ACT SCIENCE PRACTICE PAPER 7

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.

Convection is a heat transfer process caused by moving liquid or gas currents from a hot region to a cold region. As a liquid or gas cools, it gets more dense. An example of a convection process is a cup of hot coffee: the liquid toward the top is cooled by the air, so it becomes more dense and sinks to the bottom of the cup; the hotter liquid toward the bottom of the cup is less dense, so it rises toward the top. See Figure 1, below.

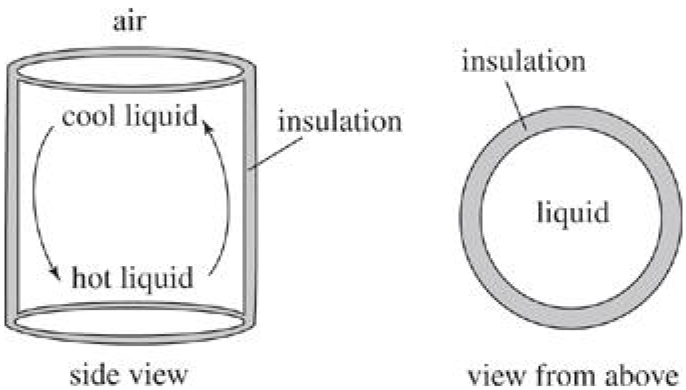


Figure 1

The temperature of the liquid at the hot end of the insulated system is higher than the temperature at the cool end of the system. The difference (ΔT) between the hot liquid at the bottom and the cold liquid at the top changes depending on the starting temperature of the system. Table 1 gives ΔT for 500 mL of water in an insulated container with a height of 6.0 cm and a cross-sectional area of 4.0 cm^2 when the container is heated to different temperatures.

Table 1	
Heated temperature (°C)	Δ*T* (°C)
80	1
100	4

120	10
140	19

Figure 2 shows how ΔT changes with cross-sectional area for 500 mL of 100°C water in a container with a height of 6.0 cm. Figure 3 shows how ΔT changes with height for 500 mL 100°C water in a container with a cross-sectional area of 4.0 cm^2.

