

# Reading Test

65 MINUTES, 52 QUESTIONS

Turn to Section 1 of your answer sheet to answer the questions in this section.

## DIRECTIONS

Each passage or pair of passages below is followed by a number of questions. After reading each passage or pair, choose the best answer to each question based on what is stated or implied in the passage or passages and in any accompanying graphics (such as a table or graph).

### Questions 1-10 are based on the following passage.

This passage is adapted from George Eliot, *Silas Marner*. Originally published in 1861. Silas was a weaver and a notorious miser, but then the gold he had hoarded was stolen. Shortly after, Silas adopted a young child, Eppie, the daughter of an impoverished woman who had died suddenly.

Unlike the gold which needed nothing, and must be worshipped in close-locked solitude—which was hidden away from the daylight, was deaf to the song of birds, and started to no human tones—Eppie was a  
5 creature of endless claims and ever-growing desires, seeking and loving sunshine, and living sounds, and living movements; making trial of everything, with trust in new joy, and stirring the human kindness in all eyes that looked on her. The gold had kept his  
10 thoughts in an ever-repeated circle, leading to nothing beyond itself; but Eppie was an object compacted of changes and hopes that forced his thoughts onward, and carried them far away from their old eager pacing towards the same blank  
15 limit—carried them away to the new things that would come with the coming years, when Eppie would have learned to understand how her father Silas cared for her; and made him look for images of that time in the ties and charities that bound together  
20 the families of his neighbors. The gold had asked that

he should sit weaving longer and longer, deafened and blinded more and more to all things except the monotony of his loom and the repetition of his web; but Eppie called him away from his weaving, and  
25 made him think all its pauses a holiday, reawakening his senses with her fresh life, even to the old winter-flies that came crawling forth in the early spring sunshine, and warming him into joy because she had joy.

30 And when the sunshine grew strong and lasting, so that the buttercups were thick in the meadows, Silas might be seen in the sunny mid-day, or in the late afternoon when the shadows were lengthening under the hedgerows, strolling out with uncovered  
35 head to carry Eppie beyond the Stone-pits to where the flowers grew, till they reached some favorite bank where he could sit down, while Eppie toddled to pluck the flowers, and make remarks to the winged things that murmured happily above the bright  
40 petals, calling “Dad-dad’s” attention continually by bringing him the flowers. Then she would turn her ear to some sudden bird-note, and Silas learned to please her by making signs of hushed stillness, that they might listen for the note to come again: so that  
45 when it came, she set up her small back and laughed with gurgling triumph. Sitting on the banks in this way, Silas began to look for the once familiar herbs again; and as the leaves, with their unchanged outline and markings, lay on his palm, there was a sense of  
50 crowding remembrances from which he turned away timidly, taking refuge in Eppie’s little world, that lay lightly on his enfeebled spirit.

As the child's mind was growing into knowledge, his mind was growing into memory: as her life  
 55 unfolded, his soul, long stupefied in a cold narrow prison, was unfolding too, and trembling gradually into full consciousness.

It was an influence which must gather force with every new year: the tones that stirred Silas' heart  
 60 grew articulate, and called for more distinct answers; shapes and sounds grew clearer for Eppie's eyes and ears, and there was more that "Dad-dad" was imperatively required to notice and account for. Also, by the time Eppie was three years old, she  
 65 developed a fine capacity for mischief, and for devising ingenious ways of being troublesome, which found much exercise, not only for Silas' patience, but for his watchfulness and penetration. Sorely was poor Silas puzzled on such occasions by the incompatible  
 70 demands of love.

1

Which choice best describes a major theme of the passage?

- A) The corrupting influence of a materialistic society
- B) The moral purity of young children
- C) The bittersweet brevity of childhood naïveté
- D) The restorative power of parental love

2

As compared with Silas's gold, Eppie is portrayed as having more

- A) vitality.
- B) durability.
- C) protection.
- D) self-sufficiency.

3

Which statement best describes a technique the narrator uses to represent Silas's character before he adopted Eppie?

- A) The narrator emphasizes Silas's former obsession with wealth by depicting his gold as requiring certain behaviors on his part.
- B) The narrator underscores Silas's former greed by describing his gold as seeming to reproduce on its own.
- C) The narrator hints at Silas's former antisocial attitude by contrasting his present behavior toward his neighbors with his past behavior toward them.
- D) The narrator demonstrates Silas's former lack of self-awareness by implying that he is unable to recall life before Eppie.

4

The narrator uses the phrase "making trial of everything" (line 7) to present Eppie as

- A) friendly.
- B) curious.
- C) disobedient.
- D) judgmental.

