ACT Science

Improving College Admission Test Scores

Student Workbook

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FOREWORD

The purpose of this workbook is to help improve competency in important academic content and reasoning skill areas, the kind of capabilities that are examined in college admission tests such as the ACT. The workbook will also develop familiarity with testing formats used for the ACT. A review of academic knowledge and skills, together with familiarity with testing formats, can help you to perform to your potential on college admission examinations.

The ACT measures competencies in four fields: English, mathematics, reading, and science. It gauges your educational development and academic achievement.

The exercises in this workbook cannot substitute for years of solid class work. They can, however, reinforce prior schoolwork as well as correct some deficiencies. Use this workbook as a diagnostic tool and as a refresher/review program to build confidence and self-assurance.

Instructivision wishes you the best of success on examination day.

INTRODUCTION

The ACT is a comprehensive test as part of a system of data collection, processing, and reporting designed to assist students in the transition from high school to college. Used in combination with a student's high school record, the ACT score report summarizes information about each student's interests, plans, college choices, and current level of educational development. It offers useful information that can help high school counselors advise their students about suitable colleges and programs and can help colleges compare and assess student qualifications.

The academic tests—in English, mathematics, reading, and science—emphasize reasoning and problem-solving skills. The test items represent scholastic tasks required in college level work and are oriented toward the major areas of high school and college instructional programs.

ACT questions are designed to measure a wide range of abilities and knowledge. Consequently, some of the items are difficult while others are fairly easy. It is important not to become discouraged when you encounter questions you find difficult.

The ACT Assessment represents a singular intellectual challenge to high school students. A background of strong academic courses combined with a thorough review will enable you to meet this challenge successfully.

The Science Test

The ACT Science Test is a 40-question, 35-minute examination that measures the interpretation, analysis, evaluation, reasoning, and problem-solving skills required in the natural sciences. The test includes seven sets of questions, each of which consists of some scientific information (the stimulus) and related multiple-choice test items. In order to select the best answer to each question, you must examine the choices, and, applying abilities and skills in scientific reasoning, select the best answer.

Read and examine all the scientific information presented before responding to the questions. Underlining important ideas may prove useful, as will noticing possible flaws in experiments and determining ways that experiments can be improved. Making notes in the margins of the test booklet is encouraged. In the set that focuses on conflicting viewpoints, you should consider summarizing each viewpoint next to that section of the text. If you spend two to three minutes reading each passage, you will have 35 to 41 seconds to answer each question. It is important not to spend too much time on any one question. Use any remaining time to review or to return to questions that seemed difficult. Because there is no penalty for guessing, you are encouraged to answer every question.

The scale on which ACT academic test scores are reported is from 1 to 36, with a mean of 18, based on a nationally representative sample of October-tested 12th grade students who plan to enter two-year or four-year colleges or universities. One score is reported for the ACT Science Test: a total test score based on all 40 questions. A guidance counselor will be glad to answer questions regarding the scoring process and the score reports.

How to Use the Science Workbook

The Student Workbook consists of the introduction, four practice tests, and skill builders covering essential reading comprehension skills. The objectives of the program are to build self-confidence, refresh cognitive skills, identify strengths and weaknesses, and give practice in working with test questions.

Practice Tests: There are four full-length practice tests in this workbook. Under actual testing conditions, you would be allowed 35 minutes to answer all the questions in a full-length test. We therefore recommend that you take at least one of the practice tests in the time allotted on the actual test. The instructions should be followed carefully. Answers should be marked on the appropriate spaces of the student book.

Skill Builders: The skill builders are designed to reinforce science reasoning skills in the principal subsections of the test; they may or may not conform to the length of passages and number of questions found in the actual test.

NOTE: The answers to the sample tests and the skill builder exercises are not found in the Student Workbook. They are included in the Teacher Manual.

Points to Remember

- Do not spend too much time on any one passage.
- Do not spend too much time on any one question (not more than 41 seconds on the average after reading the passage, preferably less).
- Read the entire passage carefully before answering the questions.
- Underline important ideas.
- Use the margins in the test booklet for notes.
- Read all the choices before selecting the best answer.
- Eliminate known incorrect choices before guessing.
- Do not concern yourself with whether a viewpoint is correct; instead, focus on similarities and differences.
- Examine experiments carefully, but keep in mind possible flaws or ways to improve the experiments.
- Familiarize yourself with the content and format of the tests.

ACT Science Test Sections

Content Covered. The content of the Science Test is drawn from biology, chemistry, physics, and the physical sciences (e.g., geology, astronomy, and meteorology). Advanced knowledge in these subjects is not required, but background knowledge at the level of a high school general science course may be needed to answer some of the questions. Advanced mathematical skills are not required, but minimal arithmetic computations may be needed for some questions. The reading portion of the test is concise and clear, so that reading comprehension should not present difficulties. Thus, the test emphasizes scientific reasoning skills rather than recall of scientific content, skill in mathematics, or reading ability. The scientific information is conveyed in one of three different formats:

- **Data Representation.** This format presents graphic and tabular material similar to that found in science journals and texts. The items associated with this format measure skills such as graph reading, interpretation of scatter plots, and interpretation of information presented in tables.

- **Research Summaries.** This format provides descriptions of one or more related experiments. The items focus on the design of experiments and the interpretation of experimental results. All relevant information is completely presented in the text of the stimulus or in the test questions.

- **Conflicting Viewpoints.** This format presents expressions of several hypotheses or views that, being based on differing premises or on incomplete data, are inconsistent with one another. The items focus on the understanding, analysis, and comparison of alternative viewpoints or hypotheses.

The appropriate proportion of the test devoted to each of the three formats is given in the following table.

ACT Assessment Science Test
40 items, 35 minutes

Content Area*	Format	Proportion of Test	Number of Items
Biology Physical Sciences Chemistry Physics	Data Representation	38%	15
	Research Summaries	45%	18
	Conflicting Viewpoints	17%	7
	Total	**100%**	**40**

*Note: Content areas are distributed over the different formats.

PRACTICE TEST A

DIRECTIONS: *There are seven passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and mark the corresponding oval on the answer sheet. You may refer to the passage as often as necessary.*

Passage I

The study of genetics is based on the work of Gregor Mendel who studied specific traits in pea plants He observed self-pollination with tall and short pea plants. The traits that seemed to appear most often he labeled dominant traits. Those traits that seemed to be hidden were considered recessive traits.

A Punnett square is used to find the probability whether a dominant trait or recessive trait shows in a cross. A monohybrid cross is used for one trait. To find two traits, you use a dihybrid Punnett square as shown below.

For the corn color, yellow (pp) is recessive and purple (PP, Pp) is dominant. For the skin texture, wrinkled (ss) is recessive and smooth (SS, Ss) is dominant. The four possible gene combinations are:

PS Ps pS ps

If you cross a heterozygous parent PpSs with a heterozygous PpSs, the results are shown below.

	PS	Ps	pS	ps
PS	PPSS	PPSs	PpSS	PpSs
Ps	PPSs	PPss	PpSs	Ppss
pS	PpSS	PpSs	ppSS	ppSs
ps	PpSs	Ppss	ppSs	ppss

Use the Punnett square to determine the probability of corn color and skin texture.

1. What proportion of the progeny carries the allele for wrinkled skin in the genotype?

   A. $\frac{2}{3}$

   B. $\frac{1}{2}$

   C. $\frac{1}{4}$

   D. $\frac{3}{4}$

2. How many of the ears of corn are yellow with smooth skin?

   F. $\frac{1}{16}$

   G. $\frac{3}{16}$

   H. $\frac{5}{16}$

   J. $\frac{9}{16}$

3. How many of the ears of corn are purple with wrinkled skin?

A. $\frac{1}{16}$

B. $\frac{3}{16}$

C. $\frac{5}{16}$

D. $\frac{9}{16}$

4. What proportion of the progeny is heterozygous for corn color?

F. $\frac{2}{3}$

G. $\frac{1}{2}$

H. $\frac{1}{4}$

J. $\frac{3}{4}$

5. What is the standard genotype ratio for the combinations of traits in the Punnett square when you cross the two traits, PpSs with PpSs?

A. 10:3:2:1
B. 8:4:3:2
C. 9:3:3:1
D. 9:4:1:2

6. You want to produce a crop of purple wrinkled corn for the autumn season. What chance do you have in developing the breed of plant you desire?

F. $\frac{1}{16}$

G. $\frac{3}{16}$

H. $\frac{5}{16}$

J. $\frac{9}{16}$

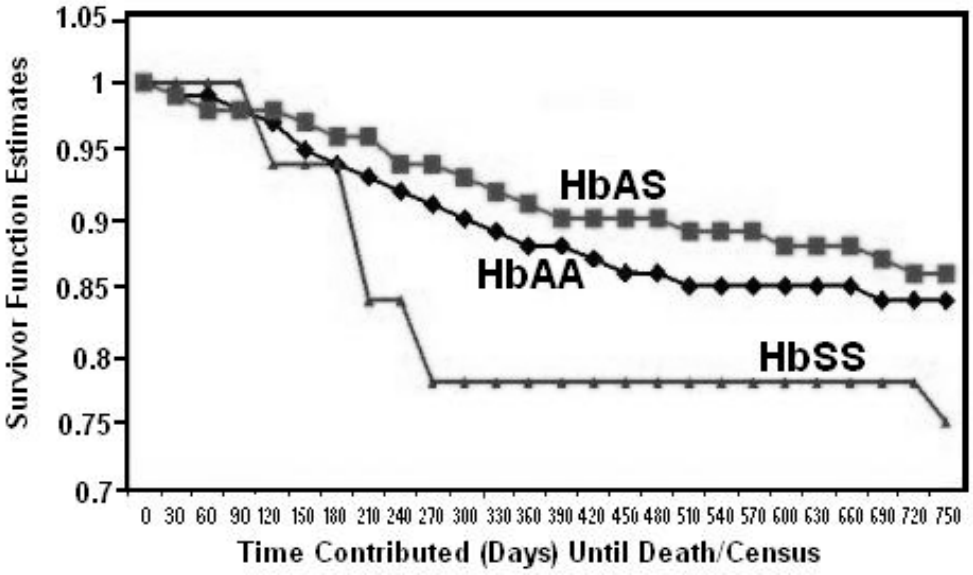
Passage II

Sickle cell anemia is a genetic disorder found in many African populations. The human red blood cell is normally shaped as a round disc. People with sickle cell anemia have a red blood cell, shaped like a sickle that creates a shorter life expectancy for the person. People with this genetic disorder suffer with severe pain, shortness of breath, fevers, etc.

People who carry the sickle cell (trait) have a protective advantage against malaria according to the Centers for Disease Control (CDC). They found that there is a higher frequency of carriers living in an area where malaria is predominating. Below are some statistics from the CDC.

Figure 1

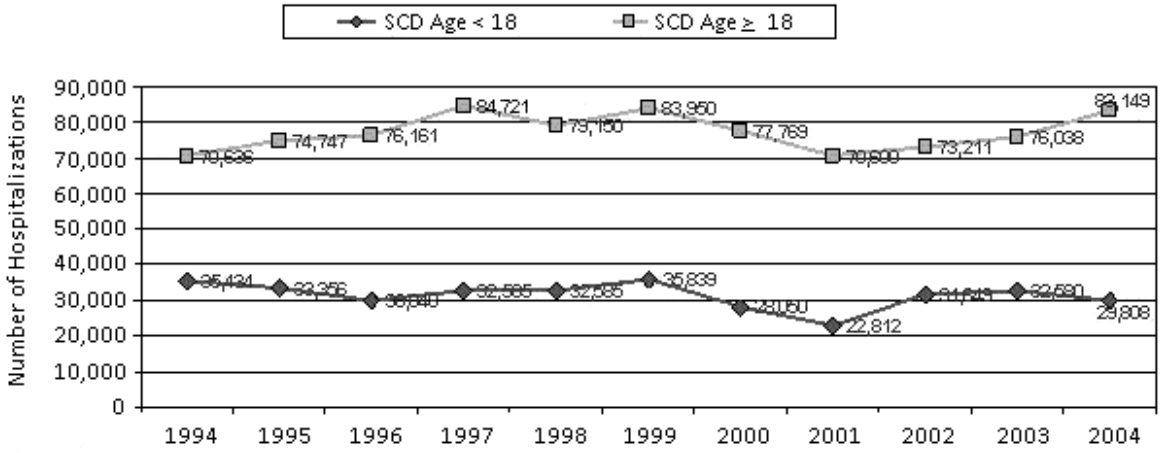
Sickle-cell Trait Confers Protection Against Mortality Between 2-16 Months of Life in Western Kenya



Graph of survival curves ("survival function estimates") of children without any sickle cell genes (HbAA), children with sickle cell trait (HbAS), and children with sickle cell disease (HbSS).

Figure 2

Nationwide Hospitalizations for Children and Adults with Sickle Cell Disease (SCD), 1994-2004

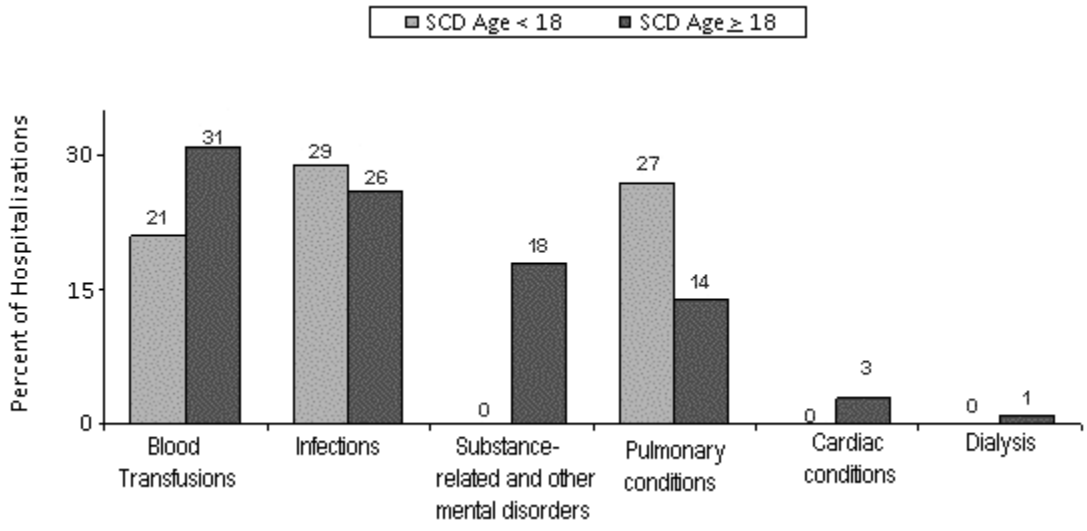


Note: Number of hospitalizations include all listed sickle cell disease diagnoses.

Source: AHRQ, Center for Delivery, Organization, and Markets, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample.

Figure 3

Selected Conditions and Procedures Associated with Principal Diagnosis of Sickle Cell Disease



Note: Number of hospitalizations include all listed sickle cell disease diagnoses.

Source: AHRQ, Center for Delivery, Organization, and Markets, Healthcare Cost and Utilization Project, Nationwide Inpatient Sample.

7. Why would there be a higher frequency of carriers for the sickle cell trait (HbAS) in areas with high risk of malaria infection?

   A. According to Figure 1, children with the HbSS genotype have the lowest death rate.
   B. According to Figure 1, there are more children with the HbAS than the HbAA genotype.
   C. According to Figure 1, the children with the HbAS genotype have a slight survival advantage.
   D. There is no reason for a higher frequency of the HbAS genotype in areas with high risk of malaria infection.

8. Based on the data in Figure 1, when does the child with sickle cell anemia suffer a severe downfall?

   F. 60 days
   G. 90 days
   H. 120 days
   J. 210 days

9. In Figure 2 what year had the highest number of hospitalizations for children with sickle cell anemia?

   A. 1996
   B. 1997
   C. 2000
   D. 2001

10. Which conclusion can be correctly drawn from the three figures that have been provided on sickle cell disease?

    F. Children with the sickle cell trait (HbAS) or sickle cell disease (HbSS) are less likely to survive than children without any sickle cell genes (HbAA).
    G. The number of hospitalizations for adults with sickle cell disease was greater than the number of hospitalizations for children with sickle cell disease from 1994 to 2004.
    H. The most hospitalizations for both adults and children with sickle cell disease were due to infections.
    J. The number of hospitalizations for children and adults with sickle cell disease has decreased from 1994 to 2004 due to advances in medicine.

11. According to Figure 3, what condition or procedure experienced the highest percentage of adults with sickle cell disease (SCD)?

    A. Blood transfusions
    B. Infections
    C. Pulmonary conditions
    D. Mental disorders

12. According to the passage on sickle cell disease, what is a plausible explanation for the data on blood transfusions in Figure 3?

    F. Sickle cell anemia is a genetic condition in which the red blood cell is shaped like a sickle instead of a round disc; therefore, patients with sickle cell disease need blood transfusions.
    G. People with sickle cell anemia do not need blood transfusions because they have a protective advantage against malaria.
    H. Sickle cell patients who receive blood transfusions will have a shorter life expectancy.
    J. Cardiac conditions cause a higher percentage of hospitalizations than blood transfusions in people with sickle cell disease because sickle cell is a disorder of the heart.

Passage III

The property of diffusion is where substances intermix. Diffusion occurs very fast in a gas, fast in a liquid, and does not occur in a solid. In the case of solids in liquids, however, diffusion takes place at a very slow rate.

When a solid is in contact with an excess of solvent (liquid) in which it is soluble (dissolves), some of the solid gets dissolved. This process is called dissolution, where diffusion of solid particles into a liquid takes place.

Experiment 1

A scientist puts five grams of copper sulfate crystals (solid) into a 100 mL beaker. 50 mL of water are added to the beaker. The scientist lets this mixture stand for a few minutes. The water starts to turn blue. The scientist continues to observe until all of the copper sulfate crystals disappear.

Experiment 2

The scientist adds five grams of copper sulfate to three different beakers. She pours 100 mL of distilled water in one of the beakers. Then the scientist pours 100 mL of cold water slowly into the second beaker. She creates a third setup by putting the last beaker on a tripod stand for heating.

Here is a chart she created after observing the diffusion process and the dissolution of the copper sulfate crystals.

Table 1

Beaker Number	Temperature of Water	Time (minutes)
1	25°C	15
2	10°C	20
3	70°C	10

Experiment 3

The scientist adds 50 mL of water to three different beakers. She measures 5 grams of copper sulfate by crystal size—small, medium, and large—and puts the crystals in each beaker. Again she observes and records the time required for complete dissolution.

Table 2

Beaker Number	Crystal Size	Time (minutes)
1	Large	20
2	Medium	15
3	Small	10

13. What is the control in Experiment 2?

A. The amount of copper sulfate used
B. The time the copper sulfate is submerged in water
C. The temperature of the water used
D. The amount of heat applied to each beaker

14. Why do you need a control in an experiment?

F. The control determines the dependent and independent variables.
G. The control determines how to set up the experiment.
H. The control is the baseline for the experiment and allows results of other experiments to be compared.
J The control determines the length of the experiment.

15. What is the variable in Experiment 2?

A. Temperature
B. Time
C. Size of beakers
D. There was no variable in this experiment.

16. What was the conclusion of Experiment 2?

F. The color of the water was blue.
G. The time stayed the same.
H. The rate of diffusion varies with time
J. The rate of diffusion varies directly with temperature.

17. What could you say about the conclusion in Experiment 3?

A. Large particles underwent diffusion quicker than smaller particles.
B. Small particles undergo diffusion quicker than larger particles.
C. Medium particles underwent diffusion all of the time.
D. Large and medium particles had an equal rate of diffusion.

18. What result appears in all three experiments?

F. When solids such as copper sulfate come in contact with a liquid such as water, diffusion takes place.
G. When liquid such as water mixes with a solid like copper sulfate, the temperature decreases.
H. When a solid is a very large crystal, diffusion does not take place.
J. When the temperature increases, diffusion does not take place very quickly.

Passage IV

Study the data table represented below. The table shows the densities of some common materials in either solid/liquid or gas states of matter. Pure water (H_20) has a density of 1.000 grams per cubic centimeter (g/cm^3) at 4°C. If a substance has a mass-to-volume less than 1.000 g/cm^3, the substance floats. If a substance has a mass-to-volume ratio greater than 1.000 g/cm^3, the substance sinks. *Density = mass ÷ volume* is the ratio of the mass of an object to its volume.

Densities of Some Common Materials

Solids and Liquids		Gases	
Material	**Density at 20° (g/cm^3)**	**Material**	**Density at 20° (g/L)**
Gold	19.30	Chlorine	2.95
Mercury	13.60	Carbon Dioxide	1.83
Lead	11.40	Argon	1.66
Aluminum	2.70	Oxygen	1.33
Table Sugar	1.59	Air	1.20
Corn Syrup	1.35 – 1.38	Nitrogen	1.17
Water (4°C)	1.000	Neon	0.84
Corn Oil	0.922	Ammonia	0.718
Ice (0°C)	0.917	Methane	0.665
Ethanol	0.789	Helium	0.166
Gasoline	0.66 – 0.69	Hydrogen	0.084

19. According to the information in the table, which of the following solids has a density closest to that of water?

    A. Table sugar
    B. Aluminum
    C. Lead
    D. Gold

20. If you are given a 10 g block of lead and a 10 g block of aluminum, which block has the greater volume?

    F. Lead
    G. Aluminum
    H. They have the same volume because they are both 10 g.
    J. There is not enough information given.

21. How many solids or liquids listed in the table would sink in water?

    A. 4
    B. 5
    C. 6
    D. 7

22. What materials float according to the table?

    F. Corn syrup, corn oil, ice, and ethanol
    G. Gasoline, ethanol, ice, and corn oil
    H. Ethanol, ice, corn oil, and corn syrup
    J. Ethanol, ice, corn oil, and table sugar

23. Which of the following gases is denser than water?

    A. Neon
    B. Oxygen
    C. Methane
    D. None of the above

24. Mercury is denser than water. What is the difference in density between oxygen and mercury?

F. 14.6 g/L
G. 13.6 g/L
H. 12.6 g/L
J. 12.4 g/L

25. Why does ice float and not sink in water?

A. Ice contains air that is lighter than water.
B. Ice has a lower temperature than water.
C. Solid water sinks because this material is denser than liquid water.
D. Solid water floats because this material is less dense than liquid water.

26. A 72 gram bar of gold is cut into 3 equal pieces. How does the density of each piece compare to the density of the original bar?

F. The density stays the same at 19.3 g/cm^3.
G. The density multiples by three.
H. The density divides by three.
J. The density increases by one-third.

Passage V

There are four clues that a scientist uses to tell whether a chemical change has taken place:

1. A transfer of energy,
2. A change in color,
3. The production of a gas, or
4. The formation of a precipitate (a solid that forms and settles out of a liquid measure)

Acids dissolve certain substances when mixed together. Gases are given off forming bubbles. Heat usually makes the bubbles form faster.

Experiment 1

Measure one test tube with 20 milliliters (mL) of hydrochloric acid (HCl). Add one piece of chalk (calcium carbonate $CaCO_3$) that measures 3 centimeters (cm) long Add the chalk to the test tube. Small bubbles form when the chalk is added to the test tube. The chalk appears to have slightly decreased in size.

Experiment 2

Measure one test tube with 20 milliliters of hydrochloric acid. Add one piece of chalk that measures 3 centimeters long. Heat the test tube using a Bunsen burner. Add the chalk to the test tube. Very large bubbles form when the chalk is added to the test tube. The chalk appears significantly smaller in size.

27. What is the control?

    A. The chalk
    B. The test tube with 20 mL of HCl
    C. The bubbles
    D. The heat

28. What is the variable?

    F. The chalk
    G. The test tube with 20 mL of HCl
    H. The bubbles
    J. The heat

29. What was the conclusion for Experiment 2?

    A. Heat creates larger bubbles, increasing the speed of the reaction.
    B. Heat creates larger bubbles but does not increase the speed of the reaction.
    C. Bubbles do not form when you apply heat
    D. Bubbles form only on the test tube.

30. Why does the chalk appear to decrease in size in both experiments?

    F. The chalk is soluble in the acid.
    G. The chalk is chemically changed by the acid into other substances.
    H. The chalk is insoluble in the acid.
    J. The chalk dissolves in the acid.

31. How do you know that a chemical change occurred in Experiment 1?

    A. Chalk does not dissolve.
    B. Chalk does not shrink in size.
    C. Bubbles form representing a gas release.
    D. Bubbles do not form when the chalk is added.

32. What is the difference between Experiment 1 and Experiment 2?

    F. Chalk does not dissolve.
    G. The resulting size of the chalk is the same.
    H. Bubbles do not form when the chalk is added.
    J. Larger bubbles form when the test tube is heated.

Passage VI

Geologists have identified thousands of minerals. In order to identify specific minerals, geologists use many properties. You can either look at a mineral to observe some of the properties or conduct certain tests on a mineral. Streak, luster, density, hardness, crystal systems, cleavage, and fracture are some of the tests used to identify minerals

In 1812 the Mohs scale of mineral hardness was devised by the German mineralogist Frederich Mohs (1773-1839), who selected the ten minerals because they were common or readily available. The scale is not a linear scale but somewhat arbitrary.

Table 1

Mohs Scale of Mineral Hardness

Hardness	Mineral	Associations and Uses
1	Talc	Talc is used in the manufacture of many items including paper, paint, plastic, rubber, pharmaceuticals, baby power and more
2	Gypsum	Used in fertilizers and plaster. Gypsum is formed when seawater evaporates from the Earth's surface.
3	Calcite	Used in manufacture of anti-aircraft weaponry during World War II
4	Fluorite	Fluorine in fluorite prevents tooth decay.
5	Apatite	Used in the manufacturer of fertilizer and sometimes as a gemstone
6	Orthoclase	Orthoclase is a type of feldspar, used in making glass
7	Quartz	Second most abundant mineral in Earth's crust. Often used in making jewelry and hard-stone carvings.
8	Topaz	Commonly used as gemstone in the making of jewelry
9	Corundum	Sapphire and ruby are varieties of corundum. Has industrial as well as ornamental uses. Twice as hard as topaz.
10	Diamond	Used in jewelry and cutting tools. Four times as hard as corundum.

Table 2

No.	Mineral	Color	Luster	Streak	Hardness
1	Talc	White, green, gray	Pearly, greasy	White	1
2	Gypsum	White, gray	Silky	White	2
3	Calcite	White, yellow, brown, blue	Vitreous, earthy	White	3
4	Fluorite	Green, yellow, purple	Vitreous	White	4
5	Apatite	Green, colorless, yellow, blue, violet, pink, brown	Vitreous	White	5
6	Feldspar	Pink, white, gray, brown	Vitreous	None	6
7	Quartz	Colorless, white	Vitreous	None	7
8	Topaz	Blue, brown, orange, gray, yellow, green, pink and reddish pink	Vitreous	White	8
9	Corundum	Colorless, gray, brown, pink, pigeon-blood-red, orange, yellow, green, blue cornflower, blue violet	Adamantine, vitreous	None	9

Table 3

Mineral	Mohs Relative Hardness	Scratch Test	Rosiwal Absolute Hardness	Vickers Kp/mm^2
Talc	1	Scratches with fingernail	0.03	2.4
Gypsum	2	Scratches with fingernail	1.25	36
Calcite	3	Scratches with copper coin	4.5	109
Fluorite	4	Easily scratches with knife	5	189
Apatite	5	Still scratches with knife	6.5	536
Orthoclase	6	Scratches with steel file	37	795
Quartz	7	Scratches window glass	120	1,120
Topaz	8	Scratches quartz	175	1,427
Corundum	9	Scratches topaz	1,000	2,060
Diamond	10	Scratches corundum	140,000	10,060

33. A mineral can scratch any mineral that is softer but can be scratched if a mineral is harder. A copper penny has a hardness of 3. According to Figure 1, what minerals can a copper penny scratch?

    A. Quartz and talc
    B. Gypsum and talc
    C. Talc and feldspar
    D. Gypsum and topaz

34. Apatite is a mineral with hardness 5. Apatite can scratch azurite, another mineral. To determine the hardness of azurite, you try to scratch it with talc, gypsum, and calcite. If none of these minerals scratches azurite, what is the hardness of azurite?

