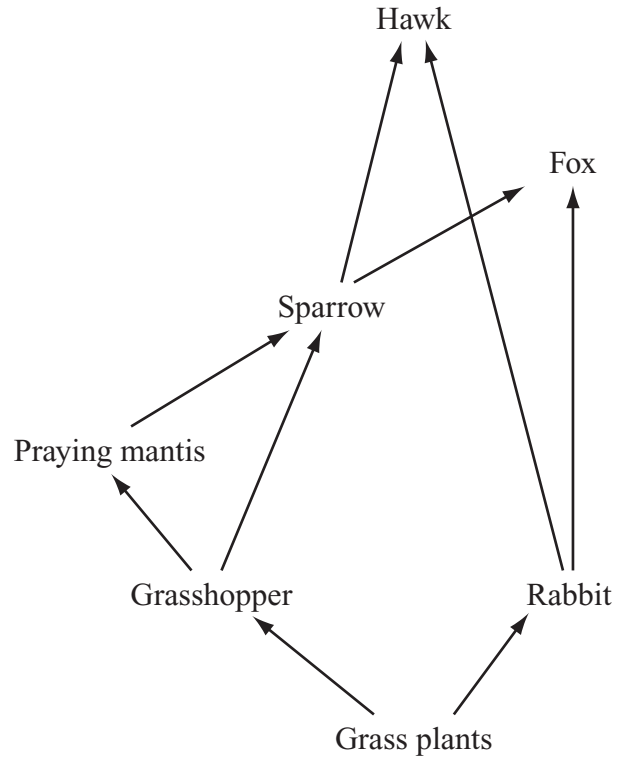
5 In the deserts of the southwestern United States, rock formations made from lava flows are found scattered across the sand. The rock pocket mouse, which has dark fur, lives on the black lava rocks. The Apache pocket mouse, which has light fur, lives on the tan sand.

Which of the following statements **best** explains how these two types of mice could have evolved from a common ancestor?

- A. Individual mice changed their fur color to escape their predators.
- B. Natural selection favored different fur colors in the different habitats.
- C. The emigration of mice changed the gene pools in the original population.
- D. The original population of mice spread out geographically to relieve overcrowding.

- 6 Which of the following normally results from meiosis in a human cell that contains 46 chromosomes?
- A. an egg cell with 46 chromosomes
 - B. a liver cell with 23 chromosomes
 - C. a blood cell with 46 chromosomes
 - D. a sperm cell with 23 chromosomes

- 7 A partial food web is shown below.



Which of the following changes is **most likely** to occur if the sparrow population decreases?

- A. The fox population decreases.
- B. The hawk population increases.
- C. The grasshopper population competes less with the praying mantis population.
- D. The hawk population and the fox population prey more heavily on grasshoppers.

The following section focuses on several human digestive enzymes.

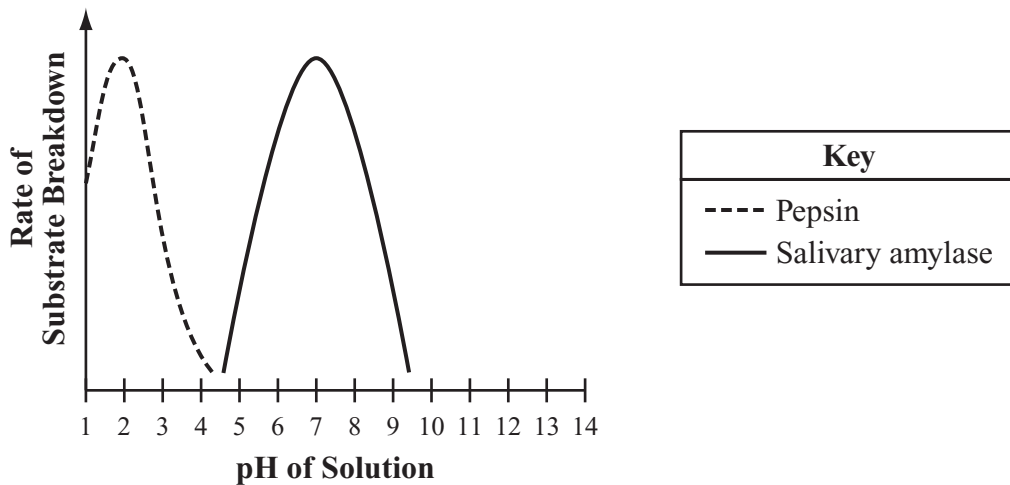
Read the information below and use it to answer the four multiple-choice questions and one open-response question that follow.

