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

SLEEPLESS is a fruit fly gene involved in sleep regulation. The normal form of this gene (S^+) produces *sleep factor protein*; a mutant form (S^-) does not produce the protein.

Researchers studied the sleep patterns and survival of flies of the same age that had the genotype S^+S^+, S^+S^-, or S^-S^-. Figure 1 shows the amount of sleep, and the number of sleep events, per day per fly for each genotype. Figure 2 shows the amount of *recovery sleep* (additional sleep needed following 6 hr of sleep deprivation) per day per fly for each genotype. Figure 3 shows how percent survival varied with age for each genotype.

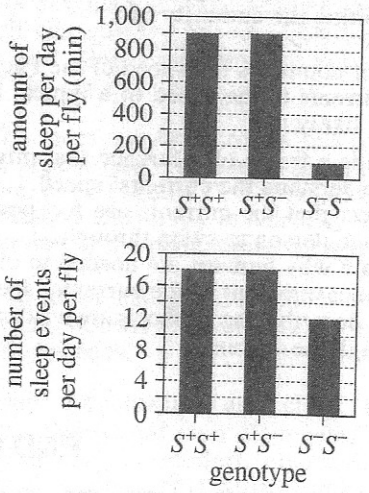


Figure 1

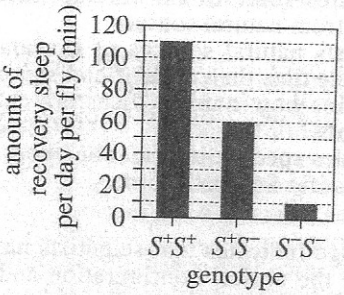


Figure 2

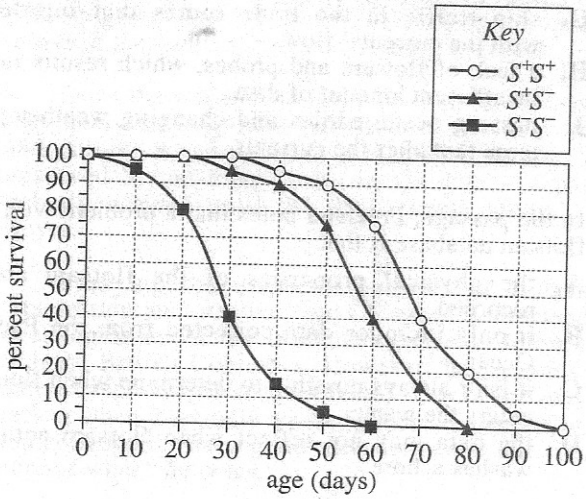


Figure 3

Figures adapted from Kyunghee Koh et al., "Identification of SLEEPLESS, a Sleep-Promoting Factor." ©2008 by the American Association for the Advancement of Science.

1. According to Figures 2 and 3, the flies with the genotype associated with the least amount of recovery sleep per day had a maximum life span of:

   A. 60 days.
   B. 70 days.
   C. 80 days.
   D. 100 days.

2. According to Figure 2, the amount of recovery sleep per day per fly for the S^+S^+ genotype was approximately how many times as great as that for the S^+S^- genotype?

   F. 2
   G. 4
   H. 6
   J. 10

3. Based on Figures 1 and 3, of the flies that had an average of 12 sleep events per day, the percent that reached 35 days of age was most likely closest to which of the following?

   A. 5%
   B. 15%
   C. 25%
   D. 40%

4. According to Figure 1, the amount of sleep per day per fly for the S^-S^- genotype was approximately what percent of the amount of sleep per day per fly for the S^+S^+ genotype?

   F. 10%
   G. 20%
   H. 30%
   J. 50%

5. Suppose that a fly with the genotype S^+S^+ is crossed with a fly with the genotype S^-S^-, resulting in 80 offspring. Based on Figure 3, the number of these offspring still alive at 50 days of age will most likely be closest to which of the following?

   A. 0
   B. 40
   C. 60
   D. 75

Passage II

An object is dropped from a height H above the top of a spring, compressing it. The top of the spring is a distance y below its initial position (see Figure 1) when the spring begins its rebound. At that moment, the object has its maximum upward acceleration, a.

