TEST 4: SCIENCE TEST

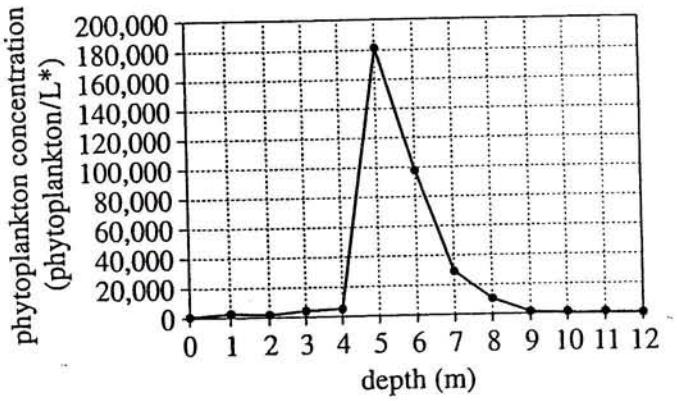
30 Minutes—28 Questions

DIRECTIONS: There are six 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 folder. You may refer to the passages as often as necessary.

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

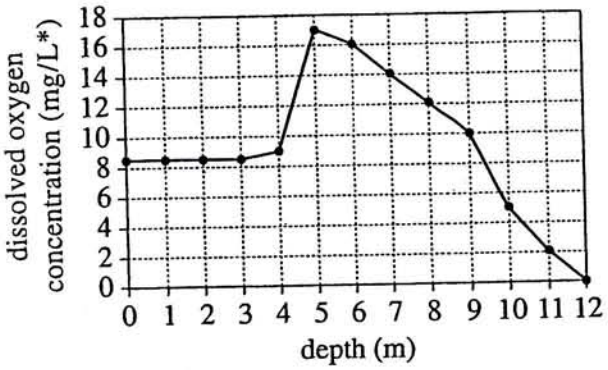
Passage I

Scientists studied how conditions in Lake A change as the depth of the water changes. They collected a sample of lake water at the lake's surface (depth = 0 m) and at 1 m intervals below the lake's surface. For each sample, the scientists determined the concentration of *phytoplankton* (microscopic organisms that use sunlight to make food) and the concentration of dissolved oxygen (see Figures 1 and 2, respectively). The scientists also measured, at 1 m intervals below the lake's surface, the percent of sunlight that penetrated the water (see Figure 3).



*L = liter

Figure 1



*mg/L = milligrams per liter

Figure 2

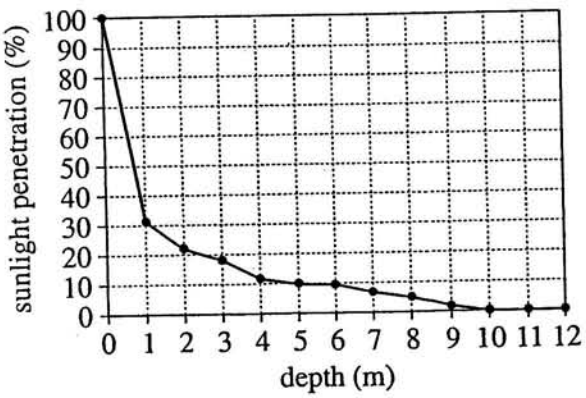


Figure 3

1. According to Figure 1, a Lake A water sample collected between which of the following depths will most likely contain the greatest concentration of phytoplankton?

   A. 3 m and 4 m
   B. 5 m and 6 m
   C. 7 m and 8 m
   D. 9 m and 10 m

2. A scientist claimed that there was not enough sunlight for the phytoplankton to survive at a depth of 12 m. Does Figure 3 support this claim?

   F. No, because at 12 m, the sunlight penetration was 100%.
   G. No, because at 12 m, the sunlight penetration was 0%.
   H. Yes, because at 12 m, the sunlight penetration was 100%.
   J. Yes, because at 12 m, the sunlight penetration was 0%.

3. According to Figure 3, the greatest change in sunlight penetration occurred over which of the following ranges of depth?

   A. From 0 m to 1 m
   B. From 1 m to 2 m
   C. From 3 m to 4 m
   D. From 4 m to 5 m

4. According to Figures 2 and 3, the lake water had a dissolved oxygen concentration of 8.5 mg/L and a sunlight penetration of 23% at what depth?