    F. 4
    G. 5
    H. 7
    J. 8

35. According to the tables, which mineral is green, has a white streak, a vitreous luster, and can scratch fluorite?

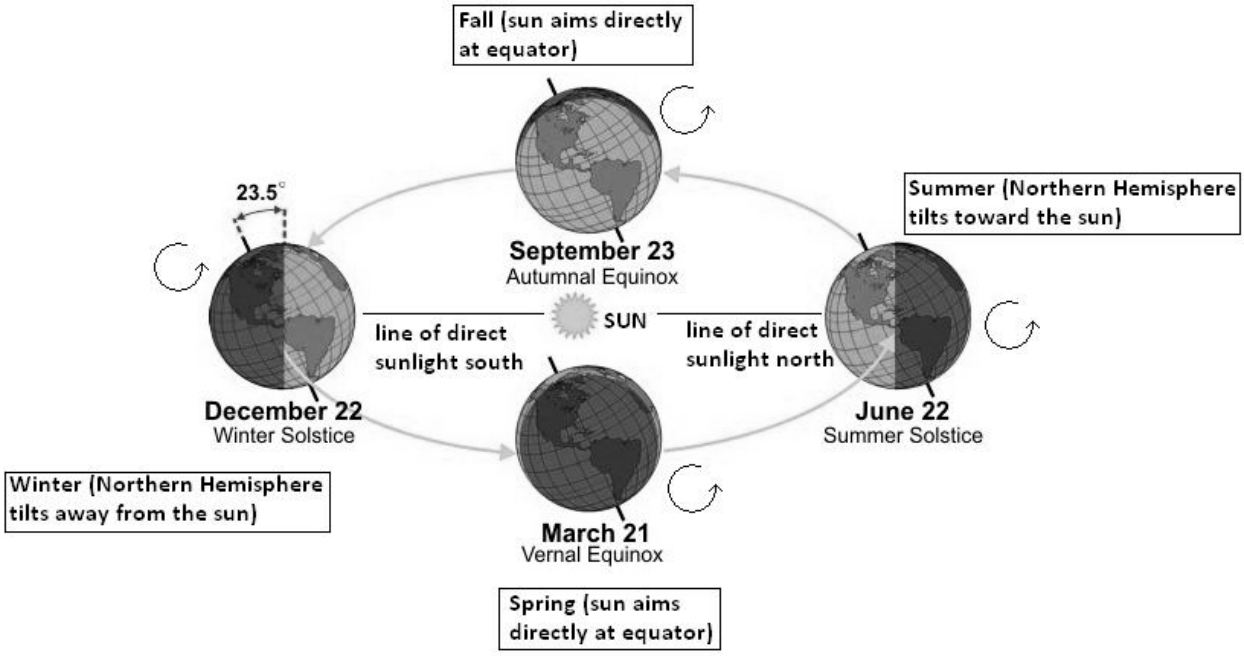
A. Quartz
B. Talc
C. Fluorite
D. Apatite

36. According to the Rosiwal Scale of Hardness, how many more times harder is a diamond than corundum?

F. 1,400
G. 4,000
H. 14,000
J. 140,000

Passage VII

Most places on the planet outside of the tropics have four seasons: summer, autumn, winter, and spring. The seasons are caused by the tilt of the Earth's axis, which is an imaginary line that runs through the Earth's center and passes through both poles.



37. If the Northern Hemisphere is closest to the sun during the winter, why is it coldest in the northeast United States during the winter season?

    A. The Earth is on a tilt of 23.5 degrees toward the sun.
    B. The Earth is on a tilt of 23.5 degrees away from the sun.
    C. The sun is rotated away from the Earth.
    D. The sun aims directly at the equator.

38. When the north end of the Earth is tilted towards the sun, what season is occurring in the Southern Hemisphere?

    F. Spring
    G. Summer
    H. Autumn
    J. Winter

39. Why is a day in the Northern Hemisphere in December shorter than a day in the Northern Hemisphere in June?

    A. Because the Northern Hemisphere tilts away from the line of direct sunlight
    B. Because the Earth is rotating in a counterclockwise fashion around its axis
    C. Because of daylight savings time
    D. Because the Earth rotates faster in the Summer months

40. Why are the seasons in the Northern Hemisphere and Southern Hemisphere opposite?

    F. The sun aims directly at the Southern Hemisphere.
    G. The equator creates a dividing line.
    H. The Earth is rotating in a counterclock-wise fashion around its axis.
    J. The axial tilt of the Southern Hemisphere is exactly opposite of the direction in the Northern Hemisphere.

ACT

PRACTICE TEST B

DIRECTIONS: *There are seven passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and mark the corresponding oval on the answer sheet. You may refer to the passage as often as necessary.*

Passage I

When the Voyager probes (Voyager 1 and 2) were launched in 1977, their mission was to explore the Jovian planets. Scientists could not begin to anticipate the discoveries they would make as they traveled through the solar system. As Voyager 2 approached Jupiter in the summer of 1979, images of Jupiter's moon, Io, revealed what appeared to be an erupting volcano on a celestial body otherwise devoid of an atmosphere or any form of liquid. This was a spectacular discovery since the photo revealed the only known active volcano beyond earth. Additional photos revealed Io to be an incredibly geologically active world with extensive sulfur deposits on its surface.

After the Voyager encounters of Io, a scientific debate ensued regarding the nature of the volcanoes observed on Io's surface. Two competing viewpoints are presented below.

Volcanic calderas, lava flows and cliffs are seen in this image of a region near the south pole of Jupiter's moon, Io. (Courtesy NASA)

Scientist 1

Io is Jupiter's innermost Galilean moon. It was large enough to be one of the four moons visible to Galileo through his early telescope. It is, however, a relatively small body, with a diameter approximately one-quarter that of Earth's. Despite its small size, it has become quite a geologic phenomenon. As a consequence of its proximity to Jupiter, it is caught in a gravitational "tug of war" between Jupiter and the outer "Galilean" moons. This gravitational action is the core of Io's extreme volcanic activity. This volcanic activity, characterized by extensive flows of molten sulfur on Io's surface and likely a wide range of compounds containing sulfur, makes Io's volcanic activity quite different from volcanic activity observed here on Earth. To further support their position, this scientist argues for sulfur flows as sulfur melts at a much lower temperature than that required by the lava flows observed here on Earth.

Scientist 2

An alternate theory suggests that the volcanoes on Io are, in fact, similar to those found on Earth. Based only upon the Voyager photos, this scientist argues the existence of 10 km (6.2 miles) tall volcanic mountains composed primarily of sulfur. Tall mountains require the presence of silicate rocks, and therefore these volcanoes must be similar in composition to those found on earth.

1. According to the information provided, both scientists would likely agree upon the

   A. temperature of the lava flows on Io's surface.
   B. root cause for Io's extreme volcanic activity.
   C. chemical composition of lava on Io's surface.
   D. chemical composition of magma within Io's interior.

2. The best argument Scientist 2 could make to Scientist 1 to support his point of view is

   F. sulfur can't exist on other celestial bodies.
   G. gravitational stress on Io prevents sulfur or its compounds from forming.
   H. the analysis of Io's surface sulfur must be incorrect because volcanoes composed primarily of sulfur can't grow to great heights.
   J. while the volcanoes are composed of primarily silicate rocks (those rich in silicon and oxygen), they are erupting sulfur-rich materials.

3. Scientist 2 would likely argue that tall silicate mountains are more common on Io than tall sulfur-rich volcanoes because

   A. Sulfur is too soft a material, and silicates are much harder. As such, tall mountains composed of silicate materials can form where tall mountains composed of sulfur cannot form to such heights.
   B. Silicate is too soft a material, and sulfur compounds are much harder. As such, tall mountains composed of sulfur compounds can form where tall mountains composed of silicates cannot form to such heights.
   C. Sulfur-rich mountains once did form on Io, but they were reduced in size due to the forces of weathering and erosion caused by Io's atmosphere and flowing water.
   D. Silicate-rich mountains once did form on Io, but they were reduced in size due to the forces of weathering and erosion caused by Io's atmosphere and flowing water.

4. The active volcanism on Io in both scientists' views is likely the result of

   F. tectonic plate motions along with convective activity within the moon's mantle.
   G. Jupiter's extreme gravity causing the volcanoes to grow.
   H. gravitational stress created due to Io's orbital position.
   J. friction created by movement along Io's surface.

5. If Scientist 1 is correct and Io's razor thin atmosphere could be tested, traces of which gas might be found?

   A. Carbon dioxide
   B. Sulfur dioxide
   C. Oxygen
   D. Water vapor

6. Many scientists believe earth's early atmosphere originated from out-gassing from the planet's interior. Essentially, volcanic activity helped to produce earth's early atmosphere. When compared to earth's atmosphere, Io's atmosphere is razor thin. The best explanation for this is

   F. Io is much smaller than Earth and, as such, has a smaller gravitational field. Thus, it lost any atmosphere produced from the out-gassing.
   G. Jupiter's great gravitational field removed Io's atmosphere.
   H. Io's volcanoes erupt with such force they eject the gases into space before Io can capture these gases to form an atmosphere.
   J. Io's volcanoes do not emit any gases.

7. If Scientist 2 is correct, which of the following rock types is most likely to be found on Io's surface?

   A. Obsidian – often referred to as volcanic glass, forms when lava solidifies quickly such as when lava flows into the ocean here on earth
   B. Basalt – an extrusive igneous rock, forms in a rapid-cooling environment
   C. Granite – an intrusive igneous rock, forms in a slow-cooling environment such as beneath the surface. It is later found at the surface after the process of weathering and regional uplift due to plate tectonics
   D. Sandstone – a sedimentary rock that forms in shallow seas

Passage II

Graham's Law of Effusion is a mathematical relationship that applies to gases and confirms that "lighter" gases, those with lower molecular weights, will travel faster than "heavier" gases, those with higher molecular weights. A student decides to conduct an experiment using two highly soluble ionic solids to determine whether a similar relationship exists in aqueous solution. To discover a relationship, she prepared several experiments. In all cases, the reaction involved taking a sample of potassium iodide (KI) and lead (II) nitrate ($Pb(NO_3)_2$) and placing each at opposite ends of a circular petri dish.

In aqueous solution, the net-ionic equation for this reaction looks like: $Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$

Relevant data: atomic weight of lead = 207; molecular weight of iodide = 127

Experiment 1

Varying amounts of potassium iodide are added to the far left side of the petri dish while 2.00 g of lead (II) nitrate are added to the far right side of the petri dish. The diameter of the petri dish is 10.0 cm. The dish contains 50.0 mL of water at 20°C prior to the introduction of the two salts. The results are presented in Table 1.

Table 1

Trial	Quantity of KI (g)	Quantity of $Pb(NO_3)_2$ (g)	Time for Reaction Front to Appear (sec)	Distance of Reaction Front From KI (cm)
1	1.00	2.00	6.0	7.3
2	2.00	2.00	6.1	7.2
3	4.00	2.00	6.0	7.4
4	8.00	2.00	5.9	7.3

Experiment 2

Experiment 1 was repeated; however, in each case 2.00 g of each salt was introduced to opposite ends of the dish as the temperature of the water was varied. The results are presented in Table 2.

Table 2

Trial	Temperature (°C)	Time for Reaction Front to Appear (sec)	Distance of Reaction Front From KI (cm)
5	20	6.0	7.2
6	30	5.4	7.3
7	40	4.6	7.4
8	50	3.6	7.3

Experiment 3

Experiment 2 was repeated, but this time varying the amount of lead nitrate differed in each trial as illustrated in Table 3.

Table 3

Trial	Quantity of KI (g)	Quantity of $Pb(NO_3)_2$ (g)	Time for Reaction Front to Appear (sec)	Distance of Reaction Front From KI (cm)
9	2.00	2.00	6.0	7.3
10	2.00	4.00	5.9	7.4
11	2.00	6.00	6.0	7.4
12	2.00	8.00	6.0	7.2

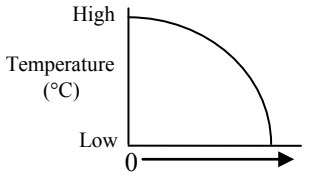
8. Based upon the data collected, which of the following conclusions can be drawn?

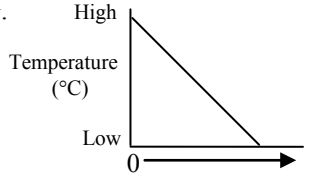
   F. In each case the reaction occurred closer to the lead nitrate; therefore, the lead ion traveled faster than the iodide ion.
   G. In each case the reaction occurred closer to the lead nitrate; therefore, the iodide ion traveled faster than the lead ion.
   H. In each case the reaction occurred closer to the potassium iodide; therefore, the lead ion traveled faster than the iodide ion.
   J. In each case the reaction occurred closer to the potassium iodide; therefore, the iodide ion traveled faster than the lead ion.

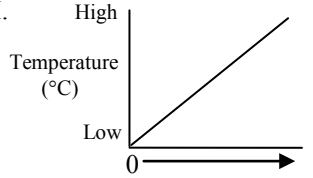
9. In experiment 2, the variable is

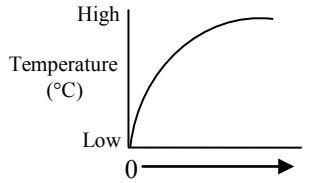
   A. temperature.
   B. time for the reaction to appear.
   C. distance of reaction from the reaction front.
   D. quantity of potassium iodide.

10. Which of the following graphs depicts the relationship between the temperature of the water in which the reaction occurs and the time for the reaction front to form?

F.


G.


H.


J.


11. Considering all data collected in all trials, if a petri dish with a diameter of 20 cm were used with all other conditions being the same, the average distance the reaction would occur from the KI would be

    A. 3.7 cm.
    B. 7.3 cm.
    C. 14.6 cm.
    D. 29.2 cm.

12. If a student wanted to suggest a new experiment to confirm the results observed in this experiment, the best suggestion might be to

    F. select two different salts where one is not soluble in water.
    G. select two different salts of the same atomic weight where both are soluble in water.
    H. select two different salts of differing atomic weights where both are soluble in water.
    J. use the same salts but vary the volume of water in the petri dish.

13. Based upon the results collected in all three experiments, if potassium chloride were substituted for potassium iodide, and trial 1 were repeated using KCl instead of KI, knowing chloride has an atomic weight of 35.4, the most likely location of the reaction front would be

    A. 9.0 cm from the KCl.
    B. 7.3 cm from the KCl.
    C. 5.0 cm from the KCl.
    D. 2.4 cm from the KCl.

Passage III

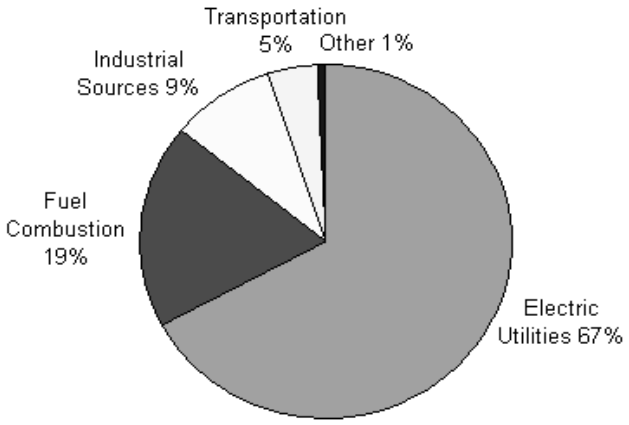
Acid rain is an ongoing and widespread problem found across much of the Northeastern United States. Acid rain is responsible for harming both vegetation and lakes, which in turn hurts life within the affected lakes. Many lakes, but not all, are severely affected.

Study 1

A study was conducted to identify the sources of a major atmospheric pollutant, sulfur dioxide. Table 1 below illustrates sources of sulfur dioxide in the United States. Sulfur dioxide is a pollutant that will react with water to form sulfuric acid, a strong acid that can negatively impact the environment.

Table 1

United States - 2002 SO_2



Study 2

Several lakes were studied from 1990 to 2000 in the Catskills of Southeastern New York and the Kittatinny Mountains of Northwestern New Jersey. The lakes are identified as numbers 1 through 5 in the information shown in Table 2 and the results shown in Table 3.

Table 2: Five Lake Study

Lake Number	Size (sq mi)	Average Spring Temperature (C)	Elevation (ft)	Underlying Bedrock
1	2.5	14	1200	granite
2	7.3	13	1600	slate
3	4.7	16	900	limestone
4	10.6	12	1500	shale
5	4.9	15	1000	granite

Table 3: Average Spring pH from 1990 - 2000

Lake Number	1990	1992	1994	1996	1998	2000
1	5.1	5.1	4.7	4.8	4.7	4.6
2	5.3	5.1	4.8	4.9	4.7	4.7
3	6.8	6.8	6.6	6.8	6.8	6.8
4	5.4	5.4	5.3	5.2	5.1	5.0
5	5.1	5.0	4.8	4.7	4.6	4.5

14. If you were in charge of a committee that had to recommend just one source of sulfur dioxide to focus upon to reduce its output, which source would be the best to select for "remediation"?

    F. Transportation
    G. Industrial
    H. Fuel combustion
    J. Electric

15. A pH of less than 5.0 can mean real trouble for any life in a lake. In 1994 how many lakes would meet the criteria where life is in serious trouble?

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

16. Based upon the data presented in Table 3, the acid rain problem in most lakes

    F. continues to get worse.
    G. has stabilized.
    H. is improving.
    J. The data is inconclusive.

17. Based upon the information provided in Table 2, one may hypothesize that which rock type can actually neutralize acid rain?

    A. Granite
    B. Slate
    C. Limestone
    D. Shale

18. Knowing that there are only three strong acids (sulfuric, nitric and hydrochloric), which of the following gases is likely associated with acid rain?

    F. Oxygen
    G. Carbon dioxide
    H. Nitrogen dioxide
    J. Water vapor

19. It appears pH levels dropped significantly from 1992 to 1994. What is a reasonable hypothesis to explain this?

    A. Increased evaporation from the lakes concentrated the acids within them.
    B. Increased acidic rainfall occurred that spring season.
    C. The previous winter was quite snowy, and there was increased runoff from snowmelt.
    D. Additional data would be required to assess the true factor that created these conditions that spring.

Passage IV

Earth's atmosphere has an average surface temperature of about 15°C. This temperature created conditions on our planet that have allowed life to evolve and flourish. The observed temperature results from a series of interactions that occur between earth and its primary energy source, the sun, and then between the planet and its atmosphere. The following charts explore that relationship.

Table 1: Radiation Emitted by the Sun and Earth

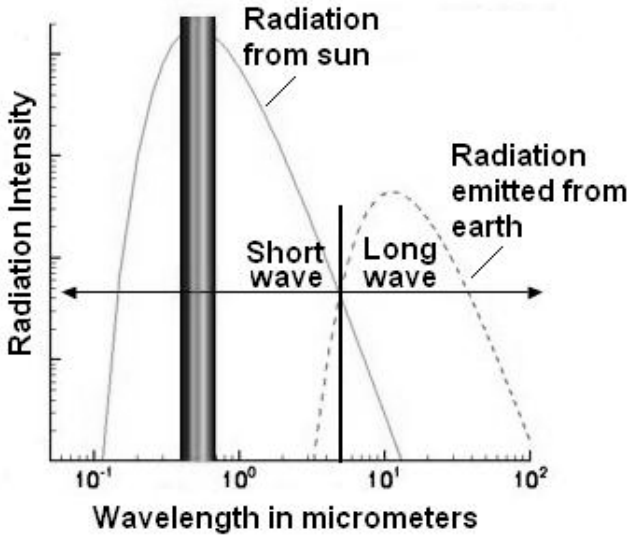
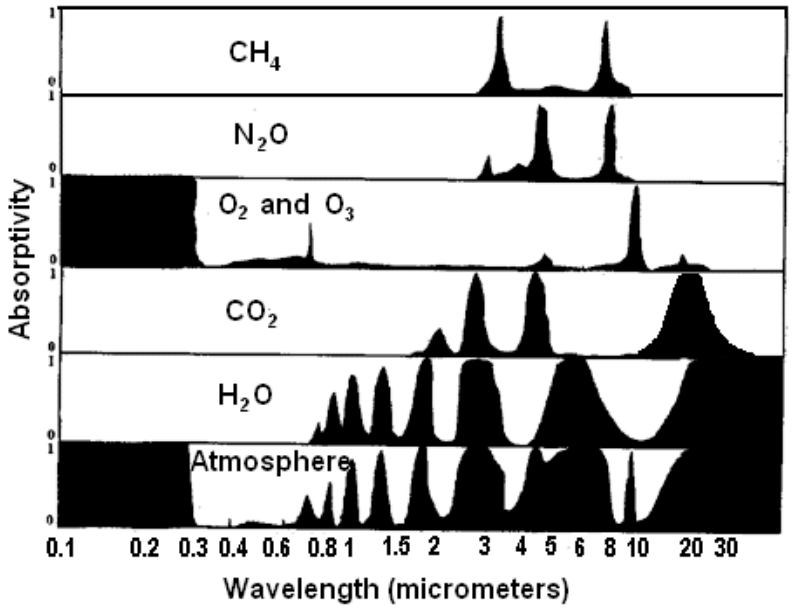


Table 2: Absorption of Energy by Various Gases in Earth's Atmosphere

(0 = no absorption, 1 = total absorption)



20. According to Table 1, which of the following may be concluded?

    F. The sun emits shortwave radiation. Earth then absorbs longwave and emits longwave radiation.
    G. The sun emits shortwave radiation. Earth then absorbs shortwave and emits longwave radiation.
    H. Earth emits longwave radiation, which is then absorbed as shortwave radiation by the sun.
    J. The sun emits shortwave radiation and earth emits longwave radiation.

21. According to Table 2, for wavelengths greater than 1 micrometer, which gas is greatest absorber?

    A. CH_4
    B. N_2O
    C. CO_2
    D. H_2O

22. Methane (CH_4) is a strong absorber at which wavelength(s)?

    F. 0.3 and 0.8 micrometers.
    G. 0.3 and 8 micrometers.
    H. 3 and 0.8 micrometers.
    J. 3 and 8 micrometers.

23. If all methane were removed from earth's atmosphere, surface temperatures would

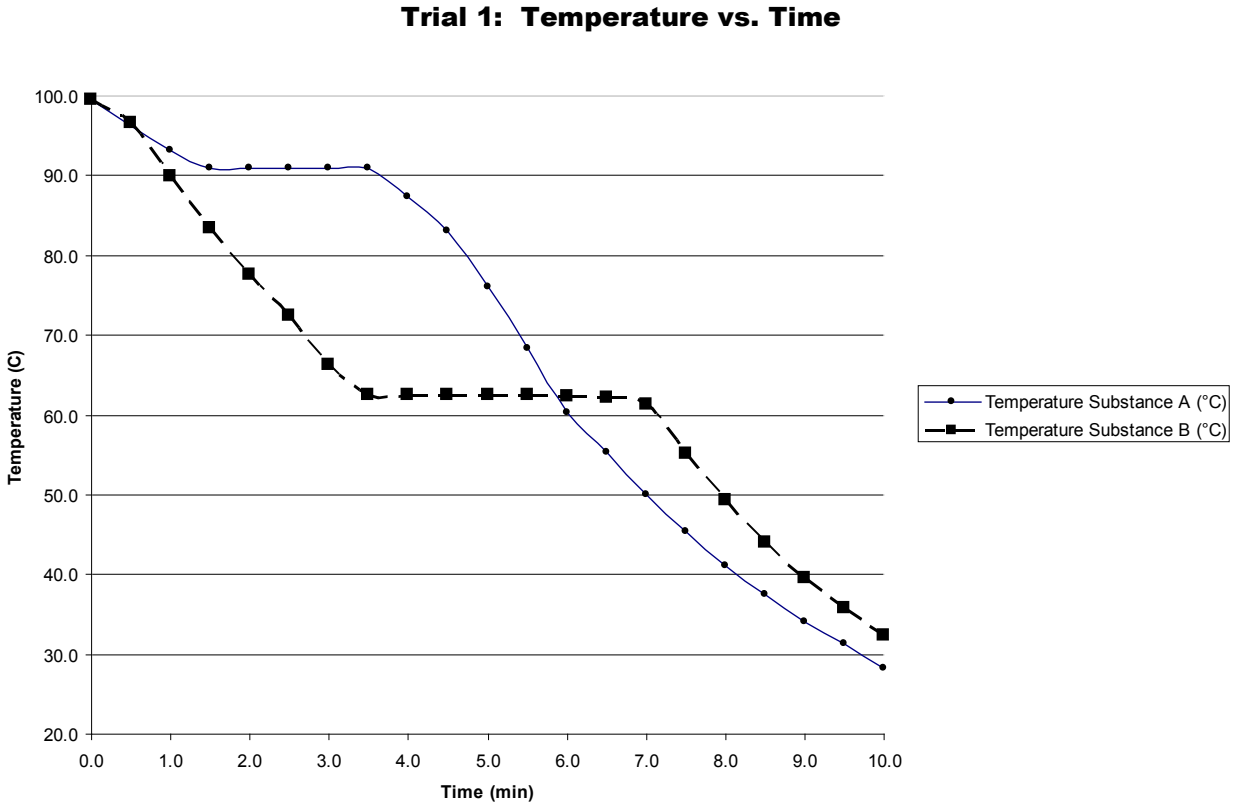
    A. increase.
    B. not change at all.
    C. decrease.
    D. methane is not a greenhouse gas and does not impact this system.

24. Earth's strongest emissions occur at approximately

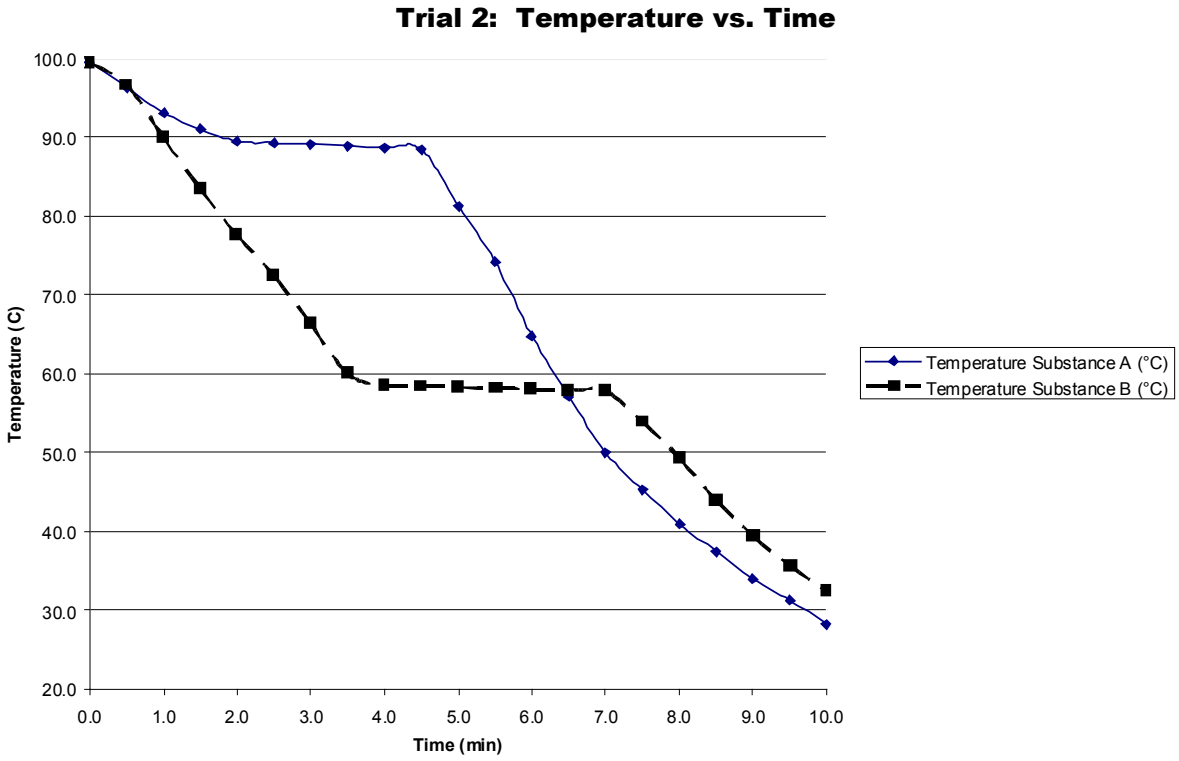
    F. 0.5 micrometers.
    G. 2 micrometers.
    H. 10 micrometers.
    J. 20 micrometers.

Passage V

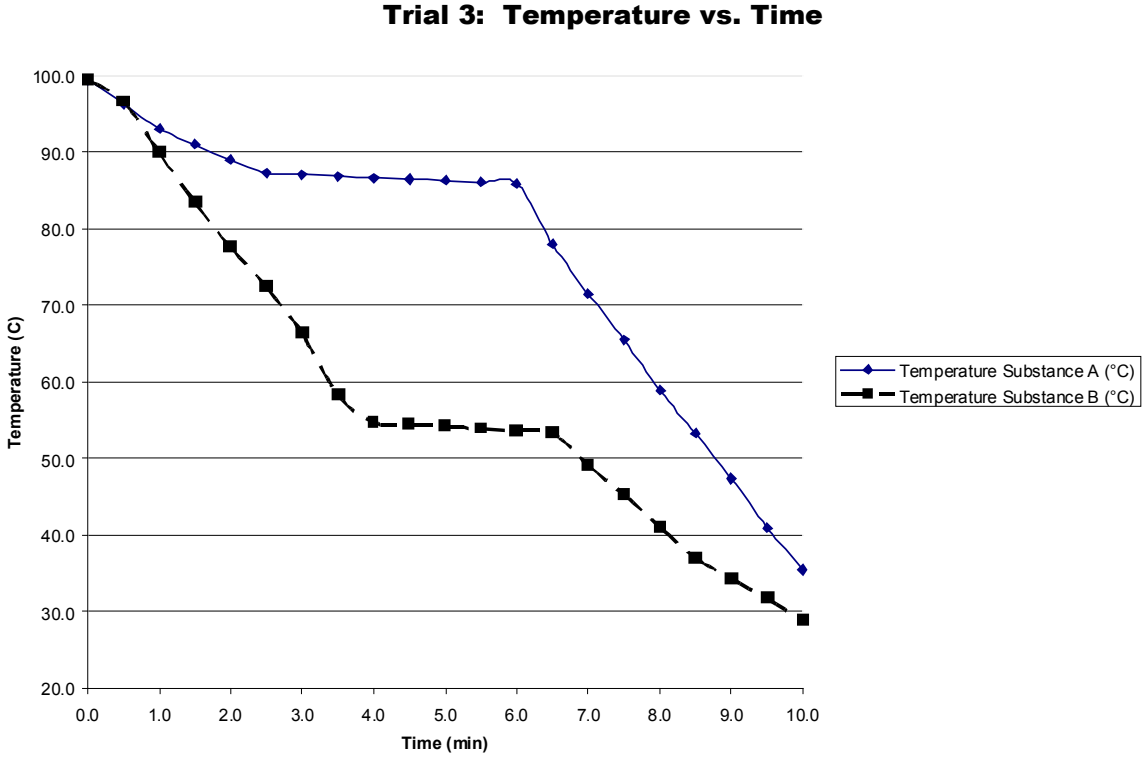
Pure substances exhibit an interesting property when cooling from the liquid state into the solid state. During the freezing process, temperatures remain constant as energy is transferred from the substance to the surrounding environment. After freezing has occurred, the temperature begins to fall again. This experiment involved taking 10.0 g samples of two pure substances, each in its own test tube, and heating them in boiling water. They were then removed from the boiling water and allowed to cool while held by a clamp in the air. The air temperature was recorded as being 20°C. The data collected during this experiment is recorded in the graph below labeled Trial 1.