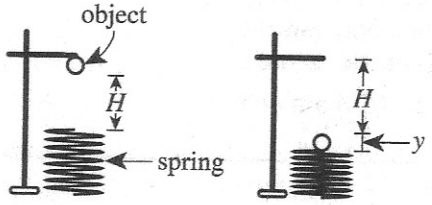


Figure 1

Figure 2 shows, for each of 3 springs—Spring X (the least stiff spring), Spring Y, and Spring Z (the stiffest spring)—a graph of the ratio $\frac{a}{g}$ versus H; g is the acceleration due to gravity.

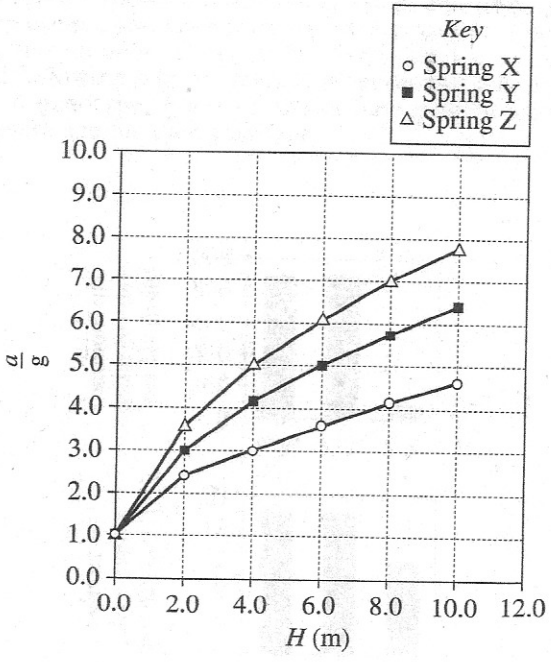


Figure 2

Figure 3 is a graph of y versus H for Spring X.

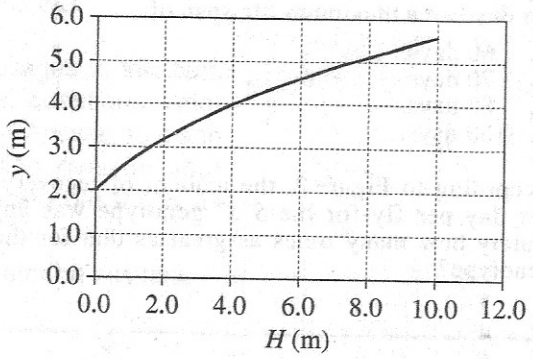


Figure 3

Figure 4 is a graph of the force, F, in newtons (N), exerted by Spring X on the object versus y.

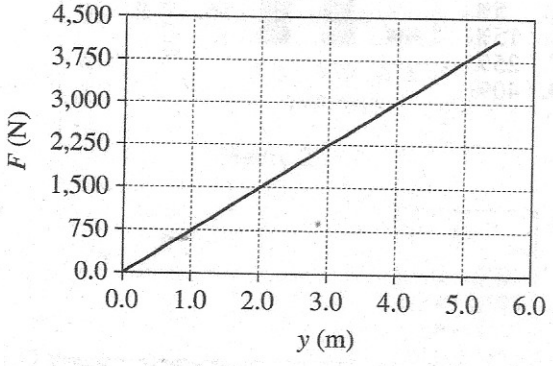


Figure 4

6. Based on Figure 3, if H equals 12 m, y for Spring X is most likely closest to which of the following?

F. 2 m
G. 4 m
H. 6 m
J. 8 m

7. Suppose that another spring, Spring W, is tested using the same procedures as those used with the other 3 springs; assume that the stiffness of Spring W is much greater than that of Spring X, Y, or Z. Based on Figure 2, for $H = 4.0$ m, $\frac{a}{g}$ will most likely be:

   A. less than 3.0.
   B. between 3.0 and 4.0.
   C. between 4.0 and 5.0.
   D. greater than 5.0.

8. Based on the data, when Spring X is compressed its maximum amount, such that the spring begins its rebound, and the force exerted on Spring X equals 3,000 N, the top of the spring is approximately how far below its original position?

   F. 1.0 m
   G. 2.0 m
   H. 3.0 m
   J. 4.0 m

9. The acceleration due to gravity is approximately 10 m/sec^2. Based on Figure 2, when H equals 8.0 m for Spring Z, what approximately is a ?

   A. 10 m/sec^2
   B. 30 m/sec^2
   C. 50 m/sec^2
   D. 70 m/sec^2

10. Why, for a given H, is the object's acceleration greatest when the top of a spring is a distance y meters below its initial position?

