Form E23

(December 2021)

The ACT® 2021 | 2022

In response to your request for Test Information Release materials, this booklet contains the test questions, scoring keys, and conversion tables used in determining your ACT scores. Enclosed with this booklet is a report that lists each of your answers, shows whether your answer was correct, and, if your answer was not correct, gives the correct answer.

Directions

This booklet contains tests in English, mathematics, reading, and science. These tests measure skills and abilities highly related to high school course work and success in college. **Calculators may be used on the mathematics test only.**

The questions in each test are numbered, and the suggested answers for each question are lettered. On the answer document, the rows of ovals are numbered to match the questions, and the ovals in each row are lettered to correspond to the suggested answers.

For each question, first decide which answer is best. Next, locate on the answer document the row of ovals numbered the same as the question. Then, locate the oval in that row lettered the same as your answer. Finally, fill in the oval completely. Use a soft lead pencil and make your marks heavy and black. **Do not use ink or a mechanical pencil.**

Mark only one answer to each question. If you change your mind about an answer, erase your first mark thoroughly before marking your new answer. For each question, make certain that you mark in the row of ovals with the same number as the question.

Only responses marked on your answer document will be scored. Your score on each test will be based only on the number of questions you answer correctly during the time allowed for that test. You will **not** be penalized for guessing. **It is to your advantage to answer every question even if you must guess.**

You may work on each test **only** when the testing staff tells you to do so. If you finish a test before time is called for that test, you should use the time remaining to reconsider questions you are uncertain about in that test. You may **not** look back to a test on which time has already been called, and you may **not** go ahead to another test. To do so will disqualify you from the examination.

Lay your pencil down immediately when time is called at the end of each test. You may **not** for any reason fill in or alter ovals for a test after time is called for that test. To do so will disqualify you from the examination.

Do not fold or tear the pages of your test booklet.

**DO NOT OPEN THIS BOOKLET
UNTIL TOLD TO DO SO.**

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

NASA's Inaugural Artist in Residence

[1]

For over forty years, Laurie Anderson has appropriated electronics, video, and sound, to create art that defies categorization. In 1972,

1. **A.** NO CHANGE
   B. sound, to create,
   C. sound to create,
   D. sound to create

Anderson ignited her career; by conducting a symphony using only car horns. [A] Five years

2. **F.** NO CHANGE
   G. Anderson, to ignite her career,
   H. Anderson igniting her career
   J. Anderson ignited her career

later, she invented a violin that clones as an audiotape player. Anderson went on to stage technology-enhanced

3. **A.** NO CHANGE
   B. duplicates
   C. doubles
   D. copies

performance art, direct music videos, and invent tools to manipulate sound. [B] In 2002, Anderson's fascination with technology contributed to her being named the first artist in residence at NASA, where she was given free rein to explore the facilities in search of inspiration. [C]

4. **F.** NO CHANGE
   G. the invention of
   H. inventing
   J. to invent

[2]

She found her inspiration in how technology has developed over time. When Anderson was growing up in the 1950s, space travel and artificial intelligence existed only in science fiction stories.

A half century later, at NASA, Anderson witnessed the
realization of both. During a visit to a virtual airport

5

control center, Anderson viewed panoramic images of

6

the red planet, courtesy from a video feed provided of

7

the Mars Global Surveyor satellite. At the Jet Propulsion

Laboratory in Pasadena, California, she was introduced

to robots that function autonomously through control-

and-sensor-processing software. [D]

[3]

Drawing on her NASA experiences, Anderson

wrote and produced a ninety-minute performance

art piece titled *The End of the Moon*. The performance

features Anderson on a candlelit stage, standing

8

in front of an image of the moon's surface. [9]

5. Which choice provides the most effective transition
from the first two sentences of the paragraph to the rest
of the paragraph?
- **A.** NO CHANGE
- **B.** In fact, science fiction masters like Ray Bradbury
and Isaac Asimov received much acclaim for their
work at this time.
- **C.** Anderson, who grew up in Chicago, studied classi-
cal violin as a child.
- **D.** NASA has grown considerably since it was estab-
lished in 1958.

6. **F.** NO CHANGE
- **G.** eyeballed all-encompassing snapshots
- **H.** beheld wide-ranging pictorial images
- **J.** ogled comprehensive photographs

7. **A.** NO CHANGE
- **B.** from a video feed provided by
- **C.** of a video feed provided by
- **D.** by a video feed provided of

8. Which of the following alternatives to the underlined
portion would NOT be acceptable?
- **F.** stage, where she stands
- **G.** stage as she stands
- **H.** stage. She stands
- **J.** stage; standing

9. At this point, the writer is considering adding the fol-
lowing true sentence:

Neil Armstrong was the first man to be photo-
graphed walking on the moon's surface.

Should the writer make this addition?
- **A.** Yes, because the sentence contributes to the para-
graph's discussion of how Anderson uses photog-
raphy in her performance art.
- **B.** Yes, because the sentence contributes to the para-
graph's discussion of how and why *The End of the
Moon* is a reimagining of NASA's first moon
landing.
- **C.** No, because the sentence is not relevant to the
paragraph's description and interpretation of *The
End of the Moon*.
- **D.** No, because the sentence is not relevant to the
paragraph's critique of Anderson's struggle to
make performance art commercially viable.

GO ON TO THE NEXT PAGE.

Anderson begins the show by referencing the

technology to which she was privy at NASA.
                  _____
                        10

Anderson then complements these references by

subtly demonstrating its impact on music. While
                      __
                      11

sweeping the bow over the strings of a viola, Anderson
_____
                    12

manipulates the music via a laptop computer. The string

music that transforms into electronic sounds, which then
_____
         13

reverberate into futuristic, otherworldly music. The result

is surreal and stimulating exactly what you might expect
                 _____
                        14

from NASA's inaugural artist in residence.

10. F. NO CHANGE
   G. to, which she was privy,
   H. to which, she was privy,
   J. to which she was privy,

11. A. NO CHANGE
   B. technology's
   C. one's
   D. this

12. Which choice provides the most vivid description of Anderson's action?
   F. NO CHANGE
   G. moving a bow over a stringed instrument,
   H. producing music by playing a viola,
   J. rubbing an instrument with a bow,

13. A. NO CHANGE
   B. music is transformed
   C. music, transforming
   D. music transforming

14. F. NO CHANGE
   G. stimulating: and
   H. stimulating—
   J. stimulating;

Question 15 asks about the preceding passage as a whole.

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

> Her "talking stick," for instance, was a six-foot-long baton that could record and replicate sounds.

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

   A. Point A in Paragraph 1.
   B. Point B in Paragraph 1.
   C. Point C in Paragraph 1.
   D. Point D in Paragraph 2.

PASSAGE II

Zebra ID: Biological Bar Codes

[1]

Even though every zebra has a unique pattern of

bold stripes on its coat, the animals look remarkably alike.

Zebras are willful animals. When in a herd, they become
_____
         16

a mass of blended stripes and similar features that confuses

a lion on the hunt. One zebra resembling another is not

16. Which choice most effectively leads the reader from the first sentence of this paragraph to the information that follows in the rest of the paragraph?
   F. NO CHANGE
   G. Observing zebras in a small group, rather than in a herd, might not make a difference.
   H. Researchers don't celebrate this about zebras.
   J. This is helpful to zebras.

beneficial to researchers, though. Biologists trying to monitor individual zebras sometimes joke that finding one in the wild typically is easy it's finding the same one twice that's hard.
<u>easy</u>
17

[2]

Working together, scientists at the University of Illinois and Princeton University developed a software program called StripeSpotter, which catalogs and identifies zebras. StripeSpotter translates the pattern of stripes on a zebra's side, into an identifier, similar to a bar code, that can be compared to other zebra stripe-pattern identifiers that have been stored in a database. ⬚**20**
<u>Working together</u>
18
<u>side, into an identifier,</u>
19

[3]

The process begins when a researcher uploads a still photograph of a zebra to StripeSpotter. [A] The researcher then crops a rectangular section of the photograph, making sure to capture the stripes on the zebra's side.
<u>capture</u>
21

[B] StripeSpotter converts that section into a stark black-and-white image composed of parallel, vertical lines.
<u>a stark black-and-white image composed of parallel, vertical lines.</u>
22

17. **A.** NO CHANGE
B. easy for them
C. easy;
D. easy,

18. Which choice most effectively leads the reader from the preceding paragraph into the rest of the essay?
F. NO CHANGE
G. Thinking about how computer science could play a role,
H. Aware that biologists enjoy the joke,
J. To solve this problem,

19. **A.** NO CHANGE
B. side into an identifier,
C. side, into an identifier
D. side into an identifier

20. At this point, the writer is considering adding the following true sentence:

Some researchers believe that the stripes on zebras help the animals identify one another in a herd.

Should the writer make this addition here?

F. Yes, because it makes clear that zebras have always been able to do what StripeSpotter can do.
G. Yes, because it shifts the essay back to its main topic, interpreting the stripes on zebras.
H. No, because it isn't relevant to the explanation of what StripeSpotter is and how it works.
J. No, because it doesn't specify why it is important that zebras are able to identify one another.

21. **A.** NO CHANGE
B. apprehend
C. acquire
D. take

22. The writer is considering revising the underlined portion to the following:

an image of even, black-and-white lines.

Given that the information is accurate, should the writer make this revision?

F. Yes, because the revision reveals that StripeSpotter can be used to make line art based on a zebra's stripes.
G. Yes, because unlike the original wording, the revision highlights that a zebra identification code is made up of parallel lines.
H. No, because the revision lacks the clarity and specificity of the description in the original wording.
J. No, because the revision suggests that the means through which StripeSpotter creates images are largely unscientific.

The widths of the lines <u>correspond</u> perfectly to the widths
₂₃

of the zebra's stripes. <u>Providing</u> the zebra's "StripeCode,"
₂₄
unique to each animal in much the same way a fingerprint

is unique to each person. The StripeCode is logged in the

database, where a researcher uploading a new photograph

of a zebra can scan the stored codes to find a potential

match.

[4]

[C] StripeSpotter has proved so useful that

<u>it's developers</u> plan to design similar programs
₂₅

for identifying other <u>animals</u>. Any pattern
₂₆

<u>present</u> over an animal's life could be translated
₂₇
into an identification code—spots on a leopard's

hide, <u>the wrinkled trunk of an elephant</u>, rings on
₂₈
a tortoise's shell. So far, StripeSpotter has helped

researchers <u>thoroughly</u> monitor the social interactions
₂₉
and migration patterns of endangered zebra species

in Kenya. [D]

23. A. NO CHANGE
  B. has corresponded
  C. is corresponding
  D. corresponds

24. F. NO CHANGE
  G. Resulting in
  H. This is
  J. As

25. A. NO CHANGE
  B. its' developers
  C. its developers'
  D. its developers

26. F. NO CHANGE
  G. animals, though these programs have not yet been created.
  H. animals through a comparable means.
  J. animals that are not zebras.

27. The writer is considering revising the underlined portion to the following:

  that stays relatively constant

  Should the writer make this revision?

  A. Yes, because the revision more clearly indicates that some animal patterns are more precise than a zebra's stripes when used for identification.
  B. Yes, because the revision more clearly explains the key characteristic an animal pattern must have to be useful as the basis of an identification code.
  C. No, because the revision provides less support for the essay's earlier claim that a zebra's stripes can be translated into an identification code with ease.
  D. No, because the revision offers a less clear explanation of how researchers decide which animal patterns can be used for identification.

28. Which choice is most consistent with the word pattern used in the other two examples in this sentence?

  F. NO CHANGE
  G. an elephant's trunk that has wrinkles,
  H. wrinkles on the trunk of an elephant,
  J. wrinkles on an elephant's trunk,

29. Which choice most strongly emphasizes that one benefit of StripeSpotter is that it allows researchers to monitor the activities of zebras without causing the animals harm or distress?

  A. NO CHANGE
  B. conveniently
  C. inventively
  D. humanely

GO ON TO THE NEXT PAGE.

Question 30 asks about the preceding passage as a whole.

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

> He or she has to be sure not to include any grass, foliage, or other surrounding objects or animals in the cropped area.

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

F. Point A in Paragraph 3.
G. Point B in Paragraph 3.
H. Point C in Paragraph 4.
J. Point D in Paragraph 4.

PASSAGE III

Celadon Remnants

[1] At the Broadway Station of the Long Island Rail Road in Flushing, Queens, commuters ponder a mural spanning over three hundred square feet on the station's south wall. [2] But as they come closer, commuters notice the silhouettes are also mosaics, constructed entirely of ceramic shards. [3] From afar, the mural appears as a series of aquamarine, vase-shaped silhouettes against a white tile background. 32

The mural, titled *Celadon Remnants*, is artist Jean Shin's homage on the Korean American community in Flushing. When she was commissioned by the Metropolitan Transportation Authority of New York City to spawn a site-specific artwork, visually representing her dual identity was a means sought by Shin as an American and a Korean. She chose to use traditional celadon pottery, albeit in a new way.

31. A. NO CHANGE
B. Station, of the Long Island Rail Road,
C. Station of, the Long Island Rail Road,
D. Station, of the Long Island Rail Road

32. Which sequence of sentences makes this paragraph most logical?
F. NO CHANGE
G. 1, 3, 2
H. 2, 1, 3
J. 3, 1, 2

33. A. NO CHANGE
B. about
C. to
D. of

34. F. NO CHANGE
G. accomplish
H. perform
J. produce

35. A. NO CHANGE
B. sought by Shin was a means of visually representing her dual identity
C. a means of visually representing her dual identity was sought by Shin
D. Shin sought a means of visually representing her dual identity

Celadon is a ceramic ware named for its' [36] aquamarine glaze. Originally from China, celadon was further developed in the tenth and eleventh centuries in Korea, in which inlaid designs and decorative elements [37] were added. Over the centuries, celadon became a cultural treasure in Korea. [38] Today, South Korean ceramicists will accept nothing less than perfection in creating their art. In fact, if the ceramicist deems a piece imperfect, he or she will often scrap it entirely.

Shin decided that these scraps, or shards, would be an ideal medium for her mural. In 2008, she contacted ceramicists in the South Korean city of Icheon for celadon shards and arranged to be shipped to Queens. [39] The ceramicists sent Shin over six thousand shards.

Using the shards—many of whose are adorned with [40] alphabetic symbols and assorted patterns—Shin [41] constructed her mural.

For Shin, the shards themselves took on significance: they represented her feeling of [42] being broken off or "fractured" from their birthplace [43] of Seoul, South Korea. In Queens, Shin's use of [44] the fragments to construct an artwork that celebrated a Korean tradition. The result is sublime.