5

According to the narrator, one consequence of Silas adopting Eppie is that he

- A) has renounced all desire for money.
- B) better understands his place in nature.
- C) seems more accepting of help from others.
- D) looks forward to a different kind of future.

6

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 9-11 (“The gold . . . itself”)
- B) Lines 11-16 (“but Eppie . . . years”)
- C) Lines 41-43 (“Then . . . stillness”)
- D) Lines 61-63 (“shapes . . . for”)

7

What function does the second paragraph (lines 30-52) serve in the passage as a whole?

- A) It presents the particular moment at which Silas realized that Eppie was changing him.
- B) It highlights Silas’s love for Eppie by depicting the sacrifices that he makes for her.
- C) It illustrates the effect that Eppie has on Silas by describing the interaction between them.
- D) It reveals a significant alteration in the relationship between Silas and Eppie.

8

In describing the relationship between Eppie and Silas, the narrator draws a connection between Eppie’s

- A) physical vulnerability and Silas’s emotional fragility.
- B) expanding awareness and Silas’s increasing engagement with life.
- C) boundless energy and Silas’s insatiable desire for wealth.
- D) physical growth and Silas’s painful perception of his own mortality.

9

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 1-9 (“Unlike . . . her”)
- B) Lines 30-41 (“And when . . . flowers”)
- C) Lines 46-48 (“Sitting . . . again”)
- D) Lines 53-57 (“As the . . . consciousness”)

10

As used in line 65, “fine” most nearly means

- A) acceptable.
- B) delicate.
- C) ornate.
- D) keen.

**Questions 11-21 are based on the following passage and supplementary material.**

This passage is adapted from David Rotman, “How Technology Is Destroying Jobs.” ©2013 by MIT Technology Review.

MIT business scholars Erik Brynjolfsson and Andrew McAfee have argued that impressive advances in computer technology—from improved industrial robotics to automated translation services—are largely behind the sluggish employment growth of the last 10 to 15 years. Even more ominous for workers, they foresee dismal prospects for many types of jobs as these powerful new technologies are increasingly adopted not only in manufacturing, clerical, and retail work but in professions such as law, financial services, education, and medicine.

That robots, automation, and software can replace people might seem obvious to anyone who’s worked in automotive manufacturing or as a travel agent. But Brynjolfsson and McAfee’s claim is more troubling and controversial. They believe that rapid technological change has been destroying jobs faster than it is creating them, contributing to the stagnation of median income and the growth of inequality in the United States. And, they suspect, something similar is happening in other technologically advanced countries.

As evidence, Brynjolfsson and McAfee point to a chart that only an economist could love. In economics, productivity—the amount of economic value created for a given unit of input, such as an hour of labor—is a crucial indicator of growth and wealth creation. It is a measure of progress. On the chart Brynjolfsson likes to show, separate lines represent productivity and total employment in the United States. For years after World War II, the two lines closely tracked each other, with increases in jobs corresponding to increases in productivity. The pattern is clear: as businesses generated more value from their workers, the country as a whole became richer, which fueled more economic activity and created even more jobs. Then, beginning in 2000, the

lines diverge; productivity continues to rise robustly, but employment suddenly wilts. By 2011, a significant gap appears between the two lines, showing economic growth with no parallel increase in job creation. Brynjolfsson and McAfee call it the “great decoupling.” And Brynjolfsson says he is confident that technology is behind both the healthy growth in productivity and the weak growth in jobs.

It’s a startling assertion because it threatens the faith that many economists place in technological progress. Brynjolfsson and McAfee still believe that technology boosts productivity and makes societies wealthier, but they think that it can also have a dark side: technological progress is eliminating the need for many types of jobs and leaving the typical worker worse off than before. Brynjolfsson can point to a second chart indicating that median income is failing to rise even as the gross domestic product soars. “It’s the great paradox of our era,” he says. “Productivity is at record levels, innovation has never been faster, and yet at the same time, we have a falling median income and we have fewer jobs. People are falling behind because technology is advancing so fast and our skills and organizations aren’t keeping up.”

While technological changes can be painful for workers whose skills no longer match the needs of employers, Lawrence Katz, a Harvard economist, says that no historical pattern shows these shifts leading to a net decrease in jobs over an extended period. Katz has done extensive research on how technological advances have affected jobs over the last few centuries—describing, for example, how highly skilled artisans in the mid-19th century were displaced by lower-skilled workers in factories. While it can take decades for workers to acquire the expertise needed for new types of employment, he says, “we never have run out of jobs. There is no long-term trend of eliminating work for people. Over the long term, employment rates are fairly stable. People have always been able to create new jobs. People come up with new things to do.”