    F. The force F is least.
    G. The force F is greatest.
    H. The acceleration g is least.
    J. The acceleration g is greatest.

Passage III

The *tropopause* is the transition between 2 layers of Earth's atmosphere: the *troposphere* (the layer that begins at Earth's surface) and the *stratosphere* (the layer just above the troposphere). Figure 1 shows how air temperature changes with altitude at 3 latitudes (0°, 45° N, and 90° N), as well as the average tropopause altitude for each of those latitudes. Figure 2 shows, for the tropical latitudes, the monthly averages for tropopause altitude, tropopause air pressure, and tropopause air temperature determined for a particular 30-year period.

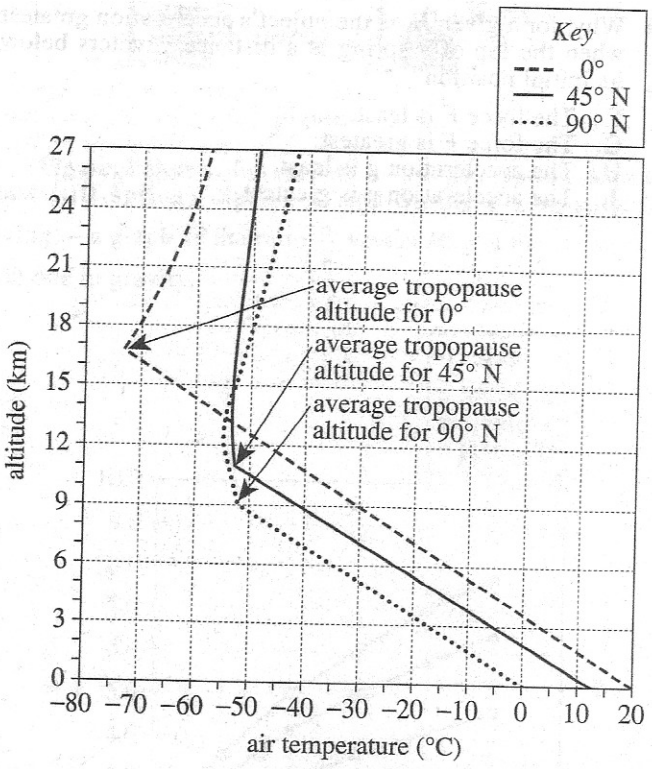


Figure 1

Figure 1 adapted from Frederick Lutgens, Edward Tarbuck, and Dennis Tasa, *The Atmosphere*, 11th ed. ©2001 by Prentice Hall.

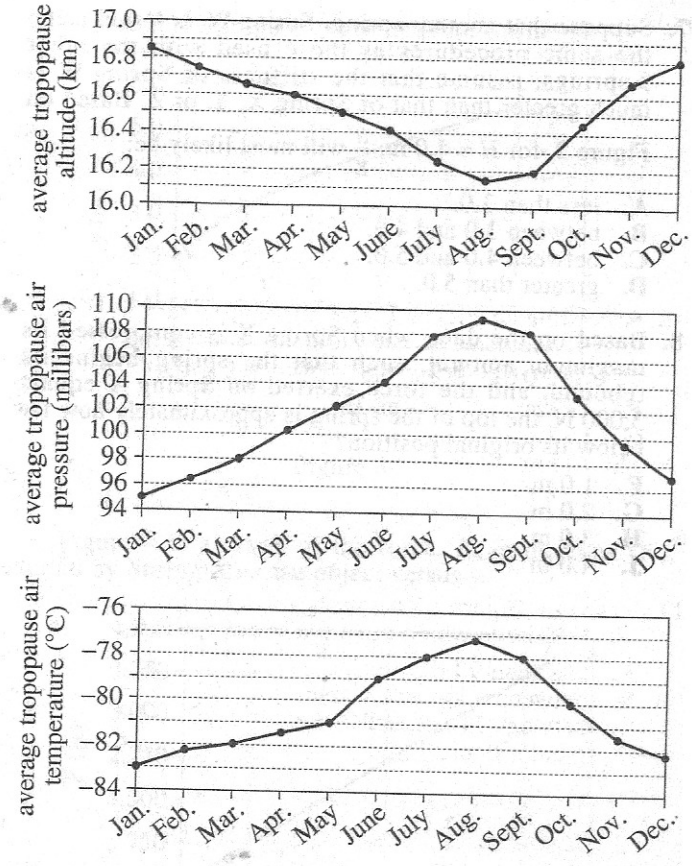


Figure 2

Figure 2 adapted from Dian Seidel et al., "Climatological Characteristics of the Tropical Tropopause as Revealed by Radiosondes." ©2001 by American Geophysical Union.

