ACT Science Practice Paper 10

SET 1

Directions: 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.

The *Citric cycle* is an essential process used to transform carbohydrates, lipids, and proteins into energy in aerobic organisms. If yeast is unable to produce *succinate*, it cannot survive. The Citric cycle steps leading to the creation of succinate in yeast are shown in Figure 1. Each step in this cycle is catalyzed by an enzyme, which is essential to overcome the energy barrier between reactant and product. In the first step, Enzyme 1 is the enzyme, citrate is the reactant, and isocitrate is the product.

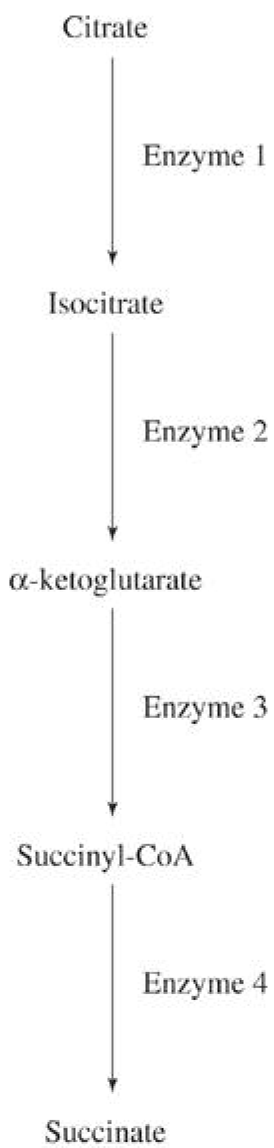


Figure 1

Experiment

A scientist grew four strains of yeast on several different growth media. Each strain was unable to produce succinate because it lacked one of the enzymes required for the reaction pathway shown in Figure 1. Table 1 shows the results of the scientist's experiment: "Yes" indicates that the strain was able to grow in the basic nutrition solution (BNS) + the particular chemical. An undamaged strain of yeast would be able to grow in the basic nutrition solution without any additional chemical. If a strain was able to grow in a given growth medium, then it was able to produce succinate from the additional chemical added to the basic nutrition solution.

Table 1				
Growth Medium	Yeast Strain			
	W	X	Y	Z
BNS				
BNS + Isocitrate	Yes			
BNS + α- ketoglutarate	Yes	Yes		
BNS + Succinyl-CoA	Yes	Yes	Yes	
BNS + Succinate	Yes	Yes	Yes	Yes

If certain genes are damaged, the essential enzymes cannot be produced, which means that the reactions that the enzyme catalyzes cannot go. Table 2 lists the genes responsible for the enzymes in the steps of the Citric cycle leading to succinate production in yeast. If an enzyme cannot be produced, then the product of the reaction that enzyme catalyzes cannot be synthesized and the reactant in that reaction will become highly concentrated. If a gene is damaged, then it is notated with a superscript negative sign, as in $Cat3^{-}$; if a gene is not damaged it is notated with a superscript positive sign, as in $Cat3^{+}$.

Table 2	
Gene	Enzyme
Cat1	Enzyme 1
Cat2	Enzyme 2
Cat3	Enzyme 3
Cat4	Enzyme 4

1. Based on the information presented, the highest concentration of isocitrate would most likely be found in which of the following yeasts?

A. Yeast that cannot produce Enzyme 1

B. Yeast that cannot produce Enzyme 2

C. Yeast that cannot produce Enzyme 3

D. Yeast that cannot produce Enzyme 4

2. According to the information in the passage and **Table 2**, a strain of yeast that is $Cat1^{+}$ $Cat2^{-}$ $Cat3^{-}$ $Cat4^{+}$ CANNOT produce:

F. Enzyme 1 and Enzyme 4.

G. Enzyme 3 and Enzyme 4.

H. Enzyme 2 and Enzyme 3.

J. Enzyme 1 and Enzyme 2.

3. Which of the following statements best describes the relationships between citrate, isocitrate, and α-ketoglutarate as shown in Figure 1?

A. Isocitrate is a product of a reaction of α-ketoglutarate, and α-ketoglutarate is a product of a reaction of citrate.

B. α-ketoglutarate is a product of a reaction of isocitrate, and isocitrate is a product of a reaction of citrate.

C. α-ketoglutarate is a product of a reaction of citrate, and citrate is a product of a reaction of isocitrate.

D. Citrate is a product of a reaction of isocitrate, and isocitrate is a product of a reaction of α-ketoglutarate.

4. Strain X yeast was most likely unable to synthesize:

F. isocitrate from citrate.

G. α-ketoglutarate from isocitrate.

H. succinyl-CoA from α-ketoglutarate.

J. succinate from succinyl-CoA.

5. One of the growth media shown in **Table 1** was a control that the scientist used to demonstrate that all four strains of yeast had genetic damage that prevented the reactions shown in Figure 1, the reactions which are responsible for the synthesis of succinate. Which growth media was used as a control?