36.
F. NO CHANGE
G. it is
H. it's
J. its

37.
A. NO CHANGE
B. whereas
C. where
D. past

38. Given that all the choices are true, which one most effectively leads the reader from the first two sentences of the paragraph to the rest of the paragraph?
F. NO CHANGE
G. The celadon's color is a result of iron oxide's transformation from ferric to ferrous iron during the firing process.
H. It has been theorized that the name "celadon" derives from the Sanskrit words for *green* and *stone*.
J. Shin Sang-ho, one of Korea's most celebrated modern ceramicists, began his career re-creating traditional celadon.

39. The best placement for the underlined portion would be:
A. where it is now.
B. after the word *ceramicists*.
C. after the word *city*.
D. after the word *arranged*.

40.
F. NO CHANGE
G. which
H. whom
J. that

41. Which choice provides the most specific description of the adornments on the shards of celadon?
A. NO CHANGE
B. Korean characters and labyrinthine patterns—
C. different letters and a plethora of patterns—
D. numerous symbols and various designs—

42.
F. NO CHANGE
G. significance: and
H. significance,
J. significance

43.
A. NO CHANGE
B. they're
C. her
D. its

44.
F. NO CHANGE
G. Shin used
H. using
J. DELETE the underlined portion.

The silhouettes merge Shin's past and present, creating
an exquisite meditation on Korean American identity.
45

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

    A. present to create
    B. present and they create
    C. present. They create
    D. present; they create

PASSAGE IV

Captain Charles Young's Road to the Giant Sequoias

    Able to grow as tall as a twenty-six-story building and as wide as a city street, Earth has the largest living things, which are giant sequoia trees. Sequoia National Park in California's Sierra Nevada mountain range
46

contains 275 known caves. Yet until 1903, few visitors
47
could gain access to the trees in the park's Giant

Forest: there was no completed road.
48

    The US Army—which from 1891 to 1913 was
49
responsible for improving national parks during the summer months—had managed to complete only about six miles to the road of the Giant Forest. Army Captain
50
Charles Young, however, was not deterred. The first black superintendent of a national park and a revered leader of the army's all-black 9th and 10th Cavalries, Young had the
51
experience needed to direct the completion of the project.

46. **F.** NO CHANGE
    G. it is known that the largest living things on Earth are giant sequoia trees.
    H. on Earth are the largest living things—giant sequoia trees.
    J. giant sequoia trees are the largest living things on Earth.

47. Given that all the choices are accurate, which one provides the most effective transition between the first sentence of this paragraph and the last sentence of this paragraph?
    A. NO CHANGE
    B. harbors endangered species like the bighorn sheep and the California condor.
    C. boasts the greatest concentration of giant sequoia groves in the world.
    D. is approximately 84% wilderness.

48. **F.** NO CHANGE
    G. Forest: because there was
    H. Forest; because there was
    J. Forest;

49. **A.** NO CHANGE
    B. Army, which—
    C. Army, which
    D. Army which,

50. **F.** NO CHANGE
    G. to the road from
    H. from the road to
    J. of the road to

51. **A.** NO CHANGE
    B. Cavalries, Young having
    C. Cavalries; Young had
    D. Cavalries. Young had

In June 1903, under Young's command, the soldiers began work on the road. Soon the eleven-mile route was complete. By the middle of August, vehicles could enter the park. Young and his troops had succeeded where no one else had; they enabled visitors to get to the giant sequoias more easily.

Because he had his troops
52

send most of their efforts into the road,
53
Young was just as concerned with maintaining the park's natural features. His troops guarded the grounds against illegal grazing, poaching, and logging. Nevertheless, since tourist foot traffic tended to damage
54
some of the giant sequoias, Young had his soldiers place fences around the most damaged trees to protect them from future bad stuff.
55

Over one hundred years later, the contributions Young made possible has been counted among the
56

most significant in the park's history. 57 In 2003, the National Park Service decided to formally recognize the efforts of Captain Young (who

being promoted to lieutenant colonel in 1916).
58

52. **F.** NO CHANGE
G. Although
H. Unless
J. If

53. **A.** NO CHANGE
B. channel
C. convey
D. shape

54. **F.** NO CHANGE
G. Additionally,
H. Thus,
J. Still,

55. **A.** NO CHANGE
B. further harm in the future.
C. further harm.
D. bad stuff.

56. **F.** NO CHANGE
G. was
H. are
J. is

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

> Park enthusiast George Palmer was the one who petitioned the National Park Service to recognize Young's contributions.

Should the writer make this addition here?

A. Yes, because it explains why it took so long for the National Park Service to formally recognize Young's accomplishments.
B. Yes, because it provides information about how Palmer inspired Young's actions at the park.
C. No, because it suggests that other people besides Palmer had already petitioned the National Park Service on Young's behalf.
D. No, because it provides information that is only loosely related to the main subject of the essay.

58. **F.** NO CHANGE
G. having been
H. had been
J. DELETE the underlined portion.

Today, those who visit the park use Young's road to reach the Giant Forest, which is home to General Sherman, the world's largest tree.
<u>59</u>

59. Which of the following choices best concludes the sentence and the essay?
   A. NO CHANGE
   B. where, among the trees dedicated to and named for US generals and presidents, the Colonel Young Tree also stands.
   C. where, even beneath the cover of nightfall, people can enjoy park-sponsored activities such as lantern tours.
   D. which is a popular place to visit.

Question 60 asks about the preceding passage as a whole.

60. Suppose the writer's primary purpose had been to provide an overview of the history of Sequoia National Park. Would this essay accomplish that purpose?
   F. Yes, because it explains how the construction of roads through the park has led to broadscale changes from the park's establishment to today.
   G. Yes, because it describes how Young's contributions led to a historic surge in annual visits to the park.
   H. No, because it focuses on Young's military career rather than on the history of the park.
   J. No, because it instead chronicles one significant part of the park's history.

PASSAGE V

The Curious Case of *Turritopsis Dohrnii*

For decades, the diminutive jellyfish *Turritopsis dohrnii*—mere millimeters wide as an adult—did not unveil much notice from scientists. But in 1988,
<u>61</u>

marine biology student Christian Sommer observed
<u>62</u>

T. dohrnii doing something astonishing. Reverting
<u>63</u>
from mature jellyfish to hydroid colonies, an earlier

61. A. NO CHANGE
    B. disclose
    C. reveal
    D. elicit

62. F. NO CHANGE
    G. marine, biology student, Christian Sommer,
    H. marine biology student, Christian Sommer,
    J. marine biology student Christian Sommer,

63. A. NO CHANGE
    B. astonishing: reverting
    C. astonishing; reverting
    D. astonishing reverting

life stage. <u>In a sense, they grew younger.</u>
 ₆₄

T. dohrnii has <u>no brain or heart.</u> After fertilization,
 ₆₅
a *T. dohrnii* egg develops into a free-swimming, ovoid

larva. In time, the larva settles on the ocean floor and

transforms into a mound of cells—a hydroid colony.

Buds grow on the colony and develop into young jellyfish

with the familiar bell-like shape and tentacles. These

jellyfish then detach from the <u>colony, and drift away</u>
 ₆₆
reaching maturity in a few weeks.

After Sommer's discovery, studies confirmed that

T. dohrnii's life cycle is not a one-way street. An adult

<u>*T. dohrnii*, if stressed—</u>by injury, disease, or even just
 ₆₇
old age, has the ability to revert to a hydroid colony. That

colony can then create new jellyfish, which in turn can

also revert to hydroid colonies. There's no apparent limit

to these <u>perpetual cycles of metamorphic transformation.</u>
 ₆₈

In the 1990s, <u>journalists nicknamed *T. dohrnii* the</u>
 ₆₉

"immortal jellyfish." It is true that <u>scientists have</u>
 ₇₀
<u>replicated all stages of *T. dohrnii*'s life cycle,</u> but
 ₇₀
each individual *T. dohrnii* isn't immortal. Although

the cells of the adult are essentially recycled during

its transformation, all the new jellyfish grow into

separate organisms—albeit genetically equivalent ones.

64. If the writer were to delete the underlined sentence, the paragraph would primarily lose:
- **F.** information explaining that *T. dohrnii* had been observed reverting from maturity to an earlier life stage.
- **G.** a statement that helps clarify the previous details about *T. dohrnii*'s reversion to hydroid colonies.
- **H.** an alternate perspective that contradicts Sommer's conclusions about *T. dohrnii*.
- **J.** evidence that Sommer continued to observe *T. dohrnii* over time.

65. Given that all the choices are accurate, which one best helps the sentence introduce the main focus of the paragraph?
- **A.** NO CHANGE
- **B.** been found primarily in the Mediterranean Sea and in waters near Japan.
- **C.** only eight tentacles as a young jellyfish but over eighty as an adult.
- **D.** a multistage life cycle.

66. F. NO CHANGE
- **G.** colony and, drift away
- **H.** colony and drift away,
- **J.** colony and drift away

67. A. NO CHANGE
- **B.** *T. dohrnii*, if stressed
- **C.** *T. dohrnii* if stressed,
- **D.** *T. dohrnii* if stressed

68. F. NO CHANGE
- **G.** endlessly recurring cycles of transformation.
- **H.** transformative cycles of metamorphosis.
- **J.** cycles of transformation.

69. Which of the following alternatives to the underlined portion would NOT be acceptable?
- **A.** journalists invented a nickname for *T. dohrnii*:
- **B.** journalists nicknamed *T. dohrnii*, calling it the
- **C.** journalists' nickname for *T. dohrnii*: the
- **D.** journalists began calling *T. dohrnii* the

70. Given that all the choices are accurate, which one provides the most relevant information at this point in the essay?
- **F.** NO CHANGE
- **G.** the cells and genes of *T. dohrnii* can, theoretically, live indefinitely,
- **H.** an adult *T. dohrnii* is about as big as a trimmed pinkie nail,
- **J.** *T. dohrnii* has spread throughout many oceans of the world,

In a way, the new jellyfish are clones amidst the
originating adult.

Scientists are still studying how *T. dohrnii* achieves
its transformations. At the cellular level, what the jellyfish

does, which is called transdifferentiation, wherein one

type of cell becomes another type. [74] Understanding
the mechanisms of *T. dohrnii*'s particular kind of

transdifferentiation may yield insights into aging
and disease in all animals, including humans.

71. A. NO CHANGE
   B. with
   C. of
   D. to

72. F. NO CHANGE
   G. all of their
   H. all of it's
   J. their

73. A. NO CHANGE
   B. does to transform,
   C. does is
   D. does,

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

> *T. dohrnii*'s abilities, however, can't save it from lethal encounters with, say, boat propellers or ravenous sea slugs.

Should the writer make this addition here?

   F. Yes, because it adds details about the environmental dangers that *T. dohrnii* may face.
   G. Yes, because it reveals that individual *T. dohrnii* aren't actually immortal.
   H. No, because it suggests that boat propellers and sea slugs are the only true dangers for *T. dohrnii*.
   J. No, because it interrupts the discussion of *T. dohrnii*'s cellular transdifferentiation.

75. Given that all the choices are accurate, which one would best conclude the essay by emphasizing specific benefits of *T. dohrnii* research?

   A. NO CHANGE
   B. is the life's work of Shin Kubota, who studies the only thriving captive population of *T. dohrnii*.
   C. is really important, although there are few experts devoted to the study of this fascinating creature.
   D. will require much diligence, since *T. dohrnii* only produces offspring under very specific conditions.

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. For all nonzero values of x and y, which of the following expressions is equivalent to $-\dfrac{35x^5y^4}{5xy}$?

   A. $-7x^4y^3$
   B. $-7x^5y^4$
   C. $-7x^6y^5$
   D. $-30x^4y^3$
   E. $-40x^4y^3$

2. The degree measures of the 3 angles of the triangle below are expressed in terms of x. What is the value of x ?
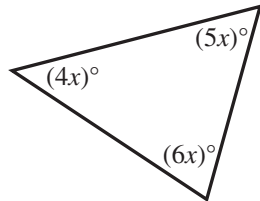
   F. 10
   G. 12
   H. 24
   J. 30
   K. 36

3. A 48.5-ounce batch of cologne will be used to fill empty bottles. Each full bottle will contain 0.35 ounces of cologne. This batch of cologne will fill at most how many bottles full of cologne?

   A. 13
   B. 14
   C. 122
   D. 138
   E. 139

4. Of the 200 parking spaces in a parking lot, 6% of the spaces are reserved for handicapped parking. Of those parking spaces NOT reserved for handicapped parking, 20 are suitable for compact cars only. How many spaces that are NOT reserved for handicapped parking are suitable for noncompact cars?

   F. 160
   G. 168
   H. 174
   J. 180
   K. 188

DO YOUR FIGURING HERE.

GO ON TO THE NEXT PAGE.

5. What is the value of $2|2 - 9| - 3(5 + 2)$?

   A. −35
   B. −27
   C. −18
   D. −8
   E. −7

DO YOUR FIGURING HERE.

6. Ricardo started a savings account for his daughter Ruth by depositing $500 into the account for her 1st birthday. For each successive birthday, Ricardo deposits $200 more than the amount deposited for the previous birthday. This is the only money deposited into the account. What is the total amount of money Ricardo will have deposited into the account for Ruth up to and including her 6th birthday?

   F. $4,000
   G. $4,200
   H. $4,700
   J. $4,900
   K. $6,000

7. Tawanna bought a used car. She made an initial payment of $700.00. She then made 36 equal monthly payments. The total amount Tawanna paid for the car was $7,000.00. What was the amount of each of her monthly payments?

   A. $ 19.44
   B. $175.00
   C. $194.44
   D. $213.89
   E. $360.00

8. Which of the following matrices is equal to

$$\begin{bmatrix} 9 & 2 \\ -4 & 1 \end{bmatrix} + \begin{bmatrix} -6 & 8 \\ 7 & 6 \end{bmatrix} ?$$

   F. $\begin{bmatrix} -40 & 84 \\ 31 & -26 \end{bmatrix}$

   G. $\begin{bmatrix} 3 & 10 \\ 11 & 7 \end{bmatrix}$

   H. $\begin{bmatrix} 3 & 10 \\ 3 & 7 \end{bmatrix}$

   J. $\begin{bmatrix} 11 & 2 \\ -3 & 13 \end{bmatrix}$

   K. $\begin{bmatrix} 15 & 10 \\ 11 & 7 \end{bmatrix}$

9. Lyle and Ming are painting an art room. They started with 4 gallons of paint. On the first day, Lyle used $\frac{1}{2}$ gallon of paint and Ming used $1\frac{1}{4}$ gallons of paint. How many gallons of paint were left when they completed their first day of painting?