11. According to Figure 1, at 45° N latitude, the air temperature at Earth's surface is closest to which of the following?

A. −5°C
B. 0°C
C. 12°C
D. 20°C

12. According to Figure 1, the air temperature at 0° latitude is the same as the air temperature at 45° N latitude at an altitude closest to which of the following?

F. 11 km
G. 13 km
H. 15 km
J. 17 km

13. Based on Figure 1, the average tropopause altitude for 30° N latitude would most likely be:

A. less than 9 km.
B. between 9 km and 11 km.
C. between 11 km and 17 km.
D. greater than 17 km.

14. Based on Figure 2, was the average tropopause air pressure inversely related or directly related to the average tropopause altitude?

F. Inversely, because from January to December, as altitude decreased, air pressure decreased, and as altitude increased, air pressure increased.
G. Inversely, because from January to December, as altitude decreased, air pressure increased, and as altitude increased, air pressure decreased.
H. Directly, because from January to December, as altitude decreased, air pressure decreased, and as altitude increased, air pressure increased.
J. Directly, because from January to December, as altitude decreased, air pressure increased, and as altitude increased, air pressure decreased.

15. According to Figure 1, at 0° latitude, how does the air temperature in the troposphere change with increasing altitude from Earth's surface to the tropopause, and how does the air temperature in the stratosphere change with increasing altitude from the tropopause to 27 km ?

	troposphere	stratosphere
A.	increases only	increases only
B.	increases only	decreases only
C.	decreases only	decreases only
D.	decreases only	increases only

Passage IV

Companies W–Z were suspected of diluting pure (100%) honey before packaging it for sale. Students investigated each company's product by using the process of *osmosis*. During osmosis, H_2O flows across a *semipermeable membrane* (such as dialysis tubing) from a solution having a lower solute concentration into one with a higher solute concentration. Smaller molecules (such as H_2O) can pass through tiny pores in the dialysis tubing, but larger molecules (such as sugars) cannot.

Experiment 1

Two mL of 100% honey was mixed with 8 mL of H_2O to form a 20% honey solution. A 40%, a 60%, and an 80% honey solution were also made. A sample of 1 of the 4 solutions, 100% honey, or pure H_2O was added to each of 6 bags made of dialysis tubing. Air was pressed out of the bags, the bags were sealed, and the initial mass of each bag plus its contents was measured. Each bag was fully submerged in a separate beaker of pure H_2O at 25°C for 2 hr. The bags were then removed and dried off, and the final mass of each bag plus its contents was measured (see Table 1).

Table 1

Sample	Initial mass (g)	Final mass (g)	Percent change in mass
20% honey	11.2	13.4	20
40% honey	11.6	15.3	32
60% honey	12.2	17.7	45
80% honey	13.6	24.1	77
100% honey	14.5	28.3	95
Pure H_2O	10.2	10.2	0

Experiment 2

A sample of each company's product was added to a separate bag and tested as in Experiment 1 (see Table 2).

Table 2

Sample from Company	Initial mass (g)	Final mass (g)	Percent change in mass
W	14.1	27.6	96
X	13.8	26.9	95
Y	13.1	24.3	85
Z	13.9	25.0	80

Tables adapted from *Don't Blame the Bees: Teacher's Guide*.

Experiment 3

A sample of Company Z's product was added to 5 bags. The samples were tested as in Experiment 1, except that the bags were submerged in separate beakers containing, respectively, 20%, 40%, 60%, 80%, or 100% honey. The mass of the bag plus its contents increased for 4 of the bags, but decreased for 1 of the bags.

16. Suppose that in Experiment 1 the students had also tested a 70% honey solution. Based on the results of Experiment 1, the percent change in mass would most likely have been between:

F. 20% and 32%.
G. 32% and 45%.
H. 45% and 77%.
J. 77% and 95%.

17. When the students added the samples to the bags in Experiments 1–3, they only partially filled the bags. The most likely reason for this is that the students wanted to allow room for:

A. H_2O to enter the bag.
B. H_2O to exit the bag.
C. the sugar molecules in the honey to enter the bag.
D. the sugar molecules in the honey to exit the bag.