In the second part of this experiment, the student wished to determine the effect of adding a solute to each pure substance. Enough solute was added to create a solution with a concentration of 1 molal. (The molal is a unit of concentration.) The results are reported in the graph labeled Trial 2.



In the third part of this experiment, the student wished to determine the effect of adding a solute to each pure substance. Enough solute was added to create a solution with a concentration of 2 molal. The results are reported in the graph labeled Trial 3.



25. According to the data presented in Trial 1, freezing of Substance A occurs at a temperature of

    A. 100° C.
    B. 91° C.
    C. 62° C.
    D. 29° C.

26. The best reason for conducting Trial 1 with more than one pure substance is to

    F. determine whether all substances freeze at the same temperature.
    G. determine whether both substances would freeze.
    H. determine whether the freezing behavior described in the introduction of this passage occurs with multiple substances.
    J. determine whether all substances freeze in the same period of time.

27. If 20 g of Substance B were used in Trial 1, the period of time where the temperature does not change would be

    A. longer.
    B. unchanged.
    C. shorter.
    D. longer if the mass of Substance A is also increased.

28. From the study of Trials 1, 2 and 3, it can be stated that, in general, adding a solute to a pure substance

    F. increases the temperature at which it freezes.
    G. does not change the temperature at which it freezes.
    H. decreases the temperature at which it freezes.
    J. depends upon the nature of the substance.

29. According to the data, what is the freezing temperature of a 2 molal solution containing Substance B when compared to the freezing temperature of pure Substance B?

    A. They are the same; both are about 62° C.
    B. The solution freezes at a temperature that is about 4° C less than the pure substance.
    C. The solution freezes at a temperature that is about 8° C less than the pure substance.
    D. The solution freezes at a temperature that is about 8° C more than the pure substance.

30. When studying freezing point properties, the freezing point constant (K_f) can be determined if both the change in freezing point (ΔT_f) and molality (*m)* are known. The equation that describes this relationship is $\Delta T_f = (K_f)(m)$. Given the data provided in the graphs, determine the freezing point constant for Substance A.

    F. 0
    G. 1
    H. 2
    J. 4

Passage VI

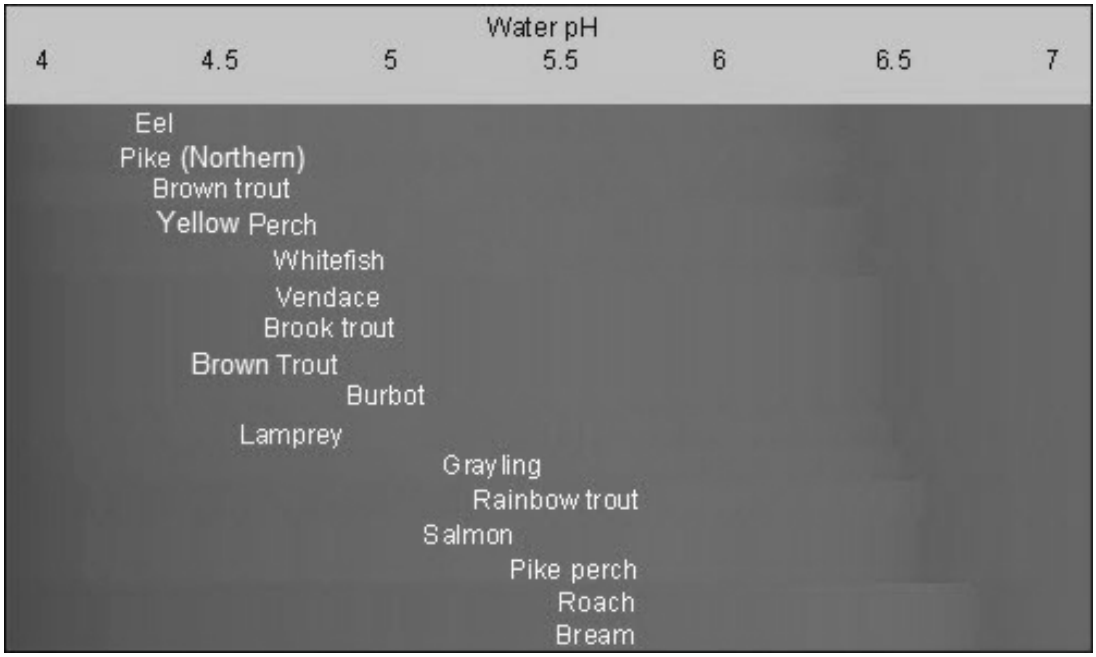
In a recent study of northern freshwater fish, the following conclusions were drawn after studying a number of species over a period of years. Table 1 reports a number of properties regarding the thermal conditions preferred and required for each species.

Table 1

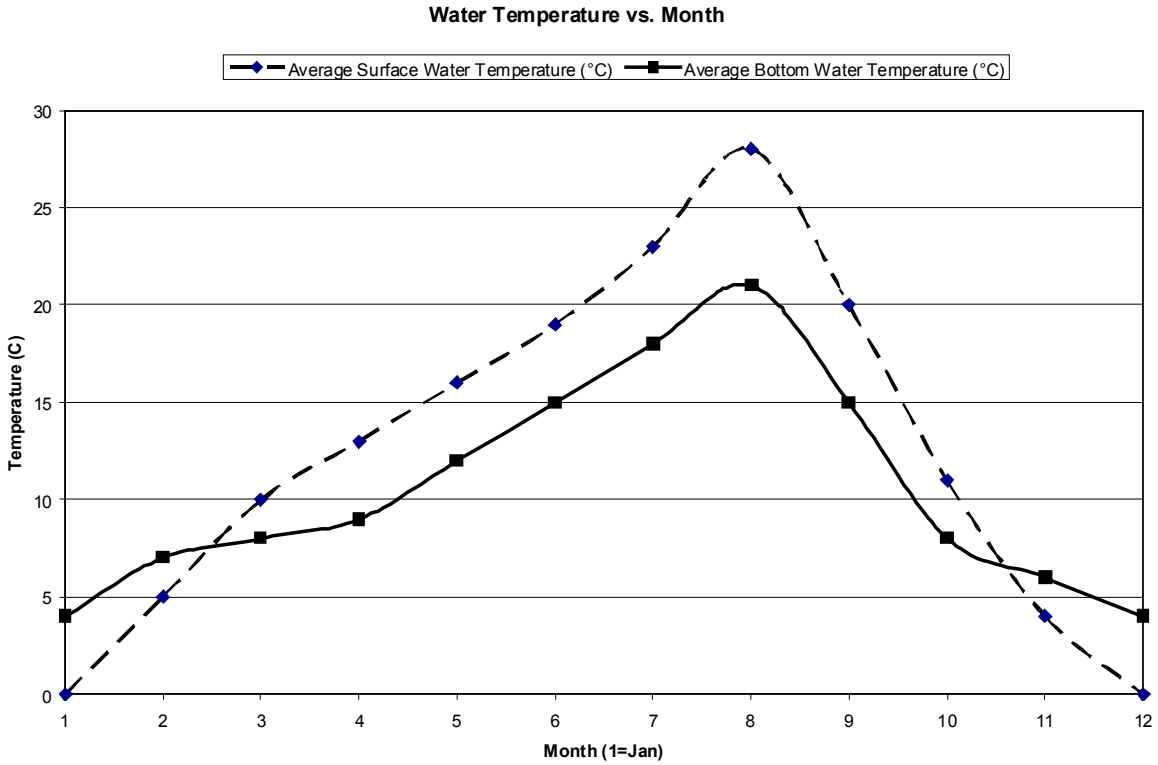
Species	Optimal Living Temperature (°C)	Upper Lethal Temperature (°C)	Spawning Temperature (°C)	Juvenile Growth Temperature (°C)
Chinook Salmon	13 - 20	25	8-14	8-14
Coho Salmon	8 - 15	26	5-9	12-14
Steelhead trout	n/a	24	4-9	8-14
Brown trout	n/a	24	7-13	4-21
Largemouth bass	16 - 26	37	21	32
Northern pike	13 - 23	31	5-7	n/a
Yellow Perch	16 - 28	29	n/a	n/a

Chart 1: pH Range Preferred by Various Freshwater Species

(pH values to the left of the name are considered lethal for each individual species.)



Graph 1: Average Seasonal Water Temperatures (Surface and Bottom) for a Lake Containing Many of These Species



31. If water temperatures were to increase, which species is best able to live within a warmer environment?

    A. Chinook salmon
    B. Coho salmon
    C. Largemouth bass
    D. Northern pike

32. Which species that appears in Table 1 is most sensitive to acid rain?

    F. Salmon (both species)
    G. Brown trout
    H. Northern pike
    J. Yellow perch

33. If water temperatures rose by 5°C in a sudden accident, which species would have its existence threatened?

    A. Both salmon species
    B. Both trout species
    C. Widemouth bass, Northern pike and Yellow perch
    D. Both the salmon and trout species

34. Which species must spawn in the summer?

    F. Northern pike
    G. Largemouth bass
    H. Brown trout
    J. Coho salmon

35. Which species is most able to grow during the juvenile phase and adapt to a variety of thermal conditions?

    A. Coho salmon
    B. Steelhead trout
    C. Brown trout
    D. Largemouth bass

Passage VII

As gasoline prices rise and concerns over the environment increase, experts are searching for a viable alternative to its use in cars. Several alternative fuels are compared to gasoline in Table 1 below.

Table 1: Gasoline and Several Alternative Fuels

Fuel	Vehicle Emissions of NOx (g/mile)	Vehicle Emissions Non-methane Hydrocarbons (g/mile)	Energy Density (J/ml)	Specific Energy (J/g)
Conventional gasoline	0.86	0.51	32,000	42,000
Compressed natural gas	0.72	0.24	8,300	50,000
Electric	0.46*	n/a	300	150
E85	0.79	0.40	22,700	29,100
Liquefied propane (LPG)	0.72	0.30	24,000	46,100
M85	0.79	0.40	18,200	23,200
Reformulated gasoline (RFG)	0.83	0.44	31,300	41,300

*Estimated based upon a coal fired plant

Car owners must also consider the cost of owning a car that runs on alternative fuel. The following chart compares the cost of using gasoline to that of several alternative fuels. Several aspects of using an alternative fuel are considered as illustrated by the data in each column.

Table 2

Fuel	Additional Cost per Car (dollars)	Cost of the Fuel in Dollars (per gasoline equivalent gallon)	Cost of Maintenance (dollars over a 5 year period)
Conventional gasoline	0	0	0
Compressed natural gas	4000	-0.15	-300**
Electric	8500	n/a	-500**
E85	300	1.00	0
Liquefied propane (LPG)	1400	0.05	0
M85	300	0.40	250
Reformulated gasoline (RFG)	0	0.05	0

**Estimated savings

36. American drivers like to drive long distances between filling up their tanks. For example, if an alternative-fuel car will only go 100 miles between "fill-ups," most drivers will not purchase that vehicle. Energy density is one such measurement that can provide clues as to how much fuel can be carried in the car's "gas" tank (which, by nature of the car's design, cannot exceed a certain size) and enable the driver to travel the maximum distance. Which fuel, other than conventional gasoline, will provide the greatest potential to travel as far as we currently can with conventional gasoline?

    F. Compressed natural gas
    G. Electric
    H. M85
    J. Reformulated gasoline (RFG)

37. Vehicular emissions are also of concern when selecting a fuel. How does conventional gasoline compare to its alternatives when considering non-methane hydrocarbons?

    A. Gasoline is the cleanest fuel.
    B. One of the alternatives is cleaner than gasoline.
    C. Two of the alternatives are cleaner than gasoline.
    D. Three or more of the alternatives are cleaner than gasoline.

38. If you were to argue against compressed natural gas, the two strongest points to suggest avoiding it are

    F. high NOx emissions and low energy density.
    G. low energy density and a high additional cost to build the car.
    H. high NOx emissions and high additional cost to build the car.
    J. low energy density and high specific energy.

39. If you wanted to argue in favor of reformulated gasoline, what would your strongest arguments be?

    A. There is no added cost to the car, and it retains a high energy density and specific energy rating.
    B. There is no added cost to the car, and it is a much cleaner fuel than conventional gasoline.
    C. There is no added cost to the fuel, and it retains a high energy density and specific energy rating.
    D. The cost of the fuel is only slightly higher than conventional gasoline.

40. If a fuel should have both a high energy density and specific energy, the fuel (other than conventional gasoline) with the best combination of both is

    F. compressed natural gas.
    G. electric.
    H. M85.
    J. reformulated gasoline (RFG).

DIRECTIONS: *There are seven passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and mark the corresponding oval on the answer sheet. You may refer to the passage as often as necessary.*

Passage I

Marsh system	Average soil concentrations of heavy metals (parts per million)					Dominant vegetation type	Number of different invertebrate species in marsh system	Number of specimens for invertebrate species in marsh system (per square meter)
	Cu	Cr	Ni	Pb	Cd			
Sawmill Creek (SC)	164.5	253.5	63.3	151.5	2.4	*Phragmites australis* *Spartina alterniflora*	12	5,912.5
Mill Creek Site 1 (MC1)	79.5	174.7	53.9	247.0	1.7	*Phragmites australis* *Spartina alterniflora*	9	5,568.5
Mill Creek Site 2 (MC2)	717.8	1,092.7	64.8	503.5	1.0	*Phragmites australis*	4	107.5

Three different marsh systems were compared with respect to concentrations of various pollutants (heavy metals) present in the soil, dominant vegetation type, the total number of invertebrate species present, and the total number of individuals of all invertebrate species present. The table shows the results of this study for the three different marshes.

1. According to the table, which of the following heavy metals occurs in the highest concentration at Mill Creek Site 2 (MC2)?

   A. Cu
   B. Cr
   C. Ni
   D. Pb

2. It was hypothesized that Sawmill Creek (SC) had better overall water quality than Mill Creek Site 2 (MC2) and, therefore, that SC should have lower levels of heavy metals than MC2. According to the table, the data for which of the following heavy metal concentrations does NOT support this hypothesis?

   F. Cu
   G. Cr
   H. Ni
   J. Cd

3. It was also hypothesized that, since heavy metals are in highest concentrations at the surface of the soil, artificial removal of top soil layers at Mill Creek Site 1 (MC1) had caused the heavy metal concentrations at this site to be less than the other two marshes. According to the table, which data for the following heavy metals supports this hypothesis?

   A. Cu, Cr, Ni
   B. Cr, Ni, Pb
   C. Ni, Pb, Cd
   D. Cu, Ni, Pb

4. Which of the following conclusions is consistent with the data presented in the table?

   F. If a marsh has higher levels of a particular heavy metal than other marshes, it will also have higher levels of all other heavy metals than the other marshes.
   G. The marsh that has the lowest amounts of Cu, Cr, and Ni has the largest number of different invertebrate species present.
   H. The marsh with only *Phragmites australis* growing has the fewest number of invertebrate species.
   J. The marsh with the largest number of invertebrate species has the fewest specimens.

5. From the given data, which of the following can one conclude about marshes, pollution in marshes, and associated plant and animal life?

   A. Marshes located along the same Creek system (i.e., SC, MC, etc.) all have the same number of invertebrate species and same number of specimens.
   B. Factors other than heavy metal concentrations determine the number of invertebrate species and the number of specimens in a marsh.
   C. Marshes with the same vegetation types have the same number of invertebrate species and the same number of specimens.
   D. The marsh with the lowest amount of Cu should also have the largest number of invertebrate species.

Passage II

A student was interested in understanding the nature of the chemical reaction between a metal and nitric acid. He conducted three experiments, varying conditions between each. Each experiment was conducted using a flask with a rubber stopper to contain the system as it reacts.

Experiment 1

In the first experiment, he conducted a chemical reaction between a clear, colorless sample of nitric acid (HNO_3) and a copper penny. He chose nitric acid as it is known to be a strong acid, capable of reacting with (oxidizing) many substances. The copper penny was composed of an element known to be a stable metal (which resists oxidation.) A reaction ensued. His observations follow:

Mass of nitric acid	7.25g
Mass of penny	2.00g
Initial color of the acid	clear, colorless
Initial color of the penny	copper
Initial temperature	22.5ºC
Maximum observed temperature	73.3ºC
Mass of products after reaction	9.25g

His observations of the products included the following: A dark blue-green liquid and a red-brown gas (with a suffocating odor) formed. The penny was gone. The student noted the similar color of the gas that formed to his penny, and then made some changes.

Experiment 2

This experiment used the same amount of nitric acid, but the coin of choice was a silver colored nickel (also known to be a stable metal). It was an old nickel, so it was composed entirely of the element nickel. His observations included the following:

Mass of nitric acid	7.50g
Mass of nickel	3.00g
Initial color of the acid	clear, colorless
Initial color of the nickel	silver
Initial temperature	22.5ºC
Maximum observed temperature	78.5ºC
Mass of products after reaction	10.20g

His observations of the products included the following: A dark blue-green liquid and a red-brown gas (with a suffocating odor) formed. The nickel was gone.

Experiment 3

This experiment used sulfuric acid and a copper penny. His observations included the following:

Mass of sulfuric acid	7.25g
Mass of penny	2.00g
Initial color of the acid	clear, colorless
Initial color of the penny	copper
Initial temperature	22.5ºC
Maximum observed temperature	65.1ºC
Mass of products after reaction	9.25g

His observations of the products included the following: A dark blue-green liquid and a light brown gas (with a suffocating odor) formed. The penny was gone.

6. Consider the choices the student made when designing Experiment 2. What was the student's most likely hypothesis after conducting Experiment 1?

   F. Increasing the quantity of each reactant will produce a different gas.
   G. Selecting a coin with a different color will produce a different gas with a different color.
   H. Selecting a coin with a different color will make the reaction proceed more quickly.
   J. Increasing the quantity of each reactant will make the reaction proceed more quickly.

7. The mass of the products is the same as the mass of the reactants in Experiments 1 and 3. In Experiment 2, the mass of the products is less than the reactants. The best explanation is that

   A. mass is not always conserved in a chemical reaction.
   B. energy is the ultimate conservative force in nature.
   C. some of the gas produced may have escaped.
   D. too much nickel was present as a reactant.

8. If a fourth experiment is conducted, to follow the scientific method, the student should

   F. use a nickel and react it with sulfuric acid.
   G. use a nickel and react it with hydrochloric acid.
   H. change the initial temperature.
   J. use two nickels and react them with nitric acid.

9. Based upon the data presented in Experiments 1 and 2, the gas produced is most likely

   A. CuO.
   B. H_2O.
   C. NO_2.
   D. CuH_2.

10. One may safely conclude that a chemical reaction in Experiment 2 occurred because

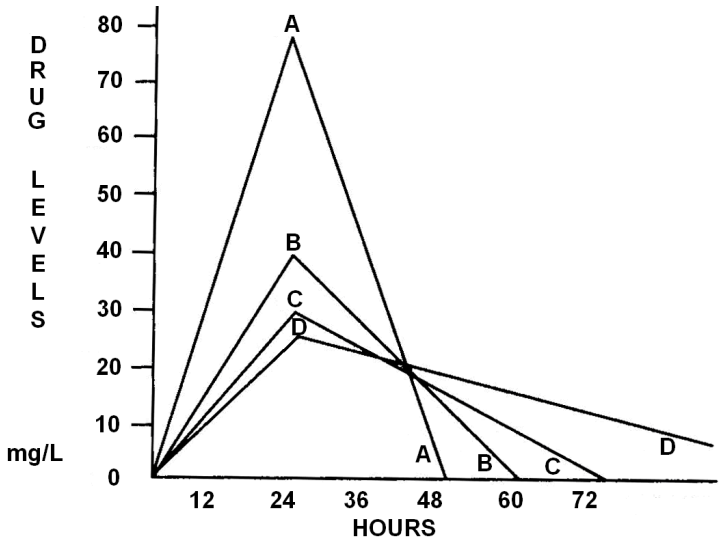
    F. the nickel was gone at the end of the reaction and no gas was produced.
    G. the nickel was gone at the end of the reaction and the final mass was less than the initial mass.
    H. the nickel was gone at the end of the reaction, a gas was produced, and a temperature change was observed.
    J. the nickel was gone at the end of the reaction, the final mass was less than the initial mass, and a gas was produced.

11. In each experiment, the limiting reagent is

    A. the initial temperature.
    B. the metal coin.
    C. the acid.
    D. the gas.

Passage III

Laboratory animals were given equal amounts of four different forms of a new drug. Each form of the drug reaches a maximum concentration in the blood of the animal at a certain time and then declines. The maximum level and rate of accumulation and decline is different for each form of the drug. The following graph represents a summary of the amounts of each of these forms of the drug in the blood of laboratory animals at different times after injection. Amounts of the drug are measured as milligrams per Liter of blood (mg/L).



12. According to the graph, what is the level of Form B of the drug at 24 hours?

    F. 20 mg/L
    G. 40 mg/L
    H. 60 mg/L
    J. 80 mg/L

13. According to the graph, which of the following conclusions about Form A of the drug would be most accurate?

    A. It reaches the highest concentration in the blood compared to all other forms.
    B. It disappears from the blood more slowly than the other forms.
    C. It remains in the blood for the longest time.
    D. It is the most powerful form of the drug.

14. If a researcher could perform only one measurement of drug levels in the blood, which time period would best differentiate between these forms of the drug?

    F. 12 hours
    G. 24 hours
    H. 36 hours
    J. 48 hours

15. A researcher hypothesized that there would be one period at which the concentration of all four forms of the drug would be similar. At what time does the concentration support that conclusion?

    A. 12 hours
    B. 24 hours
    C. 48 hours
    D. 72 hours

16. A fifth form (E) of the drug was discovered and was found to have a maximum concentration of 60 mg/L at 24 hours. Assuming that this new form behaves similarly to the other forms of the drug, at what time period would this new form be completely absent from the blood?

    F. 20 hours
    G. 30 hours
    H. 42 hours
    J. 54 hours

Passage IV

During space flight under conditions of zero gravity, the larger skeletal bones weaken due to a rapid loss of bone density. This loss of bone density is correlated with an increased excretion of calcium in the urine and a decrease in the mineral content of the bones. Three possible treatments were tested on rats while in a zero gravity orbit for five days. The concentrations of calcium in their urine and the mineral content of their spinal vertebrae were measured before, during, and one day after their flight.

Experiment 1

Animals were given free access to a high calcium diet for one month before and then during the flight. The average urinary calcium levels and bone mineral contents of the animals are shown below.

	Control Diet	**Test Diet**
Urinary Calcium (mg/ml)		
Before flight	50	79
Day 1 of flight	59	86
Day 3 of flight	73	88
Day 5 of flight	74	86
After flight	53	71
Bone Mineral Content (gm/cm^2)		
Before flight	0.227	0.232
After flight	0.098	0.109

Experiment 2

Some hormonal growth factors, such as insulin-like growth factor (IGF), can stimulate bone cell replication. The animals were injected with various doses of IGF the day before the flight. The results are shown below:

	IGF (mg per rat)			
Urinary Calcium (mg/ml)	Control	5	50	500
Day 1 of flight	59	57	58	59
Day 3 of flight	74	68	64	61
Day 5 of flight	77	76	74	61
Bone Mineral Content (gm/cm^2)				
Before flight	0.244	0.239	0.236	0.241
After flight	0.097	0.106	0.178	0.230

Experiment 3

The animals were housed in activity wheels driven by timed motors and given periods of wheel running activity each day while in flight. In place of urinary calcium concentrations, the muscle mass of the hind legs was measured and is expressed as the ratio of post-flight to pre-flight measurements. The data are shown below.

	Wheel Running Activity per Day (hours)			
	0	**2**	**4**	**6**
Muscle Mass				
(post-flight/pre-flight)	0.80	0.85	0.90	0.95
Bone Mineral Content (gm/cm^2)				
Before flight	0.234	0.209	0.216	0.231
After flight	0.087	0.106	0.178	0.228

17. Do the results of these experiments support the conclusion that the loss of bone density in zero gravity can be prevented?

    A. Yes, in Experiments 2 and 3, bone mineral content increased with growth factor injection and wheel.
    B. No, in Experiment 2 the urinary calcium levels on days 3 and 5 were greater in control animals than in the IGF-treated animals.
    C. Yes, in Experiment 1 the bone mineral content of treated animals was similar to that in the control animals after the flight.
    D. No, in Experiment 3 wheel running activity could not increase either muscle mass or bone mineral content above preflight values.

18. Which of the following factors was an experimental variable in Experiment 1?

    F. Weight of the animals
    G. Volume of urine produced
    H. Time spent in zero gravity conditions
    J. Duration of treatment with the test diet before flight

19. If 50 mg of IGF were injected into each animal every day while in flight, one would predict that in contrast to a single 50 mg pre-flight injection of IGF

    A. the bone mineral content after the flight would be much lower than the pre-flight bone mineral content.
    B. urinary calcium concentrations might not rise between day 3 and day 5.
    C. the decline in bone mineral content that occurred during flight might proceed more rapidly.
    D. urinary calcium concentrations might exceed control values on Day 5.

20. From the data presented here, which of the following can one conclude about possible treatments for preventing the loss of bone density in space flight?

    F. Neither diet nor physical exercise has any measurable effect on the loss of bone density in flight.
    G. Treatment with IGF is especially promising because of its ability to increase urinary calcium excretion.
    H. Physical exercise has a smaller effect on bone mineral content than the other potential treatments, such as high calcium diet and IG injection.
    J. Increasing the amount of calcium in the diet is the least effective treatment tested in preventing the loss of bone density in flight.

21. In contrast to Experiment 1, Experiment 3 was probably a better designed experiment for which of the following reasons?

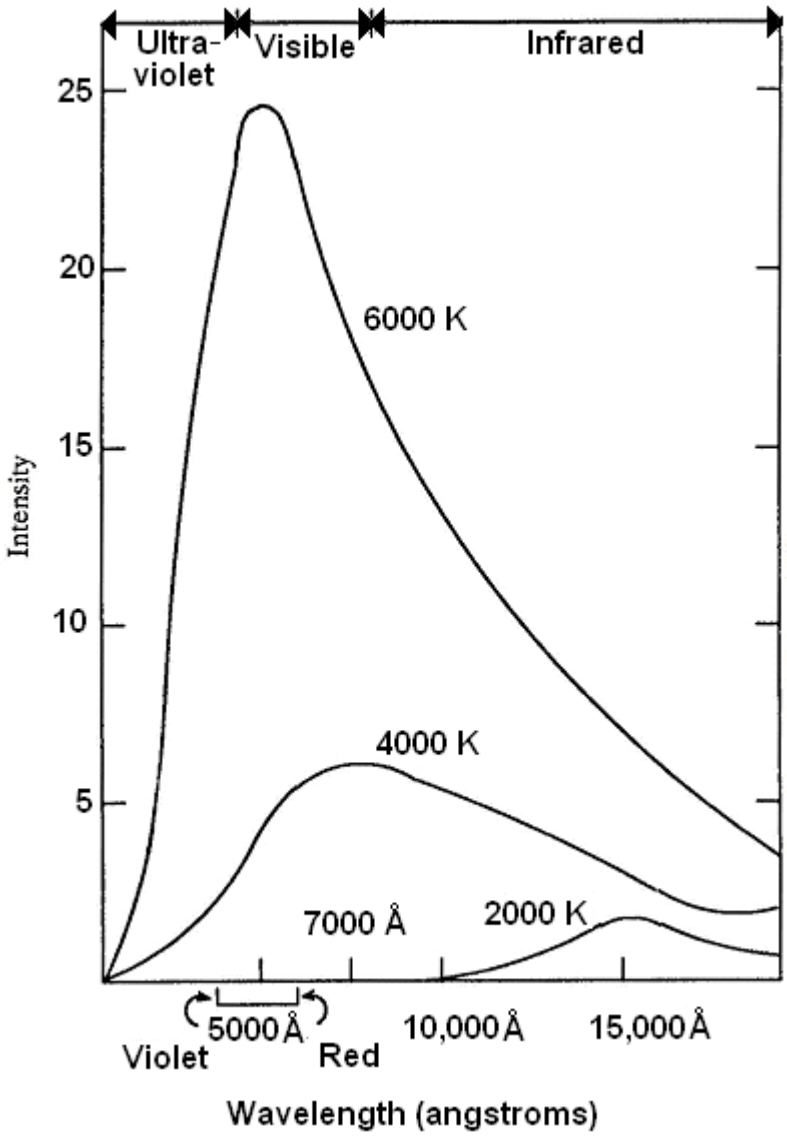
    A. The amount of the test diet eaten in Experiment 1 was not controlled while the time spent wheel running in Experiment 3 was controlled.
    B. The test diet was given for a month before the flight while the wheel running was performed during the flight.
    C. Muscle mass was measured in Experiment 3 but not in Experiment 1.
    D. Animals in the control group in Experiment 3 showed a greater loss of bone mineral content than did animals in the control group in Experiment 1.

22. On the basis of the experimental results, what treatment is most likely to succeed in maintaining the bone mineral content of astronauts during extended space flight?