A. $1\frac{3}{4}$

B. $2\frac{1}{4}$

C. $2\frac{3}{4}$

D. $3\frac{1}{4}$

E. $3\frac{1}{2}$

**10.** In the standard (x,y) coordinate plane, what is the slope of the line through $(-3,1)$ and $(5,6)$?

F. $-\frac{5}{2}$

G. $-\frac{5}{8}$

H. $\frac{5}{8}$

J. $\frac{5}{2}$

K. $\frac{7}{2}$

11. The lengths of corresponding sides of 2 similar right triangles are in the ratio 4:5. The hypotenuse of the smaller triangle is 24 inches long. How many inches long is the hypotenuse of the larger triangle?

A. 1.25
B. 9
C. 20
D. 25
E. 30

12. The lengths of the 3 sides of right triangle $\triangle ABC$ shown below are given in meters. What is $\sin A$?
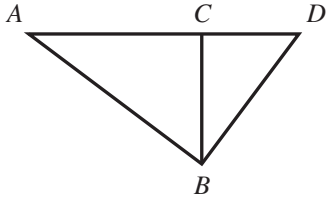
F. $\frac{8}{17}$

G. $\frac{8}{15}$

H. $\frac{15}{17}$

J. $\frac{17}{15}$

K. $\frac{17}{8}$
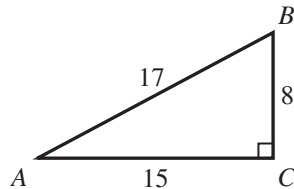
DO YOUR FIGURING HERE.
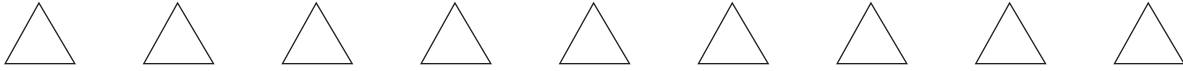
13. In the figure shown below, C is on the segment with endpoints A and D. The distance between A and B is 2,000 km, between A and C is 1,600 km, between A and D is 2,500 km, and between B and C is 1,200 km. What is the distance, in kilometers, between B and D ?

- **A.** $100\sqrt{481}$
- **B.** $300\sqrt{7}$
- **C.** 900
- **D.** 1,200
- **E.** 1,500

14. What is the sum of the 2 solutions of the equation $x^2 - 4x - 45 = 0$?

- **F.** −45
- **G.** −5
- **H.** 0
- **J.** 4
- **K.** 9

15. In the figure shown below, all angles are right angles, and the side lengths given are in inches. What is the area, in square inches, of the figure?
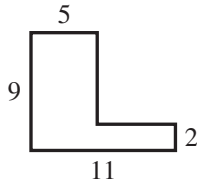
- **A.** 42
- **B.** 57
- **C.** 67
- **D.** 89
- **E.** 99

16. Quadrant I of the standard (x,y) coordinate plane is shown on a large computer screen. A blinking dot is positioned at $(2,3)$. The dot makes exactly 2 moves: first, horizontally in the positive x direction for 4 seconds at a speed of 0.5 coordinate units per second; then, vertically in the positive y direction for 2 seconds at the same speed. At what point is the dot located after these 2 moves?

- **F.** $(2,6)$
- **G.** $(3,5)$
- **H.** $(4,4)$
- **J.** $(5,3)$
- **K.** $(6,5)$

17

> Use the following information to answer questions 17–19.

A weeklong summer camp is held in June for children in Grades 3–6. Parents and guardians who enrolled their children for camp by May 15 received a 20% discount off the regular enrollment fee for each child enrolled. For each grade, the table below gives the number of children enrolled by May 15 as well as the *regular* enrollment fee per child. The grade of any child is that child's grade in school as of May 15.

Grade	Enrollment by May 15	Regular enrollment fee
3	20	$350
4	15	$400
5	28	$450
6	18	$500

17. By May 15, Mr. Ramirez had enrolled his 2 children for camp. One child was in Grade 4, and the other was in Grade 6. What was the total amount Mr. Ramirez paid to enroll his 2 children?

- **A.** $720
- **B.** $800
- **C.** $820
- **D.** $860
- **E.** $880

18. Which of the following equations gives a true relationship between the *regular* enrollment fee, f, and the grade, g, of any child enrolled in the camp?

- **F.** $f = g + 50$
- **G.** $f = 50g$
- **H.** $f = 50g + 200$
- **J.** $f = 50g + 300$
- **K.** $f = 300g + 50$

19. By May 15, Ms. Chen had enrolled her 2 children for camp. One child was in Grade 3, and the other was in Grade 4. For each grade, the names of all the children enrolled by May 15 will be entered into a drawing for a free T-shirt. For each grade, 1 name will be randomly drawn. What is the probability that the names of both of Ms. Chen's children will be drawn?

- **A.** $\dfrac{7}{60}$
- **B.** $\dfrac{2}{81}$
- **C.** $\dfrac{1}{300}$
- **D.** $\dfrac{100}{2,187}$
- **E.** $\dfrac{1}{3,240}$
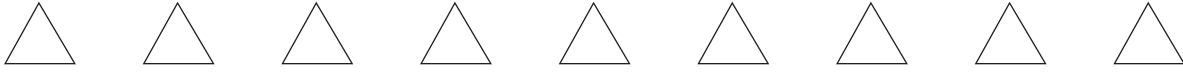
20. You drove 18 miles in 20 minutes at a constant speed and did NOT exceed the speed limit, given in miles per hour. Among the following, which is the *lowest* that the speed limit could have been?

    F. 45
    G. 50
    H. 55
    J. 60
    K. 65

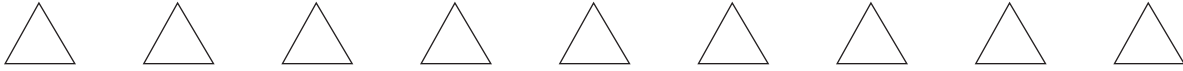21. What value of x makes the equation $-\dfrac{1}{81} = -3^x$ true?

    A. −4

    B. 4

    C. 27

    D. $-\dfrac{1}{4}$

    E. $\dfrac{1}{243}$

22. The equation $R = \dfrac{P}{I^2}$ gives the resistance, R, in terms of the power, P, and the current, I, of an electrical system. Which of the following expressions gives I in terms of P and R ?

    F. $\sqrt{\dfrac{R}{P}}$

    G. $\sqrt{\dfrac{P}{R}}$

    H. $\dfrac{P}{R}$

    J. $\dfrac{R}{P}$

    K. PR

23. One welcome sign flashes every 8 seconds, and another welcome sign flashes every 12 seconds. At a certain instant, the 2 signs flash at the same time. How many seconds elapse until the 2 signs next flash at the same time?

    A. 4
    B. 10
    C. 20
    D. 24
    E. 96

DO YOUR FIGURING HERE.

GO ON TO THE NEXT PAGE.

24. The area of a certain square is 900 square inches. What is the perimeter of this square, in inches?

   F. 30
   G. 60
   H. 120
   J. 225
   K. 450

25. The Department of Natural Resources (DNR) is estimating the deer population in Twin Pines County. Several months ago, DNR rangers captured, tagged, and then released 108 deer. Recently, DNR rangers captured 54 deer in the county and found that 36 of them had been tagged in the earlier capture. The DNR estimates the deer population in the county using the proportion below. What is the DNR estimate of the deer population in the county?

$$\frac{\text{tagged deer in capture 1}}{\text{deer population}} = \frac{\text{tagged deer in capture 2}}{\text{deer in capture 2}}$$

   A. 108
   B. 126
   C. 144
   D. 162
   E. 198

26. In an arithmetic sequence, the 10th term (a_{10}) is 30 and the common difference is 2. What is the 1st term (a_1) ?

   F. −28
   G.   6
   H. 11
   J. 12
   K. 15

27. A *pedometer* records the number of steps a person takes as he or she walks. When a pedometer records 3,898 steps taken by a person who covers a distance of 2.25 feet per step, how much distance, to the nearest 0.1 mile, did the person cover?

   (Note: 1 mile = 5,280 feet)

   A. 0.3
   B. 0.6
   C. 1.4
   D. 1.7
   E. 3.0

28. Among a group of 20 students, 13 students are members of the Math Club, 11 students are members of the Drama Club, and 9 students are members of both clubs. How many of the 20 students are NOT members of either club?

   F.   4
   G.   5
   H.   6
   J. 11
   K. 13

DO YOUR FIGURING HERE.

DO YOUR FIGURING HERE.

29. To increase the mean of 7 numbers by 4, by how much would the sum of the 7 numbers have to increase?

    A.   4
    B.   7
    C. 11
    D. 28
    E. 56

30. Which of the following is an equation of the circle in the standard (x,y) coordinate plane whose center is at $(4,-3)$ and whose radius is 5 coordinate units long?

    F. $(x - 4)^2 + (y + 3)^2 = 5$
    G. $(x - 4)^2 + (y + 3)^2 = 25$
    H. $(x - 3)^2 + (y + 4)^2 = 25$
    J. $(x + 3)^2 + (y - 4)^2 = 5$
    K. $(x + 4)^2 + (y - 3)^2 = 25$

31. All 25 students in a chemistry class took a test. Each student earned a test score that was an integer number of points, and no 2 students earned the same test score. The median test score was 80 points. How many students earned a test score that was greater than 80 points?

    A.   5
    B. 12
    C. 13
    D. 14
    E. 20

32. Shefali goes to a farmers' market every Saturday. Two Saturdays ago, Shefali purchased 3 apples and 4 oranges for a total of $3.47. Last Saturday, she purchased 12 oranges, but no apples, and spent $6.36. Today, she only has one $10 bill. Given that none of the prices have changed over the last 3 weeks, what is the maximum number of apples she can purchase today?

(Note: No sales tax is charged at this farmers' market.)

    F. 18
    G. 19
    H. 21
    J. 22
    K. 23

DO YOUR FIGURING HERE.

Use the following information to answer questions 33–36.

Fletcher purchased 5 items at Hippity-Bippity Toy Store for a total of $18.55, which included sales tax. When he arrived home, he discovered that his receipt was torn and did not show the price of the bag of balloons or the 6% sales tax applied to the sum of the 5 prices. The partial receipt is shown below.

Hippity-Bippity Toy Store

Date: 12-20-2014
Time: 2:30 p.m.

Item	Price
Bag of marbles	$2.00
Doll	$6.00
Car	$3.00
Jump rope	$4.00
Bag of balloo	

33. Fletcher left his home 1 hour 15 minutes before he entered the store. He spent 25 minutes in the store before he made his purchase. What time did Fletcher leave his home?

A. 12:50 p.m.
B. 1:10 p.m.
C. 1:20 p.m.
D. 1:30 p.m.
E. 1:40 p.m.

34. To the nearest $0.10, what was the price of the bag of balloons?

F. $1.10
G. $2.40
H. $2.50
J. $2.70
K. $3.50

35. The price of the doll was how much greater than the mean of the 4 prices shown on the partial receipt?

A. $1.50
B. $2.00
C. $2.25
D. $2.50
E. $3.00

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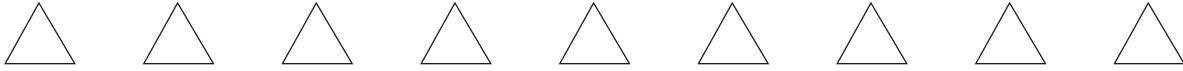
36. Malik will spend a total of $30.00 before sales tax on *x* bags of marbles and *y* cars purchased at the prices shown on the partial receipt. One of the following line segments graphed in the standard (*x,y*) coordinate plane contains points for all possible combinations of *x* and *y*. Which one?

F.

J.

G.

K.

H.
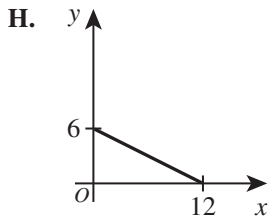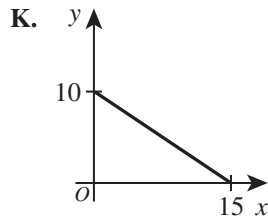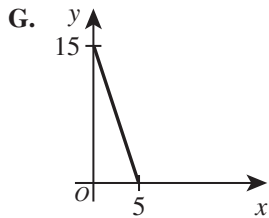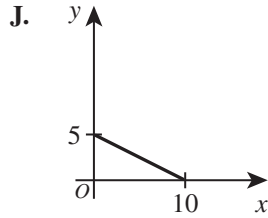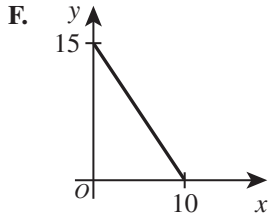
37. In △*DEF*, shown in the figure below, $\overline{EG}$ is an altitude, ∠*DEF* is a right angle, *EF* = 20 centimeters, and the measure of ∠*EDF* is 30°. What is *EG*, in centimeters?
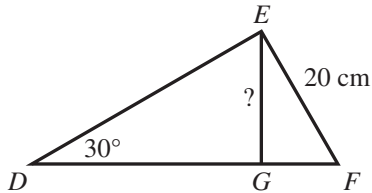
A. 10

B. $10\sqrt{3}$

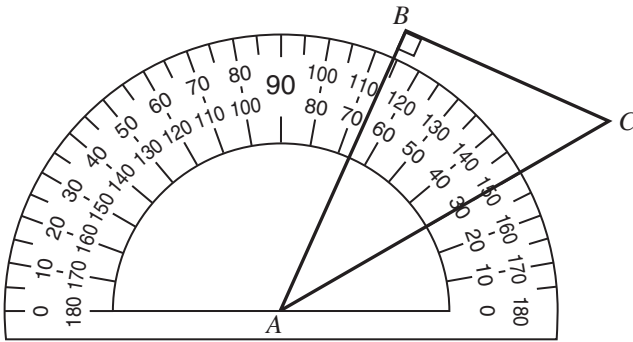**C.** 20

D. $20\sqrt{3}$

E. 40

38. Let the polynomial functions f and g be defined as $f(x) = x^2 + 7x - 3$ and $g(x) = x^2 - 4x + 5$. Let $h(x) = f(x) - g(x)$. What is $h(2)$?

F. -16
G. 8
H. 14
J. 22
K. 24

39. A student is using a protractor, as shown below, to find the measures of the interior angles of $\triangle ABC$. Which of the following is closest to the degree measure of $\angle C$?