18. In Experiment 1, to make the 60% honey solution, the students most likely mixed which of the following?

F. 4 mL of 100% honey with 4 mL of H_2O
G. 4 mL of 100% honey with 6 mL of H_2O
H. 6 mL of 100% honey with 4 mL of H_2O
J. 6 mL of 100% honey with 6 mL of H_2O

19. According to the results of Experiment 1, for the 40% honey solution, did the mass of the solution in the bag increase or decrease as a result of the bag having been submerged, and why?

A. Increase, because the sample had a lower solute concentration than did the H_2O.
B. Increase, because the sample had a higher solute concentration than did the H_2O.
C. Decrease, because the sample had a lower solute concentration than did the H_2O.
D. Decrease, because the sample had a higher solute concentration than did the H_2O.

20. Based on the results of Experiments 1 and 2, the concentration of honey in the sample from Company Y was most likely:

F. greater than 40% but less than 60%.
G. greater than 60% but less than 80%.
H. greater than 80% but less than 100%.
J. 100%.

21. In Experiment 3, the mass of 1 of the bags plus its contents decreased. This bag had most likely been submerged in the beaker containing:

A. 40% honey.
B. 60% honey.
C. 80% honey.
D. 100% honey.

Passage V

When an electrical current flows through a metal strip in a magnetic field, a magnetic force is exerted on some electrons in the strip. These electrons are pushed to an edge of the strip, making that edge negatively charged (see Figure 1).

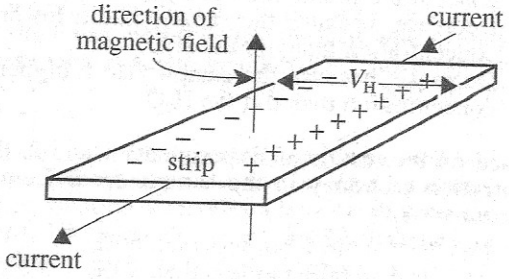


Figure 1

The opposite edge of the strip, which develops a shortage of electrons, becomes positively charged, and so a voltage, V_H, develops between these 2 edges of the strip.

A physics class conducted 3 studies of this phenomenon, called the *Hall effect*.

In each trial of the studies, an aluminum strip having a thickness d was clamped to a ring stand. The 2 ends of the strip were connected to an electrical circuit containing a DC power supply, and the 2 edges of the strip were connected to a voltmeter (see Figure 2).

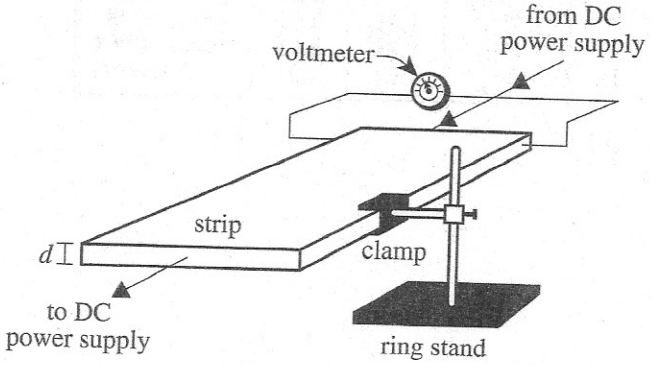


Figure 2

The strip was also positioned horizontally between the poles of an electromagnet (see Figure 3).

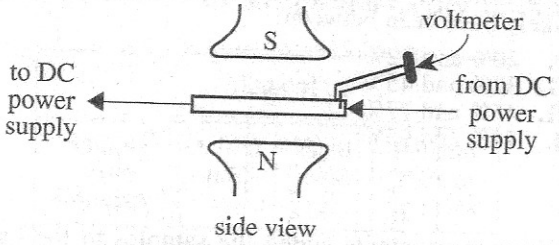


Figure 3

The students adjusted the power supply output as needed so that the desired current, I, flowed through the strip. Finally, the students adjusted the electromagnet as needed to produce the desired magnetic field strength, B, and recorded the resulting V_H.

Study 1

With d equal to 15 mm and B equal to 0.6 tesla (T), the students found V_H, in nanovolts (nV; 1 nV = 10^{-9} V), for various I, in amperes (A) (see Table 1).

Table 1

Trial	I (A)	V_H (nV)
1	10	13
2	15	19
3	20	25
4	25	32

Study 2

With d equal to 15 mm and I equal to 25 A, the students found V_H for various B (see Table 2).

