

## ENGLISH TEST

45 Minutes—75 Questions

**DIRECTIONS:** In the five passages that follow, certain words and phrases are underlined and numbered. In the right-hand column, you will find alternatives for the underlined part. In most cases, you are to choose the one that best expresses the idea, makes the statement appropriate for standard written English, or is worded most consistently with the style and tone of the passage as a whole. If you think the original version is best, choose "NO CHANGE." In some cases, you will find in the right-hand column a question about the underlined part. You are to choose the best answer to the question.

You will also find questions about a section of the passage, or about the passage as a whole. These questions do not refer to an underlined portion of the passage, but rather are identified by a number or numbers in a box.

For each question, choose the alternative you consider best and fill in the corresponding oval on your answer document. Read each passage through once before you begin to answer the questions that accompany it. For many of the questions, you must read several sentences beyond the question to determine the answer. Be sure that you have read far enough ahead each time you choose an alternative.

## PASSAGE I

## Paul Revere Williams and the La Concha Motel

[1]

Architect Paul Revere Williams opened his own firm in 1922, and his vision and willingness to experiment led to a successful fifty-year career of planning buildings, primarily near Los Angeles. [A] He helped create more than 3,000 buildings, which varied in type, as well as homes for the Hollywood elite. However, Williams did not limit his work to Southern California. His architecture stretches from Washington, DC, to Bogotá,

Colombia. One of his most interesting designs were

in Las Vegas; the La Concha Motel.

1. A. NO CHANGE  
B. lead to  
C. led too  
D. lead on
2. The writer is considering revising the underlined portion to the following accurate phrase:  
including hotels, government offices, and hospitals,  
If the writer were to make this revision, the essay would primarily gain:  
F. details about the total number of buildings Williams helped create.  
G. information about the kinds of buildings that Williams helped create.  
H. a visual description of Williams's style of architecture.  
J. the idea that Williams preferred designing hotels over designing other kinds of structures.
3. A. NO CHANGE  
B. have stood  
C. were built  
D. stood
4. F. NO CHANGE  
G. Vegas; namely,  
H. Vegas—  
J. Vegas



[2]

In 1961, Williams, by then a renowned architect, was hired to design a new 100-room motel. Situated among larger Las Vegas hotels, the La Concha needed to stand out. Williams was tasked with creating an eye-catching design that would attract guests. He drew inspiration from a Southern California architectural trend known as Googie. [B]

[3]

Envisioning a motel that combined the name La Concha (which translates to "shell") with the arched roofs typical of Googie architecture, the lobby that Williams designed was meant to

appear, from a distance like a giant shell. On three

of the ones, Williams designed twenty-eight-foot-high

concrete arches that jutted out over the sidewalks. [C]

Inside, the lobby, which was a place for gathering, consisted of a large, open space that functioned as

a social gathering place, and included the registration desk.

5. A. NO CHANGE  
B. out, and Williams was hired to design it in 1961.  
C. out from its neighbors: larger Las Vegas hotels.  
D. out and be different.

6. F. NO CHANGE  
G. it had a lobby designed by Williams and  
H. Williams designed a lobby that  
J. the design for Williams's lobby

7. A. NO CHANGE  
B. appear, from a distance, like  
C. appear, from a distance like,  
D. appear from, a distance like

8. F. NO CHANGE  
G. sides of the building,  
H. of those sides,  
J. of them,

9. A. NO CHANGE  
B. extended themselves out lengthily  
C. went and stuck out  
D. stuck super far out

10. F. NO CHANGE  
G. lobby was a large space that  
H. lobby's interior  
J. lobby

11. A. NO CHANGE  
B. place, and included,  
C. place and included  
D. place and, included





[4]

Indeed most of the La Concha Motel was torn down in 2005, the famous shell-like lobby lives on. [D] Preservation groups saved it from <sup>12</sup>demolition, and, in 2006, the lobby was moved across town in pieces. Reassembled, it became the visitors' center of the Neon Museum, where retired neon signs are put on display (the famous neon sign of the cowboy named Vegas Vic was erected in 1951). With <sup>13</sup>a distinctive design that enhances the Neon Museum, Williams's lobby is one of the last remaining celebrated <sup>14</sup>examples of Googie architecture in the United States.

12. F. NO CHANGE  
 G. Although  
 H. Later  
 J. Yet
13. A. NO CHANGE  
 B. demolition and in 2006.  
 C. demolition, and in, 2006  
 D. demolition and in, 2006
14. Given that all the choices are accurate, which one provides the most relevant information at this point in the essay?  
 F. NO CHANGE  
 G. (including the La Concha's original sign).  
 H. (Las Vegas has over a dozen museums).  
 J. (visitors must buy tickets in advance).

Question 15 asks about the preceding passage as a whole.

15. The writer wants to add the following sentence to the essay:  
 Beneath each of the three arches was a glass wall with doors opening into the motel.  
 This sentence would most logically be placed at:  
 A. Point A in Paragraph 1.  
 B. Point B in Paragraph 2.  
 C. Point C in Paragraph 3.  
 D. Point D in Paragraph 4.

**PASSAGE II**

**For Octopuses, Play's the Thing**

Often dismissed as aquatic oddities, the octopus is part of a species that are among <sup>16</sup>the most intelligent animals on Earth. With the largest brains of any invertebrate, octopuses can solve complex problems. Researchers have documented octopuses navigating intricate mazes and <sup>17</sup>octopuses even open screw-top jars.

In 2012, at the New England Aquarium, an octopus used its anatomical siphon to propel a pill bottle <sup>18</sup>crossed its tank. When the pill bottle reached the other side, a jet stream in the tank returned it to the octopus. Amazingly,

16. F. NO CHANGE  
 G. octopuses are  
 H. a species of octopus is  
 J. an octopus is
17. A. NO CHANGE  
 B. they have even observed them opening  
 C. even opening  
 D. even open
18. F. NO CHANGE  
 G. across its  
 H. across it's  
 J. cross it's

1 ■ ■ ■ ■ ■ ■ ■ ■ ■ ■

the octopus propelled the pill bottle back toward the jet stream. The researchers at the aquarium realized the octopus was doing something extraordinary: inventing a version of pitch-and-catch.

In inventing this game, the actions of the octopus were not based<sup>19</sup> on survival. The octopus simply wanted to play. Evolutionary biologists believe play could have an important role through animals<sup>20</sup> cognitive development. According to the Theory of Flexibility, play, the theory says,<sup>21</sup> teaches an animal to modify its behaviors,<sup>22</sup> helping the animal prepare for unexpected situations.

Embracing this idea, researchers at Cincinnati's Newport Aquarium have compiled an "Octopus Enrichment Handbook." Crazy, right? Yet this book<sup>23</sup> provides in-depth descriptions of toys and puzzles<sup>24</sup> researchers have invented for octopuses. One such puzzle is a series of nesting cubes. Each cube features a different latch for the octopus has to open until the octopus reaches<sup>25</sup> the smallest cube. Typically, after just a few weeks, octopuses master this puzzle, solving it in a matter of minutes. 26

19. A. NO CHANGE  
B. basis of the octopus's actions was not  
C. octopus's actions were not based  
D. octopus did not base its actions
20. F. NO CHANGE  
G. through an animals'  
H. in an animal's  
J. in animals
21. A. NO CHANGE  
B. play could be significant for cognitive ability; it  
C. play could have an important role because it  
D. play
22. F. NO CHANGE  
G. behaviors and this is something that can help  
H. behaviors, this, it seems, helps  
J. behaviors, this process helps
23. A. NO CHANGE  
B. It isn't just a super engaging read because the  
C. This is for real. The  
D. This
24. F. NO CHANGE  
G. toys, and puzzles  
H. toys and, puzzles  
J. toys and puzzles,
25. A. NO CHANGE  
B. and  
C. so  
D. DELETE the underlined portion.
26. If the writer were to delete the phrases "after just a few weeks," and "solving it in a matter of minutes" from the previous sentence (adjusting the punctuation as needed), the paragraph would primarily lose:  
E. details emphasizing how adept octopuses are at mastering the puzzles created by the researchers.  
G. clarifications about how researchers gauge octopuses' interest in solving a given puzzle.  
H. clarifications about the length of time octopuses should be allowed to work on the puzzles.  
J. details emphasizing the intricacy of the puzzles created by the researchers.





Next, Yahav uses smooth, winding motions with four fingers to great effect, transforming the first woman's limp hair into curls. With one swipe of her index finger, Yahav smudges out the woman's tear. Still, she flicks both hands

42

to add at once flowers to the woman's hair.

43

[4]

[D] Yahav plans and memorizes every frame of her stories, outlining the scenes on a storyboard similar to the kind filmmakers use. 44 As she explains, "I use only my hands, my fingers, and my soul."

42. F. NO CHANGE

G. Consequently,

H. Nevertheless,

J. Finally,

43. In order to most clearly indicate that Yahav moves both hands simultaneously when adding flowers to the woman's hair, the best placement for the underlined portion would be:

A. where it is now.

B. after the word *hands*.

C. after the word *flowers*.

D. after the word *hair* (and before the period).

44. Which of the following statements, if added here, would provide the most logical transition from the preceding sentence to the last sentence of the paragraph?

F. Though Yahav uses sand to create images on the glass, she likens her art to the act of dancing.

G. As Yahav tells a story on the glass, though, the images she creates overlap and eventually "erase" each other.

H. Unlike many filmmakers, though, Yahav keeps her audiences mesmerized without using complicated digital effects.

J. "You've Got a Friend" begins with Yahav framing the scene by spreading sand on the bottom half of the glass to create a horizon line.

Question 45 asks about the preceding passage as a whole.

45. The writer is considering adding the following sentence to the essay:

She might toss a fistful of sand across the glass to create a stormy night sky or a dark background.

If the writer were to add the sentence, it would most logically be placed at:

A. Point A in Paragraph 1.

B. Point B in Paragraph 2.

C. Point C in Paragraph 3.

D. Point D in Paragraph 4.

PASSAGE IV

House of the Sun

[1]

I had to drag myself out of bed to see the sunrise. Kayla had been insistent. And so there I was in her car, it being 3:30 in the morning, equipped with a seldom-used hoodie and a giant thermos of coffee. "You'll need this at the top," she said. She handed me a wool hat, which I regarded skeptically. We were in Maui, after all; we had spent the day before lying on the beach.

Further, I decided to take her word for it. I had never been to the top of Mount Haleakala, the "House of the Sun." [A]

[2]

Supposedly, a view of the most beautiful sunrise in the world from the summit of the dormant volcano, 10,023 feet above sea level. [B] Tourists and locals alike make the arduous 38-mile drive, cheerfully navigating the hairpin turns in the dark hours of early morning. Kayla was one of them. I, on the other hand, clutched my coffee and tried not to focus on the well-traveled road before us.

[3]

Once we reached the summit and parked the car, my misgivings were compounded by the shocking cold; being, at most, 40 degrees Fahrenheit. [C] I grudgingly pulled on the wool hat, trudging behind Kayla until we reached the main observation point. About a hundred people had already gathered, a guard rail the only thing separating them from the crater's edge. Granted, all I could see were clouds.

46. F. NO CHANGE  
G. car, the time being  
H. car at the time  
J. car at

47. A. NO CHANGE  
B. Consequently,  
C. Instead,  
D. Still,

48. E. NO CHANGE  
G. one can view  
H. viewing  
J. DELETE the underlined portion.

49. A. NO CHANGE  
B. alike, make the arduous,  
C. alike make, the arduous,  
D. alike, make the arduous

50. Which choice most effectively illustrates that the drive up the volcano was unsettling for the narrator?  
E. NO CHANGE  
G. steep tangle of road looming  
H. road that unfolded  
J. winding road

51. A. NO CHANGE  
B. because it was,  
C. it was,  
D. DELETE the underlined portion.

52. E. NO CHANGE  
G. gathered, a guard rail was  
H. gathered a guard rail was  
J. gathered a guard rail



1 ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ 1

A thick lid of them foamed slowly over the crater,  
creating what looked like the surface of another planet.  
It was strange to stand before such alien beauty and hear  
the familiar murmurs of chitchat and the casual slurps of

coffee coming from the collective crowd that had gathered.

[4]

At exactly 5:57 a.m., the sun made its way out of the

clouds. Not to mention that someone standing near us  
began a *mele oli*, a native Hawaiian chant. We observers  
stood next to each other shoulder to shoulder and observed

as the ascending sun lit the sky golden and casted a rosy  
blush onto the clouds below. [D] I was simply grateful to  
be there at that moment, with Kayla, watching the new day  
break over the island.

Questions 59 and 60 ask about the preceding passage as a whole.

59. The writer wants to add the following sentence to the essay:

Suddenly I didn't feel so tired and so cold.

This sentence would most logically be placed at:

- A. Point A in Paragraph 1.
- B. Point B in Paragraph 2.
- C. Point C in Paragraph 3.
- D. Point D in Paragraph 4.

53. The writer is considering revising the underlined portion to the following:  
a certain effect.

Should the writer make this revision?

- A. Yes, because it conveys the narrator's enthusiasm for the crater.
- B. Yes, because it is more concise.
- C. No, because it presents the narrator's opinion instead of factual information about the crater.
- D. No, because it less clearly conveys the striking appearance of the crater.

54. F. NO CHANGE

- G. crowd.
- H. crowd of about a hundred people.
- J. crowd who stood together by the crater's edge.

55. A. NO CHANGE

- B. itself
- C. its'
- D. it's

56. F. NO CHANGE

- G. In any event, someone
- H. To conclude, someone
- J. Someone

57. A. NO CHANGE

- B. next to each other, observing
- C. shoulder to shoulder
- D. close and observed

58. F. NO CHANGE

- G. alighted the sky golden and casted
- H. alighted the sky golden and cast
- J. lit the sky golden and cast

60. Suppose the writer's primary purpose had been to explain how Mount Haleakala became a popular tourist destination. Would this essay accomplish that purpose?