A. BNS

B. BNS + succinate

C. BNS + isocitrate

D. BNS + succinyl-CoA

6. For each of the four strains of yeast, W-Z, shown in Table 1, if a given strain was able to grow in BNS + succinyl-CoA, then it was also able to grow in:

F. BNS.

G. BNS + isocitrate.

H. BNS + α-ketoglutarate.

J. BNS + succinate.

Many viruses are known to persist more prevalently during certain times of the year. A study of four relatively unknown viruses was conducted to examine their annual rate of prevalence and mortality in a host population. A large survey was conducted of local populations for the presence of antigen markers indicative of viral exposures to the four virus types. Measurements were acquired monthly beginning in January of 2000 and concluding two years later. All monthly measurements were averaged for comparison.

Figure 1 shows the incidence (cases per 1,000 individuals studied) of viral infections attributed to each viral type over the duration of the study. Figure 2 shows the number of deaths (per 1,000 individuals studied) attributed to virus A and D infections.

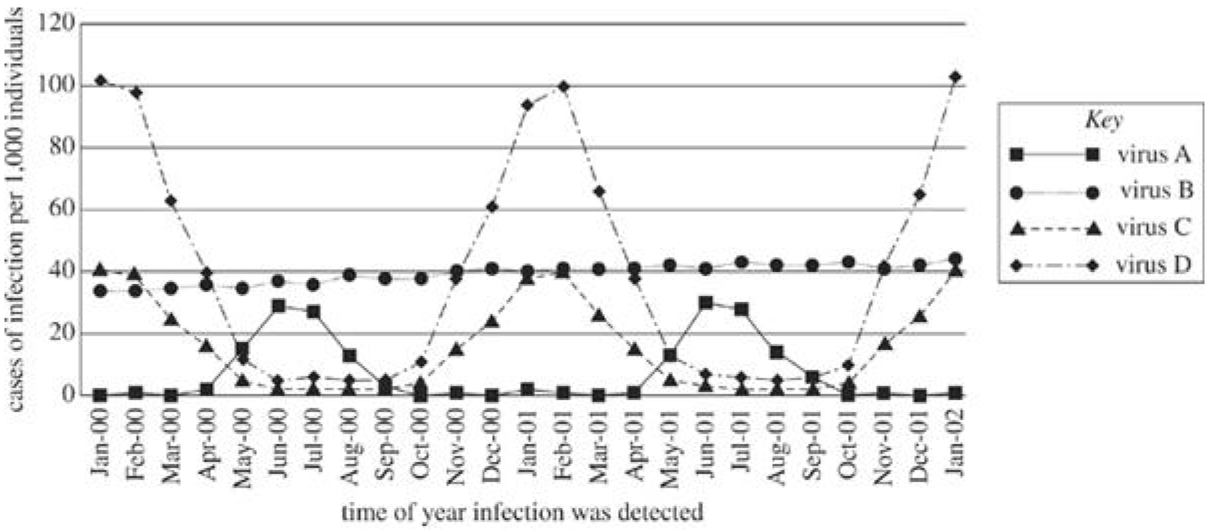


Figure 1

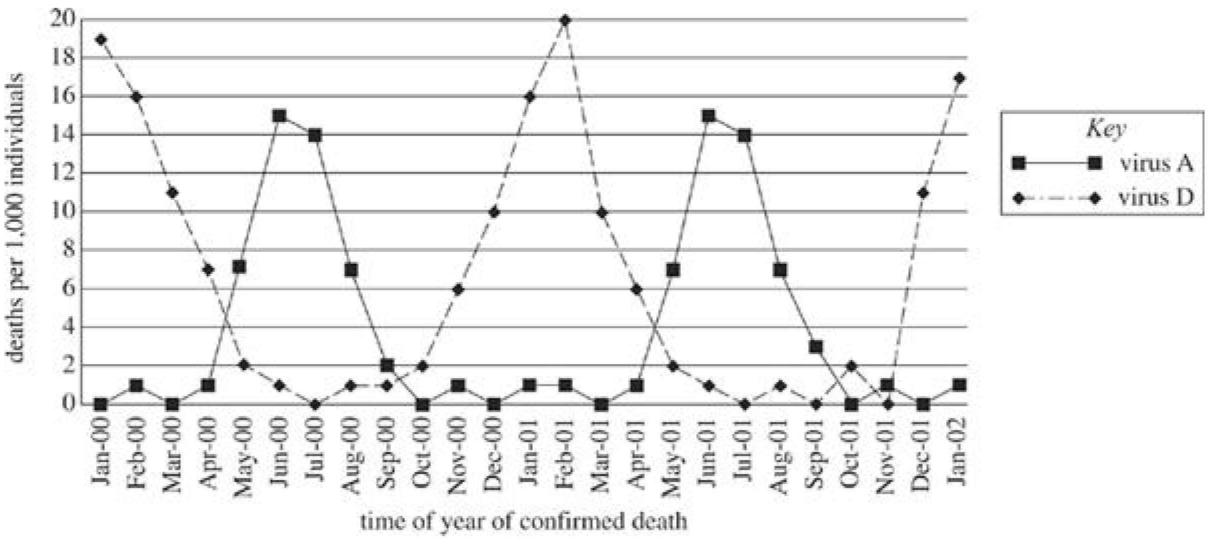


Figure 2

7. According to Figure 1, the incidence of virus A is *greatest* during which season of the year?

A. Spring (Mar-May)

B. Summer (Jun-Aug)

C. Fall (Sep-Nov)

D. Winter (Dec-Feb)

8. According to Figure 1, during April 2001, which virus was *least* prevalent in the studied population?

F. Virus A

G. Virus B

H. Virus C

J. Virus D

9. In a previous study, a virologist claimed that the incidence of virus B has always exceeded the incidence of virus C. As shown in Figure 1, the data for which of the following months is *inconsistent* with the virologist's claims?

A. Jan-00

B. 1-Feb

C. 1-Aug

D. 1-Dec

10. According to Figure 1, the incidence of *at least 3* of the viruses is most alike during which of the following months?

F. Apr-00