Table 2

Trial	B (T)	V_H (nV)
5	0.2	11
6	0.4	21
7	0.8	42
8	1.0	53

Study 3

With B equal to 0.6 T and I equal to 25 A, the students found V_H for various d (see Table 3).

Table 3

Trial	d (mm)	V_H (nV)
9	3	160
10	6	79
11	9	53
12	12	40

22. In Study 1, as I was increased, the number of electrons that were pushed to one edge of the strip:

F. increased only.
G. decreased only.
H. varied, but with no general trend.
J. remained the same.

23. The clamp that fastened a strip to the ring stand was electrically insulated from the strip. This insulation was most likely needed to:

A. promote the flow of electrons between the clamp and the strip.
B. prevent the flow of electrons between the clamp and the strip.
C. ensure that the strip remained at room temperature.
D. ensure that the strip did not reach room temperature.

24. In Study 1, which variable was independent, and which variable was dependent?

	independent	dependent
F.	I	B
G.	I	V_H
H.	V_H	I
J.	B	I

25. Suppose a new trial were conducted using the procedure from Trial 1, except that $B = 0.2$ T. Based on the results of Study 2, V_H for this trial would most likely be:

A. less than 13 nV.
B. between 13 nV and 19 nV.
C. between 19 nV and 25 nV.
D. greater than 25 nV.

26. Based on the information given, the letter N in Figure 3 identifies:

F. a nanometer.
G. a new aluminum strip.
H. the north pole of the electromagnet.
J. the negative electrode of the power supply.

27. Based on the results of the studies, which of the following equations correctly relates V_H to I, B, and d ?

(Note: k is a constant.)

A. $V_H = k\frac{I}{Bd}$

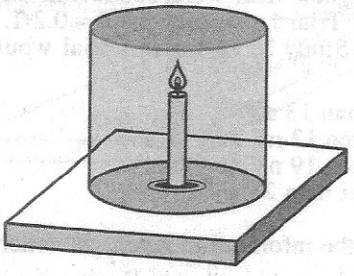
B. $V_H = k\frac{B}{Id}$

C. $V_H = k\frac{Bd}{I}$

D. $V_H = k\frac{IB}{d}$

Passage VI

A science teacher lights a new wax candle (which, if left undisturbed, would burn for several hours) in her classroom. She then shows her students a glass jar and asks them to predict what will happen if she places the jar over the lit candle, completely sealing off the candle from the surrounding atmosphere (see figure).



Four students give their viewpoints about why the candle burns and about what will happen to the burning candle once it is under the jar.

Student 1

The candle's flame results from a combustion reaction. When the candle is lit, the flame that lights the candle heats the candle, which causes the candle to give off fumes of wax. The wax fumes act as a fuel that reacts with the O_2 present in the air. The reaction gives off energy, which heats the surrounding air, producing a flame. If the jar is placed over the lit candle, the candle will soon stop burning because the O_2 in the air under the jar will be quickly used up.

Student 2

Student 1 is correct except that the fuel reacts with the N_2, not with the O_2, in the air.

Student 3

None of the components of air are involved in the burning of the candle. When the candle is lit, the energy from the flame causes the fuel (candle wax fumes) to spontaneously decompose. The heat from the decomposition reaction causes the reaction to continue. Thus, if the jar is placed over the lit candle, the candle will continue to burn until all of the fuel is used up.

Student 4

When the candle is lit, the energy from the flame causes the fuel (candle wax fumes) to spontaneously decompose into a massless substance called *heat*. None of the components of air chemically react with the fuel, but the O_2 present in air is necessary for the sustained decomposition reaction. The O_2 is needed because as the heat is produced, the heat must be absorbed for the reaction to continue, and O_2 is the only component of air that absorbs heat. When O_2 absorbs heat, the O_2 is not chemically altered. If the jar is placed over the lit candle, the candle will soon stop burning because the O_2 in the air under the jar will quickly become saturated with heat.

28. Which of the students, if any, claim(s) that when the jar is placed over the lit candle, the candle's flame will go out instantly?

F. Student 2 only
G. Student 4 only
H. All of the students
J. None of the students

29. Which of the students predict(s) that after the jar is placed over the lit candle, the candle will stop burning before all the candle wax is used up?

A. Student 3 only
B. Students 1 and 2 only
C. Students 3 and 4 only
D. Students 1, 2, and 4 only

30. Which of the following unbalanced equations for the reaction that occurs when a candle is lit is most consistent with Student 1's viewpoint?