A. $36°$
B. $44°$
C. $46°$
D. $54°$
E. $66°$

40. For real numbers x and y such that $0 \le x \le 5$ and $y \ge 9$, the expression $\dfrac{x+y}{y}$ can have which of the following values?

F. 0

G. $\dfrac{10}{9}$

H. $\dfrac{14}{5}$

J. 5

K. 6

41. Given the functions $f(x) = x^2 + 1$ and $g(x) = x - 3$, which of the following expressions is $f(g(x))$?

A. $x^2 - 8$
B. $x^2 - 6x + 10$
C. $x^2 + x - 2$
D. $x^3 + x - 3$
E. $x^3 - 3x^2 + x - 3$

24

GO ON TO THE NEXT PAGE.

42. Given that the equation $\frac{4x - y}{x + y} = \frac{5}{2}$ is true, what is the value of $\frac{x}{y}$?

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

    G. $\frac{5}{2}$

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

    J. $\frac{7}{5}$

    K. $\frac{7}{18}$

DO YOUR FIGURING HERE.

43. Juro traveled to 3 locations during a workday. Juro remained at each location a whole number of hours. The graph below shows the relationship between time, in hours, into his workday and total distance, in kilometers, traveled. Which of the following values is closest to Juro's average speed, in kilometers per hour, for the parts of the workday when he was traveling?
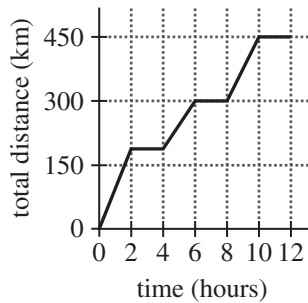
    A. 45
    B. 57
    C. 60
    D. 75
    E. 94

44. What is the amplitude of the function $y = 3 \sin x$?

    F. 1

    G. 3

    H. 6

    J. $\frac{1}{3}$

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

45. For all nonzero values of w, which of the following expressions is equivalent to $\frac{4}{w} + \frac{2}{w^2}$?

A. $\dfrac{2w+1}{w^2}$

B. $\dfrac{4w+2}{w^2}$

C. $\dfrac{6}{w+w^2}$

D. $\dfrac{6}{w^2}$

E. $\dfrac{6}{w^3}$

46. Let A, B, and C represent the digits in the hundreds, tens, and ones places, respectively, of a certain 3-digit whole number. Let D, E, and F represent the digits in the hundreds, tens, and ones places, respectively, of a different 3-digit whole number. The positive difference between the 2 numbers is greater than 100. Which of the following inequalities *must* be true?

F. $|A - D| \geq 1$

G. $|B - E| \geq 1$

H. $|C - F| \geq 1$

J. $A - D \geq 1$

K. $B - E \geq 1$

47. A number line graph includes the points at real numbers a and b, as shown below. Which of the following inequalities expresses an interval that must include the product ab ?
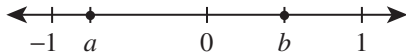
A. $-1 < ab < a$
B. $a < ab < 0$
C. $0 < ab < b$
D. $b < ab < 1$
E. $1 < ab < 2$

48. Sani's course grade in his chemistry class is based on 3 tests and 1 final exam. Each of the 3 test scores is weighted as 20% of the course grade, and the final exam score is weighted as 40% of the course grade. Sani's 3 test scores are 78, 86, and 82, respectively. What is the minimum score that Sani will have to earn on the final exam in order to receive a course grade of at least 86 ?

F. 82
G. 84
H. 90
J. 92
K. 98

49. The triangle below has vertices $A(-1,-2)$, $B(2,2)$, and $C(-1,4)$. What is the area of $\triangle ABC$, in square coordinate units?
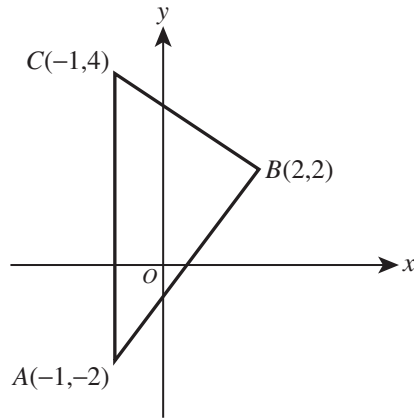
A. 9

B. 15

C. 18

D. $\frac{5}{2}\sqrt{13}$

E. $3\sqrt{13}$

50. For some real number x, $\sqrt{x^2} \neq x$. Therefore x is:

   F. zero.
   G. greater than π.
   H. irrational.
   J. negative.
   K. undefined.

51. In the standard (x,y) coordinate plane below, point A has coordinates $(2,-4)$, and point $B(8,-1)$ divides $\overline{AC}$ so that the ratio $AB{:}BC$ is 1:3. What are the coordinates of point C ?
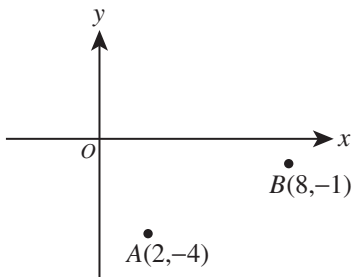
   A. $(-16,-13)$
   B. $(\ 10,\ \ \ 0)$
   C. $(\ 14,\ \ \ 2)$
   D. $(\ 26,\ \ \ 8)$
   E. $(\ 32,\ \ 11)$

52. A wire binds 4 identical posts together as shown below. Each post has a 3-inch radius. What is the length, to the nearest inch, of the shortest wire that will go around the 4 posts without overlap?

   F. 21
   G. 31
   H. 33
   J. 43
   K. 52
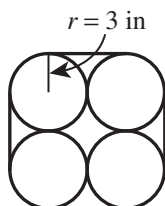
53. Given that *b* is rational and $i = \sqrt{-1}$, the product of the expression $(3 + bi)$ and which of the following expressions must be a rational number?

A. i
B. bi
C. $3bi$
D. $3 + bi$
E. $3 - bi$

54. For positive integers *x* and *y* where $x < 8$, $\log_x 8 = y$. What is the value of *y* ?

F.   1
G.   2
H.   3
J.   4
K.   8

55. The right triangle shown below is 8 squares high and 10 squares long. One of the following values is the ratio of the shaded area to the unshaded area. Which one?

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

B. $\frac{3}{10}$

C. $\frac{7}{13}$

D. $\frac{7}{20}$

E. $\frac{15}{28}$
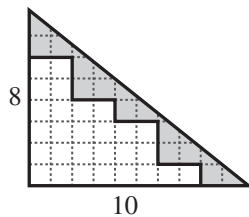
56. For all positive integers *x*, which of the following expressions is equivalent to $x^{\frac{1}{4}} \cdot x^{\frac{1}{6}}$?

F. $\sqrt{x^{24}}$

G. $\sqrt[5]{x}$

H. $\sqrt[5]{x^{12}}$

J. $\sqrt[12]{x^5}$

K. $\sqrt[24]{x}$

57. One day on the New York Currency Exchange, 1 British pound (£1) could be exchanged for $2.75 in U.S. currency, and 1 Canadian dollar ($1) could be exchanged for $0.92 in U.S. currency. On that day, how much Canadian currency, rounded to the nearest Canadian cent, could be exchanged for £2 ?

- **A.** $0.41
- **B.** $1.84
- **C.** $2.07
- **D.** $5.06
- **E.** $5.98

58. The sides of an acute triangle measure 17 cm, 16 cm, and 15 cm, respectively. The measure of the smallest angle of the triangle is a solution for *A* to which of the following equations?

- **F.** $17^2 = 15^2 + 16^2 - 2(15)(16)\sin A$
- **G.** $17^2 = 15^2 + 16^2 - 2(15)(16)\cos A$
- **H.** $16^2 = 15^2 + 17^2 - 2(15)(17)\cos A$
- **J.** $15^2 = 16^2 + 17^2 - 2(16)(17)\sin A$
- **K.** $15^2 = 16^2 + 17^2 - 2(16)(17)\cos A$

59. Set A and Set B each consist of 5 distinct numbers. The 2 sets contain identical numbers with the exception of the number with the least value in each set. The number with the least value in Set B is greater than the number with the least value in Set A. The value of which of the following measures *must* be greater for Set B than for Set A ?

- **A.** Mean only
- **B.** Median only
- **C.** Range only
- **D.** Mean and range only
- **E.** Mean, median, and range

60. Of the 16 cars on a rental-car lot, 6 are minivans, 7 are sedans, and 3 are hatchbacks. Thalia will rent 3 of these cars, chosen at random, for business associates. What is the probability that Thalia will rent 1 of each of the 3 types of cars?

- **F.** $\dfrac{1}{3}$
- **G.** $\dfrac{1}{16}$
- **H.** $\dfrac{3}{16}$
- **J.** $\dfrac{9}{40}$
- **K.** $\dfrac{9}{80}$

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

Passage A by Edna Ferber

The printing shop and pressroom were separated from the front office only by a doorway, and the door never was closed. There were the type forms and tables, the linotype machine (a new and fearsome invention to
5　me), the small press, the big newspaper press, the boiler plate, the trays of type, all the paraphernalia that goes to make up the heart of a small-town newspaper. The front room is its head, but without the back room it could not function or even live. The linotype and the
10　small press went all day, for there the advertising was set up and printed, as well as handbills, programs, all the odds and ends classified as job printing. Mac, who ruled this domain, was the perfect example of the fictional printer. He had come in years before, his brown
15　hair curled over a mild brow, his limp shirt seemed perennial. But his eye was infallible, and few if any shrdlus and etaoins marred the fair sequence of Mac's copy. His voice was soft, gentle, drawling, but he was boss of the print shop from the cat to the linotype oper-
20　ator. Mac seldom talked but sometimes—rarely—he appeared in the front office, a drooping figure, with a piece of news by which he had come in some devious way. Standing at the side of the city editor's desk he would deliver himself of this information, looking mild
25　and limply romantic. It always proved to be a bombshell.

Such was the make-up of the Appleton, Wisconsin, Daily Crescent office.

In the past thirty years all sorts of ex-newspaper
30　men from Richard Harding Davis to Vincent Sheean and John Gunther have written about the lure of the reporter's life, the smell of printer's ink, the adventure of reporting. It all sounds slightly sentimental and silly, but it's true—or it was, at least, in my newspaper expe-
35　rience. To this day I can't smell the scent of white paper, wet ink, oil, hot lead, mucilage and cats that goes to make up the peculiar odor of any newspaper plant, be

it Appleton, Wisconsin, or Cairo, Egypt, that I don't get a pang of nostalgia for the old reporting days. "I was
40　once a newspaper man myself" has come to be a fun phrase. But practically everyone seems to have been, or to have wanted to be, a newspaper reporter.

Passage B by Dan Barry

Ink. The building smelled of ink, spilled and bled. It was a tart and chemical smell, the kind that weaves
45　into the fabric of your clothes and then under your skin, the kind that comes home with you, sits with you at the dinner table, tells you constantly what it is you do. Car mechanics know their smell, as do fishermen and hair stylists, nurses and short-order cooks. You are a man
50　who chases halibut, a woman who perms hair. You smell of it.

I waded into that invisible veil of ink, inhaled it deeply, allowed it to wash over me. It smelled of words and phrases, rants and ideas, sports scores and felony
55　arrests, announcements of marriage and notices of death. Maybe the chemical-like aroma was inducing hallucination, but I doubted it. In a squat concrete building, no different from all the others in a drab Connecticut industrial park, I was experiencing a moment
60　of revelation—an epiphany, really, at the age of twenty-five.

This is what I do.

Pinned like a manifesto to a bulletin board in the center of this ink-perfumed building was a typewritten
65　note from my new employer, announcing that on this day, October 17, 1983, I would begin working as a reporter for a daily newspaper. The note formalized my calling in life with a splash of perspective that would stay with me forever:

70　　*Dan is a former intern at the* Daily News *in New York and a graduate assistant for the journalism department at New York University. His writing has appeared in the* Daily News, *the* New York Times *and the* Rocky Mountain News. *Soon it will appear in*
75　*trashcans throughout north-central Connecticut. Please make him feel relevant.*

Reading the note, I thought, I'm home.

Finding my way had not been easy. The internship at the *Daily News* had ended, the graduate degree from
80 NYU had been shoved in a drawer, and I had returned to living beside the sump pump in my parents' basement. I spent my days splitting sod for a lawn and sprinkling company alongside Eddie, who had taken to calling me "Professor," and my nights typing out pro-
85 fessional love letters to the *New London Day*, the *Asbury Park Press*, the *Poughkeepsie Journal*, the *Stamford Advocate*, the *Anywhere Clarion-Bugle-Star-Record-Sentinel*, and every other Northeastern newspaper that I had never read.

Questions 1–4 ask about Passage A.

1. It can reasonably be inferred that Passage A is narrated from the point of view of someone who:

  A. once worked in the newspaper business.
  B. recently started a career in the newspaper business.
  C. is outside the newspaper business and is evaluating the inner workings of various news offices.
  D. is outside the newspaper business and longs to be a reporter.

2. Based on Passage A, the narrator believes that, compared to what goes on in the front office, what goes on in the printing shop and pressroom is:

  F. more tedious.
  G. equally critical.
  H. equally chaotic.
  J. less regulated.

3. The narrator of Passage A most nearly characterizes Mac as both:

  A. innately talented and professionally incompetent.
  B. innately talented and professionally inexperienced.
  C. temperamentally unimposing and professionally inexperienced.
  D. temperamentally unimposing and professionally invaluable.

4. According to the narrator of Passage A, Mac would occasionally appear in the front office in order to:

  F. set up and print the advertising.
  G. supervise the linotype operator.
  H. chastise the reporters for having too many errors in their copy.
  J. share newsworthy information with the city editor.

Questions 5–7 ask about Passage B.

5. What is the epiphany the narrator of Passage B experienced at the age of twenty-five?

  A. He couldn't live in his parents' basement forever.
  B. His dream of being a reporter had finally been realized.
  C. He would rather write news stories than work for a lawn company.
  D. His success as a reporter would depend on his work ethic.

6. Based on Passage B, the note that the narrator's employer wrote can best be described as:

  F. mildly sarcastic.
  G. overtly solemn.
  H. blatantly apologetic.
  J. particularly optimistic.

7. The last sentence of Passage B mainly serves to indicate that the narrator:

  A. had disdain for most northeastern newspapers.
  B. was familiar with the newspapers published around the area.
  C. was desperate to find a newswriting job.
  D. had extensive newswriting experience.

Questions 8–10 ask about both passages.

8. Compared to the description of the newspaper office mentioned in Passage A, the description of the newspaper office mentioned in Passage B provides less information about the:

  F. types of machines used to print the newspaper.
  G. outside appearance of the office building.
  H. number of people who work in the office.
  J. types of stories being written and printed for the newspaper.