G. Sep-00

H. 1-Nov

J. Jan-02

11. During both years of the survey, in one month every year, 7 out of 1,000 individuals died as a result of infection with virus A and 2 out of 1,000 individuals died as a result of infection with virus D. According to Figure 2, these data most likely were obtained during which of the following months?

A. January

B. March

C. May

D. October

SET 2

The pH at which a protein is uncharged is called its *isoelectric point (pI)*. As the surrounding pH decreases, proteins gain an increasing positive charge. As the surrounding pH increases, proteins gain an increasingly negative charge. In *gel electrophoresis*, a mixture of proteins can be separated based on their relative charge. The proteins are first dissolved in a solvent and then placed at the starting point of an agarose gel. A current is applied to the gel and the proteins migrate different distances according to their charge (see Figure 1).

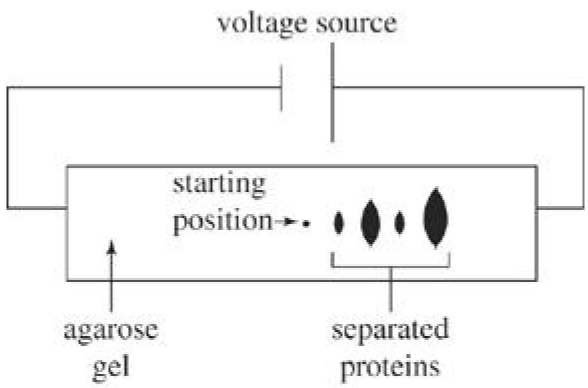


Figure 1

The following experiments were done to determine how varying the pH of a solvent affects the separation of proteins with gel electrophoresis. Table 1 shows the isoelectric points of the proteins and the pH values of the solvents used. The pH scale is logarithmic. Solutions with a pH less than 7.0 are acidic, while those with a pH more than 7.0 are basic.

Table 1

Protein	*pI*
A	8.2
B	7.4
C	6.8
D	5.9
Solvent	**pH**
1	8.9
2	9.6
3	10.2

Experiment 1

A special paper 150 mm long is treated with an agarose gel. Electrodes were attached on each end and wired to a 100-volt source. A 150 µg mixture of proteins A-D was added to Solvent 1 to make a 200 µL solution. The solution was placed at the starting point of the gel and allowed to separate for 60 minutes. The density of the separated proteins was plotted as a percentage over their distance traveled. The procedure was repeated for Solvents 2 and 3 and the results presented in Figure 2.