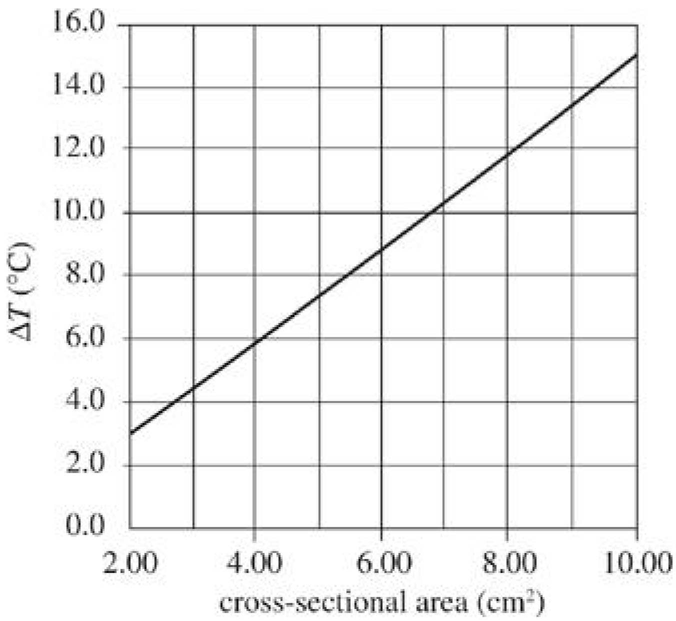


Figure 2

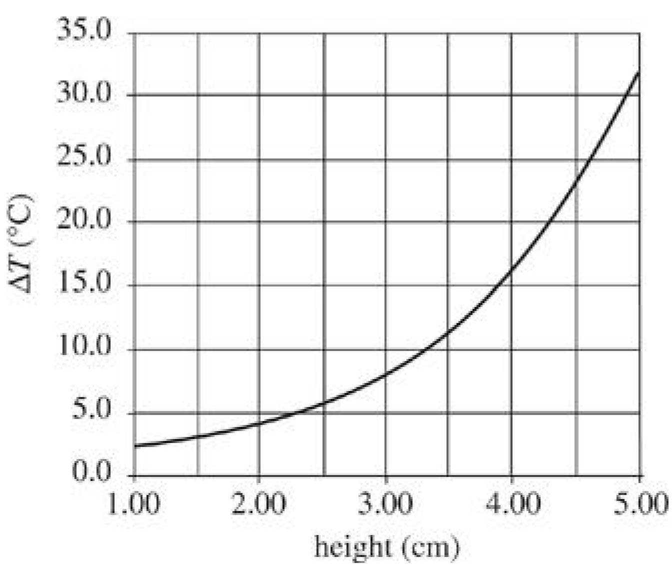


Figure 3

1. System 1 and System 2 are two convection systems. Based on

Figure 2, if System 1 were the same height as System 2, but had two times the cross-sectional area and the systems were heated to the same temperature, the ratio of ΔT for System 1 to ΔT for System 2 would be:

F. 1:01

G. 1:02

H. 2:01

J. 3:01

2. For the systems described in the passage, if the containers were metal containers rather than insulated containers, heat would be transferred from the water to the container by which of the following heat transfer processes?

I. Convection

II. Conduction

III. Radiation

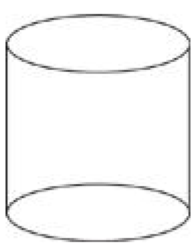
A. I only

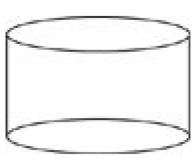
B. II only

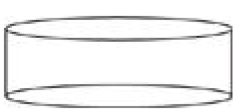
C. I and III only

D. I and II only

3. Which of the following systems, if all were heated to the same temperature, would have the greatest ΔT?

F. 

G. 

H. 

J. 

4. Based on the information in

Table 1, if an insulated container of 500 mL of water with a height of 6.0 cm and a cross-sectional area of 4.0 cm^2 were heated to 120°C, which of the following pairs could represent the temperatures of the liquid at the top and bottom ends of the container?

<u>Bottom end</u> <u>Top/Exposed to air end</u>

A. 140°C 120°C

B. 140°C 110°C

C. 115°C 115°C

D. 120°C 110°C

5. The data in the passage supports the hypothesis that Δ*T* increases as which of the following increases?

F. Amount of insulation

G. Volume of liquid

H. Radius of the container

J. Air temperature

Metallic *alloys*, solid mixtures of metal, are useful for coin production when they contain a high percentage of zinc. When electric current is applied to zinc in the presence of precious metal solutions of *silver nitrate*, *copper sulfate* or *potassium gold cyanide*, the precious metals *plate* (form a coating) on the zinc surface.

- Silver nitrate, formed when silver dissolves in nitric acid, reacts with zinc to form solid silver and zinc nitrate.

- Copper sulfate, formed when copper dissolves in sulfuric acid, reacts with zinc to form solid copper and zinc sulfate.

- Potassium gold cyanide contains reactive gold ions.

A chemist performed experiments on precious metal plating.

Experiment 1

The chemist obtained 4 coin-like samples of a high percentage zinc alloy. All samples were circular, had a radius of 1 cm, and had the same thickness. The mass of each coin was recorded. Each coin was wired via a battery to a strip of either pure silver or copper metal. Coins wired to silver were placed in dilute nitric acid and coins wired to copper were placed in dilute sulfuric acid. Electric current of either 1,000 milliamperes (mA) or 2,000 mA was applied for 30 minutes to each sample. The coins were removed and the increase in mass from precious metal plating was recorded in milligrams. Results of the experiment are shown in Table 1.

Table 1			
Coin sample	Precious metal solution		Increased mass from plating (mg)
	Identity	Electric Current (mA)	
I	silver nitrate	1,000	2.0
II	silver nitrate	2,000	4.0
III	copper sulfate	1,000	1.2
IV	copper sulfate	2,000	2.4

Experiment 2

The chemist completely dissolved equal amounts of pure silver in 4 beakers of nitric acid. He then placed equivalent coin-like samples of zinc into the beakers for different lengths of time measured in minutes (min). The coin surfaces developed a silver metal coating without any electric current applied. The concentrations of silver coating on the coin and zinc nitrate in the surrounding solution were determined in parts per billion (ppb) and recorded in Table 2.