9. Compared to Passage A, the style of Passage B is more strongly characterized by its use of:

  A. technical jargon.
  B. dialogue.
  C. formal diction.
  D. figurative language.

10. Based on the passages, who would be most likely to associate the smell of ink with pleasant memories?

  F. The narrator of Passage A only
  G. The narrator of Passage B only
  H. Both narrators
  J. Neither narrator

Passage II

SOCIAL SCIENCE: This passage is adapted from the book *Lost Discoveries: The Ancient Roots of Modern Science—from the Babylonians to the Maya* by Dick Teresi (©2002 by Dick Teresi).

"In the history of culture," wrote mathematician Tobias Dantzig in 1930, "the discovery of zero will always stand out as one of the greatest single achievements of the human race." Zero, he said, marked a
5 "turning point" in math, science, and industry. He also noted that the zero was invented not in the West but by the Indians in the early centuries after Christ. Negative numbers followed soon thereafter. The Maya invented zero in the New World at approximately the same time.
10 Europe, says Dantzig, did not accept zero as a number until the twelfth or thirteenth century.

There are many "biographies of zero," and Dantzig's concise and spirited account of the birth of a number is adequate for most of us. He sees zero's
15 invention appearing on an Indian's counting board in, say, the first or second century A.D. The Indian counting board had columns for the ones, tens, hundreds, thousands, and so on. To "write" 302, for instance, a mathematician would put a 2 in the first (right) column
20 and a 3 in the third, leaving the second column empty. On one fateful day, as Dantzig sees it, an unknown Indian drew an oval in the second column. He called it *sunya*, for "empty" or "blank." *Sunyata*, an important concept in Buddhism, is often translated as "emptiness"
25 or "void."

The Arabs turned *sunya* into *sifr* ("empty" in Arabic), which became *zephirum* in Italy, and eventually zero. In Germany and elsewhere, *sifr* became *cifra*, and then, in English, *cipher*. In other words, it took
30 over a thousand years for Western civilization to accept a number for "nothing." Dantzig blames the Greeks. "The concrete mind of the ancient Greeks could not conceive the void as a number, let alone endow the void with a symbol."

35 That's the short version, and not a bad one. You don't want to hear the long version, so let's suffice with a medium-sized tale.

Zero lay rustling in the weeds for many centuries before that Indian drew it on a counting board. It was
40 an unnamed, unwritten force. It took many more centuries after the Indians and the Maya dared speak its name before zero was promoted to a full-fledged number.

The U.S. Library of Congress defends our calendar
45 and its missing zero. "There has never been a system of recording reigns, dynasties, or eras," the library states, "that did not designate its first year as the year 1." In fact, the Maya had both years 0 and days 0.

The Babylonians had no zero, but they knew some-
50 thing was wrong. If they numbered the first year of each king's reign as year 1, then added up the number of years of each separate reign, they'd end up with too many years unless each king died just before midnight on New Year's Eve and his successor took the throne
55 after midnight. Thus, the Babylonians called a king's first year the *accession year*. The following year was year 1. The accession year was a kind of year 0. The Babylonians, so far as we know, never articulated zero, but seemed aware that there was a missing number in
60 their system.

The contemporary mathematician who has conducted the most rigorous research on nothing is Robert Kaplan, the author of *The Nothing That Is: A Natural History of Zero*. Zero turns up throughout history in dif-
65 ferent cultures as a series of dots and circles, and Kaplan writes of following "the swarm of dots we find in writings from a host of languages, across great spans of time, and on topics mathematical and otherwise."

Kaplan traces the roots of zero to Sumer and
70 Babylonia. The Sumerians counted by tens and sixties, a system adopted by the Babylonians, who eclipsed them in Mesopotamia. The Babylonians, far ahead of the Romans and Greeks to come, imposed a positional notation on the old Sumerian sexagesimal system. Writ-
75 ing their numbers on clay, the Babylonians needed a symbol to put in the "empty" columns, just as we today use zero to differentiate between 302 and 32.

Somewhere between the sixth and third centuries B.C., the Babylonians began using two slanted tacklike
80 symbols to insert in the empty columns. They borrowed the slanty tacks from their language, where they were used as periods, among other things. However, the Babylonians used their "zero" only in the middle of numbers, never at the end. Clearly, this was not a full-
85 fledged zero.

Kaplan argues that when Alexander invaded the Babylonian empire in 331 B.C., he hauled off zero along with the gold. Shortly thereafter we find the symbol 0 for zero in the papyri of Greek astronomers, but the
90 mathematicians never pursued the concept.

11. According to the passage, the Babylonian and Indian civilizations were similar in that they both:

  A. wrote zero using tacklike symbols.
  B. referred to their rulers' first year in power as the *accession year*.
  C. derived their names for zero from their respective religions.
  D. used a symbol for zero in the middle of numbers.

12. As it is presented in the second paragraph (lines 12–25), the story of an unknown person drawing an oval on a counting board is best described as:

F. a factual account from a document Dantzig discovered.

G. a factual account from ancient Indian writings.

H. Dantzig's theory of how a historic invention occurred.

J. Kaplan's theory of how a historic invention occurred.

13. According to the passage, the Maya invented zero at about the same time as:

A. the Indians invented zero.

B. the Sumerians invented zero.

C. Alexander invaded Babylonia.

D. Europe accepted zero as a number.

14. As it is used in line 21, the phrase *fateful day* most nearly refers to a day that was:

F. unfortunate.

G. momentous.

H. ominous.

J. foretold.

15. According to the passage, in Germany, the word for zero became:

A. *sunya*.

B. *zephirum*.

C. *sifr*.

D. *cifra*.

16. In the passage, Dantzig criticizes the ancient Greeks because he thinks they:

F. lacked the abstract thinking necessary to think of the void as a number.

G. attempted to use zero in their mathematics before they understood it fully.

H. were unwilling to share their knowledge of zero with other European countries.

J. focused so much on negative numbers that they couldn't imagine a number for the void.

17. The passage author most clearly indicates that he thinks his readers wouldn't be interested in hearing:

A. the story of how the Maya conceived of zero.

B. what Dantzig contributed to mathematics.

C. the long version of the story of zero.

D. who drew the oval on the counting board in India.

18. The statement "Zero lay rustling in the weeds for many centuries" (line 38) most nearly means that the concept of zero:

F. had far-reaching effects on mathematics.

G. existed long before it was articulated.

H. had been developed and then forgotten.

J. was initially rejected by mathematicians.

19. The passage author responds to the US Library of Congress's statement that there has never been a system of dates with a year 0 by:

A. arguing that undiscovered civilizations may have had years 0.

B. citing an expert who disagrees with the statement.

C. suggesting that the Library of Congress's research is authoritative.

D. providing an example that contradicts the statement.

20. The passage author most clearly indicates that compared to other contemporary mathematicians' research on zero, Kaplan's research is more:

F. interesting.

G. speculative.

H. thorough.

J. admired.

Passage III

HUMANITIES: This passage is adapted from *I'll Take You There: Mavis Staples, The Staples Singers, and the March Up Freedom's Highway* by Greg Kot (©2014 by Greg Kot).

To fans of the Staples Singers in the '60s, the relative anonymity of Mavis Staples was puzzling. With an improbably deep voice bursting out of a diminutive five-foot frame, she projected the deepest commitment
5 to whatever she was singing, losing herself in every word as though reliving a critical moment in her personal story.

And yet she still wasn't a marquee name like Aretha Franklin, Gladys Knight, Diana Ross, and Dusty
10 Springfield. Part of this was by design—Mavis enjoyed singing with her family and preferred to melt into the group. Even when her father brought her out front to sing lead after her brother Pervis's voice changed in the '50s, she did so reluctantly. "I loved singing those bari-
15 tone harmonies, I always thought that was the best job you could have," Mavis said. She also felt a certain comfort being guided by her father, who had essentially taught her how and what to sing. Little had changed in the decades since, even as it was apparent that Mavis
20 had star power. "Mavis was and is a quartet singer," says Anthony Heilbut. "From a very early age she grew up singing harmony or singing lead in a group with four voices and her father's guitar. She was trained to sing with the guitar, whereas Aretha sang with the piano. It's
25 a very different approach."

Not only that, Pops's idiosyncratic guitar style made it difficult for Mavis to easily adapt to a different context. So, too, was the unspoken communication between Mavis and her siblings, the way they harmo-
30 nized with her, even the way they clapped hands together, a high-speed ripple that approximated an entire percussion section by itself. "I've been singing a long time," Mavis says, "and I could never find anyone to clap like Pervis and Cleedi."

35 But Al Bell never forgot the day in Arkansas when the teenage Mavis's voice bowled him over and left him in tears in what was essentially a solo performance of "On My Way to Heaven" during a Staples Singers show.

40 "In signing the Staples Singers, I thought of it as signing three acts in one," Bell says. "I wanted to record Pops and Mavis as solo artists. I knew it would add more to them from a personal appearance stand-point, bring them a broader, more diverse audience. I
45 would hear Pops sitting around and just playing his guitar at Stax Records and I thought, 'I've got to get this man down on tape.' His singing, I knew there was a lot more songs that could have been done with Pops as a vocalist, because he was so distinctive. With Mavis I
50 saw no boundaries at all—I saw her walking past all of them."

Steve Cropper had already won the Staples family's trust while recording *Soul Folk in Action*, so Bell had him produce what would be Mavis's self-titled
55 debut album.

"The attitude at Stax was that she's a superstar who nobody really knows about, and we have to figure out how to get her out there," Cropper recalls. "But it wasn't easy, because she puts limits on herself. There
60 were only certain songs she would try. Her upbringing, her feeling about what songs would or wouldn't go down with Pops, gave me the impression she didn't want to go too far too fast. So I approached the whole thing with kid gloves. I didn't want to lose her trust or
65 do something damaging."

Cropper found Pops a thoughtful and willing collaborator in the studio, but there was no question his word still counted more than anyone else's in the family, even though his children were well into adult-
70 hood. "Every now and then, Mavis would reference Pops in terms of putting his foot down about dating," Cropper says. "There were lines he didn't want to cross when it came to his family's well-being, and that included what kind of songs they would sing, what
75 message they would put out."

The guitarist knew he was running a risk present-ing Mavis with a set of secular songs that didn't have any of the gospel or message-oriented underpinnings favored by Pops and the Staples Singers. Whereas her
80 first attempt at cutting a solo single, a cover of "Crying in the Chapel" for Epic Records, had some tenuous reli-gious imagery, the tracks chosen for the *Mavis Staples* solo album were the sort of pop-oriented love and rela-tionship songs that Pops typically shunned.

85 But Mavis was hardly insulated from the pop world as a fan and listener. She swooned over Sam Cooke's "You Send Me" the first time she heard it, and her cover of it on her debut album sounds wistful, as if she were singing both to a newfound love and Cooke's
90 memory.

21. The main purpose of the passage is to:
- **A.** introduce Bell as an important figure in the career of the Staples Singers.
- **B.** compare Mavis Staples to other famous female singers like Ross and Franklin.
- **C.** present a theory that Pops Staples was the driving force behind Mavis Staples's success as a singer.
- **D.** describe Mavis Staples's transition from a quartet singer to a solo artist.

22. It can most reasonably be inferred from the passage that Mavis Staples's relative anonymity in the '60s was puzzling to her fans mainly because she had a:

   F. more distinct voice than her brother, who became more famous than she did.
   G. greater vocal range than many other artists of the time.
   H. voice that reminded fans of singers whose names were on the marquee.
   J. powerful voice and a personal approach to her performances.

23. In the context of the passage, what does the author most nearly mean when he states, "Part of this was by design" (line 10)?

   A. The Staples Singers had perfected their harmonies.
   B. Mavis Staples did not initially desire a solo career.
   C. Female singers in the '60s usually performed solo.
   D. Mavis Staples had planned her career trajectory at a young age.

24. The main purpose of the third paragraph (lines 26–34) is to:

   F. clarify how each member of the Staples Singers contributed to creating the group's unique sound.
   G. show that change was difficult for Mavis Staples because of her musical connection with her family.
   H. explain that Pops Staples chose the songs his family sang during concerts.
   J. describe the performance style of the Staples Singers.

25. The main idea of the seventh paragraph (lines 56–65) is that:

   A. Cropper brought the Staples Singers success by pushing them to try genres outside of their usual repertoire.
   B. Cropper was careful about how he encouraged Mavis Staples to explore new opportunities with her music.
   C. Stax Records was innovative because they took risks by signing unknown singers.
   D. Mavis Staples was initially unwilling to perform without backup singers.

26. Based on the passage, regarding his family, Pops Staples's attitude can best be described as:

   F. tolerant.
   G. resentful.
   H. protective.
   J. ambivalent.

27. As it is used in line 5, the phrase *losing herself* most nearly refers to the way Mavis Staples:

   A. sang as if the song lyrics evoked poignant episodes from her past.
   B. clapped her hands along with a song.
   C. transitioned to a new song when she felt moved by her siblings' harmonies.
   D. danced on stage when her father or brother sang.

28. According to the passage, what event led directly to Mavis Staples becoming the lead singer of the Staples Singers?

   F. Pops Staples leaving the group
   G. Cleedi Staples learning the guitar
   H. Pervis Staples's voice changing
   J. Mavis Staples's voice becoming deeper

29. Based on the passage, Bell's reaction to hearing Mavis Staples's performance of "On My Way to Heaven" can most nearly be described as one of:

   A. utter dismay.
   B. reluctant acceptance.
   C. mild amusement.
   D. deep admiration.

30. The passage indicates that, compared to the songs traditionally chosen by the Staples Singers, the songs chosen for Mavis Staples's first solo album were:

   F. more serious; they focused on global issues.
   G. more pop oriented; they focused on love and relationships.
   H. less personal; they were not originally written for her.
   J. less upbeat; they were not meant to be played on a dance floor.

Passage IV

NATURAL SCIENCE: This passage is adapted from the book *Mycophilia: Revelations from the Weird World of Mushrooms* by Eugenia Bone (©2011 by Eugenia Bone).

There are a number of fungi that live in mutualist relationships in which a balance of interests occurs between two organisms. Lichen has a mutualistic relationship with photosynthesizing algae and bacteria.
5 And there are also commensal relationships, where the fungus may not be doing the host any good or any harm, either—the raison d'être of some yeasts in our body, for example, is unknown and may be commensal. But mycorrhizal fungi are the princes of mutualism.
10 "Fungi can't make their own food," said Gary Lincoff. "So they made a strategic choice to team up with plants."