- F. Yes, because it provides information about how many people make the trip up the volcano to see the sunrise each year.
- G. Yes, because it demonstrates that local Hawaiians as well as tourists enjoy watching the sunrise from the top of the volcano.
- H. No, because it instead describes one person's experience watching the sunrise from the top of the volcano.
- J. No, because it instead focuses on tourism in Maui in general.



PASSAGE V

Take to the Sky

In 1797, André-Jacques Garnerin caused a stir in Paris when, at an elevation of 3,200 feet, he detached the basket he was riding in from its hot air balloon. Suspended under a twenty-three-foot-wide canopy of silk, people were shocked as Garnerin and his<sup>61</sup> basket floated to the ground. His stunt is widely

regarded as the first trial<sup>62</sup> parachute jump. About three hundred years before Garnerin designed his

parachute however, Italian artist, Leonardo da Vinci,<sup>63</sup> had sketched a similar contraption in the margins of

a notebook<sup>64</sup> centuries before.

Leonardo wrote prolifically in his<sup>65</sup> notebooks about an enormous range of ideas.<sup>65</sup>

Unlike the nylon parachutes of today, these<sup>66</sup> bend as they catch the air, Leonardo's design, if constructed, would be rigid and unwieldy: its frame consisted of twenty-two-foot-long wooden poles shaped into a pyramid.

- 61. A. NO CHANGE  
B. it was a shaky but ultimately safe journey as Garnerin  
C. the crowd admired Garnerin's bravery as he  
D. Garnerin
- 62. The writer wants to indicate that other people had attempted to parachute jump before Garnerin's public stunt in Paris. Which choice best accomplishes that goal?  
E. NO CHANGE  
G. successful  
H. ever  
J. DELETE the underlined portion.
- 63. A. NO CHANGE  
B. parachute, however, Italian artist Leonardo da Vinci  
C. parachute however, Italian artist Leonardo da Vinci,  
D. parachute, however, Italian artist, Leonardo da Vinci
- 64. E. NO CHANGE  
G. notebook—a sketch that resembled Garnerin's own parachute design.  
H. notebook that contained his sketches.  
J. notebook.
- 65. Given that all the choices are accurate, which one most effectively leads readers into the rest of the essay?  
A. NO CHANGE  
B. and sketched out ideas for related innovations, including several types of flying machines and a device to measure wind speed.  
C. down his inventive ideas during the Italian Renaissance—a time when creativity was widely stimulated and encouraged.  
D. that his invention would enable a person to "jump from any great height whatsoever without injury."
- 66. F. NO CHANGE  
G. which  
H. those  
J. they



1

It was unclear whether the linen panels anchored to the frame would catch enough air to ensure a jumper's safe landing. Leonardo himself never actually built his parachute. 67

[1] In 2000, British skydiver Adrian Nicholas decided to test Leonardo's design. [2] The finished parachute weighed 187 pounds; about 172 pounds heavier than a modern parachute. <sup>68</sup> [3] He constructed the parachute according to Leonardo's plans, using only materials that would have been available in fifteenth-century Milan.

[4] Because of it's weight, Nicholas had to cut himself <sup>69</sup>

free near the end of the jump and deploy his backup <sub>70</sub>

parachute. [5] Still, he had proved that Leonardo's <sub>71</sub>

pyramidal design could slow a parachutist's descent. 72

67. If the writer were to delete the preceding sentence, the essay would primarily lose a:

- A. suggestion that Leonardo's parachute was ultimately credited to a different inventor.
- B. description of the obstacles Leonardo faced when attempting to construct his parachute.
- C. clarification that Leonardo's parachute was theoretical.
- D. detail that reveals the impracticality of Leonardo's parachute.

68. F. NO CHANGE  
G. pounds; which is  
H. pounds—  
J. pounds

69. A. NO CHANGE  
B. there  
C. its'  
D. its

70. Which of the following alternatives to the underlined portion would NOT be acceptable?

- F. jump so he could deploy
- G. jump that deployed
- H. jump, deploying
- J. jump to deploy

71. A. NO CHANGE  
B. Coincidentally,  
C. Likewise,  
D. Again,

72. For the sake of logic and cohesion, Sentence 2 should be placed:

- F. where it is now.
- G. before Sentence 1.
- H. after Sentence 3.
- J. after Sentence 5.



Eight years later, Swiss parachutist Olivier Vietti-Teppa modernized Leonardo's original concept. His parachute was constructed with nylon and without the heavy wooden frame. Despite his inability to steer the parachute, Vietti-Teppa managed to complete what he called a perfect jump. <sup>73</sup> The pyramidal shape of the

parachute allowed him to glide gracefully—and safely to

<sup>74</sup>

the ground. Before long, Leonardo's historic sketch had become a modern reality. <sup>75</sup>

73. At this point, the writer is considering adding the following true statement:

Vietti-Teppa performed this jump in Payerne, Switzerland, near Geneva.

Should the writer make this addition here?

- A. Yes, because it shows that Vietti-Teppa has completed parachute jumps all over the world.  
 B. Yes, because it indicates why Vietti-Teppa chose to test Leonardo's parachute design in Switzerland.  
 C. No, because it is unrelated to the technical information given about Vietti-Teppa's parachute jump.  
 D. No, because it repeats information about Vietti-Teppa that is presented earlier in the paragraph.
74. F. NO CHANGE  
 G. gracefully—and safely—  
 H. gracefully, (and safely)  
 J. gracefully and safely,
75. A. NO CHANGE  
 B. Until the last,  
 C. At long last,  
 D. Long ago,

**END OF TEST 1**

**STOP! DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.**





## MATHEMATICS TEST

60 Minutes—60 Questions

**DIRECTIONS:** Solve each problem, choose the correct answer, and then fill in the corresponding oval on your answer document.

Do not linger over problems that take too much time. Solve as many as you can; then return to the others in the time you have left for this test.

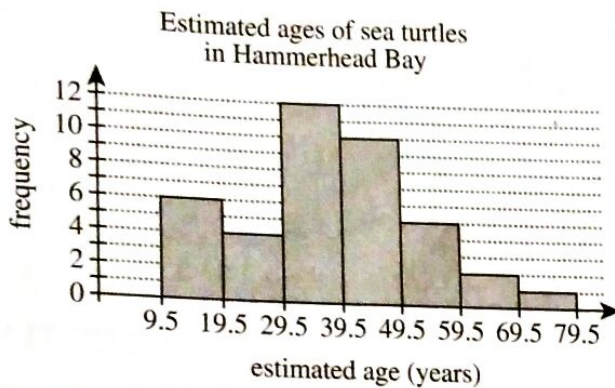
You are permitted to use a calculator on this test. You may use your calculator for any problems you choose,

but some of the problems may best be done without using a calculator.

Note: Unless otherwise stated, all of the following should be assumed.

1. Illustrative figures are NOT necessarily drawn to scale.
2. Geometric figures lie in a plane.
3. The word *line* indicates a straight line.
4. The word *average* indicates arithmetic mean.

1. Marine biologists collected a sample of 40 adult sea turtles from Hammerhead Bay and estimated the age, in whole years, of each turtle. The histogram below shows the frequency of sea turtles for each of the estimated age groups. What is the maximum possible number of sea turtles that could have had an estimated age of 45 years?



- A. 1  
B. 5  
C. 9  
D. 10  
E. 40

2. The sum of the measures of the interior angles of a convex polygon with  $t$  sides is  $180(t - 2)$  degrees. What is the sum of the measures of the interior angles of a convex polygon with 10 sides?

- F.  $900^\circ$   
G.  $1,440^\circ$   
H.  $1,798^\circ$   
J.  $1,800^\circ$   
K.  $2,160^\circ$

**DO YOUR FIGURING HERE.**

**DO YOUR FIGURING HERE.**

3. In the standard  $(x,y)$  coordinate plane, point  $A$  has coordinates  $(-8,-3)$ . Point  $A$  is translated 8 units to the right and 3 units up, and that image is labeled  $A'$ . What are the coordinates of  $A'$  ?

A.  $(-16, -6)$   
B.  $(-11, -11)$   
C.  $(-8, -6)$   
D.  $(0, 0)$   
E.  $(16, 6)$

4. For all nonzero values of  $x$  and  $y$ , which of the following expressions is equivalent to  $-\frac{28x^4y^3}{4xy}$  ?

F.  $-7x^3y^2$   
G.  $-7x^4y^4$   
H.  $-7x^5y^4$   
J.  $-24x^3y^2$   
K.  $-32x^3y^2$

5. What is the volume, in cubic inches, of a right circular cone with radius 3 inches and height 6 inches?

(Note: The volume of a right circular cone with radius  $r$  and height  $h$  is  $\frac{1}{3}\pi r^2h$ .)

A.  $6\pi$   
B.  $12\pi$   
C.  $18\pi$   
D.  $27\pi$   
E.  $36\pi$

6. The expression  $(x^4)^6$  is equivalent to:

F.  $x^{10}$   
G.  $x^{24}$   
H.  $x^{4.096}$   
J.  $6x^2$   
K.  $6x^3$

7. Milo earns his regular pay of \$12.00 per hour for up to 40 hours of work per week. For each hour over 40 hours of work per week, Milo earns  $1\frac{1}{2}$  times his regular pay. How much does Milo earn in a week in which he works 45 hours?

A. \$337.50  
B. \$540.00  
C. \$570.00  
D. \$607.50  
E. \$810.00





8. Which of the following matrices is equal to

$$\begin{bmatrix} 5 & 7 \\ -4 & 4 \end{bmatrix} + \begin{bmatrix} -6 & 3 \\ 6 & 8 \end{bmatrix} ?$$

F.  $\begin{bmatrix} -1 & 10 \\ 2 & 12 \end{bmatrix}$

G.  $\begin{bmatrix} -1 & 10 \\ 10 & 12 \end{bmatrix}$

H.  $\begin{bmatrix} 11 & 10 \\ 10 & 12 \end{bmatrix}$

J.  $\begin{bmatrix} 12 & -3 \\ 0 & 14 \end{bmatrix}$

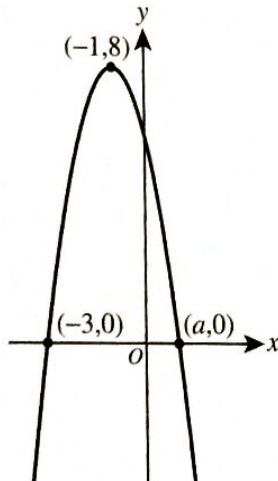
K.  $\begin{bmatrix} 12 & 71 \\ 48 & 20 \end{bmatrix}$

DO YOUR FIGURING HERE.

9. Tomi has 6 pairs of shoes, 4 pairs of pants, and 6 shirts, which can be worn in any combination. He needs to choose a clothes combination to wear to the school dance. How many different combinations consisting of 1 of his 6 pairs of shoes, 1 of his 4 pairs of pants, and 1 of his 6 shirts are possible for Tomi to wear to the dance?

- A. 10  
B. 16  
C. 24  
D. 48  
E. 144

10. In the standard  $(x,y)$  coordinate plane below, the graph of the equation  $y = -2(x+1)^2 + 8$  intersects the  $x$ -axis at points  $(-3,0)$  and  $(a,0)$  and has its vertex at point  $(-1,8)$ . What is the value of  $a$ ?



- F.  $\frac{1}{2}$   
G. 1  
H.  $\frac{3}{2}$   
J. 2  
K. 3

11. What is the least common denominator of the fractions

$$\frac{4}{21}, \frac{1}{24}, \text{ and } \frac{3}{16} ?$$

- A. 112  
B. 336  
C. 504  
D. 2,688  
E. 8,064



12. In the standard  $(x,y)$  coordinate plane, what is the slope of the line through  $(-7,3)$  and  $(2,4)$  ?

F.  $-\frac{7}{5}$

G.  $-\frac{1}{5}$

H.  $-\frac{1}{9}$

J.  $\frac{1}{9}$

K.  $\frac{1}{5}$

**DO YOUR FIGURING HERE.**

13. A group of 60 students and 4 sponsors took a field trip to a local museum. For their first guided tour, students were given a choice of 1 of 3 art exhibits. Of the 60 students,  $\frac{1}{2}$  chose Modern,  $\frac{1}{4}$  chose American Folk, and  $\frac{1}{6}$  chose Western. Each student that expressed a choice chose exactly 1 exhibit. The remaining students expressed no choice. How many of the students expressed no choice?

- A. 5  
B. 6  
C. 10  
D. 15  
E. 30

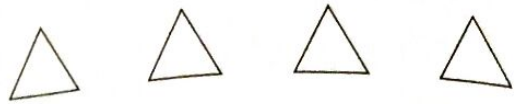
14. What is the greatest integer solution to  $6x - 2 \leq 11.2$  ?

- F. -2  
G. -1  
H. 1  
J. 2  
K. 3

15. Classics Online charges a onetime registration fee of \$17.50 and sells classical music downloads for \$0.70 per song. Ian has \$50.00 that he will use to pay the registration fee and buy classical music from Classics Online. What is the maximum number of songs Ian can buy?

- A. 25  
B. 32  
C. 35  
D. 46  
E. 53





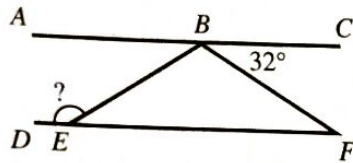
DO YOUR FIGURING HERE.