Table 2			
Coin sample	Time (min)	Silver coating concentration (ppb)	Zinc nitrate concentration (ppb)
V	5	75	30
VI	15	125	55
VII	30	200	75
VIII	60	500	85

6. A comparison of the results for coin samples II and IV supports the hypothesis that zinc is plated more extensively when exposed to:

A. silver nitrate and a current of 1,000 mA than silver nitrate and a current of 2,000 mA.

B. copper sulfate and a current of 1,000 mA than copper sulfate and a current of 2,000 mA.

C. silver nitrate than when exposed to copper sulfate.

D. copper sulfate than when exposed to silver nitrate.

7. If the chemist were to repeat Experiment 1, but compress each coin sample to a radius of 0.5 cm to decrease the surface area exposed to the surrounding solution, how would the mass of precious metal plated most likely be affected?

F. The mass of precious metal plated would decrease for all coin samples.

G. The mass of precious metal plated would decrease for coin samples I and III and increase for coin samples II and IV.

H. The mass of precious metal plated would remain constant for all coin samples.

J. The mass of precious metal plated would increase for all coin samples.

8. According to the information in the passage, a zinc alloy coin sample exposed to which of the following conditions would result in the greatest concentration of zinc nitrate?

A. 10 minutes in a solution with a high initial concentration of silver nitrate

B. 10 minutes in a solution with a low initial concentration of silver nitrate

C. 6 minutes in a solution with a high initial concentration of silver nitrate

D. 6 minutes in a solution with a low initial concentration of silver nitrate

9. In Experiment 1, if the chemist had applied 1,580 mA to a 1 cm radius zinc alloy coin sample in a copper sulfate solution, approximately how much copper would have plated after 30 minutes?

F. 0.6 mg

G. 1.1 mg

H. 1.9 mg

J. 4.6 mg

10. In Experiment 1, which of the following variables was the same for all 4 zinc alloy coin sample trials?

A. Change in mass from plating

B. Electric current applied

C. Type of precious metal solution used

D. Initial radius of the sample

11. According to the passage, if a chemist wants to study the effect of plating zinc alloys with silver, the chemist should monitor the concentration of which of the following substances in the surrounding solution?

F. Potassium gold cyanide

G. Zinc nitrate

H. Copper sulfate

J. Sulfuric acid

SET 2

Organic compounds are molecules that frequently contain carbon (C), hydrogen (H), and oxygen (O) joined together by covalent bonds (symbolized by straight lines in chemical notation). As the number of bonds to oxygen atoms increases in a carbon chain, the overall molecule is increasingly oxidized. For example, aldehydes are more oxidized than alcohols, which are more oxidized than alkanes as shown in Table 1. The melting points of these compounds are listed in Table 2, and their viscosities (resistance to flow, or "stickiness,") are listed in Table 3.

Table 1

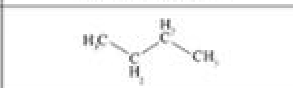
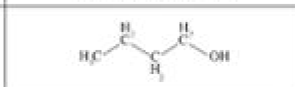
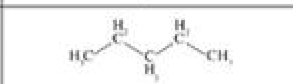
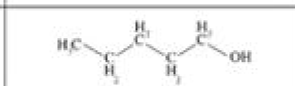
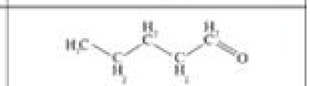
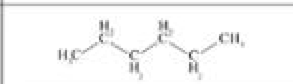
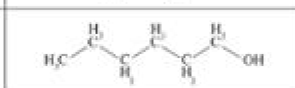
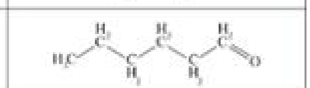
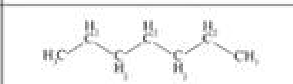
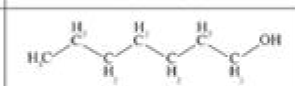
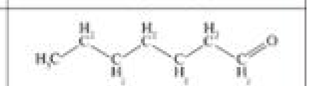
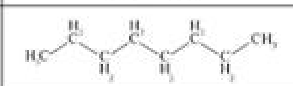
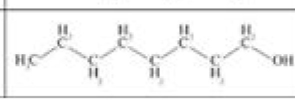
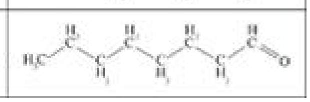
Carbons in the chain	Name prefix	Structure		
		alkane (suffix -ane)	alcohol (suffix -anol)	aldehyde (suffix -analdehyde)
4	but-			
5	pent-			
6	hex-			
7	hept-			
8	oct-			

Table 2

Carbons in the chain	Melting point (K)		
	alkane	alcohol	aldehyde
4	135	183	174
5	143	194	213
6	178	221	217
7	182	239	231
8	216	257	285

Table 3			
Carbons in the chain	Viscosity (cP)		
	alkane	alcohol	aldehyde
4	0.01	3.0	0.4
5	0.24	5.1	0.5
6	0.29	5.4	0.8
7	0.39	5.8	1.0
8	0.54	8.4	1.2

1. Which organic compounds in

Table 2 are solids at 215 K?