Ninety percent of natural land plants are thought to have mycorrhizal fungi partners. It's a masterpiece of
15 evolution: Mycorrhizal fungi break down nutrients like phosphorus, carbon, water, and nitrogen into a readily assimilable form and deliver them to the plant in return for sugar produced by the plant via photosynthesis. The fungus needs sugar for energy and to launch its spores,
20 and the tree needs nutrients because (despite what I learned in school) tree roots don't do the job adequately. Tree roots primarily anchor the tree in the soil. While tree roots will absorb moisture if watered and nutrients if fertilized, it is the mycorrhizal fungus *grow-*
25 *ing on and in the tree roots* that provides the tree with the lion's share of its nutrition and water. Mycorrhizal fungi significantly expand the reach of plant roots, and by extending the root system, increase the tree's nutrient and water uptake.

30 In the wild, mycorrhizal fungi are key to not just the health of single trees but to healthy forest ecosystems. A single fungal genotype or clone can colonize the roots and maintain the nutritional requirements of many trees at once. And multiple fungi can colonize the
35 roots of all or most of the trees in a forest. The hyphae, those threadlike strings of cells that are the fungus, function as pathways for shuttling nutrients, water, and organic compounds around the forest. The mycologist Paul Stamets believes that mycorrhizal fungi function
40 as a giant communications network between multiple trees in a forest—he calls it "nature's Internet." Others have described this linkage as the "architecture of the wood-wide web."

Weaker plants are able to tap into this network,
45 too, like hitchhikers on a nutritional superhighway. Young seedlings struggling to grow in the shadow of established trees tap into the larger, older tree's fungal network to improve their nutritional uptake. This network exists to benefit not only established trees and
50 seedlings of the same species but also trees from different species, and at different stages of development. So one multitasking fungus, its hyphae attached to the roots of multiple trees in the forest, can simultaneously provide a different nutritional load as needed to differ-
55 ent trees. It's a couture service.

The old trees in a forest function as hubs for these mycelial networks. "Like spokes of a wheel," said Suzanne Simard, a professor of forestry at the University of British Columbia who studies mycorrhizae. Rhi-
60 zomorphs (ropes of hyphae) connect the foundation tree with other trees—like an express stop on a subway system where lots of local trains come through—and the bigger the tree, the larger the hub. That's because the largest trees have the greatest root system, and the
65 more roots there are, the more real estate there is for the fungus to colonize. "In one forest, we found 47 trees linked by two species of fungi composed of 12 individuals," said Simard. (By individuals, she means two genetically distinct fungal entities.) "Talk about two
70 degrees of separation!" Even nonphotosynthesizing plants take advantage of "the hub." Parasites like the Indian pipe depend totally on mycorrhizal fungi for its nutritive needs. It taps into the nutrients and water provided by the mycorrhizae and connects via the mycor-
75 rhizae to a photosynthesizing plant for sugar.

Despite the fact that fungi are microscopic organisms, the functions they perform are often on an ecosystem or landscape scale. If you could take an x-ray look at the soil, you'd see that underneath the forest duff
80 there is a layer of mycorrhizal mycelium running between, on, and in the roots of plants. It's like a stratum of life between the duff and the soil that holds water and nutrients in the ground. And when that stratum is disrupted, or not present, plants suffer. In fact,
85 ecosystems with inadequate mycorrhizal fungi can experience catastrophic losses of plant biomass.

31. The main purpose of the passage is to:
  A. contrast mutualist relationships with commensal relationships and contend that mycorrhizal fungi have a commensal relationship with plants.
  B. describe mycorrhizal fungi's relationship with plants and explain how this relationship plays an integral role in ecosystems.
  C. summarize how the Internet was inspired by networks of mycorrhizal fungi and clarify how the Internet and mycorrhizal networks are similar.
  D. establish that mycorrhizal fungi pose a threat to forests and suggest a way of curbing their influence on ecosystems.

32. According to the passage, compared to the typical amount of water a tree's roots provide the tree, the typical amount of water mycorrhizal fungi provide the tree is:
  F. about the same.
  G. much larger.
  H. much smaller.
  J. somewhat smaller.

33. The main idea of the fourth paragraph (lines 44–55) is that:

    A. networks of fungi benefit different species of trees at various levels of development.

    B. young seedlings typically tap into the roots of trees that are the same species as the seedlings.

    C. established trees genetically alter fungal networks to benefit different species of trees.

    D. different species of trees can be identified based on their nutritional uptake.

34. The author uses the metaphor of an express stop in a subway system in order to:

    F. explain why parasites are harmful to larger trees.

    G. contrast two distinct mycelial networks.

    H. clarify how larger trees function in a mycelial network.

    J. illustrate how different species of fungi grow to be different sizes.

35. In the passage, the relationship between yeast and the human body is cited as an example of a:

    A. definite commensal relationship.

    B. possible commensal relationship.

    C. definite mutualist relationship.

    D. possible mutualist relationship.

36. The author most likely includes the quote from Lincoff (lines 10–12) to:

    F. suggest that mycorrhizal fungi have a commensal relationship with plants.

    G. contend that mycorrhizal fungi serve the same function as some yeasts in the human body.

    H. indicate why mycorrhizal fungi have a mutualist relationship with plants.

    J. explain why mycorrhizal fungi cannot make their own food.

37. As it is used in line 44, the phrase *tap into* most nearly means:

    A. endorse.

    B. finish.

    C. lift.

    D. use.

38. Based on the passage, young seedlings are often dependent on fungal networks because the seedlings are:

    F. struggling to grow in an established tree's shadow.

    G. trying to defend themselves against parasites.

    H. in need of a specific nutrient that is unused by established trees.

    J. susceptible to a wider range of diseases than established trees are.

39. Based on the passage, the author would most likely agree that Indian pipe's level of dependency on mycorrhizal fungi is:

    A. absolute.

    B. about the same as its dependence on nonphotosynthesizing plants.

    C. less than its dependence on nonphotosynthesizing plants.

    D. uncertain.

40. Which of the following statements, if true, would most WEAKEN the claim made by the author in lines 83–86 of the passage?

    F. Over a three-year span, two forests with different tree types increase the amount of mycorrhizal mycelium at the same rate.

    G. Over a three-year span, two forests with the same amount of mycorrhizal mycelium both lost the majority of their plant biomass.

    H. During a given year, after the majority of mycorrhizal mycelium dies in a forest, the plants in the forests flourish.

    J. During a given year, after the majority of mycorrhizal mycelium dies in a forest, the plants in the forests suffer.

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

The freezing point of an aqueous solution (T_f), in °C, can be calculated using the equation

$$T_f = -1.86 \times m \times i$$

where m is the concentration of the solute in moles of solute per kilogram of H_2O (mol/kg H_2O) and i is the average number of particles produced by 1 formula unit of the solute when the formula unit dissolves in H_2O. The *theoretical i value* of a solute is the total number of particles produced when 1 formula unit of the solute dissolves in H_2O. Table 1 gives, for 4 ionic compounds, the chemical formula and the theoretical i value. Table 2 shows how the *observed i value* at 25°C for these compounds changes with solute concentration.

Table 1		
Name	Chemical formula	Theoretical *i* value
Sodium chloride	NaCl	2
Potassium chloride	KCl	2
Magnesium chloride	$MgCl_2$	3
Ammonium sulfate	$(NH_4)_2SO_4$	3

Table 2				
Concentration of aqueous solution (mol/kg H_2O)	Observed *i* value at 25°C for:			
	NaCl	KCl	$MgCl_2$	$(NH_4)_2SO_4$
0.1	1.87	1.85	2.58	2.30
0.2	1.85	1.83	2.63	2.19
0.3	1.84	1.81	2.68	2.12
0.4	1.84	1.80	2.76	2.07
0.5	1.84	1.80	2.84	2.03
0.6	1.85	1.80	2.92	2.00
0.7	1.85	1.79	3.01	1.97
0.8	1.86	1.79	3.11	1.96
0.9	1.86	1.79	3.21	1.94
1.0	1.87	1.80	3.32	1.92
2.0	1.97	1.83	4.57	1.87

Table 2 adapted from B. A. Kunkel, "Comments on 'A Generalized Equation for the Solution Effect in Droplet Growth.'" ©1969 by American Meteorological Society.

1. Based on Table 2, what is the observed i value for a 0.6 mol/kg H_2O solution of $(NH_4)_2SO_4$?

   A. 1.97
   B. 2.00
   C. 2.03
   D. 2.92

2. According to Table 2, which compounds have observed i values less than 2.50 at all the concentrations listed?

   F. NaCl, KCl, and $MgCl_2$ only
   G. NaCl, KCl, and $(NH_4)_2SO_4$ only
   H. KCl, $MgCl_2$, and $(NH_4)_2SO_4$ only
   J. NaCl, KCl, $MgCl_2$, and $(NH_4)_2SO_4$

3. According to Table 2, at which of the following concentrations is the observed i value for KCl the *lowest* ?

   A. 0.3 mol/kg H_2O
   B. 0.6 mol/kg H_2O
   C. 0.9 mol/kg H_2O
   D. 2.0 mol/kg H_2O

4. Based on Tables 1 and 2, which ionic compound has the largest deviation from its theoretical i value at a concentration of 2.0 mol/kg H_2O ?

   F. NaCl
   G. KCl
   H. $MgCl_2$
   J. $(NH_4)_2SO_4$

5. Consider the following substances: sodium chloride, potassium chloride, magnesium chloride, ammonium sulfate, and water. Which of these substances would be classified as a solvent in the solutions represented in Table 2 ?

   A. Ammonium sulfate only
   B. Water only
   C. Sodium chloride, potassium chloride, and magnesium chloride only
   D. Water, sodium chloride, potassium chloride, magnesium chloride, and ammonium sulfate

6. Sucrose ($C_{12}H_{22}O_{11}$) is a molecular compound and remains intact when it dissolves in water. Based on this information and the passage, would the theoretical i value for $C_{12}H_{22}O_{11}$ more likely be less than that of KCl or greater than that of KCl ?

   F. Less; the theoretical i value for $C_{12}H_{22}O_{11}$ is most likely 1.
   G. Less; the theoretical i value for $C_{12}H_{22}O_{11}$ is most likely 4 or greater.
   H. Greater; the theoretical i value for $C_{12}H_{22}O_{11}$ is most likely 1.
   J. Greater; the theoretical i value for $C_{12}H_{22}O_{11}$ is most likely 4 or greater.

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Passage II

Some mutations in *Escherichia coli* allow the bacteria to survive exposure to an antibiotic. These antibiotic-resistant bacteria may have a different *relative fitness* (a measure of survival and reproductive success) than *E. coli* without mutations. Scientists conducted a study to determine the relative fitness of 5 *E. coli* strains—1 nonmutated (Strain U) and 4 mutated (Strains W, X, Y, and Z)—when the strains were exposed for 24 hr to each of 5 different concentrations of the antibiotic *streptomycin* (see Table 1). The effect of the mutation in each of Strains W–Z is listed in Table 2.

Table 1					
	Relative fitness of *E. coli* exposed for 24 hr to a streptomycin concentration (in µg/mL*) of:				
Strain	0	2	4	6	8
U	1.0	0.5	0.0	0.0	0.0
W	1.2	0.3	0.1	0.0	0.0
X	0.9	0.8	0.5	0.2	0.0
Y	0.7	0.8	0.7	0.5	0.3
Z	1.0	0.1	0.9	0.8	1.5

*micrograms per milliliter

Note: A relative fitness of 0.0 indicates no surviving bacteria.

Table 1 adapted from Viktória Lázár et al., "Bacterial Evolution of Antibiotic Hypersensitivity." ©2013 by EMBO and Macmillan Publishers Limited.

Table 2	
Strain	Effect of mutation
W	Increased rate of cell division
X	Increased rate of streptomycin removal from the cell
Y	Decreased rate of streptomycin entry into the cell
Z	Decreased rate of DNA damage repair

7. Based on Table 1, as streptomycin concentration increased, the relative fitness of Strain Y:

A. increased only.
B. decreased only.
C. increased and then decreased.
D. decreased and then increased.

8. Based on Table 1, if Strain X had been exposed for 24 hr to a streptomycin concentration of 3 µg/mL, its relative fitness would most likely have been:

F. less than 0.5.
G. between 0.5 and 0.8.
H. between 0.8 and 0.9.
J. greater than 0.9.

9. According to Table 2, which of the following statements best describes the effect of the mutation in Strain X cells? Compared to nonmutated *E. coli* cells, Strain X cells move streptomycin:

A. into the cell at a decreased rate.
B. into the cell at an increased rate.
C. out of the cell at a decreased rate.
D. out of the cell at an increased rate.

10. Suppose an equal number of Strain W cells and Strain X cells were exposed for 24 hr to a streptomycin concentration of 2 µg/mL. Based on Table 1, which of Strain W or Strain X would more likely have the greater number of cells survive and reproduce?

F. Strain W; Strain W had a relative fitness of 0.3, and Strain X had a relative fitness of 0.8.
G. Strain W; Strain W had a relative fitness of 1.2, and Strain X had a relative fitness of 0.9.
H. Strain X; Strain X had a relative fitness of 0.8, and Strain W had a relative fitness of 0.3.
J. Strain X; Strain X had a relative fitness of 0.9, and Strain W had a relative fitness of 1.2.

40

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11. Consider the mutated strain with an increased rate of cell division. According to Table 1, what was the relative fitness of this strain when it was exposed for 24 hr to a streptomycin concentration of 4 µg/mL ?

    A. 0.0
    B. 0.1
    C. 0.5
    D. 0.7

12. In the study, the relative fitness of a nonmutated strain that was grown for 24 hr in the absence of an antibiotic was set to 1.0. Was this strain more likely Strain U or Strain Z, and was this strain grown for 24 hr at a streptomycin concentration of 0 µg/mL or at a streptomycin concentration of 8 µg/mL ?

    F. Strain U; 0 µg/mL
    G. Strain U; 8 µg/mL
    H. Strain Z; 0 µg/mL
    J. Strain Z; 8 µg/mL

Passage III

Antimony trioxide (Sb_2O_3) is a chemical compound that is used as a flame retardant in manufacturing plastic bottles made of *polyethylene terephthalate* (PET). PET bottles can retain some Sb_2O_3 after manufacturing, and small amounts of the antimony ion (Sb^{3+}) can be absorbed out of the plastic by water stored in those bottles. Two experiments were performed to study the absorption of Sb^{3+} by water stored in clear plastic bottles made of PET.