Still, Katz doesn’t dismiss the notion that there is something different about today’s digital technologies—something that could affect an even broader range of work. The question, he says, is whether economic history will serve as a useful

85 guide. Will the job disruptions caused by technology  
 be temporary as the workforce adapts, or will we see  
 a science-fiction scenario in which automated  
 processes and robots with superhuman skills take  
 over a broad swath of human tasks? Though Katz  
 90 expects the historical pattern to hold, it is “genuinely  
 a question,” he says. “If technology disrupts enough,  
 who knows what will happen?”

**Figure 1**

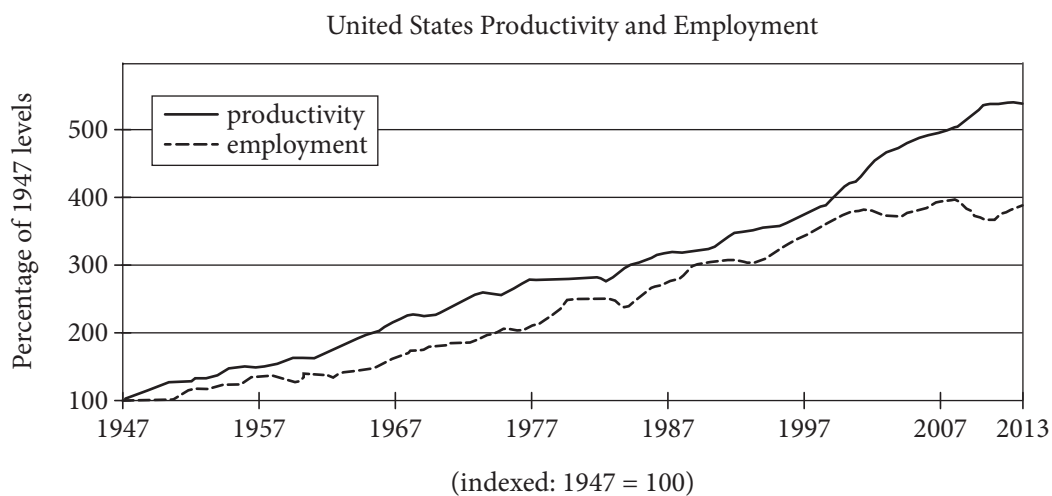
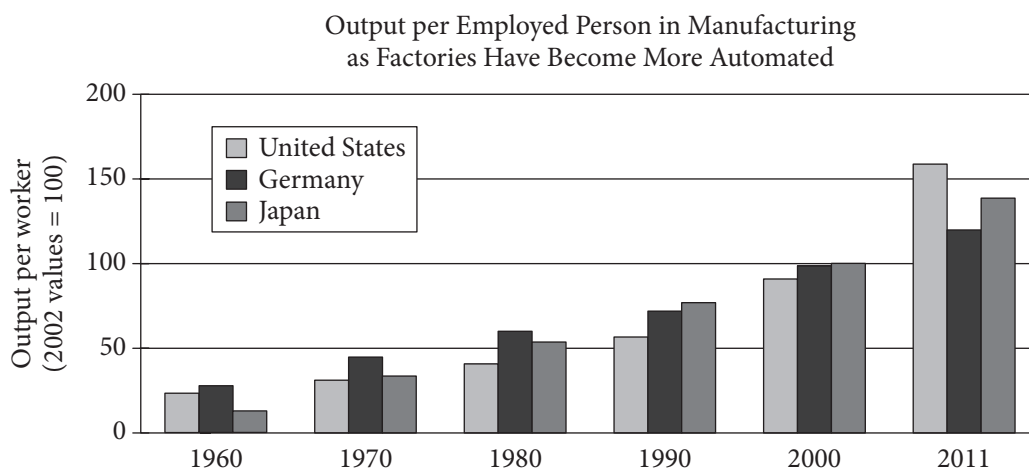


**Figure 2**



11

The main purpose of the passage is to

- A) examine the role of technology in workers' lives during the last century.
- B) advocate for better technology to enhance workplace conditions.
- C) argue for changes in how technology is deployed in the workplace.
- D) assess the impact of advancements in technology on overall job growth.

12

According to Brynjolfsson and McAfee, advancements in technology since approximately the year 2000 have resulted in

- A) low job growth in the United States.
- B) global workplace changes.
- C) more skilled laborers in the United States.
- D) no global creation of new jobs.

13

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 1-6 ("MIT . . . years")
- B) Lines 13-15 ("That . . . agent")
- C) Lines 21-23 ("And . . . countries")
- D) Lines 35-38 ("as businesses . . . jobs")

14

The primary purpose of lines 26-28 ("the amount . . . labor") is to

- A) describe a process.
- B) highlight a dilemma.
- C) clarify a claim.
- D) explain a term.