Biology students investigated various human digestive enzymes. The table below summarizes the functions of several different digestive enzymes.

Enzyme	Function
salivary amylase	begins to break down starch into smaller polysaccharides or the disaccharide maltose
pepsin	begins to break down proteins into small polypeptides
pancreatic amylase	continues to break down starch and smaller polysaccharides into disaccharides
lipase	breaks down fats into glycerol, fatty acids, or glycerides
aminopeptidase	breaks down small polypeptides into amino acids

The students conducted experiments to study digestive enzyme activity. In the first experiment, the students observed the rate at which salivary amylase breaks down starch (the substrate) in solutions with different pH values. The students then performed the same type of experiment with pepsin. The graph below shows the students' results for the two experiments.

Pepsin and Salivary Amylase Activity at Different pH Values



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 Salivary amylase breaks down which class of organic molecules?

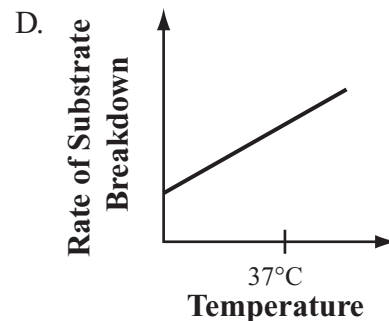
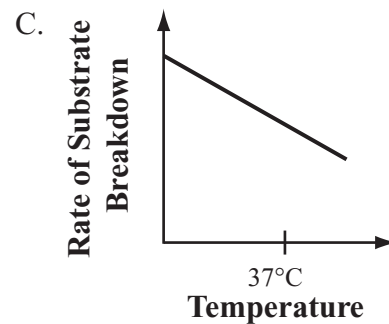
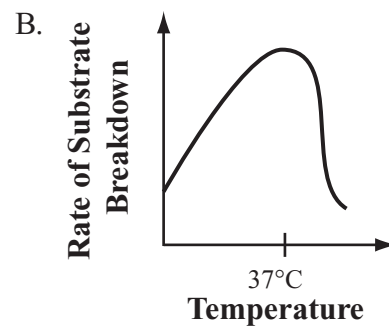
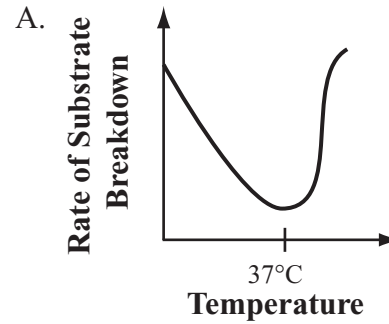
- A. carbohydrates
- B. lipids
- C. nucleic acids
- D. proteins

9 Which of the following statements **best** describes an effect of pH on the functioning of salivary amylase?

- A. Salivary amylase functions most effectively at a pH of about 4.
- B. Salivary amylase functions most effectively at a pH of about 7.
- C. Salivary amylase cannot break down starch into maltose at pH values less than 7.
- D. Salivary amylase breaks down protein instead of starch at pH values greater than 9.

- 10 Fatty acids are one of the products that result from the action of lipase in the digestive system. What is one way that fatty acids are used in the body?
- A. for storing energy
 - B. for encoding genetic information
 - C. as the building blocks of antibodies
 - D. as the building blocks of hemoglobin

- 11 The students also plan to conduct an experiment to study the effect of temperature on pepsin activity. Which of the following graphs shows the expected results of this experiment?



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.**

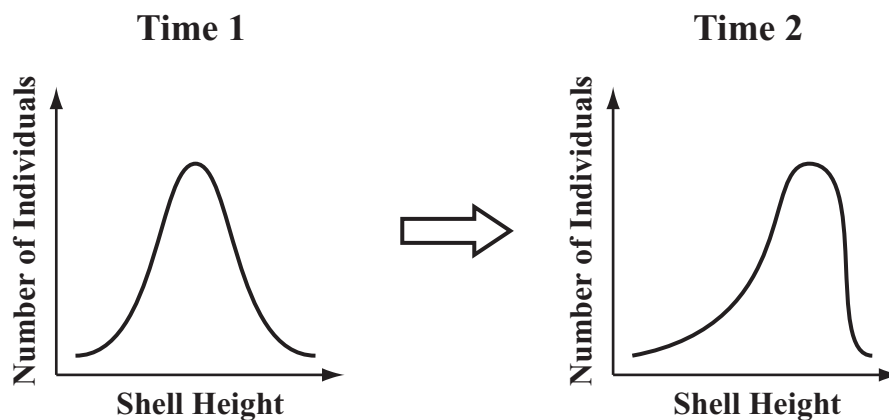
Write your answer to question 12 in the space provided in your Student Answer Booklet.