A. All alkanes, alcohols, and aldehydes with 5 carbons or fewer.

B. Alcohols and aldehydes with 6 or more carbons and octane.

C. The 4- and 5-carbon alcohols and aldehydes, and all alkanes with 7 or fewer carbons.

D. The 5-carbon pentane and pentanol compounds and the 4-carbon butane, butanol, and butanaldehyde.

2. According to

Tables 1 and

3, which organic compound has the highest viscosity?

F. Octanol

G. Octanaldehyde

H. Hexanol

J. Butane

3. According to

Table 3, how do the different types of 5-carbon molecules differ with respect to their viscosity?

A. The alkane has a higher viscosity than the aldehyde and the aldehyde has a higher viscosity than the alcohol.

B. The alkane has a higher viscosity than the alcohol and the alcohol has a higher viscosity than the aldehyde.

C. The alcohol has a higher viscosity than the alkane and the alkane has a higher viscosity than the aldehyde.

D. The alcohol has a higher viscosity than the aldehyde and the aldehyde has a higher viscosity than the alkane.

4. For each type of organic compound, what is the relationship between the length of the carbon chain to the melting point and viscosity? As the number of carbons in the chain increases, the melting point:

F. decreases and the viscosity decreases.

G. increases and the viscosity increases.

H. increases but the viscosity decreases.

J. decreases but the viscosity increases.

5. According to

Table 2, the difference in melting point between an alkane and an alcohol with the same number of carbons is approximately how much?

A. 25 K

B. 35 K

C. 45 K

D. 65 K

A mass suspended by a lightweight thread and swinging back and forth approximates the motion of a *simple gravity pendulum*, a system in which gravity is the only force acting on the mass, causing an acceleration of 9.8 m/sec^2. The time to complete one cycle of swinging back and forth is the *period* and is inversely related to gravitational acceleration.

Using the same type and length of thread, 2 cubes were suspended, lifted to the same starting angle, and let go. The amount of time required for each pendulum to complete one swinging cycle (1 period) was recorded with a timer capable of reading to the nearest 0.01 sec. The measured times were used to calculate acceleration.

Experiment 1

A cube of lead (11.3 grams) and a cube of tin (7.4 grams) were suspended from a 0.5 m length of thread. Both cubes had the same length. (Note: A cube's volume is proportional to its length cubed; its surface area is proportional to its length squared.) The cubes were set in motion from a fixed starting angle, and the period for each was recorded.

Table 1		
Trial	Measured period (sec)	
	lead cube	tin cube
1	1.48	1.51
2	1.45	1.47
3	1.46	1.42
4	1.49	1.45
5	1.39	1.53

The average periods were 1.46 sec and 1.48 sec for the lead and tin cubes, respectively. The average accelerations were 9.3 m/sec^2 for lead and 9.1 m/sec^2 for tin.

Experiment 2

The same procedures used in Experiment 1 were repeated using a thread length of 1.0 m and the same fixed starting angle. Results were recorded in Table 2.

Table 2		
Trial	Measured period (sec)	
	lead cube	tin cube
6	2.10	2.12
7	2.04	2.06
8	2.05	2.07
9	2.12	2.11
10	2.00	2.10

The average periods were 2.06 sec and 2.09 sec for the lead and tin cubes, respectively. The average accelerations were 9.3 m/sec^2 for lead and 9.0 m/sec^2 for tin.

Experiment 3

Given the results of the first 2 experiments, the accuracy of the timer was tested. The procedures of Experiment 1 were repeated using only the lead cube. The trials were recorded on digital video at 100 frames per second. The video was then reviewed to obtain precise measurements of the period for each trial and results are shown in Table 3.

Table 3	
Trial	Measured period (sec)
11	1.47
12	1.42
13	1.49
14	1.50
15	1.46

The average period recorded in Table 3 was 1.47 sec.