15

As used in line 35, "clear" most nearly means

- A) pure.
- B) keen.
- C) untroubled.
- D) unmistakable.

16

Which of the following best characterizes Katz's attitude toward "today's digital technologies" (lines 81-82)?

- A) He is alarmed about countries' increasing reliance on them.
- B) He is unconcerned about their effect on the economy.
- C) He is uncertain how they might affect job growth.
- D) He is optimistic that they will spur job creation to a degree not seen since the mid-nineteenth century.

17

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 68-72 (“Katz . . . factories”)
- B) Lines 73-75 (“While . . . jobs”)
- C) Line 79 (“People come . . . do”)
- D) Lines 91-92 (“If . . . happen”)

18

As used in line 83, “range” most nearly means

- A) region.
- B) scope.
- C) distance.
- D) position.

19

According to figure 1, which of the following years showed the widest gap between percentages of productivity and employment?

- A) 1987
- B) 1997
- C) 2007
- D) 2013

20

Which statement is supported by figure 2?

- A) The country with the greatest growth in output per manufacturing worker from 1960 to 1990 was Germany.
- B) Japan experienced its smallest increase in output per manufacturing worker from 2000 to 2011.
- C) Each of the three countries experienced an increase in its output per manufacturing worker from 1960 to 2011.
- D) Of the three countries, the United States had the greatest output per manufacturing worker for each of the years shown.

21

Which additional information, if presented in figure 2, would be most useful in evaluating the statement in lines 57-60 (“Productivity . . . jobs”)?

- A) The median income of employees as it compares across all three countries in a single year
- B) The number of people employed in factories from 1960 to 2011
- C) The types of organizations at which output of employed persons was measured
- D) The kinds of manufacturing tasks most frequently taken over by machines

**Questions 22-31 are based on the following passage.**

This passage is adapted from Patricia Waldron, “Why Birds Fly in a V Formation.” ©2014 by American Association for the Advancement of Science.

Anyone watching the autumn sky knows that migrating birds fly in a V formation, but scientists have long debated why. A new study of ibises finds that these big-winged birds carefully position their wingtips and sync their flapping, presumably to catch the preceding bird’s updraft—and save energy during flight.

There are two reasons birds might fly in a V formation: It may make flight easier, or they’re simply following the leader. Squadrons of planes can save fuel by flying in a V formation, and many scientists suspect that migrating birds do the same. Models that treated flapping birds like fixed-wing airplanes estimate that they save energy by drafting off each other, but currents created by airplanes are far more stable than the oscillating eddies coming off of a bird. “Air gets pretty unpredictable behind a flapping wing,” says James Usherwood, a locomotor biomechanist at the Royal Veterinary College at the University of London in Hatfield, where the research took place.

The study, published in *Nature*, took advantage of an existing project to reintroduce endangered northern bald ibises (*Geronticus eremita*) to Europe. Scientists used a microlight plane to show hand-raised birds their ancestral migration route from Austria to Italy. A flock of 14 juveniles carried data loggers specially built by Usherwood and his lab. The device’s GPS determined each bird’s flight position to within 30 cm, and an accelerometer showed the timing of the wing flaps.

Just as aerodynamic estimates would predict, the birds positioned themselves to fly just behind and to the side of the bird in front, timing their wing beats to catch the uplifting eddies. When a bird flew directly behind another, the timing of the flapping reversed so that it could minimize the effects of the downdraft coming off the back of the bird’s body. “We didn’t think this was possible,” Usherwood says, considering that the feat requires careful flight and incredible awareness of one’s neighbors. “Perhaps these big V formation birds can be thought of quite like an airplane with wings that go up and down.”

The findings likely apply to other long-winged birds, such as pelicans, storks, and geese, Usherwood says. Smaller birds create more complex wakes that would make drafting too difficult. The researchers did not attempt to calculate the bird’s energy savings because the necessary physiological measurements would be too invasive for an endangered species. Previous studies estimate that birds can use 20 percent to 30 percent less energy while flying in a V.

“From a behavioral perspective it’s really a breakthrough,” says David Lentink, a mechanical engineer at Stanford University in Palo Alto, California, who was not involved in the work. “Showing that birds care about syncing their wing beats is definitely an important insight that we didn’t have before.”

Scientists do not know how the birds find that aerodynamic sweet spot, but they suspect that the animals align themselves either by sight or by sensing air currents through their feathers. Alternatively, they may move around until they find the location with the least resistance. In future studies, the researchers will switch to more common birds, such as pigeons or geese. They plan to investigate how the animals decide who sets the course and the pace, and whether a mistake made by the leader can ripple through the rest of the flock to cause traffic jams.