- 12** The digestive enzymes in the table function in some organs to perform the chemical digestion of food. The major organs of the digestive system are the esophagus, large intestine, mouth, pharynx, small intestine, and stomach.
- List these six organs in the order in which food passes through them.
 - Identify which of these organs is primarily responsible for absorbing nutrients from digested food.
 - Describe the functions of **two** of the organs listed other than the one you identified in part (b).

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 The shape and height of a tortoise's shell influence how high the tortoise can raise its head. A tortoise with a high shell that leaves a large gap can raise its head higher than a tortoise with a lower shell and a smaller gap.

In a population of herbivorous tortoises, a shift in the frequency of different shell heights is observed over time. A set of graphs representing the change in frequency of the different shell heights is shown below.



Which of the following selection pressures **most likely** produced the shift in frequency?

- A. lack of vegetation at ground level
- B. dry, hot weather conditions for several years
- C. habitat changes that forced nesting sites farther inland
- D. intense competition with other species of tortoises with high shells

- 14 Female cattle that have white coats are crossed with male cattle that have red coats. Both male and female offspring have roan coats, which are coats with both red hairs and white hairs.

Which of the following **best** describes the genetics of coat color in the cattle?

- A. The red and white alleles are sex-linked.
- B. The red and white alleles are codominant.
- C. The red allele is recessive to the white allele.
- D. The red allele is dominant to the white allele.

- 15 An endangered species is **most** vulnerable to extinction when it has which of the following characteristics?

- A. a high birthrate
- B. a large variety in its diet
- C. a small amount of competition
- D. a small amount of genetic diversity

- 16 The amount of water a plant has in its tissues is determined primarily by the balance of which of the following processes?

- A. runoff and root absorption
- B. respiration and photosynthesis
- C. precipitation and photosynthesis
- D. root absorption and transpiration

- 17 Which type of cell must contain a mutation in order for the mutation to be passed from a woman to her offspring?

- A. blood cell
- B. brain cell
- C. egg cell
- D. skin cell

- 18 In tomato plants, the tall vine allele (**T**) is dominant to the short vine allele (**t**). Two tomato plants are crossed. Among the offspring plants grown from seed, 45% have tall vines and 55% have short vines.

What are the **most likely** genotypes of the parent plants?

- A. **TT** and **tt**
- B. **Tt** and **TT**
- C. **Tt** and **tt**
- D. **tt** and **tt**

- 19 The pea weevil is a type of insect. The table below shows the average time it takes for pea weevil eggs to hatch at different temperatures.

Temperature (°C)	Average Hatching Time (days)
11	38
14	20
16	16
18	10
22	10
24	7
25	5
27	5
28	7

Based on the data, which of the following conditions would promote the highest population growth rate in pea weevils?

- A. cold springs with temperatures from 11°C to 16°C
- B. moderate summers with temperatures from 25°C to 27°C
- C. heat waves in which the temperature is sustained well above 28°C
- D. overnight frosts after which the temperature warms from 0°C to 11°C

- 20 Partial amino acid sequences for a particular protein in three animal species are shown below. Each letter in the sequence stands for an amino acid. For example, Q stands for glutamine, and L stands for leucine.

Species	Amino Acid Sequence
Green junglefowl (bird)	QHEPHERKRM
Nile crocodile (reptile)	SHDPAQQKRL
Domestic chicken (bird)	QHEPHKRRKM

Which of the following statements **best** explains how these sequence data are evidence for evolution?

- A. All species translate the amino acid sequences of their proteins in a similar way.
- B. The species that are most closely related have the most similar amino acid sequences.
- C. Individual organisms acquire changes in their amino acid sequences over their lifetimes.
- D. The organisms that evolved at the same time in geologic history have identical amino acid sequences.