6. To demonstrate that a pendulum's acceleration is reduced by drag force from air resistance, which additional experiment can be performed in addition to those in the passage?

F. The cubes are suspended by 0.5 m and 1 m springs and set in motion by extending the spring 9.8 cm and letting go in a vacuum chamber with no air pressure.

G. The cubes are suspended by 0.5 m and 1 m threads and set in motion from the same starting angle in a vacuum chamber with no air pressure.

H. The cubes are suspended by 0.5 m and 1 m springs and set in motion by extending the spring 9.8 cm and letting go in a vacuum chamber at 1 atmosphere of pressure.

J. The cubes are suspended by 0.5 m and 1 m threads and set in motion from the same starting angle in a vacuum chamber at 1 atmosphere of pressure.

7. In Experiment 1, could a timer that reads to the nearest second be used to obtain similar results, and why?

A. No, because the period of both pendulums was between 1 and 2 seconds.

B. No, because the pendulums would have traveled farther in 1 second than they did in 1 period.

C. Yes, because the period of both pendulums was approximately 1.5 seconds.

D. Yes, because the pendulums would not have traveled as far in 1 second as they did in 1 period.

8. The results of the experiments indicate that forces other than gravity are acting on the pendulums because the calculated values of acceleration were:

F. the same for pendulums of different lengths.

G. the same for cubes of different mass.

H. lower than the expected 9.8 m/sec^2 from gravity alone.

J. greater than the expected 9.8 m/sec^2 from gravity alone.

9. Based on the passage, if a tin cube is suspended from a 2.0 m thread and set in motion multiple times from the same starting angle, the average measured period will most likely be:

A. less than 1.48 sec.

B. approximately 1.48 sec.

C. approximately 2.09 sec.

D. greater than 2.09 sec.

10. In Experiment 2, if an additional trial were conducted using the lead cube, the cube's measured period would most likely be nearest:

F. 1.90 sec.

G. 2.05 sec.

H. 2.15 sec.

J. 2.20 sec.

11. Experiments 1 and 2 were conducted using lead and tin cubes most likely to determine whether a pendulum's period was altered by the material attached to the string and the cube's:

A. length.

B. surface area.

C. starting angle.

D. mass.

SET 3

Accepted classification systems of life do not include *viruses*. Although viruses possess certain features of cellular organisms, including genetic material that codes for making new viral particles, they cannot *replicate* (make copies of) themselves without first infecting a living cell. Biologists agree that viruses originated from genetic material called *nucleic acid*, but it is difficult to prove any single theory regarding how this occurred. Three hypotheses of viral origin are presented here.

Coevolution Hypothesis

Some biologists argue that viruses evolved alongside other organisms over billions of years. They suggest that simple molecules of *ribonucleic acid* (RNA), a *nucleotide* that forms the genetic code for proteins, joined to form more complex sequences. These RNA sequences developed enzyme-like abilities including the ability to self-replicate and insert themselves into other nucleotide sequences. While some RNA sequences became incorporated into membrane-bound cells, others were packaged inside proteins as the first viral particles that could replicate after infecting cellular organisms (see Figure 1).

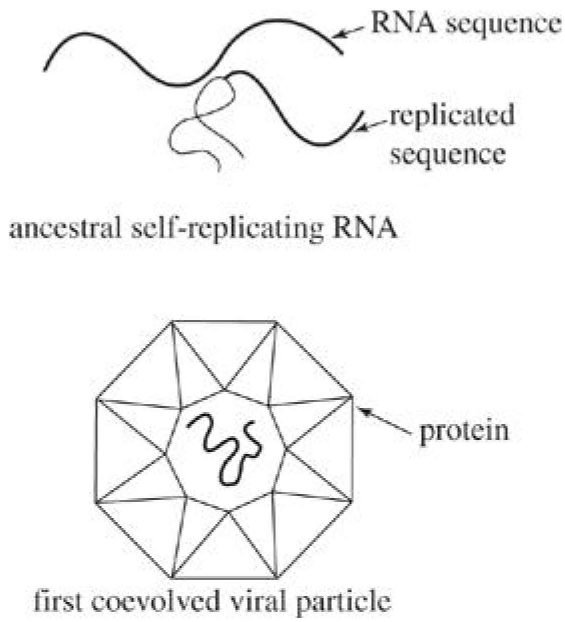


Figure 1

Cellular Origin Hypothesis

Some biologists claim that nucleotide sequences within *prokaryotic* (non-nucleated) and *eukaryotic* (nucleated) cellular organisms incorporated into a protein coating and escaped from the cell as a viral particle. Initially, DNA or RNA nucleotide sequences gained the code required for other cells to replicate them. Next, these sequences associated with proteins to form an outer *capsid*. Finally, the *virion* (viral particle) became capable of passing through the cell membrane and infecting other cells where it could be replicated. After the initial escape, viruses evolved independently from their initial host and ultimately could infect either prokaryotic or eukaryotic cells.