“It’s a pretty impressive piece of work as it is, but it does suggest that there’s a lot more to learn,” says Ty Hedrick, a biologist at the University of North Carolina, Chapel Hill, who studies flight aerodynamics in birds and insects. However they do it, he says, “birds are awfully good hang-glider pilots.”

22

The main purpose of the passage is to

- A) describe how squadrons of planes can save fuel by flying in a V formation.
- B) discuss the effects of downdrafts on birds and airplanes.
- C) explain research conducted to study why some birds fly in a V formation.
- D) illustrate how birds sense air currents through their feathers.

23

The author includes the quotation “Air gets pretty unpredictable behind a flapping wing” (lines 17-18) to

- A) explain that the current created by a bird differs from that of an airplane.
- B) stress the amount of control exerted by birds flying in a V formation.
- C) indicate that wind movement is continuously changing.
- D) emphasize that the flapping of a bird’s wings is powerful.

24

What can reasonably be inferred about the reason Usherwood used northern bald ibises as the subjects of his study?

- A) The ibises were well acquainted with their migration route.
- B) Usherwood knew the ibises were familiar with carrying data loggers during migration.
- C) The ibises have a body design that is similar to that of a modern airplane.
- D) The ibises were easily accessible for Usherwood and his team to track and observe.

25

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 3-7 (“A new . . . flight”)
- B) Lines 10-12 (“Squadrons . . . same”)
- C) Lines 22-24 (“The study . . . Europe”)
- D) Lines 29-31 (“The device’s . . . flaps”)

26

What is the most likely reason the author includes the 30 cm measurement in line 30?

- A) To demonstrate the accuracy with which the data loggers collected the data
- B) To present recorded data about how far an ibis flies between successive wing flaps
- C) To provide the wingspan length of a juvenile ibis
- D) To show how far behind the microlight plane each ibis flew

27

What does the author imply about pelicans, storks, and geese flying in a V formation?

- A) They communicate with each other in the same way as do ibises.
- B) They have the same migration routes as those of ibises.
- C) They create a similar wake to that of ibises.
- D) They expend more energy than do ibises.

28

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 35-38 (“When . . . body”)
- B) Lines 47-48 (“Smaller . . . difficult”)
- C) Lines 52-54 (“Previous . . . a V”)
- D) Lines 66-67 (“Alternatively . . . resistance”)

29

What is a main idea of the seventh paragraph (lines 62-73)?

- A) Different types of hierarchies exist in each flock of birds.
- B) Mistakes can happen when long-winged birds create a V formation.
- C) Future research will help scientists to better understand V formations.
- D) Long-winged birds watch the lead bird closely to keep a V formation intact.

30

The author uses the phrase “aerodynamic sweet spot” in line 63 most likely to

- A) describe how the proper structural design of an airplane helps to save fuel.
- B) show that flying can be an exhilarating experience.
- C) describe the birds’ synchronized wing movement.
- D) suggest that a certain position in a V formation has the least amount of wind resistance.

31

As used in line 72, “ripple” most nearly means

- A) fluctuate.
- B) spread.
- C) wave.
- D) undulate.

**Questions 32-41 are based on the following passages.**

Passage 1 is adapted from Alexis de Tocqueville, *Democracy in America*, Volume 2. Originally published in 1840. Passage 2 is adapted from Harriet Taylor Mill, "Enfranchisement of Women." Originally published in 1851. As United States and European societies grew increasingly democratic during the nineteenth century, debates arose about whether freedoms enjoyed by men should be extended to women as well.

**Passage 1**

I have shown how democracy destroys or modifies the different inequalities which originate in society; but is this all? or does it not ultimately affect  
 Line that great inequality of man and woman which has  
 5 seemed, up to the present day, to be eternally based in human nature? I believe that the social changes which bring nearer to the same level the father and son, the master and servant, and superiors and inferiors generally speaking, will raise woman and  
 10 make her more and more the equal of man. But here, more than ever, I feel the necessity of making myself clearly understood; for there is no subject on which the coarse and lawless fancies of our age have taken a freer range.

15 There are people in Europe who, confounding together the different characteristics of the sexes, would make of man and woman beings not only equal but alike. They would give to both the same functions, impose on both the same duties, and grant  
 20 to both the same rights; they would mix them in all things—their occupations, their pleasures, their business. It may readily be conceived, that by thus attempting to make one sex equal to the other, both are degraded; and from so preposterous a medley of  
 25 the works of nature nothing could ever result but weak men and disorderly women.