   F. 2 m
   G. 3 m
   H. 4 m
   J. 5 m

Passage II

Two studies were done in a lab to investigate how the amount of carbon dioxide (CO_2) in a volume of gas affects the rate at which the temperature of the gas increases.

Two identical glass tanks with airtight lids (Tanks A and B) were opened, and the same quantity of black sand was added to each. To heat the gas in the tanks, a lamp with a 150-watt lightbulb was placed at one end. A thermometer was set up at the other end so that the bottom of the thermometer would be in the gas and 5 cm above the top of the sand (see diagram).

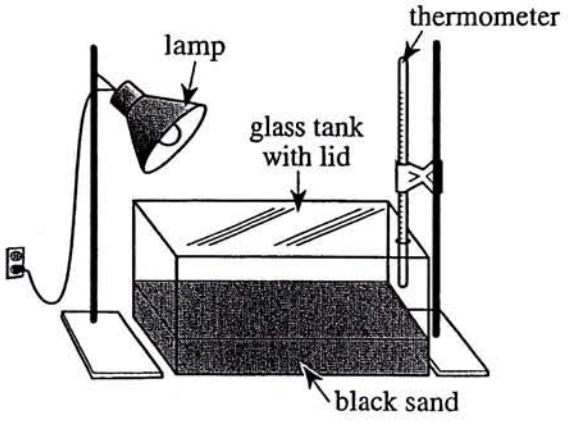


diagram of setup for a tank

Study 1

The lid of Tank A was closed after the sand was added. Five minutes (min) later, the temperature of the gas in the tank was recorded. (The pressure of the gas in the tank equaled atmospheric pressure.) Immediately afterward, the lamp was turned on, and the temperature of the gas in the tank, in degrees Celsius (°C), was recorded every 30 seconds (sec) for 10 min. The results are shown in Figure 1.

Study 2

The lid of Tank B was closed after the sand was added. Through a tiny hole made in the lid, all the gas that was present was removed from the tank and replaced with 100% CO_2 at atmospheric pressure. Immediately after the CO_2 was added, the hole was sealed with an airtight material. Five min later, the temperature of the gas in the tank was recorded. Immediately afterward, the lamp was turned on, and the temperature of the gas in the tank was recorded every 30 sec for 10 min. The results are shown in Figure 2. (Note: The light received by Tank B was of the same brightness and at the same angle as the light that had been received by Tank A.)

