Science:

Robot Quiz 2:

Experiments

Passage II

Scientists noted an increase in plant growth in a lake. Increased growth of lake weeds and algae is usually the result of an increased input of nutrients, especially phosphates and nitrates. Nitrates are easily carried by water moving through the soil (*groundwater*) or streams. Phosphates can attach to soil or stream sediment particles. To determine the primary source of nutrients entering the lake, scientists conducted the following experiments.

Experiment 1

Scientists deduced that one source of phosphates and nitrates was seepage from wastewater systems buried in the soil near houses adjacent to the lake. Sampling wells were placed in locations where samples of groundwater, flowing from houses toward the lake, could be obtained daily. The results are presented in Table 1.

| Table 1		
Date	Phosphate concentration (mg/L)	Nitrate concentration (mg/L)
House 1		
May 2	7.4	17.2
May 3	8.4	17.9
May 4	8.0	18.3
May 5	7.7	17.5
May 6	7.2	21.7
House 2		
May 2	9.1	22.8
May 3	9.7	25.1
May 4	11.8	22.5
May 5	9.1	21.3
May 6	8.8	18.2

Experiment 2

Scientists suspected that another source of nutrients was the runoff from nearby farm lands where fertilizers were applied. Water and suspended-sediment samples were obtained from two streams that flowed into the lake. These streams intercept surface runoff from the farm lands during rainfall and snowmelt. The results are depicted in Table 2.

Table 2		
Date	Suspended sediment concentration (mg/L)	Phosphate concentration (mg/L)	Nitrate concentration (mg/L)
Stream 1			
May 2	14.1	8.6	37.4
May 3	16.4	10.3	36.3
May 4	477.2	45.8	38.9
May 5	1,080.9	90.2	61.1
May 6	568.6	50.3	58.2
Stream 2			
May 2	8.3	7.6	10.7
May 3	15.5	15.2	24.8
May 4	25.1	27.3	27.4
May 5	17.2	16.9	21.6
May 6	8.3	10.4	11.1

6. How do the designs of Experiments 1 and 2 differ in terms of the sampling procedure?

   F. In Experiment 1, sampling was performed daily, whereas in Experiment 2, sampling was performed weekly.
   G. In Experiment 1, groundwater was sampled, whereas in Experiment 2, stream water was sampled.
   H. In Experiment 1, suspended sediment concentration was sampled, whereas in Experiment 2, suspended sediment concentration was not sampled.
   J. In Experiment 1, only nitrate concentration was sampled, whereas in Experiment 2, only phosphate concentration was sampled.

7. In order to obtain more information about the relationship between phosphates, nitrates, and plant growth, which of the following procedures should be performed next?

   A. Studying how the lake weeds grow in water maintained at different temperatures
   B. Growing algae in water samples containing several different phosphate and nitrate concentrations
   C. Adding large amounts of phosphates and nitrates to the soil of House 1
   D. Decreasing the amount of irrigation used by local farmers

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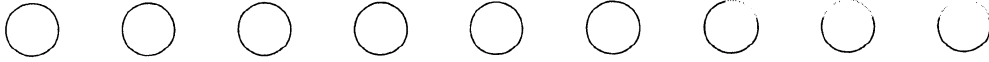
8. Scientists suspected that fertilizers applied to farm lands also contaminated groundwater, which in turn increased nutrient input into the lake. In order to best test this hypothesis, which of the following should the scientists do next?

F. Sample water from three different streams
G. Measure the increase in algae and plant growth in the lake
H. Increase the amount of fertilizer applied to nearby farm lands
J. Vary the amount of fertilizer applied to nearby farm lands and sample groundwater flowing toward the lake in these fields

9. What was the scientists' hypothesis concerning lake plant growth in Experiment 1 ?

A. Wastewater from houses increases lake plant growth.
B. Runoff from farm lands decreases lake plant growth.
C. Rain falling in the vicinity of the houses and lake decreases lake plant growth.
D. Lake sediments release nitrates and phosphates into areas where plants are least abundant.