    F. A high calcium diet in addition to four hours of exercise daily
    G. A pre-flight administration of growth factors combined with four hours of daily exercise
    H. A daily administration of growth factors with a high calcium diet
    J. A four-hour period of daily exercise combined with daily administration of growth factors

Passage V

The graph below shows the spectra of radiation emitted by objects heated to various temperatures. Each curve is a plot of intensity versus wavelength in Angstroms; one Angstrom, Å, equals 10^{-8}cm (or about four billionths of an inch). The graphs are the same regardless of the phase (solid, liquid, or gas) or composition of the object. The emission spectrum of the sun is similar to the 6000K curve which peaks in the range of visible wavelengths, but the spectrum of sunlight as we see it is distorted due to absorption by cooler matter in both the solar and terrestrial atmospheres.



23. According to the graph, the intensity of radiation of 10,000Å wavelength varies with the temperature of the emitting object

    A. in direct proportion.
    B. inversely, decreasing as the temperature increases.
    C. more rapidly than in direct proportion.
    D. less rapidly than in direct proportion.

24. Outdoor color film is designed to respond realistically to sunlit objects. Objects photographed with this film while illuminated by a filament heated to 4000K would

    F. look too violet in the photo.
    G. look too reddish in the photo.
    H. not appear in the photo at all.
    J. be black, gray, or white.

25. The human eye is well adapted to the radiation coming from the sun: it is most sensitive to green light of about 5500Å. According to the figure, what would a person with normal vision see if an object at 2000K were placed before him or her in a dark room?

    A. A violet glow
    B. A white glow
    C. Darkness
    D. Green

26. Stephan's law (1879) says that the total power radiated by a hot object (the areas under the curves in the figure) is proportional to the fourth power of the temperature. This law seems to be true because

    F. the area under the 4000K curve is much greater than that under the 2000K curve.
    G. the wavelength of maximum intensity appears directly proportional to the temperature.
    H. the intensity at 7000Å decreases sharply with temperature.
    J. the area under the 6000K curve is much smaller than that under the 2000K curve.

27. Ozone strongly absorbs radiation of wavelengths from 2200Å to 3000Å. A small but significant amount of this gas in the upper atmosphere makes sunlight less injurious because it

    A. screens out burning infrared radiation.
    B. shifts the wavelength of maximum intensity of sunlight toward the ultraviolet.
    C. increases the intensity of ultraviolet radiation.
    D. distorts the sea-level solar spectrum, making it less intense in the toxic ultraviolet.

Passage VI

Where do extracellular biological materials come from?

There are many substances in the body that accumulate outside cells (extracellular). These include: bone, teeth, cartilage, ligaments, and numerous other important structures, including membranes.

There is a particular membrane that appears in a space between two layers of cells. This membrane is known as the dense membrane, and the cell layers are known as the outer cell layer and the inner cell layer. The cells that make up the two layers are suspected of producing the dense membrane.

Biologist 1

When the dense membrane is fully formed, it is possible to scrape off large numbers of the cells from the outer layer, grind them up, and subject them to chemical tests. Using this technique, Biologist 1 found that these cells contain many of the same biochemicals as found in the dense membrane. Biologist 1 concluded that the dense membrane is therefore formed only by the cells of the outer layer.

Biologist 2

Using a powerful microscope, Biologist 2 saw what appeared to be small particles of the dense membrane within individual cells of the inner layer. These cells then deposited the particles in the space between the inner and outer cell layers as the dense membrane was forming. Biologist 2 then used special chemical tests to show that these small particles were composed of the same biochemicals as those found in the dense membrane. Biologist 2 concluded that the dense membrane was produced only by the inner layer of cells.

28. Which of the following is a similarity between the experiments of Biologist 1 and Biologist 2? They both

    F. removed and tested large numbers of cells.
    G. studied bone, cartilage, and ligaments.
    H. used a microscope to study the dense membrane.
    J. identified the biochemicals of the dense membrane.

29. Which of the following experimental procedures could have led Biologist 1 to reach a faulty conclusion?

    A. Large numbers of cells were scraped off to be tested.
    B. Chemical tests were used to test biological material.
    C. Some of the dense membrane was scraped off with the cells.
    D. It was necessary to grind up the cells to perform the test.

30. The hypothesis of Biologist 2, that the dense membrane is produced only by the cells of the inner layer, could best be DISPROVED by proving that

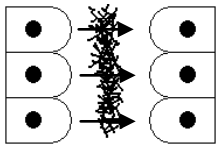
    F. similar particles exist in the cells of the outer layer.
    G. membrane particles exist in the cells of the inner layer.
    H. the material of the dense membrane is found in other parts of the body.
    J. the cells of the inner and outer layers are similar in appearance.

31. Which of the following procedures would provide the strongest support for the hypothesis of Biologist 1, that the dense membrane is formed by the cells of the outer layer?

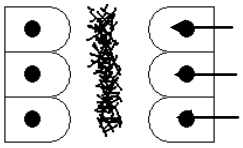
    A. Try to scrape off large numbers of the inner cells and perform the same chemical tests.
    B. Use a different chemical test on the cells of the outer layer.
    C. Grind up the dense membrane and mix it with the cells of both layers.
    D. Repeat the original experiment several times, using only cells of the outer layer.

32. Which of the following diagrams best depicts the conclusions of Biologist 2?

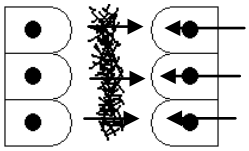
F. INNER OUTER



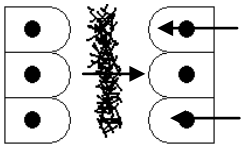
G. INNER OUTER



H. INNER OUTER



J. INNER OUTER



33. If you could place a radioactive marker on the unique chemicals that are used only to make up the dense membrane and you injected that marked chemical into an animal, which cell layer would become radioactive if the hypothesis of Biologist 1 was correct?

A. The inner layer of cells only
B. The outer layer of cells only
C. First the inner layer and then the outer layer of cells
D. Both the inner and outer layers of cells

34. In some animals, the inner cell layer is not present. When this happens, the dense membrane never appears. This new evidence would

F. support the hypothesis of Biologist 1.
G. support the hypothesis of Biologist 2.
H. contradict the hypothesis of Biologist 2.
J. support the hypotheses of both Biologists 1 and 2.

Passage VII

Hormones are chemical substances that circulate in the blood of all animals and regulate many body functions and activities. Hormone A and Hormone B are found in most animals under normal circumstances and influence the level of physical activity of the animal. A set of experiments was designed, using laboratory mice, to determine the relationship between Hormone A and Hormone B. All experimental mice were compared to a group of control mice that received no hormones or surgery.

Experiment 1

Hormone A can be injected directly into the animal or given in the form of pills hidden in the food. High amounts of Hormone A were given to a group of laboratory mice. The levels of Hormone B were then measured and found to be lower than in normal control mice.

Experiment 2

Hormone B is a very powerful hormone and very small amounts will have a dramatic effect; however, this hormone can only be given by injection. Large amounts of Hormone B were injected into a group of laboratory mice. The levels of Hormone A were then measured and found to be higher than in normal control mice.

Experiment 3

The part of the body that produces Hormone A was surgically removed from a group of mice. Soon after the operation, there was an increase in the levels of Hormone B in the blood of all the operated animals, as compared to the control group.

35. Which of the following best describes the relationship between Hormones A and B?

    A. They are not related to each other in any way.
    B. They appear to have some control over each other in the body.
    C. They both rise and fall simultaneously.
    D. When the level of one hormone goes down, the other always goes up.

36. From the experiments, the researchers can conclude that in the blood of normal mice, when the level of Hormone B increases, the level of Hormone A

    F. increases.
    G. does not change.
    H. decreases.
    J. falls and then rises.

37. From these experiments, it is reasonable to conclude that

    A. Hormones A and B are produced by the same part of the body.
    B. the levels of hormones in the body never change.
    C. levels of Hormone B are reduced when any part of the body is removed.
    D. there is a mechanism in mice that regulates the levels of hormones in their bodies.

38. In Experiment 2, should the researcher have administered Hormone B in the form of pills hidden in the food of the animals?

    F. No, because Hormone B will only work if it is injected.
    G. Yes, because the experiments are testing the way in which the drug is administered.
    H. Yes, because Hormone B should be administered in exactly the same way as Hormone A.
    J. Yes, because this would serve as a better control.

39. What would you expect to happen if you removed the part of the body that produced Hormone B?

    A. Levels of Hormone B would increase.
    B. Levels of Hormone A would increase.
    C. Levels of Hormone A would decrease.
    D. Levels of both Hormones A and B would increase.

40. If high levels of Hormone A cause the animal to become active and lower levels of Hormone A cause the animal to fall asleep, what would happen if you injected extra amounts of Hormone B?

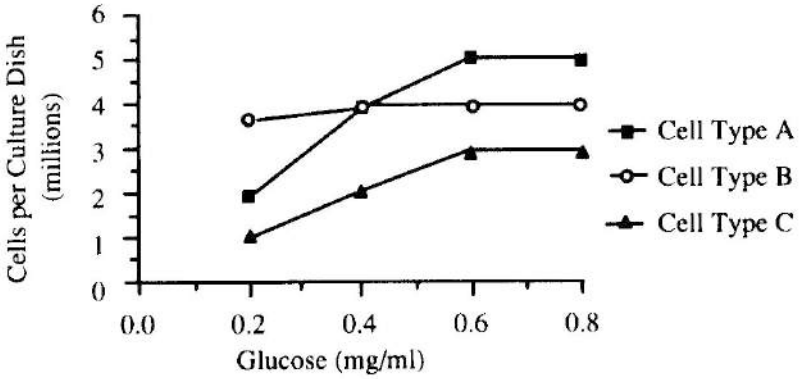
    F. The animal would sleep.
    G. There would be no effect.
    H. The animal would require more sleep than usual.
    J. The animal would become more active.

DIRECTIONS: *There are seven passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and mark the corresponding oval on the answer sheet. You may refer to the passage as often as necessary.*

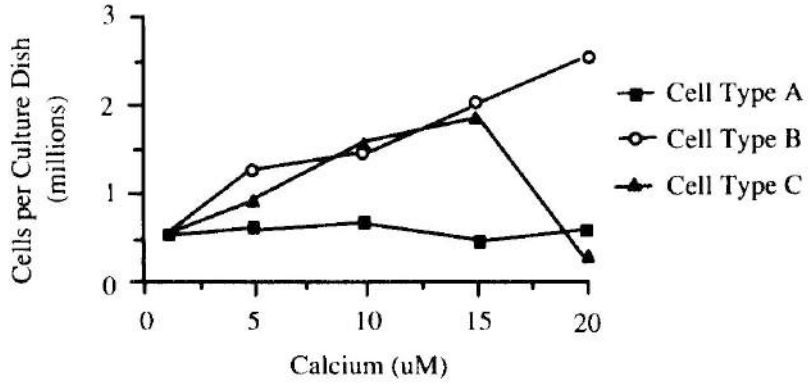
Passage I

The growth (i.e., proliferation) of tumor cells in culture depends on the amount of nutrients in the culture media in which the cells are maintained. Cell proliferation can be determined by counting the number of cells. The effects of various media concentrations of glucose and calcium on the growth of three different cell types were tested. Each culture dish began the test with 0.5 million cells to which were added fresh media containing known concentrations of either glucose or calcium. The results after three days are shown below.

GRAPH 1



GRAPH 2



1. On the basis of the information in Graphs 1 and 2, one would predict that the growth of Cell Type A would be greater than that of Cell Type B in media containing

   A. 0.2 mg/ml glucose and 5 uM of calcium.
   B. 0.4 mg/ml glucose and 5 uM of calcium.
   C. 0.6 mg/ml glucose and 1 uM of calcium.
   D. 0.2 mg/ml glucose and 1 uM of calcium.

2. Which of the following conclusions is consistent with the data presented in Graph 2?

   F. High concentrations of calcium can have detrimental effects on the growth of some cell types.
   G. Media calcium concentrations of 5 to 20 uM stimulate the growth of Cell Types A, B, and C.
   H. The growth of Cell Type B is less affected by the concentration of calcium in the media than is the growth of Cell Type A.
   J. The relationship between the media concentration of calcium and the number of cells per dish is the same for Cell Types A and B.

3. Which of the above data supports the conclusion that increasing the concentrations of nutrients in the media does NOT necessarily increase cell growth?

   A. The growth of Type B cells when the three higher concentrations of calcium were tested
   B. The growth of Type B cells when the three higher concentrations of glucose were tested
   C. The growth of Type C cells when the three lower concentrations of calcium were tested
   D. The growth of Type C cells when the three lower concentrations of glucose were tested

4. Which of the following variables is represented by the vertical axis of the graphs?

   F. The number of cells per culture dish after three days
   G. The concentration of glucose or calcium present in the media after three days
   H. The number of cells added to each culture dish on the first day
   J. The concentration of glucose or calcium present in the media on the first day

5. On the basis of the data shown in Graph 1, which of the following conclusions about the necessity of glucose for cell growth is most accurate?

   A. All three-cell types require at least 0.8 mg/ml of glucose for maximal growth.
   B. Type B cells require more glucose than Type A cells for maximal growth.
   C. At glucose concentrations less than 0.4 mg/ml, Type A cells proliferate more than Type B or C cells.
   D. Cell Types A, B, and C will achieve maximal growth in media containing 0.6 mg/ml glucose.

Passage II

An increasing concern in many regions is ground level air pollution. There are several "agents" that can cause symptoms in humans. One such air pollutant, ozone, is the subject of this series of experiments. Ozone (O_3) is a major component of photochemical smog. It forms when a variety of nitrogen oxides (NO_x), largely from industry and automobiles, reacts with volatile organic compounds (VOCs) in the intense summer heat and solar radiation across much of the United States. When solar radiation is less intense, ozone will not develop. Ambient ozone concentrations in excess of 0.08 ppm averaged over a period of 8 hours are generally considered to be unhealthy.

Experiment 1

Human subjects were exposed to exercise in an atmosphere contaminated with ozone at a concentration of 0.12 ppm (parts per million) over a period of 4 hours with 10 minutes rest per hour. FEV, or forced expiratory volume, was measured at the end of each hour. FEV is the volume of air a person can exhale in one breath. The results of the experiment appear below:

Exercise Time	FEV
Pre-exposure	4.55 Liters
After 60 minutes	4.39 Liters
After 120 minutes	4.19 Liters
After 180 minutes	3.91 Liters
After 240 minutes	3.76 Liters

Data from a 1994 study originally published in American Journal of Respiratory and Critical Care Medicine, vol. 149, pp. 98-105

Experiment 2

Effect of Time of Day: After the initial study reported above, a new research team elected to conduct a similar experiment designed to identify whether ozone levels change throughout the day. Subjects started exercising at 8:00 a.m., and the same group of subjects exercised again at 5:00 p.m. each day for the month of July. All subjects were deemed to be in excellent physical condition prior to being accepted into the study and, in an ozone free environment, showed no significant change between 8:00 a.m. and 5:00 p.m. exercise. Data were collected and averaged results follow:

Exercise Time	FEV 8:00 a.m.	FEV 5:00 p.m.
Pre-exposure	4.75 Liters	4.49 Liters
After 60 mins.	4.74 Liters	4.29 Liters
After 120 mins.	4.74 Liters	4.07 Liters
After 180 mins.	4.73 Liters	3.84 Liters
After 240 mins.	4.72 Liters	3.57 Liters

Experiment 3

In another study, two groups were tested during the mid-afternoon, ozone levels were always 0.12 ppm when the testing started. The subjects were divided into two groups as follows: Group A was composed of men, in average physical condition, over 40 years old. Group B was composed of men and women, in good physical condition, between the ages of 18 and 25.

Exercise Time	Group A	Group B
Pre-exposure	4.52 Liters	4.73 Liters
After 60 mins.	4.34 Liters	4.70 Liters
After 120 mins.	4.16 Liters	4.65 Liters
After 180 mins.	3.97 Liters	4.59 Liters
After 240 mins.	3.78 Liters	4.54 Liters

6. According to the data presented in Experiment 1, the longer one exercises, the reduction in FEV from hour to hour (in Liters)

   F. is constant.
   G. becomes more severe as each hour passes.
   H. varies with no clear trend to conclude.
   J. becomes less severe as each hour passes.

7. If the researchers that conducted Experiment 1 did in fact suspect ozone to cause a reduction in FEV, he or she would most likely predict the FEV in human subjects exposed to 0.16-ppm ozone after 4 hours of exercise to be

   A. 3.44 L.
   B. 3.76 L.
   C. 3.91 L.
   D. 4.33 L.

8. According to the data presented in Experiment 2, researchers may conclude that

   F. ozone levels are higher in the morning than in the late afternoon/early evening.
   G. ozone levels are higher in the late afternoon/ early evening since darkness falls during these hours.
   H. ozone levels are higher in the late afternoon/ early evening since photochemical smog develops during the maximum heating of the day in the mid-late afternoon.
   J. people are in their best condition and performance is best before noon.

9. Study Experiment 3. The best conclusion from this data is that

   A. over time, older people suffer a larger decrease in FEV when exercising than younger people.
   B. people in average health suffer a larger decrease in FEV over time when exercising than people in good health.
   C. men suffer a greater FEV decline over time than women.
   D. the experiment has designed too many factors that vary between the two groups of subjects to draw a firm conclusion as to why Group A saw a larger decline in FEV than Group B.

10. Considering the findings from all three experiments, action should be taken to reduce

    F. ozone emissions during the spring and summer months.
    G. ozone emissions during the winter months.
    H. NO_x and VOC emissions during the summer months.
    J. NO_x and VOC emissions during the winter months.

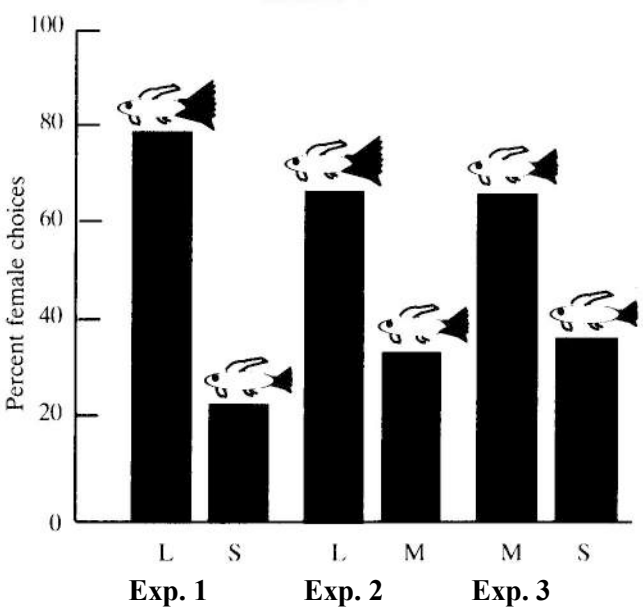
11. If additional research demonstrated that physical condition was more important than age, which of the following individuals would likely report the highest FEV after 4 hours of exercise?

    A. 35 year old, excellent physical condition, January test
    B. 35 year old, excellent physical condition, July test
    C. 22 year old, average physical condition, January test
    D. 22 year old, average physical condition, July test

Passage III

In many vertebrate species, females choose their mates. Researchers studied female choice in guppies, a species of fish. They performed three experiments in which females were presented with a choice between males of two different tail sizes: (1) large and small, (2) large and medium, and (3) medium and small. The researchers also counted the number of dance-like displays that males of different tail sizes performed in their mating ritual. The results are presented below.

Graph 1
Mating Preference of Female Guppies



L = large, M = medium, S = small

Table 1
Average Rates of Male Guppy Mating Displays

Male Tail Size	Large	Medium	Small
Average Tail Size (mm^2)	71	45	16
Average Display Rate per Mating Ritual (number)	2.3	1.6	1.7

12. According to the data, approximately what percentage of females chose males with medium tails when presented with a choice between males with large tails and males with medium tails?

    F. 70%
    G. 65%
    H. 35%
    J. 0%

13. Based on the data, which of the following results could be expected if females were presented with a choice between males with small tails and a new category of males with extremely small tails, assuming that females can differentiate between the two size classes?

    A. More females would choose males with small tails than males with extremely small tails.
    B. More females would choose males with extremely small tails than males with small tails.
    C. Females would show no preference between males with small tails and those with extremely small tails.
    D. Females would reject both males with small tails and males with extremely small tails.

14. The hypothesis that females choose males with larger tails at least three times as often as they choose males with smaller tails is NOT supported by which experiment?

    I. L vs. S
    II. L vs. M
    III. M vs. S

    F. I only
    G. II only
    H. I and III only
    J. II and III only

15. Based on the data, one could hypothesize that in the male guppies' mating ritual

    A. as tail size increases display rate decreases.
    B. as tail size increases display rate increases.
    C. those with small tails tend not to display.
    D. those with large tails tend to display most frequently.

16. According to the data, the hypothesis that females prefer males that exhibit a greater number of dance-like displays is inconsistent with which comparison?

    I. L vs. S
    II. L vs. M
    III. M vs. S

    F. I only
    G. II only
    H. III only
    J. II and III only

Passage IV

To understand better the role of various chemicals in genetics, the following experiments were carried out.

Experiment 1

The Tobacco Mosaic Virus (TMV) causes disease in tobacco leaves and is made up only of protein and the nucleic acid RNA. Two mutant strains of TMV called A and B were developed. They contained chemically altered protein and RNA. The proteins and RNAs from these strains could be separated and then recombined to create new combinations called hybrids. One hybrid called Strain C contains protein from Strain A and RNA from Strain B. When the three strains were allowed to infect tobacco leaves, their offspring were analyzed for their protein and RNA compositions. The results are given in Table 1.

Table 1

TMV Strain	Parent		Offspring	
	Protein	RNA	Protein	RNA
A	A	A	A	A
B	B	B	B	B
C	A	B	B	B

Experiment 2

Researchers using another virus called T-4 which infects and reproduces only inside the bacterium *E. coli* were able to radioactively label this virus. T-4 contains only protein and the nucleic acid DNA. P^{32} was used to label the phosphate groups of DNA and any other phosphate-containing compounds, and S^{35} was used to label the sulfur-containing amino acids of protein and any other sulfur-containing compounds in T-4. After allowing the radioactively labeled T-4 to infect *E. coli* the researchers were able to separate by shearing and centrifuging the portion of T-4 that was injected into *E. coli* from the portion that remained outside *E. coli*. The results of their radioactive analysis are shown in Table 2.

Table 2

Radioactive Label	Found in *E. coli*	Found Outside *E. coli*
P^{32}	X	
S^{35}		X

17. In order to be able to identify proteins and DNA when both are present, which of the following conditions was assumed to be true in Experiment 2?

    A. DNA contains no sulfur and protein contains no phosphate.
    B. T-4 can reproduce outside *E. coli*.
    C. T-4 DNA contains sulfur.
    D. DNA will be labeled by the S^{35} and protein by the P^{32}.

18. Do the results of Experiment 1 support the conclusion that the nucleic acid RNA controls production of TMV?

    F. Yes, because the protein of the offspring are like the parent strain's protein.
    G. No, because strain C does not produce its own unique protein.
    H. Yes, because all offspring's protein and RNA are the same as the parent strain's RNA.
    J. No, because the offspring's protein and RNA are the same as the parent strain's protein.

19. Based on the information in Experiment 2, what is the genetic material in T-4?

    A. RNA
    B. DNA
    C. Protein
    D. Both protein and DNA

20. In Experiment 1, if a new hybrid Strain D were made containing protein from Strain B and RNA from Strain A, its offspring after infection would most likely resemble

    F. Strain A.
    G. Strain B.
    H. Strain C.
    J. Strain D.

21. To investigate further the role of protein in infection, the experimenters tried unsuccessfully to infect *E. coli* with T-4 DNA by itself. Therefore, the role of protein in infection probably includes

    A. providing nutrition for T-4 between infections.
    B. protecting T-4 DNA after it is inside *E. coli.*
    C. controlling production of new T-4 protein.
    D. providing the mechanism for injecting DNA into *E. coli.*

22. On the basis of the results of Experiments 1 and 2, which of the following would be most likely to permanently change the characteristics of a cell into which it has been injected?

    F. Protein
    G. Amino acids
    H. DNA
    J. Phosphate

Passage V

Prolactin is a hormone required for milk production. In female rats, prolactin secretion is stimulated by not only the suckling of newborn pups but also the sight, smell, and sound of suckling of newborn pups. Experiments were performed to compare the ability of these stimuli to induce prolactin secretion. Prolactin concentrations were measured in the blood of female rats after exposure to the sight, odor, and/or sound of newborn pups. The results are shown below.

	Prolactin Concentrations in nanograms/milliliter (ng/ml)	
Stimulus	10 Minute Exposure	30 Minute Exposure
No stimulus	16.7	17.0
Sight alone of:		
2 pups	18.0	25.3
10 pups	17.9	37.7
Odor alone of:		
2 pups	32.1	19.0
10 pups	42.8	24.3
Sound alone of:		
2 pups	37.5	35.6
10 pups	36.9	37.7
Sight and sound of:		
2 pups	36.9	37.3
10 pups	37.0	36.9
Sound and odor of:		
2 pups	49.1	48.8
10 pups	48.8	49.2
Sight and odor of:		
2 pups	40.3	20.2
10 pups	44.4	24.9

23. According to the table, in what range are the prolactin concentrations in untreated female rats?

    A. Between 25 and 50 ng/ml
    B. Between 30 and 35 ng/ml
    C. Between 20 and 50 ng/ml
    D. Between 15 and 20 ng/ml

24. Is the statement "The sound of 10 pups causes a more rapid increase in prolactin secretion than does the sight of 10 pups" supported by the information in the table?

    F. Yes, prolactin concentrations are greater 10 minutes following the sound of 10 pups than following the sight of 10 pups.
    G. Yes, prolactin concentrations are greater 30 minutes following the sound of 10 pups than following the sight of 10 pups.
    H. No, after 30 minutes, prolactin concentrations are greater following the sight of 10 pups than following the sound of 10 pups.
    J. No, both stimuli increased prolactin concentrations equally after 10 minutes.

25. What is the relationship between the strength of the pups' odor and prolactin secretion after 10 minutes' exposure?

    A. The greater the number of pups providing the odor the smaller the prolactin response.
    B. The smaller the number of pups providing the odor the greater the prolactin response.
    C. The greater the number of pups providing the odor the greater the prolactin response.
    D. The odor of the pups was unrelated to the prolactin response.

26. If an additional measurement had been taken after 60 minutes of exposure to the combined sight and odor of 10 pups, what would the prolactin concentrations most likely have been?

    F. The prolactin concentrations would have been higher at 60 minutes than at 30 minutes.
    G. The prolactin concentrations would have been the same at 60 minutes as at 10 minutes.
    H. The prolactin concentrations would have been greater at 60 minutes than at 10 or 30 minutes.
    J. The prolactin concentrations would have been smaller at 60 minutes than at 10 or 30 minutes.

27. Which of the following conclusions is consistent with the data presented in the table?

    A. The sound of the pups is the least potent stimulus for initiation of prolactin secretion.
    B. The sound and odor of the pups induce more prolactin secretion when presented together than when presented individually.
    C. The sight of the pups induces a more rapid increase in prolactin secretion than does the sound of the pups.
    D. Prolactin secretion increases above and then returns to control levels during 30 minutes of exposure to the sight of the pups.

Passage VI

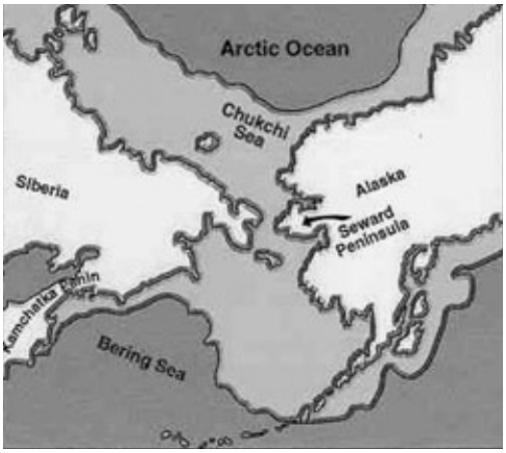
A continuing debate among paleontologists has been the answer to the question of when humans first entered the Americas. Specifically, the point of contention is: Did they enter the Americas before 12,000 years ago or after that time? Two archeologists present their points of view on this matter.

Archeologist 1

Archeologist 1 has presented evidence pointing to the existence of humans in the Americas before 12,000 years ago. Archeologist 1 discovered what appears to be an ancient human encampment on the swampy bank of a small creek. This archeological site is called Monte Verde. Using the analytical technique of radiocarbon dating on various types of material recovered from Monte Verde, Archeologist 1 dated items taken from this site as 13,000 years old. These items included bone, wood, and charcoal. The charcoal was located in the recesses of a cave. Furthermore, there is a remarkable feature at Monte Verde consisting of a series of rectangular arrangements of logs. Archeologist 1 has concluded that these logs formed the foundations of human dwellings and, therefore, believes that humans entered the Americas more than 12,000 years ago.

Archeologist 2

However, Archeologist 2 is not yet convinced by the evidence unearthed at Monte Verde that humans entered the Americas more than 12,000 years ago. Archeologist 2 believes that people could not have entered the Americas earlier than 12,000 years ago. Archeologist 2 bases this belief on the theory that people could only have migrated into the Americas during a period of time when great glaciers captured and held so much water that the ocean levels dropped hundreds of feet. This drop in ocean levels allowed mass migration into the Americas by exposing land bridges that tied Siberia to North America. Evidence cited by Archeologist 2 suggests that this period of severe glaciation occurred 11,500 years ago. Finally, Archeologist 2 suggests that the pattern of logs interpreted by Archeologist 1 to be a foundation built by humans was simply the result of natural tree fall.