16. The lengths of corresponding sides of 2 similar right triangles are in the ratio 2:9. The hypotenuse of the smaller triangle is 8 inches long. How many inches long is the hypotenuse of the larger triangle?
- F. 4.5  
G. 11  
H. 15  
J. 18  
K. 36

17. The mean age of the 5 people in a room is 30 years. One of the 5 people, whose age is 50 years, leaves the room. What is the mean age of the 4 people remaining in the room?
- A. 14  
B. 20  
C. 25  
D. 30  
E. 35

18. In the figure below,  $B$  lies on  $\overline{AC}$ ,  $E$  lies on  $\overline{DF}$ ,  $\overline{AC} \parallel \overline{DF}$ ,  $\triangle EBF$  is isosceles with  $\overline{BE} \cong \overline{BF}$ , and  $\angle CBF$  measures  $32^\circ$ . What is the measure of  $\angle BED$ ?

- F.  $106^\circ$   
G.  $116^\circ$   
H.  $122^\circ$   
J.  $132^\circ$   
K.  $148^\circ$



19. If  $x = -1$  and  $y = 2$ , what is the value of  $x^3 - 2x^2y - 4xy^2 + 8$ ?
- A. -13  
B. -5  
C. 19  
D. 23  
E. 27

20. A retailer is comparing the costs of buying 3 products from 1 of 2 companies. The cost of each product from both companies is shown in the table below.

	Company A	Company B
Product 1	\$ 5.00	\$5.50
Product 2	\$10.00	\$9.50
Product 3	\$ 6.00	\$5.75

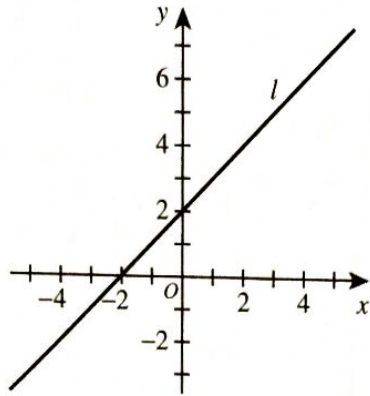
The retailer will buy 10 of Product 1, 12 of Product 2, and 5 of Product 3. How much more will it cost the retailer to purchase these products from Company A than to purchase these products from Company B?

- F. \$ 0.25  
G. \$ 1.25  
H. \$ 2.25  
J. \$ 6.75  
K. \$12.25



21. Line  $l$  is shown in the standard  $(x,y)$  coordinate plane below. Alicia drew line  $p$  with a slope that is  $\frac{1}{2}$  of the slope of line  $l$  and with a  $y$ -intercept that is 3 times the  $y$ -intercept of line  $l$ . One of the following equations represents line  $p$ . Which one?

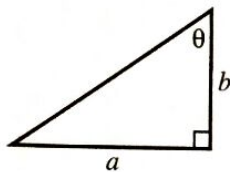
- A.  $y = x + 3$   
 B.  $y = -3x + 1$   
 C.  $y = 3x + 1$   
 D.  $y = -\frac{1}{2}x + 6$   
 E.  $y = \frac{1}{2}x + 6$



DO YOUR FIGURING HERE.

22. One angle measure and 2 side lengths, in inches, are given in the right scalene triangle below. In terms of  $a$  and  $b$ , what is  $\sin \theta$ ?

- F.  $\frac{a}{b}$   
 G.  $\frac{b}{a}$   
 H.  $\frac{a}{\sqrt{a^2 + b^2}}$   
 J.  $\frac{b}{\sqrt{a^2 + b^2}}$   
 K.  $\frac{\sqrt{a^2 + b^2}}{b}$



23. Each side of square  $ABCD$  has a length of 50 cm. A certain rectangle whose area is equal to the area of  $ABCD$  has a width of 10 cm. What is the length, in centimeters, of the rectangle?

- A. 40  
 B. 50  
 C. 60  
 D. 125  
 E. 250
24. If  $f(x) = 5x^2 - 6x + 1$  and  $g(x) = x^2 - 2$ , which of the following expressions represents  $(fg)(x)$ ?
- F.  $6x^2 - 6x - 1$   
 G.  $5x^4 - 26x^2 + 33$   
 H.  $5x^4 - 20x^2 - 6x + 21$   
 J.  $5x^4 - 6x^3 - 9x^2 + 12x - 2$   
 K.  $25x^4 - 60x^3 + 46x^2 - 12x - 1$





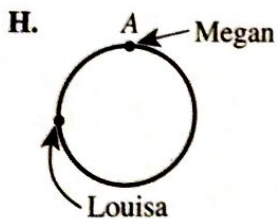
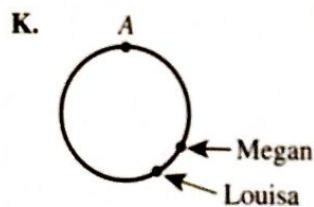
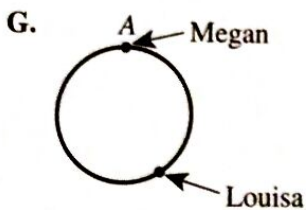
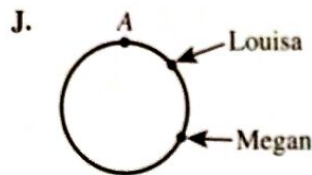
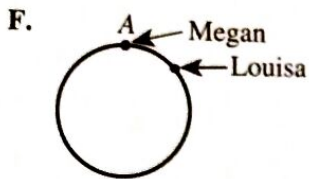
25. A bag contains 12 red marbles, 14 yellow marbles, and 8 green marbles. How many additional red marbles must be added to the 34 marbles already in the bag so that the probability of randomly drawing a red marble is  $\frac{3}{5}$ ?

- A. 16  
B. 21  
C. 29  
D. 34  
E. 44

26. Megan and Louisa are side-by-side (at point A in the figure shown below) when they begin to run at the same time clockwise ( $\curvearrowright$ ) around a small circular track. Megan runs at a rate of 40 seconds per lap, while Louisa runs at a rate of 70 seconds per lap.



Which of the following figures best represents Megan's and Louisa's locations 120 seconds after they begin to run?



27. The statement  $3x - (x + 6) + 8 = 2x + 14$  is true for:

- A.  $x = 0$  only.  
B.  $x = 4$  only.  
C.  $x = 7$  only.  
D. all values of  $x$ .  
E. no values of  $x$ .



28. The first 7 terms in an arithmetic sequence are listed below. What is the difference between the mean and the median of the 7 terms?

$$\frac{1}{2}, 1, \frac{3}{2}, 2, \frac{5}{2}, 3, \frac{7}{2}$$

F. 0

G.  $\frac{3}{7}$

H.  $\frac{1}{2}$

J. 2

K. 9

DO YOUR FIGURING HERE.

29. What is the product of the complex numbers  $(-2i + 5)$  and  $(2i + 5)$ ?

A. 3

B. 21

C. 29

D.  $20i - 21$

E.  $20i + 21$

30. Which of the following expressions represents the sum of  $3.8 \times 10^5$  and  $6.4 \times 10^4$  in scientific notation?

F.  $1.02 \times 10^{10}$

G.  $4.44 \times 10^4$

H.  $4.44 \times 10^5$

J.  $10.2 \times 10^{20}$

K.  $44.4 \times 10^4$

31. Lian has  $6\frac{1}{2}$  yards of ribbon she will use to make bows. She will use  $\frac{3}{4}$  yard of ribbon to make each bow. After Lian has made all the bows possible with the ribbon, what length of ribbon, in yards, will NOT have been used to make bows?

A. 0

B.  $\frac{1}{2}$

C.  $\frac{21}{32}$

D.  $\frac{2}{3}$

E.  $\frac{7}{8}$





DO YOUR FIGURING HERE.

Use the following information to answer questions 32–34.

Carl purchased a new car. The fuel economy window sticker on the new car contained the information shown below. In this figure, MPG is miles per gallon.

EPA DOT Fuel Economy		You Save	
<b>Fuel Economy</b>		<b>\$3,500*</b>	
<b>25</b> MPG	22 32	in fuel costs	
combined	city highway	over 5 years	
city/highway		compared to	
		the average	
		new vehicle.	
<b>Annual fuel COST</b>	*Cost estimates are based on the		
<b>\$2,400*</b>	combined city/highway MPG, a		
	certain number of miles per year		
	the car is driven, and an average		
	fuel cost of \$4.00 per gallon.		

32. Carl is planning a trip in his new car that will include 350 miles of highway driving. Using the average fuel cost per gallon given in the fuel economy window sticker, which of the following dollar amounts is closest to his total cost for fuel over the 350 miles of highway driving?
- F. \$43.75  
G. \$51.85  
H. \$56.00  
J. \$63.64  
K. \$87.50
33. The cost estimates are based on a certain number of miles driven per year. To the nearest 1,000 miles, what is this number?
- A. 13,000  
B. 15,000  
C. 16,000  
D. 19,000  
E. 22,000
34. Based on the annual fuel cost estimate for this car and the estimate for how much Carl will save in fuel costs over the next 5 years, what would be the expected annual fuel cost of an average new vehicle?
- F. \$1,180  
G. \$2,950  
H. \$3,100  
J. \$3,500  
K. \$3,980



35. A certain race car has a maximum speed of 240 miles per hour. Which of the following is an expression for this maximum speed in feet per second?

**DO YOUR FIGURING HERE.**

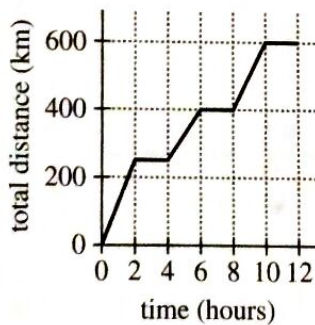
(Note: 1 mile = 5,280 feet)

- A.  $\frac{240(5,280)}{36,000}$
- B.  $\frac{240(3,600)}{5,280}$
- C.  $\frac{240(5,280)}{3,600}$
- D.  $\frac{60(5,280)}{240}$
- E.  $\frac{240(5,280)}{360}$

36. A chemist needs 1 ounce of element X. The only way which the chemist can get element X is to buy compound Y, which contains 10% X. Compound Y costs \$2.40 per pound (16 ounces). How much must the chemist pay in order to ensure that she receives 1 ounce of element X?

- F. \$ .15
- G. \$ .24
- H. \$1.50
- J. \$2.40
- K. \$3.84

37. Emi traveled to 3 locations during a workday. Emi remained at each location a whole number of hours. The graph below shows the relationship between time, in hours, into her workday and total distance, in kilometers, traveled. Which of the following values is closest to Emi's average speed, in kilometers per hour, for the parts of the workday when she was traveling?



- A. 60
- B. 75
- C. 80
- D. 100
- E. 125

38. What are all and only the values of  $x$  that are NOT in the domain of the function  $f(x) = \frac{(x-7)(x+2)}{(x+6)(x-8)}$ ?

- F. -8 and 6
- G. -6 and 8
- H. -2 and 7
- J. -8, -7, 2, and 6
- K. -6, -2, 7, and 8





DO YOUR FIGURING HERE.

39. A new band asked its audience to rate the band's performance on a scale from 1 (poor) through 5 (excellent). The table below gives the percentage of the audience that gave each of the ratings. To the nearest 0.1, what was the mean rating given by this audience?

Rating	Percentage
1	0%
2	0%
3	10%
4	70%
5	20%

- A. 2.0  
 B. 2.8  
 C. 3.0  
 D. 4.0  
 E. 4.1
40. In  $\triangle DEF$ , the length of  $\overline{DE}$  is  $\sqrt{60}$  cm, and the length of  $\overline{EF}$  is 6 cm. If it can be determined, what is the length, in centimeters, of  $\overline{DF}$ ?
- F. 6  
 G.  $\sqrt{60}$   
 H.  $\sqrt{66}$   
 J.  $\sqrt{96}$   
 K. Cannot be determined from the given information
41. Let  $a$  and  $b$  represent real numbers with the property  $|a - b - 1| > 0$ . Which of the following statements about  $a$  and  $b$  CANNOT be true?
- A.  $a - b < 1$   
 B.  $a - b = 1$   
 C.  $a < 1$  and  $b > 0$   
 D.  $a < 1$  and  $b = 0$   
 E.  $a < 0$  and  $b > 0$
42. Juwan has 150 cm of wire. For a craft project, he uses all the wire to make 1 circle with a radius of 5 cm and 1 square. To the nearest 0.1 cm, what is the side length of the square?
- F. 17.9  
 G. 29.6  
 H. 32.6  
 J. 33.6  
 K. 118.6



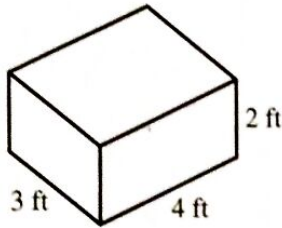
Use the following information to answer questions 43–46.

DO YOUR FIGURING HERE.

A local recycling center pays customers for cans, bottles, and cardboard. After processing these items, the center then resells them to XYZ Inc. The recycling center's payments to customers and the resale prices paid by XYZ Inc. are given in the table below.

Item	Payment	Resale price
Can	\$0.05 each	\$0.15 each
Bottle	\$0.10 each	\$0.18 each
Cardboard	\$0.01 per pound	\$0.02 per pound

43. The closed box with no overlapping pieces whose dimensions are given below is made with cardboard that weighs 1 pound per square foot of the surface area of the box. Which of the following values is closest to the amount the recycling center will pay a customer for this box?