- 21 Degenerative nerve diseases destroy nerve cells. These diseases can lead to paralysis by interfering with which of the following?
- A. transport of hormones that stimulate muscle cells
 - B. production of ATP that is required by muscle cells
 - C. transmission of electrochemical signals from the brain to muscle cells
 - D. exchange of oxygen and carbon dioxide between neurons and muscle cells

- 22 In fish of the species *Perissodus microlepis*, some individuals have mouths that open to the right and some individuals have mouths that open to the left. The direction of the mouth opening is a genetic trait controlled by a single gene. The allele for a right-opening mouth (**R**) is dominant to the allele for a left-opening mouth (**r**).

If two fish heterozygous for the mouth trait are crossed, what is the expected ratio of phenotypes in the offspring?

- A. 1 right-opening mouth : 3 left-opening mouth
- B. 2 right-opening mouth : 2 left-opening mouth
- C. 3 right-opening mouth : 1 left-opening mouth
- D. 4 right-opening mouth : 0 left-opening mouth

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** DNA is found in the cells of all organisms. The structure of DNA is directly linked to its function.
- a. Describe the function of DNA in organisms.
 - b. In your Student Answer Booklet, draw and label a simple model of DNA that includes the sugar/phosphate backbone and nitrogenous bases.
 - c. Explain how the structure of DNA enables it to perform the function you described in part (a).

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 statements **best** describes the relationship of the kidneys and the liver to the circulatory system?
- A. The kidneys and the liver pump blood.
 - B. The kidneys and the liver produce blood cells.
 - C. The kidneys and the liver remove wastes from blood.
 - D. The kidneys and the liver make blood-clotting proteins.
- 25 Garden pea plants can have yellow seeds or green seeds. In a pea plant that is heterozygous for seed color, the allele for yellow seeds masks the effects of the allele for green seeds.
- Which of the following terms best describes the allele for yellow seeds?
- A. codominant
 - B. dominant
 - C. recessive
 - D. sex-linked
- 26 The scientific name for the woodchuck is *Marmota monax*, and the scientific name for the long-tailed marmot is *Marmota caudata*. Which of the following statements describes the taxonomic relationship between the woodchuck and the long-tailed marmot?
- A. They belong to different phyla.
 - B. They belong to the same genus.
 - C. They belong to the same species.
 - D. They belong to different families.
- 27 Which of the following is incapable of reproducing outside a host cell?
- A. alga
 - B. mold
 - C. moss
 - D. virus

28 Which of the following statements describes the role of ATP in animal cells?

- A. ATP stores and releases energy.
- B. ATP forms the channels in the plasma membrane.
- C. ATP serves as the hereditary material in the nucleus.
- D. ATP attaches to and digests unneeded organic molecules.

29 The bones that make up the forelimbs of monkeys, cats, whales, and birds are similar. Which of the following statements **best** supports the evolutionary relationship of these animals?

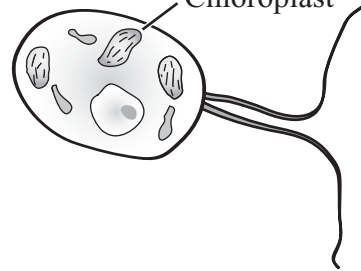
- A. The animals have different ancestries but have adapted to similar environments.
- B. The animals share a common ancestry but have adapted to different environments.
- C. The animals at one time lived in different environments but now share an environment.
- D. The animals use their forelimbs for identical activities but live in different environments.

30 Which of the following diagrams shows a prokaryotic cell?

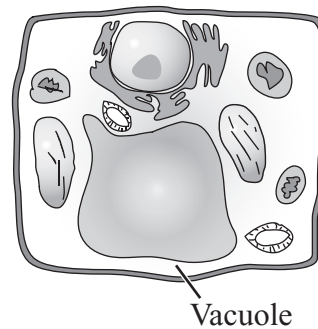
A. Protein coat



B. Chloroplast



C.



D.



- 31 Scientists have found geysers on one of Saturn's moons. The geysers release water vapor containing complex organic compounds, which may indicate the presence of life.

Which of the following elements is most likely abundant in the organic compounds in the water vapor?