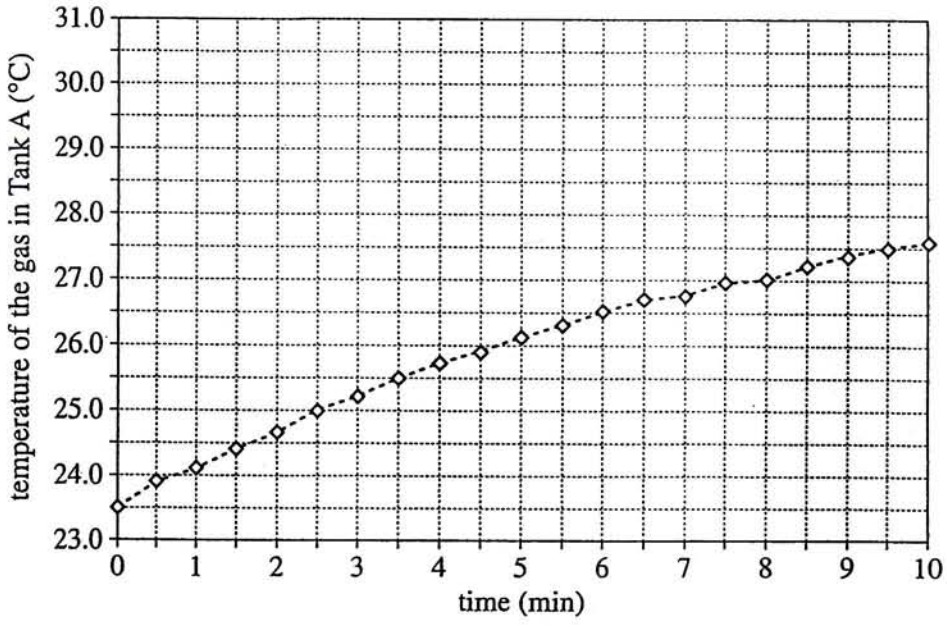


Figure 1

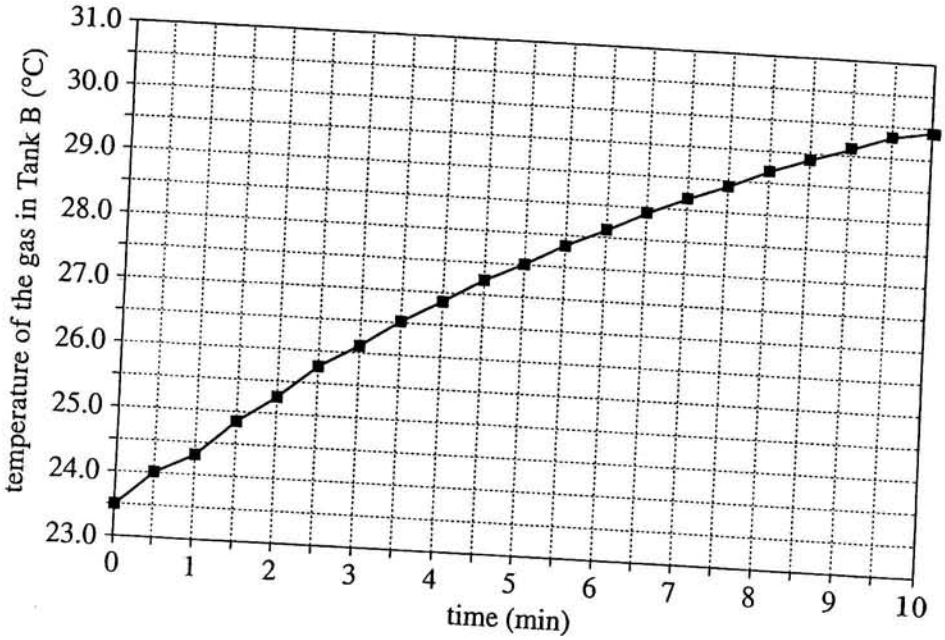


Figure 2

5. According to the results of Study 1, the temperature of the gas in Tank A at 0 min was:

   A. 22.0°C.
   B. 22.5°C.
   C. 23.0°C.
   D. 23.5°C.

6. According to the results of Studies 1 and 2, the temperature of the gas in Tank A at 10 min was most nearly the same as the temperature of the gas in Tank B at:

   F. 5 min.
   G. 7 min.
   H. 9 min.
   J. 11 min.

7. The temperature of the gas in which tank increased more quickly, and why?

   A. Tank A, because the gas in that tank contained less CO_2 than did the gas in Tank B.
   B. Tank A, because the gas in that tank contained more CO_2 than did the gas in Tank B.
   C. Tank B, because the gas in that tank contained less CO_2 than did the gas in Tank A.
   D. Tank B, because the gas in that tank contained more CO_2 than did the gas in Tank A.

8. Suppose that what occurred in Tanks A and B after the lamps were turned on was intended to model how the temperature of Earth's atmosphere changes as the amount of CO_2 in the air changes. What would have been represented by the black sand and what would have been represented by the lamp's light?

	black sand	lamp's light
F.	Earth's surface	Earth's atmosphere
G.	Earth's surface	Sun's energy
H.	Earth's atmosphere	Earth's surface
J.	Earth's atmosphere	Sun's energy

9. Were Studies 1 and 2, together, designed to determine if the brightness of light received by a volume of gas affects the rate at which the temperature of the gas increases?

   A. No, because only Tank A had a light shining on it.
   B. No, because the brightness of light received was the same for both tanks.
   C. Yes, because only Tank B had a light shining on it.
   D. Yes, because the brightness of light received was different for each tank.

Passage III

A solid metal ball, initially at rest, was dropped from a height of 10.0 m above the ground. The ball's height, speed, gravitational potential energy (GPE), and kinetic energy (KE) were determined as the ball fell to the ground. Figure 1 shows how the ball's height changed over time. Figure 2 shows how the ball's speed, in meters per second (m/sec), changed over time. Figure 3 shows how the ball's GPE and KE, both measured in joules (J), changed over time.