Experiment 1

The following steps were performed:

1. An unused PET bottle was filled with 2.0 L of pure water and sealed.

2. The bottle was placed into a box that was maintained at 10°C. An ultraviolet (UV) lightbulb was mounted inside the box (see diagram); only UV light was shone upon the bottle for 16 hr.

diagram
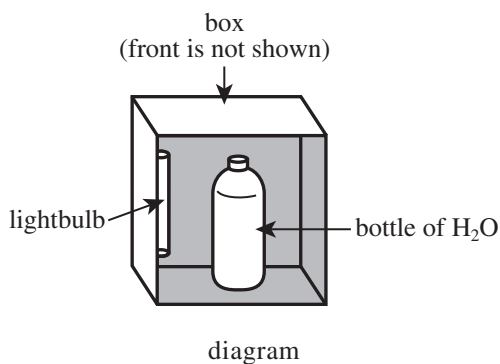
3. The bottle was then removed from the box, opened, and a 2.0 mL sample of water was removed. The concentration of Sb^{3+} in the sample of water, in nanograms per liter (ng/L; 1 ng = 10^{-9} g), was determined.

4. The bottle was emptied, cleaned, and air-dried.

5. The same bottle was then refilled with 2.0 L of pure water and sealed.

6. Steps 2–5 were repeated until the bottle had been reused 28 times at the temperature of 10°C.

Steps 1–6 were repeated 2 more times, except that the box was maintained at temperatures of 30°C and 50°C, respectively. The results for each of the 3 temperatures are shown in Figure 1.
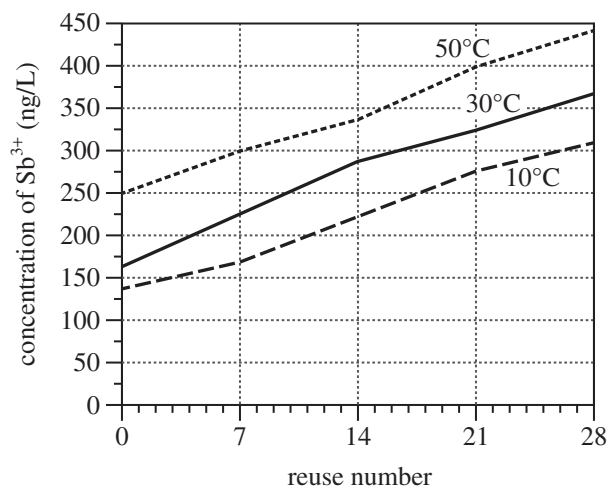
Figure 1

Experiment 2

The procedure in Experiment 1 was repeated, except that in Step 2, the lightbulb inside the box was one that emitted only visible light. The results for each of the 3 temperatures are shown in Figure 2.
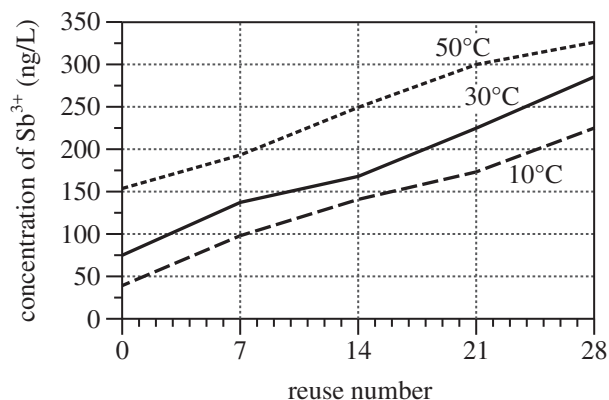
Figure 2

13. How many times in Experiment 2 was a bottle placed into the box when the box was maintained at 10°C ?

   A. 7
   B. 14
   C. 29
   D. 58

14. Suppose that in Experiment 2 the bottle containing water stored at 50°C had been reused 35 times. At that reuse number, the approximate concentration of Sb^{3+} in the water would have been:

   F. less than 270 ng/L.
   G. between 270 ng/L and 300 ng/L.
   H. between 300 ng/L and 330 ng/L.
   J. greater than 330 ng/L.

15. Assume that the maximum acceptable concentration of Sb^{3+} in drinking water is 6,000 ng/L. This concentration of Sb^{3+} is how many times as great as the concentration of Sb^{3+} in water stored at 50°C in a bottle that was reused 21 times in Experiment 2 ?

   A. 2
   B. 3
   C. 20
   D. 30

16. Which set of experimental conditions resulted in an Sb^{3+} concentration of 140 ng/L in water stored in a bottle that had been reused 14 times?

   F. 10°C, UV light
   G. 10°C, visible light
   H. 30°C, UV light
   J. 30°C, visible light

17. The substance composing the bottles tested in the experiments is best classified as which of the following?

   A. Alloy
   B. Polymer
   C. Element
   D. Salt

18. Suppose that in Experiment 1 a temperature of 20°C had been tested. At a reuse number of 21, the Sb^{3+} concentration would most likely have been between:

   F. 125 ng/L and 175 ng/L.
   G. 175 ng/L and 225 ng/L.
   H. 225 ng/L and 275 ng/L.
   J. 275 ng/L and 325 ng/L.

19. Did Experiment 1 and Experiment 2, respectively, take more than 1 day or less than 1 day to complete?

	Experiment 1	Experiment 2
A.	more	more
B.	more	less
C.	less	more
D.	less	less

Passage IV

Introduction

During the *early Earth period* (the first 2 billion years after Earth formed), the Sun produced only about 70% of the light and heat that it does today. Consequently, if early Earth's atmosphere had been identical to Earth's atmosphere today, the average surface temperature would have been well below the freezing point of water. However, geologic evidence indicates that a large amount of liquid water was present on the surface. Two hypotheses were proposed to explain how 3 heat-absorbing greenhouse gases—carbon dioxide (CO_2), ammonia (NH_3), and methane (CH_4)—in early Earth's atmosphere contributed to the presence of liquid water on the surface.

Hypothesis 1

During the early Earth period, volcanic eruptions released both CO_2 and NH_3 into the atmosphere. In addition, microbes produced CH_4 by metabolizing hydrogen (H_2) gas. Compared with atmospheric greenhouse gas concentrations at present day, those on early Earth were considerably greater: the CO_2 concentration was about 100 times as great, the NH_3 concentration was about 20 times as great, and the CH_4 concentration was about 1,000 times as great. These higher-than-present atmospheric concentrations of CO_2, NH_3, and CH_4 absorbed enough heat to maintain an average surface temperature that allowed for liquid water.

Hypothesis 2

The only source of atmospheric CO_2, NH_3, and CH_4 on early Earth was volcanic eruptions. Compared with atmospheric CO_2 and NH_3 concentrations at present day, those on early Earth were somewhat greater: the CO_2 concentration was about 40 times as great and the NH_3 concentration was about 10 times as great. The CH_4 concentration was about the same as its present value. At those concentrations, the 3 gases by themselves would not have absorbed enough heat to raise the average surface temperature above freezing. However, atmospheric concentrations of both nitrogen (N_2) and H_2 were approximately twice what they are today. These higher-than-present concentrations of N_2 and H_2 greatly enhanced the heat-absorbing effects of the 3 greenhouse gases, maintaining an average surface temperature that allowed for liquid water.

20. A supporter of Hypothesis 1 and a supporter of Hypothesis 2 would be likely to agree that, during the early Earth period, magma from beneath Earth's crust contained:

F. carbon compounds but not nitrogen compounds.
G. nitrogen compounds but not carbon compounds.
H. both carbon compounds and nitrogen compounds.
J. neither carbon compounds nor nitrogen compounds.

21. Suppose that the current atmospheric CO_2 concentration on Earth is approximately 395 parts per million (ppm). Based on Hypothesis 2, the atmospheric CO_2 concentration on early Earth was most likely closest to which of the following values?

A. 395 ppm
B. 15,800 ppm
C. 39,500 ppm
D. 197,500 ppm

22. Which of the hypotheses, if either, indicated that 2 additional gases were necessary for CO_2, NH_3, and CH_4 to absorb enough heat for liquid water to exist on early Earth's surface?

F. Hypothesis 1 only
G. Hypothesis 2 only
H. Both Hypothesis 1 and Hypothesis 2
J. Neither Hypothesis 1 nor Hypothesis 2

23. In regard to the source of CH_4 in early Earth's atmosphere, which of the following statements describes a difference between Hypothesis 1 and Hypothesis 2 ? According to Hypothesis 1, CH_4 was:

A. released from volcanic eruptions, whereas according to Hypothesis 2, CH_4 was produced by microbial metabolism.
B. released from volcanic eruptions, whereas according to Hypothesis 2, CH_4 was produced by chemical reactions between CO_2 and H_2O.
C. produced by microbial metabolism, whereas according to Hypothesis 2, CH_4 was released from volcanic eruptions.
D. produced by microbial metabolism, whereas according to Hypothesis 2, CH_4 was produced by chemical reactions between CO_2 and H_2O.

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24. The metabolism of the microbes referred to in Hypothesis 1 is most likely represented by which of the following balanced chemical equations?

   F. $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$
   G. $CO_2 + 2H_2O \rightarrow CH_4 + 2O_2$
   H. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
   J. $CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$

25. Hypothesis 1 would be best supported by which of the following findings involving CO_2 or CH_4 ?

   A. Evidence that 4 billion years ago the concentration of CO_2 was 20 times the present concentration
   B. Evidence that 4 billion years ago the concentration of CH_4 was 20 times the present concentration
   C. 3.5-billion-year-old rock samples containing evidence of CO_2 produced by microbes
   D. 3.5-billion-year-old rock samples containing evidence of CH_4 produced by microbes

26. Suppose that if Earth's atmospheric N_2 concentration were increased from its present value, the atmosphere would scatter a higher percentage of incoming sunlight, resulting in cooler surface temperatures. This information would *weaken* which of the hypotheses, if either?

   F. Hypothesis 1 only
   G. Hypothesis 2 only
   H. Both Hypothesis 1 and Hypothesis 2
   J. Neither Hypothesis 1 nor Hypothesis 2

Passage V

Viscous fluid flow occurs when various parts of a fluid interact with each other to produce forces that inhibit flow and generate heat. Students performed 3 studies of viscous fluid flow using the experimental setup shown in Figure 1 below.
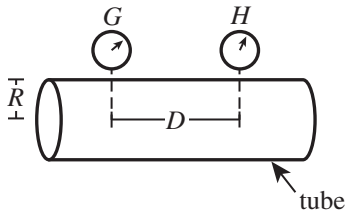
Figure 1

In each trial of the studies, the students sent a fluid through a tube such that the fluid completely filled the tube. The fluid had a viscosity η; the tube had a radius R and was fitted with 2 pressure gauges, Gauge G and Gauge H, that were a distance D apart. The pressure of the fluid at Gauge G minus the pressure of the fluid at Gauge H always equaled 5 kilopascals. (A *kilopascal*, kPa, is a unit of pressure, which is defined as force per unit area.) Using a flow meter, the students measured the fluid's flow rate through the tube, F, in milliliters per second (mL/sec).

Study 1

The students measured F for various fluids, each having a different η, that flowed, one at a time, through a tube having an R of 5.00 mm and a D of 1.00 m (see Table 1).

Table 1	
η (10^{-3} Pa·sec*)	F (mL/sec)
1.00	1,230
2.00	615
3.00	410
4.00	307
5.00	246
*pascal second	

Study 2

The students measured F for a fluid having an η of 1.0×10^{-3} Pa·sec that flowed through each of various tubes having the same D, 1.00 m, but different R (see Table 2).

Table 2	
R (mm)	F (mL/sec)
1.00	1.97
2.00	31.5
3.00	159
4.00	504
5.00	1,230

Study 3

The students measured F for a fluid having an η of 1.0×10^{-3} Pa·sec that flowed through each of various tubes having the same R, 5.00 mm, but different D (see Table 3).

Table 3	
D (m)	F (mL/sec)
0.50	2,460
1.00	1,230
1.50	820
2.00	615
2.50	492

27. Suppose that a sixth trial had been performed in Study 1 for which the fluid's flow rate had equaled 920 mL/sec. In that trial, the viscosity of the fluid would most likely have been:

A. less than 1.00×10^{-3} Pa·sec.
B. between 1.00×10^{-3} Pa·sec and 2.00×10^{-3} Pa·sec.
C. between 2.00×10^{-3} Pa·sec and 3.00×10^{-3} Pa·sec.
D. greater than 3.00×10^{-3} Pa·sec.

28. In Study 2, which variables were held constant?

   F. R and F
   G. F and η
   H. η and D
   J. R and D

29. Based on the information given, if the pressure at Gauge G was 105 kPa, what was the pressure at Gauge H ?

   A.   95 kPa
   B. 100 kPa
   C. 105 kPa
   D. 110 kPa

30. Based on the information given, in what direction was the fluid flowing?

   F. From Gauge G toward Gauge H, because the pressure at Gauge G was greater than the pressure at Gauge H.
   G. From Gauge G toward Gauge H, because the pressure at Gauge G was less than the pressure at Gauge H.
   H. From Gauge H toward Gauge G, because the pressure at Gauge H was greater than the pressure at Gauge G.
   J. From Gauge H toward Gauge G, because the pressure at Gauge H was less than the pressure at Gauge G.

31. The viscosity of each fluid investigated in the studies resulted from which of the following types of interaction between parts of the fluid?

   A. Friction
   B. Combustion
   C. Magnetism
   D. Gravity

32. In Study 3, when D was equal to 2.50 m, approximately what volume of fluid flowed past either gauge in 1 *minute* ?

   F. 25,000 mL
   G. 30,000 mL
   H. 37,000 mL
   J. 49,000 mL

33. The *pressure gradient* between any 2 points lying on a horizontal line inside a tube equaled the absolute value of the difference in pressure between the 2 points divided by the distance between the 2 points. What was the pressure gradient between Gauges G and H during Study 1 ?

   A. 5 kPa/m
   B. 1 kPa/m
   C. 5 kPa/mm
   D. 1 kPa/mm

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Passage VI

Wheat growth is negatively affected by higher-than-normal salt (NaCl) concentrations in the soil. Scientists investigated whether the negative effects are countered by adding to the soil either a species of bacteria (Species R) or a mixture of proteins from marine algae (PMA).

Study 1

First, 240 identical 2 L pots were each filled with 1.5 kg of a certain soil. Next, 5 wheat seeds were planted in each pot, and the pots were divided equally into 4 groups (Groups 1–4). Then, all the pots in each group received 1 of 4 treatments (see Table 1).