- A. \$0.24  
 B. \$0.36  
 C. \$0.48  
 D. \$0.52  
 E. \$1.04
44. The cost of processing cans and bottles at the recycling center is \$0.03 per can and \$0.02 per bottle. After paying the processing cost and the payment to customers, what is the recycling center's profit on the resale of 200 cans and 300 bottles to XYZ Inc. ?
- F. \$ 32.00  
 G. \$ 40.00  
 H. \$ 48.00  
 J. \$ 84.00  
 K. \$112.00
45. To the nearest 1%, the recycling center's payment to a customer for a bottle is what percent of the resale price of a bottle sold to XYZ Inc. ?
- A. 8%  
 B. 56%  
 C. 80%  
 D. 125%  
 E. 180%
46. In 1 shipment, the recycling center sold a total of 2,700 cans and bottles to XYZ Inc. for \$441.00. How many bottles were in the shipment?
- F. 1,200  
 G. 1,230  
 H. 1,350  
 J. 1,470  
 K. 1,500





DO YOUR FIGURING HERE.

47. Given constants  $c$ ,  $d$ ,  $m$ , and  $n$  such that  $x^2 + mx + c$  has factors of  $(x + 2)$  and  $(x + 4)$  and  $x^2 + nx + d$  has factors of  $(x + 3)$  and  $(x + 7)$ , what is  $mn$ ?

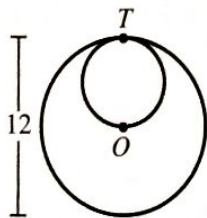
- A. 16  
B. 18  
C. 29  
D. 60  
E. 168

48. For every angle  $\theta$ , measured in radians, which of the following is equal to  $\sin(2\pi + \theta)$ ?

- F.  $\sin(-\pi + \theta)$   
G.  $\sin(\theta)$   
H.  $\sin\left(\frac{\pi}{2} + \theta\right)$   
J.  $\sin\left(\frac{2\pi}{3} + \theta\right)$   
K.  $\sin(\pi + \theta)$

49. A small circle and a large circle are tangent at  $T$ , as shown in the figure below. The center,  $O$ , of the large circle lies on the small circle. The diameter of the large circle is 12 cm. What is the ratio of the area of the small circle to the area of the large circle?

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



50. For all positive values of  $a$  and  $b$ , which of the following expressions is equal to  $\frac{2a}{b} + \frac{b}{2a}$ ?

- F.  $\frac{2a+b}{b+2a}$   
G.  $\frac{2a+b}{2ab}$   
H.  $\frac{4a+b}{2ab}$   
J.  $\frac{4a^2+b^2}{2ab}$   
K.  $\frac{4a^2+b^2}{2a+b}$



51. The vector  $\mathbf{i}$  represents 1 mile per hour east, and the vector  $\mathbf{j}$  represents 1 mile per hour north. According to her GPS, at a particular instant, Tia is biking  $30^\circ$  west of north at 16 miles per hour. One of the following vectors represents Tia's velocity, in miles per hour, at that instant. Which one?

- A.  $-8\mathbf{i} - 8\sqrt{3}\mathbf{j}$   
 B.  $-8\mathbf{i} + 8\sqrt{3}\mathbf{j}$   
 C.  $8\mathbf{i} + 8\sqrt{3}\mathbf{j}$   
 D.  $8\sqrt{3}\mathbf{i} - 8\mathbf{j}$   
 E.  $8\sqrt{3}\mathbf{i} + 8\mathbf{j}$

DO YOUR FIGURING HERE.

52. Let  $(f \circ g)(x) = \sqrt[3]{x+1} - 2$  and  $g(x) = x + 1$ . Which of the following expressions defines  $(g \circ f)(x)$ ?

- F.  $\sqrt[3]{x-1}$   
 G.  $\sqrt[3]{x} - 1$   
 H.  $\sqrt[3]{x} - 2$   
 J.  $(x+2)^3 - 1$   
 K.  $(x-1)^3 + 2$

53. Consider sets  $A$ ,  $B$ ,  $C$ , and  $D$  such that  $B$  is a subset of  $A$ ,  $C$  is a subset of  $B$ , and  $D$  is a subset of  $C$ . Whenever  $x$  is an element of  $B$ ,  $x$  *must* be an element of:

- A.  $A$ .  
 B.  $D$ .  
 C.  $A$  and  $C$ .  
 D.  $C$  and  $D$ .  
 E.  $A$ ,  $C$ , and  $D$ .

54. For all positive values of  $x$ , which of the following expressions is equivalent to  $\sqrt[6]{x^4}(\sqrt[3]{x^4})$ ?

- F.  $x^{\frac{8}{9}}$   
 G.  $x$   
 H.  $x^{\frac{9}{8}}$   
 J.  $x^2$   
 K.  $x^{\frac{9}{4}}$





DO YOUR FIGURING HERE.

55. A company sells ice cream in 2-quart containers for \$3.00 per container. The company also sells ice cream in 1.5-quart containers for \$2.50 per container. What is the ratio of the price per quart for the 2-quart container to the price per quart for the 1.5-quart container?

- A.  $\frac{9}{10}$
- B.  $\frac{10}{9}$
- C.  $\frac{3}{2}$
- D.  $\frac{5}{3}$
- E.  $\frac{5}{2}$

56. Each of 100 distinct playing cards is 1 of 5 solid colors and is numbered with 1 integer. There are 20 each of blue, red, yellow, green, and orange cards numbered 1–20. One of the 100 cards will be selected at random. What is the probability that the selected card will be blue OR numbered 17?

- F.  $\frac{5}{100}$
- G.  $\frac{17}{100}$
- H.  $\frac{20}{100}$
- J.  $\frac{24}{100}$
- K.  $\frac{25}{100}$

57. The changes in a city's population from one decade to the next decade for 3 consecutive decades were a 20% increase, a 30% increase, and a 20% decrease. About what percent was the increase in the city's population over the 3 decades?

- A. 10%
- B. 20%
- C. 25%
- D. 30%
- E. 70%

58. Four golfers will be randomly split into 2 groups of 2 for a tournament. If Jill and Ramona are among the 4, what is the probability that they will be paired together?

- F.  $\frac{1}{12}$
- G.  $\frac{1}{8}$
- H.  $\frac{1}{6}$
- J.  $\frac{1}{4}$
- K.  $\frac{1}{3}$

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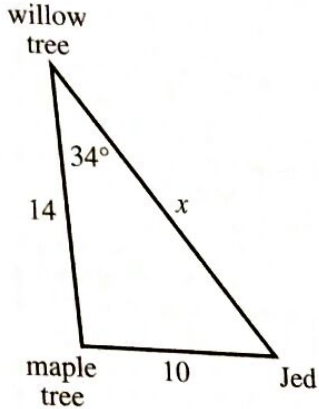
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59. Jed is standing 10 meters from a maple tree that is 14 meters from a willow tree, as shown in the figure below, in which the measure of an angle is given. Which of the following equations, when solved for  $x$ , gives the distance,  $x$  meters, between Jed and the willow tree?

(Note: For a triangle with sides of length  $a$ ,  $b$ , and  $c$  that are opposite angles  $\angle A$ ,  $\angle B$ , and  $\angle C$ , respectively,  $c^2 = a^2 + b^2 - 2ab \cos \angle C$ .)



- A.  $10^2 = x^2 + 14^2 - 2x(14)(\cos 34^\circ)$   
 B.  $10^2 = x^2 + 14^2 - 2(10)(14)(\cos 34^\circ)$   
 C.  $14^2 = x^2 + 10^2 - 2x(14)(\cos 34^\circ)$   
 D.  $x^2 = 10^2 + 14^2 - 2x(14)(\cos 34^\circ)$   
 E.  $x^2 = 10^2 + 14^2 - 2(10)(14)(\cos 34^\circ)$
60. Suppose the equations  $(x - 4)^2 + (y - 3)^2 = 4$  and  $\frac{(x-4)^2}{4} + \frac{(y-10)^2}{16} = 1$  are graphed in the same standard  $(x,y)$  coordinate plane. How many points of intersection do these graphs share?

- F. 0  
 G. 1  
 H. 2  
 J. 3  
 K. 4

DO YOUR FIGURING HERE.

END OF TEST 2

STOP! DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.

DO NOT RETURN TO THE PREVIOUS TEST.



## READING TEST

35 Minutes—40 Questions

**DIRECTIONS:** There are several passages in this test. Each passage is accompanied by several questions. After reading a passage, choose the best answer to each question and fill in the corresponding oval on your answer document. You may refer to the passages as often as necessary.

## Passage I

**LITERARY NARRATIVE:** This passage is adapted from the book *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants* by Robin Wall Kimmerer (©2013 by Robin Wall Kimmerer).

Even now, after more than fifty Strawberry Moons, finding a patch of wild strawberries still touches me with a sensation of surprise, a feeling of unworthiness and gratitude for the generosity and kindness that comes with an unexpected gift all wrapped in red and green. “Really? For me? Oh, you shouldn’t have.” After fifty years they still raise the question of how to respond to their generosity. Sometimes it feels like a silly question with a very simple answer: eat them.

10 But I know that someone else has wondered these same things. In our Creation stories the origin of strawberries is important. Skywoman’s beautiful daughter, whom she carried in her womb from Skyworld, grew on the good green earth, loving and loved by all the other  
15 beings. But tragedy befell her when she died giving birth to her twins, Flint and Sapling. Heartbroken, Skywoman buried her beloved daughter in the earth. Her final gifts, our most revered plants, grew from her body. The strawberry arose from her heart. In Potawatomi, the  
20 strawberry is *ode min*, the heart berry. We recognize them as the leaders of the berries, the first to bear fruit.

Strawberries first shaped my view of a world full of gifts simply scattered at your feet. A gift comes to you through no action of your own, free, having moved  
25 toward you without your beckoning. It is not a reward; you cannot earn it, or call it to you, or even deserve it. And yet it appears. Your only role is to be open-eyed and present. Gifts exist in a realm of humility and mystery—as with random acts of kindness, we do not  
30 know their source.

Those fields of my childhood showered us with strawberries, raspberries, blackberries, hickory nuts in the fall, bouquets of wildflowers brought to my mom, and family walks on Sunday afternoon. They were our  
35 playground, retreat, wildlife sanctuary, and ecology classroom. All for free. Or so I thought.

I experienced the world in that time as a gift economy, “goods and services” not purchased but received

as gifts from the earth. Of course I was blissfully  
40 unaware of how my parents must have struggled to make ends meet in the wage economy raging far from this field.

In our family, the presents we gave one another were almost always homemade. I thought that was the  
45 definition of a gift: something you made for someone else. We made all our Christmas gifts: piggy banks from old bottles of bleach, hot pads from broken clothespins, and puppets from retired socks. My mother says it was because we had no money for store-bought  
50 presents. It didn’t seem like a hardship to me; it was something special.

My father loves wild strawberries, so for Father’s Day my mother would almost always make him strawberry shortcake. She baked the crusty shortcakes and  
55 whipped the heavy cream, but we kids were responsible for the berries. We each got an old jar or two and spent the Saturday before the celebration out in the fields, taking forever to fill them as more and more berries ended up in our mouths. Finally, we returned home and  
60 poured them out on the kitchen table to sort out the bugs. I’m sure we missed some, but Dad never mentioned the extra protein.

In fact, he thought wild strawberry shortcake was the best possible present, or so he had us convinced. It  
65 was a gift that could never be bought. As children raised by strawberries, we were probably unaware that the gift of berries was from the fields themselves, not from us. Our gift was time and attention and care and red-stained fingers. Heart berries, indeed.

70 Gifts from the earth or from each other establish a particular relationship, an obligation of sorts to give, to receive, and to reciprocate. The field gave to us, we gave to my dad, and we tried to give back to the strawberries. When the berry season was done, the plants  
75 would send out slender red runners to make new plants. Because I was fascinated by the way they would travel over the ground looking for good places to take root, I would weed out little patches of bare ground where the runners touched down. Sure enough, tiny little roots  
80 would emerge from the runner and by the end of the season there were even more plants, ready to bloom under the next Strawberry Moon. No person taught us this—the strawberries showed us. Because they had



given us a gift, an ongoing relationship opened between  
85 us.

Farmers around us grew a lot of strawberries and frequently hired kids to pick for them. My siblings and I would ride our bikes a long way to Crandall's farm to pick berries to earn spending money. A dime for every  
90 quart we picked.

1. The point of view from which the passage is told can best be described as that of a:
  - A. first person narrator describing the experience of picking strawberries as it happens.
  - B. first person narrator describing events from the past that influenced her beliefs about gifts.
  - C. third person narrator describing how each member of a family feels about gifts of nature.
  - D. third person narrator describing a young girl's thoughts about the importance of strawberries in her family's celebrations.
2. Based on the passage, the word *they* in line 7 refers to:
  - F. the fields of the narrator's childhood.
  - G. people who present the narrator with gifts.
  - H. wild strawberries.
  - J. the narrator's parents.
3. The main purpose of the second paragraph (lines 10–21) is to:
  - A. explain why the narrator's father encouraged his children to give strawberries as gifts.
  - B. describe what the first strawberries looked like to the narrator's ancestors.
  - C. provide a cultural context for the significance of strawberries to the narrator's family.
  - D. emphasize the importance of plants in traditional Potawatomi stories.
4. Based on the passage, which action was part of the narrator's attempt to "give back to the strawberries" (lines 73–74)?
  - F. She refrained from picking strawberries before they were ready.
  - G. She weeded out patches of ground where the plants would take root.
  - H. She made the strawberries into a gift for her father.
  - J. She honored the legend of Skywoman by continuing to tell the story.
5. It can most reasonably be inferred from the passage that the narrator learned about the growth cycle of strawberries by:
  - A. observing the runners and roots of the plants.
  - B. listening to her father talk about berry seasons.
  - C. planting berries with her siblings to earn money.
  - D. reading about how to help strawberries grow.
6. The quotation in line 6 is most likely included to:
  - F. demonstrate what the narrator typically says to a person giving her a gift.
  - G. represent the narrator's surprise and gratitude when finding strawberries.
  - H. clarify how the narrator believes a person should react when given a gift.
  - J. explain what the narrator's father often said when given strawberries.
7. As it is used in line 20, the word *recognize* most nearly means:
  - A. diagnose.
  - B. concede.
  - C. notice.
  - D. acknowledge.
8. In the passage, the narrator states that as a child, she experienced her world as a:
  - F. gift economy based on gifts from the earth.
  - G. wage economy in which her family struggled.
  - H. playground she visited on rare but wonderful occasions.
  - J. classroom filled with friends and neighbors.
9. According to the passage, picking the strawberries for their father's shortcake took the narrator and her siblings a long time because:
  - A. they kept eating the strawberries they picked.
  - B. the strawberry patches had many bugs.
  - C. their father expected only the ripest strawberries.
  - D. they could gather the strawberries only on Saturdays.
10. According to the passage, runners appeared on berry plants in the field when:
  - F. the Strawberry Moon first appeared.
  - G. a patch of ground was cleared for them.
  - H. berry season was over.
  - J. the berry plant was dying.