28. Which of the following statements about the technique of radiocarbon dating would cast doubt on the validity of Archeologist 1's results?

    F. It is of limited use because the material to be dated must consist only of organic matter and not of inorganic substances.
    G. It is a technique used by archeologists to date fossils that is based on measuring the radio-active decay of an isotope of carbon.
    H. It can only accurately date objects that differ by 500 years in age.
    J. It sometimes gives misrepresentative results due to older material contaminating younger artifacts.

29. A majority of other archeologists agree with Archeologist 2 that humans did not enter into the Americas before 12,000 years ago. What is the most likely reason many scientists selected this date?

    A. The discovery, at different archeological sites, of the sudden appearance of a large amount of evidence of human people shortly after 12,000 years ago.
    B. No land bridges existed prior to 12,000 years ago and humans were not known to build boats that early in their history.
    C. There is much debate over when the ice age occurred that allowed glaciers to grow and lower sea level.
    D. There were explanations for each of the observations reported by Archeologist 1 that did not require humans to be present at Monte Verde 13,000 years ago.

30. Using the map provided and the information in this passage, what is the initial direction of migration as humans entered North America?

    F. East to west
    G. West to east
    H. North to south
    J. South to north

31. Which of the following additional observations would NOT substantiate the claim by Archeologist 1 that the observed fallen logs represented a human dwelling?

    A. The logs were secured with wooden pegs from a different species of tree.
    B. There was great variance in the logs' diameter, and several of the logs had long branches attached to them.
    C. There was evidence of reeds tied around the logs.
    D. There were symmetrically displaced notches at each end of the logs.

32. The location of the charcoal found at Monte Verde is MOST consistent with which archeologist's claim?

    F. Archeologist 1, because the charcoal most likely resulted from human-produced fire, since natural fires would be unlikely to spread into the recesses of a cave.
    G. Archeologist 1, because radiocarbon dating suggests humans occupied this site 13,000 years ago.
    H. Archeologist 2, because the formation of glaciers enabled land bridges to form about 12,000 years ago allowing migration between Siberia and North America.
    J. Archeologist 2, because the charcoal most likely resulted from a natural fire and no humans were present to produce it.

33. Most archeologists would likely agree that the ice age ended around 10,000 years ago. Archeologist 2 would likely argue that

    A. all human migration to North America ceased after that date.
    B. any migration after that date would require vessels such as boats.
    C. there is no evidence of human migration after that date.
    D. the ice age actually continued for a longer period of time than some suggest, thus allowing more human migration via the land bridge.

34. Which of the following occurrences would BEST support the position of Archeologist 1?

F. The discovery of drawings on the cave walls at Monte Verde that depicted both a religious ceremony and a successful hunt
G. The use of a superior and less controversial technique than radiocarbon dating that more accurately dated the items found at Monte Verde as 11,890 years old
H. The discovery at Monte Verde of three identically sized spear points with precise markings that could only have been produced by human hands
J. The discovery by a different archeologist of another human encampment in the Americas with items dated as 13,500 years old

Passage VII

To better understand the factors that impact a chemical reaction's initial rate of reaction, the following data was collected in three sets of trials. A series of experiments were conducted using the following chemical system described by the net ionic equation below:

$$BrO^{-}_{3(aq)} + 5Br^{-}_{(aq)} + 6H^{+}_{(aq)} \rightarrow 3Br_{2(l)} + 3H_2O_{(l)}$$

The first set of trials was conducted and the following data was collected:

Trial #	Initial Concentration of BrO_3 (mol/L)	Initial Concentration of Br (mol/L)	Initial Concentration of H^+ (mol/L)	Initial Rate (mol/Ls) ($x10^{-3}$)
1	0.10	0.10	0.10	0.8
2	0.20	0.10	0.10	1.6
3	0.20	0.20	0.10	3.2
4	0.10	0.10	0.20	3.2

In a second set of trials, the following data was collected:

Trial #	Initial Concentration of BrO_3 (mol/L)	Initial Concentration of Br (mol/L)	Initial Concentration of H^+ (mol/L)	Initial Rate (mol/Ls) ($x10^{-3}$)	Initial Temperature
5	0.10	0.10	0.10	0.80	20.0ºC
6	0.10	0.10	0.10	0.88	40.0ºC
7	0.10	0.10	0.10	0.96	60.0ºC
8	0.10	0.10	0.10	1.04	80.0ºC

In a third set of trials, an additional substance was added to the reacting mixture, and was recovered after the reaction. The following data was collected:

Trial #	Initial Concentration of BrO_3 (mol/L)	Initial Concentration of Br (mol/L)	Initial Concentration of H^+ (mol/L)	Initial Rate (mol/Ls) ($x10^{-3}$)
9	0.10	0.10	0.10	1.6
10	0.20	0.10	0.10	3.2
11	0.20	0.20	0.10	6.4
12	0.10	0.10	0.20	6.4

35. When the initial concentration of bromide ion (Br^-) is doubled, what effect does it have upon the initial rate of the reaction?

    A. No effect
    B. Decreases the initial rate by 50%
    C. Increases the initial rate by 50%
    D. Increases the initial rate by 100%

36. Changing the initial concentration of which reactant causes the greatest impact upon the initial rate of reaction?

    F. BrO_3^-
    G. Br^-
    H. H^+
    J. They all have an equal impact upon the initial rate of reaction when their initial concentrations are changed.

37. Identify the independent variable in trials 5 through 8.

A. Initial concentration of BrO_3^-
B. Initial concentration of Br^-
C. Initial concentration of H^+
D. Initial temperature

38. Based upon the data presented, predict the initial rate of reaction if the initial temperature is raised to 120ºC.

F. 1.06×10^{-3} mol/Ls
G. 1.12×10^{-3} mol/Ls
H. 1.20×10^{-3} mol/Ls
J. 1.92×10^{-3} mol/Ls

39. Comparing trials 1 through 4 to trials 9 through 12, what impact did adding the additional substance have upon the reacting systems initial rate of reaction?

A. No effect
B. Decreases the initial rate by 50%
C. Increases the initial rate by 50%
D. Increases the initial rate by 100%

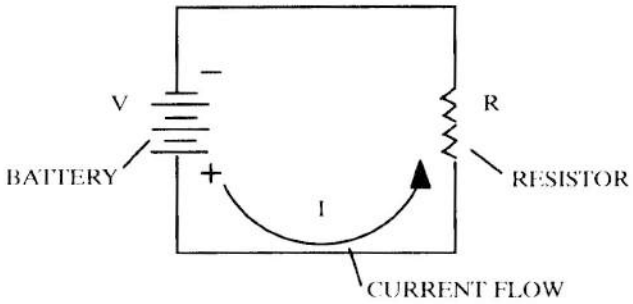
40. The substance added in trials 9 through 12 is best classified as a catalyst because

F. it is acting to increase the initial rate of reaction and is recovered after the reaction is complete.
G. it is acting to reduce the initial rate of reaction and is recovered after the reaction is complete.
H. without it, the reaction does not occur.
J. it affected the initial rate of reaction and is recovered after the reaction is complete.

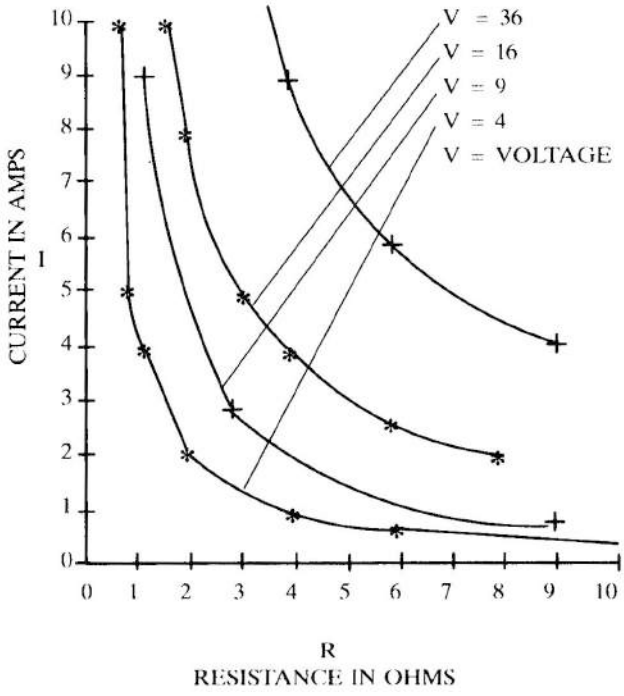
DATA REPRESENTATION

Passage I

In the electrical circuit diagrammed below, V is a voltage source, R a resistance, and I is the amount of current flowing through the circuit. For several different voltages, the resistance is varied, and the effect on the current flow is plotted in the graph below.



V = VOLTAGE IN VOLTS
I = CURRENT IN AMPS
R = RESISTANCE IN OHMS



1. According to the graph when a potential of 9 volts is applied to a 3-ohm resistor, the current flow will be about

   A. 1 amp.
   B. 3 amps.
   C. 6 amps.
   D. 9 amps.

2. Generalizing from the diagram, one can conclude that if a current of 4 amps is flowing through a 6-ohm resistor, the voltage is

   F. between 0 and 4 volts.
   G. between 4 and 9 volts.
   H. between 9 and 16 volts.
   J. between 16 and 36 volts.

3. Which of the following hypotheses about the relationship between voltage and current is supported by the graph?

   A. For any given resistance, current is inversely proportional to voltage.
   B. For any given resistance, current is directly proportional to voltage.
   C. For any given resistance, voltage times current is always constant.
   D. For any given resistance, voltage plus current is always constant.

4. According to the diagram, if a resistor of less than 5 ohms is observed to have a current of less than 5 amps flowing through it, one can conclude that the voltage cannot be greater than

   F. 4 volts.
   G. 9 volts.
   H. 16 volts.
   J. 36 volts.

5. The hypothesis that for any given voltage, resistance and current are inversely proportional is supported by which of the following observations?

   A. The constant voltage curves move farther from the origin with increasing voltage.
   B. The constant voltage curves never intersect each other.
   C. The product I times R is constant along any curve.
   D. The ratio I divided by R is constant along any curve.

Passage II

A fixed quantity of gas is confined in a cylinder with a piston. An experimenter can continuously vary the volume of the gas by moving the piston and the temperature by heating or cooling the gas. As volume and temperature are changed, gas pressure may be affected. As the experimenter alters the temperature or volume of the gas, the volume, temperature, and pressure of the gas are recorded. Data recorded at certain intervals are presented in the four tables.

Table A

Pressure	Temperature	Volume
10	500	1
5	500	2
3.16	500	3.16
2	500	5
1	1,500	10

Table B

Pressure	Temperature	Volume
3	150	1
3	300	2
3	450	3
3	600	4
3	750	5

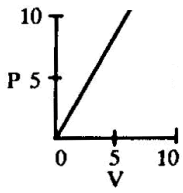
Table C

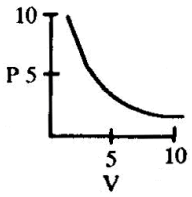
Pressure	Temperature	Volume
1	250	5
2	500	5
3	750	5
4	1,000	5
5	1,250	5

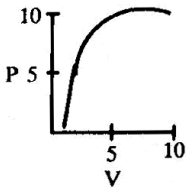
Table D

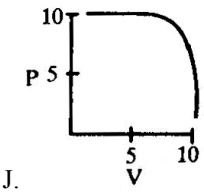
Pressure	Temperature	Volume
1	500	10
2	900	9
3	1,200	8
4	1,400	7
5	1,500	6

6. Which of the following graphs best depicts the relationship between pressure and volume displayed in Table A?

F. 

G. 

H. 

J. 

7. Which table contains data that most directly supports the conclusion that for a fixed volume of gas, pressure is proportional to temperature?

   A. Table A
   B. Table B
   C. Table C
   D. Table D

8. On the basis of the data in Table D, it can be concluded that the gas is undergoing which of the following changes?

   F. Increasing temperature and pressure while being compressed
   G. Increasing pressure and volume while being heated
   H. Decreasing temperature and pressure while being compressed
   J. Decreasing pressure and volume while being heated

9. Which of the following mathematical relationships best describes the data in the graphs? [P = Pressure, V = Volume, T = Temperature]

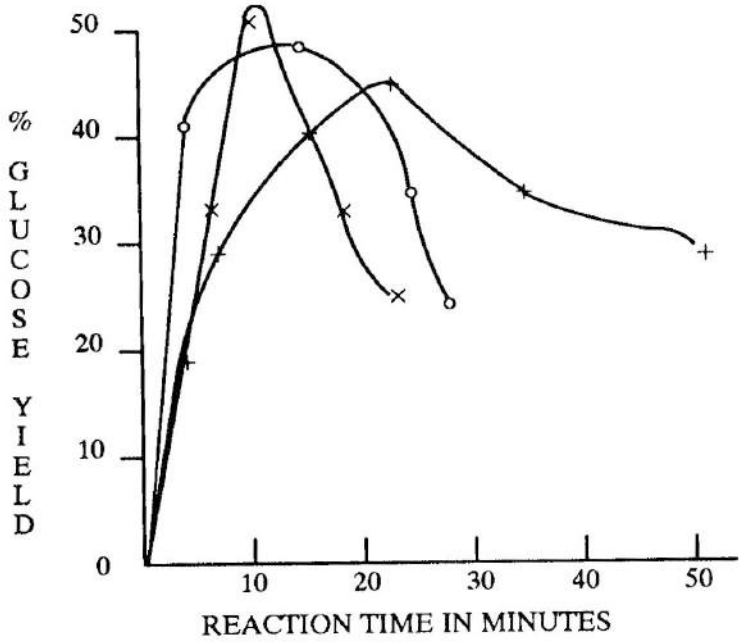
   A. 50TV = P
   B. 50PT = V
   C. PV = 50T
   D. 50PV = T

10. On the basis of the data in Table B, one can conclude that to remain at constant pressure, a gas

    F. expands as it is cooled.
    G. contracts as it is heated.
    H. expands as it is heated.
    J. maintains constant volume as it is heated.

Passage III

Wood and paper waste products contain large amounts of cellulose. Acid hydrolysis can convert this waste cellulose into the sugar glucose, which can then be used to produce fuels and other useful products. An experiment to investigate the effect of temperature on the acid hydrolysis reaction was run at three different temperatures, and yielded the data below.



+ 425 degrees Fahrenheit.
o 450 degrees Fahrenheit.
× 475 degrees Fahrenheit.

11. On the basis of the diagram, if another experiment were conducted at 400 degrees, one would expect the glucose yield to have a

    A. lower peak and more rapid decline with reaction time.
    B. higher peak and more gradual decline with reaction time.
    C. lower peak and more gradual decline with reaction time.
    D. higher peak and more rapid decline with reaction time.

12. According to the diagram, at a reaction temperature of 425 degrees, maximum glucose yield occurs at a reaction time of about

    F. 5 minutes.
    G. 20 minutes.
    H. 40 minutes.
    J. 50 minutes.

13. On the basis of the information in the diagram, which of the following observations supports the hypothesis that to obtain maximum glucose yield the reaction time must be increased as temperature is lowered?

    A. The peak of the 425-degree curve lies to the right of the other peaks.
    B. The peak of the 425-degree curve is lower than that of the other peaks.
    C. The 425 degree curve declines more slowly than the other curves.
    D. The curves for 450 and 475 degrees are similar.

14. On the basis of the information in the diagram, which of the following observations supports the hypothesis that changes in reaction time have a greater effect on glucose yield at higher temperatures than at lower ones?

F. The 450 and 475 degree curves are more similar to each other than to the 425-degree curve.
G. The 450 and 475-degree curves have a higher peak yield than the 425-degree curve.
H. The 450 and 475 degree curves peak at a lower reaction time than the 425-degree curve.
J. The 450 and 475 degree curves are more sharply peaked than the 425-degree curve.

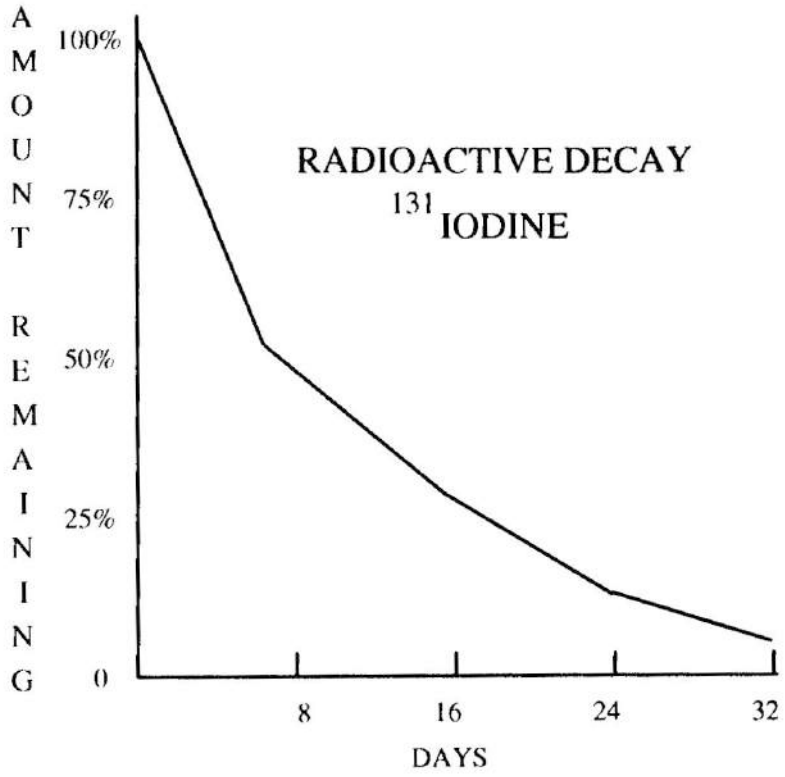
15. Based on the information in the diagram, which of the following temperature curves supports the hypothesis that peak glucose yield increases with increasing temperature?

I. 425 degrees
II. 450 degrees
III. 475 degrees

A. I and II only
B. II and III only
C. I and III only
D. I, II, and III

Passage IV

The half-life of a radioactive isotope is defined as the length of time required for it to decay to one-half of any original amount. The following graph is a plot of the radioactive decay of the isotope, ^{131}Iodine. The half-life of this isotope is eight days. Radioactive elements are measured in metric units called Curies. Commonly used measurements include: nanoCuries, picoCuries, micro-Curies, and milliCuries.



16. Which of the following variables is represented on the vertical axis of the graph?

    F. Days of decay of the isotope on the graph
    G. Half-life of the isotope on the graph
    H. MicroCuries of original amount remaining
    J. Percentage of original amount remaining

17. The radioactive element ^{99}Technetium decays in a manner similar to ^{131}Iodine, but has a half-life of approximately eight hours. If you changed the units on the horizontal axis of the graph from *days* to *hours* and graphed the decay of ^{99}Technetium, what would you expect the graph to look like?

    A. The curve would not change.
    B. The curve would be steeper.
    C. The curve would be flatter.
    D. You could not draw any graph from these data.

18. A small amount of ^{131}Iodine was injected into an animal. Eight days later, only 10 percent of the original amount remained in the animal. On the basis of the data provided in the graph, which of the following conclusions regarding the loss of the isotope can be supported?

    F. The amount remaining in the animal is explained by radioactive decay alone.
    G. There must be another process in the animal that removed the isotope.
    H. There is a process in the animal that stores radioactive elements.
    J. When injected into animals, the number of radioactive atoms never change.

19. On the basis of the data, which of the following conclusions about the rate (speed) of radioactive decay can be drawn?

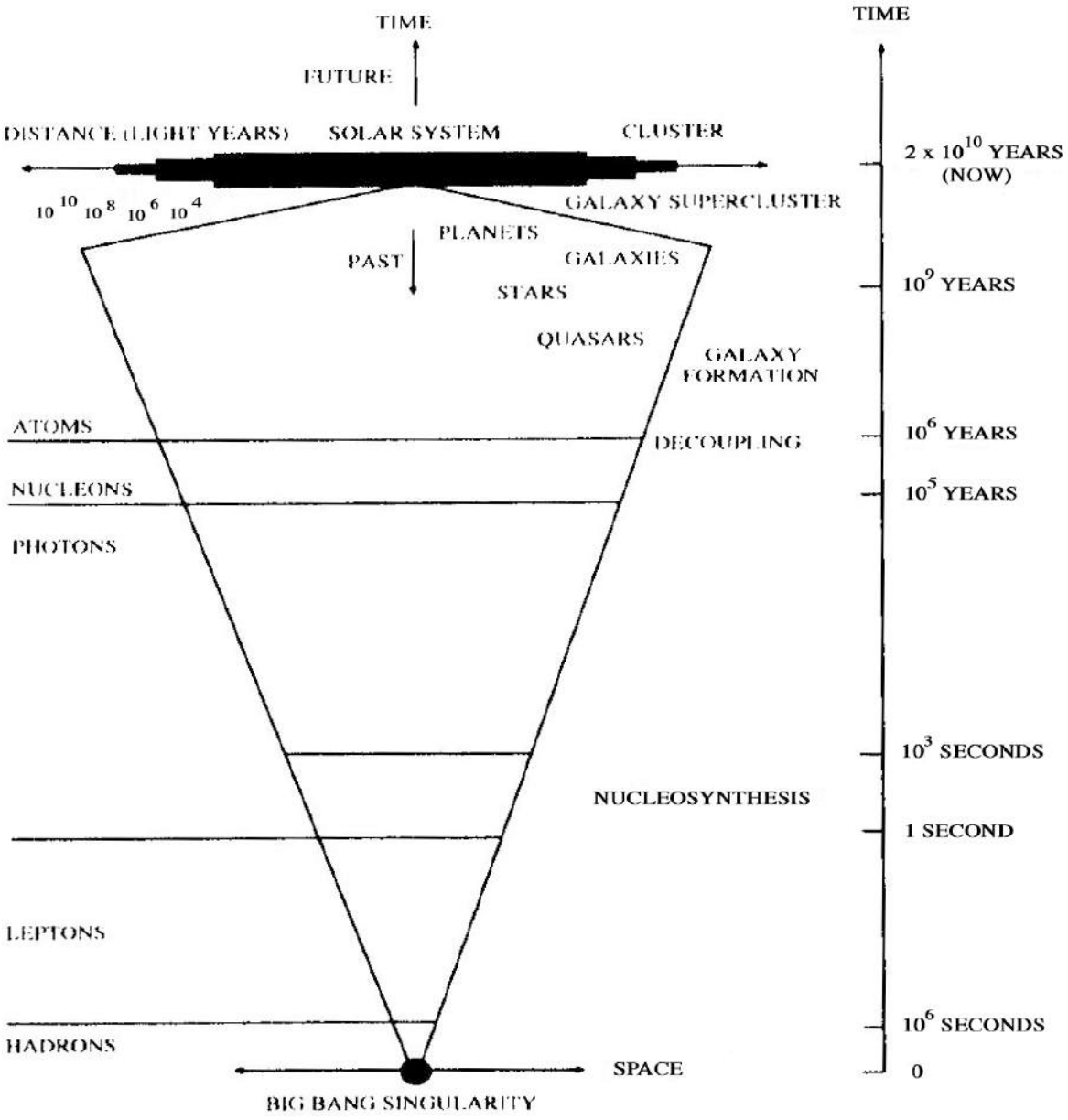
    A. Radioactive decay is a process that is dependent upon the original amount of the material.
    B. The speed of radioactive decay changes from day to day.
    C. Radioactive decay is a constant process independent of all other factors.
    D. The graph clearly indicates that temperature will affect the speed of radioactive decay.

20. A researcher found that a sealed vial had only 12.5 percent of the ^{131}Iodine it was previously known to contain. According to the graph, how many days must have passed since the vial was first measured?

    F. 8 days
    G. 16 days
    H. 24 days
    J. 32 days

Passage V

The following is a Space-Time diagram of the universe. This diagram depicts the history of the universe from a singular "Big Bang" event roughly 20 billion years ago, up to the present. The dark shaded area at the top represents the horizon of a hypothetical observer who can see the entire history, including the origin of the "Big Bang."



—*Scientific American*, April 1980, p. 118

21. According to the diagram, approximately how long after the "Big Bang" did atoms first appear in the universe?

    A. 10^3 years
    B. 10^5 year
    C. 10^6 years
    D. 10^9 years

22. Which of the following hypotheses regarding the size of the universe is supported by the information in the diagram?

    F. The universe has been expanding since its creation.
    G. The universe has been shrinking since its creation.
    H. The universe is the same size now as it was when first created.
    J. The universe has gone through alternate periods of expansion and shrinking.

23. Atoms are composed of subatomic particles, which include nucleons, photons, and leptons. Which of the following hypotheses regarding the formation of these particles is supported by the information in the diagram?

    A. Atoms were formed first and then broke up into the particles.
    B. Subatomic particles and atoms were formed simultaneously.
    C. Subatomic particles were formed first and then combined to form atoms.
    D. Atoms constantly formed, broke up into particles and formed again.

24. If the model of the universe presented in the diagram is accurate, which of the following findings about the material of the universe would be made by a spacecraft that landed on a planet in a distant galaxy?

    F. The materials found would be composed of atoms totally different from those we have on earth.
    G. The materials found would be composed of photons and nucleons but not atoms.
    H. The atoms found there would be older than those found on earth.
    J. The materials found would be very similar to those found throughout our solar system.

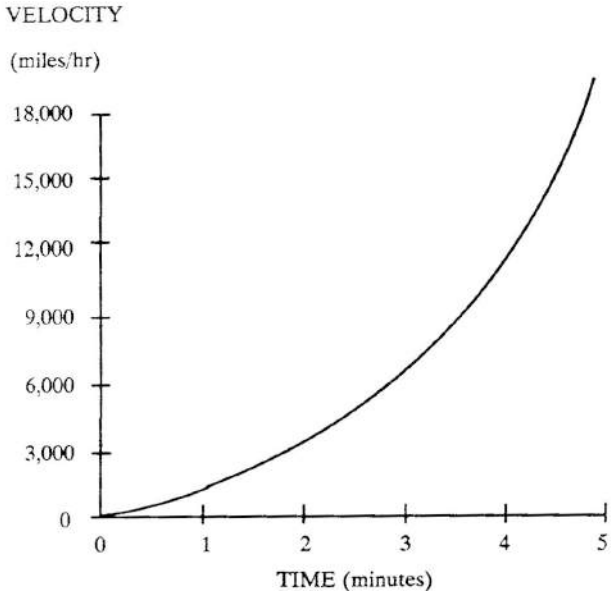
25. Which of the following conclusions about the sequence of events in the universe is consistent with the data provided in the diagram?

    A. The planets were formed shortly after the Big Bang.
    B. Galaxy formation and the formation of the solar system occurred simultaneously.
    C. Quasars appeared after the galaxy supercluster.
    D. Stars were formed before the planets.

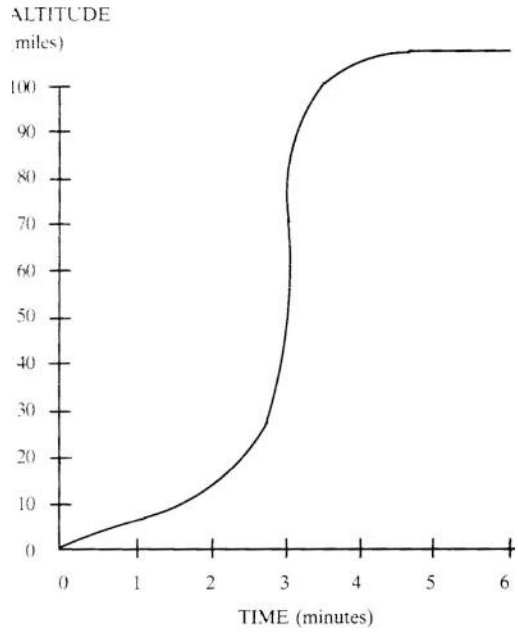
Passage VI

A rocket is launched from the earth's surface. Instruments collect data on the velocity, altitude, and fuel remaining, from ignition to engine shutdown.

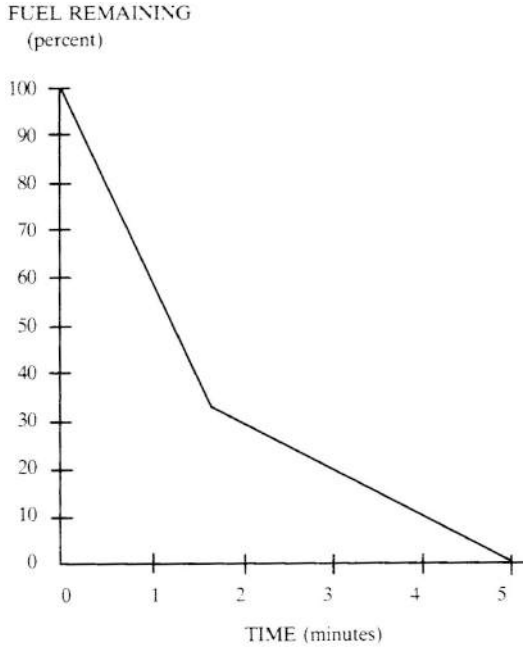
Graph 1



Graph 2



Graph 3



26. The most reasonable explanation for the bend in Graph 3 is that the rocket engine

    F. developed a fuel leak during the flight.
    G. did not consume all available fuel during the flight.
    H. consumed fuel at a greater rate during the first stage of the flight.
    J. consumed fuel at a greater rate during the last half of the flight.