10. Given the results of Experiments 1 and 2, all of the following measures would reduce the input of phosphorus and nitrogen into the lake EXCEPT:

F. increasing the number of houses surrounding the lake.
G. limiting surface runoff and erosion on upstream farm lands.
H. limiting fertilizer application on upstream farm lands.
J. installing pipes to carry wastewater to a central treatment facility.

11. As phosphates move farther from their source, they are more likely to be adsorbed by the soil (removed from the water). Which of the following would most likely be the approximate phosphate concentration for House 1 on May 3 if the sampling well were closer to the wastewater system of the house?

A. 6.0 mg/L
B. 7.0 mg/L
C. 8.0 mg/L
D. 9.0 mg/L

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Passage III

Motor vehicle exhaust is a significant source of several air pollutants, including the nitrogen oxides, NO_2 and NO. Scientists performed two experiments to investigate the levels and behavior of these pollutants and naturally occurring gases in the atmosphere near busy roadways.

Experiment 1

Scientists studied how NO_2 levels vary with vehicle use. They measured NO_2 levels hourly for a 24-hour period, 10 meters (m) downwind from six roadways. Each roadway had a combination of a different speed limit and *vehicle usage* (approximate number of vehicles per day). An average NO_2 value for each roadway was calculated in parts per billion (ppb). The results are in Table 1.

Table 1		
Roadway speed limit (km/hr)	Vehicle usage (vehicles/day)	Average NO_2 level (ppb)
60	10,000	5
	20,000	9
	30,000	13
100	10,000	8
	20,000	13
	30,000	22

Experiment 2

Next, the levels of NO_2 and NO were measured at 0, 50, and 100 m downwind from the 100 km/hr roadway which averaged 30,000 vehicles per day. The level of NO_2 decreased from 30 ppb at 0 m to 17 ppb at 100 m. The level of NO decreased from 150 ppb at 0 m to 42 ppb at 100 m.

(Note: The levels of NO_2 and NO that would be found far from pollution sources are 15 ppb and 35 ppb, respectively.)

Experiment 3

Ozone (O_3) is a naturally occurring gas in the atmosphere. Levels of ozone, in parts per million (ppm) were taken at various distances downwind from the 100 km/hr roadway which averaged 30,000 vehicles per day. The results are in Table 2.

(Note: The naturally occurring ozone concentration is 0.12 ppm.)

Table 2	
Distance from roadway (m)	Ozone level (ppm)
0	0.0075
50	0.02
100	0.04
150	0.075
200	0.09

12. Which of the following factors was varied in Experiment 3 ?

F. Background concentration of NO_2
G. Background level of ozone
H. Distance from roadway
J. Speed limit

13. According to the experimental results, one way to reduce levels of NO_2 in an area would be to:

A. reduce the levels of naturally occurring ozone near roadways.
B. lower speed limits on the roadways.
C. raise speed limits on the roadways.
D. require installation of ozone filters in motor vehicle exhaust systems.

14. According to the experimental results, if one compared ozone levels near a major highway to those in a remote wilderness location, ozone levels:

F. near the highway would be higher than at the wilderness location.
G. near the highway would be lower than at the wilderness location.
H. near the highway would be the same as those in the wilderness location.
J. would be detectable only near the highway.

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15. Carbon monoxide (CO) is another pollutant associated with motor vehicle exhaust. If carbon monoxide behaves like the nitrogen oxides in the experiments, one would expect that carbon monoxide levels:

    A. would decrease over time.
    B. would stay the same over time.
    C. are higher near roadways than farther away from them.
    D. are lower near roadways than farther away from them.

16. According to the results of the experiments, as distance from the roadway increases:

    F. NO_2 and ozone levels both increase.
    G. NO_2 levels increase and ozone levels decrease.
    H. NO_2 levels increase and ozone levels stay the same.
    J. NO_2 levels decrease and ozone levels increase.