## Passage II

**SOCIAL SCIENCE:** This passage is adapted from *The Airplane: How Ideas Gave Us Wings* by Jay Spenser (©2008 by Jay Spenser).

The invention of the airplane was a battleground for two warring paradigms about what the airplane would be like. Paradigms are mind-sets created by what we think we know. Depending on how closely they match the actuality, these mental models either can help us succeed or can place blinders over our eyes that keep us from perceiving what we later realize was obvious all along.

Working under the right paradigm helped Americans Orville and Wilbur Wright to succeed even as a wrong one sabotaged the hopes of Europe's many experimenters. If not for this situation, the French—who felt they had invented flight because of the success of the Montgolfiers' hot-air balloons in 1783—might well have been first. If so, the airplane, like the automobile before it, would have been a European invention.

What led Europe's aerial experimenters astray? It was William Samuel Henson. Or more accurately, it was the powerful sway of Henson's persuasive vision of what aviation would be.

First published in the early 1840s, the engraved illustrations of the Henson Aerial Steam Carriage (a passenger-carrying airplane) continued to appear off and on in newspapers, magazines, and books for more than a half century. More thrilling artwork of heavier-than-air flying machines was hard to imagine, and the very sight of this aerial stagecoach spurred Europe's aerial experimenters to redouble their efforts. Unfortunately, however, it also handed them a lot of incorrect notions.

The concept of an aerial carriage brought with it a concomitant expectation that people would drive airplanes around the sky making flat turns as they did in horse-drawn vehicles. This unquestioned assumption shaped how France's early experimentation approached airplane design, and it cost them dearly.

Part of Henson's paradigm worked. For example, airplanes would indeed pitch their noses up or down to climb or descend. This was intuitive because horse-drawn carriages do just that when traversing hilly countryside. But carriages don't tilt sideways, or at least not very far, because that leads to a catastrophic upset.

Henson's vision told Europe's early experimenters that their airplanes must not be permitted to tilt side to side or else catastrophe would ensue. To ensure that this never happened, some experimenters used strongly upward-angled wings so that the airplane would be self-righting in flight. Others placed vertical fore-and-aft fabric panels between the wings of their biplanes to prevent sideslips. Both these features suggest that Europe's pioneers were terrified of *banking*, or dropping a wing in flight.

Another place where Henson's Aerial Steam Carriage paradigm misled people was the vital issue of controllability. Controlling horse-drawn vehicles does not require constant active involvement on the driver's part. The horses are set in motion and the reins are not used again until the horses need further instruction.

Consequently, Europe's "early birds" were remarkably cavalier about controllability. To them, all one needed to do was create an inherently stable craft whose wings never dropped to either side. After nosing this vehicle aloft, one would simply "drive" it around the sky.

A wealthy Brazilian named Alberto Santos-Dumont performed Europe's first heavier-than-air flights late in 1906. His *14-bis* was largely uncontrollable, but that didn't bother him; his goal was simply to get into the air. This disregard for a key requirement of flight was then so pervasive that more than a year would pass before any European figured out how to actually land where he had taken off.

Wilbur and Orville worked under a different mindset. They too had seen Henson's artwork, but it didn't sing to them because they were bicyclists. Their intimate association with this vehicle, its operation, and its manufacture led them to approach flight development in a different way than their European counterparts.

Wilbur and Orville were not in the least scared of tilting to one side or the other in flight. Banking in flight seemed natural to them because a bicyclist leans into turns. What's more, they understood from the outset that the airplane needed to be controllable around all three axes and that the pilot had to be intimately involved with this process while aloft. These two insights were intuitive because the bicyclist must constantly direct his two-wheeled vehicle by means of a combination of active balance and coordinated use of handlebars, acceleration, and braking. If the bicyclist doesn't stay on top of these things every minute, he's in for a spill.

11. Which of the following details from the passage best supports the author's claim about the impact of paradigms on success?
- Illustrations of the Henson Aerial Steam Carriage were first published in the early 1840s.
  - The Wrights' knowledge of bicycles made banking an airplane seem natural to them.
  - Alberto Santos-Dumont was the first to achieve heavier-than-air flight in Europe.
  - The first automobile was a European invention.



12. The passage can best be described as:
- F. a critique of the solutions early aerial experimenters found to the problems they faced.
  - G. an overview of how various European inventions evolved.
  - H. an explanation of how Henson's paradigm helped to improve early aircraft design.
  - J. an analysis of how two different paradigms affected early aircraft design.
13. The main idea of the fourth paragraph (lines 21–30) is that Henson's illustrations:
- A. were so popular that they appeared in newspapers and magazines for over half a century.
  - B. encouraged experimenters to imagine even more thrilling airplane designs than Henson had.
  - C. inspired experimenters and helped them build the first working airplanes more quickly.
  - D. motivated experimenters but hindered their ability to invent a successful airplane.
14. The main idea of the seventh paragraph (lines 43–52) is that Henson's vision led Europe's experimenters to:
- F. debate whether upward-angled wings or vertical fabric panels more effectively balanced a plane.
  - G. find innovative solutions to make their planes as strong as horse-drawn carriages.
  - H. invent ways to prevent planes from tilting because the inventors were mistakenly fearful of banking the planes.
  - J. design airplanes to withstand any catastrophe that might occur.
15. The author most likely includes the example of Santos-Dumont's flights in 1906 to:
- A. illustrate how an inaccurate paradigm can impede overall success.
  - B. praise Santos-Dumont for being the first to achieve heavier-than-air flights.
  - C. describe the plane that inspired the Wrights to shift their paradigm.
  - D. explain why controlling a plane was less vital than the Wrights believed.

16. According to the passage, compared to Europe's early experimenters, the Wrights were less inspired by Henson's vision because they were:
- F. determined not to copy other designers' work.
  - G. unaware of Henson's work with hot-air balloons.
  - H. accustomed to a different mode of transportation.
  - J. more inspired by Santos-Dumont's vision.
17. As it is used in line 90, the phrase "stay on top of" most nearly means:
- A. fly over.
  - B. pay attention to.
  - C. remain above.
  - D. keep learning about.
18. As presented in the passage, the idea that human flight was invented when the Montgolfiers successfully launched their hot-air balloons reflects the perspective of:
- F. the passage author.
  - G. the Wrights.
  - H. Henson.
  - J. the French.
19. As it is used in line 19, the word *sway* most nearly means:
- A. fluctuation.
  - B. influence.
  - C. regime.
  - D. grace.
20. The passage most strongly suggests that compared to early airplanes, horse-drawn vehicles:
- F. required less continuous steering.
  - G. were less inherently stable.
  - H. could more safely tilt from side to side.
  - J. were more difficult to control.



## Passage III

**HUMANITIES:** Passage A is adapted from the biography *Duke: A Life of Duke Ellington* by Terry Teachout (©2013 by Terry Teachout). Passage B is adapted from the biography *I'll Take You There: Mavis Staples, The Staples Singers, and the March Up Freedom's Highway* by Greg Kot (©2014 by Greg Kot).

## Passage A by Terry Teachout

What Duke Ellington sought and got from his “accumulation of personalities” was a loose, festive ensemble sound far removed from the clean precision of Benny Goodman’s band. He had no interest in the smoothly blended playing that leaders like Goodman, Jimmie Lunceford, and Artie Shaw demanded from their groups. He preferred to hire musicians with homemade techniques that were different to the point of apparent incompatibility, then juxtapose their idiosyncratic sounds as a pointillist painter might place dots of red and green side by side on his canvas, finding inspiration in their technical limitations (“With a musician who plays the full compass of his instrument as fast or as slow as possible, there seems, paradoxically, less opportunity to create”). That is why his charts never sound quite right when performed by other groups, however accomplished the individual players may be. It is also why a keen-eared virtuoso like Jack Teagarden, the greatest jazz trombonist of his generation, found it impossible to enjoy the Ellington band. “I never did like anything Ellington ever did,” he said. “He never had a band all in tune, always had a bad tone quality and bad blend.” What Teagarden meant, whether he knew it or not, was that the band had an *unconventional* tone quality, one that had little in common with received ideas about how a big band ought to sound. Asked why he hired Al Hibbler when he already had a singer on the payroll, Ellington replied, “My ear makes my decision.” To him, no other ear mattered.

Billy Strayhorn, who saw Ellington’s working methods up close and understood them best, gave them a name in a 1952 article about his mentor: “Ellington plays the piano, but his real instrument is the band. Each member of his band is to him a distinctive tone color and set of emotions, which he mixes with others equally distinctive to produce a third thing, which I call the Ellington Effect.” Sometimes he worked “on” his players as a choreographer makes a ballet “on” his dancers, passing out or dictating scraps of music, then shaping and reshaping them on the spot into a piece that would later be reduced to written form. Even a work that had already been notated was subject in the heat of the moment to total transformation motivated solely by the whim of the composer. The goal, he explained, was “to mold the music around the man,” and the men around whom his music was so tightly molded rarely sounded more themselves than when they were playing it.

## Passage B by Greg Kot

In a six-member male gospel group calling themselves the Trumpet Jubilees, Pops was third lead,

singing mostly in a falsetto voice, and managed the group, booking their appearances and scheduling the rehearsals. He was a stickler for punctuality and precision, for looking and sounding sharp, for taking the job seriously. But not everyone in the group shared his commitment; his exasperation mounted until one day he quit. Pops decided to devote his time to a singing group that he could run from top to bottom, that would show up on time at every rehearsal, no questions asked. Mostly, he wanted to sing because it was a crucial part of his identity; since boyhood all he could remember was the pleasure singing brought him and his older brothers and sisters. When singing in the Trumpet Jubilees became a chore, he turned to his family.

“One night he came home early because the guys in the Trumpet Jubilees didn’t show up for rehearsal,” Mavis says. “He was disgusted. He went into the closet in the living room and got a little guitar he had brought home from the pawnshop. It didn’t have more than three or four strings on it, but it was enough to get us started.”

Mavis, Pervis, Cleotha, and Yvonne sat in a semicircle in front of their father on the beige carpet in their living room at 506 East 33rd Street. Pops hunched over his \$7 guitar and plucked a series of notes, assigning one to each of his children.

“People always ask, ‘How do we get the sound we have?’ And that came from my father—the sound he had with his family in Mississippi when they sang on the gallery after dinner. He gave us [an E chord] and the parts his brothers and sisters would sing. He would hit a note on his guitar and would say, ‘Now, Mavis go here,’ a baritone part, because even then I had the deepest voice. Pervis was second lead behind Pops because he had the most experience, and he could hit those high notes like Michael Jackson later could. Cleedi had the high harmony. The first song he taught us was ‘Will the Circle Be Unbroken.’”

## Questions 21–24 ask about Passage A.

21. In Passage A, the phrase “smoothly blended playing” (line 5) most nearly describes:
- the quality that Ellington elicited from a group of dissimilar musicians.
  - a sound that band leaders Goodman, Shaw, and Lunceford demanded from their musicians.
  - a sound that Shaw achieved more successfully than did Lunceford and Goodman.
  - a specific goal Ellington set for his band but found hard to achieve.



22. Based on Passage A, which statement best expresses Teagarden's opinion of Ellington?
- F. Teagarden viewed Ellington as his mentor.
  - G. Teagarden admired Ellington's piano playing but not his work as a band leader.
  - H. Teagarden found Ellington's work unappealing until he had a chance to play with the band.
  - J. Teagarden did not like anything about Ellington's band's music.

23. The author of Passage A indicates that Ellington based his decisions about whom to hire to join his band largely on:
- A. input from the members of his band.
  - B. his desire to appeal to a modern audience.
  - C. his trust in his own ear.
  - D. his training as a pianist.

24. One of the main ideas of the second paragraph of Passage A (lines 30–48) is that in the process of achieving the sound he wanted from his band, Ellington:
- F. accepted that the individual excellence of the players might occasionally be sacrificed.
  - G. elicited from his players performances that tapped their particular musical gifts.
  - H. invited each musician to articulate performance goals that he then helped them reach.
  - J. maintained a strict rehearsal schedule that some of the musicians rebelled against.

Questions 25–27 ask about Passage B.

25. The point of view from which Passage B is told is best described as that of a:
- A. first person narrator describing the personal sacrifices she made to succeed as a musician.
  - B. first person narrator comparing two styles of music as performed by the same band.
  - C. third person narrator who features the experiences and opinions of Pops and Mavis.
  - D. third person narrator who expresses opinions of Pops that contrast with those expressed by Mavis.

26. Which of the following statements about Pops's childhood is best supported by Passage B?
- F. He grew up in Mississippi with brothers and sisters who liked to sing together.
  - G. He started the Trumpet Jubilees with his siblings but quit by the time he was a teenager.
  - H. His musical career started in a small apartment where he taught himself to play guitar.
  - J. With his brothers, he was part of a singing group that gained Michael Jackson's admiration.