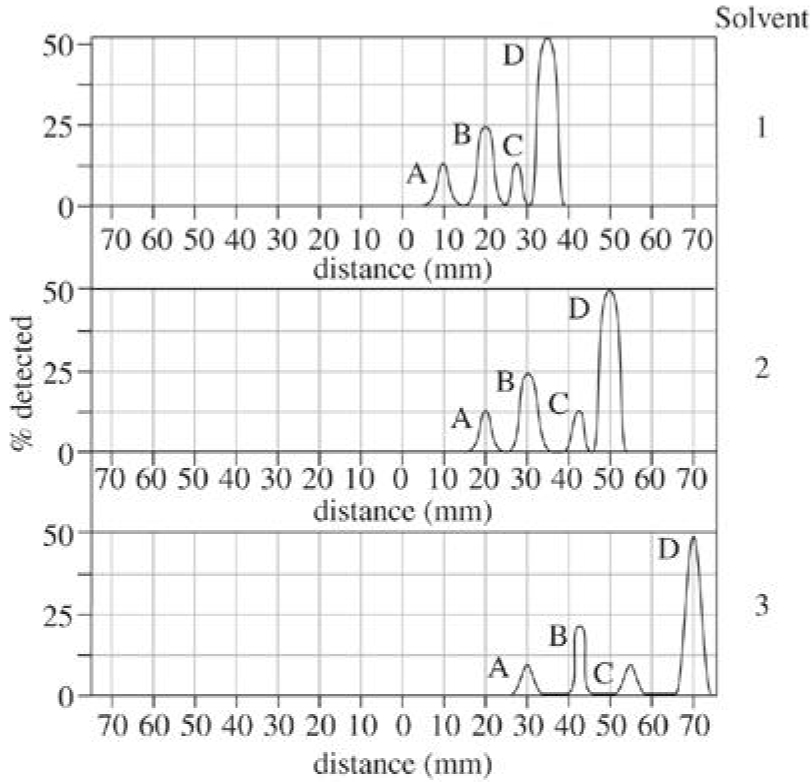


Figure 2

Experiment 2

The procedures of Experiment 1 were repeated after reversing the electrode attachments on the voltage source. Results are shown in Figure 3.

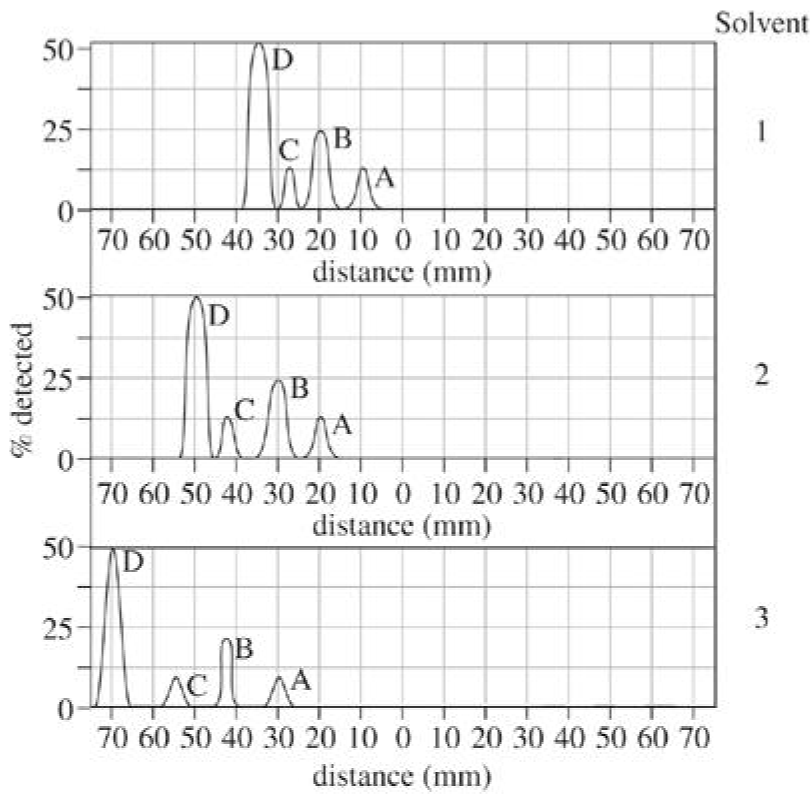


Figure 3

1. In Experiment 2, when Solvent 2 was used, the majority of Protein D migrated a distance from the starting point closest to:

F. 15 mm.

G. 35 mm.

H. 50 mm.

J. 65 mm.

2. Suppose that Experiment 1 were repeated using a solvent with a pH of 8.4. The migration distance of Protein A would most likely peak at:

A. less than 10 mm.

B. between 10 mm and 20 mm.

C. between 20 mm and 30 mm.

D. greater than 30 mm.

3. Protein L has an isoelectric point (*pI*) of 6.6. The results of Experiments 1 and 2 would be most similar to the plots shown in Figures 1 and 2 if, in each trial, Protein L were added to the protein mixture after removing:

F. Protein A.

G. Protein B.

H. Protein C.

J. Protein D.

4. The *resolution* of gel electrophoresis decreases as the overall distance between the peaks on the density plot decreases. Based on the results of Experiments 1 and 2, which of the following sets of conditions had the lowest resolution for the separation?