Regressive Evolution Hypothesis

An alternative explanation of viral origin is that viruses evolved from cellular organisms. Some cellular organisms, particularly certain bacteria, are *obligate intracellular parasites* because they must infect a host cell in order to reproduce. Regressive evolution suggests that some bacterial parasites gradually lost the structures required for survival outside of a cell. The result was a virus particle containing only nucleotides, a capsid (protein coating), and at times an outer membrane or envelope. This would account readily for viruses that contain complex *deoxyribonucleic acid* (DNA) similar to that found in bacteria and other cellular organisms (see Figure 2).

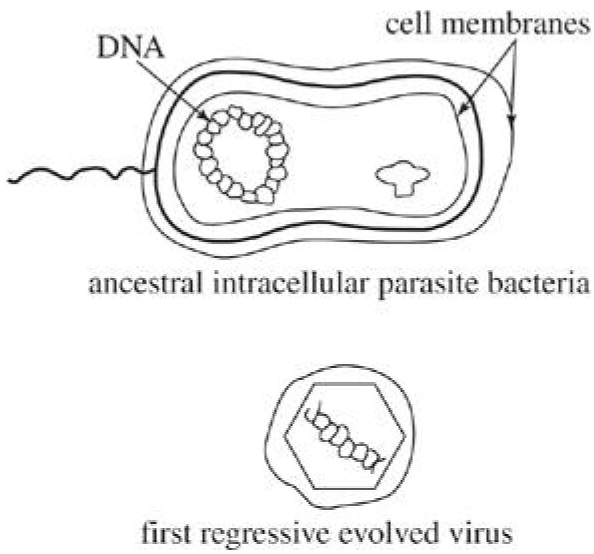


Figure 2

1. The development of which of the following is addressed in the passage by the Coevolution Hypothesis, but NOT by the Regressive Evolution Hypothesis?

F. Self-replication

G. Capsid

H. Deoxyribonucleic acid

J. Cell membrane transit

2. Supporters of all of the theories presented in the passage would agree with the conclusion that the first viruses:

A. evolved from bacteria.

B. could self-replicate outside a cell.

C. were enclosed within a membrane.

D. contained nucleic acid.

3. The Coevolution Hypothesis does NOT provide an explanation for the earliest virus particles possessing:

F. protein.

G. enzyme-like activity.

H. nucleotides.

J. DNA.

4. If the Cellular Origin Hypothesis is correct, which of the following conclusions can be made about modern T4 DNA viruses, which infect *Escherichia coli* bacteria, and modern PP7 RNA viruses, which infect *Pseudomonas aeruginosa* bacteria?

A. T4 and PP7 are more closely related to each other than to bacteria genetically.

B. T4 and PP7 are only distantly related genetically through a cellular organism.

C. T4 and PP7 both evolved from prokaryotic organisms.

D. T4 and PP7 both evolved from eukaryotic organisms.

5. The discovery of which of the following living organisms would provide the most support for the Regressive Evolution Hypothesis?

F. Extracellular parasites with DNA resembling a known virus

G. Extracellular parasites with unique RNA nucleotide sequences

H. Intracellular parasites with DNA resembling a known virus

J. Intracellular parasites with unique RNA nucleotide sequences

6. Supporters of all the theories presented would agree with which of the following conclusions about the origin of viruses?