27. It is reasonable to conclude from the data in Graph 2 that the rocket

    A. climbed vertically from ignition to engine shutdown.
    B. achieved a constant altitude at engine shutdown.
    C. achieved its most rapid acceleration during the first two minutes of the flight.
    D. maintained a constant velocity from ignition to engine shutdown.

28. If Graph 1 is typical of any rocket flight, one can conclude that, in general, during a powered flight a rocket accelerates

    F. more rapidly as the flight progresses.
    G. less rapidly as the flight progresses.
    H. at a constant rate.
    J. slowly, then faster, then slower again.

29. According to Graph 1, the rocket's velocity increases most rapidly

    A. at the start of the powered flight.
    B. at the midpoint of the powered flight.
    C. at the end of the powered flight.
    D. after the powered portion of the flight.

30. The altitude changes displayed in Graph 2 indicate that the rocket gains altitude

    F. at a steadily increasing rate.
    G. at a steadily decreasing rate.
    H. most rapidly during the middle portion of the flight.
    J. most rapidly at the beginning and end of the flight.

31. According to Graph 1, just prior to engine shutdown, the acceleration of the rocket is

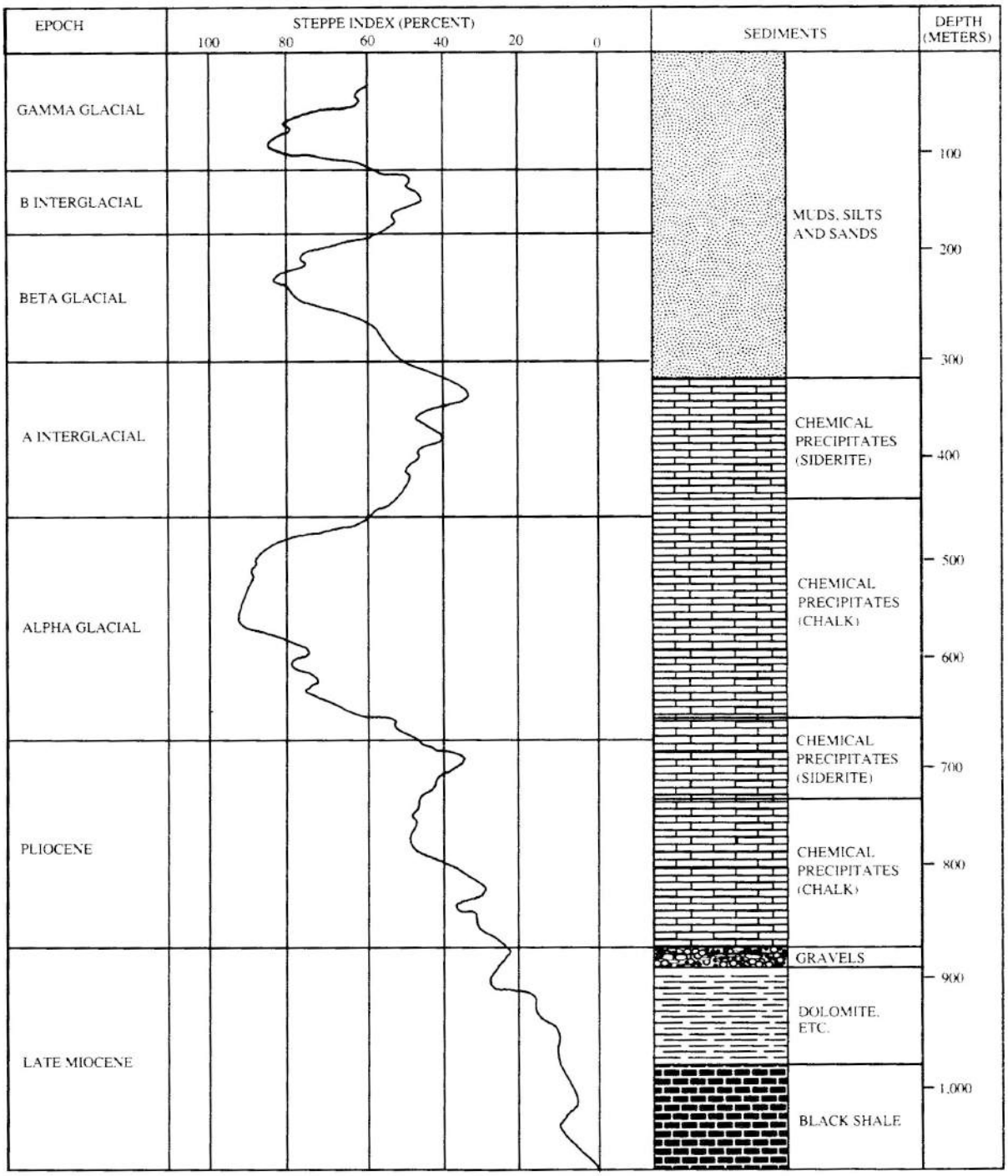
    A. greater than at any other time in the flight.
    B. less than at the beginning of the flight.
    C. equal to the acceleration halfway through the flight.
    D. less than at any other time in the flight.

32. According to Graph 1, as altitude increases, the rate of altitude change

    F. steadily increases.
    G. steadily decreases.
    H. increases, then decreases.
    J. decreases, then increases.

Passage VII

The following chart represents characteristics of samples obtained by drilling into the floor of the Black Sea. The samples are arranged according to their depth from the surface, their chemical properties, and the epoch (Time) in which they were believed to have been deposited. The Steppe index indicates the amounts of cold weather pollen found in the sediments.



33. According to the chart, at 1,000 meters below the surface, the seabed is composed mainly of

    A. muds, silts, and sands.
    B. black shale.
    C. chemical precipitates (siderite).
    D. chalk and gravel.

34. Which of the following hypotheses regarding the deposition of chalk and siderite on the sea floor is supported by the data in the chart?

    F. The deposition of chalk is always preceded by the deposition of siderite.
    G. The deposition of siderite is always preceded by the deposition of chalk.
    H. Deposits of siderite are usually thicker than deposits of chalk.
    J. Chalk and siderite are only deposited during glacial periods.

35. Dolomite and gravels indicate a very shallow water environment. This fact supports the hypothesis that the depth of the Black Sea was

    A. never shallow.
    B. always deep.
    C. always shallow.
    D. once shallow.

36. A Steppe index in excess of 80 percent indicates a cold, glacial period and a value below 60 percent indicates a warm, sub-tropical climate. What would you expect the climate in the area of the Black Sea to have been during the Miocene period?

    F. Glacial, as in earth's current polar regions
    G. Moderate, as in earth's current temperate zones
    H. Tropical, as in earth's current rain forests
    J. Very hot, as in earth's current desert regions

37. Black shale, dolomite, gravels, and chemical precipitate layers are highly compacted, whereas the mud, silt, and sand are relatively loose. The difference between the compacted and loose materials is most likely due to the

    A. chemical composition of the layer itself.
    B. age of the layer.
    C. depth of the layer below the earth's surface.
    D. Steppe index.

Passage VIII

The protein content of a solution can be measured with a colormetric assay using reagents that become darker in the presence of protein. The results of this chemical reaction are measured with a spectrophotometer and are expressed in terms of the amount of light absorbed by the test solution. In the graph and table below are the results of an assay using two types of protein and the data from four unknown samples.

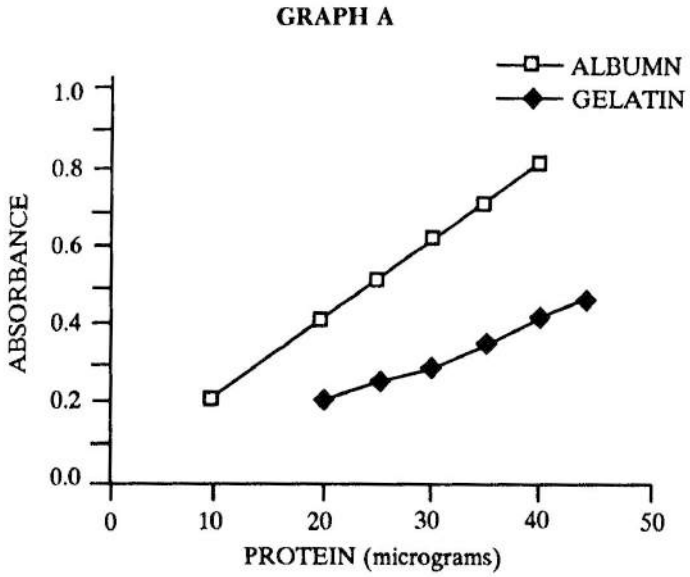


Table 1

Unknown Sample	Light Absorbance
1	.30
2	.20
3	.25
4	.40

38. Which of the following variables is represented by the vertical axis of the graph?

    F. The amount of protein expressed in micrograms
    G. The amount of light absorbed by the solution as measured by the spectrophotometer
    H. The wavelength of light recorded by the spectrophotometer
    J. The type of protein in the solution

39. Which statement best describes the relationship between protein content of a sample and the results obtained with the spectrophotometer?

    A. The higher the protein content, the greater the light absorbance.
    B. The higher the protein content, the lower the light absorbance.
    C. The spectrophotometer determines the type of protein by measuring the amount of light absorbed by the sample.
    D. The albumin content of a sample is related to the amount of protein measured by the spectrophotometer.

40. Which of the following conclusions is NOT true based on the relationship between the amount of a protein in a solution and the amount of light absorbance caused by that solution, as shown in the graph?

    F. For a given amount of protein, albumin causes greater light absorbance than does gelatin.
    G. This protein assay can be used to determine which type of protein is in a sample containing an unknown amount of protein.
    H. The relationship between protein content and the amount of light absorbance is linear whether the protein in that sample is gelatin or albumin.
    J. Albumin and gelatin differ in some of their chemical properties.

41. On the basis of the protein assay results in Graph A and the unknown sample data in Table 1, which of the following statements is true?

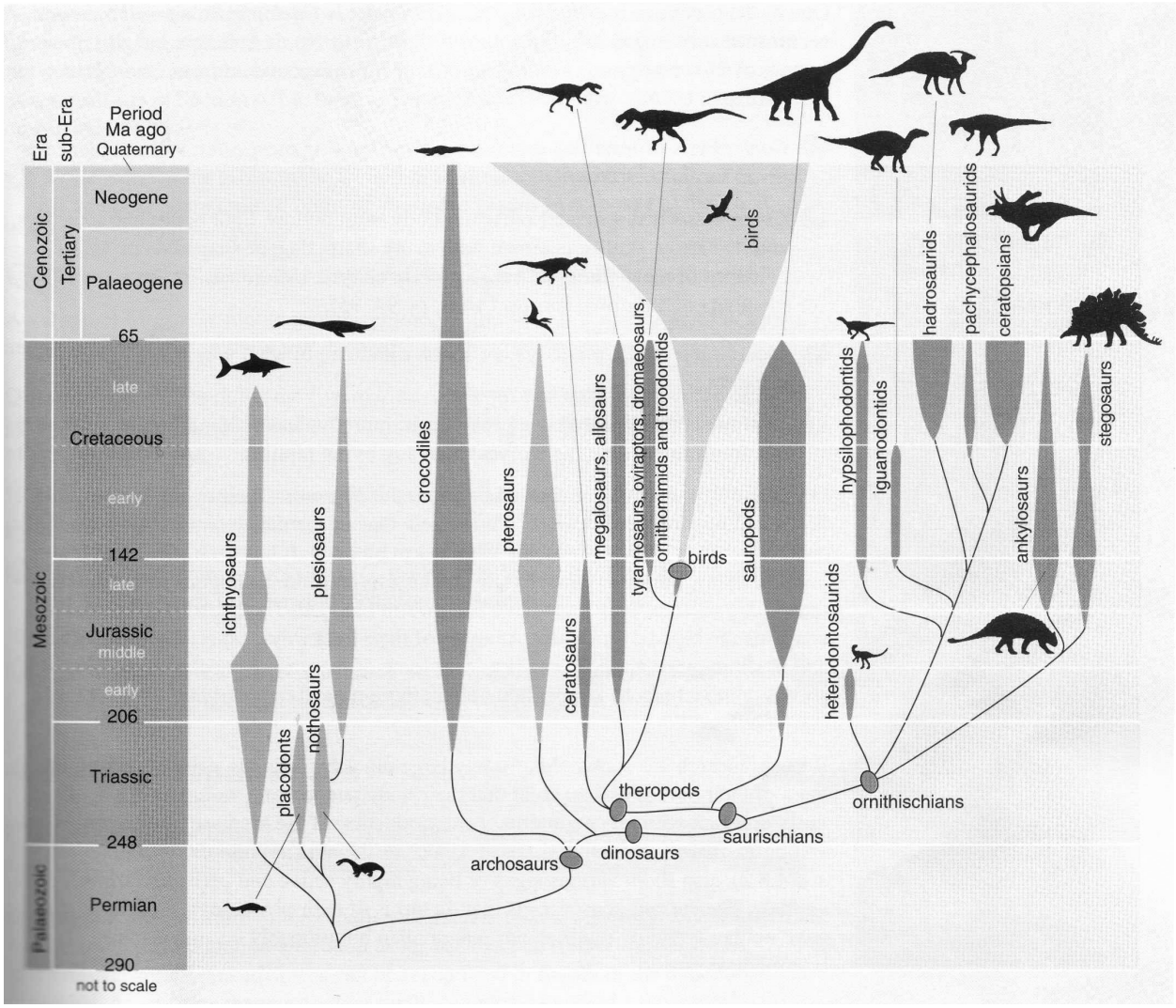
    A. Unknown Sample 2 contains more protein than Unknown Sample 1.
    B. Unknown Sample 1 contains more protein than Unknown Sample 4.
    C. Unknown Sample 4 contains more protein than Unknown Sample 1.
    D. Unknown Sample 3 contains more protein than Unknown Sample 1.

42. A sample containing 20 micrograms of albumin would absorb only 50 percent as much light as would a sample containing

    F. 10 micrograms of albumin.
    G. 25 micrograms of albumin.
    H. 40 micrograms of albumin.
    J. 80 micrograms of albumin.

Passage IX

Study the tree of life represented below. Take note that some (certainly not all) of the species found on earth are represented on this chart. This chart reports the existence of life forms from approximately 290 million years ago until the present. Each species is represented by a band of varying thickness. The thicker the band, the greater a species diversity. Answer the questions that follow on the basis of the information presented in this chart.



43. The most recent geologic time period represented on this chart is the

    A. Quaternary.
    B. Tertiary.
    C. Cenozoic.
    D. Permian.

44. The species to achieve the greatest diversity on this chart is

    F. ichthyosaurus.
    G. crocodiles.
    H. birds.
    J. sauropods.

45. The oldest species that still exists today is

A. plesiosaurs.
B. crocodiles.
C. birds.
D. ceratopsians.

46. Crocodiles evolved from

F. dinosaurs.
G. archosaurs.
H. birds.
J. plesiosaurs.

47. Identify the time period where there was apparently a major disruption in life forms.

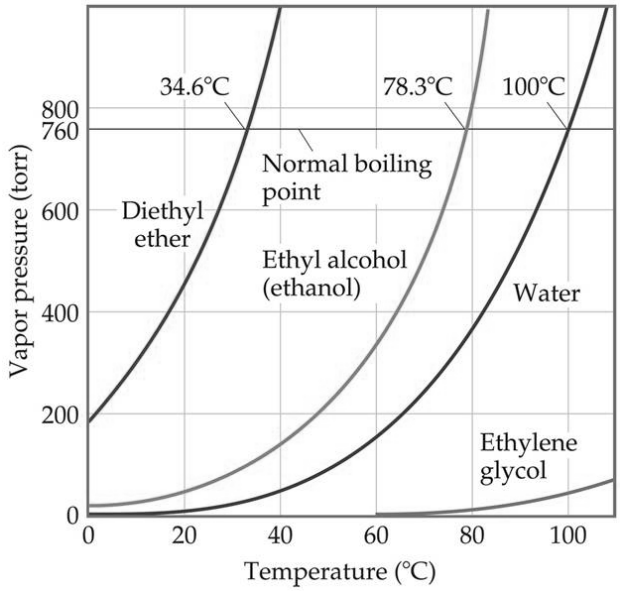
A. Quaternary
B. Late Cretaceous
C. Early Cretaceous
D. Middle Jurassic

48. Theropods are a common ancestor to both

F. birds and tyrannosaurs.
G. birds and sauropods.
H. birds and crocodiles.
J. tyranosaurs and sauropods.

Passage X

The following chart details the vapor pressure as a function of temperature for four different pure substances. It also depicts the "normal" boiling point for each substance. The normal boiling point is defined as the temperature at which a liquid boils at normal atmospheric pressure of 760 torr (1 atmosphere).



49. Identify the substance with the highest normal boiling point.

    A. Diethyl ether
    B. Ethyl alcohol
    C. Water
    D. Ethylene glycol

50. Air pressure is typically lower at higher altitudes. A certain mountain community typically experiences pressures of 600 torr. At these pressures, at what temperature will ethyl alcohol boil?

    F. 28°C
    G. 73°C
    H. 78.3°C
    J. 92°C

51. Studies show that heat of vaporization (energy required to boil a pure substance) and boiling point are directly related. Based upon this statement, which pure substance must have the greatest heat of vaporization?

    A. Diethyl ether
    B. Ethyl alcohol
    C. Water
    D. Ethylene glycol

52. Substance "X" has a normal boiling point of 65°C. As with each of the four compounds detailed in this experiment, it is a pure substance and follows a similar curve. At 800 torr, its boiling point is most likely approximately

    F. 48°C.
    G. 63°C.
    H. 67°C.
    J. 100°C.

53. If the chart is extended to a temperature of 150°C, which substance will exhibit the greatest vapor pressure?

    A. Diethyl ether
    B. Ethyl alcohol
    C. Water
    D. Ethylene glycol

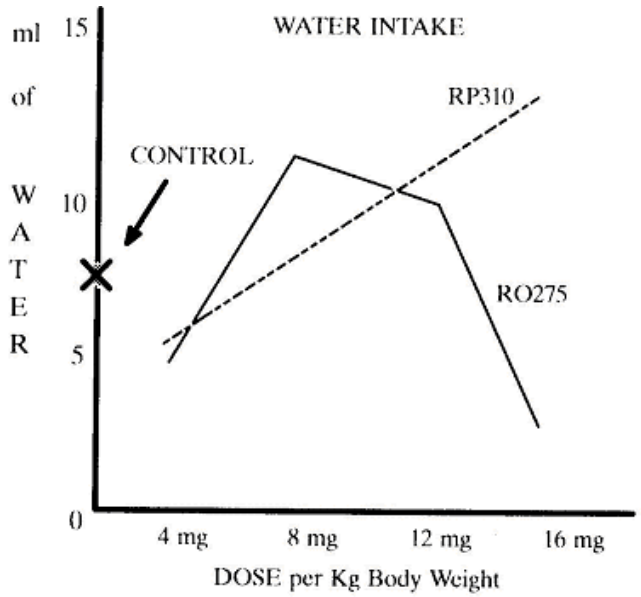
ACT

SKILL BUILDER TWO

RESEARCH SUMMARIES

Passage I

A scientist wanted to determine the effects of different doses of two experimental drugs (#RO275 and #RP310) on water intake in laboratory rats. Experimental groups, consisting of five rats each, were injected with either a 4 mg/kg, 8 mg/kg, 12 mg/kg, or 16 mg/kg dose (per kg body weight) of each drug. A control group of five rats received injections of 0 mg/kg body weight. The volume of injections for each group was physiologically insignificant. Several hours after the injection, the volume of water which each rat had consumed was measured and recorded. The results of the experiment are presented below. Each data point represents the average volume consumed for the five rats in each group.



1. It was hypothesized that higher drug doses would result in an increase in water consumption. The results of which experimental trial support the theory of higher consumption with higher dose?

   A. Drug #RO275
   B. Drug #RP310
   C. Control group
   D. Both #RO275 and #RP310

2. At approximately what point on the graph do the data for the two experimental groups converge?

   F. 10 ml at 4 mg/kg
   G. 5 ml at 8 mg/kg
   H. 10 ml at 12 mg/kg
   J. 5 ml at 16 mg/kg

3. Which of the following most closely describes the relationship between water consumption and increasing doses of drug #RO275? As the dose of the drug increases, water consumption

   A. increases.
   B. decreases.
   C. remains constant.
   D. increases and then decreases.

4. A new experimental drug, #TF113, was discovered that was believed to have properties identical to #RO275 and #RP310. A similar experiment was devised to test the effects of increasing doses of this drug on water consumption. What result would you predict, if the maximum amount of drug #TF113 was kept small and never more than 8 mg/kg body weight? Water consumption would probably

   F. increase with increasing doses.
   G. decrease with increasing doses.
   H. increase and then decrease.
   J. not be affected.

5. It was hypothesized that for this family of experimental drugs, low doses would inhibit water consumption while higher doses would stimulate water consumption. The results of which experimental trial support this hypothesis?

   A. #RO275
   B. #RP310
   C. Both #RO275 and #RP310
   D. Control group

Passage II

The following experiments were designed to test the effects of liquid diet supplements on the growth of immature animals.

Experiment 1

Groups of immature female rats were given either normal drinking water or liquid diet Supplement A or B in place of their drinking water. All the animals were no longer nursing and were fed a standard diet of solid food in addition to the liquid supplements. Body weight, body length, and body fat were measured after six weeks, by which time the animals were adults. The results are shown below.

Treatment	Average Body Weight (gm)	Average Body Length (cm)	Average Body Fat (gm)
No supplement	180	10.7	20.0
Supplement A	240	10.9	36.0
Supplement B	260	10.8	35.0

Experiment 2

Groups of immature male and immature female rats were given either normal drinking water, Supplement A, or Supplement B and were then weighed after six weeks. When maintained on normal drinking water, male rats weighed more as adults than did female rats. Those females given either Supplement A or Supplement B had adult body weights similar to those of male rats maintained on normal drinking water. In male rats, Supplement B but not Supplement A increased the adult weight above that of males given only water.

Experiment 3

Groups of immature male rats were given either normal drinking water, Supplement A, or Supplement B. The animals were given only 80 percent of their normal ration of solid food. All the animals were weighed before and after six weeks of supplement treatment. The animals given Supplement A or B had body weights greater than those animals given only water.

6. Which of the following factors was a variable in Experiment 1?

   F. Type of diet supplement
   G. Type of solid food
   H. Amount of supplement given to each animal
   J. Amount of solid food given to each animal

7. Which of the following hypotheses is supported by the changes in body weight and length seen after treatment with the diet supplements in Experiment 1?

   A. Giving adult animals diet supplements will increase their body weight.
   B. Diet supplements given to immature rats will not affect the ratio of body weight to body length.
   C. Adult body weights can be increased by giving either diet Supplement A or B to immature rats.
   D. Immature rats achieve their final adult body length sooner when given diet supplements.

8. In future studies designed to determine the effects of diet supplements on the growth of immature animals, which of the following experimental variables would be of LEAST importance?

   F. Body weight
   G. Sex of animal
   H. Body length
   J. Body fat

9. If in a subsequent experiment a new supplement was tested, one would predict, based on the results of Experiments 1 and 2, that this new supplement would increase

   A. the body weight of male and female rats.
   B. the body length of male and female rats.
   C. the ratio of body length to body fat in adults.
   D. the body fat of female rats.

10. Given the results of Experiments 1 and 2, which conclusion best describes the effects of diet supplements A and B on rats?

    F. Diet supplements increase body weight but do not affect the ratio of body length to body weight.
    G. The increase in female body weight after diet supplement treatment is due, in part, to an increase in body fat.
    H. When immature animals are given diet supplements they achieve their adult body weight sooner.
    J. Diet supplements are equally effective in increasing the body weight of male and female rats.

11. Which procedural difference would most likely account for the fact that in Experiment 2, but not in Experiment 3, males given Supplement B had greater body weights than males given normal water?

    A. In Experiment 2, but not in Experiment 3, animals given only water were allowed to eat more solid food than those animals given Supplement B.
    B. In Experiment 3, but not in Experiment 2, the animals were forced to obtain more of their nutritional requirements from the diet supplements.
    C. In Experiment 3, but not Experiment 2, the amount of supplement consumed was controlled.
    D. In Experiment 2, but not Experiment 3, male rats were housed in the same room as female rats.

Passage III

For many plant species, the seasonal flowering process is triggered by a photoperiod (each day's alternating period of light and darkness), which changes with the season. It is known that the cocklebur is a plant that depends on the photoperiod for the initiation of flowering. The following experiments were performed on four groups of cocklebur plants. Each group contained 20 subjects. All groups were exposed to a 12-hour light cycle followed by a 12-hour dark cycle.

Group 1: The dark period was not interrupted. Flowering occurred in all subjects.

Group 2: The dark period was interrupted by a single flash of white light. The flash was delivered either 3, 5, 8, or 10 hours into the dark period. Flowering occurred in the subjects receiving a flash at 3 or 10 hours into the dark period. NO flowering occurred in the subjects receiving a flash at 5 or 8 hours into the dark period.

Group 3: The dark period was interrupted by a single flash of infrared (short wavelength) light. The flash was delivered at either 3, 5, 8, or 10 hours into the dark period. Flowering occurred in all subjects.

Group 4: The dark period was interrupted by a single flash of white light followed by a single flash of infrared light. Flash pairs were delivered at either 3, 5, 8, or 10 hours into the dark period. Flowering occurred in all subjects.

12. The theory that the flowering of plants is determined by the photoperiod assumes that

    F. plants are capable of measuring time.
    G. plants are capable of seasonal changes.
    H. hormonal changes are involved in flowering.
    J. plants are capable of producing seeds.

13. Which of the following conclusions about how the red flash changes the effect of the white flash is supported by the experimental results?

    A. The red flash increases the effect of the white flash.
    B. The red flash reverses the effect of the white flash.
    C. The red and white flash are independent and do not interact.
    D. The red flash decreases, but does not eliminate the effect of the white flash.

14. Different subjects received the flash of light at different time intervals into the dark period. What was the significance of using this type of procedure?

    F. The procedure was used to determine the effect of multiple flashes.
    G. The procedure was used to evaluate the effects of different flash durations.
    H. The procedure was used to eliminate the need for a control group.
    J. The procedure was used to examine different phases of the dark period.

15. If a cocklebur is exposed to a 14-hour light cycle followed by a 10-hour dark cycle, which of the following procedures could be used to prevent flowering?

    A. A single flash of white light, delivered 4 hours into the dark period
    B. A single white/red flash pair, delivered 2 hours into the dark period
    C. A single flash of red light, delivered 3 hours into the dark period
    D. A single flash of white light, delivered 1 hour into the dark period

16. Given the results observed in Groups 1 and 2, which of the following can one conclude about the nature of the flowering process in the cocklebur?

    F. Flowering is determined by the number of transitions from light to dark.
    G. Flowering is determined by the length of the uninterrupted light period.
    H. Flowering is determined by the length of the uninterrupted dark period.
    J. Flowering is determined by the ratio of light period duration to dark period duration.

17. Keeping the results of all the experiments in mind, which of the following procedures would be MOST helpful in further investigating the effect observed in Group 4?

    A. Deliver the flash pair earlier in the dark period.
    B. Change the wavelength of the second flash.
    C. Increase the duration of the dark period.
    D. Eliminate the delivery of the second flash.

Passage IV

An experiment is conducted to determine the effect of an insecticide on the thickness of hens' eggshells. A batch of 100 hens of the same age and strain are selected for this study. The hens are randomly divided into two groups—Group A and Group B—prior to carrying out the experiments.

Experiment 1

The hens from Group A were put on a normal diet of feed grain for a period of 30 days. After that period, the eggs were collected for five successive days and were examined for their eggshell thickness. The average values from the analysis are as follows:

# of Hens	Average Eggshell Thickness (mm)
10	< 0.2
30	0.2 – 0.5
8	> 0.5
2	did not lay eggs

Experiment 2

Hens from Group B were fed the same but with 10 mg of the insecticide. After 30 days on this diet the eggs were collected for five successive days and examined for their eggshell thickness. The average values from the analysis are as follows:

# of Hens	Average Eggshell Thickness (mm)
21	< 0.2
18	0.2 – 0.5
6	> 0.5
5	did not lay eggs

Experiment 3

The diet of the hens in Group B was fortified with 50 mg of calcium. After keeping the hens for an additional 30 days on both calcium and insecticide, the eggs were collected for five successive days and examined for their shell thickness. The average values from the analysis are as follows:

# of Hens	Average Eggshell Thickness (mm)
25	< 0.2
14	0.2 – 0.5
5	> 0.5
6	did not lay eggs

18. Which of the three experiments served as a control?

    F. Experiment 1 only
    G. Experiment 2 only
    H. Experiment 3 only
    J. Both Experiments 1 and 3

19. Do the results of Experiment 2 support the conclusion that insecticide causes hens to lay eggs with thinner shells?

    A. No, because the number of hens that did not lay eggs is about the same compared to Group A.
    B. No, because the number of hens that had eggshells thicker than 0.5 mm decreased only slightly compared to Group A.
    C. Yes, because the number of hens that laid eggs is about the same compared to Group A.
    D. Yes, because the number of hens that laid eggs with shells below 0.2 mm thickness doubled.

20. Which of the hypotheses is consistent with the data from both Experiment 2 and Experiment 3?

    I. Trace amounts of insecticide in the hens' diet produces eggs with thinner shells.
    II. Calcium eaten in the free state by the hen does not affect eggshell thickness.
    III. Calcium eaten in the free state by the hen increases its eggshell thickness.