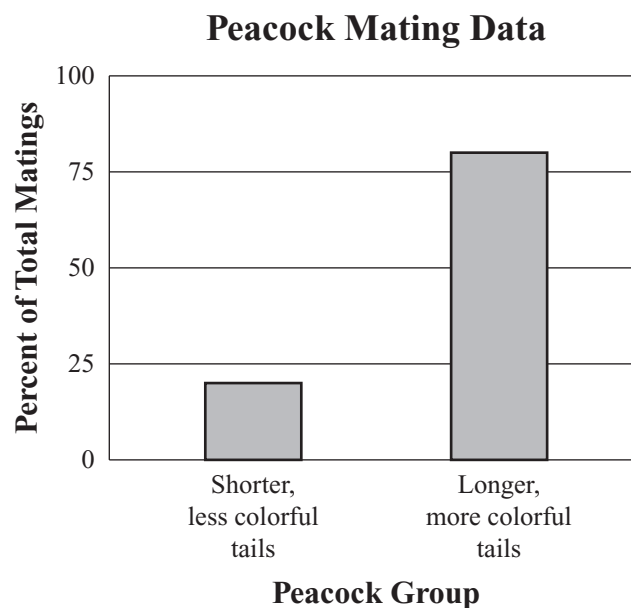
- A. carbon
- B. chlorine
- C. iron
- D. zinc

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 Male peafowl, called peacocks, have long, colorful tail feathers. Among peacocks there is variation in the size, brightness, and pattern of the tail. Scientists observed the mating success of two groups of peacocks. The graph below shows the scientists' data.

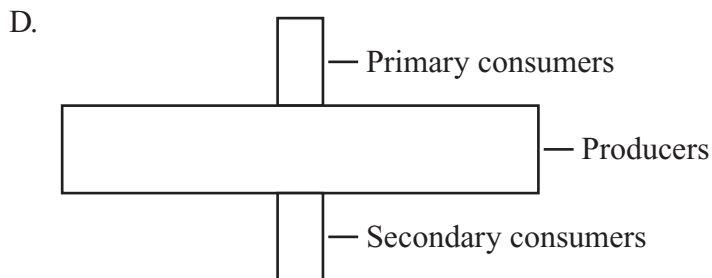
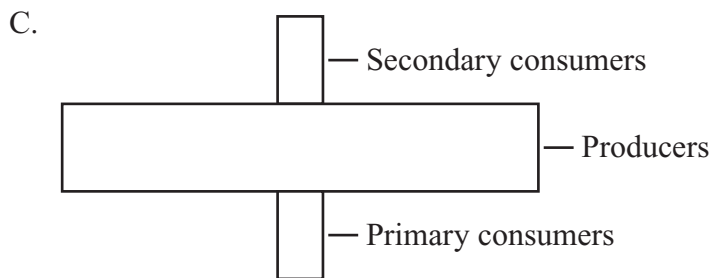
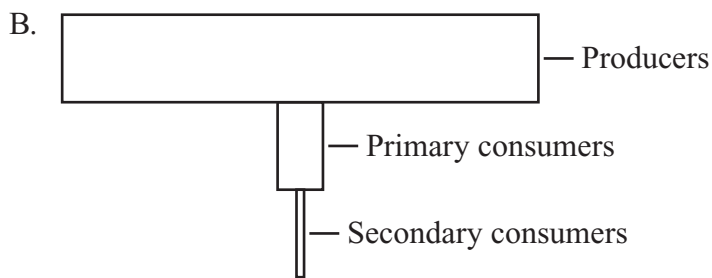
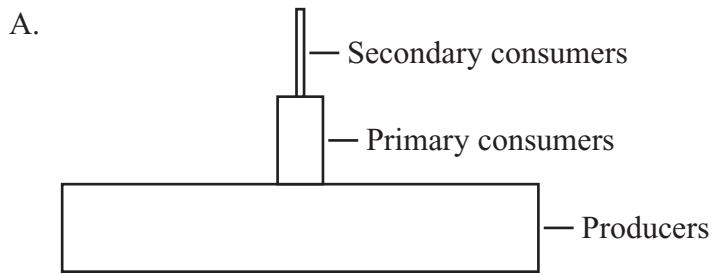


- Explain what the data show about the advantage of longer, more colorful tails for peacocks.
- Identify **one** disadvantage that longer, more colorful tails have for peacocks.
- Explain in detail how the longer, more colorful tails evolved in peacocks despite causing disadvantages for the males.