27. According to Passage B, who had the deepest voice in the family's singing group?
- A. Pops
  - B. Mavis
  - C. Pervis
  - D. Cleotha

Questions 28–30 ask about both passages.

28. Compared to Passage A, Passage B presents events in an order that is:
- F. chronologically opposite; it proceeds from describing present events to describing events consistently further back in time.
  - G. chronologically more vague; it gives no indication of how the events described relate to one another in time.
  - H. anchored more firmly in one stretch of time while making occasional references to events before and after that stretch of time.
  - J. very similar, as it initially presents the musician at the height of his fame and then examines the multiple steps that led to that fame.

29. Which of the following comparisons between one of the musicians mentioned in Passage A and Pops is best supported by the passages?
- A. Like Hibbler, Pops was hired to join an established jazz band.
  - B. Like Ellington, Pops is compared to a painter putting different colors side by side on a canvas.
  - C. Like Strayhorn, Pops had a mentor he turned to throughout his life.
  - D. Like Goodman, Pops valued a sound that was precise.

30. Both passages make use of which of the following?
- F. Lyrics from the musical compositions that Ellington or Pops made famous
  - G. References to professional music critics who followed the careers of Ellington or Pops
  - H. Excerpts from the memoirs of family members who have mixed opinions about Ellington or Pops
  - J. Quotations from people who observed up close the working styles of Ellington or Pops



## Passage IV

**NATURAL SCIENCE:** This passage is adapted from the article "Tales from the Pit" by Andrew Curry (©2014 by Smithsonian Institution).

The Messel Pit, located in central Germany, is known for its fossils of mammals from the Eocene epoch.

At some point around 50 million years ago, underground water came into contact with a vein of molten rock. High-pressure steam erupted, forming a crater with steep sides. As water seeped in, it created a lake shaped more like a drinking glass than a soup bowl. Any animal that fell in sank quickly to the bottom.

Still, that alone doesn't explain why so many land mammals—not to mention birds, bats and insects—perished in the lake that became the Messel Pit. One theory is that carbon dioxide periodically bubbled up from deep beneath the lake bottom, smothering animals near the shore. Another possibility is that some of the summer algae blooms were toxic, poisoning animals that had chosen the wrong time and place to slake their thirst. Or perhaps smaller animals died nearby and were washed in by small floods or rushing streams.

The lake was so deep that oxygen didn't circulate near the bottom, which meant that there were no bottom feeders around to consume the dead and dying animals. Year after year, algae scumming the lake surface bloomed and died, and so layers of fine clay and dead micro-organisms drifted to the bottom. Each layer was as thick as a strand of hair. It took 250 years to build up an inch of mud. Over millions and millions of years, plants and animals were preserved like flowers pressed between the pages of a book, and the algae and other organic matter turned into oil shale.

Among the thousands of fossils that paleontologists have recovered at Messel Pit are specimens representing nearly 45 different mammal species. Those finds are critical to understanding how warm-blooded creatures evolved. Mammals and dinosaurs appeared at nearly the same time around 200 million years ago. But dinosaurs were so well suited to the environment that they crowded out any competition. Mammals lived on the margins, mostly tiny creatures eking out a living by eating insects under the cover of darkness. "They just tried to stay out of the way," says Thomas Lehmann, a Senckenberg Research Institute paleontologist. And so it went for nearly 150 million years.

Then, in an instant, everything changed, apparently when an asteroid or comet struck Earth 66 million years ago and dramatically altered the climate, eventually wiping out the giant reptiles. The diversity of species found among the Messel Pit fossils reveals that mammals rushed to fill every empty ecological nook and cranny they could find. "They really tried everything—flying, jumping, running, tree-dwelling, ant-eating," says Lehmann. "From the point of view of evolution, Messel is a fantastic laboratory to see what life might have given us."

Might have, but in many cases didn't. Messel's most fascinating specimens may be those species that have no living relatives, though they look jarringly familiar. In the visitor center, kids crowd around to watch as a conservator armed with toothbrushes, dental picks and scalpels cleans layers of oil shale away from a fossil unearthed just a few weeks earlier. To me, the skeleton of *Ailuravus macrurus* looks like that of a giant squirrel. It's three feet long, including its bushy tail. Near the ribs a black stain traces the creature's fossilized digestive tract. Despite its tail, *Ailuravus* is no squirrel ancestor. It's an evolutionary dead end; *Ailuravus* and all of its relatives died out more than 37 million years ago. Why? Maybe they fell victim to climate changes, or a better-adapted competitor, or disappearing food sources, or simple bad luck.

*Ailuravus*' resemblance to a modern squirrel is an example of evolutionary convergence. Given enough time, adaptations may lead to nearly identical solutions—bushy tails, say, or powerful, kangaroo-like hind legs—popping up in different species. "It's like using the same interlocking toy bricks to build different forms," says Lehmann.

And there are forms aplenty at the Messel Pit. The exquisitely preserved fossils have provided paleontologists with unprecedented insights into the adaptive strategies—some successful, others not—adopted by mammals for feeding, movement and even reproduction. For instance, the contents of the tiny prehistoric horse's stomach—fossilized leaves and grape seeds—indicate that the animal was not a grazer but a browser, eating what it found on the forest floor. The paleontologists also found eight fossilized specimens of pregnant mares, each carrying a single foal. That discovery suggests that the early horses had already adopted herd behavior, since joint care would be the best way to guarantee the survival of small numbers of offspring.

31. The main idea of the passage is that the Messel Pit is significant primarily because it:
- A. substantiates the theory that mammals appeared 200 million years ago.
  - B. features fossils of mammals and dinosaurs interacting.
  - C. contains fossils that reveal how warm-blooded animals evolved.
  - D. has fossils of dinosaurs that have not been found elsewhere.
32. The main purpose of the second paragraph (lines 7–16) is to discuss:
- F. potential explanations for the large number of animal fossils in the lake.
  - G. conditions in the lake that led to the large number of dinosaur fossils.
  - H. the toxic prehistoric plants that grew in or near the lake.
  - J. feeding habits of mammals that lived near the lake.



33. The passage indicates that dinosaurs and mammals coexisted for approximately how many millions of years?
- 200
  - 150
  - 66
  - 50
34. In the passage, *Ailuravus macrurus* most nearly serves as an example of a species that:
- evolved into a modern-day animal, despite competition from similar animals.
  - adapted to its environment in ways scientists hadn't seen previously.
  - developed physical traits that its modern-day descendants did not inherit.
  - left no descendants, despite its apparent resemblance to modern-day animals.
35. Based on the passage, which of the following scenarios most nearly represents an example of evolutionary convergence?
- Several species of birds each evolving a different beak to take advantage of new food sources
  - One bird species becoming extinct because of competition from a similar species
  - Distinct species of birds developing wings that are nearly identical in structure
  - Many bird species moving to the same region because of food scarcity
36. According to the passage, the Messel Pit crater was formed by:
- an impact from an asteroid.
  - erosion from a river.
  - steam erupting from underground.
  - a volcano spewing molten rock.
37. It can reasonably be inferred from the passage that fewer fossils would have been preserved in the Messel Pit if the lake they were in had contained:
- oxygen circulating near the bottom.
  - layers of clay on the bottom.
  - abundant algae on the surface.
  - carbon dioxide that rose to the surface.
38. It can most reasonably be inferred from the passage that mammals survived the impact that killed the dinosaurs because mammals:
- existed in such large numbers.
  - ate food that dinosaurs could not.
  - had the ability to reproduce rapidly.
  - were able to adapt to the change in climate.
39. According to the passage, by examining the contents of a prehistoric horse's stomach, paleontologists determined that the horse ate:
- more grass than modern horses eat.
  - many plants that modern horses eat.
  - food from the ground of forests.
  - food from a prehistoric open plain.
40. Based on the passage, which of the following pieces of evidence supports the conclusion that prehistoric horses had adopted herd behavior?
- Specimens of pregnant mares were found near fossils of young foals.
  - Eight fossils of mares were found with the same kinds of plants in their digestive tracts.
  - Fossils of mare hoofprints that all pointed in the same direction were found.
  - Fossils of pregnant mares that each carried a single foal were found.

**END OF TEST 3**  
**STOP! DO NOT TURN THE PAGE UNTIL TOLD TO DO SO.**  
**DO NOT RETURN TO A PREVIOUS TEST.**



## SCIENCE TEST

35 Minutes—40 Questions

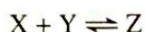
**DIRECTIONS:** There are several passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and fill in the corresponding oval on your answer document. You may refer to the passages as often as necessary.

You are NOT permitted to use a calculator on this test.

## Passage I

A reaction is at *equilibrium* when the rate of the forward reaction equals the rate of the reverse reaction. At equilibrium, the ratio of product concentration(s) to reactant concentration(s) is the *equilibrium constant*,  $K$ .

Consider the following reaction at equilibrium:



For this reaction,  $K$  is given by:

$$K = \frac{[Z]}{[X][Y]}$$

The brackets ([ ]) around the symbol for a substance indicate the equilibrium concentration of the substance.

This reaction was studied in 10 trials. Trials 1–5 were conducted at the same temperature (see Table 1), and Trials 6–10 were conducted at different temperatures (see Table 2).

Trial	[X] (mol/L*)	[Y] (mol/L)	[Z] (mol/L)	K
1	1.00	1.50	0.15	0.10
2	1.00	2.00	0.20	0.10
3	2.00	1.00	0.20	0.10
4	2.00	1.50	0.30	0.10
5	2.00	2.50	0.50	0.10

\*moles per liter

Note: The *initial* concentration of X, of Y, and of Z was varied across Trials 1–5. In no trial was the initial concentration of one substance equal to that of either of the other two substances.

Trial	Temperature (°C)	[X] (mol/L*)	[Y] (mol/L)	[Z] (mol/L)	K
6	-15	0.15	0.65	1.00	10.5
7	0	0.68	1.18	0.47	0.59
8	10	1.00	1.50	0.15	0.10
9	25	1.13	1.63	0.016	0.0087
10	40	1.15	1.65	0.002	0.0011

\*moles per liter

Note: The *initial* concentration of X, of Y, and of Z was the same in each of Trials 6–10. In no trial was the initial concentration of one substance equal to that of either of the other two substances.

- According to Table 1, in Trial 5, what was the equilibrium concentration of Z?
  - 0.10 mol/L
  - 0.50 mol/L
  - 2.00 mol/L
  - 2.50 mol/L
- Suppose that Trial 7 had been conducted at  $-5^{\circ}\text{C}$ . Based on Table 2,  $K$  would most likely have been closest to which of the following?
  - 0.020
  - 0.20
  - 2.0
  - 20



3. Suppose an additional trial had been conducted at the same temperature at which Trials 1–5 were conducted. If [X] and [Y] had each been 2.00 mol/L, [Z] would most likely have been:
- A. 0.15 mol/L.
  - B. 0.20 mol/L.
  - C. 0.40 mol/L.
  - D. 0.60 mol/L.
4. Based on Tables 1 and 2, how many trials were most likely conducted at temperatures above the freezing point of water?
- F. 3
  - G. 5
  - H. 8
  - J. 10
5. Consider the temperature data in Table 2. Did the reaction more likely reach equilibrium faster in Trial 6 or Trial 10?
- A. Trial 6, because the rate of a reaction is generally greater at a lower temperature.
  - B. Trial 6, because the rate of a reaction is generally greater at a higher temperature.
  - C. Trial 10, because the rate of a reaction is generally greater at a lower temperature.
  - D. Trial 10, because the rate of a reaction is generally greater at a higher temperature.
6. Assume that substances X, Y, and Z were gases throughout each trial. The boiling points of X, Y, and Z must each be:
- F. below  $-15^{\circ}\text{C}$ .
  - G. between  $-15^{\circ}\text{C}$  and  $10^{\circ}\text{C}$ .
  - H. between  $10^{\circ}\text{C}$  and  $40^{\circ}\text{C}$ .
  - J. above  $40^{\circ}\text{C}$ .



**Passage II**

Juvenile *Callinectes sapidus* (a species of crab) typically hide among *Zostera marina* (a species of sea grass) to avoid detection by aquatic predators. Two experiments examined how *Z. marina* population density and *C. sapidus* body size affect the ability of juvenile *C. sapidus* to avoid predation in a particular coastal area.

**Experiment 1**

Each of 200 small (4.5 mm wide) juvenile *C. sapidus* was prepared for testing as follows: One end of a 1.0 m piece of nylon fishing line was tied around the middle of the *C. sapidus*, and the knot was then securely attached to the *C. sapidus* with *cyanoacrylate* (a strong waterproof glue). The other end of the line was tied to its own metal rod. After being prepared, the 200 *C. sapidus* were equally divided into 4 groups (Groups 1–4).

Each rod associated with a Group 1 *C. sapidus* was randomly placed within a 100 m<sup>2</sup> plot having a *Z. marina* population density of 0 shoots/m<sup>2</sup> (sand only, no plants). Twenty-four hours later, the number of surviving Group 1 *C. sapidus* was determined.

The procedure for Group 1 was repeated for Groups 2–4, except that Group 2, Group 3, and Group 4 were placed in plots having a *Z. marina* population density of 380 shoots/m<sup>2</sup>, 760 shoots/m<sup>2</sup>, and 1,600 shoots/m<sup>2</sup>, respectively.

The results are shown in Table 1.

Group	<i>Z. marina</i> population density (shoots/m <sup>2</sup> )	Number of surviving <i>C. sapidus</i>
1	0	26
2	380	31
3	760	24
4	1,600	12

**Experiment 2**

Each of 200 large (23.3 mm wide) juvenile *C. sapidus* was prepared as in Experiment 1. After being prepared, the *C. sapidus* were equally divided into 4 groups (Groups 5–8). The procedures for Groups 1–4 were repeated for Groups 5–8 (see Table 2).