Experiment 1

A. Solvent 1

B. Solvent 3

C. Solvent 2

D. Solvent 3

5. Suppose that Experiment 1 will be repeated using Solvent 2, but Protein Y (*pI* = 7.1) is added to the overall mixture. Which of the following best predicts the order of migration distances of the 5 proteins, from shortest to longest?

F. D, C, Y, B, A

G. D, Y, C, B, A

H. A, B, Y, C, D

J. A, Y, B, C, D

6. In Experiment 2, for Solvent 2, at the migration distance where Protein B returned to its 0% migration detection, the percent of Protein A that migrated using Solvent 3 was closest to:

A. 0%.

B. 25%.

C. 50%.

D. 75%.

Students studying gravity and motion were given the following information:

o *Gravity* is an attractive force between two bodies that is directly related to their *mass* and indirectly related to the square of the *distance* between their centers.

o *Acceleration due to gravity* is the acceleration of an object that results from the *force* of gravity.

o *Weight* is the *force* on an object that results from *gravity*, and is not the same as *mass*.

o *Drag* is a force directly related to the *velocity* of a moving object and which results from air resistance and acts to *slow* an object down.

o When the *drag* on a free falling object is equivalent to the *weight* of that object, the object maintains a constant velocity called *terminal velocity*.

The students' teacher then described the following experiment:

The experimenter dropped a ball from a known height and recorded the time it took to hit the ground. In a second location, a second ball was dropped from the same height and the experimenter observed that it took a longer time to fall to the ground.

Providing no additional information, the teacher asked her three students to provide an explanation of the experimental conditions that would account for the different times it took the two balls to fall.

Student 1

Both trials were conducted in air with the same atmospheric properties. The balls had the same mass and weight, but the second ball had a larger radius and *surface area*. Therefore, the second ball was subjected to more drag and reached a lower terminal velocity than the first. This resulted in an increased fall time.

Student 2

Each ball had identical dimensions, but the first ball was made of a denser material giving it both greater mass and weight. Each ball was dropped through air with the same atmospheric properties. Since the second ball was subjected to less gravitational force and weighed less, it reached a lower terminal velocity compared to the first. Therefore, the second ball took more time to hit the ground.

Student 3

Both balls had the same dimensions and mass. The first ball was dropped above the Earth, while the second ball was dropped above the Moon. The first ball reached terminal velocity in the Earth's atmosphere. The second ball was not subjected to any atmosphere or air resistance. However, there was substantially less gravitational force on the second ball and subsequently it weighed less than the first ball. The overall net result was that the second ball fell more slowly and took longer to hit the ground.

7. Based on Student 1's explanation, the velocity of the first ball as it landed most likely equaled:

F. the product of acceleration of gravity and the time it took to fall.

G. the product of one-half the acceleration of gravity and the time it took to fall squared.

H. the velocity of the ball directly before it landed.

J. zero.

8. The teacher added another question to the students' assignment: Suppose the experimenter repeated the experiment by dropping two balls at the same time from the same height in a single *vacuum*, where no air resistance was present. The balls have different dimensions but identical weights, and they hit the ground at the same time. This new result is consistent with the explanations of which student(s)?