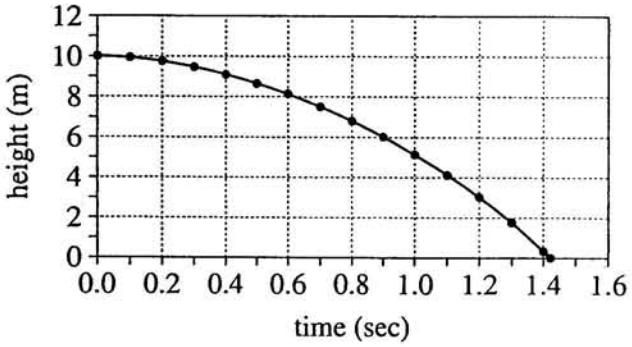


Figure 1

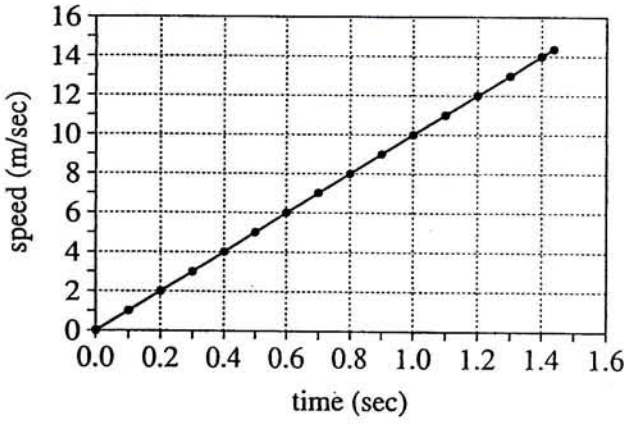


Figure 2

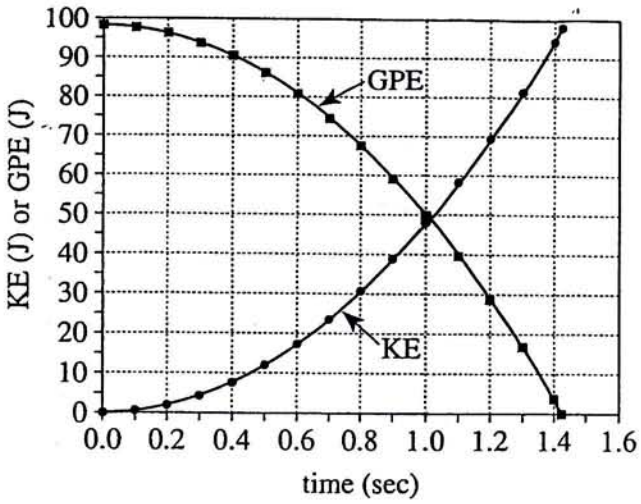


Figure 3

10. Based on Figure 1, approximately how long did it take for the ball to hit the ground?

    F. 1.4 sec
    G. 1.6 sec
    H. 1.8 sec
    J. 2.0 sec

11. According to Figure 3, at the moment the ball was dropped, its GPE was closest to which of the following?

    A. 0 J
    B. 50 J
    C. 100 J
    D. 150 J

12. Suppose that the sphere had been dropped from a height of 10.0 m above the Moon's surface. Based on Figure 2, 0.4 sec after the sphere was released, its speed would have been:

F. less than 4 m/sec, because gravity on the Moon is stronger than gravity on Earth.
G. less than 4 m/sec, because gravity on the Moon is weaker than gravity on Earth.
H. greater than 4 m/sec, because gravity on the Moon is stronger than gravity on Earth.
J. greater than 4 m/sec, because gravity on the Moon is weaker than gravity on Earth.