F. Wax fumes + $O_2 \rightarrow CO_2 + H_2O$
G. Wax fumes + $N_2 \rightarrow CN + H_2$
H. $CO_2 + H_2O \rightarrow$ wax fumes + O_2
J. $CN + H_2 \rightarrow$ wax fumes + N_2

31. Based on Student 2's viewpoint, how will the concentrations (in mg/L) of O_2 and N_2 in the jar vary with time, if at all, after the jar is placed over the lit candle?

	concentration of O_2	concentration of N_2
A.	decrease	decrease
B.	remain constant	decrease
C.	increase	remain constant
D.	remain constant	remain constant

32. In the 1600s, most scientists believed that when materials burned, they gave off a substance called *phlogiston*. These scientists also believed that a material would burn until the air could no longer take in more phlogiston. This theory is most similar to the viewpoint given by:

F. Student 1.
G. Student 2.
H. Student 3.
J. Student 4.

33. The most scientifically accurate viewpoint is given by:

A. Student 1.
B. Student 2.
C. Student 3.
D. Student 4.

34. Which of the students would agree with the statement "After the jar is placed over the lit candle, the mass of O_2 under the jar will *decrease*"?

F. Student 1 only
G. Students 1 and 2 only
H. Students 1 and 4 only
J. Students 1, 2, 3, and 4

Passage VII

Three studies examined how the depth of plant roots, and the soil's carbon (C) and nitrogen (N) contents, change once shrubs have replaced grasses as the dominant plant species in an area.

In one area, 3 sites (Sites X, Y, and Z) were selected. Each site consisted of 2 adjacent plots of land: one covered only with grasses (grass plot) and one that had once been covered only with shrubs (shrub plot). The average annual precipitation for each site is shown in Table 1.

Study 1

Five vertical soil cores were taken from each of the 2 plots at Sites X, Y, and Z. Each core was 0.06 m in diameter and 3.5 m deep, which was a few centimeters deeper than the deepest plant roots. Starting at the top, each core was cut horizontally into 10 cm sections. Each section was dried, crushed, and passed through screens so that all root material could be collected and weighed. The average *95% root mass depth* (see Figure 1) for each plot was determined (see Table 1).

Table 1

Site	Average annual precipitation (mm)	Average 95% root mass depth (m)	
		grass plot	shrub plot
X	660	0.5	1.6
Y	840	0.9	2.4
Z	1,070	1.5	3.3

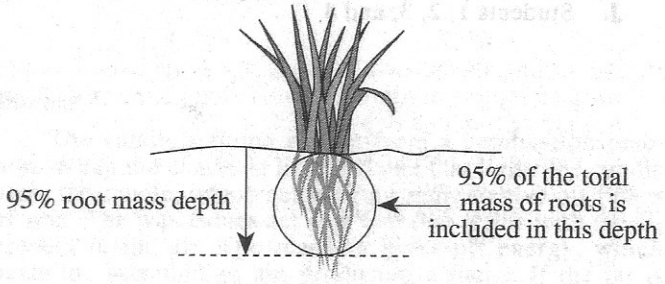


Figure 1

Study 2

For each of 5 additional soil cores taken from each plot at Site X, soil samples were taken from the top of the core, and then every 0.25 m down the core to a depth of 2.0 m. The 5 samples from a given depth and plot were thoroughly mixed. Each resulting mixture was then analyzed for C content, in percent by mass. These procedures were repeated for 5 additional cores from each plot at Site Y and for 5 additional cores from each plot at Site Z (see Figure 2).