It is not thus that the Americans understand that species of democratic equality which may be established between the sexes. They admit, that as  
 30 nature has appointed such wide differences between the physical and moral constitution of man and woman, her manifest design was to give a distinct employment to their various faculties; and they hold

that improvement does not consist in making beings  
 35 so dissimilar do pretty nearly the same things, but in getting each of them to fulfill their respective tasks in the best possible manner. The Americans have applied to the sexes the great principle of political economy which governs the manufactures of our age,  
 40 by carefully dividing the duties of man from those of woman, in order that the great work of society may be the better carried on.

**Passage 2**

As society was constituted until the last few generations, inequality was its very basis; association  
 45 grounded on equal rights scarcely existed; to be equals was to be enemies; two persons could hardly coöperate in anything, or meet in any amicable relation, without the law's appointing that one of them should be the superior of the other.  
 50 Mankind have outgrown this state, and all things now tend to substitute, as the general principle of human relations, a just equality, instead of the dominion of the strongest. But of all relations, that between men and women, being the nearest and  
 55 most intimate, and connected with the greatest number of strong emotions, was sure to be the last to throw off the old rule, and receive the new; for, in proportion to the strength of a feeling is the tenacity with which it clings to the forms and  
 60 circumstances with which it has even accidentally become associated. . . .

. . . The proper sphere for all human beings is the largest and highest which they are able to attain to. What this is, cannot be ascertained without complete  
 65 liberty of choice. . . . Let every occupation be open to all, without favor or discouragement to any, and employments will fall into the hands of those men or women who are found by experience to be most capable of worthily exercising them. There need be  
 70 no fear that women will take out of the hands of men any occupation which men perform better than they. Each individual will prove his or her capacities, in the only way in which capacities can be proved,—by trial; and the world will have the benefit of the best  
 75 faculties of all its inhabitants. But to interfere beforehand by an arbitrary limit, and declare that whatever be the genius, talent, energy, or force of

mind, of an individual of a certain sex or class, those faculties shall not be exerted, or shall be exerted only in some few of the many modes in which others are permitted to use theirs, is not only an injustice to the individual, and a detriment to society, which loses what it can ill spare, but is also the most effectual way of providing that, in the sex or class so fettered, the qualities which are not permitted to be exercised shall not exist.

32

As used in line 9, “raise” most nearly means

- A) increase.
- B) cultivate.
- C) nurture.
- D) elevate.

33

In Passage 1, Tocqueville implies that treatment of men and women as identical in nature would have which consequence?

- A) Neither sex would feel oppressed.
- B) Both sexes would be greatly harmed.
- C) Men would try to reclaim their lost authority.
- D) Men and women would have privileges they do not need.

34

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 15-18 (“There . . . alike”)
- B) Lines 18-20 (“They . . . rights”)
- C) Lines 22-24 (“It may . . . degraded”)
- D) Lines 27-29 (“It is . . . sexes”)

35

As used in line 53, “dominion” most nearly means

- A) omnipotence.
- B) supremacy.
- C) ownership.
- D) territory.

36

In Passage 2, Mill most strongly suggests that gender roles are resistant to change because they

- A) have long served as the basis for the formal organization of society.
- B) are matters of deeply entrenched tradition.
- C) can be influenced by legislative reforms only indirectly.
- D) benefit the groups and institutions currently in power.

37

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 43-44 (“As society . . . basis”)
- B) Lines 46-49 (“two . . . other”)
- C) Lines 58-61 (“in proportion . . . associated”)
- D) Lines 67-69 (“employments . . . them”)

38

Both authors would most likely agree that the changes in gender roles that they describe would be

- A) part of a broad social shift toward greater equality.
- B) unlikely to provide benefits that outweigh their costs.
- C) inevitable given the economic advantages of gender equality.
- D) at odds with the principles of American democracy.

39

Tocqueville in Passage 1 would most likely characterize the position taken by Mill in lines 65-69 in Passage 2 (“Let . . . them”) as

- A) less radical about gender roles than it might initially seem.
- B) persuasive in the abstract but difficult to implement in practice.
- C) ill-advised but consistent with a view held by some other advocates of gender equality.
- D) compatible with economic progress in the United States but not in Europe.

40

Which choice best describes the ways that the two authors conceive of the individual’s proper position in society?

- A) Tocqueville believes that an individual’s position should be defined in important ways by that individual’s sex, while Mill believes that an individual’s abilities should be the determining factor.
- B) Tocqueville believes that an individual’s economic class should determine that individual’s position, while Mill believes that class is not a legitimate consideration.
- C) Tocqueville believes that an individual’s temperament should determine that individual’s position, while Mill believes that temperament should not be a factor in an individual’s position.
- D) Tocqueville believes that an individual’s position should be determined by what is most beneficial to society, while Mill believes it should be determined by what an individual finds most rewarding.