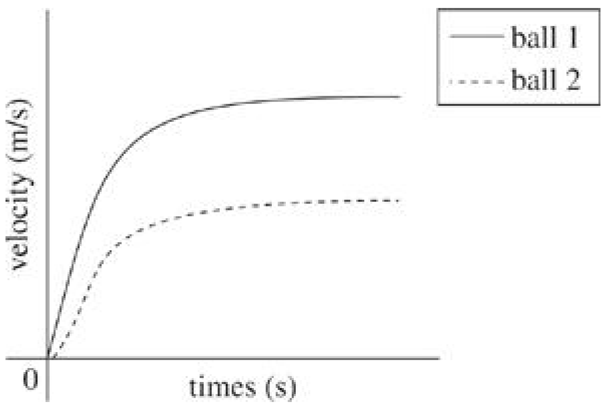
A. Student 1 only

B. Student 2 only

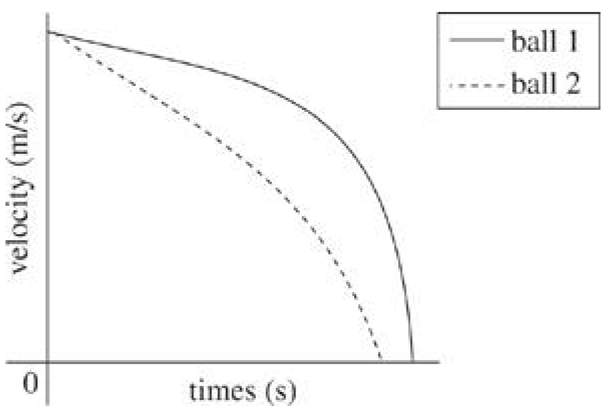
C. Students 1 and 2 only

D. Students 1, 2, and 3

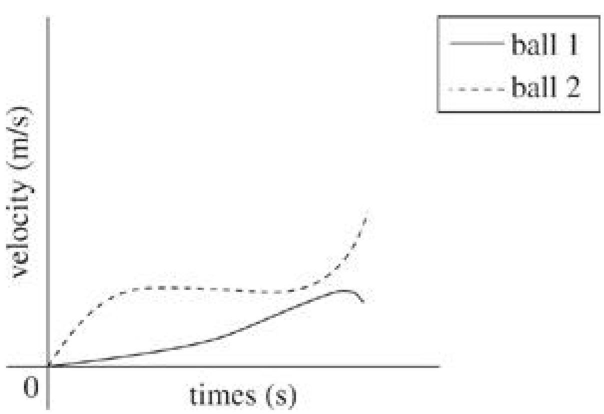
9. According to Student 1, which of the following graphs demonstrates the velocity of the two balls as time increases?



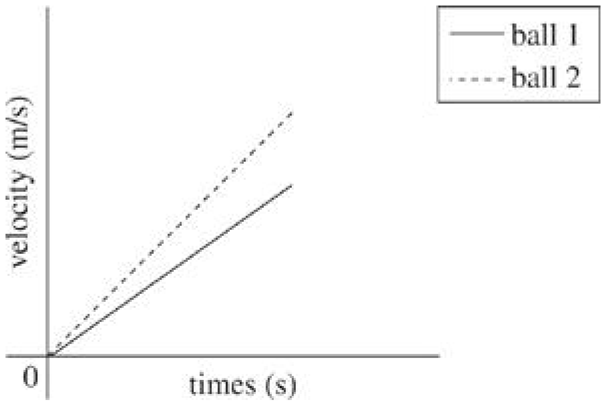
F.



G.



H.

J. 

10. According to Student 1, did the surface area of the second ball have an effect on its terminal velocity?

A. Yes; as the surface area of a ball decreases, its terminal velocity decreases only.

B. Yes; as the surface area of a ball increases, its terminal velocity decreases only.

C. No; as the surface area of a ball increases, its terminal velocity decreases, then increases.

D. No; as the surface area of a ball increases, its terminal velocity is not affected.

11. Assuming that Student 3's explanation is correct, once the second ball starts falling, does it reach terminal velocity?

F. Yes, because the weight of the ball was constant and drag force increased.

G. Yes, because the weight of the ball decreased and no drag force was present.

H. No, because the weight of the ball decreased and drag force was constant.

J. No, because the weight of the ball was constant and no drag force was present.

12. The 3 explanations of the motion of the balls are similar to each other in that all 3 explanations suggest that:

A. differences in the gravitational force are responsible for the change in falling times.

B. increases in velocity result from gravity.

C. drag plays only a small part in determining how long it takes an object to fall.

D. a lead ball would have fallen faster.

13. Based on the explanations of the 3 students, what did all 3 students assume about the first ball?

F. The velocity did not change.

G. The velocity increased only.

H. The velocity decreased only.

J. The velocity increased for a time, and then reached terminal velocity.

SET 3

Sylvatic, or jungle, Yellow Fever is caused by a virus transmitted by mosquitoes from monkeys to humans. Figure 1 shows the life cycle of the mosquitoes who carry this disease. These mosquitoes' eggs do not hatch unless there is enough water for the next two stages of their life cycles. Yellow Fever is passed when an adult of these mosquitoes first bites a monkey that is infected with the virus and then bites a human.