    F. II only
    G. III only
    H. I and II only
    J. II and III only

21. To test the hypothesis that trace amounts of insecticide lower the blood level calcium concentration, the researcher should examine the blood of the

    A. normal hens in Group A.
    B. normal hens in Group B.
    C. affected hens in Group B and compare it against the blood of the normal hens in Group A.
    D. normal hens in Group B and compare it against the blood of the normal hens in Group A.

22. On the basis of the results of the experiments, one can generalize that insecticides

    F. are the leading cause of bird mortality.
    G. are the leading cause of poor eggshell development among chickens.
    H. are more useful than harmful.
    J. affect the normal metabolism of birds.

23. To further investigate the effects of insecticide on shell thickness, the researcher should vary which of the following in another experiment consisting of one control group and several experimental groups?

    A. The insecticide level in each experimental group
    B. The number of hens in each experimental group
    C. The amount of feed grain in each experimental group
    D. The calcium level in each experimental group

24. If Experiment 2 had been continued for another 30 days, the results would be

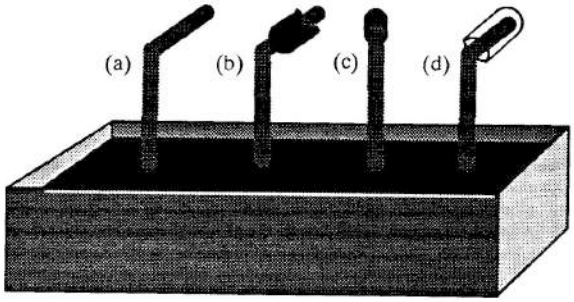
    F. different from the 30-day experiment.
    G. the same as the 30 day experiment.
    H. identical to the results in Experiment 3
    J. undeterminable from the information given.

Passage V

A scientist carried out the following experiments to better understand why plants grow toward light.

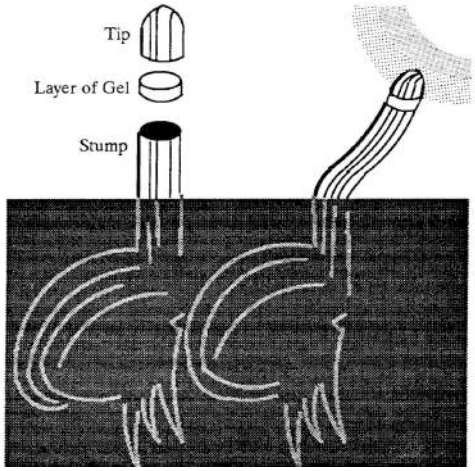
Experiment 1

Oat seedlings were prepared in the way shown. The seedlings with no cap or a transparent cap grew toward the light. The seedling with an opaque cap at the tip did not grow toward the light, while the seedling with a black ring around it below the tip grew toward the light.



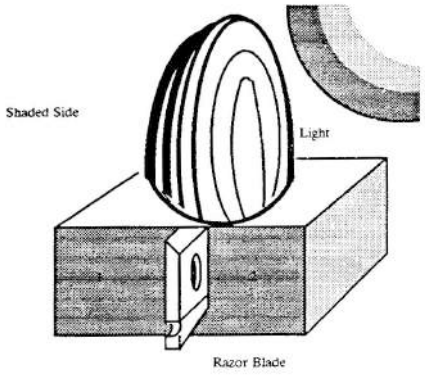
Experiment 2

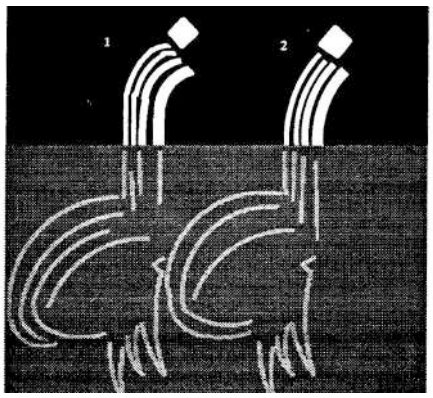
The tip of an oat shoot was cut off as shown. A layer of agar, a jelly-like material through which liquids can diffuse, was placed between the tip and the stump. The tip of another was cut off and the tip was not replaced. When the plants were exposed to light, the one with the replaced tip bent toward the light. The one without the tip did not.



Experiment 3

A razor blade was used to cut into an agar block (see diagram) to prevent diffusion from one side of the block to the other. The tip of a shoot was placed on the block as shown and illuminated from one side. Then the pieces of agar were placed on the edges of shoots from which the tip had been cut and the shoots were placed in the dark. The plant with agar piece 1 bent more than twice as much as the one with agar piece 2.





25. Which of the following plants served as the controls in Experiment 1?

    A. Plants D and B
    B. Plants B and C
    C. Plants A and B
    D. Plants A and D

26. Based on the information in Experiment 1, which of the following hypotheses would be most appropriate in explaining the plant's tendency to bend toward the light?

    F. The weight of the caps
    G. A bending factor produced in the tip of the plant
    H. A bending factor produced at the base of the plant
    J. A bending factor produced in the middle of the stem

27. Which of the following conclusions about the pattern of the growth of the plants in Experiment 3 is best supported by the data from Experiment 3?

    A. More of the bending factor is on the illuminated side of the plant.
    B. The bending factor is equally distributed in the plant.
    C. More of the bending factor is on the shaded side of the plant.
    D. The bending factor moves back and forth from one side of the plant to the other.

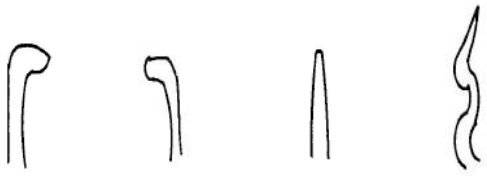
28. If a pot was turned on its side so that the plant growing in it was parallel to the surface under a source of light, one could predict that

    F. the plant would continue to grow parallel to the surface.
    G. the plant would bend in a downward direction.
    H. the plant would bend in an upward direction.
    J. the plant would stop growing.

29. If a metal disk were substituted for the agar in Experiment 2, one could predict that

    A. the plant would continue to grow toward light.
    B. the plant would grow away from light.
    C. the plant would not bend in response to light.
    D. the plant would grow at right angles to the light.

30. A bending factor is injected into and evenly distributed along the right side of a plant and the plant is placed in a dark box. Based on the results of Experiment 3, which diagram reflects the most probable result?



Passage VI

When sodium chloride (NaCl) dissolves in water, particles called ions move about freely and electrical conductivity is achieved. The movement of these charged particles in water solution accounts for the conductivity of an NaCl solution. Salts, which are compounds composed of metallic and non-metallic ions, are good conductors when they dissolve in water. Sugar, a non-conductor of electricity in water solution, does not contain these charged particles.

To learn more about electrical conductivity, the following experiments were conducted. An apparatus was set up that tested the ability of substances to conduct electricity. If the substances conducted electricity, an electric bulb would either light dimly, moderately, or brightly.

Experiment 1

Water alone was tested and found to be a non-conductor. Sodium chloride—NaCl (table salt) was tested and found to be a non-conductor when solid, an excellent conductor when dissolved in water. Sugar was found to be a non-conductor when solid, a non-conductor when dissolved in water, a non-conductor when melted. Silver nitrate—$AgNO_3$ (a salt) was tested and found to be a non-conductor as a solid or when dissolved in alcohol, an excellent conductor when melted, an excellent conductor when dissolved in water.

Experiment 2

When a few crystals of sodium chloride (NaCl) were added to water the solution showed conductivity. When additional crystals were added, the solution showed excellent conductivity.

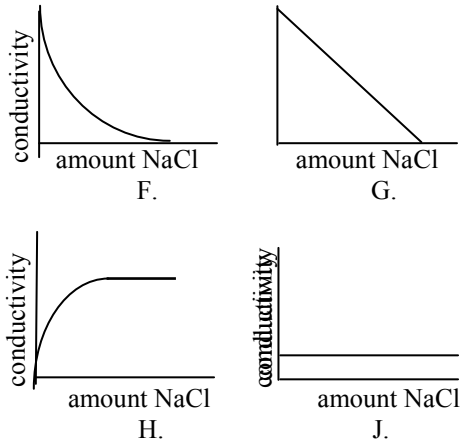
Experiment 3

Benzene, a liquid, was found to be a non-conductor. When the gas hydrogen chloride was dissolved in benzene, no conductivity was evident. A water solution of hydrogen chloride (HCl) proved to be an excellent conductor. When water was added to the solution that contained hydrogen chloride dissolved in benzene, the conductivity increases significantly.

31. Experiment 1 indicates that silver nitrate conducts electricity when it

    A. dissolves in alcohol.
    B. dissolves in water or when it melts.
    C. dissolves in benzene.
    D. is tested as a solid.

32. Which of the following graphs represents the relationship between the amounts of sodium chloride (NaCl) dissolved in water and its conductivity?



33. Silver chloride (AgCl) is a salt that is only slightly soluble in water. Very little can be dissolved. Based on the preceding experiments, one can predict that a solution of AgCl in water will be a

    A. good conductor of electricity.
    B. non-conductor of electricity.
    C. poor conductor of electricity.
    D. good conductor when more silver chloride is added.

34. In order for a substance to be a conductor of electricity, what property must it have?

    F. Ions in a crystal
    G. A substance dissolved in a solvent
    H. Charged particles free to move
    J. Rapidly moving molecules

35. The evidence from Experiment 1 would allow one to predict that

    A. melting of sugar would result in conductivity.
    B. melting of salt would result in conductivity.
    C. mixing of solid sodium chloride and sugar would result in conductivity.
    D. water is essential in order to have conductivity.

36. When hydrogen chloride (HCl) is dissolved in benzene, the solution is a non-conductor. How can this be explained?

    F. Hydrogen chloride does not separate into ions when mixed with benzene.
    G. Hydrogen chloride becomes an acid when mixed with benzene.
    H. Hydrogen chloride decomposes when mixed with benzene.
    J. Benzene is a poor solvent for HCl.

Passage VII

In 1928 Frederick Griffith postulated that bacteria are capable of transferring genetic information through a process known as transformation. He experimented with two strains of *Pneumococcus* (a bacteria that infects mice): Type III-S (smooth) and Type II-R (rough). The III-S strain covers itself with a polysaccharide capsule that protects it from the host's immune system, resulting in the death of the host. The II-R strain doesn't have that protective capsule and is defeated by the host's immune system.

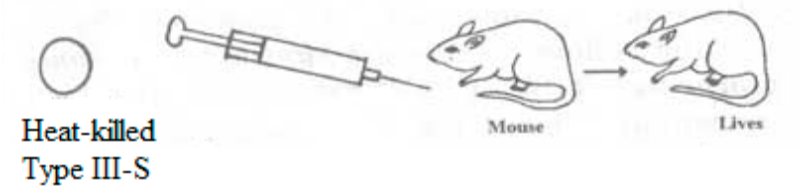
Stage One

Mice injected with virulent Type III-S were killed by the bacteria.

Mice injected with nonvirulent Type II-R showed few symptoms of infection.

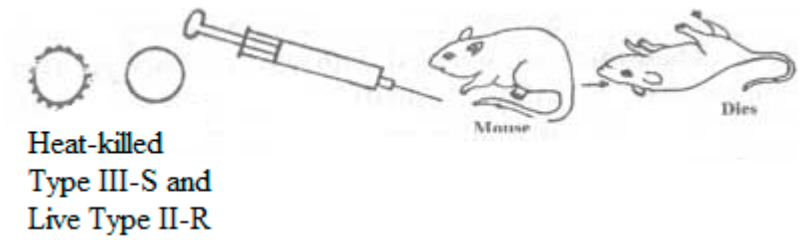
Stage Two

In this experiment, Type III-S bacteria were killed by heat and injected into the mice. The mice lived.



Stage Three

In this experiment, the heat-killed Type III-S bacteria were added to the II-R strain bacteria. The combination killed the mice. Griffith isolated both live II-R and live III-S strains from the blood of the dead mice.



37. Based on the results of his experiments, you can conclude that

    A. the heat-killed III-S bacteria reproduced in the mice, creating more III-S bacteria.
    B. even though dead, the heat-killed III-S bacteria were strong enough to kill the mice.
    C. genetic information from the II-R bacteria transformed the dead III-S strain.
    D. genetic information from the dead III-S bacteria transformed the live II-R strain.

38. You can infer from these experiments that the DNA of the III-S strain contains the genes

    F. that reverse the effects of the heat on the III-S bacteria.
    G. that form the protective polysaccharide capsule.
    H. that cause the immune system of the mice to fail.
    J. that destroy the protective polysaccharide capsule of the II-R bacteria.

39. Griffith's experiment disproved bacteriologists' belief that

    A. information could be passed from one strain of bacteria to another.
    B. strains of bacteria could be transformed.
    C. types of bacteria were fixed and unchangeable from one generation to another.
    D. heat could destroy the virulent strain of *Pneumococcus* bacteria.

40. If there was a fourth stage of the experiment in which heat-killed II-R bacteria were combined with the live III-S strain, what would be the most likely result?

    F. The mice would live since genetic information from the II-R bacteria would be transferred to the III-S strain.
    G. The mice would live since the heat-killed II-R bacteria would make the virulent strain vulnerable to the host's immune system.
    H. The mice would die since genetic information from the II-R bacteria would be transferred to the III-S strain.
    J. The mice would die since the live III-S bacteria contain a protective capsule that protects them from the host's immune system.

Passage VIII

An environmentalist collects the following data by visiting an ecosystem in the month of April for 4 consecutive years.

Experiment A

He hired researchers to study the rabbit population for all types of rabbits but limited his study to only white and black rabbits. Here are the results:

Year	Relative abundance of white rabbits (%)	Relative abundance of black rabbits (%)
2004	45	55
2005	53	47
2006	58	42
2007	60	40
2008	51	49

Experiment B

To explore the observed changes from year to year, the environmentalist conferred with the National Weather Service to study climatic data collected during the same time period for that ecosystem. The data is presented as follows:

Seasonal Snowfall
(Normal snowfall: 45 inches)

Year	Snowfall (inches)
2004	42
2005	58
2006	66
2007	63
2008	39

Winter Temperatures
(Normal: 1.5°C)

Year	Average winter temperature (°C)
2004	3.5
2005	-2.7
2006	2.3
2007	1.9
2008	0.8

Experiment C

The environmentalist decided to review the data collected over the four-year period to study brown and grey rabbits. What follows is the data for these two types of rabbits for the same time period:

Year	Relative abundance of brown rabbits (%)	Relative abundance of grey rabbits (%)
2004	37	63
2005	38	62
2006	37	63
2007	36	64
2008	36	64

41. Based upon the results in Experiment A alone, the most likely reason for the increase in the relative abundance of white rabbits from 2004 to 2006 is

    A. an increase in the adaptive value for rabbits with the trait of white fur.
    B. a decrease in the adaptive value for rabbits with the trait of white fur.
    C. an increase in the number of genetic mutations, resulting in rabbits with white fur.
    D. an increase in the total population of rabbits.

42. Based upon the data recorded in Experiment B and considering the results in Experiment A, the best conclusion is

    F. white rabbits thrive during winters with above normal snowfall and below normal temperatures.
    G. white rabbits thrive during winters with above normal snowfall and above normal temperatures.
    H. white rabbits thrive during winters with above normal snowfall and temperatures are not as significant as the snowfall record.
    J. white rabbits thrive during winters with below normal snowfall and below normal temperatures.

43. According to the data collected in Experiment C, it is best to conclude that when the relative abundance of brown rabbits is compared to grey rabbits, the conditions experienced during the winter

    A. favor brown rabbits during snowy winters.
    B. favor grey rabbits during snowy winters.
    C. favor brown rabbits during cold winters.
    D. do not seem to impact the relative abundance of these two types of rabbits.

44. The researcher wanted to use the data to predict the relative abundance of white vs. black rabbits in April 2009. Based upon the data he should conclude

    F. white rabbits will increase their dominance as the data reveals a steady trend towards winters with above average snowfall and below normal temperatures.
    G. black rabbits will increase their dominance as the data reveals a steady trend towards winters with above average snowfall and below normal temperatures.
    H. white rabbits will increase their dominance if the winter of 2008-2009 turns out to have above normal snowfall.
    J. white rabbits will increase their dominance if the winter of 2008-2009 turns out to have above normal snowfall and below normal temperatures.

45. If the next three winters are very cold with below normal temperatures, but are also very dry with limited snowfall, one may conclude that

    A. black rabbits will become much more abundant than white rabbits.
    B. white rabbits will become much more abundant than black rabbits.
    C. black rabbits will become much more abundant than grey rabbits.
    D. black rabbits will become much more abundant than brown rabbits.

46. If a study designed to compare white rabbits to brown rabbits were conducted, the results would likely be

    F. similar to those found in the white vs. black rabbit study because white rabbits enjoy snowy winters.
    G. similar to those found in the white vs. black rabbit study because white rabbits are camouflaged better during snowy winters.
    H. similar to those found in the white vs. black rabbit study because white rabbits have feet that are adapted better to travel through snow than black rabbits.
    J. different from those found in the white vs. black rabbit study but there is not enough information to make any predictions.

Passage IX

Mary conducted a science fair project where she wanted to see how different plants responded to different types of conditions and which was most favorable for growth. She used four types of household plants. For the study these are labeled as "Type A," "Type B," "Type C," and "Type D." She ran the study for a total of four weeks, measuring growth (as total height) once per week for each plant type and reported the experimental results as follows:

Experiment 1

Control Group (These plants were placed on a windowsill and watered 3 times a week. No further care was applied. The windowsill they were placed on received direct sunlight for 3 hours per day during the mid-afternoon. (All measurements have an accuracy of ± 0.1cm)

Week	Type A height (cm)	Type B height (cm)	Type C height (cm)	Type D height (cm)
1	7.0	9.0	7.5	8.0
2	7.5	10.0	7.7	9.3
3	7.9	11.0	7.8	10.5
4	8.5	11.9	7.8	11.8

Experiment 2

To explore the effect of sunlight deprivation, a sample of each plant was placed in a darkened closet for the study period. The results are as follows. (All measurements have an accuracy of ± 0.1cm)

Week	Type A height (cm)	Type B height (cm)	Type C height (cm)	Type D height (cm)
1	7.0	9.0	7.5	8.0
2	7.4	9.1	7.5	8.4
3	7.8	9.1	7.6	9.0
4	8.3	9.2	7.6	9.3

Experiment 3

To test the hypothesis that plants grow better in a carbon dioxide rich environment, experiment 1 was repeated with the addition of a carbon dioxide generator which effectively doubled the concentration of carbon dioxide near the plants from that found in the free atmosphere. (All measurements have an accuracy of ± 0.1cm)

Week	Type A height (cm)	Type B height (cm)	Type C height (cm)	Type D height (cm)
1	7.0	9.0	7.5	8.0
2	7.8	12.3	7.7	8.4
3	8.6	15.7	7.8	8.7
4	9.4	19.1	7.9	8.9

47. Which plants best support the hypothesis that carbon dioxide rich environments facilitate plant growth?

    A. Type A only
    B. Types A and B
    C. Types A, B, and C
    D. All four types of plants

48. When plant Type A is a member of the control group, it grew at a rate of approximately

    F. 0.1 cm/week.
    G. 0.5 cm/week.
    H. 1.0 cm/week.
    J. 7.0 cm/week.

49. Which plant type seems to require the least amount of sunlight to grow?

    A. Type A
    B. Type B
    C. Type C
    D. Type D

50. Since Experiment 3 produced some results with the use of carbon dioxide, if the concentration of carbon dioxide were increased by an equivalent amount again, for Plant B, what is the expected height after four weeks of exposure?

    F. 9.0 cm
    G. 19.1 cm
    H. 25.0 cm
    J. 41.0 cm

51. If an experiment were conducted where the sunlight were doubled from 3 to 6 hours in an atmosphere with normal amounts of carbon dioxide, which plant is most likely to respond with the greatest growth?

    A. Type B because it also was very sensitive to exposure to carbon dioxide.
    B. Type B because it had the greatest decline in growth when light was removed.
    C. Type B because it grew to the greatest height in Experiment 3.
    D. Type C because it failed to grow significantly under any other conditions.

52. Through the course of these three experiments, which of the following was controlled?

    F. The frequency of watering for each plant
    G. The temperature each plant was exposed to
    H. The atmospheric composition each plant was exposed to
    J. The amount of light each plant was exposed to

ACT

SKILL BUILDER THREE

CONFLICTING VIEWPOINTS

Passage I

How are white blood cells formed?

Human blood contains many different types of cells, including red blood cells (RBCs) and several types of white blood cells (WBCs). Most of these blood cells are formed in the bone marrow. There are numerous theories regarding the formation of the different types of white blood cells. In particular, scientists and physicians have questioned whether all white blood cells arise from one single parent cell known as a universal stem cell, or if each type of white blood cell has its own individual family with separate parent stem cells.

Scientist 1

Small samples of circulating blood and bone marrow can be taken from normal healthy persons and carefully examined with a microscope. Using this method, Scientist 1 was able to visually identify all the stages of growth of these cells, from the most primitive stem cell through the fully mature adult white cell. Based on these observations, Scientist 1 concluded that each type of white blood cell has its own separate family, each with a separate stem cell. According to this theory, one type of white blood cell could never turn into any other type of white blood cell and once a white blood cell is formed it cannot change.

Scientist 2

Using many different techniques including centrifugation, filtration, and chemical gradients, Scientist 2 was able to prepare pure samples of each of the different types of white blood cell from the blood and marrow of volunteers. These pure samples were then each placed in separate test tubes with special nutrients and allowed to grow. When samples from these tubes were examined with a microscope, some contained two or more different types of white blood cells. From this evidence, Scientist 2 concluded that white blood cells have the ability to develop or change into the other different types. All white blood cells therefore, develop from a common ancestor or single universal stem cell which can give rise to all the white cells found in the blood. Additionally, some cells can change into cells of different types.

1. According to the hypothesis of Scientist 1, if a person had abnormalities in one of the stem cells, would this abnormality also be seen in the white blood cells of that person?

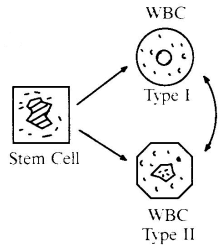
   A. No, the red blood cells would be abnormal.
   B. Yes, but all types of white blood cells would be abnormal.
   C. No, the white blood cells would all be normal.
   D. Yes, but only one type of white blood cell would be abnormal.

2. Which of the following is the most likely technical error of Scientist 2 that could have resulted in his difference of opinion with Scientist 1?

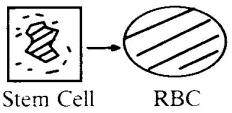
   F. Some red blood cells became mixed with the white blood cells in the test tubes.
   G. The white blood cells put in the test tubes were not all of one type.
   H. The blood was taken from volunteers.
   J. Many different techniques were used to prepare and separate the white blood cells.

3. Which of the following diagrams best describes the conclusion of Scientist 2? [WBC = white blood cells; RBC = red blood cells]

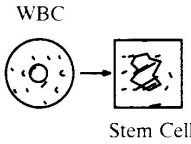
A.



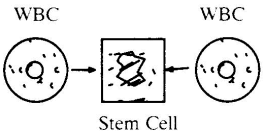
B.



C.



D.



4. An experiment was performed in which a special chemical marker that "tags" only stem cells was injected into the body of a test subject. The special tag was later found on all the white blood cells in the subject's blood. This experiment

   F. supports the hypothesis of Scientist 1.
   G. supports the hypothesis of Scientist 2.
   H. does not provide support for either Scientist 1 or Scientist 2.
   J. serves as a control for the experiment of Scientist 2.

5. Which of the following procedures would be most effective to test which of the hypotheses regarding formation of white blood cells is most likely to be correct?

   A. Mark several different white blood cells and inject them into a test subject where they will grow.
   B. Mark a stem cell and then inject it into a test subject where it will grow.
   C. Add a chemical that destroys all stem cells to a test tube containing blood.
   D. Place some white blood cells in a tube and let them grow.

6. Scientist 1 and Scientist 2 would most likely agree on which of the following statements regarding the formation of white blood cells?

   F. White blood cells arise from a common ancestor.
   G. The origin of white blood cells cannot be determined using only a microscope.
   H. Each type of white blood cell arises from a separate stem cell.
   J. The origin of white blood cells is a complex and not yet fully understood process.

7. Which of the following known facts provides support for the hypothesis of Scientist 2?

   A. Serious diseases of individual stem cells also affect many different types of mature white blood cells.
   B. Some blood diseases affect either white or red blood cells.
   C. When a person loses blood, both white and red blood cells are replaced naturally by the body.
   D. When there is an infection, many different types of white blood cells appear to defend the body.

Passage II

How do humans age? Two differing views are presented below.

Scientist 1

The body's replaceable cells, constantly abused by stress, improper nutrition, lack of fresh air, insufficient exercise, and excessive toxins are forced to use up their longevity potential decades before nature intended. Experiments reveal that most human cells can duplicate and replace themselves only a finite number of times before they lose this capacity and die. Not unlike the metaphorical nine lives of a cat, each human cell has fifty lives, that is, approximately fifty duplications before the cell automatically shuts down and dies.

How we choose to stretch these lives out over time is largely related to the way we live and how we care for our health. The combination of stressful living with unhealthful lifestyles can serve to speed up the cellular aging process considerably, leading to disease and death long before our true biological potential has been realized.

Scientist 2

The major components of the body's natural immune system are two types of white blood cells, "B" cells and "T" cells. B cells are primarily concerned with fighting bacteria and viruses by releasing appropriate antibodies in the bloodstream, while the main job of T cells is to attack and destroy cells foreign to the body such as transplant and cancer cells. For reasons not now understood, the body's immunological system sometimes breaks down and becomes less able to rid the body of harmful agents and therefore less able to deter aging. In addition, when the immunological system degenerates in this fashion, its capacity for discrimination is diminished, creating a situation in which the body's own disease fighting system turns against itself and kills healthy tissue. The gradual deterioration and degeneration of the body's immune system is at the root of most age-related sickness and breakdown.

—Adapted from *Theories of Aging*, © 1981 by Alberto Villoldo and Ken Dychtwald.
From *Millennium: Glimpses into the 21st Century.*

8. Scientist 1's theory of aging would be best supported by demonstrating that

   F. B cells fail to fight invading bacteria.
   G. dead cells are replaced by new cells a finite number of times.
   H. proper nutrition causes cells to die prematurely.
   J. T cells lose the ability to destroy foreign cells.

9. If true, which of the following findings would NOT be consistent with Scientist 1's theory?

   A. A damaged cell is irreplaceable.
   B. A cell that is damaged can be replaced a finite number of times.
   C. Our life span depends on how we stretch out the life of each cell.
   D. Stressful living and unhealthful lifestyles speed up the cellular aging process.

10. Scientist 2's theory on aging would be most weakened if it were found that

    F. there is strong evidence for the cell duplication theory.
    G. the blood count on white blood cells is the same for young and old people.
    H. the aging process is a complex biological process and is not totally dependent on the performance of B and T cells.
    J. weakening of the immune system causes sickness, but not aging.

11. The hypothesis of Scientist 2 that gradual weakening of the immune system causes aging would be best supported if it were found that

    I. old people in general had weaker immune systems compared to those of younger people.
    II. the immune system loses its capacity to differentiate body cells from foreign cells with increasing age of the person.
    III. the longevity of a cell is shown to increase for persons with healthful habits.

    A. I only
    B. III only
    C. I and II only
    D. I and III only

12. To refute Scientist 2's theory on aging, Scientist 1 might best demonstrate that

    F. damaged cells are replaced a finite number of times before loss of this capability.
    G. the immune system does not weaken with age.
    H. B and T cells protect and defend the body.
    J. the immune system loses its capability to differentiate healthy body cells from foreign cells.

13. How does Scientist 1's theory on aging differ from that of Scientist 2?

    A. Scientist 1 believes that the cells die because of the attack from the immune system and not because of their inability to replace themselves.
    B. Scientist 1 believes that cells die when they are incapable of duplicating and not because of the failure of the immune system.
    C. Scientist 1 believes that cells die when the B and T cells fail to defend them from invading bacteria and not because of their inability to replace.
    D. There is essentially no difference between their theories.

14. If Scientist 2's theory on aging is correct, in order to increase the life span of an individual one should

    F. eliminate the toxins in the cell produced by stress and poor health habits.
    G. maintain an immune system that efficiently carries out its function.
    H. increase the longevity of each cell by incorporating proper diet and exercise.
    J. increase the number of times the cell can duplicate itself.

Passage III

The following two theories on the process of burning were held by different scientists late in the eighteenth century.

Theory 1

When an object burns in air, it releases a substance called phlogiston. An object that burns readily contains a great deal of phlogiston and generally leaves only a small amount of ash when it burns. Ordinary air is able to permit or support such burning because it does not contain much phlogiston. It absorbs phlogiston or phlogiston-rich smoke from the burning object. If burning occurs in a closed container, the air can become too rich in phlogiston. The air can then accept no more of it, and the burning process is prevented from continuing. If the products of an object that has burned are heated, they can in some cases be made to give off a gas called dephlogisticated air. This air, because it contains no phlogiston, can support the burning of objects for longer periods than can ordinary air.

Theory 2

There is no such thing as phlogiston. When an object burns, it does not release phlogiston, but instead combines with a substance called oxygen that has mass and is present in the air. In a closed container, the process of burning is prevented from continuing when the air has given up all its oxygen. The gas that can in some cases be released by heating the products of burning is not dephlogisticated air, but oxygen.

15. Which of the following assumptions about burning is being made in Theory 2 but not in Theory 1?

    A. Burning is a combining process.
    B. Burning is a decomposition, or breakdown, process.
    C. Ordinary air does not contain oxygen.
    D. Ordinary air is pure oxygen.