Group	<i>Z. marina</i> population density (shoots/m <sup>2</sup> )	Number of surviving <i>C. sapidus</i>
5	0	0
6	380	5
7	760	19
8	1,600	37

Tables adapted from J. L. Schulman, "Habitat Complexity as a Determinant of Juvenile Blue Crab Survival." ©1996 by The College of William and Mary.

7. According to the results of Experiment 2, as the *Z. marina* population density increased from 0 shoots/m<sup>2</sup> through 1,600 shoots/m<sup>2</sup>, the number of surviving large juvenile *C. sapidus*:
- increased only.
  - decreased only.
  - increased, then decreased.
  - decreased, then increased.

8. Suppose that in Experiment 2 a group of *C. sapidus* had been placed in a *Z. marina* plot having a population density of 562 shoots/m<sup>2</sup>. The number of surviving *C. sapidus* in that group would most likely have been:
- less than 5.
  - between 5 and 19.
  - between 19 and 37.
  - greater than 37.
9. To consider whether the body size of juvenile *C. sapidus* affects their ability to avoid predation, the results for which of the following 2 groups should be compared?
- Groups 1 and 4
  - Groups 2 and 5
  - Groups 4 and 8
  - Groups 5 and 7
10. Which of the nylon line and the cyanoacrylate, if either, functioned to prevent the *C. sapidus* from escaping?
- The nylon line only
  - The cyanoacrylate only
  - Both the nylon line and the cyanoacrylate
  - Neither the nylon line nor the cyanoacrylate
11. Which of *C. sapidus* or *Z. marina* would occupy the higher trophic level in a food chain?
- C. sapidus*, because *C. sapidus* is a producer and *Z. marina* is a consumer.
  - C. sapidus*, because *C. sapidus* is a consumer and *Z. marina* is a producer.
  - Z. marina*, because *Z. marina* is a producer and *C. sapidus* is a consumer.
  - Z. marina*, because *Z. marina* is a consumer and *C. sapidus* is a producer.
12. Which of the following statements describes a difference between the cells of *C. sapidus* and the cells of *Z. marina*? The cells of *C. sapidus*:
- have a nucleus, whereas the cells of *Z. marina* lack a nucleus.
  - lack a nucleus, whereas the cells of *Z. marina* have a nucleus.
  - have a cell wall, whereas the cells of *Z. marina* lack a cell wall.
  - lack a cell wall, whereas the cells of *Z. marina* have a cell wall.
13. Which of the following statements comparing an aspect of the design of the 2 experiments is accurate?
- The *C. sapidus* in Experiment 2 were exactly 3 times as wide as the *C. sapidus* in Experiment 1.
  - The length of time needed to perform Experiment 1 was less than the length of time needed to perform Experiment 2.
  - The number of surviving *Z. marina* was measured in both Experiments 1 and 2.
  - In both experiments, there were initially 50 *C. sapidus* per group.



## Passage III

Two students were each asked to experimentally determine the speed of sound in air,  $s_a$ . For the atmospheric conditions in which their experiments were performed, the correct value of  $s_a$  was 347.1 m/sec.

## Experiment 1

Student 1 placed a horn, which could emit a short pulse of sound waves, at a distance  $x$ , in m, from a tall cliff (see Figure 1).

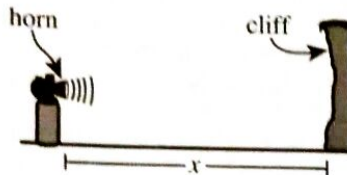


Figure 1

He started a stopwatch when he heard the horn emit a sound pulse and stopped the stopwatch when he heard an echo return from the cliff. He recorded this time interval,  $\Delta t_1$ , in sec, and then calculated  $s_a$  using the equation

$$s_a = \frac{2x}{\Delta t_1}$$

Student 1 performed 3 trials at each of 3 values of  $x$ , averaging the  $s_a$  results at each value of  $x$  (see Table 1).

Trial	$x$ (m)	$\Delta t_1$ (sec)	$s_a$ (m/sec)	Average $s_a$ (m/sec)
1	200	1.4	290	280
2		1.5	270	
3		1.4	290	
4	500	3.0	330	330
5		3.1	320	
6		3.0	330	
7	1,000	5.9	340	340
8		5.8	350	
9		5.9	340	

## Experiment 2

Student 2 placed the horn and 2 microphones— $M_1$  and  $M_2$ —in a straight line such that the microphones were separated by a distance  $y$ . She then connected a timer to both microphones (see Figure 2).

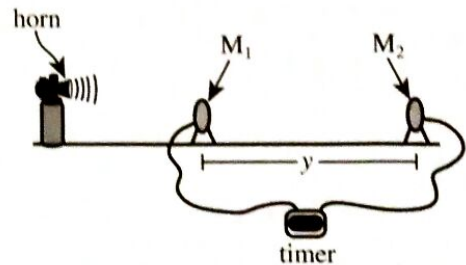


Figure 2

She set the timer to start when the first microphone detected a sound pulse and to stop when the second microphone detected a sound pulse. She recorded this time interval,  $\Delta t_2$ , and then calculated  $s_a$  using the equation

$$s_a = \frac{y}{\Delta t_2}$$

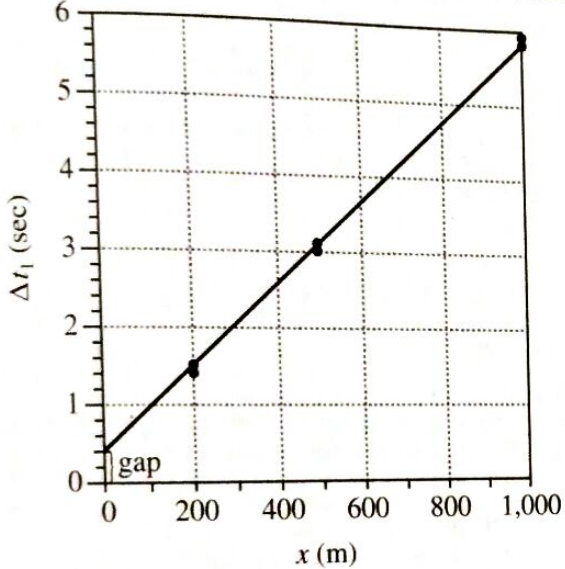
Student 2 performed 3 trials at each of 3 values of  $y$ , averaging the  $s_a$  results at each value of  $y$  (see Table 2).

Trial	$y$ (m)	$\Delta t_2$ (sec)	$s_a$ (m/sec)	Average $s_a$ (m/sec)
10	50	0.144	347	347
11		0.143	350	
12		0.145	345	
13	75	0.217	346	346
14		0.216	347	
15		0.218	344	
16	100	0.290	345	346
17		0.289	346	
18		0.288	347	



14. Suppose Student 2 had conducted a trial in which  $\Delta t_2$  was 0.191 sec. The value of  $y$  in this trial would most likely have been:
- F. less than 50 m.
  - G. between 50 m and 75 m.
  - H. between 75 m and 100 m.
  - J. greater than 100 m.
15. Which of the objects listed below were used in both Experiment 1 and Experiment 2?
- I. A horn
  - II. A microphone
  - III. A timing device
- A. I only
  - B. I and II only
  - C. I and III only
  - D. I, II, and III

16. Student 1 plotted the  $\Delta t_1$  data versus  $x$  and then graphed a line of best fit to the data, as shown below.



The gap shown near the bottom of the vertical axis suggests that even if the value of  $x$  had been 0 m, the value of  $\Delta t_1$  would not have been 0 sec, as one might expect. Based on the description of Experiment 1, this gap was most likely the result of:

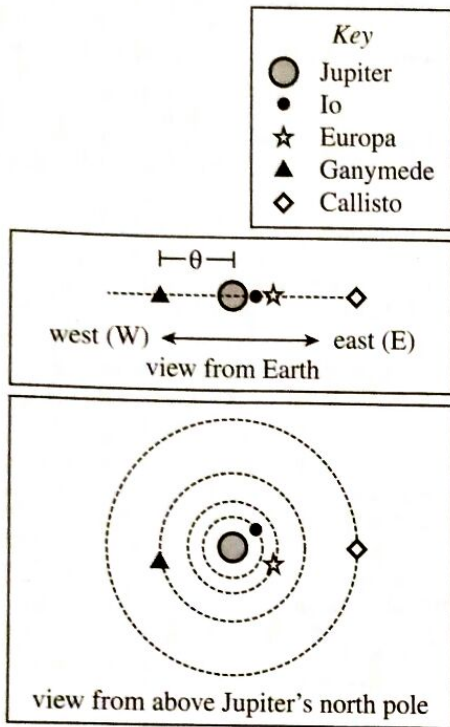
- F. errors due to human reaction time in starting and/or stopping the stopwatch.
- G. the stopwatch itself consistently underestimating the value of  $\Delta t_1$ .
- H. the echoes traveling faster than the original sound pulses.
- J. the horn being accidentally placed closer to the cliff than intended.

17. In general, the farther a sound wave travels, the more it *attenuates* (reduces in volume), making detection more difficult. In which experiment was attenuation of greater concern?
- A. Experiment 1; sound waves had to travel shorter distances in Experiment 1 than in Experiment 2.
  - B. Experiment 1; sound waves had to travel longer distances in Experiment 1 than in Experiment 2.
  - C. Experiment 2; sound waves had to travel shorter distances in Experiment 2 than in Experiment 1.
  - D. Experiment 2; sound waves had to travel longer distances in Experiment 2 than in Experiment 1.
18. Based on the results of both experiments, regardless of the apparatus or procedure used, on average, as a sound pulse's travel distance increased, the recorded time interval:
- F. increased only.
  - G. decreased only.
  - H. remained constant.
  - J. varied, but with no general trend.
19. In calculating the value of  $s_a$ , Student 1 needed to include a factor of 2 in the numerator. However, Student 2 did not include this factor because:
- A. in Experiment 1, sound had to travel over the distance  $x$  twice, whereas in Experiment 2, sound had to travel over the distance  $y$  once.
  - B. in Experiment 1, sound had to travel over the distance  $x$  once, whereas in Experiment 2, sound had to travel over the distance  $y$  twice.
  - C. every value of  $x$  was at least 2 times every value of  $y$ .
  - D. every value of  $x$  was less than 2 times every value of  $y$ .
20. Overall, which student obtained the more *accurate* set of  $s_a$  data?  
(Note: This question is concerned with the *accuracy* of a data set, NOT the *precision* of a data set.)
- F. Student 1, because the  $s_a$  values in Table 1 are spread over a larger range than are the  $s_a$  values in Table 2.
  - G. Student 1, because the  $s_a$  values in Table 1 are closer, on average, to the correct value of  $s_a$  than are the values of  $s_a$  in Table 2.
  - H. Student 2, because the  $s_a$  values in Table 2 are spread over a smaller range than are the  $s_a$  values in Table 1.
  - J. Student 2, because the  $s_a$  values in Table 2 are closer, on average, to the correct value of  $s_a$  than are the values of  $s_a$  in Table 1.



Passage IV

As viewed from Earth, Jupiter's 4 largest moons—the *Galilean* moons—appear to move relative to Jupiter along an east-west line. The farther from Jupiter a moon appears to be, the greater its *angular separation*,  $\theta$ . Figure 1 shows these moons' positions at midnight on a certain day in June 2012 as viewed from Earth (top section) and as viewed from above Jupiter's north pole (bottom section).



Note: The figure is not drawn to scale. In the top section, only  $\theta$  for Ganymede is shown.

Figure 1

Figure 2 shows  $\theta$  for each moon from midnight on June 20, 2012, to midnight on June 28, 2012. For each moon, 1 *wave cycle* represents 1 orbit around Jupiter. (The time to complete 1 orbit is the time between any 2 consecutive peaks or any 2 consecutive troughs.)

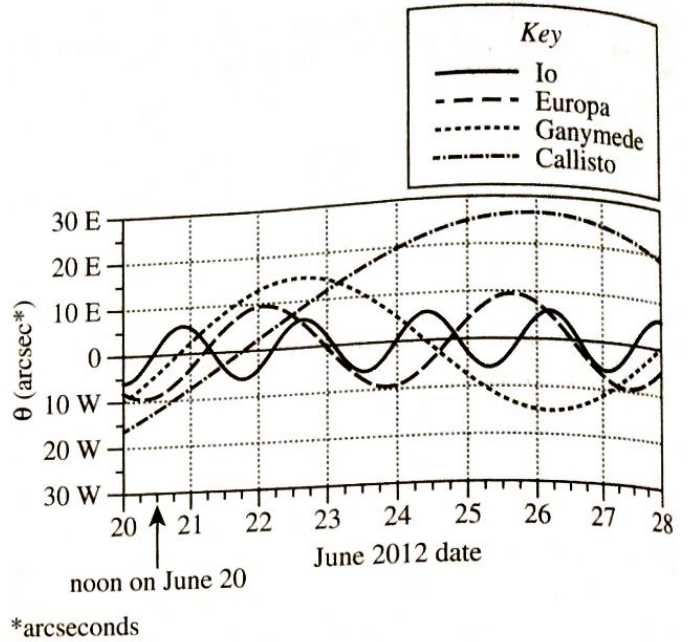


Figure 2

Figure 2 adapted from Sylvain Rondi, *Jupiter Version 2: Programme gratuit de calcul d'éphémérides des satellites galiléens de Jupiter*. ©2009 by Sylvain Rondi.