13. Based on Figures 1 and 3, the ball's GPE and the ball's KE were approximately equal when the *height* of the ball was:

A. 0.0 m.
B. 1.0 m.
C. 5.0 m.
D. 10.0 m.

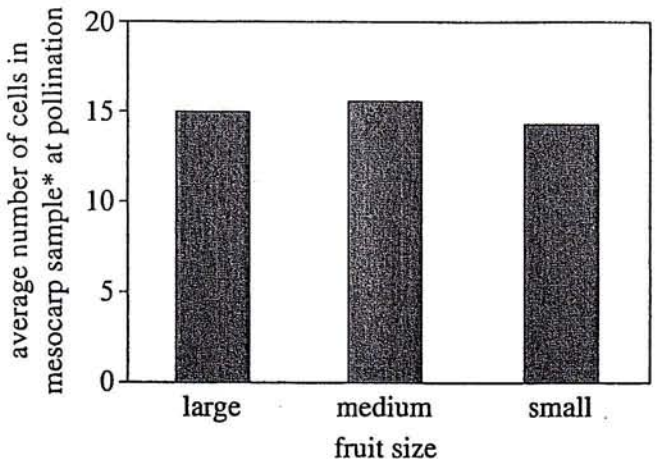
Passage IV

Fruit size in the pear *P. pyrifolia* is determined by the number of cells that grow in the *mesocarp* (edible portion of the fruit) during the *period of cell division* (average number of days of active cell division following pollination). Table 1 lists fruit size at harvest, *maturation period* (average number of days from pollination to harvest), period of cell division, and average mass of the fresh fruit at harvest for 9 strains of *P. pyrifolia* (S1–S9).

Table 1

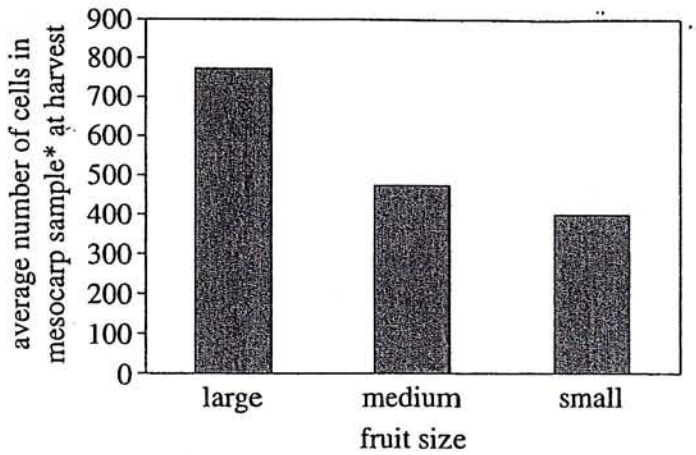
P. pyrifolia strain	Fruit size	Maturation period (days)	Period of cell division (days)	Average fresh mass (g)
S1	large	210	56	1,200
S2	large	190	53	860
S3	large	185	42	765
S4	medium	180	33	468
S5	medium	135	31	340
S6	medium	128	28	282
S7	small	120	27	186
S8	small	110	25	156
S9	small	105	23	147

The average number of cells in a mesocarp sample is shown for each of the 3 fruit sizes at pollination (see Figure 1) and at harvest (see Figure 2).



*Sample was taken from the core to the fruit surface at the fruit's largest diameter.

Figure 1



*Sample was taken from the core to the fruit surface at the fruit's largest diameter.

Figure 2

Table and figures adapted from Caixi Zhang et al., "The Impact of Cell Division and Cell Enlargement on the Evolution of Fruit Size in *Pyrus pyrifolia*." ©2006 by The Author.

14. According to Table 1, on average, a fruit of which *P. pyrifolia* strain will spend the *least* amount of time on a tree from pollination to harvest?

    F. S1
    G. S2
    H. S4
    J. S9

15. Based on Table 1, if a *P. pyrifolia* fruit were found to have a fresh mass of 810 g at harvest, would it more likely be sized as a small fruit or as a large fruit?

    A. Small, because 810 g falls between the average fresh mass of S1 and the average fresh mass of S3.
    B. Small, because 810 g falls between the average fresh mass of S7 and the average fresh mass of S9.
    C. Large, because 810 g falls between the average fresh mass of S1 and the average fresh mass of S3.
    D. Large, because 810 g falls between the average fresh mass of S7 and the average fresh mass of S9.

16. According to Table 1 and Figure 2, do the *P. pyrifolia* strains with the longest periods of cell division have the greatest number of cells in the mesocarp at harvest?