Table 1	
Group	Treatment
1	0.5 L of H_2O
2	0.5 L of H_2O containing 9.3 g/L of NaCl
3	0.5 L of H_2O containing Species R and 9.3 g/L of NaCl
4	0.5 L of H_2O containing PMA and 9.3 g/L of NaCl

Note: The addition of 9.3 g/L of NaCl to the pots in Groups 2–4 resulted in a higher-than-normal NaCl concentration in the soil in those pots.

After treatment, each pot was irrigated once every 3 days with either 0.5 L of H_2O only (Group 1) or 0.5 L of H_2O containing 9.3 g/L of NaCl (Groups 2–4). The average number of seeds germinated per pot was then determined for each group at 3, 5, 7, and 9 days after treatment (see Table 2).

	Table 2			
Days after treatment	Average number of seeds germinated per pot			
	Group 1	Group 2	Group 3	Group 4
3	4.8	0.0	1.1	2.8
5	5.0	0.0	4.3	4.0
7	5.0	0.2	5.0	4.6
9	5.0	0.4	5.0	4.8

Study 2

An additional 240 of the 2 L pots were prepared, treated, and irrigated as in Study 1. Nine days after treatment, all but 1 seedling were removed from each of the pots that had multiple seedlings. Each pot was then irrigated as in Study 1 for an additional 75 days. The average plant height was then determined for each group (see Figure 1).
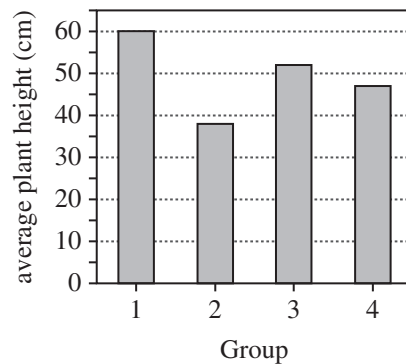

Figure 1

Table 2 and Figure 1 adapted from Elhafid Nabti et al., "Restoration of Growth of Durum Wheat (*Triticum durum* var. waha) Under Saline Conditions Due to Inoculation with the Rhizosphere Bacterium *Azospirillum brasilense* NH and Extracts of the Marine Alga *Ulva lactuca*." ©2010 by Springer Science and Business Media, LLC.

34. According to the results of Study 1, from 3 days after treatment through 9 days after treatment, the average number of seeds that had germinated per pot for Group 4:

- **F.** increased only.
- **G.** decreased only.
- **H.** increased and then remained constant.
- **J.** decreased and then remained constant.

35. Based on the results of Study 2, how many of the groups had an average plant height greater than 1 *meter* ?

- **A.** 0
- **B.** 1
- **C.** 3
- **D.** 4

36. The presence of more than 1 plant in a pot can negatively affect the growth of all the plants in the pot, due to competition among the plants. What action was taken in Study 2 to prevent competition among the plants?

- **F.** Only one seed was planted per pot.
- **G.** Only one seedling was planted per pot.
- **H.** After an initial period of growth, all seeds except one were removed from each pot that had multiple seeds.
- **J.** After an initial period of growth, all seedlings except one were removed from each pot that had multiple seedlings.

37. Consider the claim "The average height of the plants in a group was affected by the number of days that the pots in that group were irrigated." Can this claim be evaluated on the basis of the results of Study 2 ?

- **A.** Yes, because the number of days of irrigation was the same for all the groups.
- **B.** Yes, because the number of days of irrigation was different for each group.
- **C.** No, because the number of days of irrigation was the same for all the groups.
- **D.** No, because the number of days of irrigation was different for each group.

38. Consider the statement "Treatment with Species R was more effective at promoting seed germination in soil with a higher-than-normal NaCl concentration than was treatment with PMA." Are the results of Study 1 for 5, 7, and 9 days after treatment consistent with this statement?

- **F.** Yes; on each of those days, the average number of seeds germinated per pot was greater for Group 3 than for Group 4.
- **G.** Yes; on each of those days, the average number of seeds germinated per pot was greater for Group 4 than for Group 3.
- **H.** No; on each of those days, the average number of seeds germinated per pot was greater for Group 3 than for Group 4.
- **J.** No; on each of those days, the average number of seeds germinated per pot was greater for Group 4 than for Group 3.

39. Let x represent the number of days after treatment until germination was first observed among the Group 2 pots in Study 1. Based on the results of Study 1, x is given by which of the following expressions?

- **A.** $x < 3$
- **B.** $3 \leq x < 5$
- **C.** $5 < x \leq 7$
- **D.** $x > 7$

40. Consider the statement "On average, plant height was greater for the plants treated with H_2O containing PMA and NaCl than it was for the plants treated with either H_2O containing NaCl only or H_2O containing Species R and NaCl." Do the results of Study 2 support this statement?

- **F.** Yes; the average plant height in Group 3 was greater than the average plant height in Groups 2 and 4.
- **G.** Yes; the average plant height in Group 4 was greater than the average plant height in Groups 2 and 3.
- **H.** No; the average plant height in Group 3 was greater than that in Group 2 but less than that in Group 4.
- **J.** No; the average plant height in Group 4 was greater than that in Group 2 but less than that in Group 3.

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.

Scoring Keys for Form E23

Use the scoring key for each test to score your answer document for the multiple-choice tests. Mark a "1" in the blank for each question you answered correctly. Add up the numbers in each reporting category and enter the total number correct for each reporting category in the blanks provided. Also enter the total number correct for each test in the blanks provided. The total number correct for each test is the sum of the number correct in each reporting category.

Test 1: English—Scoring Key

*Reporting Categories
POW = Production of Writing
KLA = Knowledge of Language
CSE = Conventions of Standard English

Key		POW	KLA	CSE
1.	D			___
2.	J			___
3.	C		___	
4.	F			___
5.	A	___		
6.	F		___	
7.	C			___
8.	J			___
9.	C	___		
10.	F			___
11.	B			___
12.	F	___		
13.	B			___
14.	H			___
15.	B	___		
16.	J	___		
17.	C			___
18.	J	___		
19.	B			___
20.	H	___		
21.	A		___	
22.	H	___		
23.	A			___
24.	H			___
25.	D			___
26.	F		___	
27.	B	___		
28.	J		___	
29.	D	___		
30.	G	___		
31.	A			___
32.	G	___		
33.	C			___
34.	J		___	
35.	D			___
36.	J			___
37.	C			___
38.	F	___		

Key		POW	KLA	CSE
39.	D			___
40.	G			___
41.	B	___		
42.	F			___
43.	C			___
44.	G			___
45.	B			___
46.	J			___
47.	C	___		
48.	F			___
49.	A			___
50.	J			___
51.	A			___
52.	G		___	
53.	B		___	
54.	G	___		
55.	C		___	
56.	H			___
57.	D	___		
58.	H			___
59.	B	___		
60.	J	___		
61.	D		___	
62.	F			___
63.	B			___
64.	G	___		
65.	D	___		
66.	H			___
67.	B			___
68.	J		___	
69.	C			___
70.	G	___		
71.	C			___
72.	F			___
73.	C			___
74.	J	___		
75.	A	___		

Number Correct (Raw Score) for:	
Production of Writing (POW)	_____
	(24)
Knowledge of Language (KLA)	_____
	(11)
Conventions of Standard English (CSE)	_____
	(40)
Total Number Correct for English Test	_____
(POW + KLA + CSE)	(75)

Test 2: Mathematics—Scoring Key

		Reporting Category*						
		PHM						
Key		N	A	F	G	S	IES	MDL
1.	A		___					
2.	G				___			
3.	D						___	
4.	G						___	___
5.	E						___	
6.	K						___	
7.	B						___	
8.	H	___						
9.	B						___	
10.	H			___				
11.	E				___			___
12.	F				___			
13.	E				___			___
14.	J		___					
15.	B						___	
16.	H						___	
17.	A						___	___
18.	H			___				___
19.	C					___		___
20.	H						___	___
21.	A		___					
22.	G		___					
23.	D						___	
24.	H						___	
25.	D					___		___
26.	J			___				___
27.	D	___						___
28.	G					___		___
29.	D					___		
30.	G				___			___

		Reporting Category*						
		PHM						
Key		N	A	F	G	S	IES	MDL
31.	B						___	
32.	J		___					___
33.	A						___	
34.	H						___	___
35.	C						___	
36.	K		___					___
37.	B				___			
38.	H			___				
39.	D						___	
40.	G						___	
41.	B		___					
42.	H	___						
43.	D		___					
44.	G		___					
45.	B		___					
46.	F						___	___
47.	B						___	___
48.	J					___		___
49.	A						___	
50.	J	___						
51.	D				___			___
52.	J						___	___
53.	E	___						
54.	H			___				
55.	A						___	
56.	J	___						
57.	E						___	___
58.	K			___				___
59.	A						___	
60.	J					___		___

Combine the totals of these columns and put in the blank for PHM in the box below.

*Reporting Categories
PHM = Preparing for Higher Math
   N = Number & Quantity
   A = Algebra
   F = Functions
   G = Geometry
   S = Statistics & Probability
IES   = Integrating Essential Skills
MDL = Modeling

Number Correct (Raw Score) for:	
Preparing for Higher Math (PHM)	_____
(N + A + F + G + S)	(35)
Integrating Essential Skills (IES)	_____
	(25)
Total Number Correct for Mathematics Test	_____
(PHM + IES)	(60)
Modeling (MDL)	_____
(Not included in total number correct for	(23)
mathematics test raw score)	

Test 3: Reading—Scoring Key

Key		Reporting Category*			Key		Reporting Category*		
		KID	CS	IKI			KID	CS	IKI
1.	A		___		21.	D		___	
2.	G	___			22.	J	___		
3.	D	___			23.	B	___		
4.	J	___			24.	G		___	
5.	B	___			25.	B	___		
6.	F	___			26.	H	___		
7.	C		___		27.	A		___	
8.	F			___	28.	H	___		
9.	D			___	29.	D	___		
10.	H			___	30.	G	___		
11.	D	___			31.	B		___	
12.	H			___	32.	G	___		
13.	A	___			33.	A	___		
14.	G		___		34.	H		___	
15.	D	___			35.	B	___		
16.	F	___			36.	H		___	
17.	C	___			37.	D		___	
18.	G		___		38.	F	___		
19.	D	___			39.	A	___		
20.	H	___			40.	H			___

*Reporting Categories
KID = Key Ideas & Details
CS = Craft & Structure
IKI = Integration of Knowledge & Ideas

Number Correct (Raw Score) for:	
Key Ideas & Details (KID)	_____ (24)
Craft & Structure (CS)	_____ (11)
Integration of Knowledge & Ideas (IKI)	_____ (5)
Total Number Correct for Reading Test (KID + CS + IKI)	_____ (40)

Test 4: Science—Scoring Key

Key		Reporting Category*			Key		Reporting Category*		
		IOD	SIN	EMI			IOD	SIN	EMI
1.	B	___			21.	B			___
2.	G	___			22.	G			___
3.	C	___			23.	C			___
4.	H	___			24.	F			___
5.	B	___			25.	D			___
6.	F	___			26.	G			___
7.	C	___			27.	B		___	
8.	G		___		28.	H		___	
9.	D	___			29.	B	___		
10.	H	___			30.	F		___	
11.	B	___			31.	A			___
12.	F	___			32.	G	___		
13.	C		___		33.	A	___		
14.	J		___		34.	F	___		
15.	C	___			35.	A	___		
16.	G		___		36.	J		___	
17.	B	___			37.	C		___	
18.	J		___		38.	F			___
19.	A		___		39.	C	___		
20.	H			___	40.	J			___

*Reporting Categories
IOD = Interpretation of Data
SIN = Scientific Investigation
EMI = Evaluation of Models, Inferences & Experimental Results

Number Correct (Raw Score) for:	
Interpretation of Data (IOD)	_____ (18)
Scientific Investigation (SIN)	_____ (12)
Evaluation of Models, Inferences & Experimental Results (EMI)	_____ (10)
Total Number Correct for Science Test (IOD + SIN + EMI)	_____ (40)

Explanation of Procedures Used to Obtain Scale Scores from Raw Scores

On each of the four tests on which you marked any responses, the total number of correct responses yields a raw score. Use the table below to convert your raw scores to scale scores. For each test, locate and circle your raw score or the range of raw scores that includes it in the table below. Then, read across to either outside column of the table and circle the scale score that corresponds to that raw score. As you determine your scale scores, enter them in the blanks provided on the right. The highest possible scale score for each test is 36. The lowest possible scale score for any test on which you marked any responses is 1.

Next, compute the Composite score by averaging the four scale scores. To do this, add your four scale scores and divide the sum by 4. If the resulting number ends in a fraction, round it off to the nearest whole number. (Round down any fraction less than one-half; round up any fraction that is one-half or more.) Enter this number in the blank. This is your Composite score. The highest possible Composite score is 36. The lowest possible Composite score is 1.

ACT Test E23   **Your Scale Score**

English   _____

Mathematics   _____

Reading   _____

Science   _____

Sum of scores   _____

Composite score (sum ÷ 4)   _____

NOTE: If you left a test completely blank and marked no items, do not list a scale score for that test. If any test was completely blank, do not calculate a Composite score.

Scale Score	Test 1 English	Test 2 Mathematics	Test 3 Reading	Test 4 Science	Scale Score
36	73-75	59-60	39-40	39-40	36
35	70-72	57-58	38	38	35
34	68-69	55-56	37	—	34
33	67	54	36	37	33
32	66	53	35	36	32
31	65	51-52	34	35	31
30	63-64	49-50	33	34	30
29	62	47-48	32	—	29
28	60-61	45-46	31	33	28
27	59	42-44	30	32	27
26	57-58	39-41	—	30-31	26
25	55-56	37-38	29	28-29	25
24	52-54	35-36	27-28	26-27	24
23	49-51	32-34	26	24-25	23
22	46-48	30-31	24-25	22-23	22
21	43-45	29	23	21	21
20	40-42	27-28	21-22	19-20	20
19	38-39	25-26	20	18	19
18	36-37	22-24	19	16-17	18
17	34-35	19-21	17-18	15	17
16	32-33	15-18	16	13-14	16
15	28-31	12-14	14-15	12	15
14	26-27	9-11	13	11	14
13	25	7-8	11-12	10	13
12	23-24	6	9-10	9	12
11	19-22	5	8	8	11
10	16-18	4	7	7	10
9	14-15	3	6	6	9
8	12-13	—	5	5	8
7	10-11	2	4	4	7
6	8-9	—	—	3	6
5	6-7	1	3	—	5
4	5	—	2	2	4
3	3-4	—	—	1	3
2	2	—	1	—	2
1	0-1	0	0	0	1

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PO BOX 168
IOWA CITY, IA 52243-0168