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 willow flycatcher is a bird species with a summer range throughout much of the United States. Which of the following would directly decrease the size of a willow flycatcher population in a given year?
- A. the disappearance of a species that preys on willow flycatchers
 - B. the arrival of migrating willow flycatchers from populations in other areas
 - C. the emigration of male willow flycatchers that did not secure territories
 - D. the hatching of a larger percentage of eggs in the willow flycatcher population
- 34 In pure water, a red blood cell from an animal will swell and burst, but a leaf cell from a plant will not. Which structure in the leaf cell is responsible for this difference?
- A. cell membrane
 - B. cell wall
 - C. mitochondrion
 - D. nucleus

35 Which of the following energy pyramids shows the correct placement of trophic levels?



- 36 The atmosphere contains about 80% nitrogen gas, but nitrogen in this form cannot be used by plants. Which of the following processes converts atmospheric nitrogen to a useful form for plants?
- A. nitrogen decomposition
 - B. nitrogen fixation
 - C. photosynthesis
 - D. transpiration
- 37 Which of the following crosses does **not** follow Mendel's law of segregation?
- A. Two tall pea plants ($Tt \times Tt$) are expected to produce some tall offspring plants.
 - B. Two tall pea plants ($Tt \times Tt$) are expected to produce some short offspring plants.
 - C. A tall pea plant and a short pea plant ($Tt \times tt$) are expected to produce all tall offspring plants.
 - D. A tall pea plant and a short pea plant ($TT \times tt$) are expected to produce all tall offspring plants.
- 38 Which of the following processes produces the nucleotide sequence UUA from the sequence AAT?
- A. meiosis
 - B. replication
 - C. respiration
 - D. transcription
- 39 The nose serves all the following functions **except**
- A. providing an airway.
 - B. moistening inhaled air.
 - C. filtering dust and particles from inhaled air.
 - D. transferring oxygen from the air to the bloodstream.

- 40 A population is separated into two groups by a geographic barrier. Over time, enough differences develop between the two groups that they do not interbreed when reunited.

Which of the following terms **best** describes the process that has occurred?

- A. extinction
- B. hybridization
- C. immigration
- D. speciation

- 41 Hemoglobin is a protein that carries oxygen in red blood cells. The hemoglobin molecules produced by some people have one specific amino acid that is different from the amino acid at that position in normal hemoglobin.

Which of the following is the **most likely** cause of this amino acid variation?

- A. The hemoglobin gene contains a mutation.
- B. An error occurs during the folding of the hemoglobin protein.
- C. Enzymes replace the amino acid once the hemoglobin is produced.
- D. An additional amino acid is mistakenly inserted into the hemoglobin during translation.

- 42 An invasive species of green algae has become established along the coasts of the Mediterranean Sea. Which of the following statements **best** explains why this species of algae has been so successful in the Mediterranean Sea?
- A. It is not a good competitor.
 - B. It is not eaten by many animals.
 - C. It reproduces slowly in warm waters.
 - D. It requires more nutrients than most other algae.
- 43 A person who is cold shivers to generate body heat. Which of the following lists the primary body systems that interact to maintain homeostasis in this situation?
- A. nervous, excretory, and respiratory
 - B. excretory, digestive, and respiratory
 - C. digestive, muscular, and circulatory
 - D. muscular, circulatory, and nervous

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.**

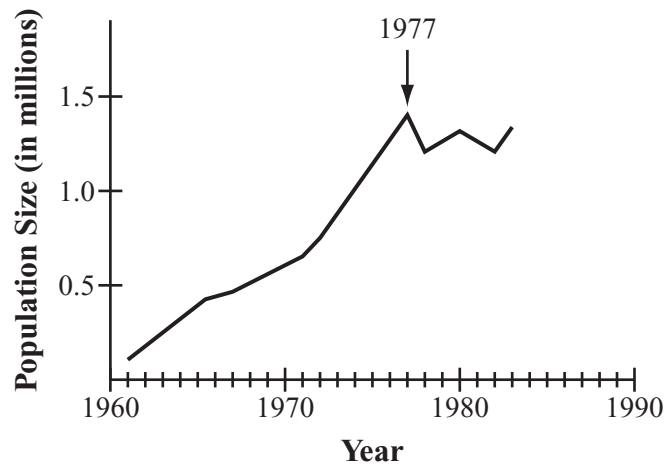
Write your answer to question 44 in the space provided in your Student Answer Booklet.