41

Based on Passage 2, Mill would most likely say that the application of the “great principle of political economy” (lines 38-39, Passage 1) to gender roles has which effect?

- A) It prevents many men and women from developing to their full potential.
- B) It makes it difficult for men and women to sympathize with each other.
- C) It unintentionally furthers the cause of gender equality.
- D) It guarantees that women take occupations that men are better suited to perform.

**Questions 42-52 are based on the following passage and supplementary material.**

This passage is adapted from Brian Greene, “How the Higgs Boson Was Found.” ©2013 by Smithsonian Institution. The Higgs boson is an elementary particle associated with the Higgs field. Experiments conducted in 2012–2013 tentatively confirmed the existence of the Higgs boson and thus of the Higgs field.

Nearly a half-century ago, Peter Higgs and a handful of other physicists were trying to understand the origin of a basic physical feature: mass. You can think of mass as an object’s heft or, a little more  
 5 precisely, as the resistance it offers to having its motion changed. Push on a freight train (or a feather) to increase its speed, and the resistance you feel reflects its mass. At a microscopic level, the freight train’s mass comes from its constituent  
 10 molecules and atoms, which are themselves built from fundamental particles, electrons and quarks. But where do the masses of these and other fundamental particles come from?

When physicists in the 1960s modeled the  
 15 behavior of these particles using equations rooted in quantum physics, they encountered a puzzle. If they imagined that the particles were all massless, then each term in the equations clicked into a perfectly symmetric pattern, like the tips of a perfect  
 20 snowflake. And this symmetry was not just mathematically elegant. It explained patterns evident in the experimental data. But—and here’s the puzzle—physicists knew that the particles did have mass, and when they modified the equations to  
 25 account for this fact, the mathematical harmony was spoiled. The equations became complex and unwieldy and, worse still, inconsistent.

What to do? Here’s the idea put forward by Higgs. Don’t shove the particles’ masses down the throat of  
 30 the beautiful equations. Instead, keep the equations pristine and symmetric, but consider them operating within a peculiar environment. Imagine that all of space is uniformly filled with an invisible substance—now called the Higgs field—that exerts a  
 35 drag force on particles when they accelerate through it. Push on a fundamental particle in an effort to increase its speed and, according to Higgs, you would

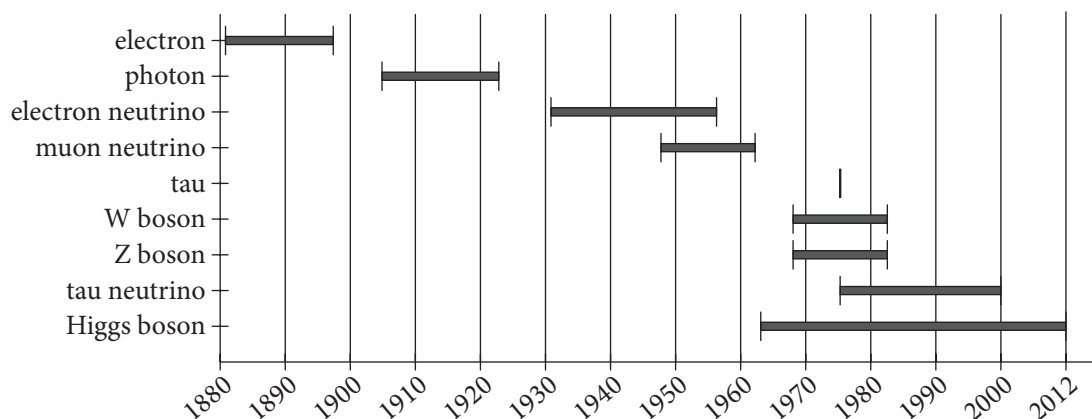
feel this drag force as a resistance. Justifiably, you would interpret the resistance as the particle’s mass.  
 40 For a mental toehold, think of a ping-pong ball submerged in water. When you push on the ping-pong ball, it will feel much more massive than it does outside of water. Its interaction with the watery environment has the effect of endowing it with mass.  
 45 So with particles submerged in the Higgs field.

In 1964, Higgs submitted a paper to a prominent physics journal in which he formulated this idea mathematically. The paper was rejected. Not because it contained a technical error, but because the  
 50 premise of an invisible something permeating space, interacting with particles to provide their mass, well, it all just seemed like heaps of overwrought speculation. The editors of the journal deemed it “of no obvious relevance to physics.”