F. No; the large fruits have a greater number of cells in the mesocarp at harvest than do smaller fruits.
G. No; the small fruits have a greater number of cells in the mesocarp at harvest than do larger fruits.
H. Yes; the large fruits have a greater number of cells in the mesocarp at harvest than do smaller fruits.
J. Yes; the small fruits have a greater number of cells in the mesocarp at harvest than do larger fruits.

17. Which of Figures 1 and 2, if either, shows for *P. pyrifolia* the average number of cells in a mesocarp sample before the period of cell division?

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

Passage V

Tooth decay is caused by bacteria in the mouth (such as lactobacilli and *S. mutans*) that turn sugars into acid that dissolves tooth enamel. Two studies involving these bacteria were performed.

Study 1

Five students (Students A–E) chewed sterile rubber bands for 5 minutes (min) without swallowing, depositing their saliva in separate, sterile containers. They added 20 milliliters (mL) of sterile test agar (TA) to each of 7 test tubes. The TA contained sugar, other nutrients necessary for the growth of only lactobacilli, and the dye *bromcresol green*, which changes from green (G) to yellow (Y) if the amount of acid increases to a certain level. In addition, they added sterile water, lactobacilli, or 0.2 mL of a student's saliva to each tube. Finally, they incubated the tubes at 37°C, noting the color of the TA at 24, 48, and 72 hours (hr) of incubation (see Table 1). The higher the concentration of lactobacilli in a student's saliva, the more quickly the TA changed from green to yellow.

Table 1

Tube	Contents TA and:	Color at: 24 hr	48 hr	72 hr
1	sterile water	G	G	G
2	lactobacilli	Y	Y	Y
3	Student A saliva	Y	Y	Y
4	Student B saliva	G	Y	Y
5	Student C saliva	G	G	G
6	Student D saliva	G	G	Y
7	Student E saliva	G	G	Y

Study 2

The students tested the effects of baking soda and hydrogen peroxide (H_2O_2) on the growth of *S. mutans*. They set up 4 growth plates, then added to each plate 2 or more of the substances listed in Table 2. Finally, they incubated the plates at 37°C, counting the number of bacteria present in each plate every 5 hr for 30 hr (see Figure 1).

Table 2

Plate	Nutrient broth (mL)	Sugar solution (mL)	*S. mutans* culture (mL)	Baking soda solution (mL)	H_2O_2 solution (mL)
W	1	none	0.5	none	none
X	1	0.5	0.5	none	none
Y	1	0.5	0.5	0.5	none
Z	1	0.5	0.5	none	0.5

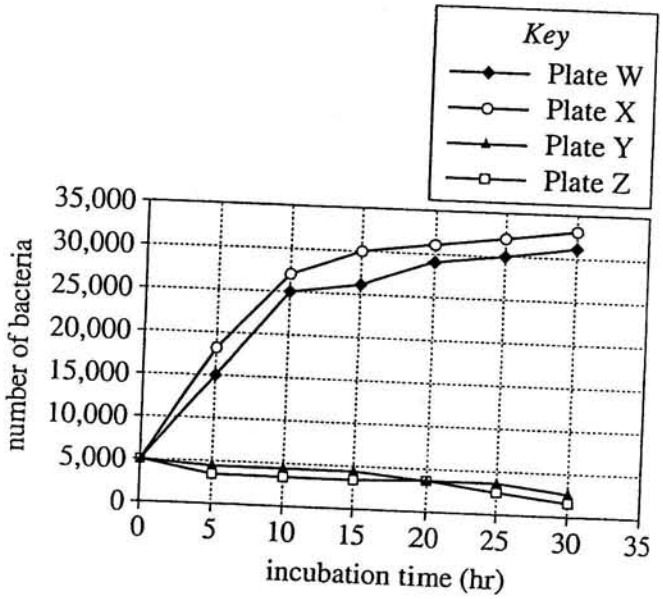


Figure 1

Table 2 and Figure 1 adapted from Kelly J. Silhacek and Kristin R. Taake, "Sodium Bicarbonate and Hydrogen Peroxide: The Effect on the Growth of *Streptococcus mutans*." ©2005 by The American Dental Hygienists' Association.