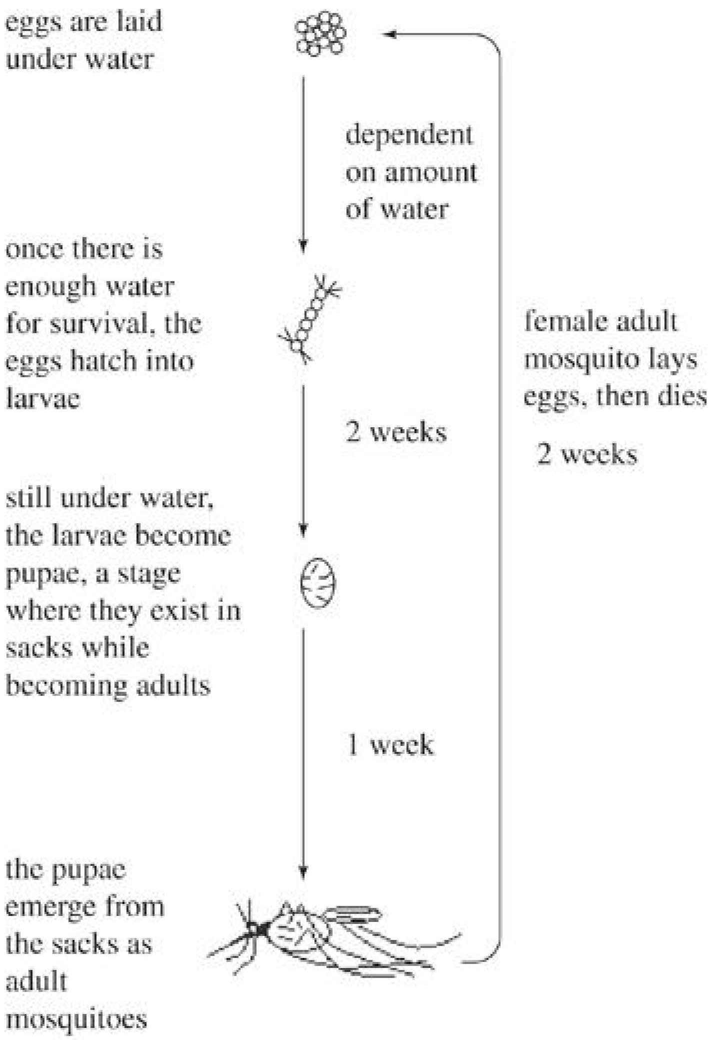


Figure 1

A study was done on a group of ecologists who went into a jungle where the monkeys carrying the Yellow Fever virus live. These ecologists were divided into groups based on how frequently they went into the jungle. The ecologists were tested monthly for Yellow Fever. Figure 2 shows the number of new cases of Yellow Fever and the amount of rainfall in the jungle. For each group, Table 1 shows the number of ecologists in each group, number of mosquito bites, and percent of each group with Yellow Fever.

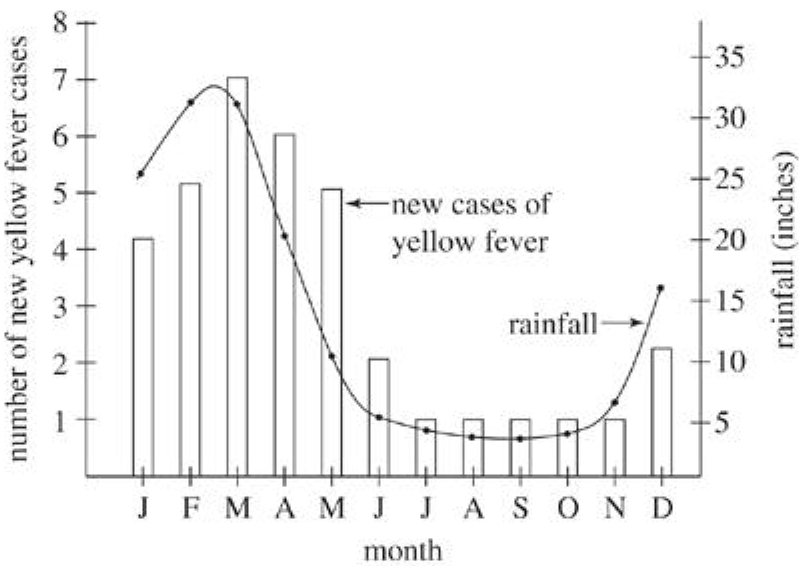


Figure 2

Table 1					
Group	Number of ecologists	Number of trips	Number of monkeys seen	Number of mosquito bites	Percent of group affected by yellow fever
A	10	0–5	36	100	10%
B	12	5–10	20	156	18%
C	10	10–15	43	210	29%
D	11	15–20	38	220	38%
E	13	20–25	58	338	52%

1. Based on Figure 1, what is essential in maintaining the mosquito population?

A. Jungle

B. Water

C. Monkeys

D. Humans

2. Based on **Table 1**, the average percent of ecologists affected by the yellow fever virus was closest to:

F. 20%.

G. 30%.

H. 60%.

J. 80%.

3. Suppose additional data had been gathered for **Table 1** about the number of mosquito bites per month. Based on Figure 2 and **Table 1**, in which of the following months would you expect to have the largest total of mosquito bites per month?