A. Viral capsids contain a protein structure similar to the cell walls of modern bacteria.

B. The first viruses did not originate before the first cellular organisms.

C. RNA viruses are more advanced than DNA viruses.

D. The first virus contained DNA and was surrounded by an envelope similar to a cell membrane.

7. Which of the following questions is raised by the Coevolution Hypothesis, but is NOT answered in the passage?

F. Why were some RNA sequences packaged into protein structures and others incorporated into cell structures?

G. Why did obligate intracellular parasites lose their ability to survive outside of cells?

H. How could two different types of cellular organisms account for the origin of viruses?

J. How did virions develop the ability to pass through the cell membrane out of the cell?

Wind causes *topsoil deflation*, a type of erosion that is affected by plant and organic cover as well as water content of the soil. Scientists performed 2 experiments using equal-sized fields containing the same volume of soil. The soil samples were primarily a mixture of sand and silt, but differed in the percentage of clay they contained. Soil X was composed of 5% clay and soil Y was composed of 40% clay. Large fans were used to simulate wind. Topsoil deflation was measured in kilograms per hectare (kg/ha) following 10 hours of wind.

Experiment 1

A mixture of compost and straw was used to represent plant and organic cover. The percentage of soil covered with the mixture was considered to approximate an equivalent percentage of natural vegetative cover. One field remained uncovered, and the other fields were covered with different percentages of compost and straw. The topsoil deflation from each field was recorded in Table 1.

Table 1				
Soil	Topsoil deflation (kg/ha) by percentage of organic cover			
	0%	25%	50%	75%
X	105,000	68,000	46,000	20,000
Y	65,000	42,000	28,500	12,000

Experiment 2

Rainfall was simulated using a sprinkler system. Sprinklers were turned on for either 4 hours or 8 hours for fields of each kind of soil. Two additional fields composed of each type of soil were left unwatered. Afterward, soil samples were taken from all of the fields to determine their water content percentage, which was recorded in Table 2. Wind was applied as in Experiment 1 and topsoil deflation for all fields was recorded in Table 3.

Table 2			
Soil	Water content of soil following various sprinkler times		
	0 hours	4 hours	8 hours
X	10%	13%	16%
Y	10%	14%	22%

Table 3			
Soil	Topsoil deflation (kg/ha) following various sprinkler times		
	0 hours	4 hours	8 hours
X	89,250	66,000	14,000
Y	53,400	40,100	10,300

8. According to the results of Experiments 1 and 2, topsoil deflation will be minimized by:

A. decreased organic cover, increased amount of rainfall, and the use of either Soil X or Y as topsoil.

B. decreased organic cover, decreased amount of rainfall, and the use of Soil Y as topsoil.

C. increased organic cover, increased amount of rainfall, and the use of Soil Y as topsoil.

D. increased organic cover, increased amount of rainfall, and the use of Soil X as topsoil.

9. If Experiment 1 were repeated using a soil containing 10% clay with 0% organic cover, which of the following would be the most likely topsoil deflation amount?

F. 110,200 kg/ha

G. 99,800 kg/ha

H. 70,700 kg/ha

J. 60,200 kg/ha

10. To further investigate the effect of water content on erosion from topsoil deflation, the scientists should repeat Experiment:

A. 1, using a different type of topsoil.

B. 1, using plastic covers over the fields.

C. 2, using no sprinklers.

D. 2, using fields exposed to various amounts of rainfall.

11. What assumption in experimental design is most important to consider when applying the findings of Experiment 1 to a practical situation?

F. The quantity of topsoil deflation is independent of the percentage of clay present in the soil.

G. The presence of straw on the soil does not accurately simulate vegetation and organic cover.

H. Air movement from fans provides an accurate simulation of the wind responsible for topsoil deflation.

J. Compost is more effective than water content in the prevention of topsoil erosion.

12. In Experiment 2, the water content in the two soil types was similar after 4 hours of sprinkling, yet the topsoil deflation was significantly different. Which of the following statements provides the best explanation for these findings?

A. Topsoil erosion is independent of the water content found in the soil.

B. Fields are susceptible to topsoil deflation only when water completely evaporates from the topsoil.

C. Soil with a lower percentage of clay is more prone to erosion from topsoil deflation than one with a higher percentage of clay.

D. Water is trapped in the topsoil by wind and this increases the rate of topsoil deflation.

13. If Experiment 2 were repeated with soil containing 10% clay, which of the following values would be expected for water content and topsoil deflation in a field following 8 hours of water sprinkling?

F. water content of 17%; topsoil deflation of 13,400 kg/ha

G. water content of 21%; topsoil deflation of 9,700 kg/ha

H. water content of 15%; topsoil deflation of 10,900 kg/ha

J. water content of 14%; topsoil deflation of 101,000 kg/ha