- The number of orbits per week is a measure of *orbital frequency*. Based on Figure 2, which Galilean moon has the highest orbital frequency?
  - Io
  - Europa
  - Ganymede
  - Callisto
- Based on Figure 2, Callisto completes 1 orbit around Jupiter in approximately how many days?
  - Fewer than 4
  - Between 4 and 6
  - Between 6 and 8
  - More than 8

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23. Based on Figure 2, as viewed from Earth at midnight on June 27, which Galilean moon appeared farthest west of Jupiter?  
A. Io  
B. Europa  
C. Ganymede  
D. Callisto

24. According to Figure 2, at noon on June 23,  $\theta$  for Ganymede was approximately:  
F. 10 arcsec east.  
G. 10 arcsec west.  
H. 14 arcsec east.  
J. 14 arcsec west.

25. According to Figure 2, at which of the following times in 2012 was the angular separation for Callisto closest to 20 arcsec east?  
A. 6:00 a.m. on June 26  
B. 6:00 a.m. on June 27  
C. 6:00 p.m. on June 26  
D. 6:00 p.m. on June 27

26. *Thebe* is one of Jupiter's smaller moons. *Thebe* completes 1 orbit of Jupiter in approximately 0.7 days. Based on Figure 2, regardless of direction, the maximum value of  $\theta$  for *Thebe* is most likely:  
F. less than 7 arcsec.  
G. between 7 arcsec and 10 arcsec.  
H. between 10 arcsec and 13 arcsec.  
J. greater than 13 arcsec.



## Passage V

Two scientists discussed the evolution of 3 animal groups: crocodiles, *nonavian dinosaurs* (all dinosaurs except modern birds), and modern birds. The scientists characterized the animals in each group by their *resting metabolic rate*, RMR (the rate at which an animal uses caloric energy when at rest), and according to whether they were *poikilothermic* (had body temperatures that varied significantly) or *homeothermic* (had body temperatures that remained relatively constant).

## Scientist 1

Crocodiles and nonavian dinosaurs evolved from a common ancestor that had a low RMR and was poikilothermic. Crocodiles retained these traits. However, nonavian dinosaurs had a high RMR and were homeothermic. Modern birds inherited these traits when the group first evolved from nonavian dinosaurs, and both traits have been retained by all modern birds.

The bones of nonavian dinosaurs had a porous structure, no growth rings, and extensive *vascularization* (channels containing blood vessels). Extensive vascularization, which is also seen in modern birds, is evidence of an efficient circulatory system and a high RMR. Efficient circulation distributes heat evenly throughout the body. Thus, nonavian dinosaurs were homeothermic and could have survived in cold climates.

## Scientist 2

Crocodiles and nonavian dinosaurs evolved from a common ancestor that had a low RMR and was poikilothermic. Crocodiles retained these traits. Nonavian dinosaurs also had a low RMR and were poikilothermic. In contrast, modern birds have had a high RMR ever since the group first evolved from nonavian dinosaurs. Modern birds only became homeothermic after nonavian dinosaurs went extinct 65 million years ago.

The bones of nonavian dinosaurs were dense and had growth rings. Each of these features indicates a low RMR, and neither is seen in the bones of modern birds. Nonavian dinosaur bones also lacked extensive vascularization, suggesting an inefficient circulatory system that would not have been able to distribute heat evenly throughout the body. Thus, nonavian dinosaurs were poikilothermic and could not have survived in cold climates.

27. Both scientists would be likely to agree that modern birds:
- evolved from crocodiles.
  - evolved from nonavian dinosaurs.
  - have always had a low RMR.
  - have always had bones with growth rings.
28. Would Scientist 2 more likely expect to find bones that have growth rings in a crocodile or in a modern bird?
- Crocodile; Scientist 2 suggested that growth rings indicate a high RMR.
  - Crocodile; Scientist 2 suggested that growth rings indicate a low RMR.
  - Modern bird; Scientist 2 suggested that growth rings indicate a high RMR.
  - Modern bird; Scientist 2 suggested that growth rings indicate a low RMR.
29. In which of the 3 animal groups would Scientist 1 most likely expect to find animals having bones with extensive vascularization?
- Crocodiles only
  - Nonavian dinosaurs only
  - Crocodiles and modern birds only
  - Nonavian dinosaurs and modern birds only
30. Consider a crocodile and a modern bird, each having the same body mass. Based on Scientist 2's discussion, which animal would more likely produce CO<sub>2</sub> at a faster rate: the crocodile or the modern bird?
- Crocodile; Scientist 2 argues that modern birds have a high RMR and that crocodiles have a low RMR.
  - Crocodile; Scientist 2 argues that modern birds have a low RMR and that crocodiles have a high RMR.
  - Modern bird; Scientist 2 argues that modern birds have a high RMR and that crocodiles have a low RMR.
  - Modern bird; Scientist 2 argues that modern birds have a low RMR and that crocodiles have a high RMR.

31. Consider a rock formation containing many bones and nesting sites from nonavian dinosaurs as well as indicators of a stable but cold climate. Suppose it were discovered that both the nonavian dinosaur fossils and climate indicators have been present together throughout the entire 50-million-year history of the formation. This discovery would support the viewpoint(s) of which of the scientists, if either?

- A. Scientist 1 only
- B. Scientist 2 only
- C. Both Scientist 1 and Scientist 2
- D. Neither Scientist 1 nor Scientist 2

32. Scientist 1 characterized the animals in which of the 3 groups as poikilothermic?

- F. Crocodiles only
- G. Modern birds only
- H. Crocodiles and nonavian dinosaurs
- J. Modern birds and nonavian dinosaurs

33. Suppose it were confirmed that the common ancestor of nonavian dinosaurs and crocodiles had a low RMR. This finding would be consistent with the viewpoint(s) of which of the scientists, if either?

- A. Scientist 1 only
- B. Scientist 2 only
- C. Both Scientist 1 and Scientist 2
- D. Neither Scientist 1 nor Scientist 2



Passage VI

Biosorption is a process that uses certain biological materials (*biomass*) to remove metal ions from a solution. Three experiments were done to study the removal of the chromium ion  $\text{Cr}^{6+}$  from aqueous solutions using a biomass composed of crushed shells of the fruit *Litchi chinensis*. In each trial in each experiment, the following steps were performed:

1. In a flask, 1.0 g of fresh biomass was added to 100 mL of an aqueous solution having a particular pH and  $\text{Cr}^{6+}$  concentration.
2. The flask was capped, and the contents were shaken for a particular time at a particular temperature.
3. Periodically, shaking was stopped so that a 0.01 mL sample could be removed from the flask. This sample was analyzed to determine the percentage of  $\text{Cr}^{6+}$  remaining in the solution.

Experiment 1

In each of Trials 1–4, an aqueous solution with an initial  $\text{Cr}^{6+}$  concentration of 100 mg/L was tested at a temperature of 30°C. The pH was varied from trial to trial. The results are shown in Figure 1.

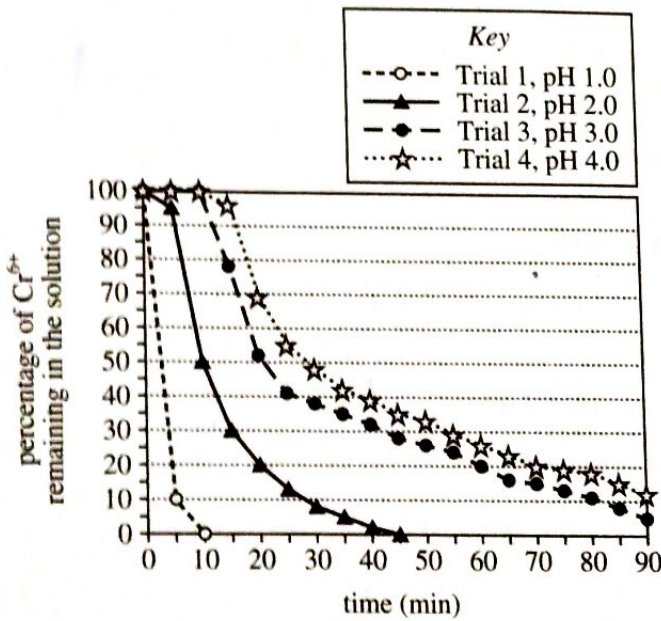


Figure 1

Experiment 2

In each of Trials 5–7, an aqueous solution with an initial  $\text{Cr}^{6+}$  concentration of 100 mg/L was tested at a pH of 1.0. The temperature was varied from trial to trial. The results are shown in Figure 2.

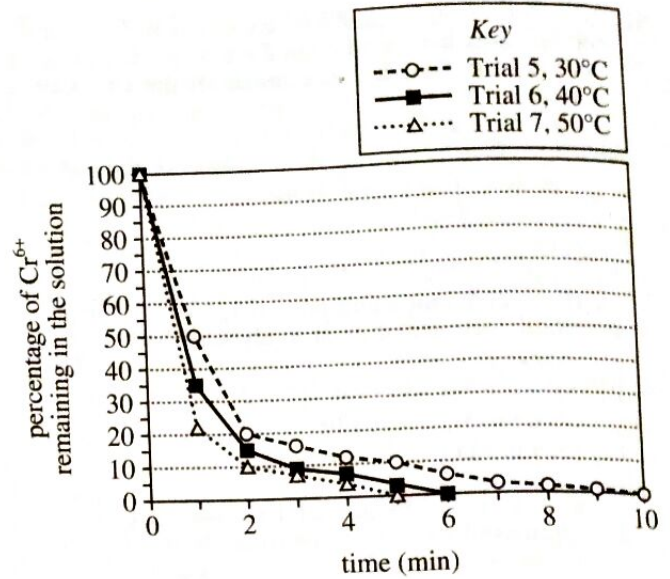


Figure 2

Experiment 3

In each of Trials 8–11, an aqueous solution at a pH of 1.0 was tested at a temperature of 30°C. The initial  $\text{Cr}^{6+}$  concentration was varied from trial to trial. The results are shown in Figure 3.

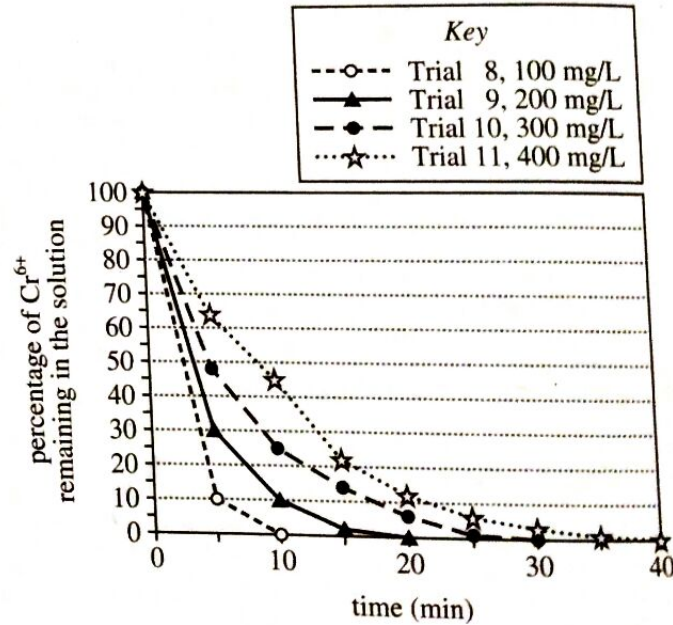


Figure 3

Figures adapted from Ismael Acosta-Rodríguez et al., "Removal of Hexavalent Chromium from Solutions and Contaminated Sites by Different Natural Biomasses." ©2013 by Ismael Acosta-Rodríguez et al.

34. According to the results of Experiment 2, as the temperature was increased from 30°C to 50°C from trial to trial, the time needed to remove all the  $\text{Cr}^{6+}$  from the solution:
- decreased only.
  - increased only.
  - decreased and then increased.
  - increased and then decreased.
35. Based on Figure 1, if a sample from Trial 3 had been analyzed at 95 min, the percentage of  $\text{Cr}^{6+}$  remaining in the solution would most likely have been:
- less than 5%.
  - between 5% and 10%.
  - between 10% and 15%.
  - greater than 15%.
36. According to the results of Experiment 1, as the pH was increased from trial to trial, the time needed to remove 90% of the  $\text{Cr}^{6+}$  from the solution:
- increased only.
  - decreased only.
  - increased and then decreased.
  - decreased and then increased.
37. In how many trials in Experiments 1–3 did the percentage of  $\text{Cr}^{6+}$  remaining in solution reach 0% in less than 1 hr?
- 0
  - 2
  - 9
  - 11
38. Biosorption using *L. chinensis* involves the one-time transfer of 3 electrons from the biomass to each chromium ion. Based on information in the passage, the resulting charge on each chromium ion after it gains 3 electrons is:
- 3+, because electrons have negative charge.
  - 3+, because electrons have positive charge.
  - 9+, because electrons have negative charge.
  - 9+, because electrons have positive charge.
39. How many of the trials performed in Experiment 1 were done at an acidic pH?
- Zero, because any pH less than 7.0 is basic.
  - Zero, because any pH less than 7.0 is acidic.
  - Four, because any pH less than 7.0 is basic.
  - Four, because any pH less than 7.0 is acidic.
40. Based on Figure 3, which of the following expressions best approximates the mass of  $\text{Cr}^{6+}$  remaining in the 200 mg/L solution at 5 min?
- $100 \text{ mL} \times \frac{1,000 \text{ mL}}{1 \text{ L}} \times \frac{200 \text{ mg}}{1 \text{ L}} \times 5\%$
  - $100 \text{ mL} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{200 \text{ mg}}{1 \text{ L}} \times 5\%$
  - $100 \text{ mL} \times \frac{1,000 \text{ mL}}{1 \text{ L}} \times \frac{200 \text{ mg}}{1 \text{ L}} \times 30\%$
  - $100 \text{ mL} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{200 \text{ mg}}{1 \text{ L}} \times 30\%$

**END OF TEST 4**

**STOP! DO NOT RETURN TO ANY OTHER TEST.**