A. April

B. June

C. August

D. November

4. According to Figure 2, the amount of rainfall was different for each of the following pairs of months EXCEPT:

F. May and December.

G. February and March.

H. January and October.

J. April and May.

5. Based on **Table 1**, as the number of trips into the jungle increased, the number of monkeys seen:

A. increased only.

B. decreased only.

C. increased, then decreased.

D. varied with no consistency.

Ethanolamines are compounds that contain both alcohol (-OH or HO-) and amine ($-NH_3$, $-RNH_2$, $-R_2NH$, or $-R_3N$) subgroups. They remove weakly acidic gases from the atmosphere of enclosed spaces such as on a submarine. An example is the use of *monoethanolamine* (MEA) to remove CO_2 from the atmosphere as shown in Figure 1.

$$2\ \text{MEA(liquid)} + \text{CO}^{2}\text{(gas)} \xrightarrow{H_2O} \text{(MEA)COO}^{-}\text{(aqueous)} + \text{(MEA)H}^{+}\text{(aqueous)} + \text{heat}$$

Figure 1

If the temperature rises sufficiently, ethanolamines will release any absorbed acidic gases back into the environment, creating a potential hazard.

Scientists studied the absorption properties of 2 ethanolamines (MEA and DEA).

Experiment 1

At 0°C and 1 atmosphere (atm) pressure, 1 mole (6.02×10^{23} molecules) of MEA was spread at the base of a reaction vessel containing CO_2 gas at a concentration of 1,000 parts per million (ppm). As the CO_2 was absorbed, its ambient concentration decreased. The *scrub time* (time for CO_2 concentration to drop to at least 10 ppm) was measured. Longer scrub times indicate a slower rate of absorption. The experimental procedure was repeated at varying temperatures and for DEA, with results recorded in Table 1.

Table 1		
Temperature (°C)	Scrub time (msec)	
	MEA	DEA
0	11,400	8,600
5	11,150	8,410
10	11,025	8,315
15	10,925	8,240
20	10,850	8,190
25	10,790	8,145
30	10,740	8,105
35	10,700	8,075

Experiment 2

The scrub times of MEA for different acidic gases were measured using the procedures of Experiment 1 at 26°C (see Table 2). Each of the gases listed is toxic and poses a significant safety hazard if its concentration becomes elevated within an enclosed space.

Table 2		
Gas	Formula	Scrub time (msec)
Hydrogen chloride*	HCl	8,500
Hydrogen cyanide	HCN	14,400
Hydrogen sulfide	H_2S	12,200
Sulfur dioxide	SO_2	8,930
Sulfur trioxide	SO_3	9,120

*Hydrogen chloride forms gaseous hydrochloric acid upon contact with atmospheric humidity.

6. In which of the following ways was the procedure of Experiment 2 different from that of Experiment 1? In Experiment 2:

F. temperature was varied; in Experiment 1, the temperature was held constant.

G. temperature was held constant; in Experiment 1, the temperature was varied.

H. only MEA was used; in Experiment 1, only DEA was used.

J. only DEA was used; in Experiment 1, only MEA was used.

7. In Experiment 1, during the DEA trial at 20°C, as the time progressed from 0 to 8,190 msec, the concentration of CO_2 in the vessel:

A. increased from 10 ppm to 1,000 ppm.

B. increased from 1,000 ppm to 10 ppm.

C. decreased from 10 ppm to 1,000 ppm.

D. decreased from 1,000 ppm to 10 ppm.

8. If, in Experiment 1, an additional trial were done at 12°C, the scrub times (in msec) for MEA and DEA would most likely be closest to which of the following?

F. 10,805

G. 10,985

H. 11,000

J. 11,025

9. Based on the information in the passage, which of the following is a possible chemical formula for an ethanolamine?

A. $HO\text{--}(CH_2)_2\text{--}NH_3$

B. $HO\text{--}(CH_2CF_2)_2\text{--}CH_3$

C. $H^3C\text{--}(CH_2)_4\text{--}NH_3$

D. $H_3N\text{--}(CH_2CHCl)_2\text{--}NH_3$

10. A scientist claims that under the same conditions, DEA will always absorb CO_2 at a faster rate than will MEA. Do the results of Experiment 1 support this claim?

F. No; at all temperatures tested, the scrub time for DEA was more than that for MEA.

G. No; at all temperatures tested, the scrub time for MEA was more than that for DEA.

H. Yes; at all temperatures tested, the scrub time for DEA was more than that for MEA.

J. Yes; at all temperatures tested, the scrub time for MEA was more than that for DEA.

11. Based on the results of Experiment 2, which acidic gas had the slowest absorption by MEA at 26°C?

A. HCl

B. HCN

C. H_2S

D. SO_2