But Higgs persevered (and his revised paper appeared later that year in another journal), and physicists who took the time to study the proposal gradually realized that his idea was a stroke of genius, one that allowed them to have their cake and eat it  
 60 too. In Higgs’s scheme, the fundamental equations can retain their pristine form because the dirty work of providing the particles’ masses is relegated to the environment.

While I wasn’t around to witness the initial  
 65 rejection of Higgs’s proposal in 1964 (well, I was around, but only barely), I can attest that by the mid-1980s, the assessment had changed. The physics community had, for the most part, fully bought into the idea that there was a Higgs field permeating  
 70 space. In fact, in a graduate course I took that covered what’s known as the Standard Model of Particle Physics (the quantum equations physicists have assembled to describe the particles of matter and the dominant forces by which they influence  
 75 each other), the professor presented the Higgs field with such certainty that for a long while I had no idea it had yet to be established experimentally. On occasion, that happens in physics. Mathematical equations can sometimes tell such a convincing tale,  
 80 they can seemingly radiate reality so strongly, that they become entrenched in the vernacular of working physicists, even before there’s data to confirm them.

Years from Introduction of Concept of Particle to Experimental Confirmation



Adapted from the editors of *The Economist*, "Worth the Wait." ©2012 by The Economist Newspaper Limited.

42

Over the course of the passage, the main focus shifts from

- A) a technical account of the Higgs field to a description of it aimed at a broad audience.
- B) a review of Higgs's work to a contextualization of that work within Higgs's era.
- C) an explanation of the Higgs field to a discussion of the response to Higgs's theory.
- D) an analysis of the Higgs field to a suggestion of future discoveries that might build upon it.

43

The main purpose of the analogy of the ping-pong ball (line 40) is to

- A) popularize a little-known fact.
- B) contrast competing scientific theories.
- C) criticize a widely accepted explanation.
- D) clarify an abstract concept.

44

The author most strongly suggests that the reason the scientific community initially rejected Higgs's idea was that the idea

- A) addressed a problem unnoticed by other physicists.
- B) only worked if the equations were flawless.
- C) rendered accepted theories in physics obsolete.
- D) appeared to have little empirical basis.

45

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 30-32 ("Instead . . . environment")
- B) Lines 46-48 ("In 1964 . . . mathematically")
- C) Lines 48-53 ("Not . . . speculation")
- D) Lines 67-70 ("The physics . . . space")

46

The author notes that one reason Higgs's theory gained acceptance was that it

- A) let scientists accept two conditions that had previously seemed irreconcilable.
- B) introduced an innovative approach that could be applied to additional problems.
- C) answered a question that earlier scientists had not even raised.
- D) explained why two distinct phenomena were being misinterpreted as one phenomenon.

47

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 36-39 ("Push . . . mass")
- B) Lines 43-45 ("Its interaction . . . field")
- C) Lines 55-63 ("But . . . environment")
- D) Lines 78-83 ("On occasion . . . them")

48

Which statement best describes the technique the author uses to advance the main point of the last paragraph?

- A) He recounts a personal experience to illustrate a characteristic of the discipline of physics.
- B) He describes his own education to show how physics has changed during his career.
- C) He provides autobiographical details to demonstrate how Higgs's theory was confirmed.
- D) He contrasts the status of Higgs's theory at two time periods to reveal how the details of the theory evolved.

49

As used in line 77, "established" most nearly means

- A) validated.
- B) founded.
- C) introduced.
- D) enacted.

50

What purpose does the graph serve in relation to the passage as a whole?

- A) It indicates that the scientific community's quick acceptance of the Higgs boson was typical.
- B) It places the discussion of the reception of the Higgs boson into a broader scientific context.
- C) It demonstrates that the Higgs boson was regarded differently than were other hypothetical particles.
- D) It clarifies the ways in which the Higgs boson represented a major discovery.

51

Which statement is best supported by the data presented in the graph?

- A) The W boson and the Z boson were proposed and experimentally confirmed at about the same time.
- B) The Higgs boson was experimentally confirmed more quickly than were most other particles.
- C) The tau neutrino was experimentally confirmed at about the same time as the tau.
- D) The muon neutrino took longer to experimentally confirm than did the electron neutrino.

52

Based on the graph, the author's depiction of Higgs's theory in the mid-1980s is most analogous to which hypothetical situation?

- A) The muon neutrino was widely disputed until being confirmed in the early 1960s.
- B) Few physicists in 2012 doubted the reality of the tau neutrino.
- C) No physicists prior to 1960 considered the possibility of the W or Z boson.
- D) Most physicists in 1940 believed in the existence of the electron neutrino.

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