- 44** Researchers studied a typical hardwood forest containing a variety of trees, other plant species, fungi, and animals. The atmospheric carbon dioxide concentrations around the forest were measured in the middle of the day. The carbon dioxide concentration was lowest right next to the forest and steadily increased as the researchers measured farther away from the forest.
- Identify **and** describe one biological process that raises carbon dioxide concentrations by adding carbon dioxide to the atmosphere.
 - Explain why the lowest carbon dioxide concentration occurs closest to the forest. Be sure to include a biological process in your answer.
 - Describe how nighttime carbon dioxide concentrations near the forest should compare with the midday concentrations near the forest. Explain your answer using **two** biological processes.

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

- 45 Cattle-like animals called wildebeests live in Africa. The wildebeest population decreased for many years because of a fatal virus. The virus was eliminated in the 1960s by vaccinating the wildebeests against the virus. The graph below shows changes in the size of the wildebeest population from 1961 to 1983.

**Wildebeest Population Size,
1961–1983**



- Describe the effect of the vaccinations on the death rate in the wildebeest population.
- Explain the change in the size of the population from 1961 to 1977 in terms of birth rate and death rate. Assume immigration and emigration rates were equal during this time.
- Based on the graph, describe what happened to the wildebeest population size from 1977 to 1983 **and** explain why this pattern most likely occurred.

High School Biology
Spring 2011 Released Items:
Reporting Categories, Standards, and Correct Answers*

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
1	301	<i>Evolution and Biodiversity</i>	5.1	D
2	301	<i>Biochemistry and Cell Biology</i>	2.1	B
3	301	<i>Anatomy and Physiology</i>	4.5	B
4	302	<i>Evolution and Biodiversity</i>	5.2	D
5	302	<i>Evolution and Biodiversity</i>	5.3	B
6	303	<i>Biochemistry and Cell Biology</i>	2.7	D
7	303	<i>Ecology</i>	6.3	A
8	305	<i>Biochemistry and Cell Biology</i>	1.2	A
9	305	<i>Biochemistry and Cell Biology</i>	1.3	B
10	306	<i>Biochemistry and Cell Biology</i>	1.2	A
11	306	<i>Biochemistry and Cell Biology</i>	1.3	B
12	307	<i>Anatomy and Physiology</i>	4.1	
13	308	<i>Evolution and Biodiversity</i>	5.3	A
14	309	<i>Genetics</i>	3.4	B
15	309	<i>Ecology</i>	6.2	D
16	309	<i>Ecology</i>	6.4	D
17	309	<i>Genetics</i>	3.3	C
18	310	<i>Genetics</i>	3.6	C
19	310	<i>Ecology</i>	6.2	B
20	311	<i>Evolution and Biodiversity</i>	5.1	B
21	311	<i>Anatomy and Physiology</i>	4.7	C
22	312	<i>Genetics</i>	3.6	C
23	313	<i>Genetics</i>	3.1	
24	314	<i>Anatomy and Physiology</i>	4.2	C
25	314	<i>Genetics</i>	3.4	B
26	314	<i>Evolution and Biodiversity</i>	5.2	B
27	314	<i>Biochemistry and Cell Biology</i>	2.8	D
28	315	<i>Biochemistry and Cell Biology</i>	2.5	A
29	315	<i>Evolution and Biodiversity</i>	5.1	B
30	315	<i>Biochemistry and Cell Biology</i>	2.2	D
31	316	<i>Biochemistry and Cell Biology</i>	1.1	A
32	317	<i>Evolution and Biodiversity</i>	5.3	
33	318	<i>Ecology</i>	6.1	C
34	318	<i>Biochemistry and Cell Biology</i>	2.3	B
35	319	<i>Ecology</i>	6.3	A
36	320	<i>Ecology</i>	6.4	B
37	320	<i>Genetics</i>	3.5	C
38	320	<i>Genetics</i>	3.2	D
39	320	<i>Anatomy and Physiology</i>	4.3	D

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
40	321	<i>Evolution and Biodiversity</i>	5.2	D
41	321	<i>Genetics</i>	3.3	A
42	322	<i>Ecology</i>	6.2	B
43	322	<i>Anatomy and Physiology</i>	4.8	D
44	323	<i>Biochemistry and Cell Biology</i>	2.4	
45	324	<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.