16. Which of the following observations, if true, would NOT be consistent with Theory 1?

    F. Phlogisticated air cannot support burning as long as dephlogisticated air can.
    G. Some objects leave a great deal of ash when they burn.
    H. The total mass of all the ashen substances produced when an object burns is greater than the mass of the object before burning.
    J. A candle sealed in a jar of dephlogisticated air burns more brightly than one sealed in a jar of ordinary air.

17. Which of the following hypotheses would proponents of Theory 2 most likely make to explain the fact that objects do not burn in a vacuum?

    A. A vacuum contains phlogiston.
    B. A vacuum does not contain oxygen.
    C. It is impossible to create a perfect vacuum.
    D. Oxygen is not always necessary to support burning.

18. Proponents of Theories 1 and 2 would be in agreement that

    F. the mass of an object can change during the burning of the object.
    G. energy is not conserved during burning.
    H. “phlogiston” and “oxygen” are different names for the same substance.
    J. phlogiston can be transferred between objects.

19. The "burning" reaction that takes place when mercury is heated in air produces no smoke. Its only visible product is solid. In order to find out whether Theory 2 is less valid than Theory 1, a scientist could study this burning reaction to determine whether

    A. the total mass of solids and gases is conserved during the reaction.
    B. the products of the reaction are less able to react with air than was the original mercury.
    C. smoky air is less able to support the reaction of the mercury than is clean air.
    D. the mass of the air above the mercury becomes less during the reaction.

20. Theory 2 could be disproved if experiments demonstrated conclusively that

    F. phlogiston does not exist.
    G. the more oxygen air contains, the less well it supports burning.
    H. the products of burning contain oxygen.
    J. some burning objects produce little or no ash.

21. If Theory 1 is valid, how would an object made of pure phlogiston behave, assuming such an object could be found?

    A. It would burn spontaneously, even if no air were present.
    B. It would not burn under any circumstances.
    C. It would burn only in dephlogisticated air.
    D. It would burn readily in air.

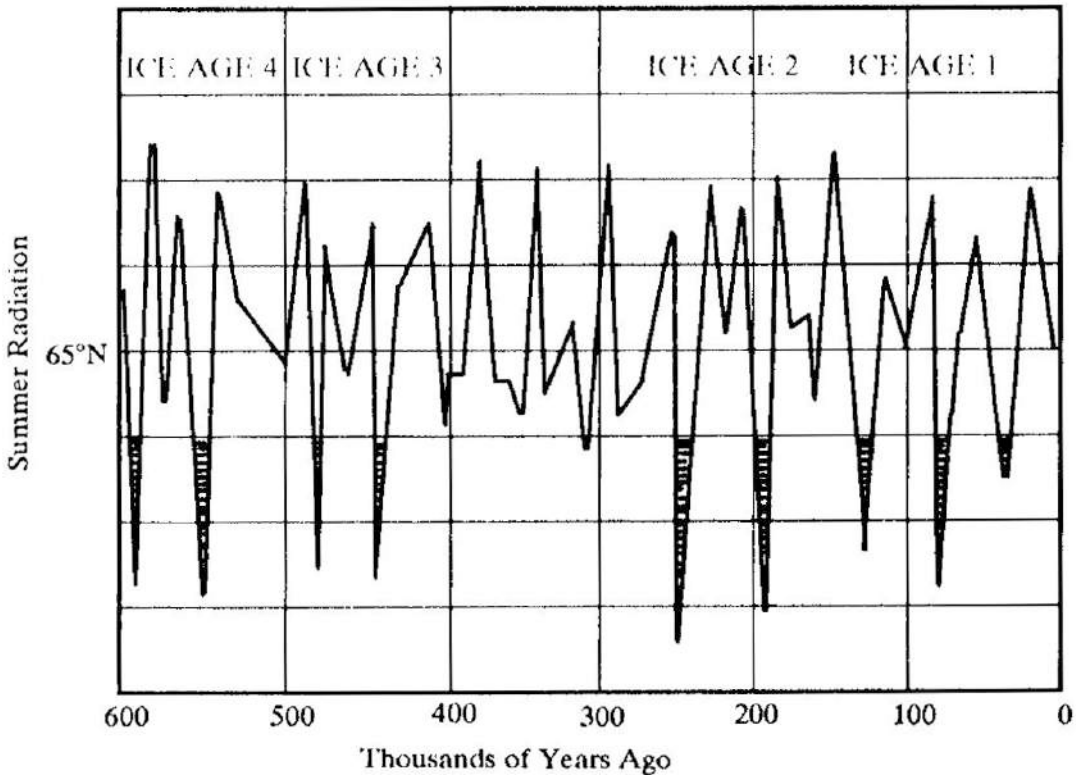
Passage IV

The causes for ice ages have remained one of the most enduring and fascinating mysteries of geology. Among the several theories proposed, the two theories that best describe this process are as follows:

Milankovitch's Theory

Milankovitch proposed that the ice ages in the past were due to reduced energy the earth received from the sun because of the earth's changing orbital characteristics. Milankovitch found that three orbital parameters determine how the sun's radiation is distributed over the planetary surface: the eccentricity of the orbit, the tilt of the axis of rotation, and the position of the equinoxes in their precessional cycle. He established that the critical factor that initiated the glaciation was the diminution of radiation during the summer. He argued that since only during the summer do the glaciers melt, any decrease in intensity of summer sunlight would inhibit melting, and lead to glacial expansion. Based on these assumptions, Milankovitch calculated how the summer radiation curve at 65°N latitude varied over the past 600,000 years (Figure 1). The low points on his curve corresponded very well with the observed European ice ages, thus validating his theory.

Figure 1



Modern Carbon Dioxide Theory

The concentration of carbon dioxide in the earth's atmosphere is the starting point for the modern ice age theory. Although this gas occurs in only minute quantities, studies indicate that it exercises an important influence on global climate. This is because carbon dioxide has a peculiar property: while it is transparent to show wave radiation that it receives from the sun, it is relatively opaque to the long wave radiation that is reflected back into space. Many scientists are convinced that the ice age would result if the levels of carbon dioxide dropped low enough. But why should such a decrease happen? Actual measurements of the CO_2 trapped in ancient ice core samples, however, do confirm the hypothesis that the carbon dioxide concentrations in the atmosphere were at the minima level during the ice ages.

22. Which of the following best supports Milankovitch's theory about ice ages?

    F. The reduced level of carbon dioxide in the atmosphere during the ice ages
    G. The increased level of carbon dioxide in the atmosphere during the ice ages
    H. The correspondence between the last four European ice ages and the low points on this radiation graph
    J. The reduced level of sunlight intensity during the winter

23. The modern carbon dioxide theory for the causes of the ice ages is weakened because

    A. there is too much carbon dioxide in the earth's atmosphere to cause any ice age.
    B. it cannot account for sufficient lowering of carbon dioxide levels to initiate ice ages.
    C. carbon dioxide actually traps heat in the earth's atmosphere.
    D. carbon dioxide is present only in trace amounts and cannot influence the earth's climate in a major way.

24. If true, which of the following observations would NOT be consistent with Milankovitch's theory?

    F. The position of the equinoxes in the earth's precession cycle affects the total radiation energy received.
    G. The changes in the eccentricity of the earth's orbit actually affect the total radiation energy received.
    H. The maximas in the radiation curve and the recorded ice ages show one-to-one correspondence.
    J. The changes in the inclination of the earth's axis actually affect the total radiation energy received.

25. If the modern carbon dioxide theory is correct, how will the rapidly increasing carbon dioxide levels of the present age affect the next ice age?

    A. It will not affect it, because the level of carbon dioxide is not the most important component causing the ice age.
    B. Will be delayed, because the increased carbon dioxide will warm the earth's surface and offset the cooling trend due to natural causes.
    C. Will be delayed, because the increased level of carbon dioxide is still very insignificant compared to the total atmosphere's volume.
    D. It will not affect it, because the increased level of carbon dioxide will dissolve in the oceans of the world and exert no influence on the planet's climate.

26. How do Milankovitch's reasons for the ice ages differ from those of the modern carbon dioxide theory?

    F. Milankovitch believes that ice ages are due to variations in the earth's orbital parameters and not decreases in the atmospheric CO_2.
    G. Milankovitch believes that the ice ages are due to increases in the earth's atmospheric CO_2 and not decreases in summer radiation.
    H. Milankovitch believes that the ice ages are due to increased summer radiation and not decreases in atmospheric carbon dioxide levels.
    J. There is essentially no difference in the reasons for the ice ages.

27. To refute Milankovitch's theory, modern scientists might best demonstrate that the

    A. eccentricity of the earth's orbit has a dominant effect on the climate.
    B. periods of the ice ages determined by modern dating methods do not coincide with the minima of the radiation curves.
    C. position of the equinoxes in the earth's precession cycle affects the total summer radiation with the minima of the radiation curves.
    D. tilt of the earth's axis has a dominant effect on the climate.

28. The hypothesis of modern scientists that low levels of carbon dioxide cause ice ages would be supported if

    I. air trapped in the ancient ice core samples indicates that concentrations of carbon dioxide dipped to low levels during ice ages.
    II. evidence was found that reduced levels of summer radiation during ice ages were due to earth's changing orbital parameters.
    III. large deposits of calcium carbonate trapping the free carbon dioxide were found to exist during ice ages.

    F. II only
    G. I and II only
    H. I and III only
    J. II and III only

Passage V

The nature of light is still one of the greatest mysteries of science. Two theories that describe the nature of light are as follows:

Newton's Particle Theory

Newton tended to visualize light as a shower of tiny particles or corpuscles shot from a luminous object, with each particle traveling in a straight line until it was reflected, refracted, absorbed, or somehow acted upon. He based his theory on the known properties of light—for example, he argued that light travels in a straight line based on the sharp edges of the shadow cast on the screen by an opaque object (Figure 1). To explain how light is bent as it passes through glass or water, Newton assumed that the corpuscles of light are pulled into water when they touch the surface. This force makes them travel faster and shifts them from the straight path they would normally follow (Figure 2). It would also seem that if particles are striking a surface, they would exert pressure on the surface and also cause it to get warmer depending on its absorbing characteristics. This has been verified by sensitive experiments that further reinforce the validity of this theory.

Figure 1

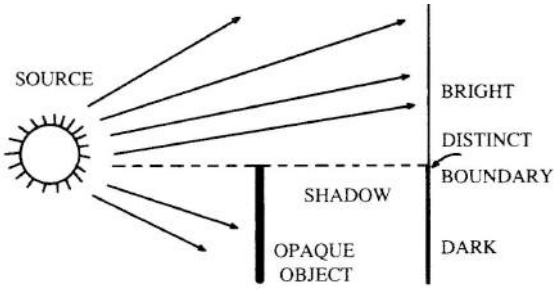
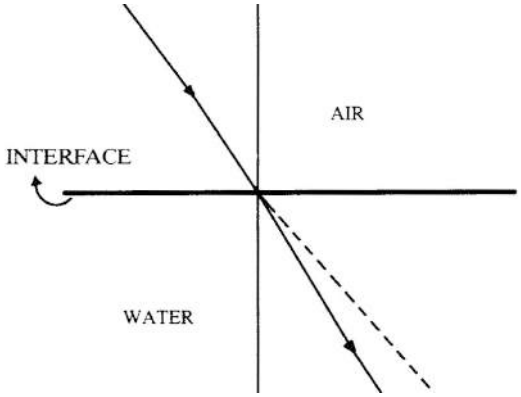


Figure 2



Huygen's Wave Theory

Huygen's theory simply assumes that light is a wave rather than, say, a stream of particles. Experiments performed several years after Newton reveal that light does bend around obstacles (Figure 3). This phenomenon is called diffraction and is readily noticeable when the size of the obstacle is small compared to the wave length (Figure 4, distance between successive troughs or crests) of light. He explained the bending of light in refraction as a consequence of its different velocity in different media. Huygen argued that the velocity of light is inversely

proportional to the refractive index of the media. The more the light was slowed the more it bent. If light were made up of streams of particles, the reverse would be true. Huygen also argued that if light was corpuscular, it could be likened to a flight of arrows, and if two flights crossed some would collide with one another. However, when two beams of light crossed, they appear not to affect each other.

Figure 3

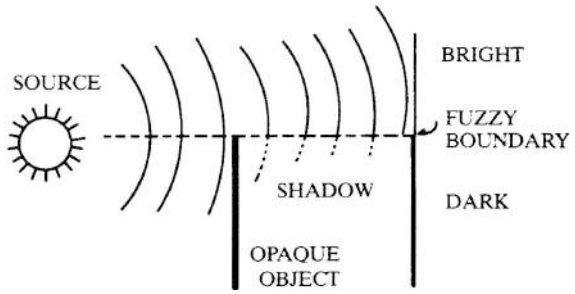
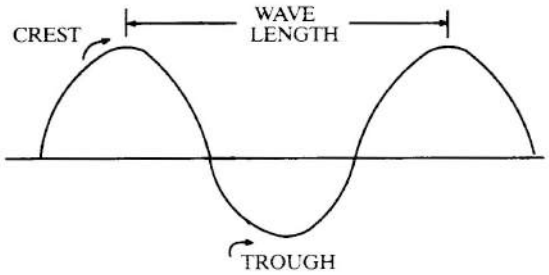


Figure 4



29. Huygen's wave theory of light is supported by

    A. sharp edges of shadow cast by opaque objects.
    B. the pressure exerted on surfaces exposed to light.
    C. the phenomenon called diffraction.
    D. passing light through water.

30. Which of the following observations would NOT be consistent with the particle theory? The velocity of light

    F. depends on the refractive index of the medium.
    G. in water is less than that in air.
    H. in glass is greater than that in air.
    J. does not depend on the source of its origination.

31. Which of the following observations, if true, would most weaken Newton's particle theory of light?

    A. Experimentally confirm the presence of particles.
    B. Opaque objects cast sharp shadows.
    C. The phenomenon of diffraction.
    D. Radiation pressure on surface exposed to light.

32. If Huygen's wave theory is correct, what will happen to the velocity of light when it goes from water to glass, given that glass is optically more dense than water?

    F. It will slow down because glass is optically more dense than water.
    G. It will slow down because glass is optically less dense that water.
    H. It will speed up because glass is optically more dense than air.
    J. It will remain unchanged because velocity of light is a universal constant.

33. Which of the following is the strongest evidence Newton could use to counter Huygen's wave theory?

    A. Demonstrate that when two beams of light cross, they do not affect each other.
    B. Demonstrate that when surfaces are exposed to light, they become warmer, due to continuous impact from light particles.
    C. Demonstrate that the velocity of light in an optically dense medium is slower.
    D. Demonstrate that the shadow cast by very small objects is not sharp.

34. To best contradict Newton's particle theory, Huygen could provide evidence that light

    F. travels faster in water than in air.
    G. bends around opaque objects.
    H. exerts pressure on surfaces.
    J. travels in a straight line.

35. How does Newton's description of light differ from that of Huygen's?

    A. Newton describes light as waves and not particles.
    B. Newton describes light as particles and not waves.
    C. There is no difference between their descriptions.
    D. Newton describes light as illusive particles.

Passage VI

Cell phone usage continues to grow rapidly worldwide. Statistics show that in 2003 there were over 1.2 billion cell phone users, and that number continues to grow. With continued growth, their safety has become the subject of debate in scientific, government, and industry circles. Undisputed facts state that cell phones operate by receiving and transmitting electromagnetic radiation (EMR) with frequencies between 800 megahertz and 2 gigahertz. These frequencies are part of the microwave and radio wave portions of the EMR spectrum. In short, cell phones transmit and receive radio frequency energy. The cell phone antenna typically has a power output of 100 watts or less.

Viewpoint A

Extensive studies have been conducted in recent years, and the FDA (Food and Drug Administration) and the FCC (Federal Communications Commission) have both stated, "the available scientific evidence does not show that any health problems are associated with using wireless phones," while noting that "there is no proof, however, that wireless phones are absolutely safe."

In one study, 420,000 cell phone users in Denmark were compared to non-cell phone user populations for the occurrence of cancer. The study concluded that the occurrence of cancer was no more frequent among either group. Additional studies continue to conclude that cell phone use does not pose any degree of elevated risk despite the proximity of microwaves to the brain. Brain cancer is relatively rare among cancers (at just over 1% of all cancers); however, it is amongst the deadliest forms of cancer.

Additional arguments center around the fact that the frequencies involved are at the low energy end of the Electromagnetic Radiation Spectrum. Radio frequencies are unable to cause DNA damage like frequencies in the x-ray region.

Viewpoint B

Evidence is mounting that suggests there is danger in the use of cell phones. In one recent study, the number of immune cancer cells doubled in mice that were exposed to microwaves. Other studies demonstrate a connection between microwave exposure, memory loss, and the formation of tumors. Dr. George Carlo of Wireless Technology Research has stated that some studies show evidence of genetic damage in human blood among cell phone users. Other studies suggest that radio frequency radiation is responsible for causing breaks in DNA strands in tissues exposed to the kinds of radiation levels experienced by cell phone users.

In yet another study, conducted at the University of Nottingham in England, the results indicate that microwaves produce heat, thus causing tissue injuries. A related study reported that 25% of all cell phone users felt heat behind their ears and reported an increased incidence of headaches, fatigue, and dizziness. Despite these findings, no study has been able to correlate cell phone use to brain cancer.

Some people are even expressing concern that the cell phone industry may be suppressing findings that would show cell phones to be dangerous.

Researchers are suggesting that cell phone use be kept to a minimum, opting for conventional phones when possible and when cell phones are used, keeping the antenna as far from your head as possible.

36. Both positions agree that

    F. cell phone usage cannot be directly correlated to brain (or any other form of) cancer.
    G. cell phone usage will increase over the next five years.
    H. there is currently no direct evidence of any dangers related to cell phone usage.
    J. All of the above

37. Major concerns among those who believe that cell phones are hazardous include

    A. the growing number of cancer cells within the body of the cell phone user and genetic damage to human blood of cell phone users.
    B. the growing number of cancer cells within the body of the cell phone user and the ability of microwaves to alter DNA of cell phone users.
    C. the genetic damage to human blood and the ability of microwaves to alter DNA of cell phone users.
    D. increased cancer and death rates among cell phone users.

38. Since cancer is a major concern of those who argue that cell phones are dangerous, the lack of reported incidence of cancer by cell phone users might best be explained by

    F. the inability of instrumentation to determine if cell phones cause cancer.
    G. the relatively long time period for cancers to develop after exposure to microwaves.
    H. the fact that while people own cell phones, they don't use them enough to be exposed to dangerous levels of microwaves.
    J. cell phones truly are safe devices.

39. The statements made by the FCC and FDA can best be described as

    A. unqualified support for Viewpoint A.
    B. unqualified support for Viewpoint B.
    C. support for Viewpoint A with the option to change their stand or position should new evidence arise.
    D. support for Viewpoint B with the option to change their stand or position should new evidence arise.

Study the table below then answer the question that follows:

Population	Number of People Studied	Reported Cases of Brain Cancer
Non-cell phone users	6,000	6
Cell phone users for 3 years	10,000	10
Cell phone users for 5 years	8,000	8

40. The data in the table support

    F. Viewpoint A since there are many variables that control the number of cancer cases in any population.
    G. Viewpoint A since the reported cases of brain cancer is the same percentage of the population for cell phone users as for non-cell phone users.
    H. Viewpoint B since there are many variables that control the number of cancer cases in any population.
    J. Viewpoint B since the reported cases of brain cancer is greater among cell phone users than among non-cell phone users.

41. In the future it is likely that

    A. time and a greater number of cell phone users will enable the FCC and FDA to take a firmer stand on the safety issue as it pertains to the use of cell phones.
    B. a greater number of cell phone users will enable the cell phone manufacturers to make safer phones.
    C. cell phones will become smaller and use a lower microwave frequency.
    D. people will cease to use cell phones and as such their safety will no longer be an issue.

Passage VII

Sleep disorders are more common in the elderly. Two theories to explain this have been proposed.

Theory A

Sleep disorders are more frequent in the elderly because of the age-related loss of specific brain neurons. These neurons release serotonin as their neurotransmitter. The serotonin released from these neurons affects the activity of other neurons responsible for consciousness and sleep. With increased age there is a decline in the amount of serotonin within the brain due to the dying off of brain serotonin neurons. This theory states that serotonin neurons slowly die in all adults and that, if the number of serotonin neurons is reduced below a critical number, normal sleep functions are disturbed. The older an individual is the more likely he or she will have too few remaining serotonin neurons to maintain normal sleep patterns. (The concentration of other neurotransmitters in the brain also changes with age and this can cause other non-sleep-related disorders, such as Parkinson's disease.)

Theory B

Sleep disorders in the elderly are due to a decrease in the amount of serotonin synthesized within the brain. Reduced serotonin synthesis results in too little serotonin being released from the neurons to maintain normal sleep-wake cycles. With increasing age, there is a gradual decline in the intestinal absorption of nutrients from food, including tryptophan, the compound from which serotonin is synthesized. The synthesis of serotonin in the brain decreases when the amount of tryptophan available in the body decreases. In the elderly, the absorption of tryptophan is further reduced because of some commonly used medications which affect stomach and intestinal function. Irregular eating habits or a generally poor diet may further reduce the amount of tryptophan absorbed in the elderly.

42. Which of the following observations would be consistent with both Theories A and B?

    F. Those people who eat a well-balanced diet have fewer sleep disorders.
    G. Many brain functions controlled by serotonin show impairment with increasing age.
    H. Gastrointestinal disorders may cause sleeplessness.
    J. Persons with Parkinson's disease are more likely to also have sleep disorders.

43. Which of the following conclusions is NOT consistent with Theory A?

    A. The occurrence of sleep disorders can be predicted in individuals by measuring the concentrations of brain serotonin.
    B. The ability of individual neurons to make serotonin decreases with age.
    C. The loss of some serotonin neurons is compensated for by the remaining serotonin neurons.
    D. There are a number of age-related changes in the brain, but only those involving serotonin neurons cause sleep disorders.

44. The two theories are similar in describing the cause of sleep disorders in that both theories maintain that

    F. the lack of serotonin within the brain causes sleep disorders.
    G. the lack of serotonin neurons within the brain causes sleep disorders.
    H. the lack of tryptophan within the brain causes sleep disorders.
    J. the lack of proper diet causes sleep disorders.

45. Which of the following experimental procedures would be best for testing Theory A?

    A. Measure serotonin in the brain of animals that have been fed tryptophan.
    B. Monitor the electrical activity of those areas of the brain responsible for consciousness in older animals.
    C. Measure serotonin in the brain of animals of different ages maintained on tryptophan-free diets.
    D. Monitor the sleep-wake patterns of animals whose serotonin neurons were destroyed with a selective neurotoxin.

46. Which of the following assumptions is implicit in the explanation for the decline in brain serotonin concentrations in Theory B?

    F. The brain's requirements for tryptophan change with age.
    G. Tryptophan is not made or stored in sufficient quantities within the body to meet all the body's needs.
    H. The ability of neurons to manufacture serotonin from tryptophan declines with age.
    J. Elderly people require more sleep and therefore use more serotonin than their neurons can make.

47. If Theory A is correct, which of the following treatments would most likely benefit people with sleep disorders?

    A. Tryptophan diet supplements
    B. Drugs that decrease serotonin release from serotonin neurons
    C. Drugs that increase serotonin release from serotonin neurons
    D. Drugs that increase nutrient absorption from the digestive system

48. Which of the following facts would support Theory A over Theory B?

    F. Foods rich in tryptophan can cause drowsiness.
    G. The brains of newborn laboratory mice have fewer serotonin neurons than the brains of adult mice.
    H. A fixed schedule for meals helps maintain a regular sleep-wake pattern.
    J. Tryptophan administration increases the amount of tryptophan within the brain, but the majority of it is within non-neuronal cells which do not synthesize serotonin.

Passage VIII

Every year a debate ensues in the late summer and early autumn as to whether or not to get the annual flu shot. Influenza, or the "flu," is a highly contagious respiratory infection. It can cause fever, chills, headache, cough, and many other symptoms including extreme fatigue. The H1N1 flu virus is more deadly than the "typical" flu, hence the debate as to whether to take the vaccine. Two scientists present their views below.

Position 1

Influenza is easily spread from person to person, primarily when an infected person coughs or sneezes. After you are infected, symptoms usually appear about 3 days afterwards. Typically, 10 to 20 percent of the population contracts the flu each year. People over age 50, the extremely young, or anyone having a chronic medical condition should get the flu shot. Additionally, health care workers and those living with someone in a high risk group should get the shot. With a serious strain like the H1N1, everyone should get the shot. Health care workers are on this list as they can become vectors of transmission. That is, they can easily transmit it to large numbers of people.

Reasons to get the shot include the fact that at least 45,000 Americans die each year from the flu (and pneumonia). This is the sixth leading cause of death in the U.S. Ninety percent of those who die are age 65 or older. Additionally, those who receive the vaccine experience 25 percent fewer episodes of upper respiratory illness and 44 percent fewer visits to the doctor's office. Furthermore, the flu shot is safe and effective. It will help you avoid days of lost productivity due to the flu even if you do not become seriously ill. For the elderly, Medicare will pay for it.

Position 2

The risks of the flu vaccine outweigh any possible benefit for many people. Many of the statistics often quoted do not indicate how many people were in the study and how many people (if any) in the study suffered adverse reactions to the vaccine. Should we trust what we hear about the vaccine when the studies are funded by the pharmaceutical industry? The problem with the vaccine begins with how it is actually produced. First, the researcher must acquire the live virus. The live virus must then be weakened for human use.

This is accomplished by serial passage: passing the virus through animal tissue several times to reduce its potency. For example, the measles virus is passed through chicken embryos, polio virus through monkey kidneys. "Killed" vaccines are "inactivated" through heat, radiation, or chemicals. The weakened germ must then be strengthened with adjuvants (antibody boosters) and stabilizers. This is done by adding drugs, antibiotics, and toxic disinfectants to the concoction: neomycin, streptomycin, sodium chloride, sodium hydroxide, aluminum hydroxide, aluminum hydrochloride, sorbitol, hydrolized gelatin, formaldehyde, and thimerosal (a mercury derivative).

Aluminum, formaldehyde, and mercury are extremely toxic substances with a long history of documented hazardous effects. Studies confirm again and again that microscopic doses of these substances can lead to cancer, neurological damage, and death. Yet each of them may be found in a variety of vaccines. In addition to the deliberately planned additives, unanticipated matter may contaminate the shots. For example, during serial passage of the virus through animal cells, animal RNA and DNA (foreign genetic material) is transferred from one host to another. Because this biological matter is injected directly into the body, researchers say it can change our genetic makeup. What happens next, once this foul concoction of live viruses, bacteria, toxic substances, and diseased animal matter is created? This witch's brew is forced into the healthy individual.

Among other things, flu vaccines are known to contain the following harmful ingredients:

1. Thimerosol - A mercury derived preservative that has been linked to brain damage and autoimmune disease.
2. Phenol - Or carbolic acid, a common component of dyes and disinfectants.
3. Ethylene Glycol - Otherwise known as anti-freeze.
4. Formaldehyde - Yep, that's the stuff they pickled the frog you dissected in biology class with.
5. Aluminum - added to promote antibody response, it is associated with Alzheimer's and seizures and has been known to cause cancer in lab mice.
6. Neomycin and Streptomycin - antibiotics to retard growth of contaminating bacteria, responsible for allergic reactions in some patients.

Even the most avid supporters of flu vaccines readily admit that taking the shot is no guarantee of avoiding the flu, and although consumers never see them, the vaccines are supposed to be accompanied by an information sheet that presents the many known side effects that are associated with them.

There are many natural alternatives to prevent or even treat the flu, too many to address in limited space here, but suffice it to say that building up natural immunity with whole foods and supplements, managing stress and getting adequate rest and exercise is a great place to start.

49. Which of the following best summarizes the argument stated in Position 2?

    A. The flu vaccine is a witch's brew and is best avoided by all.
    B. The flu vaccine has many risks, and before deciding to get the vaccine, you should understand both sides of the story.
    C. The flu vaccine should only be taken by the ill and the elderly.
    D. The flu vaccine is created through a complex series of steps, starting with bits of live virus material.

50. When a serious flu virus strain is expected, those arguing Position 1 would agree that

    F. only the elderly, those who are extremely young, and those with chronic medical conditions should be vaccinated.
    G. only the elderly should be vaccinated.
    H. everyone should be vaccinated.
    J. no one should ever have the flu vaccine administered.

51. Which of the following additives into the flu vaccine are known to interfere with brain function?

    A. Thimerosol
    B. Thimerosol and Neomycin
    C. Thimerosol and Aluminum
    D. Aluminum and Neomycin

52. Which ingredient is common to both the flu vaccine and most automobile radiators?

    F. Phenol
    G. Ethylene Glycol
    H. Formaldehyde
    J. Streptomycin

53. Researchers from both positions would likely agree upon which of the following?

    A. The flu vaccine is relatively safe, especially when compared to the risk of catching the flu.
    B. The flu vaccine should never be taken under any circumstances.
    C. The flu vaccine guarantees those who receive the vaccine from getting the flu.
    D. The flu vaccine should be taken by the elderly, especially if they are chronically ill.

54. The strongest argument supporting position 1 is

    F. 10-20% of the population contracts the flu every year.
    G. those who receive the flu vaccine experience 44% fewer doctor visits.
    H. 45,000 Americans die from the flu each year.
    J. 90% of those who die from the flu are age 65 or older.

55. Researchers supporting position 2 may consider reversing their point of view if

    A. definitive evidence was collected that the vaccine actually reduced the number of flu cases.
    B. live virus was not involved in the development of the vaccine.
    C. thimerosol and aluminum were removed as ingredients in the vaccine.
    D. the flu shot could be made to be less painful.