18. According to Table 2, in which of the following ways did Plates X and Y differ in regard to what was added to them?

F. Baking soda was not added to Plate X but was added to Plate Y.
G. Baking soda was not added to Plate Y but was added to Plate X.
H. H_2O_2 was not added to Plate X but was added to Plate Y.
J. H_2O_2 was not added to Plate Y but was added to Plate X.

19. Based on the results of Study 2, mouthwash with which of the following ingredients would best prevent tooth decay?

A. Sugar
B. *S. mutans*
C. Baking soda
D. Nutrient broth

20. In Study 1, why did the students chew sterile rubber bands for 5 min ?

F. To prevent the development of tooth decay
G. To encourage the growth of lactobacilli
H. To stimulate the flow of saliva
J. To increase the rate at which acid formed

21. In Study 1, the student whose saliva contained the lowest concentration of lactobacilli was the one whose TA was:

A. yellow at 24 hr and yellow at 48 hr.
B. green at 24 hr and yellow at 48 hr.
C. green at 48 hr and green at 72 hr.
D. green at 48 hr and yellow at 72 hr.

22. In Study 1, which of the following is the most likely reason that the containers used to collect the saliva needed to be sterile?

F. To avoid infecting the students with bacteria from their own saliva
G. To collect bacteria from the surrounding environment in addition to bacteria from the students' saliva
H. To prevent unwanted bacteria from entering the test tubes
J. To ensure proper mixing of the students' saliva

Passage VI

A teacher placed a beaker containing 100 g of tap water at room temperature on a heat source. After 8 minutes (min), the water began to boil. After 4 min of boiling, the beaker was removed from the heat source. The teacher then asked 4 students to explain why bubbles formed in the water during boiling and what was inside the bubbles. She also asked them to predict whether the mass of the water in the beaker changed over the 4 min of boiling.

Student 1

When a liquid is heated, it absorbs the heat, causing its temperature to increase. A given amount of a liquid can absorb only a certain amount of heat. If additional heat is added, bubbles of heat will form and exit the liquid. Therefore, the bubbles that formed during the boiling contained heat only. Heat has no mass, so the mass of the water did not change.

Student 2

Each water molecule is made up of 2 hydrogen (H) atoms and 1 oxygen (O) atom. When water boils, it splits apart into H atoms and O atoms. The free H atoms bond to form H_2 molecules and the free O atoms bond to form O_2 molecules. The bubbles that formed during the boiling contained H_2 and O_2 only. Thus, the mass of the water decreased.

Student 3

Liquids normally contain some dissolved air. As the temperature of a liquid increases, its ability to dissolve air decreases. When a liquid reaches its boiling point, air bubbles will form and exit the liquid. Therefore, the bubbles that formed during the boiling contained air only. Air has no mass, so the mass of the water did not change.

Student 4

When a liquid is heated to its boiling point, it will start to change from a liquid to a gas. Bubbles of gas form and escape the liquid. The bubbles that formed during the boiling contained water vapor only. Thus, the mass of the water decreased.

23. Student 2 implied that, while the water boiled, the mass of the water:

A. decreased because air has mass.
B. decreased because H_2 and O_2 have mass.
C. increased because air has mass.
D. increased because H_2 and O_2 have mass.

24. Which of the students implied that the water underwent only a change of state during boiling?

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

25. After the water was boiled for 4 min, the mass of the water in the beaker was 94 g. This finding is consistent with the explanations given by:

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

26. Which of the students implied that the water underwent a chemical reaction during boiling?

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

27. The teacher repeated the demonstration, except that the 100 g of tap water was boiled for 8 min. Which of the following sets of values for the final mass of the water in the beaker, in the original demonstration and in the new demonstration, is most consistent with Student 1's explanation?

	original demonstration	new demonstration
A.	88 g	95 g
B.	95 g	88 g
C.	95 g	100 g
D.	100 g	100 g

28. *Glycerin* is a liquid with a boiling point of 182°C. A 50 g sample of glycerin at 20°C was heated to 70°C. No bubbles formed in the liquid, and the mass of the sample at 70°C was 50 g. Is this result consistent or inconsistent with the explanations given by Students 1 and 3 ?

	Student 1	Student 3
F.	consistent	consistent
G.	consistent	inconsistent
H.	inconsistent	consistent
J.	inconsistent	inconsistent

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.