17. A certain roadway has a speed limit of 100 km/hr and an average vehicle usage of 100,000 vehicles per day. One would predict that 10 m downwind from this roadway NO_2 levels are:

    A. less than 8 ppb.
    B. between 8 and 13 ppb.
    C. between 13 and 22 ppb.
    D. above 22 ppb.

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Passage IV

The following experiments were done to study factors that affect the precession of a top. *Precession* is the revolution of a top around an imaginary line perpendicular to the surface at the point of contact (see Figure 1).
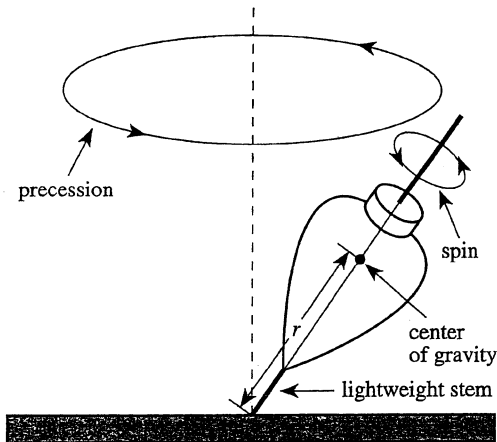

Figure 1

Experiment 1

An electric motor was attached to a top and used to give the top a known spin rate or number of revolutions per minute (rpm). Once the desired spin rate was achieved, the motor was removed and the number of precessions per minute was counted. The process was repeated using different spin rates. The results are recorded in Table 1.

| Table 1	
Spin rate (rpm)	Precession rate (rpm)
350	16
500	11
700	8
1,100	5

Experiment 2

The distance from the surface to the top's center of gravity (r) was varied by changing the length of the lightweight stem on the top from Experiment 1. The electric motor was used to generate the same spin rate in each trial. The measured precession rate is given in Table 2.

| Table 2	
r (inches)	Precession rate (rpm)
2	7.5
3	11
4	15
5	19

Experiment 3

A scientist took the top from Experiment 1 to the Moon. It was found that for a given spin rate and stem length, the precession rate was approximately one-sixth that on Earth. For example, a precession rate of 12 rpm on Earth would be approximately 2 rpm on the Moon.

18. Based on the results of Experiment 2, one can conclude that the precession rate of a top increases as the stem:

F. decreases in length.
G. increases in length.
H. remains the same length.
J. doubles in mass.

19. Which of the following graphs best represents the change in precession rate with increasing spin rate as shown in Experiment 1 ?
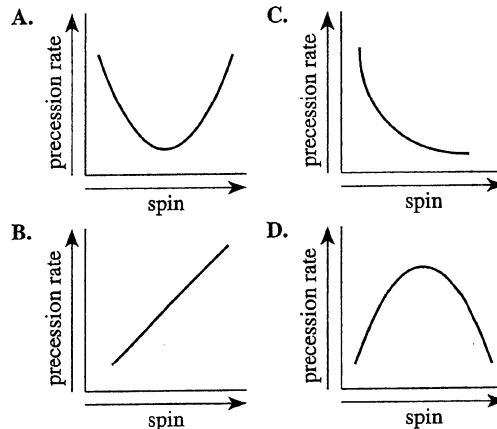
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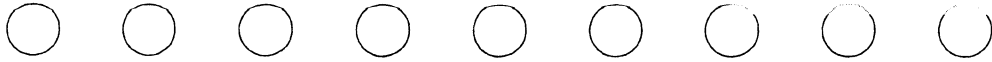
20. The scientist conducting Experiment 3 hypothesizes that precession rate is related to gravity. The best way to confirm this hypothesis would be to repeat the experiment on:

F. several different planets with varying gravities.
G. one other planet with the same gravity as Earth.
H. a planet without an atmosphere.
J. Earth using various spin rates.

21. If the spin rate used in Experiment 2 was 500 rpm, what is most likely the value of r in Experiment 1 ?

A. 3 inches
B. 4 inches
C. 5 inches
D. 6 inches

22. If the techniques of Experiment 1 had not been perfected first, how would this have affected Experiment 2 ?

F. The mass of the top would have been a factor.
G. The spin rate might not have been the same in each trial.
H. The top's mass may have redistributed itself.
J. The top's shape may have changed.

23. How would one best investigate the effect of a top's mass on the precession rate if the spin rate is constant?

A. Use tops of different colors
B. Use tops that are the same size, have the same shape, and are made from different metals
C. Try different tops and test them on both the Earth and Moon
D. Try tops with equal mass but stems of different lengths

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