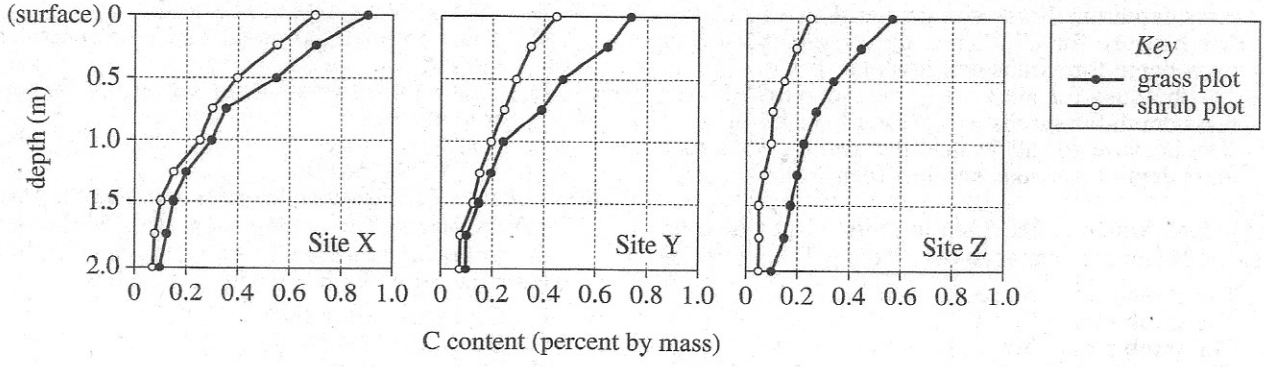


Figure 2

Study 3

Study 2 was repeated except that each mixture was analyzed for N content (see Figure 3).

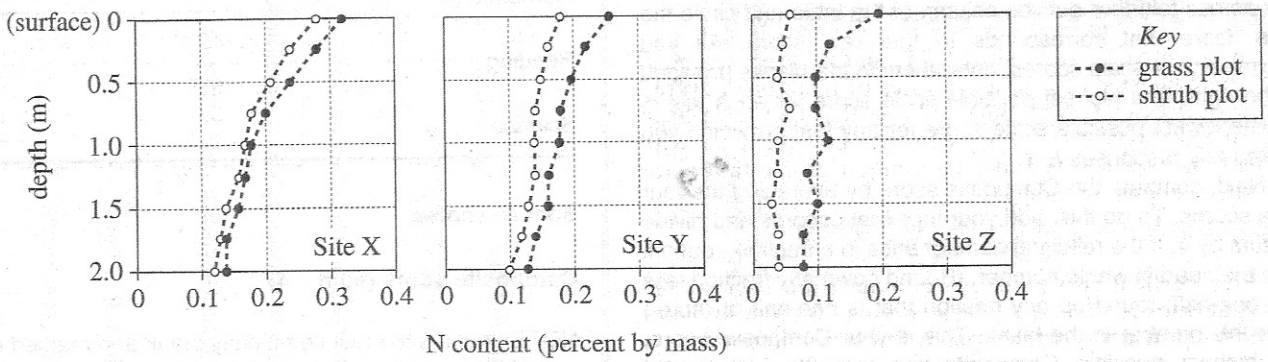


Figure 3

Table and Figures 2 and 3 adapted from Robert Jackson et al., "Ecosystem Carbon Loss with Woody Plant Invasion of Grasslands." ©2002 by the Nature Publishing Group.

35. Suppose a fourth shrub plot in the study area received an average annual precipitation of 750 mm. If that shrub plot had been included in Study 1, its average 95% root mass depth would most likely have been:

A. less than 1.6 m.
B. between 1.6 m and 2.4 m.
C. between 2.4 m and 3.3 m.
D. greater than 3.3 m.

36. Is the statement "Some shrub roots penetrated more than 1.5 m down into the soil" consistent with the results of Study 1 ?

F. No, because for all 3 sites, the average 95% root mass depth for shrubs was greater than 1.5 m.
G. No, because for all 3 sites, the average 95% root mass depth for shrubs was less than 1.5 m.
H. Yes, because for all 3 sites, the average 95% root mass depth for shrubs was greater than 1.5 m.
J. Yes, because for all 3 sites, the average 95% root mass depth for shrubs was less than 1.5 m.

37. In Study 3, which of the 3 shrub plots, if any, had the greatest N content, averaged over the top 2.0 m of soil?

A. The shrub plot at Site X
B. The shrub plot at Site Y
C. The shrub plot at Site Z
D. The averaged N contents were the same for all 3 shrub plots.

38. According to the results of Study 2, in which of the following plots did the C content change the most from a depth of 0 m to a depth of 2.0 m ?

F. The grass plot at Site X
G. The shrub plot at Site X
H. The grass plot at Site Y
J. The shrub plot at Site Z

39. The most likely reason that the soil core sections were dried before being passed through screens in Study 1 was to ensure which of the following?

A. That no C remained in the soil
B. That no N remained in the soil
C. That root material could easily be separated from the soil
D. That root material could not easily be separated from the soil

40. At each of the 3 sites, the grass plot and the shrub plot were adjacent. This arrangement ensured that which of the following variables could be assumed to be nearly identical for both plots during the studies?

F. C content of the soil
G. N content of the soil
H. Dominant plant species
J. Climate

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.